Integrated Management of Fruit Flies in India (IMFFI)

"Key Informant Survey" of Production, Value, Losses and Protection of Fruit Fly Hosts in India

Workplan and Data Sheets

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Dear Colleague,

The objective of the IMFFI Key Informant Survey is to obtain estimates, across the whole of India, for the following values:-

- Production of fruit fly hosts, divided among the major agro-ecological zones
- Farm-gate prices of fruit fly host produce
- Losses to fruit flies, host-by-host and zone-by-zone, both with and without fly controls
- Incidence of controls, host-by-host and zone-by-zone
- The relative incidence of the major pest species in causing losses, separately for the two categories of orchard fruit and cucurbit vegetables

Preliminary estimates have now been obtained and are being circulated, and all recipients are requested to comment on them. The idea is that the numbers so far will be looked at by everybody, they will comment, and then the revised numbers will be progressively improved. Please discuss these as widely as possible with colleagues and associates, and derive what, in your view, are more appropriate or more accurate values, and transmit your corrections to Dr John Stonehouse, IMFFI Project Manager, Imperial College London, UK (fax 00-44-1947-841189; e-mail j.stonehouse@imperial.ac.uk).

The principle of this circulating request is that the estimates will become gradually more accurate as more and more refining opinions are received and absorbed. It thus uses the principle of Bayesian algebra, in which successive estimates, subjective if need be, are used to refine and improve each other, and of Delphi consultations, in which opinions are circulated anonymously and discussed among a group.

The estimates follow below. On all pages columns are in pairs - "Initial" columns contain the values as estimated so far; "Revised" columns are empty and for the respondents (i.e. you) to write in corrections/alterations if you disagree with the "Initial" values. Leave the "Revised" cell empty if you do not disagree with the "Initial" value or don't know anything about it. Production data are estimated nationwide, and then estimates attributed to production, loss and protection in the major agro-ecological zones into which ICAR divides India. These zones are shown on the map below.

The estimates fall into three categories, on three different data sheets:-

1. Production and farm-gate value of major hosts nationwide as, host-by-host:
    a - Production volume for the whole of India per annum
    b - Overall average farm-gate price - the price received by the farmer in rupees/KG.

2. Production and fruit fly losses, host-by-host for each different agro-ecological zone:

2A - Relative levels of production of each host across zones, estimated by awarding a score of "100" to the zone with the greatest level of production of that host, and then others for the other zones as a percentage of that. The role of the "Volume" values in Sheet 2 is therefore to allocate the RELATIVE incidence of production of different hosts to different areas (the absolute levels of production are in Sheet 1). Volume figures are levels of production by that host in that zone as a percentage of the production in the zone where it is most abundant. So if Zone A has most production it is awarded 100; Zone B may be 80% of A so gets 80; Zone C may be 15% of A so gets 15; Zone D may be 30% of Zone A so gets 30; and all the other zones have no production so all get 0. Imperial College will then adjust these by adding up the percentages, so of the total nationwide production A would account for 100/(100+80+15+30)=44%, B would account for 80/(100+80+15+30)=36%, C for 15/(100+80+15+30)=7%, D for 30/(100+80+15+30)=13%, and the others for 0%. (Enter "0" for cultivation of any host in any zone where cultivation is absent).

2B - Percentage losses to fruit flies, when hosts are not protected from them in any way.

2C - Percentage losses to fruit flies, when hosts are protected by local controls as currently in use.

2D - The percentage incidence of the local controls whose effect is assessed in 2C. "Control incidence" in Sheet 2 is the percentage of production of that particular host which is protected against fruit flies at farm level. Protection from fruit flies may be provided by controls such as cover sprays which are not directed at them, and these should be included

3. Prevalence in causing damage, relative to each other, of the various major fruit fly species, in the two broad categories of orchard fruit pests and cucurbit pests. This is estimated by, in each agro-ecological zone, grading the most prevalent fly species with a score of "100" and the other flies present with a prevalence as a percentage of that. Values in Table 3, in other words, are the RELATIVE levels of damage caused by different fly species to the two major host groups (fruit and cucurbits) in each zone. So, as an example, imagine that in any one particular zone *dorsalis* is most damaging, it is awarded 100, *zonata* causes about 3/4 of the damage of *dorsalis* and so it is awarded 75%, and *correcta* causes about a third of the damage of *dorsalis* and so is awarded 33%. Imperial College will then attribute damage to the species by adding up the percentages awarded, so here overall damage by *dorsalis* would be 100/(100+75+33)=48%, *zonata* would be 75/(100+75+33)=36%, and *correcta* would be 33/(100+75+33)=16%. As another example, if in a given zone the prevalence is of 50% of *B cucurbitae*, 30% of *D ciliatus* and 20% of *B tau*, scores would be awarded as "100" for *cucurbitae*, "60" (30/50) for *ciliatus* and "40" (20/50) for *tau*. Scoring is done in this way to allow values to be modified while under discussion without worrying whether they add up to 100; after the consultation is complete the totals for each species in

each zone will be divided by the total scores awarded in that zone to obtain final percentage values.

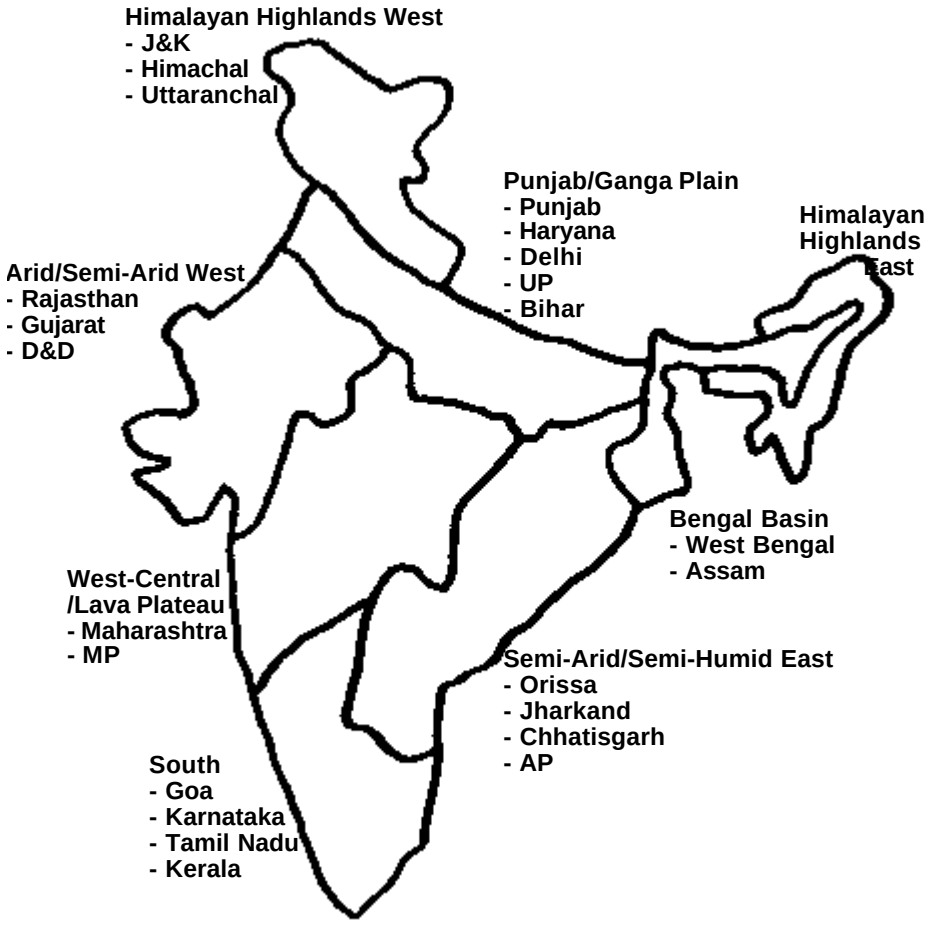
These values, once collected from all participants, will allow the estimation of losses to flies across all hosts and zones. Respondents are requested to provide corrected values where they consider the values given to be in error, and next to each provisional, current value there is a vacant cell for the entry of corrections. Values which are considered to be correct may be left as they are. Please also indicate where a category, such as major host type under (1) or a major pest species under (3), has been omitted and needs to be added.

The map below lists the major agro-ecological zones of India (the external boundaries of India on this map have not been authenticated and may not be correct).

Your assistance in this Study is gratefully appreciated, and will contribute to a useful body of work.

Best wishes,

John Stonehouse



Principal Agroecological Zones of India

Sheet 1. All-India estimates of volumes of production

All volume data are lakhs of metric tonnes (1MT=1000kg) per year nationwide.
All price data are Rupees/KG at the farm gate.

	Volume		Price	
Orchard fruit	Initial	Revised	Initial	Revised
Mango	99		10	
Guava	18		6	
Jujube	1.5		6	
Sapota	1		7	
Phalsa	0.5		8	
Peach	0.5		9	
Apricot	0.5		9	
Cucurbits				
Cucumber	28		20	
Muskmelon	30		6	
Watermelon	7		3.5	
Cooking melon	2		5	
Pumpkin	10		3.5	
Bitter gourd	10		15	
Small gourd	8		15	
Ridge gourd	8		5	
Bottle gourd	3.5		5	
Snake gourd	5		7.5	
Sponge gourd	2.5		5	
Chayot/Chao-Chao	2		5	
Ash gourd	10		5	
Sweet gourd	2		10	

Sheet 2. Production and fruit fly losses, host-by-host and zone-by-zone

	A: Relative Volume		B: % Loss Unprotected		C: % Loss Protected		D: % Control Incidence	
Product: Mango	Initial	Revised	Initial	Revised	Initial	Revised	Initial	Revised
Himalayan Highlands West	2		20		2		40	
Punjab/Ganga Plain	100		6		2		70	
Arid/Semi-Arid West	8		3		1		80	
West-Central/Lava Plateau	25		3		1		80	
South	35		25		3		50	
Semi-Arid/Semi-Humid East	20		23		3		35	
Bengal Basin	6		23		3		35	
Himalayan Highlands East	1		10		3		30	
Product: Guava								
Himalayan Highlands West	0		10		2		0	
Punjab/Ganga Plain	100		12		3		0	
Arid/Semi-Arid West	4		4		1		0	
West-Central/Lava Plateau	10		10		2		0	
South	10		10		2		0	
Semi-Arid/Semi-Humid East	40		40		10		0	
Bengal Basin	0		30		7		0	
Himalayan Highlands East	0		10		2		0	
Product: Jujube								
Himalayan Highlands West	0		10		2		5	
Punjab/Ganga Plain	30		12		3		5	
Arid/Semi-Arid West	100		4		1		5	
West-Central/Lava Plateau	20		10		2		5	
South	0		10		2		5	
Semi-Arid/Semi-Humid East	4		40		10		5	
Bengal Basin	1		30		7		5	
Himalayan Highlands East	0		10		2		5	
Product: Sapota								
Himalayan Highlands West	0		10		2		5	
Punjab/Ganga Plain	100		12		3		5	
Arid/Semi-Arid West	100		4		1		5	
West-Central/Lava Plateau	20		10		2		5	
South	20		10		2		5	
Semi-Arid/Semi-Humid East	20		40		10		5	
Bengal Basin	0		30		7		5	
Himalayan Highlands East	0		10		2		5	

Product: Phalsa								
Himalayan Highlands West	0		10		2		5	
Punjab/Ganga Plain	100		12		3		5	
Arid/Semi-Arid West	100		4		1		5	
West-Central/Lava Plateau	70		10		2		5	
South	0		10		2		5	
Semi-Arid/Semi-Humid East	40		40		10		5	
Bengal Basin	10		30		7		5	
Himalayan Highlands East	0		10		2		5	
Product: Peach								
Himalayan Highlands West	100		10		2		35	
Punjab/Ganga Plain	15		12		3		35	
Arid/Semi-Arid West	5		4		1		35	
West-Central/Lava Plateau	5		10		2		35	
South	0		10		2		35	
Semi-Arid/Semi-Humid East	0		40		10		35	
Bengal Basin	0		30		7		35	
Himalayan Highlands East	10		10		2		35	
Product: Apricot								
Himalayan Highlands West	100		10		2		35	
Punjab/Ganga Plain	15		12		3		35	
Arid/Semi-Arid West	5		4		1		35	
West-Central/Lava Plateau	5		10		2		35	
South	0		10		2		35	
Semi-Arid/Semi-Humid East	0		40		10		35	
Bengal Basin	0		30		7		35	
Himalayan Highlands East	10		10		2		35	
Product: Cucumber								
Himalayan Highlands West	100		15		5		60	
Punjab/Ganga Plain	60		20		7		60	
Arid/Semi-Arid West	10		15		5		60	
West-Central/Lava Plateau	50		20		7		60	
South	3		30		10		75	
Semi-Arid/Semi-Humid East	5		30		10		60	
Bengal Basin	0		20		7		60	
Himalayan Highlands East	0		15		5		60	

Product: Muskmelon								
Himalayan Highlands West	0		15		5		60	
Punjab/Ganga Plain	50		20		7		60	
Arid/Semi-Arid West	100		15		5		60	
West-Central/Lava Plateau	50		20		7		60	
South	10		30		10		75	
Semi-Arid/Semi-Humid East	10		30		10		60	
Bengal Basin	0		20		7		60	
Himalayan Highlands East	0		15		5		60	
Product: Watermelon								
Himalayan Highlands West	0		15		5		60	
Punjab/Ganga Plain	20		20		7		60	
Arid/Semi-Arid West	20		15		5		60	
West-Central/Lava Plateau	100		20		7		60	
South	80		30		10		75	
Semi-Arid/Semi-Humid East	10		30		10		60	
Bengal Basin	10		20		7		60	
Himalayan Highlands East	8		15		5		60	
Product: Cooking Melon								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	0		20		7		50	
Arid/Semi-Arid West	0		15		5		50	
West-Central/Lava Plateau	0		20		7		50	
South	100		30		10		70	
Semi-Arid/Semi-Humid East	0		30		10		50	
Bengal Basin	0		20		7		50	
Himalayan Highlands East	0		15		5		50	
Product: Pumpkin								
Himalayan Highlands West	0		15		5		40	
Punjab/Ganga Plain	10		20		7		40	
Arid/Semi-Arid West	20		15		5		40	
West-Central/Lava Plateau	15		20		7		40	
South	40		30		10		60	
Semi-Arid/Semi-Humid East	20		30		10		40	
Bengal Basin	20		20		7		40	
Himalayan Highlands East	100		15		5		40	

Product: Bitter Gourd								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	5		20		7		50	
Arid/Semi-Arid West	5		15		5		50	
West-Central/Lava Plateau	10		20		7		50	
South	100		30		10		70	
Semi-Arid/Semi-Humid East	40		30		10		50	
Bengal Basin	12		20		7		50	
Himalayan Highlands East	12		15		5		50	
Product: Small Gourd								
Himalayan Highlands West	0		8		3		50	
Punjab/Ganga Plain	30		10		4		50	
Arid/Semi-Arid West	10		8		3		50	
West-Central/Lava Plateau	20		10		4		50	
South	100		15		5		70	
Semi-Arid/Semi-Humid East	80		15		5		50	
Bengal Basin	20		10		4		50	
Himalayan Highlands East	60		8		3		50	
Product: Ridge Gourd								
Himalayan Highlands West	0		5		2		50	
Punjab/Ganga Plain	20		7		2		50	
Arid/Semi-Arid West	10		5		2		50	
West-Central/Lava Plateau	30		7		2		50	
South	40		10		3		70	
Semi-Arid/Semi-Humid East	100		10		3		50	
Bengal Basin	10		7		2		50	
Himalayan Highlands East	60		5		2		50	
Product: Bottle Gourd								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	30		20		7		50	
Arid/Semi-Arid West	0		15		5		50	
West-Central/Lava Plateau	100		20		7		50	
South	10		30		10		70	
Semi-Arid/Semi-Humid East	90		30		10		50	
Bengal Basin	10		20		7		50	
Himalayan Highlands East	10		15		5		50	

Product: Snake Gourd								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	10		20		7		50	
Arid/Semi-Arid West	5		15		5		50	
West-Central/Lava Plateau	5		20		7		50	
South	80		30		10		70	
Semi-Arid/Semi-Humid East	100		30		10		50	
Bengal Basin	20		20		7		50	
Himalayan Highlands East	30		15		5		50	
Product: Sponge Gourd								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	10		20		7		50	
Arid/Semi-Arid West	10		15		5		50	
West-Central/Lava Plateau	20		20		7		50	
South	20		30		10		70	
Semi-Arid/Semi-Humid East	100		30		10		50	
Bengal Basin	20		20		7		50	
Himalayan Highlands East	20		15		5		50	
Product: Chayot								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	0		20		7		50	
Arid/Semi-Arid West	0		15		5		50	
West-Central/Lava Plateau	0		20		7		50	
South	100		30		10		70	
Semi-Arid/Semi-Humid East	40		30		10		50	
Bengal Basin	0		20		7		50	
Himalayan Highlands East	70		15		5		50	
Product: Ash Gourd								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	105		20		7		50	
Arid/Semi-Arid West	5		15		5		50	
West-Central/Lava Plateau	40		20		7		50	
South	40		30		10		70	
Semi-Arid/Semi-Humid East	40		30		10		50	
Bengal Basin	60		20		7		50	
Himalayan Highlands East	60		15		5		50	

Product: Sweet Gourd								
Himalayan Highlands West	0		15		5		50	
Punjab/Ganga Plain	0		20		7		50	
Arid/Semi-Arid West	0		15		5		50	
West-Central/Lava Plateau	0		20		7		50	
South	0		30		10		70	
Semi-Arid/Semi-Humid East	0		30		10		50	
Bengal Basin	100		20		7		50	
Himalayan Highlands East	100		15		5		50	

Sheet 3. List of species by relative prevalence in causing losses, as the major economic species, and omitting species of niche importance (e.g. *Carpomyia vesuviana* in jujube, *B. oleae* in olive, Moringa fly, *B. latifrons*)

Species	*B. dorsalis*		*B. zonata*		*B. correcta*		Other	
Estimate	Initial	Revised	Initial	Revised	Initial	Revised	Initial	Revised
ORCHARD FRUIT								
Himalayan Highlands West	40		100		0			
Punjab/Ganga Plain	70		100		2			
Arid/Semi-Arid West	100		70		0			
West-Central/Lava Plateau	100		60		20			
South	100		10		30			
Semi-Arid/Semi-Humid East	67		100		7			
Bengal Basin	80		100		0			
Himalayan Highlands East	75		100		0			
	B. cucurbitae		*B. tau*		*D. ciliatus*		Other	
	Initial	Revised	Initial	Revised	Initial	Revised	Initial	Revised
CUCURBITS								
Himalayan Highlands West	100		0		5			
Punjab/Ganga Plain	100		0		10			
Arid/Semi-Arid West	100		0		12			
West-Central/Lava Plateau	100		0		12			
South	100		0		12			
Semi-Arid/Semi-Humid East	100		0		4			
Bengal Basin	100		5		0			
Himalayan Highlands East	80		100		0			

Integrated Management of Fruit Flies in India (IMFFI)

Pictorial Record of Wide-Area Study Environments

Village-level studies were conducted over a variety of ecogeographical regions and conditions. To allow meaningful analysis, a photographic record was made of the general outlook and conditions in each village, and this Appendix presents two representative images of each.

Thrissur Mango 1

Thrissur Mango 2

Thrissur Bitter Gourd 1

Thrissur Bitter Gourd 2


Thiruvananthapuram Bitter Gourd 1


Thiruvananthapuram Bitter Gourd 2


Palanpur Pumpkin 1

Palanpur Pumpkin 2

Anand Bitter Gourd 1

Anand Bitter Gourd 2

Varanasi Bitter Gourd 1


Varanasi Bitter Gourd 2


Bhubaneswar Bitter Gourd 1


Bhubaneswar Bitter Gourd 2

Integrated Management of Fruit Flies in India (IMFFI)

Pictorial Record of Laboratory Study Cages

“Choice-chamber” cages for laboratory studies of baits were made under a variety of conditions to the same basic specification. Below is a photograph of each to illustrate variation with local conditions.


Thrissur


Lucknow


Bhubaneswar


Anand


Palanpur


Varanasi


Navsari


Thiruvananthapuram

South Asia Fruit Fly Network

Newsletter

Collaborative Project
Integrated Management of Fruit Flies in India (IMFFI):
The Project, its Background and Progress

Tephritid Fruit Flies

Fruit flies (in the family Tephritidae, among the "true flies" or Diptera) are destructive pests of fruits and cucurbit vegetables (and not to be confused with the better-known Drosophilinid fruit flies, which mostly affect over-ripe and fermenting fruit and thus are largely economically harmless). After mating with a male, the adult female fly lays eggs into a healthy maturing fruit, which develop into maggots which ruin the fruit as it ripens. When the maggots are developed, they emerge from the fruit, leaving a round hole, and drop to the ground, where they burrow into the soil to form pupae, which develop into young adult male and female flies which fly into the vegetation to mate and lay more eggs.

As they do direct damage to fruit, the part of the crop plant which is harvested for human consumption, fruit flies do considerable damage even when present in relatively small numbers. Apart from the damage to fruit itself, flies damage export earning potential as many destination markets have strict quarantine regulations to prevent fruit flies from abroad establishing themselves in local fruit orchards.

Pest flies in India divide broadly into two groups. One attacks orchard fruit such as mango, guava, peach and sapota, and includes major species in the genus *Bactrocera* (ex-*Dacus*) such as *B. zonata*, *B. dorsalis* and *B. caryae*. The other group attacks cucurbits such as melon, cucumber and gourds such as bitter, small, ridge and sponge gourd, and comprises largely the melonfly *Bactrocera cucurbitae*. Although not a hard-and-fast pattern, therefore, orchard flies attack relatively high-value and productive fruit crops, some of them with export potential, whereas the melonfly attacks vegetables grown in smaller and less profitable production systems, often by small farmers for local village markets.

Controlling Fruit Flies

As fresh fruits are targets of fruit flies, control using insecticides must be carried out as fruit ripen, close to harvest, and thus may leave undesirable residues in/on the fruits. Alternative controls are available, however, which exploit the attraction of adults to certain chemicals.

The first of these is the attraction of all adults to food baits. Newly-emerged young adult

The power of parapheromones. This IMFFI parapheromone block trap in a mango orchard outside Lucknow, India, contained over 2000 flies (photo RP Shukla).

flies have grown up (as maggots inside fruit) on a diet poor in protein, and are attracted to protein foods. Food baits may be used for "Bait Application Technique" or "BAT" control, mixed with insecticide and sprayed or daubed in the field, and then attract adults to their deaths. Baits typically need to be replenished weekly to obtain satisfactory control throughout the season.

The second attraction which may be exploited is that of some chemicals which act like sexual pheromones (and hence are called "parapheromones") and strongly attract adult males (though females hardly at all). Parapheromones may be used for "Male Annihilation Tecnique" or "MAT" control, in traps, or soaked into wooden or board blocks, with a small amount of insecticide, which attract and kill males; when the males in a locality are wiped out the unmated females cannot lay fertile eggs and so fruit are not attacked.

There are two characteristic operational differences between BAT and MAT in their use. First, the wooden blocks which may be used for MAT can emit their loads relatively slowly, and so obtain a more persistent effect than BAT, lasting for two months or more and, as more powerful olfactory attractants than food baits, they may be effective when used more widely spaced - at a rate of ten blocks per hectare, for example, in contrast to the 200 bait-spots per hectare typically used for BAT; as a result of these characteristics, MAT is typically much less demanding of labour than BAT and generally cheaper to use. Second, effective MAT requires the purchase of manufactured inputs in the form of parapheromones, and thus capital investments, whereas BAT may be effectively performed, and has been in India for decades, by home-made preparations of common foodstuffs such as banana and jaggery widely available on the farm and in its vicinity (the common plant Holy Basil or *tulsi* - *Ocimum sanctum* - contains methyl eugenol, and is widely used for trapping orchard flies in India; IMFFI studies have given cause for doubt, however, that tulsi is sufficiently powerful an attractant to exert effective control, and this is being checked in the 2005 field season).

Both BAT and MAT may be presumed to need to be carried out quite thoroughly, and over an area larger than a certain minimum size, to be effective. Flies which have fed on protein are less likely to be attracted to bait, and so may penetrate areas protected by BAT. Similarly, if MAT is not thorough each surviving male may be able to mate successfully with several females, and mated females, impervious to parapheromones, may successfully penetrate, and attack fruit inside, areas protected by MAT.

The management of the two fruit fly guilds is to a great extent dictated by the fact that the parapheromone which attracts the orchard fly guild of *B. zonata* and its fellows is methyl-eugenol, a well-known chemical manufactured and sold in India as a food flavouring, and available at a reasonable price. The parapheromone which attracts the melonfly *B. cucurbitae* on the other hand, is Cue-lure, a more unusual and expensive compound which is not manufactured in India (though it may legally be imported). Cue-lure is not commercially on sale in India, but an indication of their relative costs may be seen in that the UK supplier International Pheromone Systems, which supplied most of the materials for IMFFI research, sells a kilogram of methyl eugenol for approximately £18 (eighteen British pounds - about 1440 Indian rupees) and a kilogram of cue-lure for £95 (about 7600 Indian rupees) - more than five times more. As a result of this price difference, it seems likely that for the foreseeable future the main line of defence in the control of orchard flies may be by methyl eugenol MAT, whereas the main line of defence of cucurbits against the melonfly may have to be by BAT using food baits. This is not a clear distinction however: MAT management of melonflies by cue-lure is possible, and may be economically profitable when cucurbit hosts are of high economic value; conversely, and worryingly, MAT management in orchards may not always be successful - when fly populations are large not enough males may be killed, and mated females from outside may enter the protected area - and in such cases BAT baits may also need to be used against orchard flies.

The IMFFI Research Strategy

The IMFFI project is a research project to find the best ways of controlling fruit flies in India at farm and field level. It is carried out by the Indian Council for Agricultural Research (ICAR) with financial support from the Department for International Development (DFID) of the UK Government, through the DFID Crop Protection Research Programme manager, NR International Ltd, and technical support from Imperial College London.

Field research is carried out at eight collaborating ICAR Centres:

Kerala Agricultural University (KAU), Thrissur, Kerala
Kerala Agricultural University (KAU), Thiruvananthapuram, Kerala
Navsari Agricultural University (NAU), Gandevi, Gujarat
Anand Agricultural University (AAU), Anand, Gujarat
Sardarkrishinagar Dantiwada Agricultural University (SDAU), Palanpur, Gujarat
Central Horticultural Experiment Station (CHES), Bhubaneswar, Orissa
(part of the Indian Instiute of Horticultural Research)
Indian Institute of Vegetable Research (IIVR), Varanasi, Uttar Pradesh
Central Institute for Subtropical Horticulture (CISH), Lucknow, Uttar Pradesh

Additionally, the “Knowledge Review” - a desk study to gather and collate all the information already known about tephritids and their management in South Asia, is carried out at the National Centre for Integrated Pest Management (NCIPM), New Delhi. Laboratory studies to optimise the selection of baits for BAT control are also being conducted at the ICAR Research Centre for Goa (IRCG). This allows the laboratory studies to cover much of India in three clusters of three Centres, each cluster containing two Centres studying melonfly, as the most important bait-control target, and one Centre studying the local orchard flies.

Cluster	"Western"	"Southern"	"East-Central"
Melonfly	SDAU, Palanpur AAU, Anand	KAU, Thiruvananthapuram KAU, Thrissur	CHES, Bhubaneswar IIVR, Varanasi
Orchard fly	NAU, Gandevi	IRCG, Goa	CISH, Lucknow

IMFFI research has three main areas of focus:-

1 - Finding the most attractive and cost-effective baits for farm-level BAT
Comparing and assessing baits can be conveniently done in the laboratory, using flies reared in captivity. IMFFI research places adult flies in large cages, with a choice of different baits, to see which attracts and kills the largest numbers of flies. The effectiveness of the most promising baits can then be confirmed in the field. For many years fruit flies in cucurbits have been managed by application of food baits of banana flesh or jaggery, and IMFFI studies currently seem to be confirming that both of these, mixed with insecticide, can be as good as imported, protein hydrolysate bait under local conditions, and that more exotic additives such as fruit extracts, and mixtures of banana and jaggery together, are no more effective than simple banana or jaggery preparations.

2 - Finding the most cost-effective way to use methyl eugenol for MAT
The cost-effectiveness of MAT can depend on whether lure is used in wood blocks or traps, and factors such as the types of wood and solvent, strength of soaking solution and block size. IMFFI research is measuring the effects of all these variables using blocks and traps in farmers' orchards. IMFFI studies have found that in fruit orchards such as mangoes and guavas, methyl eugenol, distributed in small wooden blocks soaked in lure and insecticide, can be very effective in obtaining MAT control, although this approach requires that a minimum area be treated and, if pest pressure is heavy, food baits can be used additionally.

3 - Quantifying the added benefit from fly control at village level
Consideration of the principle of the operation of both bait (BAT) and lure (MAT) controls suggests that they should benefit substantially from being applied in a coordinated way by all the farms within an

Cooperative control. Farmers in an IMFFI study apply fruit fly baits throughout an entire village outside Thrissur, India (photo: Jim Thomas).

area such as a village or locality, which should greatly increase the level of protection over that obtained when individual farmers act alone. IMFFI studies are comparing the level of pest control obtained by BAT and MAT used at farm and village level, by a series of large-area experiments at different sites throughout India. These studies have confirmed that, as expected, village-level area-wide coordinated control, over an area of one square kilometre, increases the level of protection by single-farm-level use, roughly doubling the level of protection obtained. This principle may be used for the protection of very large areas, and IMFFI scientists propose to test its extension to areas of ten square kilometres in Gujarat and Uttar Pradesh in 2005.

IMFFI and the Establishment of the South Asia Fruit Fly Network (SAFFN)

On January 10-11, 2005, the *Final ReviewMeeting* of the IMFFI Project was carried out, at Pusa, New Delhi, hosted by CAB International, under the overall chairmanship of Dr Gautam Kalloo, Deputy Director General (Horticulture and Crop Science), ICAR, and Drs SN Pandey, the Assistant Director General (Horticulture), ICAR, Abraham Verghese of the Indian Institute of Horticultural Research (IIHR), Bangalore, the Project Coordinator, and John Stonehouse of Imperial College London, the Project Manager.

The meeting developed a research strategy for the IMFFI research team for the field season of 2005, before the Project comes to an end on October 31st 2005. It also included a consultation with specialists from the agricultural research and extension community, including cooperatives and the private sector, to discuss requirements for the development of "extension-ready" fruit fly management technologies. It closed with the launch of the *South Asia Fruit Fly Network* (**www.SouthAsiaFruitFly.net**) which will serve as a forum for fruit fly workers, farmers and the interested public to communicate with each other, to seek, air, share and discuss information and opinions. The Network's website will disseminate the research results and control recommendations arising from IMFFI research, and encourage the discussion of all aspects of fruit flies and their management in South Asia, through the on-line *SAFFN Newsletter,* the *Fruit Fly Forum* bulletin board, a list of *Connections and Contact* to allow fruit fly workers to contact each other, and a page of announcements of upcoming events. The Network is hosted by Anand Agricultural University, Gujarat, and the site was officially opened by Dr Kalloo on January 11th, 2005.

Putting the customer first. IMFFI researchers discuss village-level fruit fly control with gourd farmers outside Bhubaneswar, India (photo: HS Singh).

Indian fruit fly control and the South Asia Fruit Fly Network

IAEA-CN-131/94P

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Programme

The project "Integrated Management of Fruit Flies in India " (IMFFI) supports researchers at eight centres in India. The areas are representative of a range of horticultural systems within the country and includes work on the major Tephritid fruit flies affecting fruits and vegetables: *Bactrocera zonata*, *B. dorsalis*, *B. cucurbitae*. Participating centres:

- Kerala Agricultural University (KAU), Thrissur and Thiruvananthapuram
- Navsari Agricultural University (NAU), Gandevi, Gujarat
- Anand Agricultural University (AAU), Anand, Gujarat
- Sardarkrushinagar Dantiwada Agricultural University (SDAU), Palanpur, Gujarat
- Central Horticultural Experiment Station (CHES), Bhubaneswar, Orissa
- Indian Institute of Vegetable Research (IIVR), Varanasi, Uttar Pradesh
- Central Institute for Subtropical Horticulture (CISH), Lucknow, Uttar Pradesh

Monitoring cucurbit fly damage in Kerala (photo: T Jiji)

Activities

Extensive trapping from 2003-2005 established seasonal patterns of fly abundance and damage. Cucurbits are worst affected in August, while tree fruit damage is spread throughout the year depending on the fruiting seasons (May for mango, July for sapota, December for guava).

Trials in 2003 and 2004 demonstrated that market quality fruit can be produced from area-wide male annihilation control. Further experiments in 2005 are testing this for vegetable fruit flies. Larger scale treatment, 1 km^2, gave double the effectiveness of male annihilation compared to farm-level treatment. Work with Mother Dairy Ltd has been examining how cooperative fruit fly control at village-level can be connected with other quality and value adding processes (such as grading and packing of produce locally) to increase small farm incomes and improve their position in the food supply chain.

A review of the Indian fruit fly literature has produced abstracts of over 300 reports and published papers in Indian journals going back to the 1930s on fruit flies in India. These will be made available to researchers through the web-based network.

Assessing damage to pumpkin (L) and mango (R) in Gujarat (photo: RK Patel)

Village-level bait application trial in Kerala (photo: J Thomas)

South Asia Fruit Fly Network

The *South Asia Fruit Fly Network* (**www.southasiafruitfly.net**) will serve as a forum for fruit fly research. The Network's website will disseminate the research results and control recommendations arising from research in the region, and encourage the discussion of all aspects of fruit flies and their management in South Asia, through the on-line *SAFFN Newsletter,* the *Fruit Fly Forum* bulletin board, a list of *Connections and Contacts* to allow fruit fly workers to contact each other, and a page of announcements of upcoming events. The Network is hosted by Anand Agricultural University, Gujarat, and the site was officially opened on 11 January, 2005.

The human network at Delhi, Jan 2005

Acknowledgement: Work funded by the UK Department for International Development Crop Protection Programme, Project R8840, collaborating with the Indian Council for Agricultural Research

Village-level suppressive fruit fly management in India: Issues determining the optimum scale of cooperative control

IAEA-CN-131/92P

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Village Cooperative Control

There are often benefits to the coordinated, suppressive control of pests over an area larger than an individual farm, but smaller those used for highly coordinated, high-technology applications such as SIT. This study evaluated the returns to fruit fly management at the scales of the "farm" and of the "village" in India, and found that village-level application had approximately double the effectiveness of farm-level application. Interviews and discussions examined the social features making cooperative control sustainable at village level.

Farmers were interviewed singly and in groups (photo: HS Singh)

Five Keys to Sustainability

1 - ***Farm Size*** Among large farms the number of farmers needed to obtain cooperative control is relatively small. Among very small farms only cooperative control may be effective, as immediate reimmigration from neighbouring plots undermines farm-level controls.

2 - ***Problem Seriousness*** Sustainable cooperative control must overcome inertia, apathy and suspicion. The perception of the problem as serious is particularly important in overcoming this.

3 - ***Shared Economy*** Sustainable cooperative control is enhanced when it can be "grafted" or "piggybacked" onto other cooperative activities - such as marketing or buying inputs – rather than begun from scratch.

4 - ***Social cohesion*** Some mutual trust is highly important. Farmers tend to trust cooperatives' recommendations for cultivation when these also buy their produce, as the farmer can see a vested interest by the cooperative in the success of production rather than the sale of the input.

5 – ***Tolerance of Imperfection*** "Forgivingness" of incomplete application of area-wide controls, so their effect is not destroyed by a few isolated untreated areas, is important where there are truculent individuals who will not cooperate with a group effort. When cooperative control aims to be suppressive, rather than eradicative, private control by each individual can still obtain a return, regardless of the participation of neighbours, undermining the "free rider" strategy. This "forgivingness" is a function of the ecology of pests which are relatively "*K*-selected", such as fruit flies, rather than "*r*-selected" such as hemiptera.

Cooperatives which buy produce are trusted to provide inputs (photo: J Stonehouse)

Cooperative pest management sits naturally alongside cooperative marketing (photos: J Thomas)

Acknowledgement: Work funded by the UK Department for International Development Crop Protection Programme, Project R8840, collaborating with the Indian Council for Agricultural Research

INTEGRATED MANAGEMENT OF FRUIT FLIES IN INDIA (IMFFI) SEMI-STRUCTURED INTERVIEW SURVEY OF FRUIT AND VEGETABLE GROWERS

Interviewers:-	
Overall -	JMS - John Stonehouse; AV - Abraham Verghese
Sardarkrushinagar -	RKP - RK Patel; BKJ - BK Joshi; RKC - RK Chowdhury
Anand -	RCJ - RC Jhala; DBS - DB Sisodiya
Ghandevi -	ZPP - ZP Patel; VSJ - VS Jagadale; MBP - MB Patel
Thrissur -	JT - Jim Thomas; CVV - CV Vidya
Thiruvananthapuram -	JR - Jiji Rajmohan; AN - Anne Napoleon; MS - M Senthilkumar; BN - Beena Nair
Bhubaneswar -	HSS - HS Singh; ASK - Ashok Kumar Mohantha JMS
Varanasi -	SR - S Rai, SS - S Swamy, SPS - S Satpathy
Lucknow -	RPS - R.P.Shukla; AM - Abu Manzar

@~S - SARDARKRUSHINAGAR.

#S001 DATE:03/03/03 TEAM: RKP/BKJ Village: Nizampura. Large/wealthy farmer. I had not my own farm but hired for seasons. Total area is 13 hectares. Eight members depend on it. My family feed farm harvest for whole year and I have no other job out side the farming.

CROPS Pumpkin with other cucurbitaceous crop. I had started growing pumpkin since last three years because my cousin are growing it from last ten years. It performed satisfactory when I grow it first time. It gives high return if market price is good. There is no market in nearby area.

PEST 1 - HELIOTHIS It becomes a problem as it enters into the fruit and inner fleshy content on it. This year infestation is not heavy. It reduces yield.

PEST 2 - FRUIT FLIES It causes 20 to 30 % losses in crop. Its attack starts from formation size fruit in pumpkin crop. Its attack reduces the yield. This year damage is less due to low rainfall during previous year. The main different of its infestation is that it reduce market price as it affect on market quality.

FRUIT FLY CONTROL I had sprayed the crop with Dimethoate @20 ml /15 liter of water. I had started it because my neighbour was used it. It gave a bit good results as it can not control the fruit fly completely. I had never used this MAT or BAT control.

#S002 DATE:03/03/03 TEAM: RKP/BKJ Village: Nizampura. Large/wealthy farmer. I had not my own farm but hired for seasons. Total area is 10 hectares. Six members depend on it. My family feed farm harvest for whole year and I have no other job out side the farming.

CROPS Pumpkin with other cucurbitaceous crop. I had started pumpkin growing since last five years because my parents were growing it. It performed well when I grow it first time. The main advantage of this crop is it has long storage life. There is no local market.

PEST 1 - HELIOTHIS Become a problem as it reduces the yield. This year infestation is medium.

PEST 2 - APHIDS & SUCKING INSECTS Its infestation shrank the leaves.

PEST 3 - FRUIT FLIES It causes30 to 40 % losses in crop. Its attack starts from formation size fruit pumpkin crop. Its attack reduces yield. This year damage is less due to low rainfall during previous year. The main different of its infestation is that yield losses is high as compare to other pest. It is very difficult to control

this pest by only chemical means. I had never used either MAT or BAT in past.

FRUIT FLY CONTROL I had sprayed the crop with Metasystox @25 ml /15 liter of water. I had started it because the shopkeeper me advised to use it. It gave poor results as it can not eradicate the fruit fly infestation. I had never used this MAT or BAT control.

#S003 DATE:03/03/03 TEAM: RKP/BKJ Village: Nizampura. Medium farmer. I had not my own farm but hired for seasons. Total area is 6 hectares. Four members depend on it. My family feed farm harvest for whole year and I have no other job out side the farming.

CROPS Pumpkin with tomato. I had started pumpkin growing since last two years because other farmer of my state Uttar Pradesh are growing it. It performed satisfactory when I grow it first time. It gives high return if market price is good. There is no market in nearby area.

PEST 1 - HELIOTHIS It damage the fruit and reduces yield as well as market value. This year infestation is heavy. It reduces yield.

PEST 2 - FRUIT FLIES It causes 15 to 20 % losses in crop. Its attack starts from formation size fruit. Its attack reduces yield. This year damage is very less due to low rainfall during previous year. The main difference of its infestation is that it reduces market price as it affect on market quality.

FRUIT FLY CONTROL: SPRAY I had sprayed the crop with Endosulfan @22 ml /15 liter of water. I had started it because the shopkeeper advised me to use it. It gave poor results as it can not control the fruit fly. I had never used this MAT or BAT control in past.

#S004 DATE:03/03/03 TEAM: RKP/BKJ Village: Nizampura. Far away from farm S001; small/poor farmer. I had not my own farm but hired for seasons. Total area is 1 hectare. Five members depend on it. My family feed farm harvest for whole year and I have no other job outside farming.

CROPS Pumpkin with bitter gourd. I had started pumpkin growing since last year because my parents were growing it. It performed medium when I grow it first time. The main advantage of this crop is it has long storage life but, there is no local market.

PEST 1 - HELIOTHIS It become a problem as it reduces the yield. This year infestation is not heavy.

PEST 2 - FRUIT FLIES It causes 20 to 30% losses in crop. Its attack starts from the initiation of flowering. So, the flowers detached from the vine. So there is reduction in yield. This year damage is average due to low rainfall previous year. The main difference of its infestation is that it reduces yield. It is very difficult to control this pest by only chemical means.

FRUIT FLY CONTROL I had not sprayed any insecticide for the control of fruit fly.

#S005 DATE:06/02/04 TEAM: RKP/BKJ/RKC/JMS Village: Nizampura (wide-area village 'A'); {There has been a very cold winter now - after ten years of normal winters this has been both long and cold. As a result, the pumpkins are completely unattacked & unblemished. All pests are at low levels. He lives in a beautifully decorated painted mud house, with sculpted mud shelves and storage spaces inside. {Feedback from these farmers is good. Muslims. Immigrants. In one sqkm are 11 families, 150 people. All came from UP (District: Bareli), 30 years ago now. Now they are all Gujeratis but their mother tongue still hindi. All 11 families - they have known each other for 30 years. If they find more land on a for-hire basis they call in other people in UP.

They used to be nearer Ahmedabad, and moved here. Always renting.}

PUMPKIN PRICES Farmer and RKP confer about the market for pumpkin. Pumpkin price is, contrary to basic economic principles, highest when the fruit is most scarce - it is highest when demand is greatest which for cultural reasons is during the wedding season. During weddings round here is pumpkin is used for feasts, particularly mixed with melon flesh into a fruit salad known as “tutti frutti”. {Later JS is told that tutti frutti is also popular in UP - also pehta}

PUMPKIN PESTS Fruit fly is less than last year. Helicoverpa or heliothis too - caterpillars on the cucurbits. He is using cymbush to control them. Larvae on the leaves. Were also bad last year. This year the green larvae are more than last year. Helicoverpa inside the flowers.

PUMPKIN SPRAYS The pumpkin now is just starting to flower and bud. Planted in November (last week of).When did the helicoverpa turn up? A month ago. How many cymbush sprays have you had to do? Every 15 or 10 days throughout the whole season. Already done 4 cymbush sprays. 15ml of cymbush in 12 litres of water. Last year used it too - at the same rate. So as far as cymbush use goes was last year about the same as this year? It doesn't control fruit flies. Nor helicoverpa, really - 'a few days control only.' Neither cymbush nor endosulfan will control helicoverpa {in India helicoverpa insecticide resistance has risen by 300 times}.

GOURD UPTAKE Gourds and tomatoes are grown by everybody. Gourds catch on, and then everybody grows. Now even native farmers are following them.

PUMPKIN MARKETS Pumpkins won't sell here - sometimes in Surat - but sell to Rajasthan, Delhi, Jodhpur etc etc.

FRUIT FLY INFESTATION PROGRESS Fruit fly is only a little. Yes, but won't it get going? Yes, it will. But we'll be ready for it. Now cucurbits are a bit late.

ROTATION DELAYS Last year they had cluster bean in these fields. Gourds go in after the harvest of cluster bean, so held up by the bean (1) and also by the cold, slowing growth (2).

GOURD VARIETY Is pumpkin the only gourd grown? No - bottle g, bitter g, ridge g, smooth g; also last time sponge g and sweet melon (very badly attacked by fruit fly). Also leaf miner on cucurbits, but not economically damaging.

CASTOR BEAN Castor cultivation is going up. It can be grown rainfed. Rs325/20kg - the best price of all crops; and it can be exported - castor oil.

#S006 DATE:06/10/04 TEAM: RKP/BKJ/RKC/JMS Village: Nizampura (wide-area village 'A'); {The team sets out to talk to the friendly farmers who hosted the village-level trial. They have moved on, taking up rental of land a good deal further away, and half a day is spent in making contact. Their new site is much more remote, and seems even more arid, but they say they moved here to take up opportunities so it has been a step up, not down. When the team arrives, and with only limited time to stay, only the headman’s son, 18, is there. He explains that the wide-area management was a success and they were all impressed. He is unsure if the group will adopt it themselves. The impression is that the fruit fly is not really serious enough to justify the physical and social effort. Part of their nomadic wanderings from one rental to another may be as a pest-escape mechanism, as the pests seem to get worse in any one area after vegetable cultivation for a few years. It may be that this is successful, as fruit flies are not being much of a problem just now.}

#S007 19/01/05 TEAM BKJ/RKP/JMS. {A very remote area. Nomad women on the road wear jewellery like suits of armour - upper and lower arms encased in sheets of silver

bangle, with ornamentation like chain mail.}

GOURD DAMAGE RESPONSE He has started growing pumpkin. The first flush of fruit is fewer fruits, but they are bigger, so get the best price. Larger gourds recover from pest attack. Smaller ones can be overcome and die and be lost.

PUMPKIN IRRIGATION WATER NEEDS He used to grow wheat and castor, but the labour demands for pumpkin are much less than for wheat/castor. Wheat needs 6/7 irrigations, Per unit of water, pumpkin will cover 4-5 acres, wheat only 1 acre. Labour needs are less. And less lumpy.

WEEDS IN WHEAT Are weeds a problem in wheat? Some - he has few problems- plant the crop in rows, plough between. You can use 24D herbicide but death to dicots - you must be careful to clean the sprayer before using it in another crop. And 24d only possible when wheat at certain stages - problems if your timing is wrong.

@~A - ANAND {Earlier Anand was the taluka place of Kheda district but recently Anand got the status of district. Farmers of Anand and Kheda districts are growing tobacco, banana, paddy, brinjal, small gourd, bitter gourd, potato, bajra, ground nut and cotton etc. The area under small gourd and bitter gourd cultivation is more in the Kheda district, just 75 km away from the headquarters (GAU, Anand), so interviews were conducted there.}

#A001 DATE:3/10/03 TEAM: RCJ/DBS Village Kachhai, Dist. Kheda - small gourd village. He is a big farmer. He has 20ha land out of which 10ha is occupied by small gourd crops, while the other 10ha land is occupied by paddy-wheat-paddy. He has to feed 15 family members. He gets income for 10 months from small gourd. He also does the business of small gourd. He collects/purchases the small gourds from small farmers and supplies to big market like Bombay, Surat, Rajkot, Ahmedabad etc. Thus he is earning good money from his farming.

CROPS He is growing mainly small gourd, paddy and wheat.

SMALL GOURD Since 40 years he and his brother are growing small gourd. He does not know how first time this crop was introduced in the village, but as this is a much more profitable crop compared to other crops, the rest of the farmers have also adopted it. As people started to grow this crop, they realized it is a remunerative crop. He said there is also a limited or no pest problem as compared to other crops, and at the same time it gives year-round income (approximately 10 months, from January to October). He planted the crop at distances of 1.5m between two rows and 0.8m between two plants.

SMALL GOURD PESTS He said since 40 years fruit fly and fruit borer (Diaphania indica) are posing the pest problem in small gourd. However since 2 to 3 years the melon weevil (Acythopeus curvirostris sp. citrulli) is found as a minor pest.

FRUIT FLY He planted the crop in January. It bears fruits in February-March. He said that the fruit fly (locally called "Bhamari") infestation starts in February-March, it reaches a peak in April-May and then it slowly declines. He further added that when numbers of fruits are less, the infestation by fruit fly will be more. According to him as there is increase in heat, the fruit fly (Bhamari) infestation increases. He said fruit fly cause 40-50% damage at peak activity. Otherwise 5-10% damage is common. As per his view, since last five years, the fruit fly infestation has decreased and he doesn't know the reason. He knows that this pest is serous because it causes direct damage to the produce hence, quality reduced and causes direct economical loss as explained by him.

FRUIT FLY CONTROLS He knows two methods for fruit fly control.

FRUIT FLY CONTROL: SPRAYS (i) Spraying of insecticides viz., fenthion (lebaycid), dichlorvos (Nuvan) by mixing with jaggery solution

FRUIT FLY CONTROL: TRAPS (ii) Fruit fly trap. He is using methyl eugenol and dichlorvos (Nuvan) both mixed together. The cotton swab is soaked in the mixture and placed in the plastic bottle. He doesn't know the exact quantity of ME & DDVP he is using, but he is using the trap every year. As per his views, spraying of insecticides mainly fenthion is giving good results rather than traps. When we have approached him to conduct experiments on his farm regarding evaluation of ply-wood blocks, he was convinced and expressed his readiness. When he show flies caught in traps next week mainly in cue lure trap, he was very happy and many of the farmers of that village have asked to give more traps.

FRUIT BORER (Diaphania indica) He said that pest incidence start from onset of monsoon i.e. from July onward and the incidence remains at peak during August-September. According to his view, 30-40% damage is caused by this pest. He is observing this pest since 15-20 years. He is mainly using insecticides viz., dichlorvos and monocrotophos to control this pest.

PADDY He is growing paddy since long back. His forefathers were also growing the paddy crop. He follows the cropping system paddy-wheat-paddy. As the farmer is facing the problem of stagnation of water during monsoon, the paddy is only crop in low land. The farmer is raising the seedlings in advance, and transplants the paddy as and when enough rainfall is available.

PADDY PESTS He said that paddy is infested by plant hoppers (locally called "Chusia", he doesn't know the species), stem borers, leaf folder, root worms etc. According to him, plant hoppers attack the crop during July-August, then the attack of stem borer and leaf folder start. Brown plant hopper and leaf folder have caused havoc in the current year. Paddy crop is totally destroyed and farmers have asked the government authority for provision of crop insurance. It shows the severity of the pest problem in paddy. The problem faced by the farmers is also published in local newspapers.

PADDY PEST CONTROL He said there is no alternative of insecticide to control pests of paddy. He applied granular insecticide viz., phorate 10G and carbofuran 3G at the time of planting of paddy. He said this practice keeps the crop free from pests up to 50-60 days. Then in standing crop according to severity of pests, he applied insecticides viz., monocrotophos, endosulfan, dichlorvos, chlorpyriphos.

#A002 DATE:3/10/03 TEAM RCJ/DBS Village Kachhai, Dist. Kheda - small gourd village. He is a medium farmer. He has 2.5ha land out of which 1ha land is occupied by small gourd, 1.0ha land by paddy-wheat-paddy and 0.5ha by brinjal and other vegetable crops. He has to feed 6 family members in the family. He is doing business of milk in the village. He is collecting the milk from the village and give price based on fat content. He is selling the milk in the city area and earning good amount of money.

CROPS He is growing small gourd, paddy, brinjal, wheat.

SMALL GOURD He is growing this crop since 50 years. When I asked about history of this crop, he said that our forefathers were growing local small gourd (similar to wild species) variety but it gave low production. Then some farmers brought the cuttings so called "English" variety (small gourd having long pale green fruits) of small gourd at the price of 50 paisa/peace of 12 inch from Bodal village near by Anand and started to grow so called English variety of small gourd. It performed very well and recorded higher yield compared to local small gourd. This is the story of 25 years back. So since 25 years, he is growing this variety of small gourd. He planted the crop at a distance of 1.5m between two rows and 0.75m between two plants in January month. He said this crop needs hard work as well as money for preparation of the pandal, insecticides, weeding, fertilizer, irrigation as well as for land

preparation. However, compared to other crop this crop is better as it gives return for 10 months in the year, he said.

PESTS He said since 50 years, he observed the fruit fly, fruit borer (Diaphania) and chharo (fruit skin becoming rough) {though it is not a pest problem}.

FRUIT FLY He said fruit fly is attacking small gourds since he is growing the crop. He further added that this pest is severe when less number of fruits /plant were observed and at that time price of the fruits is also higher (Rs.200-300/20kg). This happens in April-May. Afterward pest incidence decline. We asked reason why it happened so? He replied that it is due to heat/temperature. According to his view, this is a notorious pest as it directly attacks the fruits and makes it unfit for human consumption and ultimately causes yield loss. According to him, it causes 20-30% loss during the season.

FRUIT FLY CONTROL He knows two methods for fruit fly control.

FRUIT FLY CONTROL: SPRAY (i) Spraying insecticides He used insecticides viz., dichlorvos (Nuvan), dimethoate (Rogor), imidacloprid (Confidor), fenthion (Lebaycid) and jaggery for spraying in small gourd.

FRUIT FLY CONTROL: TRAPS (ii) Hanging of sex pheromone traps. As advised by shop keeper, he hung containing cotton swab soaked in methyl eugenol and DDVP (dichlorvos) mixture. He doesn't know about the exact quantity of ME + DDVP that he is using. He directly put the ME & DDVP on the cotton swab and put the same in the empty metal containers (particularly of container used to pack chewing tobacco of Babul brand). According to his opinion, in the early stage of the crop when vine are small, there will be a wastage of insecticide if you spray. But if you hang the ME trap it directly kills all the flies and you get the good results. He doesn't know which flies are coming inside the trap and which flies are infesting his small gourd crop. When shown the results of the Cue lure traps placed in the field of interviewee A001, he is really impressed and requests us to give traps.

FRUIT BORER He said the pest attacks the crop when rainfall start. According to him, it bores into fruit and also feeds on leaves. He observed the severity of the pest during September. According to him it causes damage up to 40% when reach to peak. He is observing this pest since 20 years. He had sprayed imidacloprid, dimethoate and dichlorvos to control this pest.

CHHARO (FRUIT SKIN BECOMING ROUGH) {Actually this is not a pest problem but farmers have misunderstood - it is due to covering/adhering of fruit with leaf during rainy season. The fruit growing in the axil of leaf, adhered with leaf and that area become rough. So he said it is "Chharo" (a disease symptom).} This happens mainly during the monsoon when there is good vegetative growth.

PADDY He is growing paddy in 1.0ha land from which he meets the requirement of rice as well as fodder for animals.

PADDY PESTS He said, immediately after planting the paddy is attacked by root worms, followed by hoppers, leaf folder, stem borer, skipper etc.

PADDY PEST CONTROL He has sprayed insecticides viz., monocrotophos, dimethoate and dichlorvos in paddy fields to control leaf folders and hoppers, while to control root worms, he broadcast phorate (Thimet) 10G and carbofuran (Furadan) 3G.

BRINJAL He said he is growing this vegetable crop grown for selling as well as for his own utilization.

BRINJAL PESTS The farmer is facing the problem of Aphid, Jassid, whitefly, shoot and

fruit borer, little leaf (a mycoplasma disease) in brinjal.

BRINJAL PEST CONTROL He said there is no pest-wise strategy. However according to him, spraying of insecticides is best to reduce the pest pressure quickly. He sprayed endosulfan, dichlorvos, dimethoate as per advised by pesticide shop keeper.

#A003 DATE:3/10/03 TEAM RCJ/DBS Village Parsotaj, Dist. Kheda - small gourd village. He is a medium farmer, has 2.5ha total land, out of which he is growing small gourd in 1.25ha. He has 10 family members and all are engaged in farming activity.

CROPS He is growing small gourd, bajra and Fenugreek.

SMALL GOURD He is growing local variety of small gourd since 20 years. He started growing crop by seeing other farmers who were growing small gourd and earning more from small gourd cultivation as compared to other crops. He also said that this crop gives remuneration up to 10 months. It is just like a buffalo, keeping which gives milk every day and thereby earning up to 10 months. He said there is minimum requirement of insecticides and no other agricultural operations viz., threshing, harvesting, winnowing etc., hence this crop is good.

SMALL GOURD PESTS Since 15 years, he is facing the problem of fruit fly, fruit borer and aphid attack in small gourd.

FRUIT FLY He said due to fruit fly infestation, 25-30% fruits get damaged and lost. He knows that this pest causes direct damage to fruit. He further added, due to increase in temperature during April-May, the infestation of this pest increases. When we asked about reason for such condition, he said it is not in our hand, it depends on power of the God. According to him every year problem of this pest remain more or less same.

FRUIT FLY CONTROL He knows two approaches of fruit fly control:

FRUIT FLY CONTROL: SPRAYS (i) Spraying of insecticides: He knows this method since he started cultivating small gourd. He has sprayed, Rogor (dimethoate) for the control of this pest and got the good results.

FRUIT FLY CONTROL: TRAPS (ii) Sex pheromone traps: He had also hung the methyl eugenol traps last year in the pandal. He used Methyl eugenol 5-10 drops and 5 drops of DDVP incorporated in the cotton swab and placed inside the plastic bottle/empty container. He said since 2-3 years, he is using this traps, however every year he is not using the traps. {This year he has not put up his own trap. We have conducted the experiment in his farm and he is happy with the results.}

FRUIT BORER He said particularly during August-September this pest is a headache for him. It directly feeds on fruits and leaves. According to him, one larva can bore into more than one fruits and can causes damage up to 30-40% in two months. For the control of this pest, he sprayed insecticides viz., dimethoate (Rogor), monocrotophos and endosulfan.

APHID He said during the earlier period (means immediately after planting) this pest ("Molo" which is local name of aphid) attacks his crop. It means when new creepers/vines climb up on pandal during February-March, aphid attacks the crop. He used to spray Rogor (dimethoate) which reduce the aphid attack.

BAJRA He said this crop is staple food for him. He is growing bajra two times, i.e. in summer and kharif/monsoon season of a year. Grains are utilized for family consumption, while fodder is utilized for his cattle and buffaloes. He said that he prepares "Rotalo" (local name of chapatti) out of flour. The family member eat Rotalo with cooked vegetables. {John S also tasted "Rotalo" prepared by a girl from Bajra

flour while he visited Vansar village during his visit at Anand.}

FENUGREEK He is growing this leafy vegetable mainly for selling. After 25-30 days of germination, crop plants are uprooted, made into bunches and sent to the market of Mahemadabad (a nearby small city) for sale.

FENUGREEK PESTS He said there is no pest problem in this crop.

#A004 DATE:3/10/03 TEAM: RCJ/DBS Village Parsotaj, Dist. Kheda - small gourd village. He is a small farmer having 1.5ha of land out of which 0.5ha is occupied by small gourd, while in the rest of the land he grows other crops as mentioned above. He has 15 family members and he has to feed all from this land. So some family members are doing labour work and earning the money and meet their requirement.

CROPS He is growing small gourd, Bajra, Fenugreek, Wheat, Cauliflower.

SMALL GOURD He said, he is growing local variety of small gourd since 15-20 years. Upon asking "why you are growing this crop?" he said this crop is giving good remuneration round the year and all people are growing, so I have adopted it. He also said this crop is good in small land holding. He planted the crop at a distance of 1.5m between two rows and 0.5m between two plants.

SMALL GOURD PESTS He said this crop is infested by fruit fly, fruit borer, melon weevil, aphids and termite. He is facing the termite problem every year.

FRUIT FLY He is facing the problem of this pest since 10 years and before that, problem was less as per his views. He said due to infestation of this pest, there is reduction of yield and it cause economical losses. He said that due to attack of fruit fly, fruit get rotted and "Kida" (maggots) are moving inside. As per his experience with this crop, he said that the infestation is ranging from 5 to 50% and peak infestation is observed during March-April. He said depending upon the year, the infestation activity goes up and down.

FRUIT FLY CONTROL He knows two methods for fruit fly control

FRUIT FLY CONTROL: SPRAY (i) Spraying of insecticides. He sprayed his crop with Nuvan (dichlorvos) at peak activity of fruit fly. He selected the insecticide as suggested by shop keeper/insecticide dealer.

FRUIT FLY CONTROL: TRAPS (ii) Sex pheromone traps He used fruit fly traps last year. He used methyl eugenol and Nuvan (dichlorvos) purchased from shop keeper at Mahemadabad (Dist. Kheda), soaked the cotton plug in the mixture and placed inside the plastic bottle. He has not followed exact measurement. He said that cotton should be completely wet, that much quantity he used. He knows this practice since 10 years.

FRUIT BORER He said that this is also a next serious pest after fruit fly and attack during monsoon period. He said that the larva feeds on fruits as well as leaves. According to him, it can cause damage up to 25-30% during August-September. However, he has not sprayed any insecticide for the control of this pest and left it to nature/God as such. When asked the reason "why you have not sprayed insecticides?" he said that all the farmers says that this pest is not controlled by any insecticide and there is no meaning of spraying insecticide.

MELON WEEVIL This is new pest observed since 2 years in this area as reported by him. Its population is negligible, hence he is not spraying any insecticide to control this pest. {We have collected adults and tried to identify based on available published literature. It seems to be Acythopeus curvirostris sp. citrulli. This is the first record of this pest in Gujarat.} This pest is locally called as "Chanchvu". It bores into fruits with its beak. It makes about 50-60 punctures on fruit. It also

bores the vine from tender portion, hence the vine from that point onward dry-off.

APHID He said that this pest is damaging the crop in the early stage. He said that Spray of Rogor (dimethoate) once or twice during the season control the pest.

TERMITE He said that this pest is severe in his field, feed on root and plant die suddenly. He is using insecticides viz., endosulfan and chlorpyriphos for managing this pest as per advice by shop keeper/insecticide dealer.

BAJRA He said that bajra is staple food for him. Fodder is utilized for cattle. He said there is no pest problem in bajra.

FENUGREEK According to him, he is growing this crop(leafy vegetable) to get more money within a short time as this crop can be up-rooted after 25-30 days of germination. He said no pest problem in this crop.

WHEAT He is growing wheat after paddy. He keeps some quantity for his own utilization, while rest is sold in the market. He said no any pest problem in wheat except termite. For the control of this pest, he is drenching the endosulfan or chlorpyriphos with irrigation water in the field.

CAULIFLOWER He is growing cauliflower since 5 years. It is also a good crop of short duration. Diamondback moth (farmer says "lili iyal") is mainly infesting the crop. He is using insecticides viz., monocrotophos, Bacillus thuringiensis based product for the control of this pest.

#A005 DATE:3/10/03 TEAM:RCJ/DBS Village Parsotaj, Dist. Kheda - small gourd village. He has a total 3.0ha land and has to feed 17 persons in the family. He has cultivated 1.0ha small gourd, while rest of the land is occupied by other crops mentioned above. Up to 10 months, he gets the income from small gourd. For rest of the months, he depends on leafy vegetables for money and thereby he meet the requirement of the family. Some family members are also doing labour work in the fields of big farmers.

CROPS He is growing small gourd, smooth gourd, bajra, fenugreek and coriander.

SMALL GOURD He is growing this crop since 40-50 years. He said, this crop is giving good remuneration so he is growing this crop. Every day he is getting income from this crop.

SMALL GOURD PESTS He said this crop is infested by fruit fly, fruit borer and aphid.

FRUIT FLY He said this pest is attacking small gourd, since 40-50 years that is since he started growing the crop. He said the pest incidence is ranging from 5-50%, and due to pest attack the whole fruit becomes rotted and maggots are seen moving inside. According to him the incidence is found at peak during April-May and increasing as heat increases. He also said that the level of incidence differ in different year.

FRUIT FLY CONTROL He knows two methods of fruit fly control:

FRUIT FLY CONTROL: SPRAYS (i) Spraying of insecticide. He used the insecticides viz., monocrotophos, Nuvan (dichlorvos), endosulfan, imidacloprid (Confidor) as per advice given by shop keeper/insecticide dealer.

FRUIT FLY CONTROL: TRAPS (ii) Sex pheromone traps. He used methyl eugenol and dichlorvos mixture soaked in cotton swab and placed in the plastic bottle/container. He is using this method since 4-5 years. He is not following exact dose of ME + DDVP.
FRUIT BORER He said this is a serious pest and remains only for 2 months and causes damage up to 30-35%. According to him there is no alternative except insecticidal spray to control this pest. He use to spray insecticides viz., monocrotophos,

dimethoate (Rogor), chlorpyriphos, fenvalerate to manage this pest.

APHID For the control of aphid, he sprayed dimethoate in the initial stage of the crop.

SMOOTH GOURD He has grown smooth gourd at a distance of 2m between two rows and 1m between two plants. According to him this is also a remunerative crop but it gives income for shorter period (4 months) compared to small gourd. He is growing this crop since 10 years. He said this crop is mainly infested by fruit fly. He also observed damage up to 40-50% in this crop. He has sprayed insecticides viz., monocrotophos, Nuvan (DDVP), endosulfan. He also hung the methyl eugenol traps suggested by a shop keeper.

BAJRA He is growing this crop for family consumption and fodder is utilized for cattle and buffaloes. He said that there is no pest problem in this crop.

FENUGREEK AND CORIANDER Both of these are leafy vegetables and also short duration crops. After up-rooting the plants, he sells the produce in the market and earns money. He said both of these crops has no pest problem.

#A006 DATE 3/10/03 TEAM RCJ/DBS Village Hariyala, Dist. Kheda. He is a medium farmer having total 3.0 ha land out of which 1.0 ha land is occupied by bitter gourd-cauliflower system, while rest of the land is occupied by paddy- wheat-bajra. Sometime, he also follow fenugreek (November-December)-bitter gourd (January-October) system. He has to feed 7 person. He said that up to 10 months, he is getting income from bitter gourd, while in rest of the period of a year, he depends on other vegetable crops viz., cauliflower, fenugreek etc. He said that from a hectare of land, his gross income from bitter gourd crop is Rs. 2.5 lakh and market price is ranging from Rs. 70 (June -September) to 400 (February - March and October)/20 kg.

CROPS He said that he is growing bitter gourd, cauliflower, fenugreek, paddy, wheat and bajra

BITTER GOURD He said that he is growing this crop since 40-50 years. He adopted this crop by seeing other people who are earning the good money by cultivating this crop. According to his views, this crop is giving good return and is a cash crop.

BITTER GOURD PESTS He said that initially crop is attacked by leaf hoppers then by fruit fly and during monsoon the fruit borer (Diaphania indica) locally known as "Lili Iyal". He said that these pests are found since he is growing the crop i.e. since 40-50 years.

FRUIT FLY He said that generally he is growing the bitter gourd in December-January months. The fruit fly infestation start as and when fruits are available. Initially it can cause more than 50% damage as fruits are available in small number. He said that it is bad because it directly cause damage to the fruits. According to his view, every year the problem of fruit fly remain same.

FRUIT FLY CONTROL He knows two methods for fruit fly control.

FRUIT FLY CONTROL: SPRAY (1) Spraying of insecticides He had sprayed his crop with insecticides viz., Confidor (imidacloprid),Nuvan (dichlorvos), Thiodan (endosulfan) and Monocil (monocrotophos) without mixing with jaggery solution but he has mixed insecticide i.e., Confidor with soluble fertilizer (Hygiene). He is doing this practice since 2 years and according to his view, result is excellent.

FRUIT FLY CONTROL: TRAPS (2) ME traps He is knowing the ME traps since he started growing the bitter gourd crop. He is using this traps during peak fruit fly activity i.e., March-April months. He doesn't know the exact quantity of ME and insecticide

(DDVP). He is applying both ME and DDVP till cotton swab become completely wet and then placed inside the container and then hang under the pandal.

LEAF HOPPERS He said that this is serious pests when crop is in initial stage. This pest is locally known as "Chusiya" (it means sap suckers). He explained that initially this pest suck up the cell sap and leaves become yellow, the symptom is he called as "Piliyu" (means yellowing). "Almost 50-60% plants are affected" he said. The Confidor and soluble fertilizer is the best to overcome this situation as per his experience.

FRUIT BORER (Diaphania indica) As per his views, the infestation of this initiate at first shower in rainy season. He said it bore the fruit and make it unfit for marketing. According to him this pest cause damage up to 20-25%. He said spraying of monocrotophos and endosulfan is giving good results.

CAULIFLOWER He is growing this crop during November to January i.e., after bitter gourd crop is over. In mid-January, he again plant bitter gourd. Thus, he is following cropping system, bitter gourd-cauliflower. He said this is good remunerative crop particularly within short period.

CAULIFLOWER PESTS He said that "Molo" (local name of aphid) and "lili iyal"(local name of diamond back moth) are the main pests of cauliflower and attacking every year. He spray insecticides viz., dimethoate, monocrotophos and endosulfan for aphid and B.t. products Delfin, Biolep etc. for diamond back moth.

FENUGREEK This is also a good short duration crop according to his view. When crop is of 30-35 days old, he uproot the plants and makes them in small bunches for sale in the market, thereby earning a good money. He said there is no pest problem in this crop.

PADDY He said that he is following cropping system viz., paddy (July to October)-wheat (October to February)-bajra (March to June) in 2.0 ha land. Required quantity of grains he kept for his own consumption, while rest he is selling in the market. Fodder is utilized for the cattle.

PADDY PESTS He said this year hopper were the serious problem and it was difficult to control in spite of spraying various insecticides viz., monocrotophos, endosulfan, dichlorvos, chlorpyriphos + cypermethrin.

WHEAT AND BAJRA He said that both crops are good cereal crop and used for own consumption as well as for selling. There is no any pest problem in these crops.

#A007 DATE 3/10/03 TEAM RCJ/DBS Village Hariyala, Dist. Kheda. He is a small/marginal farmer having 0.75 ha total land. Out of which 0.25 ha land is occupied by bitter gourd crop and above-mentioned crops occupy rest. He has 3 persons in the family and he has to feed all 3 persons. He said that from 0.25 ha bitter gourd crop, he is getting gross income Rs. 50,000/- with total expenditure of Rs. 17,500/-. He said that up to 10 months, he depends upon bitter gourd. For rest of the period, he depends on other crops.

CROPS He said that he is growing bitter gourd, smooth gourd, cauliflower, bajra, wheat and fodder sorghum.

BITTER GOURD His family is growing this crop since 50 years. He said that he has started to grow this crop by seeing neighbors who are earning more by growing this crop in comparison to other crops. This crop need less expenditure and giving good return, he said.

BITTER GOURD PESTS He said that his crop is infested with fruit fly, hoppers and

fruit borer.

FRUIT FLY He said that he is facing the problem of fruit fly since he is growing the crop. He said infestation of this pest remained at peak during March-April and then slowly decline. He said that this pest cause damage up to20-25% throughout the season. He said that every year fruit fly infestation remain more or less similar. According to him, this is notorious pest because it cause direct damage to the fruits.

FRUIT FLY CONTROL He knows two methods for the control of fruit fly.

FRUIT FLY CONTROL: SPRAY (1) Spraying of insecticides He has sprayed the crop with insecticides viz. Nuvan (dichlorvos), Confidor (imidacloprid), Rogor (dimethoate), Thimet (Phorate). He has also used fenthion (Laybacid) + jaggery and obtained a good results. He has followed this practices since 2-3 years as advised by Village Level Worker (VLW)/Gram Sevak.

FRUIT FLY CONTROL: TRAPS (2) ME traps. He said that cotton swab is soaked with the solution of ME + insecticide and placed inside the empty tobacco containers. He doesn't know the exact quantity of ME and DDVP.

HOPPERS He said that hopper attacks when crop is about one month age. As it suck up the cell sap, leaves turn yellowish in colour and plant become weak. According to him, spraying of Confidor (imidacloprid) works very well against this pest.

FRUIT BORER He said that this pest attack particularly during monsoon period. According to his views, it can cause damage up to 25-30% during its peak. Spraying of insecticides is only the way to control this pests as per his views. He sprayed the crops with insecticides viz., monocrotophos, endosulfan and dimethoate.

SMOOTH GOURD He planted the crop in 0.25 ha. He said that this is also a good remunerative crop. He said that fruit fly is the major pest attacking to this crop and cause damage up to 40%. He is using insecticides viz., dichlorvos, monocrotophos and also fenthion + jaggery to control the fruit fly.

CAULIFLOWER He said that after up-rooting the bitter gourd (i.e. in October) the land is remaining fallow up to December-January but in this period, if he grow short duration crop like cauliflower then it give good return as per his views. Therefore he following bitter gourd-cauliflower cropping system. He said that this crop is infested by aphid and "Lili iyal" (i.e. diamond back moth). He is using insecticides to manage this pests. According to the advise given by shop keeper/insecticide retailer, he is using the insecticides.

BAJRA He said that he is growing bajra mainly for his own consumption. He is growing this crop during summer season. He said there is no any pest problem in this crop.

WHEAT He said that he is growing this crop for own consumption as well as for selling purpose. He said that there is no any pest problem in this crop.

SORGHUM He said that he is growing this crop only for his cattle as a fodder crop. He said that when crop is attaining certain height, then he cuts the sorghum and feeds to cattle as a green fodder. He said that there is no any pest problem in this crop.

#A008 DATE 3/10/03 TEAM RCJ/DBS Village Hariyala, Dist. Kheda. He is a big farmer. He has about 25 ha land. He is growing bitter gourd in about 10.0 ha land, while rest of the land is occupied by smooth gourd and paddy. He is hiring persons on contract basis for cultivation of all the crops. He has to feed 25 persons. He is satisfied with the income, from the Agriculture.

CROPS He said that he is growing bitter gourd, smooth gourd and paddy.

BITTER GOURD: He said that he is growing this crop since more than 50-60 years on share basis. He said that this is good remunerative crop in comparison to other crops. It gives income up to 10 months as per his views. During last year, he had planted the crop at the distance of 2.0 m between two rows and 1.0 m between two plants. He said that he is satisfied with this crop.

BITTER GOURD PESTS He said that his crop is infested by fruit fly, leaf hoppers, fruit borer and "Dhaliya" (local name of Epilachna beetle).

FRUIT FLY As per his views, this pest cause damage up to 25 to 35% during the season but it increases only during March-April. He said that he is observing this pests since 50-60 years. According to him, this pest is main economical constraint, which cause direct loss. He said that when there is a initiation of fruit setting and market price is at it's peak (February-March), there is more fruit fly damage. Asked upon reason for this, he replied that it is due to increase in heat. As heat increases, the fruit fly infestation increases as per his views. He said that due to infestation of this pest, the fruit turn yellow and finally fall down.

FRUIT FLY CONTROL He knows two methods of fruit fly control.

FRUIT FLY CONTROL: SPRAY (1) Spraying insecticides He has sprayed his crop with Nuvan (dichlorvos), Rogor (dimethoate), Monocil (monocrotophos) and Confidor (imidacloprid). He has also applied Thimet (Phorate) in soil. He said that he is using insecticides, since he is growing the crop. He has satisfaction with the insecticide.

FRUIT FLY CONTROL: TRAPS (2) ME traps He is using methyl eugenol (ME) traps particularly during March to May i.e., peak infestation period. He doesn't know the exact quantity of ME and DDVP. Simply after soaking the cotton swab in ME and DDVP mixture, it is placed inside the trap/plastic bottle/empty metal container and hanged in the pendal. He is also using insecticides even though he has hung the ME traps.

LEAF HOPPERS He said that this pest attacks initially i.e., during February-March particularly when crop is of 1.0 to 1.5 months old. Since last 10 years, he is observing this pest. The plants become yellow and weaken due to sucking from the leaves as per his views. He has sprayed his crop with imidacloprid or dimethoate mixed with soluble fertilizer and is satisfied with this.

FRUIT BORER He said that this is notorious pests observed only during monsoon period. He is observing this pest since 10 years. He said that it can cause damage up to 35-40% particularly during July to September. The damage is so severe that spraying of insecticides is only the way out for this problem. He has sprayed the crop with monocrotophos, endosulfan, dichlorvos for the control of this pest.

EPILACHNA BEETLE (DHALIYA) He said this 'Dhaliya' (local name of epilachna beetle) attacks at the end of the crop i.e., during October month. At this stage crop is nearer to finish, so he is not applying any insecticide to control this pest as per his views. According to him, you cannot find a single green leaf when there is severe attack. He said that if attacks start early, when fruiting is on then insecticidal application is a must. He is using insecticides as per the guidance from shopkeeper/VLW.

SMOOTH GOURD He has grown the crop at a distance of 2.0 m between two rows and 1.0 m between two plants. He said that this is also a good remunerative crop next to bitter gourd. He said that fruit fly is only the pest attack severely. It can cause damage up to 50-60% during peak activity period. He has used insecticides to control this pest.

PADDY He said that he is growing the paddy for his own consumption and also for selling. He is growing paddy in the area of about 5.0 ha. The fodder is utilized for his cattle. He said that paddy is infested by leaf hoppers, leaf folders and stem borers. He is using insecticides to control the pests in paddy.

#A009 DATE 3/10/03 TEAM RCJ/DBS Village Vansar (Udhela), Dist. Kheda. He is a medium farmer. He has 1.5 ha land. He is growing bitter gourd in 0.25 ha land and rest of the land is occupied by above mentioned crops. He has to feed 15 persons. After bitter gourd crop is over, he has to depend on cattle farming.

CROPS He is growing bitter gourd, paddy and tobacco.

BITTER GOURD He said that he is growing bitter gourd since 15 years. He said that by seeing other farmers he adopted this crop as it is a good remunerative crop. He said that this is a cash crop giving round the year income and required minimum labour work. It also required a minimum quantity of pesticides. He said that this crop is good particularly to those farmers who have small land holding.

BITTER GOURD PESTS As per his views, in the initial stage of the crop leaf hoppers (locally called as "Chusiya") attacks the crop, then fruit fly infestation starts and at the end of the crop fruit borer attacks the crop.

FRUIT FLY He said that he is facing the problem of this pest since he is growing the crop. According to him, it can cause damage up to 40%. He said that fruit fly infestation starts from February and reaches to peak during April-May and then slowly decline. He further added that due to infestation by this pest, the fruit become yellow and thus it hamper the fruit quality and cause economical loss. He said that as heat increases, the fruit fly infestation increases. He said that we cannot see the maggots from outside as it remains inside the fruit and cause rotting of the fruits.

FRUIT FLY CONTROL He knows two methods of fruit fly control.

FRUIT FLY CONTROL: SPRAY (1) Spraying insecticides He said that he has sprayed the crop with dichlorvos (Nuvan), dimethoate (Rogor), monocrotophos, fenthion (Laybacid) as and when need arise. He said that spraying works well particularly during severe pest problem. He is not mixing the jaggery with insecticides because he doesn't know.

FRUIT FLY CONTROL: TRAPS (2) ME traps He said that he has hanged the ME traps made up of empty tobacco container having inside the cotton swab which is soaked in the ME + insecticide solution. He doesn't know the name of insecticide. He doesn't know which flies are attracted inside the trap and which flies are infesting his crop. On the basis of advise from the pesticide dealer/shop keeper, he is using the ME traps.

LEAF HOPPERS He said that this pest attacks during January-February i.e., in the initial stage of the crop. He knows that due to sucking of sap from the leaves, plant looks yellowish in colour. He said that spraying of insecticide is the best way for the control of this pest. He has used dimethoate (Rogor), monocrotophos and imidacloprid.

FRUIT BORER He said that this pests appears during monsoon period and directly bore the fruits and cause economical damage. He further added that it can cause damage up to 40%. It is difficult to control this pests as per his experience. He said that after spraying the insecticides, if there is rainfall, the insecticide wash-off and there is no control.

PADDY He grow paddy crop for his own consumption and also for selling. He said that the fodder is utilized for his cattle. He follow paddy-tobacco cropping system. As per his views, hoppers, leaf folders, stem borers and worms infest this crop. He said

that spraying insecticides is only the way out of the pest attack. He has used monocrotophos, dichlorvos, phorate, etofenprox, endosulfan for the control of hoppers and leaf folders during this year. He is not happy with the performance of the insecticides against hoppers and leaf folders.

TOBACCO He said that this is a good cash crop and giving good income. He is growing "Calcutti" tobacco after harvesting paddy. He said that due to disease locally called as "Kohvaro" (damping off) thousands of seedlings die in the nursery. He mentioned that drenching of fungicide viz., Ridomil M Z is giving good results. After 2-3 months of transplanting the crop, Spodoptera litura (locally called as "Lashkari Iyal") attacks the crop. He further added that it feeds on leaves and hence cause yield losses. He said that spraying insecticide is giving good results against this pest. He is using the insecticide as per guidance from the shop keeper/pesticide dealer.

#A010 DATE 3/10/03 TEAM RCJ/DBS Village Vansar (Udhela), Dist. Kheda. He is a medium farmer having 2.0 ha land. He is growing bitter gourd in 0.5 ha land. He has to feed 15 members. He said that he gets income from bitter gourd for about 9 months and then he has to depends on cattle and other crops.

CROPS He is growing bitter gourd, paddy, bajra and sesamum.

BITTER GOURD He said that he is growing bitter gourd since 15 years and it is good remunerative crop round the year. He also said that in small land holding, it gives good income and require a minimum expenditure.

BITTER GOURD PESTS He said that bitter gourd is attacked by fruit fly, leaf hoppers and fruit borer.

FRUIT FLY He said that this is notorious pest causing 30 to 25% damage to the fruits, hence it can cause economical damage. He said that it is difficult to control this pest as it is flying. According to him, infestation starts from March-April as fruits are available during this period. As per his views, adult fly cause damage by seating on the fruit. He explained that during earlier years there was lower damage compared to damage now he is observing.

FRUIT FLY CONTROL He knows two methods for the control of fruit fly.

FRUIT FLY CONTROL: SPRAYS (1) Spraying of insecticides He said that he has sprayed dimethoate (Rogor), monocrotophos, dichlorvos (Nuvan), imidacloprid (Tatamida) to control this pest. He said that this practice is good particularly during peak activity period and it is giving good results also.

FRUIT FLY CONTROL: TRAPS (2) ME traps He has hanged traps in the pendal by putting the cotton swab soaked in the ME + Nuvan (dichlorvos) mixture. He doesn't know the exact quantity of ME + Nuvan. He said that cotton swab should be completely wet. He doesn't know which flies are attracted and which flies cause damage to his crop.

LEAF HOPPERS He said that this pest attack during initial stage of the crop and cause yellowing of the plant. He has sprayed insecticide viz., dimethoate (Rogor) and imidacloprid (Tatamida) to control this pest.

FRUIT BORER He said that this is a serious pest of bitter gourd and the infestation starts from July i.e., after onset of monsoon and increases gradually and remains up to October month. He sprayed insecticides viz., monocrotophos, endosulfan, dimethoate suggested by shop keeper/pesticide dealer but he is not satisfied with the performance of insecticides.

PADDY He has grown this crop in the area of 0.25 ha for his consumption and for

fodder purpose. He explained that plant hopper, leaf folders and stem borer mainly attacks the paddy. Spraying insecticides viz., dichlorvos, monocrotophos, phorate etc. is only way out of this problem, he said.

BAJRA He is growing this crop in summer as well as kharif for his own consumption. He said that there is no any pest problem in this crop.

SESAMUM He is growing this oilseed crop for getting good market price, however he is growing this crop in a small area (0.25 ha). He said that he doesn't face any pest problem in sesamum.

#A010 DATE 15/4/4 TEAM JMS/RCJ. Total five acres. About 60 years old.

PRICES & WAGES He grows all bitter gourd. Prices here have slipped a little. Was 300rs for 20kg - a good price - now 220, even 180. Labour is short. Farmers are offering 100/day but can't get takers.

GOURD He started growing about 20 years ago - before that cereals - pearl millet, wheat, sesamum. He shifted because to a cash crop. 20 years ago the price was Rs25/20kg, now it is 80-300, mean is 150, because of new varieties - vigro and sangro (vigro is about 6" long, sangro bigger).

COST-BENEFIT He spends Rs45ooo/acre to set it up. After the pandal is up 15ooo in subsequent years. 5ooo/bigha - each bigha is 1/3 acre. Yield is 300 quintals per acre (each quintal 100kgs) @ Rs750/quintal = 75oooRs/acre {check this}. In fact about 60-70oooRs. So how long does the pandal last? The string needs replacing every year; bamboo sticks 4 years; corner poles, the thick ones, only 2 years because of timber and the termites get at them.

GOURDS Why bitter gourd rather than other gourds? Overall small gourd is better than bitter, but in the last few years has had problems; ecological change, in the atmosphere; small gourd has declined. Labour too - SG is more labour-intensive. BG has a smaller number of fruits per KG than SG, so the labour needs to harvest on KG are less. One worker in one day can harvest 300KG of BG but only 10KG of SG {?}. SG is also infested more than BG with fruit fly.

VEGETABLES Why gourd rather than other vegetables? In Oct & Nov after Divali they grow ghobi. So the whole pandal is taken down every year. Ghobi earns 30ooo net. So cauliflower, BG and wheat are what they grow. Some use of fenugreek, but doesn't fetch much - 15oooRs/acre. Why BG and ghobi? They are most remunerative. Why not grow a spread of vegetables of different types? Because the prices of BG and SG are better than other cucurbits. And they have medicinal qualities too. And if you have a number of different cucurbits it causes problems. Why? BG and SG have the best price - bottle gourd is less. What about tomato, sag, onion? Tomato has problems with ecology - short-term and often fails because of ecology. Sometimes the yield is so excessive nobody will buy it and it's fed to cows. Tomato gets Rs20 per carton of 20KG - a bad price. What ecology problem? A virus. What short-term problem? No guarantee it will yield - SG and BG produce over a longer period, so if there is a bad spell they can still yield later. Tomato has a short cycle and so is vulnerable to periodic bad patches more than gourds.

{RCJ is of the view there has been an increase in the knowledge of the role of BG in diabetes which has increased demand among the old; also at weddings BG is almost always served to counteract the huge quantities of sugar consumed.}

{So gourds are favoured because of the long fruiting season - this not only produces a steady income but provides some risk-spreading against fluctuations in prices. Gourds favoured because of long season but this entails access to a steady and reliabel water supply: RCJ observes that Gourds are distinguished from other

vegetables not by having greater water needs, but that water is needed for a longer time.}

CROPPING CYCLE Usually plant BG in January - yields in April till January; but now a problem has come it goes only up to September {they ask us why this is}. Because most people have not enough land. 1st crop 11 or 12 months, then over the years it goes down. Yield and crop duration go down. Because of continuous cropping. If you could leave it fallow it would recover; but population pressure on the land is increasing so it can't rest.

MARKET ACCESS ROLE In the switch from subsistence crops to gourds 20 years ago, how important was the main road in making it possible? The big main road wasn't here then - but the other one was. Would you have been less likely to grow BG if the road were not close? Yes. If we were not near the road growing BG would be a problem.

PERISHABILITY How long after harvest will a crop of BG remain saleable? It must go to market overnight, or it goes yellow and ripe can't be sold. 24 hours is all you get.

SMALL/BITTER GOURD HARVEST QUALITIES Small gourd produces a milky sticky lactation, BG does not - it causes problems in harvesting. Sticks to the skin and can cause a rash. You have to wash your hands.

GOURDS AND VEGETABLES So how many years have you been growing the cauliflower? At first BG was grown year-round, and one month insolation/fallow. In the last five years BG production has dropped to 7 months, yellow because of jassid, then the cauliflower comes in. In other years they grew other things. Often with irrigation people shift from cereals to BG. In other areas people move from cereals to tomato. Why in some cases BG, in others tomato? Always market access is important.

SOCIAL NON-COOPERATION An agitated discussion now arises over a local farmer who refuses to allow admission to the sprayteam doing the wide-area BAT in the surrounding sqkm (which is going on as we speak). He says he has no problems with fruit flies. He is at once labelled a 'huchhi' - a Gujarati work meaning a stubborn, antisocial person in the village - literally 'troublesome' - and leading to the saying 'Ek huchhi akhi payuga ne nade' - 'if there is one huchhi in the village he will be an obstacle to everybody.' This is an aspect of their nature - they are always negative and making problems. This huchhi says he has already sprayed - 'Marshall' imidaclorphid against sucking pests. He has no fruit fly problem so we are unnecessary. He has 10 acres, or about 4-5Ha. He has known us for ages and been friendly and helpful - on one occasion we even mixed the spray liquid on his forecourt.

THE ROLE OF SOCIAL CLASS The huchhi is derogated as thinking he's a rajput. There were of old four communities from the top (1) Brahmin (priests) (2) Shatriya (warriors) (3) Vaishya (merchants and farmers) and (4) Shudra ('untouchables'). The huchhi is a farming shatriya, thinking himself superior to the vaishyas. (A rajput is a prince, a superior shatriya). 'Patel' is a vaishya farmer. There are many subcategories (e.g. of Patel). The differences between the various categories are less clear than they used to be. Most people in this village are in fact Shatriya. The Huchhi is also a shatriya and therefore no better than most. So caste is not part of his obnoxiousness - more significant is that his brother is an MLA, and so powerful. A person with political connections is assumed as a matter of course to be richer. So has airs and graces because politically connected & well off - not because of elevated caste. (The driver, who is a Muslim, is asked about Muslim classes - oh yes: top is Sayyad, then Sheikh, then Mughal - there is no shudra equivalent). The Muslims get on well with the Shatriya, and vice-versa; they don't like the Patels because the Patels don't like them. In Shatriya and Muslim areas, if one becomes successful, the others try to pull him down; Patels don't do this. There is a story of a king imprisoning a group of Patels in a well, and a group of Shatriya in

another; a guard is placed over the Patel well, but not the Shatriya one; asked why, the king replies that a Patel may climb out, but if one Shatriya tries to climb out the others will pull him back in.

#A011 DATE 15/4/4 TEAM JMS/RCJ. Total seven acres. About 60 years old. Of his 7acres 4 are actually here.

BITTER GOURD PRICE ADVANTAGES He grows all bitter gourd. Why BG > other vegetables? More production, more economic return. Wheat is less good than BG. You get 1 ton of wheat per bigha. This is 24 quintals per acre. 16-17oooRs/acre. BG brings in 1 lakh Rs per acre. BG normally raises Rs400/20kg but now but price has fallen because of BG being brought in from S Gujarat. Because of improvements in roads & transport. Have you tried any other vegetables - tomato, cauliflower? No. Why not? He has no follow-on crop. He lets the land fallow from Oct to Jan. Started 20 years back with small gourd. After 5 years switched to bitter gourd, and grew both. Since 2003 stopped the small gourd and now grows bitter gourd only. Small gourd is more labour-intensive - particularly in harvest. How does it compare in price? Bitter gourd fetches more per kg - small gourd price is now 100/kg, bitter gourd 140. He grew potatoes once - but had to spend 10K and got 10K.

GOURD PESTS What is the worst pest? Leafhopper. Sucking pests. How about fruit fly? A problem in bg arising out of being a problem in smooth and little gourd. If BG is left to itself, sucking pests are the major problem and ff not too bad {BG is apparently relatively resistant to FF}. Infested bitter gourd, and even healthy ones, if unsold can be dried, powdered and sold - Rs25/kg. If the market price goes down, and he gets Rs50/20kg, you slice and dry it. 20kg of gourd will produce 3kg of dried chips. At 22-25Rs/kg, this price is better than for fresh. In bitter gourd, leafhopper is a problem even when fruit fly is a problem. The pandals of BG which are near to those of Small G and Smooth G get ff problems worse than the others.

GOURD PRICE DETERMINANTS Smooth gourd price is better than bitter gourd, and easier to harvest. It is added to meat in non-veg cuisine, e.g. by muslims, hotels. Non-veg biriani. Makes a good gravy. This is why the price is good.

FRUIT FLY Fruit fly is not a big problem here.

PEST SEQUENCE 1st pest to arrive - caterpillar. 2 weeks. Another 1-2 months, say 6-7 weeks, the jassid comes - when the vine reaches the pandal. Spray once and it goes away, if the temperature drops is also goes. If you are good to others, God will reward you. The soil is your mother. Worship the goddess and pest problems diminish. Believe in karma - do good and not harm.

HUCHHI PEST CONTROL A neighbour of the huchhi says he sprayed twice this year. He has had people from a pesticide company round. He doesn't know against which pest this was.

#A012 DATE 15/4/4 TEAM JMS/RCJ. Haryala village. He helps his father, only since the last 3 years.

GOURD AND VEGETABLE PROS AND CONS He has 6-7 acres. 16-17 acres he had on a share basis and he took tomatoes. Rented basis. He paid 40oooRs rent for 17 acres. 800 quintals of tomato. Sold in the market. 600 quintals was spoilt because of Heliothis. Price raised was 30rs/20kg. So he earned 124ooo. But he spent 2 lakh so suffered a loss. But he will still grow tomatoes - if you make a loss in 1 year, in 2nd year may gain. The two previous years he made money on tomato, but on less than 17 acres. Here he has 1.5 acre under BG, the rest with smooth g. Smooth g is better than BG and tomato because price is maintained, particularly in summer before the rainy season, in the rainy season the price goes down. In this season the price is 300rs/kg. In monsoon this goes down to 60rs, because production rises. In that case, what is the

advantage of bitter gourd? He started this year, but this year the price has gone down. Last three years the price was good. In Saurastra people now grow BG with the new Narmada water, pushed the price down. He cultivated small gourd 10 years back, now the soil is depleted and no longer suitable. Might you grow tomato? If the price is right he'll grow tomato.

HISTORY OF GOURD INTRODUCTION His father arrives. 20 years ago it was all cereals. Then tomato, cabbage, cauliflower, then 6-7 years ago switched to gourds. Started 7 years ago with small gourd, for 2-3 years. Then shifted to smooth gourd; BG last and this year. Now has smooth gourd and bitter gourd. Why the shift away from small gourd? Labour problems at harvest. Because small gourds are small, the labour needed to harvest a unit weight is a lot more, pushing costs up. Why the move from smooth gourd to bitter gourd? Others were, so why not try it. Last year was very good for smooth gourd. Last year ha had a big plot of smooth gourd, and little plot of bitter gourd just to see. Still this year he's not sure about bitter gourd. There is a virus in the smooth gourd. Bitter gourd gets fruit flies more than smooth gourd, which gets them more than small gourd. So his favourite is smooth gourd, even though everybody else's is bitter. Why was the shift from cabbage/cauliflower/tomato to gourds? He still grows them, after the gourd. Cauliflower after smooth gourd. In February he sows smooth gourd, which ends in September; then comes 1.5 months of fallow to fertilise; then, after Divali, cauliflower and cabbage in together, which are over by February. Why the shift from cabbage/cauliflower/tomato to gourd? Other people were trying it so he tried and it was good. Prices were better. Cabbage and cauliflower were also grown with the wheat. Wheat was grown from November to February, and over by March 1st week. Ten years ago the wheat was grown until the end of March, brinjal and/or bottle gourd up until the August, then wheat again, November to March. So why no brinjal any more? No particular reason. "Now we have come to the pandal."

LABOUR RETURNS TO GOURD HARVEST His gourds are a sharecrop - he owns the land, provides the fertiliser, water and pandal and gets 3 / 4 of the yield. The people who provide the labour get 1 / 4. A landless family do the work - weed, irrigate, spray and harvest. Does this labour sharing work for all crops? No - only smooth gourd. Why? Labourer insisted. "Less energy to smooth gourd gets more." The returns to labour in smooth gourd are better than in other crops, so advantageous to the labourer. The farmer has to agree with this, because it's what the labourer wants and we agree to be humanitarian. {i.e., returns to labour are so good, the labourer insists on a share instead of wages because they make more that way}.

PRICE COMPETITION He lost 80ooo on tomato this year - largely because of price. Tomato used to come to Ahmedabad from Jaipur and Bagerhat {?}. Now production has started here in Kheda, which has brought the price down. So seasonal fluctuation in prices. So when is the Kheda tomato season? Jan-Feb-March, just into April. Now is the lowest price - 40Rs/kg to the consumer, the farmer gets 1.5-2Rs. Why not grow tomatoes out of season, with irrigation? Nobody would do that. You could grow tomato in the monsoon, but you would need to trail them.

GOURD HISTORY 15 years back small gourd was the commonest cucurbit.

#A013 DATE 15/4/4 TEAM JMS/RCJ. Village Haryala. He has 12 acres altogether.

CROPS Of his 12 acres 1 of bitter gourd. 1.75 of smooth gourd. 0.5 of cluster bean. 5 of wheat. 1.5 of bhajra. 1 of small gourd.

CROP PRICES The relative advantages and disadvantages of crops are mostly in prices. Eg bitter gourd was 2-300Rs, now produce is there and the price is not there. Small gourd price is there but production is not there. Smooth gourd has the best price but problems of virus. Wheat and bhajra are for home consumption. "You can't eat only vegetables." The cluster bean is grown for sale. A remunerative crop but prone to disease. Powdery mildew is serious - it is possible to lose the crop. 20-25oooRs/acre

if no disease. About 3-4 months.

GOURDS AND FRUIT FLIES Are they the same or different with regard to the fruit fly? Smooth gourd and small gourd suffer from the fly more than bitter gourd.

VEGETABLES AND PESTS They grew mostly cereals until 15 years ago. Any other vegetables, or only these? He tried tomato - 3-4 years. Not succeeded. Heliothis. Brinjal - the problem was borer.

CAULIFLOWER He will grow cauliflower soon - he's not sure, maybe after the BG or possibly in a separate field. Also a good crop, but with a less-than-ideal price situation.

GOURDS & FRUIT FLIES Which crop suffers worst from pests? Worst in BG is fruit fly. Worst in small gourd is fruit fly. Worst in smooth g is leaf curl, fruit fly second. Small gourd is grown from cutting, the others from seed.

VILLAGE COOPERATION How do you get villagers to cooperate? We'ld like to have form a cooperative society. There is now no cooperative society. Why? Not possible like in milk. Have problems with cooperation. Would do applications in a coordinated way, coordinate but not cooperatively. A problem is party politics. The village hucchi is his cousin, but he is BJP, the huchhi Congress. So they hate each other. He is also shatriya. Has the village a "head man"? Yes - the tsirpanch - elected by the village council. He is BJP but not necessarily political. The village council is the ranchat. Tsirpanch not necessarily political - sometimes independent. Elected by village council, which is elected by villagers. If the tsirpanch gave some directive and can persuade people, most farmers would do it, but not all. Some are hucchis, some too poor to afford. A lot will depend on the quality of the tsirpanch.

#A014 DATE 15/5/5 TEAM JMS/RCJ/DBS. {Evaluation visit to the wide-area BAT village. Most of the day is taken in presentations, speeches and a rather good lunch, so less discussion with farmers takes place than JS would have liked. Overall the view is that the wide-area application was most successful, and the infestation was zero by the end of the season. The huchhi has kept his obstinate stand, and would still be unwilling to participate in cooperative control were it to be tried again. There is some laughter at his attitude. There is no indication that village-level wide-area cooperative control may be taken up and sustainable. JS suspects that the fact that the area is almost all under gourds, which is due to a happy confluence of factors - technology, irrigation and the road - creates a homogeneity of cultivation practice which is purely accidental and is not reflected in any real social cohesion. Wide-are management would need to be organised by the sirpanch, but he gives the impression of having enough on his plate to maintain his authority, in the light of tensions within the village, to attempt to spend political capital on such a project. The sirpanch sees social pest management in terms of risk, not of return - his losses from failure would outweigh his perceived returns to success.}

@~G - GANDHEVI

#G001 DATE:17/09/03 TEAM: ZPP/VSJ Farmer with his brother. He has a total 6 ha. land they are 8 family members. That much farm produce is not sufficient to fulfil all requirements. His two brothers are working in UK & USA.

CROPS They are growing chiku, sugarcane, mango & bitter gourd.

CHIKU (also sapota or milk tree) He has a 2.5ha orchard of chiku growing since 1968. He planted Kalipatti variety graft at a distance of 10-x 10-m with general cultural practices. They thought chiku gave fruits throughout the year and continuous income. Now chiku gives good results, steady income throughout the year, and meets the family expenses. If more fruit are produced we get low price and vice versa. There is no

risk of complete failure of crop. Amalsad Co-operative Society is good for marketing also.

CHIKU PESTS Up to last 3 - 4 years, there was not that much problem of insect pests as well as disease in chiku. But nowadays bud borer, seed borer and fruit flies causes heavy damage.

BUD BORER A very destructive insect, feeds on flower buds and leaves also. Damaged buds dry and fall down. No fruit setting. It may be major problem at time of flowering that is in October. They are spraying the insecticide recommended by Agril. Scientist Dr. P.R. Patel. He mentioned only monocrotofos and was unable to list out all. He got very good results with these insecticides.

FRUIT FLY A/C to his view, this pest is prevalent in this area from chiku cultivation. It is causing heavy damage in April to May. He thought it might be due to raising temperature. 25 to 35 percent losses caused due to pest, damaging fruits which are ready to harvest. He said that infestation is increasing every year. He is not doing any management practices in chiku. He thinks that if they are using fruit fly traps on their farm flies come from adjacent untreated farms. It is necessary to use traps on all farms. {It seems chiku is blamed for infesting mango, rather than vice-versa, because the chiku is more constantly-bearing and so keeps the fly population available throughout the year.}

MANGO He is growing mango since last 10 to 12 years (c. 1992?). Mango is labourless, high yielding and good market crop. So they start to grow it. He said that it performs very well. As it is good cash crop, but fruit fly is a major problem now days.

PESTS He listed fruit fly, jassids, shoot borer.

FRUIT FLY He said the fruit fly problem started in our area with chiku cultivation. Before that we got healthy fruits. It is major problem in March to April, coinciding with fruit maturity. He adds that they don't know anything regarding development of fruit fly. He said that 50 to 60% fruit affected. Fruit fly shifted from chiku to mango.

MANAGEMENT: FRUIT FLY TRAP They are using since last 5 to 7 years. Co-operative society gives the attracting solution free of cost and we are applying 10 to 20 drops of solution per trap, recharge them 20 - 25 days. Traps are very good method. No problems. But it is necessary to use by all farmers.

TULSI He said that tulsi plants also attract fruit fly. Previously they were growing tulsi but nowadays they get ready-made attractant solution. But also he thinks to grow tulsi this year. It is good method. {The mixture of both tulsi and ready-made attractant is explained in that attractant is distributed by society and doesn't arrive in time - usually early May - a bit too late; so tulsi home-grown is used to hold the population off and down until the deliveries arrive}.

JASSIDS It sucks the cell sap from flower & there is complete deflowering. But it is controlled totally with insecticidal spray like endosulfan, neucron, monocrotofos.

BITTER GOURD They are growing b. gourd from next year mixed in chiku orchard for home purpose. He said that they will spray crop with same as chiku but no special mgt. practice is done. Because it is on small scale - home purpose only. He mentioned, he doesn't know fruit fly damaging to b. gourd but there is unknown damage.

#G002 DATE:18/09/03 TEAM: ZPP/VSJ Village Khergam.

CHIKU He is growing Chiku, Mango, Bitter gourd, Small gourd. He is growing chiku

since last 5 years. Area-3 ha. Var. 'Kalipatti'. Planting distance:-25 x 25m.They made pits of 2 x 2 feet, added organic manure in pit. Weeding should be done two times in a year. He said that the no-risk of crop failure is the great advantage of chiku, & continuous bearing. Chiku performing solid status in area. Amalsad co-op. society sends fruits to Delhi market & other part of India, so there is no problem of market & value also. In summer, the fruits are ripe earlier due to high temp. & fall down.

PESTS seed borer, fruit fly, bud borer etc.

SEED BORER Nowadays, seed borer is a threat to chiku growers in this area. A larva feeds on seed. They don't know anything regarding how it develops & enters in seed. When the harvested fruits were washed, they saw holes on fruits. Ants entered in such fruits & fruits rotting. Chiku plantation is decreasing in area, some farmers' cut off orchard, it may be due to the seed borer. Max. infestation found after rainfall. He said that this pest is dangerous in future as it loss market value to the half of it's original value. Sometimes holed fruits rejected by co-op. society. Larva is internal feeder; it is not response to any insecticides spray. He thinks that early spraying in May-June which kills the eggs, but same time they are engaged in Mango harvesting. He said that, pest loss ranging from 25 to 50% throughout the year. He mentioned that he uses sprays of different insecticides but not able to manage them.

FRUIT FLY DAMAGE It is also one of the dangerous pests since chiku growing in our area. In the months of Mar.-July (summer) heavy damage caused to chiku fruits, & low during winter. Fallen fruits may be the reason for population build-up of fruit fly. It is a heavy problem, fruits mature early & fall down. While in market, damage can't be seen by naked eyes, so there is no problem.

FF MANAGEMENT: FRUIT FLY TRAP He is using traps since last 5-6 yrs which is distributed by co-op. society free of cost to farmers. He recharges trap every 20-25 days with attracting solution given by co-op. Easy to install. The traps are very good in trapping flies. One man should install 25- 30 traps within 1 hr. FF MANAGEMENT: TULSI PLANT He also grows Tulsi plant in & around orchard since last 6 years, for attracting fruit flies. He said that population high in summer then he sprays tulsi with insecticides which are available in farm (monocrotofos, neucron, rocket, roger, quinalphos). He has thousands of Tulsi plants in orchard. It is also good practice & without any problem.

FF MANAGEMENT: COLLECTION OF FRUITS He collects the fallen fruits & buries them deep in the field as he knows fruit flies develop in fallen fruits. He added sanitation is important.

MANGO He planted mango in between chiku, var. 'KESAR', nearly 400 trees from last 20-25 years. Mango is less labourious than chiku (complete within Oct.-June). Time & labour saving. Distance bet. trees - 25 x 25m. He added 10kg poultry manure/ tree every year. He thinks it is good but riskier than chiku. There is effect of climatic condition on bearing some times - alternate-bearing problem. Malformation is a problem but copper oxychloride works well for it.

JASSIDS He said that they suck sap from tender leaves & flowers. When humidity is high, it becomes a problem, can be managed by alternative sprayings of monocrotophos, Rocket, neemazal (antifeedant, does not kill the insects), Kareena, neucron etc. Granular insecticides mixed with 'GERU' - a kind of red clay - & painted on trunk.

FRUIT FLY Nowadays fruit flies are a major problem day by day. Mango mixed with chiku shows high damage. He thinks individual crop should be grow instead of mixed with chiku. Fruit flies are higher in May-July because mango food preferred more by them due to sweetness. All farmers are not adopting trapping system, they are lazy, it became a major problem. 20-30% loss in mango by fruit flies.

FF MANAGEMENT He said that he using same practices as per chiku. He added that co-op. society costs RS.2/ trap & attracting solution free of cost.

BITTER GOURD He is growing B.gourd since last two years. He added that he has free land so he thinks to grow B.gourd. As it has good market price & yield also. Green caterpillar (25-30%) & fruit flies (3-5%) are causing damage to fruit. He doesn't have any idea regarding which species damage B.gourd. He is not adopting any mgt. practices.

#G003 DATE:18/09/03 TEAM: ZPP/VSJ Village: Desad. Farmer with his brother.

CROPS They are growing mango, chiku, teakwood, babool, seven.

MANGO He is growing varieties of mango viz., 'Keser', 'Alpanso', 'Rajapuri', 'Totapuri' on 16 acres since 1970. They planted trees on 30 feet distance and used organic manure, DAP, Castor cake. Now they are adding 30kg poultry manure per tree. Canal Lift irrigation system is used, gives frequent irrigation from November to April at monthly interval with ring basin method. Mango is low cost farming, low fertilizer irrigation insecticide and economically sound, value-added crop. It performs very well in our area. Labourless market prices good. Only the alternate bearing is the problem.

PEST: SHOOT BORER Larva tunnels new tender shoots & feed inside. Spraying of monocrotophos will check it.

PEST: HOPPERS As they suck cell sap from tender leaves & flowers, are dangerous during March-April. Spraying of quinalphos, imidachloropid, Ektara (thiamethoxam) controls hoppers.

PEST: ANTHRACNOSE It occurs during vast flowering. He uses copper oxychloride, bordaux mixture for spray.

FRUIT FLY He said that it causes up to 10% loss. They are using traps distributed by Aajrai co-op. society. Its population is higher during summer. Traps are working very well, they are using for 7 years. But he thinks sometimes solution is adulterated which catch low fly. Co-operative society distributes solution very late during April - May. He thinks population starts build up from January - February. So attracting solution must be dispatched during January - February.

CHIKU They have 100 trees of chiku started in 1923 and 200 trees from 1970. Variety 'Kalipatti'. Crop is performing very well but due to climatic situation there is problem of late and less production in old orchard. He said that chiku gives steady income.

BUD BORER It is feeding on buds of chiku, but managed by spraying of monocrotophos & endosulfan.

"MIGNELF" is a chemical he uses to enhance flowering

FRUIT FLY He doesn't think it is so serious. He is using fruit fly trap given by Co-operative Society. He said that solution should be given at a proper time and without adulteration.

#G004 DATE:18/09/03 TEAM: ZPP/VSJ/MBP. Farmer and two neighbours. Their land will not fulfil their family expenses of 8 family members. Farmer him self is retired bank employee. His brothers are working one as a doctor and another work in USA.

CROPS He said that he is growing only chiku and mango crop.

CHIKU They are growing chiku from their forefathers before 50 years variety 'Kalippatti'. He applying organic fertilizer and NPK @ 4 kg per tree. He irrigate the crop with an interval of 12 - 15 days in winter and weekly in summer. Planting distance between trees 10 x 10 m. Chiku performing good status due to coastal climatic conditions. He think chiku is a cash crop, net return, money throughout the year as continuous bearing. If production of chiku is low then he gets high prices and vice versa. So it always gets a good market price.

PESTS Seed borer, Fruit fly are the important insect pests of chiku

SEED BORER He said that this is the dangerous pest they saw since last 2 years in our area. Mainly it starts damaging to fruits in September. Pest causes hardly 1% loss. But they can't control it by spraying any insecticide. They are spraying endosulfan but seed borer does not respond. Its damage is decreased after winter automatically.

FRUIT FLY He thinks fruit fly is the medium problem in chiku. He said that fruit fly population is highest during March - July and it is low during winter. This change may be due to environmental factors. Fruit fly loss up to 3 - 5 percent in chiku. They cause damage to ready to harvest fruits.

TRAPS He is using fruit fly traps for 4 to 5 years. It is a plastic box with two circular holes, which contains small cotton piece soaked with attracting solution. They haven't any idea regarding solution. Co-operative Society distributes such traps and solution free of cost. Our state Government gives subsidies to implement this programme some farmers taking solution from Co-operative Society and keep it as such in the houses. They are lazy and not serious. Some farmers installing traps and others not, which results in fruit flies shifting from uncontrolled farm to controlled farm. This trap proves effective.

MANGO They are growing mango since 1986 on 6 ha. He has growing different seven varieties of mangos viz., 'Kasar' - 400 trees, 'Dhaseri' - 140 trees, 'Langda' - 66 trees, 'Alphanso' - 30 trees, 'Rajapuri' - 30 trees, 'Bhadami' - 45 trees and 'Totapuri' - 23 trees. In 1986 they cut off old cultivation because low production and sloping land which created problems for irrigation. For expansion purpose. They keep ten-meter distance between two trees. Plantation requires seven years to get harvestable fruits. He got very good fruit production. But also mango has some problem like seeding of flowers, climatic effect on setting, theft problem also. Mango is not safe like chiku. Mango has short season crop, low labour cost, few irrigation marketing once. Better market price than chiku. Sometimes 100 % crop failed due to alternate bearing problem in varieties - Dhaseri and Langda.

POWDERY MILDEW Disease is also serious on flowers as well as small fruits. He thinks it may due to high relative humidity but controlled by fungicide application.

PESTS: HOPPERS He noted that fog conditions and more difference in day and night temperature during flowering is mainly responsible for hoppers attack. They suck the sap from flower & tender leaves. Flowers fall down. Black sooty mold develops on fruits due to hoppers. He shows black, sugary development on leaves, flowers and fruits also. Fruit lose market value. He noted that 25 to 100 % crops damaged if not controlled. Mainly active during the month of December to February. The hoppers remain throughout the year on the trunk. He pastes the trunk with bordeaux mixture. He sprayed crop with monocrotophos before flowering. He noted that spraying on flowers affects fruit setting problem. Confidor is special for its management. Sometimes he is using endosulfan also.

FRUIT FLY Fruit flies are causing several damages to mango fruit. Their population is highest during April - May. He noted that after rainfall mango fruit are 100 percent damaged, so they are harvested earlier. Fruit fly develops in inside the fruit. He said average loss ranging from 10 to 15 %. This pest is very bad because it damages

ready-to-harvest fruits. Farmers lose their goodwill in market due to fruit fly damage. He mentioned one example: previously Gadat co-op. society is well-known in mango marketing but nowadays they have lost goodwill in the market due to FF damage. Nowadays no known person purchases fruit from Gadat co-op. society. Fallen fruits are responsible to develop fruit flies. In mixed crop, mango damaged up to 40 % and chiku up to 10 to 15 %. 'Alpanso' and 'Kesar' varieties of mango are highly susceptible to fruit flies while variety 'Totapuri' is less susceptible. He thinks it may be due to sweetness as well as peel size.

MANAGEMENT: FRUIT FLY TRAP Co-op. society distributes traps along with insecticide DDVP & attracting solution. He is installing 20 traps per ha., recharged at an interval of 10-15 days. This technique is very effective. Sometimes they haven't time to change the solution. Co-op. society distributes solution very late in the month of April, but they think, as population high from January - February, there is necessary to install trap in January. He noted those 10 traps per ha. is false recommendation and trap number should be doubled.

TULSI Previously he grew tulsi plant to attract fruit flies and sprayed with insecticide DDVP frequently.

COLLECTION OF FRUITS They collect damaged / fallen fruits. This method is good to check further development of fruit flies. But a laborious job. Collected fruit are buried in deep pit.

#G005 DATE: 22/09/03 TEAM: ZPP/VSJ Village: Nanderkha

CROPS. Small farmer growing BG, sapota, mango, ladies finger, paddy with 9 family members. He growing BG from last 3 years because it is high demanded veg. in local market. He has 30 trees of sapota (steady income) & mango each (high market value within short period). BG&PESTS Fruit flies cause heavy damage to BG fruits (early mature, yellowing, falldown, unmarketable) up to 50% damage. He sprays crop with mixt. of monocrotophos & DDVP suggested by his son, working as a Agri. assistant. Spray gave a good result. Previously he was using ME traps, but there was no any change in damage, satisfied by observing flies in traps. Unable to answer 'WHY?'

SAPOTA&PESTS Leaf miner & Bud Borer are the major problems, damaging leaves & buds(10-15%loss). He thought that fruit flies in sapota feeds only fallen fruits so he don't take any management practice.

MANGO&PESTS Fruit flies & Jassids are the main problems. By spraying monocrotophos & DDVP, he controls Jassids completely but fruit flies are not managed. He said that fruit flies feed inside fruits so chemicals are not working well.

#G006 DATE: 01/10/03 TEAM: ZPP/VSJ Village: Chari, Chikhali. He has 8 family members with 2.5 ha. land.

CROPS He growing mainly mango, SG, Ladies finger, sugarcane, paddy

MANGO He has a 70 years old orchard of 1 ha.,planted at 10x10m distance. Varieties: Alphanso, Kesar, Langdo, and Rajapuri. Crop is advantageous due to once harvested in a year, less laborious, low fertilizer, less irrigation (3 irrigations), chemical fertilizer is not necessary. Mango variety - Lagda is highly demanded in south Gujarat & Rajstan. Keasar is utilized for small juice industries running in state. Rajapuri is famous for pickles but due to low rate farmers' cutting-off this variety.

PEST 1. JASSIDS are the important as infestation start with flowering. it sucks the cell sap from tender shoots & flowers latter turns in black shooty mould. High infestation causes complete failure of crops (100% if not controlled). He got very good result with Endosulfan & sulpher (1 spray) & Monocrotophos & Bavistin(II spray)

pesticides.

PEST 2. FRUIT FLY It was active during mansoon. It causes damage more than 50%. High humidity may be good for it's development. Kesar variety is highly susceptible (due to sweetness). Fruit flies are major pest of mango because harvested fruits are damaged. Traps are good for mgt., but they are not using any management techniques & harvest fruits before mansoon, which was chemically ripened afterwards. Others farmers using ME traps.

PEST 3. BLACK LARVA It was minor pest of mango feeding on adjacent fruits only, so they are placing dry leaves in between two adjacent fruits.

GIRDLING Special horticultural practice for max. flowering, direct sunlight, continuous flowering which also minimize insect pest & disease incidence.

BITTERGOURD (BG) & PESTS He grows Bittergourd on 0.1 ha. from 3/4 years. It has a very good local market (Valsad, Bilimora) & good market value with high income. Nematodes are the big problem in ratoon crops, controlled by drenching of Furadan. Fruit flies are active at fruiting period causing damages up to 10%. Aphids are managed well by spraying of DDVP. Some farmers are using Tobacco Extract for Aphid control.

#G007 DATE: 18/12/03 TEAM: VSJ Village: Torangam Kiliyar. They are 12 family members, on 4 ha. land. Farmer is taking advice for pest problems from Dr. ZP Patel, Asso. Res. Scientist, FRS, Gandevi.

CROPS He is growing sapota, mango, and paddy.

SAPOTA They have a 350 trees of sapota. Sapota is a profitable, commercial crop, low production cost & labour, only harvesting needs more labour (for sapota Rs1 lakh income require Rs25000 labour cost while in mango Rs5000). High price when production is low & vice versa. No risk of crop failure.

FRUIT FLIES Now days, FF are the problem. Day by day it's population increasing in the area. Milk is ooze out from sapota fruits, due to egg laying injury. They are using ME traps supplied by their Cooperative society, gives good control.

SEED BORER It is new pest problem in this area since last 4-5 years causing heavy damage to fruits. Larva feeds on seeds & make exit hole on fruit which affect quality of fruits. It's infestation is high during sept - oct. , which loss fruit yield more than 15%.

WILT High rainfall causes high problem of wilt.

MANGO They has a 150 trees of mango of 25 years. Good performance over sapota, profitable; there is a risk of alternate bearing & Couldy condition cause complete failure. Their Cooperative society has canning facilities so they got high value. Kesar variety is good in this region.

FRUIT FLIES They are coinciding with fruiting period. Infestation was ranging from 20-60%. Egg laying enjury is seen completely on fruits & mainly damages matured fruits only.

TRAPS They are using ME traps @ 1traps/ 3trees. traps kill only males. So they are doubt about the traps. There is need to kill females.

HOPPERS This is another pest causing heavy damage if not protected at proper time. He using alternate sprays of decamethrin, lamdacyhalothrin, cypermethrin. They are taken technical assistance of Dr. Z.P.Patel, Entomologist from fruit research station

Gandevi.

#G008 DATE: 03/01/04 TEAM: ZPP/VSJ Village: Chari, Chikhali. He is small farmer with 0.8 ha. land. Seven members' family lives satisfactory on agricultural produce.

CROPS Growing Paddy- BG rotation crop pattern. After paddy, land was fallow and water available for few months after rains so he thought to take BG small duration crops. Taking advantage of available water. BG performing very well, low irrigation, crop harvest before summer, Khergam-local market gives good price. Only disease, pests are the main problem.

FRUIT FLY 25% damage to the fruits. Feed inside the fruit. He sprays insecticides suggested by sellers & also installs ME traps, but also they never get good control. He satisfied by watching fruit flies trapped. Unable to answer WHY?

WILT (Huharo) It is also major problem, solved with market chemicals.

PADDY & PEST He grows paddy in rainfed condition. Ear head bug & wilt are the problems, managed by spraying insecticides.

#G009 DATE: 05/05/05 TEAM: ZPP/VSJ/JMS Meeting to evaluate the wide-area MAT in mango. The farmers gathered are highly articulate and commercialised, and the conversation takes place almost entirely in English. These farmers were already familiar with MAT, but the wide-area use of the blocks has provided substantial improvements, and they agree with JMS’s supposition that earlier methyl-eugenol deployments were not sufficiently strong, widespread or coherent. They are most interested in making this technology work. Their intention is to try to persuade the cooperatives in the area to make a big investment in it; if unsuccessful they may try it in the locality on their own initiative. They think that a 1sqkm deployment, while pretty good, still permits flies to enter and losses to occur, and that use over an even-larger area would be better. 10sqkm is suggested.

@~R - THRISSUR

#R001 DATE:08/03/03 TEAM: JT/CVV. He has 2.80 acres of land. There are four members in his family. He is a full time agriculturist and his wife is a teacher.

CROPS Earlier all were paddy fields and started vegetable cultivation before 8 years. All the vegetables for his family is cultivated in his own field.

CROPS The main cucurbit that he is cultivating is Bitter gourd. Grown twice in a year. During March- April and September- October. The crop rotation is Bitter gourd-cow pea- Bitter gourd. Snake gourd, little gourd and Ridge gourd etc. are cultivating in a few area. Cucumber, pumpkin and ash gourd are cultivated as border crops.

PESTS most serious problem in cucurbits is mosaic. Earlier stage of the crop is heavily infested by Jassids, White flies, Leaf feeders, mites etc. After fruit set fruit fly is the main problem followed by fruit borers. These pests were not that serious when he started cultivation. Pest infestation was moderate before 6 years. Uncontrollable pattern of pest incidence started just before 4 years. This year the pest incidence was comparatively less in cowpea. The application of chemical fertilizers was reduced which resulted in less pest incidence.

NATURAL ENEMIES He is using the insecticides to a less extent in last 2-3 years compared to the neighbouring plots. He has noticed more spiders in his plots.

FRUIT FLIES Infestation is more in second crop than in first crop. First crop in this year the infestation was more. He started cultivation earlier that others. So no crops around for damage. So more fruit flies inhabited in his plots. This year 30%

infestation noticed during first two harvest and thereafter it reduced. Earlier the infestation by fruit flies were only 5-10% in bitter gourd. In snake gourd the percentage of damage is around 5-10% and earlier it was only 1-2%. Fruit fly infestation is very rare in ash gourd, pumpkin and little gourd. Earlier there was no fruit fly infestation in little gourd.

FRUIT FLY CONTROL Earlier he used to spray only insecticides. For the last three years control is mainly by Neem garlic emulsion. He starts the spraying from four leaf stage at weekly intervals. When the harvest starts it reduces to once in a month. Neem cake is also used for basal application. Besides tulsi trap, which responds well, fish trap, which gives average performance and starch- not performing well- are using.

#R002 DATE:08/03/03 TEAM: JT/CVV. He has 30 cents of own land and also cultivating 50 cents in leased land. There are seven members in his family. All the family members are involved in farm activities.

CROPS Mainly grown are bitter gourd and cowpea. Crop rotation is Bitter gourd-cowpea- Bitter gourd. Bitter gourd is grown during March - April and also in September - October. Snake gourd, little gourd, cucumber, pumpkin, ash gourd etc. are also cultivated in a few area. Started cultivation three years ago, after he became a KHDP (Kerala Horticultural Development Board) member. No vegetables are bought from outside.

PESTS Main problem in bitter gourd is the incidence of mosaic. Main pest is jassid and fruit flies. These pests were noticed when he started cultivation. But he feels the infestation was comparatively less during the first year. In snake gourd and little gourd too Mosaic is the problem. Fruit fly infestation is also noticed in snake gourd.

FRUIT FLIES Infestation of fruit flies in bitter gourd is 15-20%. Percentage of infestation by fruit fly in snake gourd is 2-5%.

FRUIT FLY CONTROL He uses chemical insecticides for fruit fly control. Last season he tried with neem oil, which was found effective.

#R003 DATE:08/03 TEAM: JT/CVV. He has one acre of land. There are four members in his family.

CROPS Main crops grown were bitter gourd and cowpea. Crop rotation is Bitter gourd-cowpea- Bitter gourd. Other vegetables grown were snake gourd, little gourd and ash gourd. He started vegetable cultivation ten years back and all the vegetables for his household purpose is cultivated in his field itself. But in this season he is going to cultivate rice for a change. The plants were at thestage of transplantation. There is some water scarcity so he is much bothered about the date of transplantation.

PESTS Main pests are jassid, white flies and fruit flies. The pest incidence is very severe for the last four years. Earlier the cultivation was by very few farmers. So the pest incidence was less. Nowadays the cultivated area is very high which resulted in high pest population. Last season all the ash gourd was infested by fruit flies in early stage and the entire crop was lost.

FRUIT FLIES Fruit fly infestation in bitter gourd is 5- 10%. He thinks the infestation is less during the early stage of crop, which increases later. In snake gourd the damage is only 1-2%.

FRUIT FLY CONTROL Chemical Insecticides were used earlier. Last season he didn't use any chemicals. He tried with Neem oil emulsion, which was found effective. Banana traps were also tried and were effective.

#R004 DATE:08/03 TEAM: JT/CVV. He is cultivating vegetables in 50-100 cents of land. There are six members in the family.

CROPS Vegetables are cultivating for the last ten years and producing almost all the vegetables for the family. Main crops grown were bitter gourd and cowpea. Crop rotation is Bitter gourd- cowpea- Bitter gourd. Other vegetables grown were snake gourd, little gourd, coleus, etc.

PESTS Main pests are jassid, white flies and fruit flies. The incidence of pest is severe for the last four years. The farmers were using more chemical fertilizers, which resulted in more pest infestation.

FRUIT FLIES The infestation rate of fruit flies in bitter gourd is 5-10%. Snake gourd the infestation was very less which comes around 1-2%.

FRUIT FLY CONTROL Now the use of chemical insecticides are reducing. Last season he used only banana trap and neem oil. The infestation was very less during last season may be due to the climate. But the fruit production was also less.

#R005 DATE: 17/05/04 TEAM JT/CVV/JMS. {This is the day of the Elanad wide-area spray. "Elanad Farmers' Club." There is in evidence in many ways of Kerala's traditional involvement with politics of the left: a project at KAU, run by a politically active Marxist professor, is the "Comprehensive Coconut Care Package", giving it the pleasing initials "CCCP".}

#R006 DATE: 17/05/04 TEAM JS/JT/CVV. {In the bank. This is a cooperative bank, largely set up by the State to provide financial help to farmers as a deliberate social project. The bank is a major participant in cooperative activities, as so many of these have a major financial component. Finance can be made available for cooperatively-organised agricultural projects by groups of farmers clubbing together - indeed, this is largely what the bank is actually for. The notion of using the bank to implement cooperative pest management is suggested - the response is that this is quite a new idea for them, but that in principle, yes it could fund cooperative village-level pest management as a financial investment likely to provide a return.}

#R007 DATE: 19/05/04 TEAM JT/JMS. Village: Chalakudy. {This is probably the friendliest and most engaged of the farmers in the "urban wide-area" trial of MAT blocks who had the blocks at farm-level last year, and now at locality-level this year. The area is not really urban, but suburban/residential/agricultural with prosperous farms of a few acres interspersed with (and often occupied by) middle-class professional people who work in Thrissur and so on. The farm is on the main road from Thrissur to the airport, Kochi/Ernakulam and the South. Highway businesses such as hotels and restaurants are also in evidence. This farmer has a collection of miniature bottles of liquor (none of which he seems to have drunk).}

MAT The MAT blocks work well. This year the blocks were very good control, 0% infestation, but control dropped sharply with heavy rain, and there's been a lot of damage since. Before the rain messed them up, they were working this year {"wide-area"} better than last year, when pest infestation was more then zero. Probably due to the wide-area application. He also splashed some jaggery mixed with malathion about the place, as a thickish paint on tree trunks, and this may have helped. He watches the fruit flies at the blocks in traps (he understands how they work). He thinks it will be best to put the blocks a bit away from the fruit trees, nearby but not right at them. He suspects that the crowds of male flies attract females, and these are not killed, so you don't want to attract them to the fruit trees.

#R008 DATE: 14/10/5. TEAM JT/JMS/CVV. This is the evaluation of the wide-area village-level coordinated management. When the wide-area experiment was being set up,

it was apparent at the first meeting that one individual was trying to stir up disagreement and non-cooperation. As JT discussed matters with a group of farmer with this individual as a (self-appointed) ringleader, CVV explained to JMS that she was worried by these developments, which were a completely new departure from the friendly and cooperative tone taken at the previous meetings here. The individual leading the revolt against cooperation is arguing that the experiment is to benefit the researchers, not the farmers and is basically exploitative. Subsequently this group of farmer decide not to cooperate with the experiment. JT reports these event to JS by e-mail. The farmers here group into small cooperatives, “self-help groups” of about 20 farmers, and these in turn into larger groups of about 200. The size of the self-help group is set as the distance a man’s call will carry so that the members can hail each other. Farms here are so small that a group of about 150-200 farmers will occupy only about 20Ha, so we need five of them to take up 1sqkm. Five such groups, taking up a contiguous area, were scheduled to take part in this experiment, and it is one of these, comprising about a fifth of the area, which has now left. JT has persuaded another group, at the opposite end of the block, to join in, to bring the area back up to 1sqkm. The whole is being pushed by an energetic and ambitious farmer, who is currently the mayor of the little locality, and has greater political ambitions and clearly sees the success of the wide-area pest management as a political advantage which will cement his position and reputation. He is most useful and probably critical to the success. When the experiment is over, it is viewed as having been a great success. The group of farmers who had decided not to participate have come back, admitting rather ruefully that they were mistaken, and are now taking part. Questioned as to their motives for dropping out, they reply that they had been approached some years ago by a group of men purporting to be researchers, creating an impression quite a bit like JT’s team, but they turned out to be strictly commercial, and were only interested in taking the farmers’ money off them, and are remembered rather unhappily. JS is of the view that the distrust of these individuals is also aligned alongside the long-running tradition in Kerala of “left-wing” social activism and a distrust of the forces of unbridled capitalism. The groups are now optimistic about the sustainable introduction of wide-area fruit fly management, and believe that it will fit into existing cooperative structures. They point out that the fact the area is homogeneously gourd, with no patches of forest I particular, is important, as the cooperatives would not be able to spray with bait any uncultivated areas with no gourds, as to try to persuade farmers to do this would be going too far.

@~M - THIRUVANANTHAPURAM

#M001 DATE:08/03/03 TEAM:JR/AN Village: Vallumkode, Kalliyoor. He is one among the progressive farmers (as noted by Kalliyoor Krishi Bhavan authorities) and owns a big farm. He had his education up to tenth standard. Total area under his cultivation is about 6.5 acres. He owns about 3 acres and the rest is leased @Rs: 4000/-annum. He engages about 5 labourers in a day for various operations and the number may vary depending on the type of activity in the field. He attends the training programmes and extension activities conducted by Agrl. College, Krishi Bhavan and Panchayats. His family includes wife, 2 sons and 1 daughter. Eldest daughter has completed her plus 2, elder son passed tenth and trying to join military, youngest son studying in seventh standard.

CROPS Mainly his cultivation is centered around vegetables like cowpea (2.5 acre) amaranthus (1 acre),cucumber (1 acre) snake gourd (1 acre),bitter gourd (50 cent), little gourd (50 cent) and okra (10 cent). The whole area under his cultivation is lowland. Soil type is clayey loam. Previously rice was the main crop but due to labour unavailability and high labour charges he shifted his cultivation to vegetables. Water source for his cultivation is from canal and the water is collected mainly using kakotas. Because of the growing responsibilities towards his family, he found that paddy cultivation is not as profitable as he expected so he has shifted his pattern to vegetables. Owing to the short period of cultivation and high returns

he has found this as very reasonable.

COWPEA & PESTS Trailing type of cowpea is mainly grown in pandals. Cowpea aphid and leaf miner is the major pests and mosaic and collar rot are the major diseases. For aphids and leaf miner attack malathion and metacid were used and for collar rot fungicides like fenvalerate or blitox were drenched in the field. He grows this crop due to its luxuriant vegetative growth (leaves can be used as mulch) and reproductive growth (producing more number of fruits per plant) and hence fetch good price in the market.

AMARANTHUS & PESTS In amaranthus cultivation he notes leaf webber as the major pest and wilting and leaf spot as the major diseases. Since the leafy portion of the plant is consumed as a vegetable he avoids using any chemicals but during extreme case of attack he drenches the soil with supernatent solution of cow dung, malathion and fytolan mixture.

CUCUMBERS & PESTS He grows creeping type of cucumber plants. The damage by leaf hairy caterpillar, mosaic and premature drying of fruits were noted (might be due to vine breakage during cultural operations). He opines that there is market fluctuation in the price of the crop, so it is not extensively grown.

GOURDS & PESTS Cucurbits like snake gourd and bitter gourd are grown especially during January-March and September to December. Various cultural operations for both these crops are almost the same. The main pests for snake gourd is fruit fly, followed by snake gourd caterpillar and the disease mainly includes mosaic, little leaf and downy mildew. In bitter gourd plots also he observed fruit fly as the major pest followed by small mites sucking the juice of leaves. The disease noted was little leaf, bacterial wilt and mosaic. According to him nearly half of the fruits were damaged by fruit flies. Snake gourd caterpillar mainly eats the leafy portion and it doesn't affects the fruit. But the maggots of fruit flies exploit the pulp inside and thereafter the entire fruit will turn yellow and thus making it unfit for consumption i.e., it actually reduces yield. So he is more worried about the attack of fruit fly. Coming to the disease he is equally afraid with little leaf and mosaic since the crop will be stunted in its growth and no new flushes will be produced thereby preventing flowering.

GOURD PEST CONTROLS During that time he used to spray either Malathion or fenvalerate whichever is available in the market. But spraying was not effective and he changed different chemicals from time to time to reduce the attack. He is not interested in spraying chemicals in his field, but to avoid heavy crop havoc he sprays fenvalerate, malathion in his cucurbit fields. For fruit fly control in both cucurbit fields he practiced using banana traps after attending the training programmes of extension department. Now he practices 'palayamkodan' fruit pieces (i.e. after taking a single banana fruit he removes the skin and cuts it in to two pieces and then smeared with furadan granules on the surface of fruit)in coconut shell along with spraying malathion + jaggery mixture. Traps containing banana will be removed every week and spraying will be done twice in a month. Another control measure is that he collects such fruits and throws it in the canal. 'Thulasi' is considered as a holy plant and he knows it as a natural repellant to many pests. As banana is easily accessible he is more fond of using banana traps. He was unaware of starch -jaggery or fish traps . He knows that any sweety material along with some poison attract the fruit flies.

ORGANIC/EXPORT PRODUCTION He cultivates little gourd (koval) exclusively for export purpose and hence organic products are used in the farm. For cultivation in that particular field he uses organic manures like poultry manure, farm yard manure and coconut cakes. When disease or pest incidence occurs he manually collects the damaged fruits and destroys. If incidence is very severe he sprays neem based preparations like neemazal or neem oil but actually he is less bothered about the pest/ disease attack in his koval field. According to him he is not facing any financial loss by

the damage due to pest or disease attack. Export authorities (i.e,VFPCK - Vegetable and fruit promotion council of Kerala) collect the damaged fruits also at the same rate of fresh fruits. So he is not facing any threat by organic farming.

FARMING PRACTICES In the homestead he rears two cows, 4 goats, 2 rabbits and a dozen of love birds. He has got additional income by the selling the produce and young ones of above animals He recycles the kitchen waste, cowdung and urine for farming purpose. He uses cow's urine in a diluted form (1 litre of cow's urine diluted in 10 litres of water) for the healthy growth of the crop. He recommends this as an organic pesticide and also as a growth regulator. Even though he is a traditional farmer he doesn't advice his children to undertake farming as a profession because he opines that if we investRs.1000/- for cultivation, Rs.900/- will be either profit or loss.

INNOVATION & EXPERIMENTS He has very good contacts with the various extension workers of the college and keeps abreast of the latest developments related to the use of the various pest management practices. He has also carries out demonstration trials on his field as part of the projects in the College. So he is willing to experiment the various traps given to him as part of the projects, some of them which he finds very effective and promising. One of these traps which he has very high opinion is the Cuelure and Methyl eugenol trap. According to him those were very useful in trapping all those flies in his neighbourhood.

#M002 DATE:08/03/03 TEAM: JR/AN Village Kalliyoor. A small farmer.

FARM SYSTEM He is mainly engaged in earning income from his homestead (a peculiar type of farming noted in Kerala).He opines that the fruits and vegetables which is required for him and family members can be obtained without much cost from his surroundings itself . He selects a particular portion of his surrounding where there is abundant sunlight, water and which is highly fertile for raising the crops. The space for raising each crop depends on the number of family members; extend of shade in his farm etc. According to him he needs one cent (40 sq.m) for each member. He has constructed a fence around his field to prevent entry of cattle, dogs etc.

FRUIT & VEGETABLE CROPS & ROTATION On his field is spread little gourd, chekkurmanis and (green leafy amaranthus) trailing cowpea. In one part of his field i.e., in 1/4 area he raises vegetables and fruits. Mainly the fruit crops in that area include banana, papaya, small lemon, capsicum and pineapple .He recommends these crops to be concentrated in one area to avoid interference of these crops with others. In the shady portion of these crops mainly ginger, turmeric, amorphophallus, colocasia and yams are raised. In the rest 3/4 area of his farm vegetables are grown. He rotates mainly leafy vegetables, cucurbits, chilli, bhindi, brinjal, moringa, and tomato in his farm. He opines that if the same crop is raised season after season the chances of pest and disease incidence will be more. Previously he had one such experience in which the whole amaranthus grown in the next season was damaged by bacterial blight and he also had seen the severity of shoot and fruit borer attack when brinjal was raised in two consecutive seasons in his neighbours farm.

VEGETABLE CULTIVATION For raising chilli, amaranthus, brinjal and tomato he sows the seeds in nursery and after 45 to 50 days he transplants it to the main field and during severe summer he provides shade to the seedlings. Direct sowing is practiced in the main field for bhindi, brinjal, cowpea and cucurbits. During rainy season he grows crops mainly in raised beds and during summer season seedlings are planted in the channels.

CUCURBIT CULTIVATION For cucurbit cultivation he uses poles and coir to construct the pandal. He adds poultry manure, cowdung for healthy growth of the crop. With the good source of manures the bitter gourd flowered enormously. He also grows bitter gourd + snake gourd + cowpea in a single field. Since these are all having trailing nature no additional cost is required and chances of crop failure will also be less. For

improving the fertility condition of the soil he grows cowpea alone after the harvest of cucurbits. In a mixed cropping of above three he grows cowpea as a border crop.

BITTER GOURD FLY INFESTATION As the fruit initiation started many of the small and medium sized fruits were having a brownish yellow colour and later fell to the ground also. With some fruits he approached the krishi bhavan authorities and they examined the fruit and showed him the small maggots inside.

BITTER GOURD FLY CONTROL HISTORY The krishi bhavan authorities recommended him to spray Malathion mixed with jaggery in the field at fortnightly intervals, cover the fruits with polythene cover and also advised him to use banana fruits in coconut shell smeared with carbofuran granules. He had only about 30 to 40 plants in the field. Since the damage was severe in the field he was forced to throw all his fruits to the nearby canal. This actually helped him a lot and when the flowers came next time with the second dose of manure he gave an initial spray to the field and later hanged some banana traps here and there; along with this he used newspapers to cover the fruit. After first day itself he observed small flies in the trap (he mention it as big mosquito flies) and he was happy that the damage was less during this time. In some news paper covered (as it is cheaper and easily available he preferred news paper cover) fruits the initial symptom of brownish yellowing occurred again and it might be due to improper covering of fruits as it enlarges and also the paper was torn off after a few days.

PESTICIDE AWARENESS In each harvest he sells only15 to 20 kg of bitter gourd fruits to the nearby markets and the rest he uses for home consumption. He is very much aware of the toxicity of chemicals and so he harvests the fruits only after 3 or 4 days.

SNAKE GOURD FLY INFESTATION In snake gourd field also he noted the yellowing of fruits and he gives less importance to the attack, since he has only less number of plants. Whenever a discoloration to the fruit is noticed he plucks the fruit and use for vegetable purpose (after cutting the damaged portion). For consumption purpose no vegetables are purchased from the markets.

FARM PHILOSOPHY This small scale farmer is very much satisfied with his homestead farming. He is a retired school master who very well knows the hazards of large scale use of pesticides in vegetables. His is a nuclear family with his wife (house wife), a son going for small jobs in the nearby neighbourhood and his daughter married off. So with this mode of cultivation he is assured that his family gets fresh and pesticide free vegetables and because of this he is mentally satisfied.

#M003 DATE:08/03/03 TEAM: JR/AN Village Neyattinkara. He is a medium farmer residing at the border part of Kerala state and owns about 2 acres of land.

COOPERATION He is a member of the group farming community where farmers pool their resources and harvest the produce and the returns are divided based on the size of the holdings.

CROPS Banana intercropped in young coconut gardens is about 1 acre and 50 cents for cucurbits like bitter gourd, snake gourd and rest 50 cents for cowpea.

MOVE FROM RICE TO VEGETABLES Before growing banana, cucurbits and cowpea he raised rice crop throughout the low lying land. He faced severe threats from the rice cultivation due to lesser yield from the crop, adverse climatic condition and attack by rice bug. For raising vegetables he can utilize the family labour as the works are not as tedious as in rice crop.

VEGETABLE CULTIVATION In cultivating vegetables he concentrated mainly in cowpea, snake gourd, bitter gourd, chilli , amaranthus and brinjal. He actually rotates all

these crops in his field mainly selection depending on the market demand. Cowpea will be intercropped in pandal either with snake gourd or bitter gourd and amaranthus intercultivated in the raised beds of cucurbit field.

CUCURBIT PESTS Major pest noted for snake gourd was fruit flies followed by pumpkin beetle and the disease noted was mosaic, bacterial wilt and powdery mildew. In bitter gourd field the main attack was by fruit flies followed by epilachna beetle, jassids , white flies and the diseases were phyllody and mosaic.

FRUIT FLY CONTROLS For controlling fruit flies he resorted to his neighbors practice. His neighbors also had a small farm more or less growing the same crops. Due to fragmented small holdings of the farm three of the farmers have pooled their land to facilitate various cultural operations. He was convinced when his fellow farmer encouraged the use of traps like banana, jaggery in coconut shells for trapping fruit flies. Now in his farm the traps for catching fruit flies include banana trap and jaggery trap. In banana trap he uses red banana along with boiled jaggery for catching fruit flies. He replaces the trap every week by adding so water in the residue (after removing the dead fruit flies). He catches a good number of flies by this method and he also uses boiled jaggery (in a gummy consistency) and furadan alone for catching fruit flies. The difference from the recommended practice was that red banana pieces smashed along with jaggery and furadan or either of the components alone with furadan to catch fruit flies. When attack is severe they spray some chemicals (either rogour, metacid, mancozeb any of these chemicals which is available in the market, they don't remember the names but showed us the used up packets) which may be either fungicide or insecticide to control the pest and disease. They also practiced using banana pieces in coconut shells painted outside with yellow colour which actually serves a double purpose of collecting fruit flies and sticks other flies like pumpkin beetles and other saprophytic flies. Anyway after the initial spraying the pest and disease of the crop will be less and they will continue the same procedure week after week to get good yields from their plots.

FLY CONTROL EXPERIMENTATION The attack of fruit flies became severe and during this time only we reached their plots and we gave cue lure traps to install in their fields .The next time when we visited his field more labourers came to the spot and they were thrilled to show us the count of fruit flies in the traps which we kept and they started demanding more traps when we visit next time .We also had installed the protein hydrolysate of various concentration in one litre plastic bottles but the count we obtained was less. They started reusing the bottles (which was kept for experimenting various concentrations of protein hydrolysate) instead of coconut shells for keeping banana pieces smashed with jaggery, water and furadan. According to him the plastic bottles were more convenient in the field as the direct entry of water from the pandal could be prevented during the rainy season and during summer season easy drying of banana, water, and furadan mixture was prevented. If we cut a plastic bottle and some sugary attractant and water without adding the poison itself the flies will die due to suffocation and the dead flies in the liquid has a particular power to attract more flies thereby avoiding the use of poison and this he practised in his farm out of curiosity.

BIRD SCARING In spite of attack by insects and disease he also notices the attack of sparrow in fruits of snake gourd and cowpea. To ward off the birds from the field he uses an aluminum bucket inside of this a stone tied with a plastic thread and connection of this extends throughout the field and to a coconut tree near his house. The sound of the stone hitting the bucket wards off the flies ie, by sitting in the house itself he can practice this method.

#M004 DATE: 08/03/03 TEAM: JR/AN Village Kakkamoola. A small farmer.

CROPS Growing crops like little gourd, coconut, banana, bittergourd and cowpea. Little gourd (koval) in an area of 50 cents, snake gourd or bitter gourd or cowpea in

50 cents, banana intercropped in coconut gardens occupying 25 cents and cowpea alone in 25 cents .

LITTLE GOURD CULTIVATION Mainly he earns his income from little gourd (koval) cultivation. According to him a koval crop can stand in the field as a good yielder for at least two years and hence he could save the additional cost of replanting a crop. He raises the crop in a pandal and ordinary coir which is used by farmers is not practiced, instead plastic thin threads are used for horizontal and vertical tying to the poles. He harvests the crop twice in a week i.e., Wednesday and Saturday. For sale of produce he along with the nearby farmers in the area hire a van and carry the produce to chalai market in the Trivandrum city. He thinks that this is more remunerative than small scale selling to the nearby markets. Koval is cultivated mainly in the lowland situation where previously rice was the main crop. From each harvest from 50 cents he gets around 50 kg of koval and he sells @4/kg. He took loan from the primary society nearby for an amount of Rs: 2000/- for which he repays @200/- month. He is also practicing intercropping in the koval field in the initial stages of growth of the crop. He raises amaranthus as the canopy of the crop has not spread but in the later stages when some amount of sunlight is available he grows amorphophallus or the shady areas in the field is left fallow. So he gets profit from amaranthus /amorphophallus + koval.

LITTLE GOURD PEST MANAGEMENT In summer he practices cropping in levelled land but during rainy season he constructs mounds around the root system to facilitate easy drainage and being a perennial and hardy crop, the attack of pest and disease is very meagre. But also he sprays fenthion or malathion weekly in the koval plot.

SNAKE/BITTER GOURD & OTHER VEGETABLES Concentrating on the rest 50 cents of land he grows either snake gourd, bitter gourd or cowpea depending on seed availability and market demand. Previously in the same field he used to grow amaranthus, bhindi and brinjal. But in amaranthus due to heavy leaf damage by leaf spot and leaf webber attack, he started cultivating bhindi. Even though it was more remunerative than amaranthus, due to fruit and shoot borer attack and to heavy wilting the control measures became difficult. So now he is engaged in cultivation of snake gourd/bitter gourd/cowpea.

EVOLUTION OF FLY CONTROL IN SNAKE/BITTER GOURD When he was growing snake gourd/bitter gourd he was more interested in spraying chemicals rather than keeping banana or thulasi traps. During that time he believed that if we apply chemicals then there will be sudden death of maggots inside the fruit and only slight yellow colour persists in the fruit which he can adjust during the sale of produce. If he keeps traps it will attract flies from neighboring plots also. These flies will only suck the sap and they will not cause any serious damage to the crop. He opined that maggots are causing damage and hence he was more interested in destroying the maggots in the fruit. But later on when the people from VFPCK (Vegetable and fruit promotion council kerala) used to visit his plot and they recommended the use of traps to control flies. They made him clear that these flies are laying the eggs on the surface of fruits and the emerging maggots are causing the damage. So it became necessary for him to control the flies. So now he has kept banana traps and thulasi traps intermingled in the field @ 1 trap for 4 plants and he is satisfied with its performance and will continue to keep this trap. He also practiced use of other traps like fermented toddy + furadan, ripe pineapple fruit pieces with a small amount of yeast and furadan. According to him all these traps catch fruit flies and he keeps either depending on the availability. He mainly grows snake gourd-chilli in summer season (January-April), next season bitter gourd-tomato and in June-September when heavy rain is there he keeps the field fallow. According to his opinion if he raise the crop during that period it may be lost in severe monsoon or by pest / disease attack.

BANANA AND COWPEA PRODUCTION Mainly he grows banana in 25 cents i.e., robusta,

palayamkodan during the period from Nov-Dec to August -September mainly depending on the availability of good suckers (sword suckers). Later on if heavy rain is not available he grows vegetables like cowpea which completes its growth in 3 months is raised in the field (mainly bush type). Since it completes its growth in a short time the field may be ready for raising the second crop of banana. Cowpea according to him is a good crop where chances of attack by maggots are less. This crop also grows luxuriantly without any additional input to the field. Yield obtained is also considerable. There are only minor attacks by leaf miner and aphids and he controls them by removing the affected parts.

#M005 DATE:08/03/04 TEAM: JR/MS Village Thannimoodu. He is a homestead farmer owning only about 60 cents of land. Previously he had about 2 acres of land and due to heavy debts he was forced to sell his land. With this meagre land area also he could meet the necessities of his family. He has a son 6 years of age and wife engaged in household activities. Krishi Bhavan authorities have collected soil sample from his field and he is waiting for its result.

COCONUT CROP & PESTS Major crop in his homestead is coconut of different age groups. In older palms pepper is twined and thereby he could get additional income from the same unit of land. He is mainly facing the threat by mite infestation followed by coreid bug and mealy bug infestation. Root wilt and leaf rot in coconut were also noted in a few plants. The production from coconut palm is declining mainly due to pest and disease attack and due to old age of palms. In coconut no routine plant protection operation was done. Yearly once they resort to application of cowdung. So now he is interested in under planting of new palms in his field. From coconut he could get around Rs5 to 6 per nut.

CROP: ARECANUT Arecanut is also grown in the interspaces of young coconut gardens. Due to decline in market value of arecanut he concentrates less on its cultivation. He sells mainly the produce from coconut and arecanut only to the small sellers in his area and hence he could avoid the transportation cost. From arecanut he can get Rs30 per 100 nuts.

CROP: PEPPER He also complains about the less market value of pepper. The yield from pepper plants is higher and he could get 10 to 15 kg/plant from each harvest. Normally he is not observing any serious pest or disease attack in his pepper field.

CROP: VEGETABLES He also cultivates vegetables like brinjal, amarathus, chilli for meeting his home needs and also a small quantity of each vegetable he sells in the market.

ANIMALS He is also interested in animal husbandry operations like rearing cows and he gets around 8 to 10 litres per day. He wishes to sell the milk to nearby houses and by this he could get Rs15 /litre whereas to the society he could fetch only 9/litre.

BANANA & SPICES He used to grow banana in his field but due to heavy infestation by banana pseudostem weevil (for reducing weevil attack he used to apply furadan) he gradually shifted to spice crops like ginger and turmeric. He sells the produce in the form of dried ginger. Though the land in his area is undulating topography he doesn't grow other plantation crops in his field like coffee or rubber.

#M006 DATE:08/03/04 TEAM: JR/MS Village Thannimoodu. A big farmer.

CROPPING SYSTEM He cultivates different crops like coconut, rubber, mango, guava, tamarind, clove, tapioca, banana, cowpea, guinea grass, pepper and vegetables like snakegourd, amaranthus, cucumber and chilli. He is cultivating all these crops in the leased land and he pays about 2000 per year for each ela (a continuous strip of land where rice was the major crop but now shifted to the above crops). In ela cultivation there will be separation of different crops in the field by clayey bunds smothered

with grass. When the field is left fallow there will be grazing by animals and hence the scarcity of forage for milch animals is avoided. He owns a rubber estate at a far away place (at border near Tamil Nadu) and he selected this place mainly due to low rent of land. He is residing in a small rented house near his field mainly to supervise the day to day operations in his field. Irrigation is mainly carried out by water from the canal. During rainy season the water will be mainly muddy and during summer periods there will be shortage of water for cultivation which will be rectified by proper selection ie, drought tolerant crops like tapioca and guinea grass will be grown and rest of the land will be left fallow. In land which is of undulating nature terracing was done and in the terraces rubber is the main crop grown and in the interspaces pineapple and cover crops like calapagonium were grown.

COCONUT PESTS In coconut field around his residence place mainly attack by rhinoceros beetle, red palm weevil and leaf rot were observed.

INFORMATION SOURCES Normally the farmer depends on the advice of chemical dealers. Rarely does he approach agricultural scientists or officers.

MANGO PESTS {Normally in homesteads of Kerala there will be 2 or 3 mango trees.} In the farmer's field also there were three mango trees and during our survey time the flowering started. In mango there was attack of shoot midge, leaf webbers, and magohoppers. The variety in his field was varika mango and according to him the fruit fly infestation was not noticed yet, but he observed some stray incidence of attack by maggots that were yellow in colour but he has never seen the adult flies. He was not practising the use of any baits or insecticide to control the maggots.

RUBBER & VANILLA In rubber the latex from the stem is chiselled out and collected in coconut shells and later used for rubber sheet preparation. After collecting the latex from 10 to 12 trees he obtains about 500 to 750 g of milk and this is used for preparing a single sheet which fetches about Rs 30 to 40 in the market - this is very low when compared to the previous price of 70 to 80 and so he wishes to grow vanilla, which is fetching better market value and climatic conditions are suitable for growing.

GOURDS & FRUIT FLIES He also grows vegetables in a small area. He raises snakegourd, bittergourd and coccinia. The fruit fly infestation is severe in some cases for which they spray insecticides. We advised them to set up traps. We also explained them different cultural methods

#M007 DATE:08/03/04 TEAM: JR/MS Village Thannimoodu. A central government servant who had his 20 years of service in the Supreme court, New Delhi, and obtained a voluntary retirement from the service and now engaged in farming and allied activities in the field. He considers that farming provides him mental satisfaction and keeps him in good health. He had a severe back pain problem and had to spend a lot of money for treatment and so he obtained a voluntary retirement from the service. His wife is employed as a school teacher and his only daughter doing primary education. The produce obtained is sold to the near by markets. He employs about 5 or 6 labourers in the field daily and the scheduled time of work will be between 8am to 2pm @130/day or between 8am to 4 pm @140/day.

CROPS The main crops grown include rubber, banana, coconut, tapioca, and vegetables like cowpea, chilli, bhindi, and snake gourd and amaranthus.

PEST MANAGEMENT He is not aware of using any kind of traps in his field, only thing they do is spraying the chemicals in the field as it may ward off the pest suddenly.

RUBBER CULTIVATION He is having a good command in growing rubber and major part of his income is earned from the rubber sheet sold to the market. Depending on the grade of his rubber sheet (either A or B grade) which is mainly connected with the type of

smoking and contamination in the latex he may fetch a fixed price for his commodity in the market. Rubber sheet preparation is by using rubber latex along with a coagulant namely formic acid or acetic acid. In the early morning he collects latex from different coconut shells and pours it in the tray. Usually he gives a rest period for tapping when the drought is very severe or when there is heavy rainfall. He is practising inter cropping in rubber plantation with pineapple and later on in the season with calapagonium.

BANANA PESTS & CONTROL Main problem in the banana field was attack by pseudostem weevil followed by rhizome weevil and bunchy top of banana. He is practising use of furadan granules in the leaf axils at various stages of the crop but only he found temporary control and so we recommended the use of chlorpyriphos 2ml/l in the leaf axil. In tapioca spirally white fly incidence was more.

#M008 DATE:08/03/04 TEAM: JR/MS Village Thanimoodu. A farmer who is doing farming operation along with his job as a horoscoper. He also does pooja in nearby temple (early morning and evening).

CHANGING FARM PHILOSOPHY He gives more importance in cultivating different crops, also aware of the importance of organic farming and engages labourers for various operations in the field. According to him the sincerity of newer generation towards farming has lessened nowadays and all are trying to purchase the commodities from the market. The size of holding of each farmer has also declined thereby reducing the possibility of mechanization in the field and hence accounting more for labour cost.

CROPS Crops grown by him include coconut, banana, rice, tapioca, cowpea, vegetables like amaranthus, bhindi and snakegourd..

RICE & PESTS Rice is grown in area of 3 acres. For pest management mainly resort to pesticides like ekalux, malathion etc. Rice leaf roller, case worm, thrips are of common occurrence.

FARMER PROGRESS Farmers are not at all aware of Integrated management practices like use of Trichogramma cards, use of pheromone traps and biocontrol agents. They are not aware of biofertiliser except vermicompost that also they are not practising it.

BANANA PESTS Banana crop mainly suffers from the attack of pseudostem weevil, rhizome weevils etc. They use only the application of furadan granules. We advised them to pour chlorpyrifos solution in their leaf axils.

FRUIT FLY MANAGEMENT Snake gourd is grown in wide area. Fruit flies are seen as a major pest of the time. We told them to dispose the fruit either in water or deep in to he soil so as to prevent the emergence of adult flies after pupation. We also advised them to use different bait traps using banana and tulsi (ocimum), jaggery etc. We set up methyl eugenol and cue lure traps in their field.

GOURD PESTS Koval Coccinia is grown in sufficiently large area as it fetches good market value. Recently bittergourd is facing some problems. Virus, mite and hopper together caused serious situation in bittergourd. Coccinia is facing fruitfly infestation and gall attack.

COWPEA PESTS Cow pea is affected by pod borers. Farmers are spraying monocrotophos for their management.

AMARANTHUS PESTS Amarathus is affected by Colletotrichum leaf spot for the management of which they are spraying cowdung slurry along with fungicides.

#M009 DATE:08/03/04 TEAM: JR/MS Village Karipooru. He cultivates crops both in owned and leased lands. An outstanding farmer. He owns a shop in Nedumancaud town where he

sells his own produce.

CROPS He grows almost all vegetables like bittergourd, snakegourd, little gourd, cucumber and pumpkin. Amaranthus cultivation is found to be profitable. They use seeds of their farm only for next crop. He has vegetable shop in town where he sells the produce from his own farm.

CUCURBIT PROBLEMS This time untimely heavy rain has ruined his cucumber crop.

FRUIT FLY & CONTROL In his field we could see the fruit fly infestation in pumpkin and cucumber. They are not using any bait traps for fruitfly control. They are simply resorting to spraying insecticides like malathion, monocrotophos, rogor, etc.

BANANA CROP Banana cultivation is practised in large area in leased land. Mainly they grow Nedran, robusta, red banana, etc.

GOURD ADVANTAGES They grow crops based on market demand. Recently little gourd is fetching better market price. Moreover it is rather free of heavy infestation by insect pests. The medicinal property of little gourd also is another factor.

CROP ROTATION Normally farmers follows crop rotation. They raise cowpea after bittergourd.

CULTURE & MARKETS They grow vegetables and banana so that the harvest of this may coincide with onam season. Onam is the festival season. Presenting banana bunches (Kazchakkula) was an old custom. However a lot of vegetables and banana are required now during onam since all rich and poor prepare sadya (vegetarian feast) during the four day long onam celebrations and farmers fetch better market value for their produce. Similarly during vishu farmers raise cucumber (cucumber is one of the important items in Vishukkani). Vishu means the coming of new year according to Malayalam (language of Kerala) calendar. It falls in April. It is an auspicious occasion. In the early morning on vishu day people wish to see vishukkani which is arranged as a collection of fresh fruits and vegetables, gold and silver, all arranged in front of the idol of deity and traditional lamp.

#M010 DATE:20/10/04 TEAM: JR/BN/JMS This is the evaluation of the village-level wide-area application. It was carried out largely by the local cooperative, which is small and village-based and run by a clearly dynamic, bespectacled individual who we talk to in his little office. He is clearly very busy and in a hurry and gives little attention to the discussion. The experiment has been most useful and the villagers are hoping to introduce it as a regular activity of the cooperative.

@~B - BHUBANESWAR {In this part of Orissa some villages have specialized in the production of one or two vegetables. Over the years a large contiguous area of the villages were brought under the cultivation of a single vegetable with some other crop supporting the rotation for supplementing the income. In case of bitter gourd also a few villages have specialized exclusively for its cultivation in a large compact areas. These areas have developed well defined markets and they their produce cater to the exact specifications of demand from consumers there. It is grown as summer crop (Jan-June) as well as winter crop(Sep - March) in Coastal Orissa. It was noted that bitter gourd cultivation started 50 years back by now has become the most important cash crop. The area comes under coastal climate having annual rainfall of 1500mm concentrated from mid June to September. Villages where interview conducted are 15 KM away from city head quarter along the national highway.}

#B001 DATE:04/03/03 TEAM:JMS/HSS/ASK. Village Kumarbasta (host of BAT/MAT trial). 5 acres of bitter gourd.

BITTER GOURD HISTORY 1 Bitter gourd was introduced here from that other village. {It

is grown thanks to an ingenious rustic pandal, made of snapped off stalks of a straight-stemmed bush called Poksuan - the stems can be gathered in the bush and when stuffed into the ground in bunches, splay out about 4 feet above the ground to a bushy top along a series of which climbing gourds can be grown.} It was introduced about 50 years ago, gourd and poksuan together. BG not grown before poksuan was available - a package.

VEGETABLE AREAS AND MARKETS Why are vegetables grown in distinct areas? Water availability, labour availability and access to markets - 3 limiting factors. Do gourd areas run along roads? No - in interiors away from roads. There is less gourds near roads because near roads people can work outside agriculture, in off-farm work; away from the roads people have to farm to live. BG is in fact not very perishable, and can keep. Lorry drivers buy here and take away to quite distant markets - particularly Jarkand (Ranchi). A speciality here near the coasts is winter BG which is possible though too cold inland, so grown here in winter for export inland. The fly comes with higher temperatures.

RIDGE GOURD SEASON Summer - ridge gourd, bindhi, coriander. Seeded in May. This ends at end of July, August preparation for BG back again; sowing BG in first week in October. After the summer crop they rest for 15-20 days. {Elsewhere: BG is planted in mid-August, fruits from October-Nov; some confusion here, perhaps as a three-man translation chain JS (English) - HS (Hindi) - AK (Oriya)}.

PRICES OF BITTER & RIDGE GOURDS Economically, is BG more important than the summer crops, or the same? BG yields more and raises more money than summer crops. Quite a bit more, apparently. BG price is better than ridge gourd because exported - summer ridge gourd goes only to Bhubaneswar, where the market floods with it and the price falls.

RIDGE GOURD PRICE FLUCTUATIONS RG in Bhubaneswar market - In the early season the price is high, then it falls and rises again. So production tends to rise smoothly through the season; but fly infestation starts off low and then surges relatively sharply towards the end; so the production of uninfested fruit rises then tails off a bit when infestation takes hold; so price is an inverse of uninfested production - initially high, then dipping then recovering.

INSECTICIDE ON BITTER GOURD He does a weekly spray of insecticide. Last sprayed 6 days ago {i.e. Feb 26th?}. The whole field. Throughout the whole BG season. The spray interval increases from 6 days to 10-12 at the end. Why? Aphids become less; leaf curl becomes less; production goes down as plants age. {Therefore production dip at season-end not necessarily due to pests? - To be sure we'ld need to know if discarded fruit production also rises.}

INSECTICIDE IN SUMMER {There are 11 farmers by now, all of us sat companionably cross-legged in a network of low bushy tunnels under the Poksuan pandal. It is surprisingly dark.} Is insecticide used on the summer crops too? Yes, but less. Why less? Pest attack is less because it's so hot. "Not even a dog can survive so how can an insect?" If it rains, FF gets worse.

NEEM Neem is very smelly; consumers hate it so it needs a preharvest interval.

FRUIT FLY What is done about FF? Nothing because he doesn't know about FF as such. He knew of the damage and loss, but had not even seen the maggots until we pointed them out. He followed us about and saw the difference in losses in our experimentally-treated BAT plots when we pointed them out. Symptom for farmers is simply "discarded" but he can see that our treatments reduced it. One young farmer (Farmer 2) speaks up that he knows about FF. How so? Five years ago. He opened the fruit and saw the grubs inside. Not taught by extensionists. He can identify the maggots only - not adults - but he does know that insecticide sprays don't control

it. When JS mimes a jumping FF maggot with his hand, the first farmer and the generality of the company laugh with apparent recognition - this aspect is apparently familiar.

BITTER GOURD HISTORY 2 Farmer 2 says FF got worse about 5 years ago. Why? This was when he started growing BG. What did he grow before BG? Nothing in that plot. So why BG? He saw how others were making money from BG. BG always makes money, even when pests attack.

BITTER GOURD CONSUMPTION AT HOME Do the BG growers eat large amounts of BG? Not really, once a week - it's a vegetable like any other. But they do store it from the season, sliced and dried. It's eaten once a week both fresh and dry. Is any use made of its alleged medical properties? Not for them. {Prescribed in Ayurvedic medicine for diabetes, but it's the leaf, not the fruit.} Yes, says someone else. Sabji (Sag) is made from tender leaves and used against diabetes. The oldest man nods vigorously. Tender leaves are dried, ground to powder and kept in a jar. Then eaten for breakfast as a general tonic. The old man says he likes the leaves and would eat them anyway. Do they taste bitter? Yes. Does everybody eat them? Yes.

HISTORY OF PESTICIDES For how long have sprays been used? For ever, as far as these relatively young farmers are concerned - they can't remember a time without sprays. But earlier on the spray frequency was less. Now it's increasing day-by-day. It was monthly, now weekly. How long ago was it monthly? 5 years. So pest infestation has gone up. Why? Because the area under BG has increased a lot {quite a sophisticated answer without any prompting from us}. The insecticide most used is dimethoate. Less good than it was. Not banned - it was and still is common. Methomil has been banned. A shame. "The strongest pesticide." Most commonly used is a mix of fungicide (Barestin {?}), insecticide (endosulfan/thiodan, or rogor or dimethoate) and plant manure. Dimethoate is getting worse. Is endosulfan also getting worse? No - dimethoate was much the best, but has now got worse and is on a par with endosulfan.

PEST CONTROL ADVICE Insecticide comes from the city (Bhubaneswar). Advice comes from the shopkeeper. They take in BG to sell, say "What is this?" and follow the advice.

FRESH SEED AND DISEASES What will reduce pest infestation? Fresh seed: they now reseed their own seed and think this is tired and so pests get worse, because tired seed allows pest to develop resistance to pesticide. (On discussing more closely:-) mosaic virus a problem on the increase round here, and this is where tired seed helps. Leaf curl is rampant and so they spray pesticide like anything.

VILLAGE COMPETITION This village gets BG yields much bigger than the next village. 50 quintals/day. The other village takes less care. We learnt the technology from the next village but now we are better than them. JS: Oh ho - we'll ask them and see if they agree. "Oh they will."

PRIORITIES Interested in two problems - leaf curl and FF.

#B002 DATE:04/03 TEAM:HSS/ASK. Village Pitapalli. The total farm area is around 8 acres. The farm has to feed six family members. For 12 months in a year, farm harvest feeds the family, as the family does not works outside farm.

CROPS On his 8 acres he grows Bitter gourd crop (1 acre), Cucumber crop (0.5 acre), Ridge gourd crop (0.7 acre) and Paddy (6.0 acre)

CULTIVATION HISTORY His family has been cultivating Paddy (100 years), Bitter gourd (30 years), Cucumber (10 years) and Ridge gourd (7 years).

CHOICE OF BITTER GOURD VARIETIES He goes for the cultivation of local variety of bitter gourd, which yields low but good market price and marketing network.

Cultivation of hybrid bitter gourd creates marketing problem, as demand in the nearby local market is less due to bigger in size. Middleman do not prefer hybrid for transportation to other states.

MAJOR PEST PROBLEMS IN BITTER GOURD Semi-looper, locally known as Ghoda Poko (larva moves like a horse=Ghoda), is the main problem in bitter gourd crop, which destroys the entire plants, as a result plants die. Other insects like fruit fly & epilachna beetle cause less damage to bitter gourd crop. Semilooper became problem since last 6 to 7 years and cannot be controlled by spraying of any pesticides. Among diseases, leaf blight (burning of leaves) is main problem. This year fruiting period in case of bitter gourd crop was very short i.e. only from mid December to mid February due to crop damage by leaf blight. This year in case of bitter gourd crop, semi-looper (ghoda poko) caused serious damage as a result, the plant became severely defoliated & fruiting period shortened for which yield per acre became very reduced compared to the previous year.

MAJOR PEST PROBLEMS IN CUCUMBER In cucumber crop, leaf blight, yellow mosaic virus diseases are the main problem. In cucumber Epilachna beetle and leaf blight cause damage.

MAJOR PEST PROBLEMS IN RIDGE GOURD In ridge gourd crop, epilachna beetle, which he calls Haldia Poko (turmeric=Haldia=yellow), is the main problem. Epilachna Beetle causes damage to bitter gourd and ridge gourd since last 5 to 6 years & by now it is a main problem for ridge gourd crop. Epilachna beetle and mites are the main problems in Ridge gourd. Blight also causes loss in this crop (ridge gourd).

DISEASE Leaf blight disease causes a main problem for bitter gourd, cucumber & ridge gourd crop as a result plants wither & fruiting does not occur. Blight disease became a problem since last 10 years.

FRUIT FLY PROBLEMS IN BITTER GOURD, RIDGE GOURD & CUCUMBER He thinks Bitter gourd, Cucumber & Ridge gourd are the host crop of fruit fly. He cultivates fruit fly host crops because they fetch more profit compared to other crops per unit area. Intercultural operations are in these crops are also easy. The strong reason is good marketing facility. Farmer was not aware about fruit fly. He comes to know about the fly only after interaction with team. When explained he immediately identifies the nature of damage of fly. He said that this pest (fly) causes damage to the crop to very less extent (he assumes). Farmer is not aware about the damage of fruit fly in ridge gourd. After knowing the damage by the fruit fly he explains that a foul smell comes out of fruit as a result, fruits are not used for consumption purpose. Farmer was not aware about the fruit fly (but damage) & for first time he has seen this pest in his bitter gourd crop. It differs from other pest in the sense that its larvae seen white in colour and inside the fruit the flesh is rotten with a foul smell. Fruit fly are not so bad in the sense that its extent of damage to the bitter gourd crop is very less i.e. 5 to 6% only. Fruit Flies cause 2 to 3, 5 and 4 to 5 % damage to Bitter gourd, Ridge gourd and Cucumber, respectively.

ONSET OF FRUIT FLY ATTACK In case of bitter gourd crop, fruit fly attack develops during the last part of the cropping season i.e. in the month of March. It happens in the month of March because of rise in temperature. By his average knowledge, fruit fly infestation is not same in every year.

PESTICIDE USE He sprays pesticides like Dimethoate ("Roger") & Endosulfan at weekly interval in bitter gourd crop for the last 5 years. He came to know about pesticide application after coming in the contact pesticide with shop keeper 5 years back. Spraying of pesticides like endosulfan, monocrotophos does not has much impact for controlling the semi-looper pest. Though leaf blight was a problem for this year in case of bitter gourd crop, spraying of Mancozeb controlled the disease. This pest (fruit fly) was not controlled by spraying of any pesticides at all (sprayed for

other pests).

RICE AND ITS PESTS In rice, stem borer, brown plant hopper, gall midge are the main insects causing damage to the crop in greater extent. Diseases like bacterial leaf blight, sheath blight and gundhi bug were also reported. This is an important crop in the sense that it provides food round the year. Being high rain fall area rice is the most suited crop in the rainy season.

#B003 DATE:04/03 TEAM:HSS/ASK. Village Pitapalli. He has farm area of about 10 acres land and farm has to fed 8 family members for about twelve months in the year as the farm family is not doing any another job outside farm.

PRODUCTION HISTORY He grows Paddy, Bitter gourd, Cucumber, & Ridge gourd. Most Important Crop for the family is Bitter gourd. In his family, paddy is grown since more than 100 years, bitter gourd 30 years cucumber, 10 years and ridge gourd since 10-12 years.

BITTER GOURD CULTIVATION HISTORY Farmer started Bitter gourd cultivation for first time in his villages. He brought cultivation aspects & seeds from nearby village Kumarbasta. The farmer thought first time whether the crop will success or not & will it be profitable or not. It performed very well, fruiting was very good with very less pest attack. Bitter gourd cultivation became popular because the crop was more profitable than other crops & all the farmers of their village started bitter gourd cultivation Relative to the other crops grown round here, its great advantages are the crop is more profitable because of good marketing facility. Disadvantages are staking problem, Spraying problem, Irrigation problem, Semilooper pest problem.

BITTER GOURD PESTS Bitter gourd is attacked by Semilooper, Epilachna beetle, and fruit fly but most serious is Semi looper known as Ghoda poko. Semi looper became problem in bitter gourd crop since last 5 to 6 years. This pest affects when fruit is bigger in size i.e. at the harvest stage. It cuts the edges of leaf lamina and bores into fruits in case of bitter gourd crop. This pest caused highest damage in this year in bitter gourd crop as a result fruiting was very less.

RIDGE GOURD PESTS In Ridge gourd Epilachna Beetle is a problem. Epilachna Beetle is a problem in case of ridge gourd crop since last 4 to 5 years. Beetles feed voraciously on leaf & flowers and make irregular patches. Its attack results low fruiting in the plant.

CUCUMBER PESTS In cucumber Semilooper damages.

FRUIT FLY AS A PEST Fruit Flies cause damage to Bitter gourd - 2-3 %, Ridge gourd-4 to 5 % and Cucumber-5%. Fruit fly is causing damage since 4 to 5 years. Farmer comes to know the first time from us about the nature of damage caused by fruit fly, its infestation & its identification.

SERIOUSNESS OF FRUIT FLY ATTACK Relative to the other pests, around here, fruit fly can be particularly bad in the sense that infestation cannot be identified easily. It is bad because fruit fly infested fruits become unfit for consumption. It differs from other pests from their damage symptom because in better gourd crop its infestation can not be noticed from fruit surface, fruits start rotting & fall off from plants .

FRUIT FLY ATTACK DEVELOPMENT When an attack develops and why it happens farmer does not know. Its development is noticed during the month of March i.e. last month of harvesting. Prevalence of fruit flies from year to year is not same in every year (he correlates the extent of infestation with climatic condition). Pest attack is seen more when cloudy weather & rainfall is more during the fruiting period.

FRUIT FLY INSECTICIDAL CONTROLS For controlling fruit-flies the farmer did not use any separate measure but he sprays pesticides like endosulfan at weekly interval for other insect pests. Spraying of Endosulfan has been in use since last two years & this was started for the first time by advice from a pesticide shop keeper of Khurda town. When endosulfan used for controlling the pest infestation the farmer thought whether fruit infestation would be checked or not. To his doubt, the infestation was not controlled completely . Now he sprays endosulfan blindly for controlling the pests in the crop.

OTHER FRUIT FLY CONTROLS Farmer did not have any idea about other possible fly control methods & its advantages & disadvantages.

#B004 DATE:04/03 TEAM:HSS/ASK. Village Kumarbasta. 45 years old. There are total 6 of family members, farm of 7 acres. The farm provides livelihood to family member around the year, as family do not do any job outside farm.

CROPS Total farm area is about 7 acres, out of which 5 acres is used for paddy crops and rest 2 acres for vegetable crop. He grows Paddy, Bitter gourd Ridge gourd, and Cucumber.

RICE He grows rice basically for family consumption, however surplus he sells to locals. His family has been growing paddy crop since more than 100 years. Being staple crop rice growing has been a tradition in his family and also in the village. The main advantage of growing rice is that this crop can be grown without using irrigation water rather monsoon's natural rain. He grows rice because it is a staple food for the family and no other crop can be grown in the fields because of high rain fall and water stagnation. Its main disadvantage is that the procurement of paddy by Govt. is not done at all & also the market price becomes too low.

BITTER GOURD He has been growing bitter gourd since last 50 years. His grandfather started for first time when many farmers started the cultivation & got more prices in the local market. Initially he cultivated bitter gourd crop in a small area & gradually the area increased with time. Great advantages of growing bitter gourd is that the crop is more profitable compared to other vegetable & its market is very good. He is not able to grow hybrid bitter gourd because fruits are bigger in size, marketing becomes difficult in local market. Middleman purchases hybrid bitter gourds at low price for transportation to distant markets.

RIDGE GOURD Ridge gourd is grown from June to September after the harvest of the bitter gourd crop & he has been growing this crop since last 20 to 30 years. He started its cultivation by seeing the other farmers. Cultivation of ridge gourd is beneficial because it is marketed locally. The main advantages are that the insect pest attack is very less compared to other crops. Main disadvantage of ridge gourd cultivation is that its yield/plant is low & profit is not as high as bitter gourd crop.

RICE PESTS In paddy, rice stem borer, brown plant hopper and gall midge are main insect pests.

BITTER GOURD PESTS In Bitter gourd Epilachna beetle (Haldia poko), semilooper (Ghoda poko) and, fruit fly (Dhada poko) are the problems.

RIDGE GOURD PESTS Ridge gourd suffers from Semi looper, Epilachna beetle, mites and fruit fly.

CUCUMBER PESTS In cucumber Semi looper and fruit fly are the problem.

EPILACHNA Epilachna Beetle became a problem since last 7 to 8 years. It causes damage in bitter gourd crop during flowering & bud initiation stage. Chhua (grubs) and Mai

(mother) feed voraciously on leaf lamina & flower by making irregular patches and holes.

SEMI-LOOPER Semi-looper became main problem since last 4 to 5 years. Caterpillars cut the edges of leaf lamina, fold the leaf & feed within the roll, sometimes the attacked plants totally denuded of the leaves. Larvae also bore into the fruits.

FRUIT FLY Fruit fly is somehow a problem since last 3 to 4 years in bitter gourd. It becomes problem in the sense that larval feed on the pulp of fruits & infested fruits show brown juice oozing out of infested fruits that start rotting, get distorted fall off from plants prematurely. Relative to other pests, it is particularly bad in the sense that it can not be controlled by using of insecticides. This pest causes 3-4%, 4-5% and 2-3%, damage to bitter gourd, ridge gourd and cucumber, respectively. The detailed damage caused by fruit flies were not known to the farmer however he told that severity was noticed in the bitter gourd crop during the month of March i.e. last month of harvesting period. Its extent of damage is not the same in every.

INSECTICIDAL FRUIT FLY CONTROL For controlling fruit flies the farmer used pesticide (sevin) not any poison bait. Cover spraying of is done when the fruit shows some holes on the surface. This has been started with the consultation with local pesticide shopkeeper . When used for the first time, farmer thought whether this pesticide can control or not the symptom. It performed in the sense that it controlled (probably semi looper) to some extent.

OTHER FRUIT FLY CONTROLS Farmer is not aware of other possible means of fly control.

#B005 DATE:04/03 TEAM:HSS/ASK. Village Kumarbasta. The farm area is of about 6 acres for 7 family members. For about twelve months, the farm harvest feed the family. Farm family does not have any other job outside farm.

CROPS He grows paddy, bitter gourd, ridge gourd, brinjal okra and cucumber. From 6 acres 1 acre is meant for bitter gourd crop.

BITTER GOURD HISTORY His ancestors started bitter gourd cultivation before 50 years along with other villagers as an income generation activity. Relative to the other crops grown round here, its great advantages is that this crop gives more profit compared to other vegetable crops & grown by most of the farmers of his villages. Marketing net work for this crop is very good. The main problem is bringing pokasungha woods which is used for pandal preparations. Marketing of hybrid better gourd becomes a problem in the local market.

RIDGE GOURD HISTORY He has been growing Ridge gourd since last 30 after the harvest of bitter gourd crop. Seeds are sown in the month of June. 2 to 3 seeds are sown in one place & irrigation water is given individually to each basin with bucket or mathia. For the first time when his father started the cultivation of this crop he thought whether the crop will success or not. The crop condition was very good with little attack of insect pests. Relative to other crops the great advantages was that marketing is very good for this crop with little problems.

RICE Paddy is attacked by Rice stem borer, Gall midge and Brown plant hopper. This is an important crop as it feeds the family for 12 months.

CUCURBIT PESTS Bitter gourd is infested by Epilachna beetle and semilooper, Ridge gourd by Epilachna beetle, mites, and Cucumber by Semilooper

EPILACHNA Epilachna Beetle is a problem since last 4 to 5 years. It causes mainly damage to bitter gourd & ridge gourd crops during its peak growth & flowering stage. The beetles and grubs feed voraciously on leaf lamina & flowers by making irregular holes and patches. Relative to the other pests round here, it is particularly bad in

the sense that it seriously decreases the yield.

SEMI-LOOPER Semi looper is a problems since last 6 years in bitter gourd, ridge gourd & cucumber crops. It causes damage during the vegetative growth & fruiting stages. The attacked plants are denuded of the leaves. Larvae also bore into the fruits. In this year, semi looper caused serious damage to the bitter gourd crops as a result yield was substantially reduced. Relative to the other pests round here, it is particularly bad because in bitter gourd crop this year because semi looper damage kills the entire plant.

FRUIT FLY Fruit fly does not cause much damage (hardly 2-3%). When attack develops, larvae eat away the internal content of the fruits, as a result the fruit becomes unfit for consumption. Farmer does not know about its development & severity. It is not same in every year, more during the rainy and cloudy weather at the time of fruiting period. It differ from other pests in the sense that fruit fly infested fruits do not show any initial symptoms.

INSECTICIDAL FRUIT FLY CONTROLS For controlling the fruit flies in bitter gourd crop, pesticide spraying is the best and farmer used the pesticides dimethoate. The farmer has not used the poison bait method. This pesticide has been in use since last two years by an advice of the local pesticide shopkeeper situated at Khurda. When used for first time of the pesticide, farmer thought that whether it will control (perhaps all the pests).

OTHER FRUIT FLY CONTROLS About other methods of fly control, farmer does not have idea, so he does not know about its advantages and disadvantages.

#B006 DATE:04/03 TEAM:HSS/ASK. Village Pitapalli. He has 7 family members and the farm provides livelihood to family around the year. Family does not have off farm activity during the year.

CROPS He grows rice, bitter gourd, cucumber but most important crop is bitter gourd. He has got an area of 8 acres. Out of 8 acres he grows bitter gourd on 1 acre.

BITTER GOURD HISTORY He started bitter gourd cultivation 20 years back. He sows 4-5 seed of bitter gourd of local variety and makes pandal by using local wood known as Poksuma. He grows bitter gourd because it is more remunerative among the crops grown here with a good marketing facility. For the first time, he was not sure for the success of crop, cost involved and profitability. The crop performed well, fruiting was good cost of cultivation was sustainable and gave good profit. Bitter gourd is more preferred for cultivation, as it has got good market and better profit in comparison to other crops. The disadvantage is that it needs hard work to prepare the pandal, intercultural operation and irrigation. He cannot grow high yielding bitter gourd variety as it has poor marketing choice. September is the ideal month of bitter gourd sowing.

RICE PESTS His rice is attacked by stem borer, gall midge, sheath blight and gundhi bug.

CUCURBIT PESTS Bitter gourd and cucumber are suffered by Ghoda poko (semilooper), fruit fly, leaf blight and epilachna beetle. The most dreadful pest in bitter gourd crop is Ghoda Poko (semilooper). This has become a major problem since 6 years. Initially it feed on tender leaves because of that most of the foliage get lost. Later on it feeds on foliage as well as on the fruits. On fruits it make scratches and small holes that renders fruits unfit for marketing.

FRUIT FLY Fruit fly is not a major problem. Though its infestation was noticed 3 years back. The damage is caused in the tail part of the crop ie in the month of March. The outer infestation is normally not seen by the farmer later the fruit get

yellow and drop. On opening of the dropped fruits a foul smell comes out and Dhada Poko (white larvae) are seen. It is bad because its damage cannot be seen. The pest can not be controlled by spraying of insecticides. Infested fruits become useless. Level of damage is not same every year. Fruit fly cause 3-4 % damage to bitter gourd,4-5% in ridge gourd and 6% in cucumber. Farmer does not know why and how the damage of fly develops. He knows that the larvae remain inside but from where they come and where they go he is unaware. He knows the damaged fruits become yellow and stop developing, fall off and give a foul smell. He says the infestation level is same almost every year.

INSECTICIDES Farmer does not apply any specific measure of fruit fly control. Normally he sprays insecticides for the control of other pests but he has observed that fruit fly damage is not reduced by the application of insecticides. He has been using pesticides like endosulfan at weekly intervals. He consulted regarding pesticide application from pesticide dealer in the nearby area.

#B007 DATE:04/03 TEAM:HSS/ASK. Mahendra Badajena, Village Kumarbasta. He and his family is working at bitter gourd field. He is little bit reluctant to talk but his wife insists and he starts responding. He has a farm area of about 12 acres; this feeds family around the year and members do not have any off farm employment in the year.

CROPS He has bitter gourd on 2 of his 12 acres. He has been growing rice, bitter gourd, ridge gourd pumpkin, cucumber and brinjal. The most important crop is bitter gourd for his family for getting cash money. For feeding the family, rice is the important crop.

BITTER GOURD HISTORY He started bitter gourd cultivation 25 years back with a doubt whether the crop will perform well. It did well with good production and least infestation of insect pests. He grows bitter gourd because it fetches good money and has well established marketing infrastructure.

BITTER GOURD PEST PROBLEMS The main problem associated with this crop is that semilooper heavily infests it. The spraying of insecticides is tedious in side the erected pandal structure. Frequent sprays are needed to control the pest.

RIDGE GOURD HISTORY He is growing ridge gourd also after bitter gourd crop in the summer. This crop provides money and less infested by insect pests, however, epilachna beetle and leaf blight cause damage. When he went for ridge gourd he thought whether the crop will perform or not but it did well.

RICE & ITS PESTS In rice crop stem borer, gundhi bug are the major problem.

CUCURBIT PESTS In bitter gourd and ridge gourd semilooper causes severe damage

FRUIT FLIES Fruit fly causes very less damage (2-3% of fruits). Damage occurs in the month of March. The damage of the pest is not seen from outside and therefore it is bad. It will cause great damage if appears in large numbers. He feels lucky that the fruit fly is not a major pest. He does not know how its damage starts but he knows that Dhada Poko (white larva), whom we call fruit fly, are found inside the fruit. It differs from other pests as its damage is not seen from out side and extent of damage remains same even after spraying of insecticides. He has never used any control measure specifically for fruit fly, however he has been using endosulfan and sevin for the control of other insect pests.

#B008 DATE: 22/11/2003 TEAM: HSS/ASK. Village Banamalipur. The farmer has total an area of about 7.0 acres of land. The farm has to feed 7 family members. The farm harvest feeds the family for 12 months in the year and farmer do not do any other job outside farming.

CROPS Paddy, Brinjal, Bitter gourd, Groundnut, Wheat etc. Most important crop is Paddy & Brinjal. Paddy is most important crop because this crop was only grown during kharif season as other crops can not be grown due to excess rainfall during kharif season. Brinjal, Bitter gourd & cluster bean crops are grown during kharif season in the upland areas in small areas compared to paddy crops. Brinjal & bitter gourd crops were grown in upland areas during kharif season, because the crops are harvested during the month of October to December & at that time the market price is very high . During Rabi season, Groundnut & wheat crops are raised with artificial method of irrigation after harvest of the paddy crops.

HISTORY OF BRINJAL. Farmer has been growing the crop since last 20 years.

HISTORY OF BITTER GOURD . The farmer has been growing the bitter gourd crop since last 5 years. Farmer started growing it for higher income compared to other vegetables. Bitter gourd cultivation was not done in large area at that time for which the price was very high. Farmer purchased the bitter gourd seeds from the local market Tangi & started the cultivation with advice from the local Horticulture Dept. people. During the first time cultivation, farmer was not confident for germination, fruit setting and insect pest attack. Crop performed well but not too well because of lower fruit setting but got profit as compared to the investment made in cultivation. Relative to the other crops grown round here, its great advantages is that, the profit is more compared to other crops per unit area and its good marketability. About its disadvantages, is preparing pandals.

HISTORY OF GROUNDNUT. The crop is grown since last 10 years in Rabi season after harvest of the paddy crop at 2 to 3 years interval. Taking the seeds from Govt. Agriculture Department farmer started this crop.

HISTORY OF WHEAT. The crop is grown since last 15 years after harvest of the paddy crop during Rabi season. Taking the seeds from Govt. Agriculture Department farmer started this crop.

PESTS OF CROPS Paddy Brown plant hopper, stem borer Brinjal Fruit & shoot borer Bitter gourd Semi looper, fruit fly

FRUIT FLY DAMAGE Fruit fly causes problem in the bitter gourd crop & this pest was noticed last two to three years back. This pest was noticed during the fruit maturity stage. One spot was noticed on the outer surface of the bitter gourd & sometimes a hole was also noticed whenever fruits were broken, small white coloured insects (larvae) were seen inside the damaged fruits. Spraying of any pesticides did not control this pest. This pest was not noticed during the first time cultivation & was seen last from last two years. Relative to the other pests round there, this pest makes particularly bad because by this attack entire fruits were damaged during the last part of the crop & not controlled by spraying of pesticides.

FRUIT FLIES They cause loss to the bitter gourd to the tune of 2.5% This pest is very bad because of its natures of damage ie, insect was found inside the fruits and some times 5 to 8 nos. of insects (larvae) was observed & these fruits were not marketed at all by the customers. Farmer told that its development was started after the fruit maturity stage & was peak during the last part of the crop. This pest was observed since last two years & before that the pest problem was not so serious. This pest differs from other pests in the sense that it does not cause much damage to the fruits & this pest causes damage inside the fruits.

FRUIT FLY CONTROL Farmer knows pesticide spraying against fruit flies & mostly he sprayed the pesticide like endosulfan & Rogor. Spraying of chemical pesticide ie, endosulfan & Rogor. The farmer have been using this method since last two years by an advice from the local Horticulture Dept. Actually farmer does not sprayed this pesticides specially for fruit fly but as a broad spectrum method for all the pests

including semilooper because fruit fly does not cause much damage to the crop. For the first time used this pesticide, farmer thought about its extent of control. In farmer's view, it performed not so well but controlled to some extent. Farmer does not know much about the other possible fly control methods.

#B009 DATE: 6/11/2003 TEAM: HSS/ASK. Village Sindhiba. 40 years old. The total farm area is about of 2.5 acres. The farm feeds for eight family members. The farm harvest fed the family for about six months and besides thus the farmer was doing the labour works in his villages in Govt. E.A.A. & other works.

CROPS Orange, Lemon, Turmeric, Pineapple, Paddy. Of his 2.5 acres area orange, pineapple & turmeric crops were cultivated in 2 acre area & paddy, ragi crops are grown in rest half acre area. Pineapple & turmeric crops are intercropped with orange trees & paddy & ragi were grows in lowland & upland respectively farmer also practised the shifting cultivation for millet & Kandoola pulse. Most important crop: Orange, Pineapple, Turmeric. Farmer was growing mostly orange, pineapple & turmeric because of land topography & hilly areas. The crops were raised without use of any fertilizer pesticides & artificial irrigation & marketing of the following above mentioned crops were very easy and farmer gets good return from the crop. Pineapple & turmeric crops are inter cropped with the orange crops.

CROP: ORANGE Farmer has been growing since last 15 years. Farmer had started to grow this crop by taking the seedlings of orange from the Horticulture dept. of Orissa Government. He got the seedlings from the Govt. scheme (under Integrated tribal development agency) by an advice of the district Horticulture Department people. Farmer thought that whether this crop sustained or not in this hilly areas with high altitude & rocky soil. Also simultaneously he thought about the success of the crop in future 7 particularly about the fruit fly matter and sweetness taste. This crop performed very well and fruiting started after five years of planting and now on an average 100 fruits were obtained from each plant.

ORANGE ADVANTAGES Relative to the other crops grown round there, its great advantages is that, this crops requires much less care & farmer does not used any type of fertilizer & pesticides to the crops. By natural means and monsoon rains the fruiting was happened in the trees. Second advantage is that the marketability of the fruits were very easy because the traders from the nearby areas like Berhampur, Cuttack & Bhubaneswar were came to their villages and products were purchased from their farm itself with a price of Rs.2/ per orange. Also the OMFED, Govt. of Orissa also purchased from their farm itself for squash purposes.

ORANGE DISADVANTAGES The main problems is now occurring as prematurely fruit drop off from the plants & immediately rotten the fruits on the soil surface itself. Sometimes matured & ripened fruits were drop off from the plants & rotten itself ground level. This problem was noticed since last two years & during this current year, this problem was noticed in very acute manner ie, fruits were even dropped from the trees up to 50 to 75 %.

ORANGE PESTS I) Fruit sucking moth. II) Bark eating caterpillar. Most serious pest is fruit sucking moth.

FRUIT SUCKING MOTH This pest is becoming a problem to the orange crop since last year but it causes much damage to the fruits during this current year. During fruiting stage, the fruits were dropped off from the plants itself prematurely & also matured fruits & rotten the fruits itself. The farmer told us that he observed one radish brown colour flies were sits on the outer surface of the fruits & that particular fruits were failed down after some days & afterward rotten starts. He also noticed one dark coloured patches on the fruits outer surface. Relative to the other pests round there, it was particularly bad because of its nature of damage i.e. fruits were fall off from the plants & rotten before maturity stage for which farmer faces huge

loss. One myth was prevalent among the farmer in that village that this type of damage was mainly due to some type of flies & may be the fruit fly

FRUIT FLY Farmer totally not aware about the fruit fly & after discussion with us, he told that yes, this pest was found inside the mango & guava during ripening stage but he never seen this pest.

FRUIT FLY CONTROL Farmer also not know about any control methods used against fruit flies and he knows for the first time from us about the damage caused by fruit flies in the fruits & nature of damage to the different fruit crops.

#B010 06/10/2003 TEAM:HSS/ASK. Village: Sindhiba. The total farm area is of around 2 acre land. The farm had to fed for the total three nos. of family members. The farm harvest was fed the family for only eight months & for rest six month he was doing labour works at outside areas.

CROPS Orange, Lemon, Turmeric, Pineapple, Paddy, Ragu, and Maize. Most important crop: (I) Pineapple (ii) Turmeric (iii) Orange. Of the 2 acres he mainly grows orange, lemon, pineapple & turmeric in 1.5 acres & paddy, ragi & maize in another 0.5 acres.

CROP: ORANGE Orange (Around 150 plants) farmer was growing the crops, orange since last 12 years. Farmer was growing the crops for first time by taking g the seedlings from the horticulture, deptt. of Orissa government farmer was grown the crops by the advice from the staffs of horticulture department, Orissa govt. He started to grown the crops for more income from his hilly lands where the other crops could not be successfully grown due to highly and rocky soils. Farmers was doing the practice of shifting cultivation in his village also. He thought that whether the seedlings of orange were grown properly or not in his areas because of extreme cold and situated in High altitude area of hilly areas and of without assured irrigation during summer months. The fruiting was happened after 6 years from planting and good fruit setting was noticed from that time to at present. At present around 150 to 200 fruits were native per plant.

ORANGE ADVANTAGES Relative to the other crops grown round here its great advantage was that; more profit was got the farmers without doing any expenditure like fertilizer, pesticide and irrigation to the crops. Farmer sold the fruit. @ Rs.2.00 per fruits to the traders came from Berhampur areas and got around Rs.300.00 to Rs.400.00 per tree per annum. The other advantage is that besides the traders farmer also sold his fruits to the omfed dept. Govt of Orissa who took the fruits from the farmers from his village for preparation of squash. So marketing was very easy to the farmer because at that time oranges were not available in the Orissa.

ORANGE DISADVANTAGES The disadvantages/problems was appeared from last year onwards and became more acute in this year. The problem was that fruits were dropped off from the plants before maturity & rotten on the ground level very quickly. Last year the problem was about less to some extent but in this year about 50 to 60% of fruits were dropped off prematurely causing heavy loss to the farmer for this loss, his income was much reduced to around half before last years from orange crop.

ORANGE PESTS Farmer was told that only fruit drop prematurely from the plant was only the problem & not any pest attacked to the other crops like lemon, pineapple, turmeric, paddy, ragi & maize.

PEST: FRUIT SUCKING MOTH. in orange crop: Farmer was told us that one flies of red colour were sits on the upper surface of the fruits & after that fruits were drop off prematurely & a hole was noticed on the fruits. Farmer thought that this flies was perhaps cause this types of damage and one myth was happened in his village was that the red colour flies were sits on the upper surface of fruits & responsible for fall

off prematurely from plants. Thus problem was noticed since last one year but last year that was not so much like on this year. In this current season, about 50 to 60 % of fruits were dropped off prematurely from the plants & rotten immediately at ground level after dropped off from the plant . This type of damage was found during the fruiting stage i.e. from mid September to November end & max. was noticed during the October month. Farmer told us that except thus pest, other pests were not attacked to this crop. Farmer also told that this type of problem was not noticed in Najeera & Mosambi (one variety of sour orange). This pests was particularly very bad because, during harvesting stage, fruits were dropped off from the plants as a result a great loss was suffered by him.

PEST: FRUIT FLY. Fruit flies not causes damages to the fruits on the plant itself & some fruitfly larvae was noticed on the fallen fruits under the trees at ground level. It seems that adult female fruit flies lays eggs after fruits drop off from the plants. Trap catching was also not noticed in that villages. Farmer does not any ideas regarding the fruit fly & its damages to the crops.

FRUIT FLY CONTROLS. Farmer does not known about any control measures to be used against fruit flies.

#B011 3/9/2003 TEAM:HSS/ASK. Village: Champajhar. The total farm area is of 5.0 acres land. The farm had to fed for about seven nos. of family members. The farm harvest fed the family for total of twelve months in the year and farmer's wife doing official job in the state Govt. The farmer has not doing any job outside farming for some months.

CROPS Paddy, Brinjal, Mango (6 trees of Totapuri variety). Farmers grown all these three crops. Of the 5 acres all the areas were under paddy crop during kharif season & around 0.20 acre land is under vegetable cultivation during rabi season

CROP: PADDY Farmer's grown the paddy crop since last 25 years & before that his father & grandfather started the growing of paddy crop in smaller area. relative to the other crops grown round there, the great advantage for paddy cultivation was that this is the only crop that is successfully grown during kharif season because of monsoon rains & all the farmer's of the village were raised the paddy crop during kharif season & some farmers were grown paddy during rabi season with the help of a dug well in lowland areas.

CROP: BRINJAL The crop has been grown by farmer since last 15 years during rabi season with the help of dug well. This crop was started for the first time before 15 years because of greater income from small area during rabi season. In that year the crop was performed well but yield was not up to the mark. Relative to other crops grown round here, its great advantages that its marketing was very easy & much profit making also.

CROPS & PESTS On Paddy: Gall midge, Rice case worm, Gundhi bug. On Brinjal: Fruit & shoot borer, stem borer, wilting. On Mango: Fruit fly, hopper.

PEST: FRUIT FLY It has been a problem in mango since last 3 to 4 years. This pest problem was first noticed during last four years back for the first time when the matured fruits were remained as such in the mango tree for natural ripening. It becomes a problem because the total fruits was damaged and cannot used as it for consumption purpose. Relative to the other pests round here, it is particularly bad because it damages the entire fruits during ripening stage and was not controlled by spraying of pesticides. The loss caused by the fruit flies to the mango crop is to be around 30-40%. The attack was first noticed on the fruit by a small scratch mark (a tiny hole) & after ripening when the fruits were cut into pieces was noticed. It is as bad as it is because as a good fruit finally becomes totally when the fruit is in matured condition & going to be ripening . It is not same in every year in farmer's

mango tree because he told that in this current year, the fruit fly problem was of too high compared to last year. It differ from other pests in the way that its larvae was damaged the fruits during ripening stage.

FRUIT FLY CONTROL Farmer's did not know any things that can be used against fruit flies.

#B012 13/5/3 TEAM:HSS/ASK. Village: pitapalli; Age 30 years. The total farm area is of about 6 Acres of land. The farm had to fed for the total of 7 numbers of family members and farm harvest fed the family for all twelve months in the year and he does not done any job out side farming for some months. His education level is 'Under matric'. Annual income from all sources= Rs.4000.00.

CROPS Paddy, bitter gourd, snake gourd. Farmer cultivated bitter gourd in 1-acre area.

CROP: PADDY The crop has been growing since last 100 years or more. Farmer's grand father has started to grow this crops and continuously it was grown by his ancestors because rice is used as a staple food, its great advantage was that paddy crops was easily during Kharif season from the water. The main problem is for growing paddy crop is that the profit return from the crop was very less.

CROP: BITTER GOURD The crop has been grown since last years, farmer had started to grow the crops by noticing the neighbour farmers getting the profits from crop, during the first time crop raising farmer was thought that whether profit would returned from the crop or rot. In that year, it was not performed well because of poor growth in the crop. Relative ton the other crops its great advantages is that the profit was much more compared to other crops grown at that time.

CROP: SNAKE GOURD The crop has been growing since last 4 years and this crop was grown after the harvest of the bitter gourd crop during rainy season. Its advantage is that this crop was best suited after harvesting bitter gourd crop.

CROPS & PESTS Paddy: Stem borer, Rice case worm. Bitter gourd: Semilooper, Epilachna beetle, fruit fly. Snake gourd: Semilooper.

PEST: STEM BORER It has been a problem since last 20 years or more, farmer noticed that when there is more of rains during kharif season, Stem borer attach is more.

PEST: RICE CASE WORM It has been also a problem since last 15 years.

PEST SEMILOOPER It has been a problem in bitter gourd crops since last5 years /. It became a problem to bitter gourd crop by eating all the leaves and stems resulting total skeletonized the plants as a result death of the plant occur.

PEST: EPILACHNA BEETLE It has been a problem in bitter gourd crops since last 6 years. The pest damages the leaves by saucing & ultimately plant dies.

FRUIT FLY It has been a problem in bitter gourd crops since last 4 years. The pest damages the fruits during the harvesting stage. Relative to the other pests round here, it is particularly bad because the pests occurred every year and not controlled by spraying of pesticides.

PESTICIDES Farmer used the following insecticides for controlling different pests in the bitter gourd crops as follows: All are controlled with Endosulfan at the same dose, of 2ml/ltr of water. Application intervals do vary:- Semi looper every 07 days; Epilachna every 15 days; Fruit fly every 07 days. Farmer used the pesticide based on pest observance and he does not use any adhesive during spraying.

PEST: FRUIT FLIES Losses: Bitter gourd 5 to 10 %; Ridge gourd 5 to 6 %; Snake gourd 2 to 3 %. Farmer told that in bitter gourd crop, fruit fly damage was noticed during the last part of the harvesting season was more i.e. during the month of March and April. This is most severe during the mid March to April 1st week. The attack is same in every year. It differs from other pests by its nature of damage i.e. larvae bore into the fruits and; the pests was not controlled by spraying of pesticides.

FRUIT FLY CONTROLS Farmer knows only the spraying of chemical pesticides for controlling the fruit fly and he never used any type of poison bait and trap method of controlling the fruit fly. Spraying of chemical pesticide namely (Endosulfan + @ 2ml/litre of water at 7 days interval farmer had used this method since last 3 years. He started to use it by an advice from one pesticide shopkeeper situated at Khurda town. By using this method the pest population was controlled to some extent but not completely. Farmer did not aware about any type of other methods of fly control for which be used only this method for controlling the pest. Overall this method is very good. For controlling fruit fly, farmer's opinion about the best insecticide is Rogor/Hildon. He does not use any adhesive during spraying and he sprayed all the three inner parts in bitter gourd crop. There is a gap of 7 days between crop harvesting and spraying farmer regulated the spraying based on pest observance.

#B013 13/5/3 TEAM:HSS/ASK. Village: Pitapalli. Education: 7th passed. The total farm area is of about 5.0 acres of land. The farm had to fed for the total of 8 nos. of family members. The farm harvest fed the family for 8 months and farmer had another job outside farming for some months. Annual income from all sources: Rs. 50,000.00.

CROPS Farmer has been grown the crops like paddy, bitter gourd, snake gourd, Ridge gourd etc. Most important crop is Bitter gourd - on 0.5-1.0 of the 5 acres.

CROP: PADDY The crop has been growing since last 100 years or more by his father & grand father. Relative to the other crops grown round here, its great advantages is that it is consumed by his family members throughout the year & the disadvantage is far its profit returned from unit area compared to other crops.

CROP: BITTER GOURD The crop has been growing since last 7-8 years. He started to grow the crop by observing the profit getting by other neighbouring farmers from bitter gourd cultivation. During the first time of crop grown farmer thought about whether profit was returned from the bitter gourd cultivation or not and at that time the crop was performed well with some profit. Relative to the other crops grown round here, its great advantage that the crop was growing by most of the farmers during same time for which damage by animals & theft problems does not happened & disadvantage in its marketing for hybrid bitter groud cultivation because of bigger in size.

CROP: BITTER GOURD The crop has been growing since last 4 to 5 years & he started to grow the crop by noticing their neighbour farmers of his village.

CROP: RIDGE GOURD The crop has been growing since last 6 years & he started to grow the crop during rainy season and this is done after the harvest of bitter gourd crop cultivation.

CROPS & PESTS Paddy: B.P.H., Gundhi bug; Bitter gourd: Semilooper, Epilachna beetle & fruit fly; Snake gourd: Semilooper; Ridge gourd: Epilachna beetle

PEST: FRUIT FLY This has been caused problem since last 5 years it damages only fruits during the peak harvesting stage & maximum was noticed during the last part of the harvesting i.e. during the month of march & April. It damages the entire fruits by making a hole & rotten the fruits and drops from the plants. Fruit fly damaged fruits were not marketed properly and even not controlled by spraying of any pesticide. This pest was noticed perhaps every year & controlled to some extent by

pesticide spraying. Relative to the other pests round here , it is particularly bad because by this attack total fruits are damaged & not controlled by pesticide spraying. About its development and severity, farmer only told that the fruits damaged by fruit fly were seen more during end of the fruiting season. I.e., in the month of March 7 April. The damaged caused by fruit fly were same in every year. Fruit fly pest differs from other pests in the sense that this pest was not responsive to spraying of pesticides.

FRUIT FLY CONTROL The farmer was knew only about spraying of chemical pesticides for controlling the pests and he never used any type of poison bait and pheromone traps. Spraying of chemical pesticide against fruit fly were used since last 3 to 4 years. spraying of chemical pesticide was done from the 1st harvesting onwards at weekly interval. This method was adopted for first time by an advice of neighbour farmer. At that time of 1st spraying farmer was thought that whether it was controlled or not. Farmer told that by spraying of pesticides for first time was controlled the fruit fly to some extent. Farmer does not knows about the other possible fly control methods. So he does not knows its advantage and disadvantages. Over all farmer was rated it middling good.

#B014 9/5/3 TEAM: HSS/ASK. Village: Pitapalli. Age: 46. The total land holding is about 5.0 acres area and for total 7 number of family members farm had to fed. The farm harvest fed the family for total 12 months in the year and he does not doing any job outside farming for some months. Education: 5th Class passed. Annual income from all sources: Rs.20,000.00.

CROPS The farmer has been grown the crop like paddy, bitter gourd, ridge & snake gourd. Most important crop: Paddy, Bitter gourd. Bitter gourd area: 1acre of about 5.

CROP: PADDY The crop has been grown since last 80 years back or more by his father & grand father. Relative to the other crops grown round there, its great advantage is that rice is used by their family members as staple food & paddy crop was grown by all the farmer's in his village during kharif season and disadvantage is that the profit from crop is becoming less after deducting total expenditure.

CROP: BITTER GOURD The crop has been grown since last 20 years back & he started to grow the crop by seeing bitter gourd cultivation from Kumarbasta village after discussed with the farmers of Kumarbasta villages. He thought during the first time grew was that whether the performances of crop was good or not but at that time the performance was good up to his expect ion. Relative to the other crops grown round here, its great advantages is that this crop was best suited to him because of their crop rotation done by the villagers in up land areas & profit also higher compared to other vegetables grown at that time & one disadvantage is that marketing is becoming a problem for hybrid bitter gourd because of its bigger size.

CROP: SNAKE GOURD The crop has been grown since last 10 years this has been started because the crop was best suited for crop rotation that to be followed by other farmers of his village i.e., bitter gourd Ridge gourd/ cucumber/ snake gourd type of cropping pattern. For the first time also he thought same thing as bitter gourd cultivation. Its great advantage is that this cultivation was done during rainy season the price for snake gourd is also higher compared to other vegetables & disadvantage is its well marketing.

CROPS & PESTS Paddy: Stem borer, B.P.H. Bitter gourd: Semilooper, epilachna bettle, fruit fly. Snake gourd: [?]

PESTS & PESTICIDE The farmer was using the following pesticides against the pests in bitter gourd crops as follows: Against semilooper, 2gm. Sevin + 2ml. Rogor per ltr of water at 10-day intervals; against epilachna beetle, endosulfan at 2ml/ltr of water every 7 to 10 days; against fruit fly, rogor at 2ml/ltr every 7 days.

PEST: SEMILOOPER Creates problems in bitter gourd crops since last 15 years back. If the pesticide was not sprayed at appropriate time there is total crop loss was also happened. After spraying of pesticide, there was also loss of 20% of foliage 7 25% fruits. Relative to the other pests round here it is particularly bad because this pests damages both foliage & fruits.

PEST: EPILACHNA BEETLE It creates problem to bitter gourd & Ridge gourd crops since last 10 to 12 years. By this attack, the foliage becomes yellow in colour and plant dies if attack is severe.

PEST: FRUIT FLY It has been creates problem since last 5 to 7 years and more damage was noticed from last 3 years onwards. This pest creates problem during the last part of the harvesting season i.e., during the month of March onwards. It damages only fruits 7 by this damage total fruits were damaged & even not used for consumable purpose as a foul smell was coming out from the fruits. Relative to the other pests round here, it is particularly bad in the sense that this problem was cannot over come by spraying of any pesticide and the things about it which are not so bad in the sense that about only 5 to 6 % loss was noticed where as loss due to semilooper pest was of 25 to 30 % even though after pesticide spraying. Fruit flies damage is estimated as 5 to 6% in bitter gourd, aound 10% in ridge gourd. Farmer does not know regarding the causal organism, its etiology & made of attack. It is as bad as it is because this pest was not controlled totally by spraying of pesticide. Farmer could not able to speak about its development and severity. The fruit fly damage is same in every year as per farmers opinion. This pest differ from other pests in the sense that it damages only the fruits but other pests can able to damage both foliage & fruits.

FRUIT FLY CONTROL Farmer knows only spraying of pesticides i.e. chemical method of control was used against fruit flies and he never used the pheromone trap and poison bait method of control. Spraying of pesticides like Rogor/sevin/ endodulfan. This have been used since last 5 to 6 years . This has been used during the harvesting season at weekly interval. Farmer was used this for the first time by an advice this for the first time by an advice of a pesticide shop keeper from Khurda town. During the first time used the pesticide farmer thought that whether the pests was controlled or not by spraying with pesticide. By that time the pest population was controlled to some extent by observing the damaged fruits. Farmer does not aware about the other methods of fly controls except chemical controls. Overall, farmer rated it as very good.

PESTICIDE ON GOURD In the bitter gourd cultivation, farmer sprayed sevin + Rogor @ 1.5gm + 1.5ml at 15 days interval for controlling the semilooper pest. Farmer sprayed all the three inner parts by the knapsack sprayer & he does not used any adhesive maternal during spraying. Farmer stopped spraying prior to harvest before 7 days of harvesting & consume the bitter gourds that are sprayed. The advice regarding pesticide spraying was taken from pesticide dealer.

#B015 9/5/3 TEAM: HSS/ASK. Suresh Pradhan; Village: Pitapalli; Age: 26 years; Bitter gourd area: 0.50 acre; Education: Primary. The total farm area is about 4.0 acre & the farm had to fed the total 7 numbers of family members. The farm harvest fed the family for all the months in a year & he has done another job outsides farming for some months. Annual income from all sources: 15,000.00

CROPS Paddy, Bitter gourd, Ridge Gourd, Greens. Most important crop: Paddy & bitter gourd.

CROP: PADDY Paddy crop has been grown since last one hundred years or more. His grandfather had started to grow the crop since last 100 years or more. Paddy crop has been started since last many years by his grand father and he started to grew the crop because rice is used as staple food and this crop was grown by all the

villagers.

CROP: BITTER GOURD The bitter gourd crop has been grown since last four years and started to grow the crop because of higher profit. He thought whether profit is to be happened or not in bitter gourd cultivation for the first time. It was performed well at that time. Its great advantage is that this is best suited for cropping pattern done by other farmer in his village.

CROP: RIDGE GOURD The crop has been grown since last 10 years and his father had started to grew the crop because of higher profit return compared to other vegetable & it was best suited in crop rotation programme i.e. bitter gourd, ridge gourd, cucumber, snake gourd. For the first time the performance of crop is good relative to the other crops grown round here, its great advantages is that its marketing facility was very good, more profit compared to other vegetables & one disadvantage is that its yield was very low .

CROPS & PESTS Paddy: Stem borer, B.P.H.. Bitter gourd: Semilooper, Epilachna beetle, fruit fly. Ridge gourd: Semi looper, Epilachna beetle.

PEST: STEM BORER This has been creates problems since last 30 years or more & it occurred in paddy crops every year.

PEST: B.P.H. This has been creates problems since last 25 years around & it also occurred in paddy crops every year.

PEST: SEMI-LOOPER This has been create problem since last 2-3 years back and causes heavy damage to crops. It eats away all the foliage & bores the fruits and damages the fruits. This pest causes damage in both bitter gourd & Ridge gourd plants. If pesticide was not sprayed the entire crop was damaged.

PEST: EPILACHNA BEETLE This pest has been creates problem since last 9 years and by this attack, the pests sucks the sap from the leaf surface & leaves become yellow in colour & plant dies if attack is severe.

PEST: FRUIT FLY This pest has been creates problem since last 5 to 6 years. It damages the fruits during harvesting of the crop by making a hole on the fruit surface and its catter pillar damages the fruit by ha inside the fruits. This pest was not controlled by spraying of any type of insecticide. Relative to the other pests round here, it made the crops particularly bad because by fruit fly damage, total fruits were damaged & not controlled by spraying of any type of pesticides. Fruit flies losses - 7 to 8 % in bitter gourd, 4% in ridge gourd. When an attack develops it happens as it does ? For this question farmer could not gave any satisfactory answer. It is as bad as because by fruit fly attack, the total fruits become unsuitable for consumption purposes & not controlled by spraying of any type of pesticide. About its development & severity farmer also could not gave any satisfactory answer. He told that the pest is perhaps to be same in every year. The pests differ from other pests by its damage i.e. a foul smell was coming from the fruits.

FRUIT FLY CONTROL Farmer was only used the spraying of pesticides like sevin & endosulfan for controlling the pest & he does not used pheromone trap and poison bait method of control. Spraying of pesticides like sevin & endosulfan: Farmer have been using it since last 5 years & he started this method of control by an advice of pesticide shop keeper near Khurda town. He started spraying because he noticed that many fruits were damaged by some types of pests but he actually does not knew the name fruit fly and sprayed as a means of any type of pests. Overall, farmer rated it as middling good.

SEMI-LOOPER CONTROL The farmer was using the pesticide like hildan for the control of

semi looper pest bitter gourd at an 7 to 8 or 10 to 15 days interval depending upon the crop condition. By attack of semilooper, around 20 to 25 % of fruits are lost though spraying of pesticide was done. For the control of semilooper, he mostly used the pesticide hildan & result also satisfactory. Farmer does not use any type of adhesive during spraying. Farmer sprayed all the three inner parts & he does not used any traditional method of pest management. He stopped spraying prior to harvest at about 7 days. The gourds that are sprayed with pesticide are not consumed & sold this product to the local marketing agent. Farmer could not give any satisfactory answer regarding the question why the semilooper pest is not getting killed. The shopkeeper of Khurda was advised mainly about plant protection matter to the farmer. Farmer does not use any protection while spraying & he has to faced difficulty schedule based on pest observance.

#B016 DATE: 02/06/04 TEAM: HSS/JMS/AV. Village: Pitapalli {This is the wide-area qualitative post-experiment study. The farmers are playing cards and don't want to come and talk. Could we have a tea ("bhojun") or similar (good idea)? All a bit sleepy. Not very dynamic.}

GOURD PROBLEMS The economy round here revolves around bitter gourd. Heavy rain in 2004 led to seed rotted and the area under bitter gourd was reduced. Everybody wants loans but cannot repay. Not been a good year. Farmers gather evidently a bit reluctantly. Here, but not in the rest of India, people like round gourds, not long ones.

WIDE-AREA CONTROL EFFECTS The infestation of "white insect" (FF) has been less. Last year was much more. It was because of the medicine. The population was very less.

WIDE-AREA CONTROL PROSPECTS It is better, says the farmer, if the whole village is sprayed. Farmers would spray their own fields only, not the whole area. But if the government would spray that would be good. Noone wants to spray "useless areas". If the spray could have been a bit earlier this would have been better. (JS asks how could it have been better when infestation was less than 0.1%?)

COOPERATIVE STRUCTURES Are there any things farmers do cooperatively? Anything done in groups? No - all do independently. What about the wells? No. What about marketing? No need to set up a cooperative when the established network is there & working - middlemen come and buy.

WIDE-AREA CONTROL PROBLEMS Were there any problems with the wide-area application? No - nothing. Somebody told us somebody said the leaf-folder was made worse by it (One farmer has complained that BAT increases population of semilooper). No, not us (emphatic shakes of heads). Were there problems with people in the fields - worries about others coming into people's crops and trampling? No - if people are doing something for us we are happy. Did it cause any harm, e.g. to bees? Some farmers asked about goats and other animals - these were worries. But no negative impact was seen.

INITIAL IMPRESSIONS Were you worried before we started? Yes - before the first time there were worries it might do harm - a new insecticide. Did you know that it was not just an insecticide but bait too? We knew that it was a food.

COORDINATED CONTROL PROSPECTS Apart from the useless areas, would people all treat their own farms at once if they thought it would bring a benefit? A number of factors (1) - not everybody is in the village on the same day; (2) - the sprayers are not owned but hired - very few own sprayers, there are only 3 or 4 in the village. Would the removal of the need for a spray help - e.g. if we could apply with a broom? They couldn't all spray on the same day even if everybody owned a sprayer - the labour needs are too high. Labour. Families all have different priorities, all have different jobs they think more important.

GOURD PESTS The semi-looper is the worst problem (Diaphinia?); 2nd epilachna; FF is 3rd.

FRUIT FLY CONTROLS If protein hydrolysate were sold would anyone buy it? Yes - they would. Even though it is particular and specific and controls nothing else? Yes. Would people make and use a bait of jaggery or banana if were as good? Yes they would. They have no experience of other fruit fly controls - they were not using insecticide or anything else before we came along. Has our control made them realise fruit fly losses may be larger than they thought? They think losses are about 20. They were not doing anything before, but now they will. One farmer was a bitter gourd grower but couldn’t grow them in 2004 because of the rains, but still it worked.

PANCHAYYAT Who installed the pump for the drinking water. Panchayyat. Every village in India has a pump put in by the Panchayyat. Would the Panchayyat do pest control? Probably no.

@~V - VARANASI

#V001 DATE: 05/02/04 TEAM: SR, SS, SPS. Village: Ramna. He has farm area of about 4 bigha and he has to feed 20 family members. The farm family is not doing any other job outside farm.

CROPS He said that he is growing Dolichos, cowpea, bitter gourd and tomato.

BITTER GOURD He said that he is growing this crop since 20 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in July and October. October crop is mostly grown in river beds.

BITTER GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.

PEST CONTROL Leaf curl - Farmers locally call it as 'Gurcha'. He said that this pest is serious when the crop is in initial stage. He sprayed Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre 3 days interval.

FRUIT FLY July-sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V002 DATE: 05/02/04 TEAM: SR, SS, SPS. Village: Ramna. He has farm area of about 3 bigha and he has to feed 12 family members. The farm family is not doing any other job outside farm.

CROPS He said that he is growing bitter gourd, Dolichos and brinjal.

BITTER GOURD He said that he is growing this crop since 20 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in July and October. October crop is mostly grown in river beds.

GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.

PEST CONTROL Leaf curl - Farmers locally call it as 'Gurcha'. He said that this pest is serious when the crop is in initial stage. He sprayed Curacron + Karate + Cypermethrin + growth regulator 150ml/15 litre @ 3 days interval.

FRUIT FLIES July sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V003 DATE: 05/02/04 TEAM: SR, SS, SPS. Village: Ramna. He has farm area of about 9 bigha and he has to feed 5 family members. The farm family is not doing any other job outside farm.

CROPS He said that he is growing bitter gourd and Dolichos.

BITTER GOURD He said that he is growing this crop since 20 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in July and October. October crop is mostly grown in river beds.

BITTER GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.
PEST CONTROL Leaf curl - Farmers locally call it as 'Gurcha'. He said that this pest is serious when the crop is in initial stage. He sprayed Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre 3 days interval.

FRUIT FLIES July sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V004 DATE: 05/02/04 TEAM: SR, SS, SPS. Village: Ramna. He has farm area of about 1 bigha and he has to feed 8 family members. The farm family is not doing any other job outside farm.

CROPS He practised mixed crop of bitter gourd along with muskmelon in October. Besides these crops are raised in river bed mostly having sandy soil. Dolichos bean is also an important vegetable grown in kharif season.

BITTER GOURD He said that he is growing this crop since 20 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in July and October. October crop is mostly grown in river beds.

GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.

PEST CONTROL Leaf curl - Farmers locally call it as 'Gurcha'. He said that this pest is serious when the crop is in initial stage. He sprayed Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre 3 days interval.

FRUIT FLIES July sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V005 DATE: 05/02/04 TEAM: SR, SS, SPS. Village: Ramna. He has farm area of about 6 bigha and he has to feed 7 family members. The farm family is not doing any other job outside farm.

CROPS He practised mixed crop of bitter gourd along with muskmelon in October. Besides these crops are raised in river bed mostly having sandy soil. Dolichos bean is also an important vegetable grown in kharif season.

BITTER GOURD He said that he is growing this crop since 20 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in July and October. October crop is mostly grown in river beds.

BITTER GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.
PEST CONTROL Leaf curl - Farmers locally call it as 'Gurcha'. He said that this pest is serious when the crop is in initial stage. He sprayed Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre 3 days interval.

FRUIT FLIES July sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V006 DATE: 05/02/04 TEAM: SR, SS, SPS. Village: Ramna. He has farm area of about 7.5 bigha and he has to feed 10 family members. The farm family is not doing any other job outside farm.

CROPS He said that he is growing cowpea, okra, bitter gourd and Dolichos.

BITTER GOURD He said that he is growing this crop since 20 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in July and October. October crop is mostly grown in river beds.

BITTER GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.

PEST CONTROL Leaf curl - Farmers locally call it as 'Gurcha'. He said that this pest is serious when the crop is in initial stage. He sprayed Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre 3 days interval.

FRUIT FLIES July sown crop suffers more from fruitfly than the October crop. For controlling fruitflies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V007 DATE: 06/02/04 TEAM: SR, SS, SPS. Village: Ahi. He has farm area of about 7 bigha and he has to feed 20 family members. The farm family is not doing any other job outside farm.

CROPS He said that he is growing bitter gourd, chilli, brinjal and tomato.

BITTER GOURD He said that he is growing this crop since 10 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in June. He got fruit from August to December. He has sown only local variety.

BITTER GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.

LEAF CURL He said that this serious pest when crop is in initial stage. This pest is locally known as Gurcha. He sprayed Tataphen (50 ml/20 lit.) + Dithen M-45 (10 g/20 lit.) + Bavistin (10 g/20 lit.) + Curacron (20 ml/20 lit.) after one week interval.

FRUIT FLY July sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Curacron + Karate + Cypermethrin + growth regulator 150 ml/15 litre at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V008 06/02/04 TEAM: SR, SS, SPS. Village: Ahi. He has farm area of about 4.5 bigha and he has to feed 20 family members. The farm family is not doing any other job outside farm.

CROPS He said that he is growing bitter gourd, chilli and okra.

BITTER GOURD He said that he is growing this crop since 5 years. He adopted by seeing the neighbour crops. He felt bitter gourd is remunerative in local market. He has sown the crop in June. He got fruit from August to December. He sown only local variety.

BITTER GOURD PESTS He experienced that the kharif crop suffers most from leaf curl, jassid and leaf folder/fruit borer (Diaphania indica). The farmer didn't have knowledge about fruitfly as a pest and its infestation.

LEAF CURL He said that this serious pest when crop is in initial stage. This pest is locally known as Gurcha. He sprayed Phankil (100 ml/50 lit.) + Dithen M-45 (100 g/50 lit.) + Biomagic (20 ml/20 lit.) after one week interval.

FRUIT FLY July sown crop suffers more from fruit fly than the October crop. For controlling fruit flies he did not use any separate insecticide but he sprays Phankil (100 ml/50 lit.) + Dithen M-45 (100 g/50 lit.) + Biomagic (20 ml/20 lit.) at 3 days interval. For the first time he started taking advice from a pesticide shopkeeper of Varanasi town.

#V008 14/05/05 TEAM: SR, SS, SPS, JMS. {Evaluation of village-level wide-area experiment.}

WIDE-AREA CONTROL The control worked but the villagers were not very enthusiastic. Perhaps a factor was that gourds are only a smallish percentage of the total surface area of the village.

@~L - LUCKNOW {Survey was conducted in three fruit belts viz. Lucknow- Barabanki -Faizabad (mango) and Kanpur (guava-beside-cucurbits). Survey conducted during different parts of the year 2003 covered ten orchards having area large, medium and small farmers. Mango is the major crop in the land holdings. Vegetable (cucurbits), mustard, pea, gram and fodder also grown in the area which other wise generally used as a passage or remains fallow.}

#L001 DATE: 26/07/03 TEAM: RPS/AM. Village: Gulabkhera. Status: Large/Wealthy Farmer. I only own farm total area five ha. Five members of my family depend on this land and I have no other job outside farming.

CROPS Mango is the main crop. Mustard is also grown in fallow land during winter. Mango is being grown for the last three decades mainly because it is in the periphery of fruit belt. Initially crop performed quite satisfactory. It gives high return if market price is good.

PEST 1 - MANGO HOPPER is the main pest. Its attack started at the time of panicle

initiation stage resulting in heavy losses. Infestation was heavy during this year, so I sprayed cypermethrin @ 0.5 ml/lit. of water.

PEST 2 - MANGO MEALYBUG The second most serious pest causes damage during Jan.-April. Its attack is a regular feature. Folidol dusting around tree trunk with banding by polythene was done.

PEST 3 - FRUIT FLY is a problem only in late maturing varieties causing 30-33% damage. Attack started just before ripening of fruit. Early harvesting of fruits was done.

FRUIT FLY CONTROL Early harvesting plus spray with malathion @ 2 ml/lit. of water was done. Not aware about MAT and BAT technology.

#L002 DATE: 26/07/03 TEAM: RPS/AM. Village: Kanar, Status: Large/Wealthy Farmer. I only own farm total area five ha. Four members of my family depend on this land and have no other job outside farming.

CROPS Beside mango (the major crop) sweet pea is also grown in marginal fallow land. Started managing orchard for the last three decades. Planting was done four decades back. Heavy infestation of mango hopper and mealy bug are the serious problems.

PEST 1 - MANGO HOPPER is main pest in this area since a long time ago. Its infestation occur at the panicle initiation stage of the crop. Infestation was low particularly during this year so one spray of monocrotophos @ 1.25 ml/lit. of water was done.

PEST 2 - MANGO MEALY BUG is second most serious pest. Attack was very heavy during this year. Folidol dusting and polythene banding of tree trunk was done.

PEST 3 - FRUIT FLY is quite new in the area. This year infestation was about 29-39% which started just before ripening of the fruits.

FRUIT FLY CONTROL Early harvesting and spray of malathion @ 2 ml/lit. of water was done.

#L003: DATE: 26/07/03 TEAM: RPS/AM. Village: Habibpur, Status: Large/Wealthy Farmer. I only own farm total area five ha. Five members of family depend on my farm harvest for whole year and I have no other job outside farming.

CROPS Mango is the main crop with some vegetables during winter. I started managing mango for ten years because my village is in the fruit belt. First time it performed satisfactory. It gives high return if market price is good.

PEST 1 - MANGO HOPPER is main pest in my orchard which started attacking at the time of panicle initiation stage and causes losses. This year infestation was heavy. Two sprays one NSKE (5%) and monocrotophos @ 1.25 ml/lit. of water were done.

PEST 2 - MANGO MEALYBUG is also serious pest in my orchard causes damage during Jan. to April. Its attack is a regular phenomena. Attacks started from Feb. to April. This year attack was heavy so dusting of Folidol was done .

PEST 3 - FRUIT FLY is an emerging problem mostly found in late maturing varieties of mango. It attacks just before ripening of the fruit. Early harvesting of fruit and send to the market was done.

FRUIT FLY CONTROL Only early harvesting was done.

#L004: DATE: 13/08/03 TEAM: RPS/AM. Village: Masauli, Status: Large/Wealthy Farmer. I

only own farm total area five ha. Nine members of my family depend for farm harvest for whole year and I have no other job outside farming.

CROPS Mango is the major crop. Rice, wheat, mustard and gram are grown in marginal land. Started managing the orchard since five years. During this period heavy attack of mealy bug and mango hoppers was faced.

PEST 1 - MANGO HOPPER was major pest damaging severely during the month of Feb. and April. Infestation was moderate during this year. Spray of NSKE (5%) was done.

PEST 2 - MANGO MEALYBUG is second most important pest. It's a regular feature in the orchard. I used Folidol dusting three times around the tree trunk. No awareness about polythene banding.

PEST 3 - FRUIT FLY is becoming a serious problem mostly in late maturing varieties. Attack started just before the ripening of fruit.

PEST 4 - MANGO LEAF WEBBER is the major problem in old trees. Caterpillars feed on leaf surface by scrapping later they make web of tender shoots and leaves together and feed within.

FRUIT FLY CONTROL Early harvesting was done to save the fruit.

#L005: DATE: 14.08.03 TEAM: RPS/AM. Village: Katrauli, Status: Medium Farmer. I own farm total area three ha. Six members of my family depend on this farm harvest for whole year and I have no other job outside farming.

CROPS Besides mango major crop rice, wheat and mustard are also grown on the marginal land. Started managing the orchards for the last three years which is only ten year old. First time it performed satisfactorily. High income is assured provided market price is good.

PEST 1 - MANGO HOPPER is major pest in the village and moderate damage occur during panicle initiation stage. Infestation was moderate during Feb. to April this year. One spray of NSKE (5%) was done.

PEST 2 - MANGO MEALYBUG is a regular pest in the orchard and is also second most important pest. Folidol dusting (2 times) around the tree trunk was done. No awareness about polythene banding.

PEST 3 - MANGO FRUIT FLY is also becoming a problem in the orchard resulting 30-35% damage in late varieties which starts just before the ripening of the fruit.

FRUIT FLY CONTROL No control measures adopted.

#L006: DATE: 19/08/03 TEAM: RPS/AM. Village: Khairanpur, Status: Medium Farmer. I own farm total area two ha. Six members of my family depend on this farm harvest for whole year and I have no other job outside farming.

CROPS Mango is the major crop. Rice, wheat, mustard and gram are grown on marginal land. Started managing the orchard for last five years. First time its performance was not satisfactory due to mango malformation.

PEST 1 - MANGO HOPPER becomes a problem in the month of Feb. to April at the panicle initiation. This year infestation was moderate. NSKE (5%) and endosulfan (0.05%) spray were done.

PEST 2 - MANGO MEALYBUG causes damage in old trees which starts from Jan. to April. Folidol dusting and NSKE (5 %) around the tree trunk were done.

PEST 3 - MANGO FRUIT FLY caused damage about 30-35%. Attack started at the time of maturity. Early harvesting of fruits was done to save the crop send to the market.

FRUIT FLY CONTROL Early harvesting plus malathion (1.25 ml/lit. of water) was sprayed. No idea about BAT and MAT technology.

#L007: DATE: 19/07/03 TEAM: RPS/AM. Village: Mall, Status: Medium Farmer. Total area two ha. land. Eight family members depend on this farm and produce is not sufficient to fulfil all requirements.

CROPS Mango is the major crop. Wheat, mustard and some fodder crops are grown on vacant areas. The first time crop return was not satisfactory due problem of alternate bearing in mango tree. This year got good return due to the on season.

PEST 1 - MANGO HOPPER was very destructive pest. Major problem at time of panicle initiation stage and continue up to April. monocrotophos (0.05 %) spray gave good results.

PEST 2 - MANGO MEALYBUG est II: Mango mealy bug is also important pest. Damage occur during Feb. to April. Monocrotophos (0.05%) spray plus polythene banding in the month of Jan. gave good results

PEST 3 - MANGO FRUIT FLY prevalent in the area but not considered important. About 25-30% damage occur in some late maturing varieties. It is major problem in May-June. Not aware about development and its biology.

FRUIT FLY CONTROL One spray of endosulfan (0.05%) in April plus early harvesting is being practised. No idea about BAT and MAT application.

#L008: DATE: 11/06/03 TEAM: RPS/AM. Village: Kakori, Status: Medium Farmer. Total area two ha. land. Nine family members depend on this and farm produce is not sufficient to fulfil all requirements.

CROPS Mango is the only crop as it falls in the mango fruit belt being a typical micro climate for mango cultivation. Faces lot of problems due to insect pests. Used banned insecticides which caused heavy losses owing to in cost-benefit ratio.

PEST 1 - MANGO HOPPER most dangerous pest in the months of Feb. - April. This year infestation was not very heavy. No control measures were used.

PEST 2 - MANGO MEALYBUG Mango mealy bug is also one of the destructive pests since some times. It becomes the major pest of mango in the month of Feb.- April and infestation was heavy. Sprays and dusting of different insecticides could not able to manage them.

PEST 3 - MANGO FRUIT FLY caused damage to mango fruit. Mango fruit fly population was highest during May- June. Late maturing varieties are affected severely and not aware about the development and biology of pest.

MANAGEMENT OF FRUIT FLY For controlling fruit flies insecticide (sevin) was used. This was done with the consultation of local pesticide shopkeepers.

#L009: DATE: 15/06/03 TEAM: RPS/AM. Village: Kakori, Status: Medium Farmer. Owns farm total area 2.3 ha. Land. Nine family members depend on this farm for whole year and we have no other job outside farming.

CROPS Managing 100 years old orchard. Severe losses occurred due to indiscriminate use of pesticides, trying to manage the orchard now and high returns are assured when market price is good.

PEST 1 - MANGO HOPPER is number one pest in this area causing damage during Feb.-April. Monocrotophos is used for the controlling the pest which is able to control (mango hopper) to some extent.

PEST 2 - MANGO MEALYBUG Mango mealy bug is a also a destructive pest in this area. Polythene banding around the tree trunk was done plus Folidol dusting controlled the pest to some extent.

PEST 3 - MANGO FRUIT FLY caused about 25 -33% damage. Larvae eat the internal contents of the fruit as a result the fruit becomes unfit for consumption. Population is highest during May- Jun. Late maturing varieties are affected severely about 35-40%.Not aware about development and biology of fruit fly.

MANAGEMENT OF FRUIT FLY For controlling fruit flies we did not use separate measures only endosulfan spray was done. No idea about BAT and MAT application.

#L010: DATE: 26/06/03 TEAM: RPS/AM. Village: Katri, on the river bank of Ganga river, Kanpur, Status: Small farmer. Own farm total area 0.2 ha. land. Five family members depend on this land for feed farm harvest for whole year and no other job outside farming.

CROPS Guava is the major crop and cucurbits are grown on marginal land. This area has some specific conditions due to which round the year vegetable production and two crops of guava one in the month June- July and second in the month of Nov.-Dec. (Winter) are grown.

PEST 1 - FRUIT FLY is a major pest in his area due to some host crops in the whole year (guava and cucurbits). Caused damage about 35-45% and started damage May in (cucurbits) and July in (guava). Used number of insecticides for control of pests.

MANAGEMENT OF FRUIT FLY For controlling fruit flies insecticide sevin, monocrotophos, endosulfan and Folidol are used without consideration of hazards in the environment. We have no idea about BAT and MAT.

PEST 2 - ANAR BUTTERFLY caused damage in the month of July (rainy season) in guava crop. No control measure was used (damage 10-13 %).

#L011: DATE 22/05/04 TEAM: RPS/AM/JMS Kanpur Village 'A'. Group of gourd farmers on the Ganga river bank.

CROPS Are growing bitter g, bottle g, cucumber, smooth g, pumpkin. 15 years ago this was in the river then was drained 15 years ago. Put in guava and cucurbits and this is what they have grown ever since. Why these particular crops? A sandy soil which is good for cucurbits. The actual village is some way away - these are temporary shelters for some people some of the time. To guard crops against theft. This floods in July and August. Theft is a problem in the vegetables more than in the guava. There is a whole deciduous temporary village of huts beside the river, on land which floods every year. Guava is very good in winter. Guava tolerates being flooded when the river rises. It likes the very sandy soil.

IRRIGATION They have irrigation pump but don't always need it - a good deal of moisture stays in the soil. The water and water table are very close. The water pump is turned on to have its photograph taken; several men quickly drink as much as they can from the stream.

CUCURBITS Cucurbits are grown because the soil is sandy - there is a bit of okra grown, but the soil is not ideal. Also musk melon, which is heavily infested by FF, and watermelon, which is not infested. Watermelon yields well and the soil is suitable. Need for water is no bigger than the others. Aphids attack the leaves.

Cucurbits can be grown year-round here because it has natural advantages. Please organise a goshti for us to organise help for pest control - aphids and Heliothis.

PRICES Prices and their fluctuation are important. In the off-season one cucumber is 5rs (September and October). Now it is 1rupee - in the market in Lucknow - and only 50paise in the local markets round here. They are now putting in the crop which will yield at maximum price, so brings in good income.

FRUIT FLY FF infestation is very severe. Aphid transmitting virus is becoming a problem in vegetables. Aphids are getting worse, but coccinelid predators are to be seen. FF is still the worst pest overall. JS is fed vast quantities of cucumber until he starts to feel quite ill. In vegetative stage aphid is worse; in fruiting fruit fly is worse. Fruit fly too is worse than it used to be. Why? If it rains the fruit fly gets worse; it also gets worse if it is cold, particularly at night. Bottle gourd is most preferred host for egg-laying. Pumpkin is not very heavily attacked by FF.

PESTICIDES They discover controls by taking infested fruit and/or leaves to the pesticide dealers who make recommendations. {Many are very toxic eg dimecron; phosphamidon is shown - it is still available in the market although banned in 2002; they have a growth regulator to control flowering that they seem to think is an insecticide}.

PICKINGS Bottle gourd is picked every day or every two days, he has done 40 pickings on this stand already. Started 2 to 4 weeks back, 10rs/kg. Production season is: sow in January, pick all the way through from March to July with bottle gourd. Guava by contrast gives only two crops a year. Smooth gourd is the same as bottle gourd, Sow in winter, pick up to Jul 15. Cucumber 45 pickings.

BAT & MAT The IMFFI cue-lure traps control the FF. They see dead flies. All very nice. But does the infestation level actually go down? Yes. They did 6 sprays of PH and that didn't work. CL does work. Now bottle gourd is just coming and FF attacks at a very early stage, so all are very worried.

#L012. DATE 22/05/04 TEAM: JS/RPS/AM Kanpur guava village 'A' guava farmer.

INTERCROPPING Has tomato in among the guava. It is over now, but very profitable.

GUAVA FRUIT FLY CONTROL We'll put in the blocks in June 1st week. The monitoring traps have just a few flies. He says last year there was no infestation of guava at all by ff all because of our farm-level ME block traps. He is happy because in the wet season fruit fly population so high that guava is scarce, and the price is much higher. So it was a good wet season for him. Winter guava takes more time. This guava is starting now and goes up to July/August. Winter guava is continuous picking for 3 months. FF is present in the winter guava, but much less than in wet season. You see baskets of guava for sale in the market, with fruit fly infestation clearly visible. FF is in guava and cucurbits, not in tomato or brinjal. There are about 25km of guava here.

#L012. DATE 22/05/04 TEAM: JS/RPS/AM Kanpur guava village 'B' farmer.

FRUIT FLY GUAVA LOSSES Farmer harvests 40-50 quintals a day. He said if one quintal is infested I don't care. But after we put the ME in his orchard he said Please put it all over next year - the implication is he underestimated the real losses, and was surprised at by how much fruit fly removal increase yield.

WHEAT/GOURD INTERCROP TRANSITION There is now a wheat intercrop below the guava in many places - has now just been harvested and stubble is visible. Probably in a few years cucurbits will take its place - the economic return is better, and the irrigation and so on which will be needed is already in place.

PROJECT MEMORANDUM

on behalf of the
Department for International Development (DFID)
Renewable Natural Resources Research Strategy (RNRRS)h

Research Programme: **CROP PROTECTION**

Production System: Peri-Urban

Project Number:

Project Title: Integrated Management of Fruit Flies in India (IMFFI)

Bactrocera dorsalis Hendel (female)

Abbreviated Title: **FRUIT FLIES IN INDIA**

Version: General use / Reference

Date: 16 October 2001

Executive Summary

Fruit flies in India cause annual losses estimated at Rs2946 crores (£433 million) in mango, citrus, guava and sapota alone. Additional losses are as high as 35 to 40% of cucurbits such as gourds and melons, many of which are important nutrition sources for the rural poor and first steps to commercial cultivation by subsistence farmers. Controls are absent or rely on cover sprays.

Better control may be obtained with little expense and insecticide by exploiting the attraction of fruit flies to protein food baits and sexual "para-pheromone" lures. Drawing on experience by UK and Indian scientists, this project will, by a systematic and comprehensive cost-benefit evaluation, along with social studies with farmers, find the most cost-effective, practical and sustainable controls. Flies may also be managed by area-wide controls, which will be developed by village-level studies of cooperative control, working with villagers and their institutions.

The benefits of this project will be the best possible farm and village-level controls of these serious pests. Earlier research by Imperial College has indicated that reductions in losses of between 73% and 100% may be obtainable by the use of commercial preparations. This project will evaluate home-made alternatives, and area-wide operations, for cost-effectiveness, environmental benefit and practical usefulness to farmers.

SECTION A: KEY INFORMATION

PROJECT TEAM

1. Applicant Details

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SUMMARY PROJECT DETAILS

3. Project Research Summary

This project will develop effective on-farm and village-level controls of Tephritid fruit flies, which cause great damage to fruit and cucurbits in India. A multi-disciplinary survey will establish the economic, social and environmental costs of these fruit flies, and the constraints to their improved management. A systematic and comprehensive evaluation of food bait and sexual parapheromone lure controls, along with social studies of the resources, priorities and perceptions of farmers and village institutions, will develop controls and management strategies that will be practical, effective and sustainable at farm and village level.

4. Starting and finishing dates

1 January 2002 to 31 March 2004

6. Keywords (including subject, species, countries *etc*.)

Fruit flies, Tephritid, India, South Asia, on-farm control, village-level control, socio-economics, fruit, cucurbits

7. RNRRS Production System and Programme Purpose

Peri-Urban Interface Production System.
Purpose 1: "Volume, quality and seasonal availability of food and crop products improved through the reduction of economic and physical losses caused by pests".

8. Is the research strategic/adaptive?

Adaptive.

9. Commodity Base

Tree fruits (e.g. mango, guava, jujube), arable cucurbits (e.g. gourds, melon).

10. Geographic Focus

Research will take place in India. Outputs will be relevant in the South Asian Subcontinent.

11. Target Institutions

Collaborating institutions (see Question 2)

Other institutions with current relations:

Fruit & Vegetable Unit, Mother Dairy Fruit & Vegetables Limited (National Dairy Development Board), Industrial Area Phase I, Mangolpuri, Delhi 110 083
Tel 792 1729
safal1@del3.vsnl.net.in

AME, PO Box 7836, #368, 4th Cross, 3rd Phase, JP Nagar, Bangalore 560 078
Tel 080 658 2303/2835
amebang@giasbg01.vsnl.net.in

Kerala Horticulture Development Programme, BDR Bhavan, Foreshore Road, Kochi - 682 016, Kerala
Tel 0484 368713
khdprog@md3.vsnl.net.in

CARE India, 27 Haus Khas Village, New Delhi 110 016
Tel 011 656 4101
dkapur@careindia.org

Other target institutions
Extension services
NGOs
Growers' and buyers' cooperatives

12. Project Location

(Under central direction by Imperial College and Dr Abraham Verghese)
Field Research (eight locations), formed into three clusters in different zones of India – West (Gujarat), South (Kerala) and East-Central (the other three):-

Gujarat Agricultural University (GAU) (three campuses at Anand, Ghandevi and Palanpur)
Kerala Agricultural University (KAU) (two campuses at Thrissur and Thrivananthapuram)
Indian Institute of Vegetable Research (IIVR), Varanasi, Uttar Pradesh
Central Institute for Subtropical Horticulture (CISH), Lucknow, Uttar Pradesh
Indian Institute of Horticultural Research (IIHR), Bhubaneshwar, Orissa

Knowledge Review (one location):-

Indian Agricultural Research Institute (IARI), New Delhi

13. If the project is located overseas or if there is an overseas collaborator, has the approval of the overseas government been obtained? If so, provide details.

Yes, provisionally. The project has been developed in detailed discussion with counterparts in India, through ICAR. At the time of writing the draft Project Memorandum has been agreed, along with its proposed budget, among all the active collaborators, and is being processed by ICAR and, with ICAR support, other necessary Indian Government Agencies. The project will be covered under the extant Memorandum of Understanding between NR International and ICAR.

14. Is the project linked to work funded by other DFID sources or other funding agencies?

There are no direct links with other extant projects. Informal links exist with several other Projects and research groups, listed under 17.

SECTION B: DEMAND, UPTAKE AND GEOGRAPHIC FOCUS

15a. What is the project's purpose?

Programme output 1.1: *Improved methods for the control of weeds, insect pests, diseases and nematodes in market gardening and horticulture enterprises developed and promoted.*

Specific Research Objectives:

1 – understanding of constraints to uptake of improved farm-level controls
2 – understanding of how bait and lure controls may be (a) optimised with regard to effect and (b) made acceptable to farmers
3 – understanding of how coordinated village-wide control may be (a) effective and (b) implemented by social coordination at village level

The aim of this study is to research and develop ways to reduce the problems of fruit flies (Diptera:Tephritidae) for small farmers. The outputs will be farm- and village-level suppression technologies which are effective, low-cost, profitable in the short-term and sustainable in the long, with minimal insecticide use, risk to human health, domestic and beneficial organisms (such as honeybees and the natural enemies of pests) and collateral damage such as stimulation of the target population to evolve resistance.

Fruit flies, although a serious pest, are currently largely uncontrolled or are controlled by cover sprays of insecticide. First, the chance of better control with reduced inputs of money, labour and (particularly) pesticide is offered by controls based on attraction to food baits (Bait Application Technique, BAT) and sexual parapheromone lures (which attract males and are thus termed Male Annihilation Technique or MAT): this project aims to identify the constraints to the use of these improved technologies, and to optimise their utility to farmers at farm level. Second, due to the mobility of flies and their ability to immigrate unaffected into areas protected by attractant controls (*i.e.* mated females into MAT-protected areas, fed adults into BAT-protected areas) there may be economies of scale if controls can be coordinated over areas larger than single farms: this study aims to study both the field efficacy of area-wide control and the social structures which may allow farmers to make use of it. If these methods can be made practical for farmers, they offer considerable improvements in control. The cooperation in control may also lead to further cooperation in fruit marketing and quality which could improve rural incomes.

15b. What developmental problems or needs is the project aimed at?

A full analysis is given in Appendix I: *The Fruit Fly Problem in India*. The following is a summary.

Importance of Hosts India is the world's largest producer of tropical and subtropical fruit. The economic value (wholesale) of annual production of mango, citrus, guava and sapota alone is estimated as Rs 199 244 million (GB£ 2 930 million). Beyond commercial estimates, fruit and cucurbits (the principal hosts of Tephritids) play a vital role in maintaining subsistence for rural people, providing vitamins and other nutrients (as well as dietary diversity) at a time when nutritional quality is seen as of increasing importance as survival-level poverty continues to decline in India (the 2001 88th Indian Science Congress addressed *Food, Nutrition and Environmental Security*). Many are also a key "first step" to commercial production for subsistence farmers who can grow a small amount of tree fruit or cucurbit vines for sale, but have very little to invest in their production and protection. Guavas and cucurbits are largely the preserve of small producers, generally considered unsuitable for major commercialisation, and monitored by few official statistics.

Infestation by Fruit Flies The available evidence suggests that losses are considerable – typically 20% of untreated mangoes, 30% of sapota and jujube, and 40% of gourds, melons and summer guavas. The incidence of controls is little known, but these are limited, and largely confined to cover sprays of insecticide, which provide poor control and incur environmental and health risks.

Economic Losses Preliminary and provisional calculations given in Appendix I indicate that annual losses at wholesale level may be Rs 17 476 million (GB£ 257 million) in mango, Rs 5 508 million (£81 million) in citrus, (Rs 5 032 million (£74 million) in guava and Rs 1 428 million (£21 million) in sapota, totalling for these four crops Rs 29 460 million (£433 million). Losses may be proportionally higher among subsistence and small-commercial "first step" growers with limited access to insecticidal controls.

Additional Significance Fruit flies in India are also a good case where research, particularly social research, can deliver real improvements. Information, including the efficacy of controls, exists, but is little used (see Section 17 and Appendix II). There is a need for integration of information to obtain a quantification of the optimum control in any particular case, and for social research to understand what farmers will actually use, to provide specific management recommendations and plans which are in each case economic, appropriate and sustainable. Additionally, Tephritid control is not a "lost cause" where cover sprays are the only control that farmers will trust – methyl eugenol, which has no other use than Tephritid monitoring and control, is widely sold in India – and this may combine with the deep roots of minimum-pesticide pest control in India's cultural and religious traditions of harmony with

nature, and its wide promotion by the country's exceptionally large and effective NGO community, to provide a route for low-pesticide controls, which are of known effectiveness, to be made practical and profitable, and thus actually used, by small farmers. Low-pesticide Tephritid controls can and do work, and if optimised and based on an understanding of farmer priorities and perceptions, may not only provide valuable tools for farmers but in so doing provide a case study of the paradigm of technology transfer.

15c. What is the evidence for the demand or need for the research?

An economic assessment of the damage caused by flies is presented in Appendix I.

A study by the State Government of Uttar Pradesh in 2000 identified Tephritids as one of the ten most serious problems of the entire agricultural sector. The melon fly in particular has long been considered the most serious pest of cucurbits in Uttar Pradesh, Gujarat, Kerala and other states.

A high level of importance has been assigned to this problem, expressed as interest in participating in this Project, by ICAR and the institutions listed under (2) above, as well as by bodies in Bihar and Maharashtra.

15d. What will the project contribute to resolving these demands or needs and over what time-scale?

Problem Analysis Component It is important for any pest control to know what species are significant where - particularly in a case such as Tephritids where species differ in their susceptibility to controls. A rational pest management strategy needs understanding of the pests' economic and social damage, to which crops and social groups this damage falls, what farmers do in response and how effective these responses are. This information is essential for the cost-benefit analysis of the returns to investment in management (including research such as this Proposal). It should be a direct derivation of the social benefits sought by the project's ultimate aim: these are often not directly economically quantifiable in the case of poverty elimination and environmental benefits, and so consideration must be given to social and environmental consequences, such as the environmental and health damage of pesticides use as a response to pests.

Management Optimisation Component It is important that control and management options be assessed relative to each other, to establish which of the options is the best, not only by biological control effectiveness, but also by economic cost-benefit criteria and the "soft social science" factors of farmer acceptability, perception and practicality. The research proposed, by addressing these areas altogether, will produce management recommendations which not only control insects, but do so to the economic benefit of the farmer, and accommodate farmer perceptions and opinions so that recommendations are taken up and retained sustainably into the future.

All research will run for 2.25 years.

15e. Which are the identified target institutions?

Research Participants All participants, although primarily research bodies, have themselves roles in extension and diffusion of technology, either through their own activities or through links with extension services. These bodies are well placed for the production of training materials and advice for use by extension services.

Department of Agricultural Extension

Mother Dairy This large autonomous organisation is in contact with hundreds of farmers, and has its own extension resources. It has expressed keen interest in participating in the evaluation of research outputs from the proposed project (on a non-contractual basis) and in the subsequent extension of useful information to its client farmers.

Linkages with other stakeholders (e.g. NGOs such as AME and CARE) will be developed during the project to ensure that the dissemination pathways are as broad as possible.

15f. What are the proposed promotion pathways for the uptake of the project outputs?

i) Have any market studies for the outputs been produced?

Not to our knowledge. As low-pesticide and low-input technologies these offer limited scope for commercial exploitation.

ii) How will the outputs be made available to intended users?

The technologies produced will comprise information, not material goods or equipment. As such, there will be little opportunity for intermediaries such as traders to make money from them, and thus for the free market to provide uptake paths. Outputs will instead be made available through existing extension channels – primarily the State Extension Services, NGOs working with villagers and cooperatives and associations of farmers and of purchasers and wholesalers of produce. It is hoped that NGOs and farmer associations will provide not only technical advice on fruit fly control but also, if this is found desirable, ways of social organisation to reap the benefits of cooperative area-wide control.

iii) What are the further stages needed to develop outputs?

For recommendations to be made at local levels as to the optimum control for any particular case, preliminary testing of technology recommendations in local conditions may be advisable. This may be undertaken by local agencies as and when required.

iv) How, and by whom, might further stages be carried out and paid for?

The further stages envisaged are not complicated or demanding of time and resources, and may be carried out by local agencies within existing budgets.

v) What mechanisms will be used in dissemination, who will be the target audiences and who will handle the dissemination?

1. Stakeholder workshop: the workshop at the end of the project will review its technical outputs and develop draft management plans.
2. Personal professional contact: the research collaborators are themselves key institutions in the dissemination of information.
3. Technical reports will be disseminated in the research community. It is proposed that two of the researchers (J Stonehouse, A Verghese) attend the *6th International Symposium on Fruit Flies of Economic Importance*, in Stellenbosch, South Africa from 6 to 10 May 2002 (http://www/fruitflysymposium.co.za/home/htm), and make a presentation of the background, aims, significance and methodology of the proposed project, to raise awareness of it among researchers.

The project has links with other similar projects in the region, as listed under Section 17, and this liaison will disseminate the results in the research community.

4. Published papers: although the work proposed in this project is adaptive in nature, we expect that published papers will form one of the main means of dissemination of outputs. The main target audience for these outputs will be researchers and to some extent extension workers in collaborating projects in South Asia and elsewhere.
5. Extension recommendations: The final outputs are to be extension recommendations for management plans for fruit flies at farm and village level.

Please note that this Memorandum and proposed budget do not include, as this would be premature, specific funded dissemination activities such as booklets, training materials or other publications. If found appropriate at a future point, separate funding may be sought.

vi) What baseline data will be collected, and what markers and monitoring system will be emplaced, by the project to enable its developmental impact to be assessed?

The *Survey* component of the research, described below, has as one of its explicit objectives the establishment of a baseline database to allow improvements in fly management to be assessed.

15g. Who will the beneficiaries be and are there any groups who will be disadvantaged by the application of the research findings?

The first beneficiaries will be researchers and extension workers in South Asia working on fruit and cucurbit production. The main beneficiaries will be resource-poor farmers, who will benefit from the research when it is adopted and applied by extension workers and NGOs. These communities may see a reduction in the use of chemical inputs to fruit and cucurbit production leading to reductions in pest losses, lower production costs, improved human, animal and environmental health and a more stable production system. There are no known negative impacts to this research other than possible reductions in profits by chemical companies.

16. Is this proposal a continuation or extension of work already funded by DFID?

Yes. It picks up several themes from the (smaller) CPP Peri-Urban Interface *Pakistan - UK Fruit Fly Project*, implemented between 1997 and 2000 by Imperial College and the CABI Regional Bioscience Centre, Rawalpindi, Pakistan (R6924 and R7447, Crop Protection Programme). The work of this project provided the winning entry for the DFID Renewable Natural Resources Research Strategy Annual Award Scheme, 2000, and the current proposal is intended to use the Award grant to allow the continuation and extension of a successful research strategy and methodology, while benefiting from lessons learnt and local experience and exploring room for improvement.

SECTION C: SCIENTIFIC BACKGROUND

17. What work has previously been done, or is currently being pursued, towards the purpose, outputs and activities of the project? A review of literature should be included.

A full review of the Scientific Background of research in India, including a detailed literature review, is attached as Appendix II. *Scientific Research on Fruit Flies in India*. The following is a summary.

Tephritid Fruit Flies in India

Incidence, Infestation, Taxonomy and Biology Over 100 technical papers have been written in the last decade on the Tephritid fauna of India. A great deal is known about the incidence of flies, but knowledge is incomplete as to quantification of losses by crops and species in all areas. Taxonomic organisation of the fauna is relatively well understood. Developmental biology studies have included development and survival rates related to extrinsic variables such as temperature, and many host-preference and survival studies have illuminated the differential effects of different hosts on different fruit flies. There may be some knowledge gaps, particularly as to economic roles of different species, and the identification and filling of these is a goal of the *Knowledge Review* contained in this Proposal.

Controls

Insecticide Fruit flies are susceptible to almost all conventional insecticides. Research has shown that some perform better than others, particularly in combination with attractants such as food baits and parapheromone lures – contact insecticides are more lethal than stomach-acting ones (although both baits and parapheromones are eaten), and some are slightly repellent which undermines control. There is considerable interest in neem and other non-synthetic biological and pathogenic insecticides: many of these are slightly repellent (this is often how they have their effect) and so seem on first sight unsuitable for combination with attractants, but this has not actually to our knowledge been tested. Pathogens are often disfavoured by farmers because of their slow knock-down; when female fruit flies are attracted to baits this is often to mature eggs before first oviposition, and so the delay in the onset of lethality may be more acceptable in this case than in others.

Food Baits Commercial protein hydrolysate baits, imported for experimentation, have been shown to control flies in India (and Bangladesh and Pakistan). With imports expensive, however, and the market perhaps inadequate for establishment of a national factory, experiments and recommendations have evaluated a wide variety of home-made attractants, including yeast extracts, vanilla, meat and fish broth, fruit pulp and juice, honey and sugar, sometimes fermented and often in combinations. The general overall impression is that protein is important, and that proteinaceous baits are superior to fruit pulp, in turn superior to fruit juice, in turn superior to sugar. This is, however, complicated by many successful evaluations of fruit (and sugar) baits over many years. There are indications of differential responses by different species, and of interference in interactions when lures and baits are mixed. Similarly, application methods – sprayers, squirting bottles, brushes and a variety of traps - have all been assessed in various cases, but not systematically.

Parapheromone Lures Methyl eugenol is well-known and widely used in India. Some analogous home-made lures, particularly from *Ocimum sanctum*, have been evaluated and recommended. All are used for Male Annihilation Technique. Like much bait control, this generally makes use of traps; the alternative of wood blocks soaked in lure and insecticide, which have been shown elsewhere to be more robust, durable and economic, has been little evaluated. The evidence for the mutual augmentation of food baits and parapheromone lures is mixed at best.

Cultural and Area-Wide Control The effects of the removal of infested fruit and its burial or destruction to kill pupae have been well studied, and similar practices are widely recommended. To some extent, however, these are likely to be undermined by the arrival of adult flies from untreated areas, and so fall under the larger heading of area-wide controls: Tephritids are generally held to be susceptible to area-wide controls entailing social cooperation, and are controlled over large areas in Israel, Mauritius and elsewhere, although the scientific study of returns to area-wide control has been limited by the demands for space and resources such a study would entail. Often the difficulty with the implementation of area-wide control, as in Mauritius, is in the social and institutional factors which may make it worth farmers' while to maintain controls. In general, however, the study of the social and economic setting of fruit fly control, particularly at the small farmer level, has all over the world been studied less than biology and the mechanics of control.

Conclusion Tephritid biology, ecology and control have been widely and effectively studied in India. Three areas may be identified where further research may bring benefits:

1 – the systematic and comprehensive study of the costs and benefits of the wide variety of candidate baits and lures, alone and in combination

2 – the perceptions, priorities and difficulties of farmers who have to make decisions about control, to illuminate how controls, even when perceived as effective by researchers, may be seen as practical and profitable by farmers

3 – the quantified returns to village-level area-wide control, both with and without concurrent farm-level control, to see whether control at village level may be more cost-effective than that on the individual holding, and of how village institutions and associations may most effectively harness these benefits.

Other Fruit Fly Research Activities of Relevance

Relevant research programmes, recent and ongoing, include the following. All of them have links and communication with Imperial College and the proposed managers of this project.

Indian Ocean Commission Regional Fruit Fly Programme 1996-2000, with the financial support of the European Commission (Convention 7.ACP.RPR.400 Identification REG(RIN)7502), carried out by the Entomology Divisions of the Ministries of Agriculture of Mauritius, Reunion (France) and Seychelles, with Technical Direction by Dr John Mumford, Imperial College. Contact: Mme Indira Seewooruthun, Entomology Division, Ministry of Agriculture, Food Technology and Natural Resources, Reduit, Mauritius. E-mail ento@intnet.mu. Website: www.fruit-flies.org. This Programme has evaluated important aspects of fruit fly ecology, damage and management. Studies have included inter-specific competition, the development of controls, including home-made baits from brewers' waste yeast, and the economic evaluation of farm- and village-level controls. The species of study overlap to some extent (e.g. *Bactrocera zonata*) with the Indian guild, though others (e.g. *Ceratitis capitata*) are different. Other studies have included quarantine risk assessments and the raising of public awareness to reduce the risks of the introduction of damaging exotic species.

African Fruit Fly Initiative 1999-2004, with the financial support of the International Fund for Agricultural Development and others, carried out at the International Centre for Insect Physiology and Ecology. Contact: Dr Slawomir Lux, International Centre for Insect Physiology and Ecology (ICIPE), Nairobi, Kenya. E-mail s.a.lux@icipe.org. Website http://informatics.icipe.org/fruitfly/. This ongoing programme organises and coordinates fruit fly management research in several African countries. Studies include loss levels and distribution and economic returns to farm-level controls including home-made baits and application techniques. The species of study differ entirely from those in South Asia.

Pakistan-UK Fruit Fly Project 1998-2000, with the financial support of UK DFID, carried out by Imperial College, London, and CABI Regional Bioscience Centre, Rawalpindi. Contact: Dr John Mumford, as under (1) above. This project evaluated bait spray and male annihilation controls in a variety of locations in Pakistan, and different home-made bait ingredients and application techniques and substrates, and male annihilation soaked blocks, with a variety of laboratory, experimental field and farm field technologies developed for the purpose. Results are presented in Appendix IV.

Ongoing Fruit Fly Research of Relevance
In many countries in and adjoining the South Asia Region, research work is continuing outside specific Programmes, within National Agriculture Ministry frameworks. All research groups listed work on the on-farm management of fruit flies, and have links with Imperial College.

Israel Contact: Dr Yoav Gazit, "Israel Cohen" Institute for Biological Control, Bet-Dagan. E-mail yogazit@netvision.net.il. Work is being undertaken on the suppression of medfly and other pests. Medfly is currently controlled in Israel by wide-area sprays (usually aerial) of BAT, and research continuously seeks to improve this. More sophisticated techniques, such as SIT, are under consideration.

Bangladesh Contact: Dr M Nasiruddin, Principal Scientific Officer, Division of Entomology, Bangladesh Agricultural Research Institute. E-mail entoipm@bdcom.com.

Malaysia Contact: Prof S Vijaysegaran, Malaysian Agricultural Research Development Institute (MARDI), Kuala Lumpur. E-mail svijay@mardi.my.

South Africa Contact: Dr Brian Barnes, ARV Infruitec-Nietvoorbji, Stellenbosch. E-mail brian@infruit2.agric.za.

Australia Contact Mr Bill Woods, Sr Entomologist, Agriculture Western Australia, Perth, WA. E-mail bwoods@agric.wa.gov.au

Nepal Contact Dr Govinda Prasad Timsina, Entomologist, Agricultural Research Station-Pakhribas, Dhankuta. E-mail arsp@ccsl.com.np

SECTION D: OUTPUTS AND ACTIVITIES

18a. What are the outputs of the project?

1 - Problem analysis
- 1A - Quantification of fly damage, by which species and where
- 1B - Social consequences, and constraints to improved management

2 - Improvement of farm-level management
- 2A - Effectiveness and profitability
- 2B - Appropriateness, practicality and sustainability

3 - Improvement of village-level management
- 3A - Effectiveness and profitability
- 3B - Appropriateness, practicality and sustainability

4 - Management plans

18b. What are the expected environmental impacts (beneficial, harmful, neutral)?

Direct Environmental Impacts We envisage no hazards arising from the implementation of this project. Some insecticide applications may be carried out in the field, and insecticidal preparations will be evaluated in the field and laboratory, but these will all be of dosages and exposure levels less than those currently used by farmers. Formulations are expected to be similar to those allowed by US EPA for control operations on fruit flies in urban areas of Florida, California and Hawaii. All laboratory

cultures of flies will be of locally-caught strains, eliminating the risk of escapes leading to the establishment of alien strains.

Indirect Environmental Impacts We see no indirect environmental hazards arising from the results of this project. Positive environmental impacts may arise as a result of the implementation of reduced-chemical control measures, such as reductions in insecticide exposure of non-target organisms such as humans, wildlife, domestic animals and beneficial species such as pollinators and pest natural enemies. The expansion of tree fruit production may improve soil conservation and the habitat availability to species such as birds of agricultural and conservation value.

19. Describe the project activities

The full work plan is given in Appendix III. The following is a summary of this.

The work is proposed to take place over two and a quarter years. All field work (Activities 1.2, 2 and 3) will take place at eight points, by five administrative centres (three in Gujarat by GAU, two in Kerala by KAU, one each by CISH Lucknow, IIVR Varanasi and IIHR Bhubaneshwar). The knowledge review (Activity 1.1) will be at one institution (IARI New Delhi, with journeys). CABI Bioscience will provide assistance in administration and in liaison between Indian and UK scientific workers. These roles and their budgets have been agreed.

Imperial College will provide technical, training and material support, developing techniques combining its own past experience of Tephritid research with collaboration from local participants with local research backgrounds. Imperial College will develop, in consultation with participants, the datasheets, data spreadsheet templates, questionnaires and other research tools, to be delivered as photocopyable data sheets and software templates, the two developed together to produce spreadsheet files for the automatic processing of data, with links to allow them to be printed out in blank so that the computer data entry files will match the paper data sheets. Imperial College will also provide training in necessary research techniques: an expected benefit of this project is researchers trained and experienced in a variety of problem-oriented research techniques, from the trapping, identification and preservation of insect specimens to the cost-benefit analysis of controls and social science techniques such as semi-structured interviews and rapid rural appraisal. Dr Murdoch McAllister, an expert in biometrics and data analysis at Imperial College, has been included in the research team to ensure the validity of experimental designs and biometric and statistical methods and results.

The research timetable will be anchored by two workshops to assemble all researchers together to exchange experience, ideas and expertise. The first is provisionally to be in January (or possibly February) 2002 at IARI, New Delhi, to discuss and refine the research protocol, the second in February or March 2004 at IIHR, Bangalore, to bring together the research team (with their specimens for a systematic discussion of incidence and taxonomy), to discuss findings and implications. The final output will be the synthesis of the outputs of the research into locally-applicable plans for management of flies at farm or village level, in ways which are effective, economically realistic and maximally profitable, with minimal costs and insecticide use, and sustainable both environmentally and socially in the long term.

ACTIVITIES
1.1: Knowledge Review
1.1.1: Incidence mapping of flies and distribution
1.1.2: Tabulation and synthesis of damage and loss records
1.1.3: Review of biological research results
1.1.4: Tabulation and analysis of records of controls

This will connect the field research with the large existing body of knowledge in India, both written and in the form of individual expertise. It will entail the gathering of all available information in the following categories. Where possible, and in particular for sections 1.1.1, 1.1.2 and 1.1.4 these findings will be tabulated. It will form part of the baseline database. Knowledge gaps will be identified.

1.2: Survey
1.2.1: Trapping of adults
1.2.2: Rearing out from collected fruit
1.2.3: Key informant interview survey
1.2.4: Semi-structured interview survey

This will form part of the baseline database. At eight sites around the country it will assess the presence and infestation of fly pests, using a combination of trap catches, rearing out of larvae from infested fruit, and key informant surveys to obtain quantified estimates of (a) infestation of unprotected hosts, (b) infestation of protected hosts and (c) incidence of protection measures. Insofar as possible this will be done separately by hosts and fly species in a variety of ecological zones. Complete coverage of the whole country is not envisaged, but it is hoped that the methodology may be refined, in partnership with Indian colleagues, to obtain a robust but valid approach which may cheaply be extended to other areas. This will be combined with a wide-area, informal Semi-Structured Interview (SSI) survey, to evaluate what farmers think of current control options, how they make decisions about fruit fly control, including criteria, information sources and rationales behind them, and what are the obstacles to change and improvement.

1.3: Opening workshop. This will be held in New Delhi, at the outset of the Project.

2: Farm-Level Control Experiments
2.1: Laboratory single-killing-point study
2.2: Field single-killing-point study
2.3: On-farm control trials with farmer evaluation

Sections 2.1, 2.2 and 2.3 will form a hierarchy of experimental methods, ascending in realism and economic quantification of results, while descending in the speed, economy and convenience with which candidate technologies can be processed. Attention will focus on food bait (BAT) and pheromone lure (MAT) attractant controls controls (which offer the best chance for low-pesticide, effective and sustainable Tephritid controls), although cover applications (e.g. of neem) may also be evaluated. The three-tiered hierarchy will build on methods developed by Imperial College in Pakistan (see Appendix IV, where each paper in preparation describes fieldwork with one of the three tiers), while at the same time, in partnership with Indian colleagues, addressing their shortcomings and adapting them to the conditions in hand. The approach was developed in an attempt to "industrialise" comparisons of attractant controls by allowing the rapid, reliable, large-scale assessment of options, including mixtures and combinations, with as little use of time and resources as possible, using a hierarchy to allow only the most promising candidates to progress from one step to the next. The first two steps make use of the fact that attractants are applied in discrete "killing points" of bait spots, blocks or traps and so the relative effectiveness of these (if not their actual crop protection cost-effectiveness) may be evaluated by counting the flies attracted to, and killed by, points of different types. First, laboratory single-killing-point (SKP) studies will evaluate the relative attractant power of two killing points deployed at either end of a long choice-chamber cage into which flies are released on the centre line equidistant between the two candidate treatments. Data are counts of dead flies gathered on either side of the centre line. Second, field SKP studies, one step more realistic and resource-consuming, will deploy real killing points in actual field or orchard conditions, and count the flies falling killed from these into specially designed collectors; the measurement of the distance

travelled by dying flies will allow the calculation of the parameters of the curve of the decay of catches with distance, and thus the modelling of likely fall of dead flies outside the confines of the collecting surface itself. Third and finally, the most promising methods identified by SKP studies will be evaluated in full on-farm trials in which the controls deployed are exactly as envisaged for farm use, and the infestation and loss of fruit in farm plots treated in different ways are quantified to allow the actual economic losses in each to be set against the likely costs of candidate controls. As evaluated on actual farms, these will also allow interviews with farmers to elicit their opinions of the advantages and disadvantages of the controls evaluated.

The objective is a systematic and comprehensive evaluation of all candidate attractants and their accompanying lethal agents and deployment/application methods, individually and in combination, in order to identify the most cost-effective, making best use of locally-available and home-made components, of the many candidate controls individually assessed in the past in India and elsewhere.

3: Village-Level Studies
3.1: Institutional study of village-level organisation
3.2: Village-level control trials
3.3: Village participatory rural appraisal of trial outcome

Together these will assess the economic returns to area-wide control at village level (for research purposes estimated at one square kilometre) in comparison with those of control at farm level, by the simultaneous assessment of fly infestation and economic damage with (a) no control, (b) farm-level control only, (c) village-level control only and (d) both farm- and village-level control, in a factorial design. This will be accompanied by a study of the institutions and organisations at village level which might be able to perform the essential task of co-ordinating cooperative village-level activities by farmers. The individual controls to be used will be determined by the results of the earlier farm-level control methods evaluated by activities under 2. Assessment of both the experimental results and the institutional infrastructure will be combined by the use of village-level Participatory Rural Appraisal , along with other techniques, which will address control results and organisational roles together, in a holistic assessment of how the technique, if valuable, may be made operational and sustainable at village level with both biological and socio-economic tools.

The above workplan is intended to be carried out, at each of the participating research centres, by a suitable full-time Research Fellow with inputs of the time of other personnel as the relevant Managing Institution sees fit. It may be that at points in the research schedule the work load of each individual Research Fellow may permit additional studies to be undertaken and, as these may allow individuals opportunities to pursue particular and personal research, instead of all following the same procedures laid down by the work plan, this will be encouraged and funded if resources permit. Areas for study in these additional, personal research projects, if possible, will be decided between Imperial College and participating Institutions, but may include some of the following, which are areas where illumination would benefit the overall purposes of the proposed project:

- cultural controls, including fruit disposal
- integration of more than one control for IPM, such as by life table analysis or population modelling
- food- and mate-seeking behaviour of fruit flies
- migration and movement of fruit flies

4: Closing workshop at IIHR, Bangalore. This workshop will review outputs of the research and confirm management plans for implementation by extension agencies (governmental and non-governmental).

20a. Logframe:

Narrative Summary			
Goal	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
Volume, quality and seasonal availability of food and crop products improved through the reduction of economic and physical losses caused by pests.	Improvements in farm incomes, welfare and nutrition; reduction in purchase and application of cover spray pesticides, and of undesirable side-effects of pesticide use.	Production and infestation statistics for the volume, quality and seasonal availability host foods; availability of merchandise credibly sold as "organic"; reports of control use, farmer welfare, income and nutrition; incidence statistics of pesticide sales, use and contamination (poisonings).	Methods are adopted, effective, and remain so in the future, leading to sustainability in use both in control and in use by farmers.
Purpose	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
Improved methods for the control of insect pests in market gardening and horticulture enterprises developed and promoted.	Improved pest management methods are presented in workshops, publications and extension materials; lures and formulations are in the market; cooperative groups are formed to apply area-wide controls.	Use by farmers of new technologies; development of institutional infrastructure and adoption by NGOs, agencies, organisations etc of improved control method.	Research results and outputs are capable of translation into recommendations genuinely useful and attractive to farmers; institutions are capable of translating recommendations into farmer adoption.
Outputs	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
1. Quantification of losses caused by flies, by crops and social groups, and constraints to management improvement.	1. Published reports of losses caused by flies to crops and social groups, and constraints to management improvement.	1. Report and published paper containing structured tabulations of economic fly losses, by: area; host; fly species; farm size;also qualitative discussion of constraints and circumstances.	1. Satisfactory information can be obtained, within acceptable margins of error.
2. Identification and optimisation of effective, profitable, practical and sustainable technologies for fly control at farm level.	2. Technologies listed and evaluated for efficacy (capacity to kill flies) effectiveness (capacity to do so to optimise returns to farmers), practicality (realistic usefulness to farmers) and sustainability.	2. Report and published paper delineating evaluation of technologies, including evaluation in the field and at farm level.	2. Successful experiments; access to adequate material resources for laboratory, field and farm trials, including to farms and farmers for evaluation of results.
3. Identification and optimisation of effective, profitable, practical and sustainable technologies for fly control at village level.	3. Reports on village-level control strategies.	3. Reports and published papers.	3. Successful experiments; access to adequate resources for village trials, including to village families and groups for evaluation.
4. Development of management plans.	4. Management plans presented in reports.	4. Reports and published papers.	4. Information and insights yielded by 1 to 3 are adequate for development of plans.

Activities	Inputs	Means of Verification	Important Assumptions
1.1 Knowledge review. 1.2 Survey of incidence, infestation, losses and constraints. 1.3 Opening workshop.	1.1 Salaried and supervised researcher; travel budget. 1.2 Trap, rearing and interview survey at eight locations. 1.3 Workshop in New Delhi.	1.1 Tabulated outputs. 1.2 Survey of incidence, infestation and losses. 1.3 Opening workshop in New Delhi.	1.1 Access to libraries and respondents. 1.2 Survey of incidence, infestation and losses. 1.3 Workshop can be mounted, with access and accommodation for invitees.
2.1 Laboratory Single Killing Point (SKP) studies. 2.2 Field SKP studies. 2.3 On-Farm trials.	2.1. Attractant killing assessments in wood laboratory cages at eight locations. 2.2. Attractant killing assessments in fields in eight locations. 2.3. On-Farm trials in eight locations.	2.1. Laboratory SKP studies undertaken and written up. 2.2. Field SKP studies undertaken and written up. 2.3. On-Farm trials performed and written up.	2.1. Laboratory fly cultures maintained; non-biased and reliable choice chambers established; clear results obtained. 2.2. Suitable field sites; adequate weather and field fly populations; clear results obtained. 2.3. Access to farm sites (permission, cooperation, organisation, transport); adequate weather and field fly populations; low mortality in rearing rooms; results obtained.
3.1 Study of village-level institutions 3.2. Village-level trials 3.3. Village PRA	3.1. Output of study of village-level institutions. 3.2. Trial results. 3.3. PRA results.	3.1. Study report. 3.2. Trial report. 3.3. PRA report.	3.1. Access; communications. 3.2. Trials can be organised; participation and cooperation. 3.3. Participants accessible and willing; results of sufficient interest to participants.
4. Closing workshop.	4. Workshop in Bangalore.	4. Workshop report.	4. Participants available; outputs presented and synthesised.

20b. Activity chart over the life of the project

YEAR 1 2001-2002 **MONTH**

Activity	A	M	J	J	A	S	O	N	D	J	F	M
1.1. Knowledge review										X	X	X
1.2. Survey of incidence, infestation, losses and constraints										X	X	X
1.3. Opening workshop										X		
2.1. Laboratory SKP studies										X	X	X
2.2. Field SKP studies												X
2.3. On-farm trials												
3.1. Village institution study												
3.2. Village-level trials												
3.3. Village PRA												
4. Closing workshop												

Overseas travel

To	By	A	M	J	J	A	S	O	N	D	J	F	M
India (Research sites)	Stonehouse							X			X	X	X
India (ICAR, New Delhi)	Mumford										X		

YEAR 2 2002-2003 **MONTH**

Activity	A	M	J	J	A	S	O	N	D	J	F	M
1.1. Knowledge review	X	X	X	X	X	X						
1.2. Survey of incidence, infestation, losses and constraints	X	X	X	X	X	X	X	X	X	X	X	X
1.3. Opening workshop												
2.1. Laboratory SKP studies	X	X	X	X	X	X	X	X	X	X	X	
2.2. Field SKP studies	X	X	X	X	X	X	X	X	X	X	X	
2.3. On-farm trials	X	X	X	X	X	X	X	X	X	X	X	X
3.1. Village institution study										X	X	
3.2. Village-level trials											X	X
3.3. Village PRA												
4. Closing workshop												

Overseas travel

To	By	A	M	J	J	A	S	O	N	D	J	F	M
South Africa (Symposium)	Stonehouse		X										
South Africa (Symposium; from India)	Verghese		X										
India (Research sites)	Stonehouse					X					X	X	

YEAR 3 2003-2004 **MONTH**

Activity	A	M	J	J	A	S	O	N	D	J	F	M
1.1. Knowledge review												
1.2. Survey of incidence, infestation, losses and constraints	X	X	X	X	X	X	X	X	X			
1.3. Opening workshop												
2.1. Laboratory SKP studies												
2.2. Field SKP studies												
2.3. On-farm trials												
3.1. Village institution study												
3.2. Village-level trials	X	X	X	X	X	X	X	X	X	X		
3.3. Village PRA										X	X	
4. Closing workshop												X

Overseas travel

To	By	A	M	J	J	A	S	O	N	D	J	F	M
India (Research Sites)	Stonehouse					X							X
India (ICAR, New Delhi; IIHR, Bangalore)	Mumford												X

Appendix I. The Fruit Fly Problem in India

The Importance of Fruit Fly Hosts

India is the world's largest tropical and subtropical fruit producer. Yet yields are low and there is potential for gains. Table I.1 gives some recent estimates of production of tree fruit in India. It can be seen that recent growth in production has been limited, to 3.27% the past five years.

Table I.1. Indian fruit production in annual millions of tonnes ('000 000MT) (FAO (2000).

Year	Mango	Citrus	Others
2000	12	3.19	23.37
1999	12	3.19	23.37
1998	12	3.19	23.37
1997	12	3.19	23.34
1996	12	3.17	22.17

Segrè *et al.* (1998) found most Asian countries' exports low in comparison with South America, when compared with corresponding production levels; though a major exporter of banana, mango, guava and papaya, the potential for India as a major fruit exporter remains to be further developed, particularly considering its proximity to the major South-West Asian market (the largest importing regional bloc in the developing world, with 34% of the total in 1995). India is the world's largest mango producer, with 65% of global production, and the mango export industry is a priority area. Tree fruits are valuable sources of nutrition and vitamins at a time of growing awareness of their importance. Beyond the economic figures is the role of fruit fly hosts in rural nutrition, as borderline-subsistence poverty continues to decline in India - the 2001 88th Indian Science Congress had as its themes *Food, Nutrition and Environmental Security*. They are also largely beneficial from environmental aspects, protecting soil from water, wind and tillage erosion and, for example, sheltering birds which may eat other insect pests, such as up to 65% of white grubs while following the plough in nearby fields (GAU, pers. comm.).

Several fly hosts are of great importance for the poor and vulnerable. Guava is called "the poor man's fruit" because of its poor keeping qualities and inability to ripen after harvest, which make it unsuitable for harvesting green to ripen in transit to market, and it is widely the preserve of small and local producers. It is an indication of its small and local scale of production that it is not considered a suitable crop for commercialisation. Jujube is also called "the poor man's fruit" in north Gujarat because of its tolerance of dry conditions, allowing it often to be the only productive plant which can be grown on what is often "waste ground". Sapota is widely grown in Gujarat, and in Karnataka is sometimes valued by smallholders even more than mango, in spite of its poor-quality timber, because its production is high (up to 100-300kg/tree/year) and its fruiting season long (Bostock Wood and Wise, 1992) - though this allows fruit fly populations to build up.

Fly Infestation

Fruit flies are probably the most serious cause of pest losses to many tree fruits and most cucurbits. The melon fly has long been considered the most serious pest of cucurbits in Kerala (Dale *et al.*, 1966). This preliminary study followed earlier studies in Pakistan and Seychelles (Stonehouse *et al.*, 1998, 2001) in listing all available estimates of losses, and deriving from the lists subjective estimates of likely average infestation overall. Estimates of losses are collected in Table I.4, and the subjective estimates, from the limited study at this point, summarised in Table I.2.

Table I.2. Subjectively-derived synthesis estimates of percentage losses to fruit flies, with and without controls, from the currently incomplete survey of sources presented in Table I.4. (Moringa fruit fly losses are included although this species is a Drosophilid, not Tephritid, pest).

Host	Untreated	Treated
Gourds (various)	40	5
Cucumber	35	5
Melon	40	10
Moringa	30	5
Mango	20	3
Sapota	30	5
Phalsa	50	10
Jujube	30	3
Guava (summer)	40	10

Economic Losses

The synthesis of production data and loss estimates allow a preliminary attempt at quantification of economic losses. This is given for some of the most important tree fruit in Table I.3.

Table I.3. Production, loss and cost estimates for fruit flies in India for selected tree fruits for 1999. Production statistics are from Negi *et al.* (2000a). Price statistics are from Negi *et al.* (2000b), as wholesale prices, averaged over the major markets (Delhi, Mumbai, Kolkata, Chennai, Bangalore) weighted for tonnage marketed annually (except guava, estimated by the author). Percentage loss estimates are from Table I.4, except those for citrus, taken from Pakistan estimates by Stonehouse *et al.* (1998). Assumed exchange rate is Rs68=GB£1. Estimated annual loss totals, for these four fruits, were Rs 29460 million or £433 million.

Value (1999)	Mango	Citrus	Guava	Sapota	Totals
Production ('000MT)	9782	3707	1801	668	15958
Price (Rs 000/MT)	12.7	13.8	9.5	10.1	
Value (Rs million)	124231	51156.6	17109.5	6746.8	199244
Value (£ million)	1827	752	251	99	2930
Loss- untreated (%)	20	15	40	30	
Loss - treated (%)	3	3	10	5	
Treated area (%)	35	35	35	35	
Loss - untreated (Rs million)	16150	4988	4448	1316	26902
Loss - treated (Rs million)	1304	537	599	118	2558
Loss - total (Rs million)	17454	5525	5047	1434	29460
Loss - total (£ million)	257	81	74	21	433

It can be seen from the sketchy nature of the above analysis that many figures are unknown – particularly in host production, pest infestation and the level of practice of controls. The project's "Survey" component aims to address this.

Further Significance

Beyond these cash estimates are further aspects of importance: the very crops for which production statistics do not exist are, because of their small-scale nature and small commercial potential, of greatest significance for the poorest farmers, and for small farmers, the greatest fly damage may be to cucurbits, attacked by *B. cucurbitae* and *Dacus ciliatus*. Anecdotal evidence suggests that many small subsistence growers of staple crops such as rice and cereals, in a potential

position to move up to the cultivation of cucurbits for market, are prevented from doing so by pests, often mainly fruit flies, and so their control, particularly by cheap methods needing no access to capital goods such as sprayers, may offer significant improvements in living standards.

Finally, as the subjects of many detailed studies in the past, fruit flies represent a case of a pest where much biological information exists, including on the effectiveness of farm-level controls, but their control in India is largely either absent or by insecticide cover sprays: there seems to be a need for both an integration of information to allow the selection of the economically optimum control technique in every case, and also of the incorporation of knowledge into a social and economic framework to ensure control technologies are workable by, and valuable to, farmers. Addressing this may form to some extent a test or pilot study of how effective control technology may be taken up, in a case where there already exists a suite of different control technologies with different attributes. There are particular opportunities for controls based on information rather than products - thresholds, IPM, and wide-area social controls by farmers cooperating. Overall, the control of Tephritids is quite well understood (though not optimised for all available options), and proven effective technologies are known, so that the question is one of understanding which technology or strategy is best for farmers in any particular case, and of how they can be made workable by farmers. Additionally, fruit fly control is patently not a "lost cause" where scheduled cover sprays are the only option which farmers will trust to protect crops - methyl eugenol, which has no purpose other than low-pesticide Tephritid control, is widely available, and sold, in India. Overall, India with its traditions of non-violence and harmony with nature has favoured agriculture with conceptual characteristics such as *Swadeshi* (indigenous), *Swaavalambi* (self-reliant) and *Savayava* (organic) (anon., 1999). Synthetic chemicals are generally frowned on, many NGOs fostering organic farming, with a growing urban market for organic produce. This provides a promising base for the development of minimum-pollution IPM with minimal cover pesticide use. It is thus in a way an opportunity to scrutinise the paradigm of technology transfer: simple technologies can and do work, and in their effective deployment and extension a little knowledge goes a long way.

Table I.4. Tabulation of records of losses to fruit flies in India. This preliminary table of losses repeats the estimate processes carried out for The Seychelles and Pakistan (Stonehouse *et al.*, 1998, 2001). India's size and ecogeographic variety will necessitate a process of zoning. Data are from a literature search (cited as text references) and small Key Informant survey (cited as personal communications). At writing, the documentation searched is incomplete and many found only as abstracts; the following are from a search of the internet and the CABI pest management abstracts CD for 1990-2001. The table shows records of losses as percentages ("Loss %"), with months where given (as roman numerals from i=January), existence and nature of protection ("P" - as N=none, R=resistance, S=cover sprays, M=MAT, B=BAT, I=IPM), together with their locations and source. Expressions such as "up to" or "at least" are coded by, respectively, <= and >=. At the end of each host section is the subjectively-derived estimate for use overall (temporarily disregarding zoning requirements) called "Used" and for "All" locations, with estimates given, respectively, for Untreated and Treated areas, i.e. subjective overall estimates for jujube of "30/3" are of 30% for untreated and 3% for treated crops. This is a first step, and it is proposed to develop it into a more comprehensive data-base-based synthesis to include crop, variety, fly species, control, month(s) and year(s) and the location converted to latitude and longitude coordinates (with altitude) and to a standard system of ecogeographical zoning. Moringa fruit fly losses are included although this species is a Drosophilid, not Tephritid, pest.

Part i: Tree Fruit

Host	Loss %	months	P	Location	Source
Jujube	47	-	N	Bawal	Dashad *et al.* (1999b)
Jujube	13	-	R	Rajasthan	Faroda (1996)
Jujube	1-10	-	R	Delhi	Sharma *et al.* (1998)

Jujube	3	-	S	Bawal	Dashad *et al.* (1999b)
Jujube	>=50	-	N	Delhi	Sharma *et al.* (1998)
Jujube	72	i	N	Bawal	Dashad *et al.* (1999a)
Jujube	11-30	-	N/R	Delhi	Sharma *et al.* (1998)
Jujube	>=20	xi,xii	N	Gujarat	Bagle (1992)
Jujube	40	-	R	Punjab	Arora *et al.* (1999)
Jujube	13	xi	N	Bawal	Dashad *et al.* (1999a)
Jujube	33	-	R	Punjab	Arora *et al.* (1999)
Jujube	<=8	-	S	Hisar	Lakra *et al.* (1991)
Jujube	49	-	R	Punjab	Arora *et al.* (1999)
Jujube	22	iii	N	N. Gujarat	Patel (undated)
Jujube	77	iii	N	Gujarat	Patel (undated)
Jujube	32	-	N	Gujarat	Patel (undated)
Jujube	22	-	N(R)	Gujarat	Patel (undated)
Jujube	16	-	R	Gujarat	Patel (undated)
Jujube	<=75	-	N	Gujarat	GAU *pers. Comm.*
Jujube	30/3	Used	N/T	All	
Guava	60-80	-	N	Tamil Nadu	Jalaluddin *et al.* (1999)
Guava	19-42	vii-ix	N/R	Punjab	Arora *et al.* (1998)
Guava	16	ix	M	Kashmir	Makhmoor & Singh (1998)
Guava	82	ix	N	Kashmir	Makhmoor & Singh (1998)
Guava	30-40	vii-ix	N	S. Gujarat	ARS, Gandevi, *pers. comm.*
Guava	6-90	-	N	Tamil Nadu	Anon. (undated)
Guava	40/10	Used	N/T	All	
Mango	31-86	-	N	Punjab	Mann (1996)
Mango	30-40	vi,vii	N	S. Gujarat	GAU *pers. Comm.*
Mango	27	-	N	Gujarat	Kumar *et al.* (1994)
Mango	30-50	-	N	C. Gujarat	GAU *pers. Comm.*
Mango	20-35	-	R	Gujarat	GAU *pers. Comm.*
Mango	5	-	S	Gujarat	GAU *pers. Comm.*
Mango	19	-	N	C. Gujarat	Bagle 1996
Mango	7	-	S	C. Gujarat	Bagle 1996
Mango	15	-	N	C. Gujarat	Bagle 1997
Mango	6	-	S	C. Gujarat	Bagle 1997
Mango	27	-	N	C. Gujarat	Bagle 1998
Mango	13	-	S	C. Gujarat	Bagle 1998
Mango	4-10	-	R	-	Singh (1990)
Mango	26-31	-	N	Karnataka	Shukla *et al.* 1984
Mango	1-2	-	I	Karnataka	Shukla *et al.* 1984
Mango	2-3	-	I	Karnataka	Shukla *et al.* 1984
Mango	30-80	-	N	Karnataka	IIHR *pers. Comm.*
Mango	5	-	I	Karnataka	IIHR *pers. Comm.*
Mango	5-7	-	I	Karnataka	Tandon & Verghese 1996
Mango	<=70	-	N	Bihar	Kumar 1995
Mango	20/3	Used	N/T	All	
Moringa	23.4	iii-vi	N	Tamil Nadu	Murthy & Regupathy (1992)
Moringa	10	-	S	Tamil Nadu	Ragumoorthy *et al.* (1998)
Moringa	<=23.4	i,ii	N	Tamil Nadu	Murthy & Regupathy (1992)
Moringa	13-20	xi,xii	N	Tamil Nadu	Murthy & Regupathy (1992)
Moringa	48-9	viii,ix	N	Tamil Nadu	Murthy & Regupathy (1992)
Moringa	15	-	N	Tamil Nadu	Ragumoorthy *et al.* (1998)
Moringa	30/5	Used	N/T	All	
Phalsa	64	-	N	Punjab	Mann (1994)
Phalsa	50/10	Used	N/T	All	
Sapota	30-50	vii-ix	N	S. Gujarat	GAU, *pers. comm.*
Sapota	30/3	Used	N/T	All	

Part ii: Cucurbits

Melon	51-75	-	R	Rajasthan	Pareek & Kavadia (1995)
Melon	76-100	-	N	Rajasthan	Pareek & Kavadia (1995)
Melon	40/10	Used	N/T	All	
Bitter gourd	60	viii,ix	N	H. Pradesh	Gupta *et al.* (1992)
Bitter gourd	47	-	N	Kerala	Dale & Jiji (1997)
Bitter gourd	40/5	Used	N/T	All	
Bottle gourd	80	vii,viii	N	H. Pradesh	Gupta *et al.* (1992)
Bottle gourd	40/5	Used	N/T	All	
Cucumber	20	x-iii	N	Assam	Borah (1996)
Cucumber	80	vii,viii	N	H. Pradesh	Gupta *et al.* (1992)
Cucumber	28	iii-vi	N	Assam	Borah (1996)
Cucumber	39	vi-x	N	Assam	Borah (1996)
Cucumber	53	-	N	Karnataka	IIHR *pers. comm.*
Cucumber	21	-	S	Karnataka	IIHR *pers. comm.*
Cucumber	2	-	M	Bangladesh	Nasir Uddin *et al.* (2000c)
Cucumber	13	-	B	Bangladesh	Nasir Uddin *et al.* (2000c)
Cucumber	22	-	N	Bangladesh	Nasir Uddin *et al.* (2000c)
Cucumber	35/5	Used	N/T	All	
Little gourd	<=100	-	N	Gujarat	Farmer, *pers. comm.*
Little gourd	5	-	S	Gujarat	Farmer, *pers. comm.*
Little gourd	<=63	-	N	Gujarat	Patel (1994)
Little gourd	>=0	-	S	Gujarat	Patel (1994)
Little gourd	45	iii	N	Gujarat	Patel & Patel (1996)
Little gourd	46	iv	N	Gujarat	Patel & Patel (1996)
Little gourd	38	vi	N	Gujarat	Patel & Patel (1996)
Little gourd	3-100	-	N	Gujarat	Patel (1976)
Little gourd	40/5	Used	N/T	All	
Ridged gourd	0	-	N	Gujarat	GAU & Farmer, *pers. comm.*
Ridged gourd	0/0	Used	N/T	All	
Snake gourd	63	-	N	Assam	Borah & Dutta (1997)
Snake gourd	40/5	Used	N/T	All	
Sponge gourd	50	viii,ix	N	H. Pradesh	Gupta *et al.* (1992)
Sponge gourd	40/5	Used	N/T	All	
Gen. cucurbits	25-30	-	N	Overall	IIHR *pers. comm.*
Gen. cucurbits	10-20	-	N	Orissa	CHES *pers. comm.*
Gen. cucurbits	10-25	iv-ix	S	Bihar	Farmer *pers. comm.*
Gen. cucurbits	75	iv-ix	N	Bihar	Farmer *pers. comm.*
Gen. cucurbits	40-80	vii-x	N	Delhi	Pruthi (1941)
Gen. cucurbits	35/5	Used	N/T	All	

Appendix II. Scientific Research on Fruit Flies in India

Summary

Much is known about the taxonomy, biology, damage and management of Tephritids in India, and over 100 papers have been published in the last decade. Three areas can be identified where there remains a requirement for further studies:-

1 - A synthetic study to bring together in a standardised and comparative assessment the effectiveness of food baits and parapheromone lures, alone and in different combinations, for optimum cost-effective on-farm control, and whether and how the optimum may differ between fly species, areas and crops.

2 - Social and economic studies of the real and actual usefulness of control recommendations to farmers.

3 - Evaluation of the advantages accrued by wide-area controls, in terms of cost-effective benefits from farm cooperation to gain scale-economies of control.

Incidence and Infestation

Fruit flies have been recorded as pests in India since the nineteenth century (Maxwell-Lefroy, 1905) and much is known about their incidence and distribution throughout South Asia (Kapoor, 1989, 1993; Kapoor *et al.*, 1976, 1977; Agarwal, 1984, 1985, 1987; Agarwal and Kapoor, 1985, 1986, 1988). Trap catches have been particularly widely studied and documented, and vary between zones, predominant hosts and fly species (Gupta *et al.*, 1992; Murthy and Regupathy, 1992; Mann, 1996; Patil *et al.*, 1996; Kumar *et al.*, 1997; Verghese, 1998; Agarwal and Kumar, 1999). However, while trap catches well indicate fluctuations of a single species in time such as seasonally or annually, they poorly represent actual infestation losses, due to the extreme differential susceptibility of different species to different lures, with some being attracted to none. Also, trap catches often correlate poorly with infestation level at field level (Nasir Uddin *et al.*, 2000b, Stonehouse *et al.*, in prep.), perhaps because lure traps attract males from great distances, as can be shown by trap catches in fields empty of hosts, implying attraction from outside the farm (Nasir Uddin *et al.*, 2000d). As a result, the relative role of various species in economic damage is less well understood than their geographical distribution.

Biology and Pest Status

The main pests such as *Bactrocera dorsalis, zonata* and *cucurbitae* are well-studied. Shukla and Prasad (1985) found that the key determinants of fly abundance were (1) host availability (2) median temperature and (3) relative humidity. Similar studies have allowed the development of ecological models, allowing accuracy in prediction of up to 74% for the judicious deployment of controls (Verghese, 1998).

The study of the developmental biology, ecology and host preferences of fly species have shed light on their propensity to cause damage to different crops. Infestation rates, and therefore crop losses, as introduction risks as well as field estimates, may be illuminated by comparative assays of the success of species in hosts, such as in speed of development or percentage survival, when reared in the laboratory. For example, *Dacus ciliatus* in Gujarat is most severe in little gourd (GAU, pers.comm.) and in laboratory choice experiments it also preferred little gourd to, in order, cucumber and bitter, bottle, smooth and ridge gourds (Patel and Patel, 1998c); it also developed in little gourd faster than five other cucurbits (Patel 1994). Similarly, Gupta and Verma (1995) found that melon fly both had lower survival and slower development on sponge gourd than on bitter gourd and cucumber. Table II.1 shows some "growth indices" for laboratory cultures in India.

Table II.1. Growth indices (percentage survival from first larva to adult, divided by the number of days elapsed for the same development) for various *Bactrocera* fruit flies on various hosts (*dorsalis* data from Kumar and Agarwal 1998b; *zonata* data from Rahman *et al.*, 1993; *cucurbitae* data from Agarwal and Yazdani, 1991). Note the low scores on orange, possibly indicating a potential niche for *Ceratitis*.

	Bactrocera		
Host	*Dorsalis*	*Zonata*	*cucurbitae*
Mango	4.54	6.54	
Orange	3.42	4.46	
Papaya	4.84		
Guava	3.58		
Sapota		4.70	
Smooth gourd		5.28	6.33
Long melon			6.48
Cucumber			6.74
Bottle gourd			4.79
Bitter gourd			5.96
Pointed gourd			6.51

The validity of such exercises depends on several assumptions such as the general association between percentage survival and life-cycle duration for a given species on a range of hosts. Although the studies cited above suggest an association, Table II.2 suggests a poor such correlation between four varieties of mango. Laboratory studies seem to give coherent pointers to field attack severity, but the association cannot be taken as perfect.

Table II.2. Rank ordering of four mango varieties in five parameters affecting life cycle of *B. dorsalis* (Kalia and Srivastava, 1992a,b).

Variety	Bangalora	Malika	Dashehari	Amrapali
Oviposition preference	1	2	3	4
Number of oviposition punctures	1	2	3	4
Number of eggs per puncture	1	2	3	4
Life cycle speed	3	1	4	2
Percentage survival	1	2=	2=	4
Early attack in field	-	1	-	2

Other basic biological information may be used to inform estimates of the relative and absolute gravity of various pest species in various climatic zones and seasons - many good studies have examined the basic biology of the key species such as *Bactrocera dorsalis* (Kumar and Agarwal, 1998c), *B. zonata* (Rana *et al.*, 1992; Rahman *et al.*, 1993) and *B. cucurbitae* (Koul and Bhagat, 1994a&b) including often finding a high correlation of abundance with temperature, allowing estimates to be made of relative abundance in various zones and seasons (Patel and Patel, 1995, 1996, 1998; Agarwal and Kumar, 1999). Temperature and diet effects have also been examined for *Carpomyia vesuviana* (Dashad *et al.*, 1999a; Sangwan and Lakra, 1992) and *Gitona* (Murthy and Regupathy, 1992).

Additional to the major pests are some minority species or those currently affecting only minority crops. In Bihar *Bactrocera latifrons* is found in solanaceae such as *Solanum melongena* (Agarwal, 1984) and, though currently only abundant in wild, marginal and medicinal species, has been found in tomatoes (Rajendra Agricultural University, pers.comm.). *B. cucurbitae* is capable of infesting brinjal, as may be seen from several specimens in the National Insect Collection at the Pusa Institute in New Delhi, reared from brinjal in 1907. Similarly, the Gujarat Agricultural University

Museum has *B. dorsalis* specimens reared from banana in 1969, which apparently persists, although not a commercial problem as they are killed before emergence by the heat treatment widely used to control banana ripening (Gijarat Agriculture University, pers. comm.). *Bactrocera correcta* has been found in grapes (Mani, 1992) and carambola fly in papaya (Rangona *et al.*, 1997)

Very few crops are attacked by only one pest, and so pest management decisions are only very rarely applied to a single target in isolation. Around the country mango has many pests - the stone weevil *Sternochetus mangiferae* Fabricius may cause infestation of 17.5% in Alphonso and 13.4% in Banganapalli varieties, but may be controlled by 97.5% by one cover spray at the marble stage, but this is not a stage where fruit fly controls are normally needed. The mango shoot borer *Chlumetia transversa* Wlk can cause up to 40% damage, and mites and grey and leaf-cutting weevils also can feature in some cases.

Table II.3 shows losses to the two major pests of jujube in Gujarat. Bagle (1995-8) found that both pests may be controlled together, by two sprays of synthetic chemicals, in early October and 15 days later, alternating with neem sprays (neem alone is inadequate). This seems a case where switching fruit fly control away from cover sprays would serve little purpose, as the sprays have to be made anyway, to control the borer, and will continue to control flies at the same time, although other sources indicate that the fly and borer only rarely attack together and may be better controlled individually (Indian Institute of Horticultural Research, pers. comm.).

Table II.3. Losses of jujube to fruit fly *Carpomyia vesuviana* and fruit borer *Meridarchis scyrodes* Meyr over three years in Gujarat (Bagle 1996-8). Percentage infestations are in samples taken after treatments; infestation percentages at harvest were similar to the samples for fruit flies but less for fruit borer.

Pest	*C. vesuviana*		*M. scyrodes*	
Control	None	Sprays	None	Sprays
1996	19	7	40	8
1997	15.1	6.4	13.5	5.2
1998	27	13	50	30
Mean	20.4	8.8	34.5	14.4

Controls

Farmer responses to fly pests may comprise nothing, cover sprays, bait sprays, lures, or some form of Integrated Pest Management (IPM). Many different control options have been evaluated and/or recommended, ranging from cover sprays to cultural controls such as fallen-fruit collection to locally-derived lures and baits such as basil, fruit juice, ammonia, jaggery and molasses, often fermented.

Insecticide As cover sprays and as ingredients in other controls, there are many lethal elements used against fruit flies, including synthetic chemicals, neem, other botanicals and pathogens. Many good studies already exist of the toxicity of insecticides to fruit flies in South Asia. Full toxicity comparisons for all species may not exist, however.

Cover sprays, while considered by IPM practitioners the last resort, can and do control flies when applied in a position to do so, controlling *Carpomyia vesuviana* on jujube (Lakra *et al.*, 1991; Bagle, 1992; Saravaiya *et al.*, 1998; Dashad *et al.*, 1999b), moringa fly (Logiswaran, 1993), *Bactrocera dorsalis* on guava (Mann, 1996) and *Bactrocera cucurbitae* on bitter gourd (Reddy, 1997). Other studies have concluded that cover sprays obtain only poor control of *B. cucurbitae* (National Centre for IPM, pers.comm.).

Bait sprays have requirements not necessarily the same as for cover sprays. Shukla *et al.* (1984) found cover sprays of deltamethrin reduced mango loss from 28.725% (untreated) to 2.875% (with fenthion) and 1.814% (with the more expensive deltamethrin). In using bait sprays against melon fly, Dale and Nair (1966) found that of the six insecticides evaluated all obtained 100% mortality on the

first day after application, and none more than 20% after ten days, but that some were superior at intermediate times - at day three malation obtained over 80%, dipterex and parathion about 70%, and sevin, BHC and DDT all less than 60%. In Pakistan, Farooq (unpub.) found dipterex best for cover spray control of melon fly, attributing this to a slight attractant property, while studies in India found that in bait sprays, while better than cypermethrin (which is slightly repellent) dipterex was less effective than dichlorphos because the former, as stomach-acting, is slower in lethal infect than the contact-action of the latter (Indian Institute of Horticultural Research, pers. comm.).

Botanical and non-conventional pesticides are widely favoured by farmers and consumers, as (often) cheap or home-cultivable, less damaging to the environment and health of people and domestic and beneficial organisms, and increasingly allowing certifiably "organic" cultivation with a large price premium in discerning markets. A survey of organic bait and lure controls, largely from unpublished sources, recommends tobacco and pyrethrum as lethal components (Stoll, 2000). Neem is widely used and recommended in India - the plant grows easily along hedgerows and its properties are widely known by farmers and extended by NGOs and extensionists. It has been successfully used against pests of Cruciferae (Krishna Moorthy *et al.*, 1998, 2000), Jassids and other sucking pests attacking the early stages of bitter gourd (Soman *et al.*, 1999) and produced successful fruit fly protection in guava, jujube and cucurbits, as shown in Table II.4. It may not be a panacea, however. A farmer in Bihar reported a small-scale student trial where neem control was inferior to that of synthetic chemicals, and an apparent fertiliser effect deleteriously stimulated weed growth in neem-treated plots. It has also been reported that neem's disagreeable smell may discourage consumers - though perhaps not seriously when set against synthetic chemicals and their need for preharvest intervals, which are of growing concern among Indian consumers and farmers. Table II.4 also shows a less successful trial outcome. The different outcomes of these trials offer many interpretations, perhaps because the fly species and neem plant part and preparation may make considerable differences.

Table II.4. Percentage infestation of cucumbers by *Bactocera cucurbitae* with different cover treatments (data from provisional experiments by IIHR) and of little gourd by *Dacus ciliatus* with different cover treatments (Patel, 1994, mean of two seasons' data).

B cucurbitae on cucumber		*D ciliatus* on little gourd	
Insecticide	Infestation	Insecticide	Infestation
None	53	None	13
Neem cake[1]	6	Fenthion 0.05	4
Neem kernel extract[2]	9	Carbaryl 0.2	4
Pon cake[3]	21	Endosulfan 0.07	8
Carbaryl	21	Monocrotofos 0.04	9
Nuvacron	21	Dichlorvos 0.05	7
Dimacron	23	Deltamethrin 0.001	7
Metacid	24	Triazophos 0.04	9
		Neemark[4] 0.3	11

1 - Dry neem cake after crushing for the extraction of oil, crumbled into the soil around the base of plants and covered with soil.

2 - 75g of crushed kernel, soaked overnight in 1l water and filtered.

3 - Extract of *Pongamia glabra*, a local insecticidal plant.

4 - Commercial neem extract

Much farm-level fruit fly control depends on the attraction of flies to baits and lures, and another question is whether neem, which has a slight repellent as well as insecticidal effect, may work as the killing ingredient in these, or may repel flies and thus undermine attraction and mortality. Table II.5 shows how on at least one fruit fly its effect as an oviposition deterrent is greater than as an insecticide. At first glance it would therefore appear unsuitable, but this has never been actually tested,

and if neem can be used in attractant preparations this may offer the possibility of all-home-made controls.

Table II.5. Effect of neem (Nimbecidine 0.03%) on different life table parameters of the Moringa fruit fly, *Gitona distigma* Meigon (Diptera: Drosopholidae), in comparison with no treatment, and percentage reduction attributable to neem (Ragumoorthi and Rao, 1998).

Parameter	Neem	Nothing	% reduction
Fecundity (Eggs/female)	50.25	62.75	19.92
Oviposition (Eggs/female)	15.33	54.67	71.96
Eggs hatching (%)	57.25	69.75	17.92
Larval survival (%)	81.25	89.00	8.71
Adult emergence (%)	71.25	85.50	16.67
Adult longevity (days)	11.00	23.30	52.79

A further option may be the use of pathogens as insecticides. Sinha and Saxena (1999) found that culture filtrates of *Rhizoctonia solani*, *Trichoderma viride* and *Gliocladium virens* adversely affected the oviposition and development of *Bactrocera cucurbitae*.

Soil applications for fly control have also been evaluated. Dale *et al.* (1966) found aldrin and heptachlor killed 100% of melon fly pupae after one day, and 20-40% after 42 days, although all others tested killed only 90% at day one and one after 42. Soil applications, however, seem unlikely to be an economically viable tool, unless also benefiting from hitting another pest at the same time. They also may require economies of scale, as areas cleared by larval or pupal control are prone to reinvasion from outside (see below).

Bait A wide variety of different bait preparations has been recommended and/or used in India over many years, including protein hydrolysate (Gupta and Verma, 1982; also used against fruit-sucking moths in Uttar Pradesh), brewer's yeast (Singh, 1997; available in Indian shops as "active dried yeast"), jaggery, molasses, toddy and fruit juice and pulp. A widespread continuing recommendation (e.g. Srinavasan, 1993) is for 1% yeast protein and 1% sugar, which is apparently unchanged from an original recommendation (for 3/4oz each of yeast and brown sugar in 1 gallon of water) from 1958 (Singh, 1990). Alternative ingredients include other yeasts, meat and fish extracts (fishmeal bait is used against the sorghum shoot fly in Gujarat, one of India's most vegetarian states) and various fermented preparations. A DFID project in Pakistan evaluated meat baits (Zia *et al.*, 2001; Stonehouse *et al.*, in press and in prep.) but these are considered unacceptable for the large population of vegetarian farmers and consumers. In a review of largely unpublished sources from around the world Stoll (2000) lists in addition baits of (all in 1 litre of water):

- ½ cup of urine, 1.5 teaspoons of vanilla essence and 100g sugar
- peel or pulp of oranges or cucumber with 7.5ml of ammonia or urine
- 0.1 cups of honey, 0.1 teaspoons of vanilla essence and 0.1 cups of cucumber or fruit pulp
- 6ml of Marmite or Vegemite with 0.5g sodium sulphide (Na_2S)
- "juice mixed with sugar which will ferment"
- 0.5l of vinegar and 10 tablespoons of honey (Richardson, 2000)

In general, baits containing protein have been more effective than those containing sugar. Table II.6 shows the outcome of a comparative study in India showing protein preferred to fruit and sugar preparations by both *Bactrocera dorsalis* and *B. zonata*.

Table II.6. Average numbers of *Bactrocera* fruit flies caught per trap (N=3) by four traps with food baits between May and August 1997. *B. dorsalis* data from Kumar and Agarwal (1998); *B. zonata* data from Agarwal and Kumar (1999). There were significant differences between species caught (F=1851[1,16]*) and treatments (F=527[3,16]***) and for interactions between them (F=202[3,16]***).**

Clove oil (2ml) + Malathion 50EC (1ml) +:-	*dorsalis*	*zonata*
Protein hydrolysate (20g)	44	148
Ripe mango pulp (20g)	28	132
Fermented palm juice (20ml)	9	76
Sugar (20g)	10	16

Much of the Indian literature concerns baits rich in sugar. Among these the richer, more complex and organic preparations seem preferable to more refined simpler sugars. Thus Sasidharan *et al.* (1991) found plantain fruit superior to jaggery, honey and molasses. Altogether, there is a suspicion that baits may follow the this order of descending effectiveness:-

1 - protein sources
2 - natural fruit products
3 - unrefined sugars such as jaggery or molasses
4 - refined sugar

Some evaluations and recommendations have been of bait applied as sprays (Gupta and Verma, 1982). Dale and Nair (1966) found application as coarse drops better than as fine. For tree fruit, Singh (1997) recommended application from 60 days before ripening of 20g of brewery waste suspended in 1l of water, hydrolysed by oven baking at 40 C for 48 hours, then mixed with 1ml of malathion, fenthion or chlorpyrifos, applied as squirts from 0.5l plastic bottles with a "delivery nozzle" to leaf undersurfaces or fences. In Kerala, Dale and Nair (1966) found application to leaf undersides gave best performance, and in Pakistan Zia *et al.* (2001) found brushes as good as sprayers, and foliage much superior to sawn timber, plastic sheet and cotton cloth. Others recommendations are as traps - dishes on bamboo poles (Nasir Uddin *et al.*, 2000c) or hung from the pandal (Sasidharan *et al.*, 1991). In Bangladesh, traps against melon fly are loaded with 100g of sweet gourd and 6 drops of dichlorphos, at 50-60 per hectare and changed every three to five days (Bangladesh Agricultural Research Institute, pers. comm.). The review by Stoll (2000) includes five trap types of broadly similar design, made of old plastic bottles or coconut shells. One (from Paraguay) specifies that entry holes of 0.5cm diameter permit the entry of flies but not of honeybees; although honeybees are not conventionally found in fruit fly traps, and traps are regularly checked for their presence, we know of at least one case, in Pakistan, where an unfounded rumour of bee casualties turned farmers against bait controls. It may be worthwhile thoroughly to compare the kill, duration and cost effectiveness of traps and spot sprays.

Lure Methyl eugenol, the best-known parapheromone lure, is available and used over much of India. It is strongly attractive to males of *Bactrocera dorsalis* and *zonata*. Alternatives are available - holy basil (*Ocimum sanctum*, a known methyl eugenol analogue) is used in Kerala (as 20g of crushed leaves with 0.5g each of citric acid and of carbofuran 3G in 100ml of water, at four traps/ha; Reghunath and Indira, 2000) and in Gujarat (where it is known as *tulsi* and a sacred plant, and used in traps and also as live bushes sprayed with insecticide - a practice very different from more conventional traps in its demands for leaves, insecticide and labour, and thus whose relative effectiveness in comparison with these might be usefully examined). The attraction to methyl eugenol of the melon fly, *Bactrocera cucurbitae*, is uncertain, and the generally-used melon fly lure, Cue-Lure, is currently available in India only as research material, not commercially. A study by CIBC (1972) in Pakistan found catches of melon fly by Cue-Lure *versus* those by methyl eugenol were 120:19 in the hills, 168:47 in the foothills and 149:0 at Lahore, but 23:72 on the plains and 0:22 on the

coast. In the Faisalabad area attack on bitter gourd, presumably by *B. cucurbitae*, was reduced from 66.33 to 21.33% by methyl eugenol traps at 8 per acre (Anon., 1988).

Benzyl acetate attracts *Bactrocera cucurbitae* and *dorsalis* (Kapoor, 1993). Adult *Dacus longistylus*, apparently largely males, are attracted to the plant *Calotropis gigantea* (GAU, pers.comm.). No lure is known against *Dacus ciliatus* (Patel and Patel, 1998b; Qureshi *et al.*, 1987, who found no response to seven known lures, three plant extracts, eight essential oils and two others), which also has shown only poor attraction to protein hydrolysate on St Helena (J Mumford, pers.comm.). There is concern at the occurrence in Pakistan of *Myiopardelis pardalina*, which appears indifferent to methyl eugenol, although it is found in traps containing cue-lure and gouminal. Some role in monitoring, if not control, may be played by coloured traps which mimic ripe fruit: Jalaluddin *et al.* (1998) found that *B. correcta* is more readily attracted to yellow and orange targets than to red, green, white, violet or blue.

MAT has been successfully used for Tephritid control in South Asia in mango (Moyhuddin and Mahmood 1993; Mahmood *et al.*, 2000) and in guava (Qureshi *et al.*, 1981; Marwat *et al.*, 1992; Entomologist, 1997 - the latter showing a net increase in farmer income of 58% from MAT use, although no improvement was demonstrated in persimmon or cucurbit fields).

There is some isolated evidence of cue-lure serving for MAT control of *B. cucurbitae*. Table II.7 shows the results of a trial in Bangladesh.

Table II.7. Comparative effectiveness of BAT and MAT trapping against *B. cucurbitae* in cucumber in Bangladesh (Nasir Uddin *et al.*, 2000c). Data are means of three replicates.

Control	Nothing	Mashed pumpkin BAT	Cue-lure MAT
Percent infestation (%)	22	13	2
Yield (kg/plot of $4m^2$	150	230	260

Apart from the nature of the attractant chemicals, the trap delivery system also affects the usefulness of lure-based killing points. Methyl eugenol or *tulsi* may be used in a variety of formulations such as plastic traps, with and without insecticide, and soaked-wood killer blocks; which of these are most cost-effective for farmers with different resource availabilities in terms of chemicals, traps and labour, would be a useful study. Indian researchers have developed effective research into, for example, "lobster-pot" methyl eugenol traps which trap and kill males without insecticide (Patel and Patel, 1995, 1996, 1998). There are also available commercially prepared blocks microformulated to release lure at a steady rate (Agrisense, pers.comm.) - these may use lure more cost-effectively than simpler preparations, but may be beyond the reach of all but the most sophisticated growers. To our knowledge, soaked-block trap MAT, which offers considerable advantages over all traps in terms of durability, efficiency and relative imperviousness to destruction by sunlight, wind, theft and mischief (Stonehouse, *et al.*, in prep. 20001 a&b) has not been successfully evaluated in India.

Mixtures Bait/bait mixtures are widely recommended, as in the prevalence of mixtures of more than one ingredient in the list of different bait recommendations given above, though the specific comparison of different quantities of different ingredient have not much been systematically researched in India or anywhere. Lure/lure mixtures have recently been compared with melon fly in Bangladesh: Table II.8 shows an interesting hint that for the attraction of melon fly a combination of cuelure and methyl eugenol may show a positive interaction and be greater than the sum of its parts.

Table II.8. Inferred table (the "absent;absent" cell was in fact untried so its "0" value is assumed) of catch of *B. cucurbitae* by cuelure, methyl eugenol and both together (all with Naled) in Bangladesh (Nasir Uddin *et al.*, 2000a).

		Cue-lure	
		Absent	Present
Methyl eugenol	Absent	(0)	171.7
	Present	17.5	268.5

The record of lure/bait mixtures is patchy - in terms of the evolution of a pattern of responses to food and reproduction stimuli, there seems no *prima facie* reason why food and sex stimuli should benefit from each others' presence. Table II.9 shows how methyl eugenol mixed with protein hydrolysate was less attractive than with mango pulp and sugar, to both species, but also that the two species significantly differed in their attractions.

Table II.9. Average numbers of *Bactrocera* fruit flies caught per trap (N=3) by four traps with methyl eugenol between May and August 1997. *B. dorsalis* data from Kumar and Agarwal (1998); *B. zonata* data from Agarwal and Kumar (1999). There were significant differences between species caught (*F*=1426[1,16]*) and treatments (*F*=21[3,16]***) and for interactions between them (*F*=7[3,16]**).**

Methyl eugenol (2ml) + malathion 50EC (1ml) +:-	*dorsalis*	*zonata*
Protein hydrolysate (20g)	821	2580
Fermented palm juice (20ml)	1082	2394
Sugar (20g)	970	2648
Ripe mango pulp (20g)	1430	2797

Another study of a mixture of bait with lure, over the months of a year, found its average catch of male *B. zonata* to be higher than that of the two components separately; however this was largely because of the much higher catch in the single heaviest month - in all other months of the year, and when the monthly catches were converted to logarithms, the catch of the two combined was less than that of its components (Agarwal *et al.*, 1995). A study of attraction of *C. capitata* to trimedlure with and without protein found that the attraction of a mixture was less than that of lure alone for males, and less than that of bait alone for females, so that the total catch by the mixture was less than that by its two components separately (Stravens *et al.*, 2001).

Cultural Controls Cultural controls most effectively used are the ploughing and/or harrowing of soil to destroy pupae and the collection and destruction of fallen fruit. In general, in other areas, the difficulty with fruit collection is its destruction - burial must be to at least 15cm to prevent adult emergence (Patel, 1994). Burial to shallower depths may actually increase survival: Makhmoor and Singh (1999) found survival of *Bactrocera cucurbitae* pupae was 87% at 10cm depth, but only 7% on the surface. Gathered fruit will not immediately burn and cannot be easily composted. The practice needs precise tailoring to farmer resources and views - in Réunion fruit is sun-baked in plastic bags, whereafter it will burn (Jeffrault, 2001). It may be fed to animals, probably the most beneficial use if it may be made practical to farmers. An additional area of study may be the extent to which larval and pupal and controls depend on scale-economies - whether the complete extermination of larvae and pupae over an area of, say, 1/4 acre will offer economic protection if the area is prone to reinvasion from neighbouring fields, and thus whether coordination between farms significantly enhances the usefulness of the method.

Other cultural controls may make small but useful differences. Host plant resistance is known for fruit flies, but is generally weak. Some resistance traits have been reported in jujube (Makhmoor and Singh, 1998; Sharma *et al.*, 1998) and peach (Nijar *et al.*, 1998) but overall strengths are only

relative, and offer little real commercially resistance and are perhaps better termed "differential susceptibility" such as the different attack levels reported by several authors in bitter gourd (Tewatia and Dhankhar, 1996; Thakur *et al.*, 1992, 1994a,b, 1996). Unfortunately, such resistance traits as are found tend (perhaps unsurprisingly) to be correlated negatively with traits making for attractive eating for humans, such as sugar content, pulp content, thin skin and other appetising characteristics (Arora *et al.*, 1999; Kumar *et al.*, 1994). Some authors have reported that sprays of giberellic acid and other physiologically active compounds enhance resistance in guava (Jalaluddin *et al.*, 1998a,b) and mango (Kumar and Singh, 1993; Singh *et al.*, 1995) but the use of these seems beyond the means of small farmers.

The way that cucurbit vines are trailed may affect attack (Joshi *et al.*, 1995). Trap crops have been successfully developed for pests of Cruciferae (IIHR, undated a,b) but none are known for fruit flies. In Pakistan, Khan *et al.* (1992) found that cultural methods effectively controlled melon flies. In their trial of various techniques the best economic cost:benefit ratios were 1:9 for ash dusting, 1:7.9 for intercropped squashmelon as a trap crop and 1:2.7 for poisoned cut-melon baits. This is a curious result and not to our knowledge repeated.

Biological Control Most studies have found only low levels of parasitoid attack on South Asian fruit flies. There are, however, exceptions: in Pakistan CIBC (1972) reported individual maximum attack levels of 44% (by *Trybibliographa daci*) and 10% and 37% (by *Opius longicaudatus*), although why this might have been is unclear.

Integrated Control Most recommendations to farmers combine at least two control techniques as an integrated package. Examples in India include:

Karnataka (IIHR, pers.comm.)

- collection and destruction of fallen fruit
- raking/ploughing
- 1 or 2 cover sprays of carbaryl or decamethrin applied with reference to predictive model

Karnataka (Singh, 1997)

- fruit collection every 3 days and burial "deep"
- area-wide male annihilation, traps replenished every 10 days
- area-wide sterile male release
- bait sprays in "endemic areas"

Gujarat (GAU, pers.comm.)

- Jujube (*Carpomyia vesuviana*)
  - 2 cover sprays of malathion/fenthion/neemark
- Mango, sapota (*Bactrocera* spp.)
  - sweet basil trap crop sprayed with insecticide
  - methyl eugenol traps, at one per 12 trees
  - cover sprays every 15 days, one in 12 trees also with methyl eugenol
- Cucurbits
  - methyl eugenol traps
  - bait sprays of jaggery and insecticide every 15 days
  - collection and destruction of fallen fruit
  - deep ploughing

Tamil Nadu (anon., udated)

- methyl eugenol traps at 12 per ha
- fallen fruit destruction
- raking and ploughing to disrupt pupae
- bait spray of 1ml malathion 50EC/0.5ml fenthion 100EC with 10g of crude sugar in 1l water
- giberellic acid spray to enhance resistance
- soil drench of azadirectin (neem) or neem seed extract

Uttar Pradesh (CISH, 1998) (mango)

- need-based bait sprays of protein OR molasses every 21 days
- methyl eugenol and malathion traps at 10 per ha
- fruit collection and disposal
- ploughing
- early harvest

Area-Wide Control In many parts of the world fruit flies are controlled in a coordinated way over large areas (e.g. Mauritius, Israel, USA, South Africa), and there is a role for a study of the extent to which economies of scale accrue when control is area-wide as opposed to on individual plots, and of how the benefits of area-wide controls may be most efficiently realised. This may need to take the form of comparison of the effectiveness of control in areas of different sizes, but also of specific studies of migratory capacity, such as using marked flies to estimate migratory capacity.

The study of fly migration across barriers is difficult and has been limited so far. Stonehouse, Manrakhan and Mumford (in prep.) found that only 2% of freshly emerged *B. zonata* were intercepted by an intense grid of lure and bait attractant traps, though uncaught flies may have penetrated the barrier or been killed.

Noticeably, larval and pupal controls (parasitoids, fruit destruction, ploughing etc) all implicitly make assumptions about the mobility of emerged adults, as it is only ovipositing females whose reduction leads to savings of fruit (the destruction of eggs and small larvae, allowing their fruit to be saved, is assumed not to be practical, and assuming that emerging parasitoids damage fruit as much as flies) in assuming that reductions of populations of larvae and pupae lead to reductions in ovipositing adults which are not replaced by immigration from outside the treated area. Yet these authors know of no study, in India or anywhere else, which has specifically tested how much immigration may replace losses to the population by such controls.

Social and Economic Factors

In addition to the central role of official extension and support agencies, India is particularly rich in associations such as NGOs, cooperatives and farmers' associations, which offer different opportunities to provide farmers with key resources such as information, material inputs, group organisation and access to markets, transport and other essentials for agricultural development.

In general, much fruit fly research on a global scale is on quarantine and risk assessment, and less on cost-effective on-farm suppression, particularly imperfect but cheap controls suitable for small farmers (Stonehouse, 2001). The world literature is particularly scanty in addressing farmers' opinions and perceptions of the practical usefulness of the methods recommended to them. There are also only very few studies of the quantified cost-benefit values of practices when carried out on farms. This pattern also holds true for India, where the published information on the social and economic usefulness of control alternatives is less abundant than that on technical findings of controls in operation. The realistic assessment of farmers' perceptions of the usefulness and practicality of control operations remains a priority area.

Conclusions

There is a large volume of excellent research studies on fruit fly biology and control. Farmers, however, continue without ecological and integrated controls. There is a role for adaptive research to optimise the reliability and economy of controls from the farmers point of view, and a study of the ways in which these may be made attractive to farmers in operation.

Appendix III. Work Plan

ACTIVITIES SUMMARY

1.1: Knowledge Review
1.1.1: Incidence mapping of flies and distribution
1.1.2: Tabulation and synthesis of damage and loss records
1.1.3: Review of biological research results
1.1.4: Tabulation and analysis of records of controls
1.2: Survey
1.2.1: Trapping of adults
1.2.2: Rearing out from collected fruit
1.2.3: Key informant interview survey
1.2.4: Semi-structured interview survey
1.3: Opening workshop
2: Farm-Level Control Experiments
2.1: Laboratory single-killing-point study
2.2: Field single-killing-point study
2.3: On-farm control trials with farmer evaluation
3: Village-Level Studies
3.1: Institutional study of village-level organisation
3.2: Village-level control trials
3.3: Village participatory rural appraisal of trial outcome
4: Closing workshop

The work is proposed to take place over two and one-quarter years. Experimental and survey work (Activities 1.2, 2 and 3) will take place at eight points, by five administrative centres (three in Gujarat by GAU, two in Kerala by KAU, one each by CISH Lucknow, IIVR Varanasi and IIHR Bhubaneshwar). The knowledge review (Activity 1.1) will be centred on one institution (IARI, New Delhi, with journeys).

The research will begin and end with workshops to assemble all researchers together to exchange experience, ideas and expertise.

All research participants will require the following:

- personnel, their subsistence and travel costs
- a computer with standard software (word-processing and spreadsheets)
- reliable e-mail and telephone connections

Activity 1: Problem Analysis

Activity 1.1: Knowledge Review

Much high quality information already exists, and so a major component is to be a comprehensive review of existing knowledge, an extension of the sketchy beginning outlined in Appendix II. Literature searched will include (a) refereed papers, (b) other scientific publications such as conference proceedings, (c) annual reports by national institutes and state bodies such as Agricultural Universities, (d) "grey cover" literature such as reports by research institutes and specific projects and programmes, (e) student research theses, (f) documentation of other bodies such as NGOs, cooperatives and companies, and (g) other material such as media reports (newspapers, magazines) which throw light on agricultural problems. It will be accompanied by interviews with researchers active in the particular areas.

The knowledge review will include formal tabulations, by spreadsheet or database in conjunction with software engineers and geographers currently developing standard systems in India, for the synthesis of information. This work will also include synthesis and incorporation of many of the results obtained by the survey activities described below. The Knowledge Review researcher will also serve as the anchor point for the many of the *Survey* activities described below – many of the outputs of this latter have been designed to be incorporable into the tabulation discussed below (as in the mix of textual references and personal communications brought together in Appendix I).

1.1.1: Incidence Mapping

Much is known about the distribution and gravity of fruit fly pests throughout South Asia. The many estimates of infestation rates from the literature, from sources such as pest control trial data (both treated and untreated plots), will be brought together, for systematic evaluation. It is expected that as much information as possible from the literature survey will be systematically assembled in tabular form in databases or spreadsheets, connectable to GIS systems, with records of fly species and research locations expressed as ecogeographical zone and standard latitude and longitude coordinates. This will apply in particular to records of infestation and of controls by lures and baits.

1.1.2: Tabulation of Infestation and Damage

Fly infestation data will be gathered from sources such as damage reports and the infestation of experimental plots, both control treatments and untreated controls. All will be gathered in a systematic way to allow overall synthesis (Stonehouse *et al.*, 1998, 2001), modelled on the preliminary start presented in Appendix I.

The conversion of infestation data to economic loss quantification requires additional knowledge of both production volumes and prices. Data on Indian production of fruit and other hosts will be obtained from a variety of official and unofficial sources - FAO databases, National Horticulture Board (Negi 2000a,b). This will be combined with price data to obtain values of production of various hosts to farmers.

Findings of infestation levels will be formally tabulated as follows:-

- Host species and variety
- Loss estimate (%)
- Fly species
- Location of any preserved specimens
- Control(s) in force
- Month(s)
- Year(s)
- Any meteorological information
- Location, as placename, ecogeographical zone and latitude and longitude
- Source

1.1.3: Review of Biological Knowledge

Much valuable biological information exists, for example on determinants of fly abundance, from laboratory and field records of abundance associated with temperature, humidity, host nutritiousness, *etc*, all of which are to be tabulated by species and location.

An important component will be a tabular record of particular fly species' preferences for and survival in particular host species. Studies on oviposition preferences and host suitability by factors such as survival percentage and development speed, particularly when comparative between different hosts and flies, provide another insight into infestation and loss rates, as those species with high preference for and survival in certain hosts may reasonably be expected to be the same as do those hosts most damage. The literature survey will include reports of laboratory rearing studies showing and evaluating preferences for particular hosts by particular flies in particular areas. All will build on the tabular structures outlined in Appendices I and II.

1.1.4: Tabulation of Controls

Findings of the effectiveness of lures and bait will be tabulated as follows:-

- Nature of attractant
- Attraction level
- Fly species
- Sex of catch
- Location, as placename, ecogeographical zone and latitude and longitude
- Source

A tabulated record will be assembled of other control techniques giving the level of control obtained and the circumstances - to cover all cases of toxicities of insecticides, pathogens etc., pupal destruction, fruit removal, host resistance and natural enemies *etc*.

Knowledge Review: Material Requirements

Apart from the standard requirements above, requirements will be of photocopying facilities (it is proposed to copy all relevant articles not in the Pusa Institute main library, and to place the copies there) and a travel budget, as the researcher will be required to visit institutions and libraries.

Activity 1.2: Survey

Survey activities will be carried out at all locations (8) of "Experimental" activities. Because annual fluctuations in populations are pronounced, and vary between years, zones, hosts and fly species, the survey will be run for two years. The components of the survey are intended to be carried out at the same sampling points by the same researchers. These components are intended to address each others' strengths and weaknesses, to allow synthesis as discussed below.

While limited in the number of sample points accessible, the survey may be seen as a trial or pilot of methodology. If the monitoring activities at each sample point can be established to be useful, the number of points may be increased in a future study. Information gathered will be integrable into technified wide-area studies (particularly sharing protocols with existing computer database and GIS studies), existing insect reference specimen collections so that these are augmented, and with other plans for taxonomic and surveying studies. It will also help to establish a network of contacts between fruit fly researchers, and is hoped to be a first step to comprehensive "stress maps" of where the pressure on crops is applied, as losses in terms not only of areas but by crops (possibly even varieties), by seasons (or months), and under which control treatment regimes

1.2.1: Trapping

The survey will record incidence and abundance of species and subspecies, by a standardised suite of traps:-

1 - parapheromone lures
    methyl eugenol
    cue-lure
    trimedlure
2 - food bait
    protein hydrolysate
    fruit pulp
    jaggery
    sugar
3 - visual - coloured sticky balls
    yellow
    red

It is proposed to use home-made traps from local or re-used materials, rather than specialised, imported versions. This is not to save money *per se* so much as to minimise the cost of the "standard

trap set" so that it may economically be extended in future, if need be, to a larger number of sites (and be less prone to theft). Lure traps may be made of PET drinks bottles or plastic sachets (Verghese and Jayanthi, 2001), food traps of such bottles or plastic ice cream tubs (Nakagawa *et al.*, 1975; Rhode and Sanchez, 1982) and visual traps by painting sticky adherent to coloured plastic toy balls; the construction of these traps, however (receptacles used, number and size of holes *etc*.) will require standardisation, possibly with reference to international studies. It may be necessary to begin with some comparative studies to evaluate candidate traps for relative power, as is being done in India for cotton pink bollworm traps (Tamhankar *et al.*, 2001). In a selection of sites it is proposed also to use specialised, imported traps such as McPhail traps, to allow the relative catching power of home-made and imported versions to be calculated for calibration.

Each survey zone will include two trap set replicates in the same district, separated by at least 1km. In each trap set the lay-out will be as a circle 10m in diameter, with advantages of direction given to the less powerful - coloured sticky balls facing west and south, parapheromone lures facing north and food lures facing south and east. Traps will be monitored weekly year-round. Additional records will include the simplest ways of recording the known important extrinsic factors dictating abundance - host availability and temperature were found by many studies to be the major determinants of abundance (eg Shukla and Prasad 1985) although it may be desirable to include relative humidity, though costlier to record. Records will comprise the following:-

1: Annual Record Sheets will record each trap site's map reference, altitude, ground vegetation and building cover and the approximate percentage land surface coverage by the eight most important crops over (a) the surrounding $1km^2$ and (b) the surrounding $100km^2$. This will be done by simple ordinal scores of estimates, for example of vegetation cover as 0=none (0%); 1=small patches or isolated individuals (1-10%); 2=medium patches or several individuals (11-30%); 3=large areas or many individuals (31-60%); 4=dominant, near-continuous (61-100%).

2: Weekly Record Sheets will record:-

a - All Tephritid catches by trap, species and sex

b - Weekly near environment, as the developmental stage of each crop, with estimates of fruit production, the week's weather and other local events such as irrigation and pesticide sprays. This information, though often largely subjective and impressionistic, will enable allowance to be made for peculiar local factors such as chemical sprays or large flushes of particular host fruit, which may influence local trap catches

c - Temperature by maximum-minimum recording thermometers. Cheaper and simpler than equipment to record average temperature, which requires continuous temperature monitoring, these allow the recording of day degrees or thermal units (Aliniazee, 1976) given as the average of maximum and minimum temperatures minus 5 degrees, which was found by Shukla and Prasad (1985) to be a close predictor of fruit fly abundance.

3: All catches from food and visual traps (cleaned and prepared as necessary) and a sample of at least 30 flies from each lure trap, will be pinned out, remaining lure catches will be preserved in jars of alcohol; all will be cross-referenced to their data sheet records.

Trap Survey: Material Requirements

- Trap suite as above, with baits, lures and killing strips.
- Water, alcohol and acetone for cleaning of flies from bait and sticky traps
- Dry mounting materials - plastezote sheets, pins, labels, mounting cases, desiccant and preservative chemicals
- Wet preservation materials - alcohol and jars

1.2.2: Rearing Out

Susceptible fruit of important types will be collected for the rearing-out of fly pests and natural enemies. As very demanding of resources if done on a large scale, this part of the survey will be largely *ad hoc* rather than systematic or comprehensive, to clarify and enlighten points raised by the

other methods. In fields where losses are substantial but typical of the area, and particularly where dual attack by two (or more) species is suspected, 30 fruits will be selected, as late as possible before harvest to obtain the most accurate estimate of commercial loss. Each sampled fruit will be kept in isolation to allow records of the distribution of flies or parasitoids among fruit. Fruit will be placed on sand, regularly sieved for emerged pupae, which will then be transferred to glass phials stoppered with cotton wool to await the emergence of adults for identification. Adults will be fed and watered for 48 hours to allow colours to develop, then killed and mounted. Emergence records will be made on standard data sheets which will be copied onto standard spreadsheet analysis templates. These automatically calculate the percentage infestation, and also several variables which determine the relationship between larval population and fruit infestation (and therefore economic loss):

- average number of larvae per infested fruit
- departure of larval distribution from a random Poisson model
- spread between within-tree and between-tree variation sources
- association between infestation frequency and the number of larvae per infested fruit

Hosts will be harvested at or near harvest, to obtain the best possible economic loss estimate. It is anticipated that at any one sampling point the maximum number of batches of 30 fruit kept at any one point will be between 2 (60 fruit) and 5 (150 fruit) and that the maximum in any entire year be between 10 (300 fruit) and 20 (600 fruit).

Rearing Out Survey: Material Requirements

- A cool and ventilated rearing room, with a maximum-minimum-recording thermometer
- Vessels, sand and gauze for keeping fruit
- Sieve for extracting pupae
- Phials and cotton wool for rearing pupae
- Killing agent
- Dry mounting equipment as above

1:2.3: Key Informant Survey

Estimates of infestation and economic losses will be obtained in a survey of farmers, extensionists, researchers, NGOs, cooperatives, traders, host fruit wholesalers and retailers, and service industries such as pesticide salesmen. Key Informant Surveys allow a cost-effective intermediate between formal, full-scale randomised-sample questionnaire surveys and other informal techniques such as Rapid Rural Appraisal and other group studies, allowing individual informants' estimates of quantities such as percentages to be compared with each other and thus validated (Escalada and Heong, 1997). In comparison with formal surveys, informal surveys generally obtain results virtually as good with much lesser costs in time, manpower and other resources (Franzel, 1984). (At the moment a formal survey is not envisaged as part of this project).

As well as absolute fruit fly infestation, this survey will pay attention to fruit fly severity relative to the problems of other, perhaps more serious, pests. No pest problem can be practically addressed by consideration in isolation, and the interactions, for better or worse, of fly controls with those of other pests will greatly affect their usefulness to farmers. Fruit flies are by no means always and everywhere the most serious pest of their hosts: other pests of similar hosts include serpentine leaf miner, viruses borne by aphids and thrips, scales, shoot borers, midrib folders, seed and fruit borers, jassids, sapota bud borer, mango hopper, mealybug, leaf webber and stone weevil. Farmers often misidentify the causes of damage, and are sometimes more likely to mistake other damage for fruit fly than vice versa. Mango farmers in Vietnam, for example, commonly mistake damage by the seed borer *Deanolis albizonalis* for that by *Bactrocera dorsalis* (van Mele *et al.*, 2000). For this reason it is important to "triangulate" the estimates of farmers and other groups - particularly trained ones such as researchers and extensionists – to control possible sources of bias.

It is proposed that each survey point interview 12 to 20 respondents. Full notes must be taken of these conversations, whose usefulness is not limited to the bald replies to formulaic questions (see below).

Key Informant Survey – Draft Question Set

- Position of respondent (e.g. farmer, extension agent, farm input salesman)
- In this area what are the main crops grown - area, production and prices?
- What are, in rank order, the eight most serious pests, and on what crops (including non-fruit-fly-hosts)?
- What are the percentage losses of production to fruit flies if left uncontrolled, host by host?
- What is the incidence of local control practice(s), host by host (e.g. "10% of mango farmers use methyl eugenol traps" or "Two-thirds of cucumber farmers spray insecticide")?
- What is typical expenditure on local control practice(s) (e.g. "Most farmers spray cucumbers four times with product X or product Y; each takes A man-days per hectare and costs B rupees")?
- What are the percentage losses of production to fruit flies, with local controls, host by host?
- Overall, what do people think about the fruit fly problem and the controls available to them?

Key Informant Survey: Material Requirements

Notebooks, question lists and software

1.2.4: Semi-Structured Interview (SSI) Survey

For social goals, it is also important to establish to which social and economic groups costs and losses fall, and what are the opportunities available to farmers and pest managers. Economic considerations alone provide only a limited understanding of whether control recommendations will actually be attractive and useful to farmers. Additional questions arise of farmer resources, opinions and perceptions for fly management, and it is proposed to address these with a social-science-led study of how control options are perceived, so that candidate technologies are evaluated following considerations of farmer priorities, not ahead of them, and of the institutional and economic factors which may enhance the acceptability, value, uptake and success of control technologies. The variety of folkloric and other controls mentioned above will be acceptable and useful to farmers, or not, depending on their match with farmers' resources (access to cash for inputs which must be bought, access to labour and information for controls requiring them), opinions (in some cases different resources, for example cash, labour or information, may be to some extent inter-substitutable - when so, which farmers will prefer to use will depend on their opinions and preferences rather than any formal economic cost-benefit analysis) and perceptions (the desire to substitute low-chemical controls for large-scale pesticide use may depend largely on farmer perceptions of pesticides as unhealthy or unnatural and so requiring minimization beyond strict cost-benefit comparisons).

Farmer responses to fly pests may comprise nothing, cover sprays, bait sprays, lures, or some form of Integrated Pest Management (IPM). There is a need to know what is done, the reasons for these, their requirements for resources (such as access to sprayers) and economic and other costs (particularly of pesticide use on health, beneficial organisms and the wider environment) and perceived effectiveness and farmer satisfaction. This information requires supplementation by knowledge of the social and institutional context of controls, in terms of support services and delivery of material inputs such as pesticides and lures. Economic structures are important, providing farmers with access to markets (traders, transporters, wholesalers and retailers) and with the products or services used for pest management (pesticide and input manufacturers, importers, dealers and retailers, and contractors providing pest management services). The role and behaviour of these impinging institutions will also be considered.

In addition to the Key Informant Survey, and to some extent involving conversation with the same people, will be a qualitative survey by Semi-Structured Interviews (SSIs), in which a basic list of core questions is asked where possible, but at the same time maximum attention is given to exploiting interesting or unexpected remarks, to allow the exploration of perceptions and opinions on a wide range of relevant topics, a process often characterised as "Art as much as science" (Rhoades, 1982). In contrast to formal surveys, where the desired outcome is often statements such as "X% of farmers practise Y"; in SSI surveys the desired outcome is explanations and rationales of why people think what they do, in such statements as "Those farmers who prefer Y do so because they consider A more important than B; those who do not prefer Y consider B more important than A." Specific techniques may be used such as "elicitive contrasts" to find the reasons for choices by contrast with rejected options such as "Why did you choose this rather than that?" - which often elicits reasons better than direct questioning such as "What reasons did you use?" (Gladwin, 1983). Information may be extracted as stories or history. Simple ranking and scoring may be done, as in matrix scoring of control options (cover sprays, cultural controls, bagging, lures) with criteria of effectiveness and problems (expense, hard work, boredom etc) to allow formal cross-comparison of the pros and cons of individual options in farmers' eyes (in this sense loosely analogous to cost-benefit comparisons). The objective is to understand the reasoning, logic and other thought processes directing perception and behaviour, rather than reaching a "sample" representative of a "population" (Yin, 1994).

Semi-Structured Interview Survey – Draft Question Set

- How serious are fruit flies as pests?
- How does their attack differ from that of other pests?
- What do you and/or your neighbours do about them?
- How and why do these controls differ from those against other pests?
- How did these controls come to be used?
- Why are these controls used rather than others - were alternatives tried before rejection, and what went wrong to make them unsuitable?
- Where does advice come from, what form does it take and what effect does it have?

It is proposed that 12 to 20 farmers be interviewed for each SSI survey point. Many will be the same respondents as for the key informant survey, but researchers must ensure that respondents represent the general run of small farmers - *i.e.* the smallest smallholders. Full notes must be taken of every conversation, and these must be fully typed out, in English, into word processor files. This is particularly important: as the training and preparation for this research will address, valuable information is sometimes likely to be disregarded on first receipt, and it is all too easy to forget or omit important information when notes are being taken or typed up. Only full English-language notes will permit verifiable and checkable conclusions to be drawn and cross comparisons made between different areas (with different local languages).

Semi-Structured Interview Survey: Material Requirements

Question lists, notebooks

1.2.5: Synthesis of Survey Outputs

The quantification of infestation is complicated as each of the various methods available has weaknesses as well as strengths. Trap catches are a poor guide to infestation, as species differ in their susceptibility to lures and baits, *Dacus ciliatus* for example being relatively indifferent to both. Estimates by farmers, traders and even researchers are subjective and prone to distortion. The rearing-out of pupae from sampled fruit is complicated and costly, represents generally only small and imperfectly-selected samples, ignores losses caused by the premature fall of infested fruit, and requires repeated sample through the season to capture full losses as a sample taken only at harvest will ignore flies which have already damaged fruit, emerged and pupated.

The proposal here is to maximise reliability, by the integration of all available methods to lock together to exploit the particular strengths of each method. If, for example, *Bactrocera dorsalis* were caught as 10000 in methyl eugenol traps, 5 in protein traps and 30% by rearing-out, and *Dacus ciliatus* were caught as zero in methyl-eugenol traps, 4 in protein traps and 60% in rearing out, and the total loss estimates from key informants and literature for the neighbourhood were of 45%, one might infer overall losses of that host to *dorsalis* of 15% and to *ciliatus* of 30% - an outcome not reachable from any methods considered in isolation from the rest of the suite. Table III.1 shows the relative strengths and weaknesses of the four methods, and how their strengths offer mutual reinforcement.

Table III.1. Relative strengths (3=high; 1=low) of different methods of estimating fruit infestation.

Method	Quant-ified	Compre-hensive	Object-ive	Realistic	Inexp-ensive
Trapping	1	3	3	1	2
Rearing out	2	1	3	3	1
Key informant survey	3	3	1	3	3
Literature survey - loss	3	2	3	3	3
Literature survey - biology	1	1	3	1	3

Percentage infestation and loss figures gathered from these sources may be integrated, as by Stonehouse *et al.* (1998, 2001) in Seychelles and Pakistan, and a start to such an operation for India is sketched out in Appendix I. This approach, it should be conceded, will not obtain fully precise loss estimates due to the complexity of fruit fly losses (e.g. differential development and attack rates among sequential cohorts of fruit on the same tree and collected at the same harvest) but provide some indication, and the economic evaluations of losses, as the product of crop loss, production volumes, and crop values/prices, is essential to calculate total losses for the rational cost-benefit analysis of the returns to investment in management (including research proposals such as this one).

Economic losses may be estimated as the product of production statistics, infestation or loss rates and price data, all obtained as discussed. Current information is limited to calculations from production volumes and market prices in publications and inferred losses from the literature, but a preliminary attempt at synthesis for some of the important tree fruit is given in Table I.3. It is important to obtain estimates of the areas which are protected, and how, as opposed to unprotected; these data may be obtained from a combination of literature and key informant surveys, as outlined above.

The above will also gather, albeit in simple form, the following information:-

i - yield without fly controls
ii - yield with fly controls
iii - prices
iv - spending on controls

Thus a simple cost-benefit analysis of different control methods as currently in use may be carried out, as the estimation for each crop, area and control of the net value of control as [(i-ii)*iii-iv]. Although simple, this will allow some evaluation of the returns to existing controls, and suggest options for their improvement.

Activity 2: Farm-Level Control Experimentation

Many different control options have been evaluated and/or recommended in India. These range from cover sprays to cultural controls such as fallen-fruit collection to locally-derived lures and baits such as basil, fruit juice, ammonia, jaggery and molasses, often fermented, as described in Appendix II. This study will systematically compare the costs and benefits of these, paying particular attention to the "attractant" techniques of lures and baits, which offer promise for economical control with minimal pesticide use. Attractant controls may be efficiently and quickly assessed as "single

killing points", and these techniques will be used for the rapid evaluation of large numbers of candidate attractants.

Although the assessment of cover sprays requires full-field trial analysis, single-killing-point evaluation can evaluate both attractants and lethal ingredients. As ingredients in attractant controls, there are many lethal elements used against fruit flies, including synthetic chemicals, neem, other botanicals and pathogens. Neem may be suitable for cover application but not for combination with attractants, which depends on the attraction of flies to baits and lures, and a question is whether neem, which has a slight repellent as well as insecticidal effect, may work as the killing ingredient in these, or may repel flies and thus undermine attraction and mortality. Other botanicals such as *Ipomyia* and *Pongamia* may be worth assessment for use alongside neem. Active-ingredient comparisons may also include entomopathogens. In general, farmers distrust sprays of these because of the destruction the pests may cause in the incubation interval between being infected and overcome. If it is the case, however, as generally assumed, that many protein meals are taken by females who need the protein to develop eggs, fungal bait applications may be effective, as the fungus may develop pathogenicity in the interval needed for egg development. Several Indian research institutes have cultures and expertise of *Metarhizium, Beauvaria* and faster-acting crystalline *Bt* proteins.

This study will include a systematic evaluation of the real cost-effectiveness of different baits, with kills distinguished by sex, and with the evaluation of *p*H (Heath *et al.*, 1994) and possibly salinity and amino acid content effects. It will allow for the rapid mass-scale processing of evaluations, with reference to commercial protein hydrolysate as a standard. "Home-made" preparations will at least initially be from commercial preserved preparations, with the same batch number, to allow reliable comparability of baits in different sites - for example tinned cat food for fish.

Preliminary assessments of the autolysis of brewer's yeast cells may be carried out with use of a medical haemocytometer to record cell rupture - this may provide a quick way to assess the relative performance of proteolytic enzymes to find a cheap alternative to papain (several fruits contain proteolytic enzymes).

Methyl eugenol, the best-known parapheromone lure, is available and used over much of India to attract males of *Bactrocera dorsalis* and *zonata*. Lures may be used in a variety of formulations such as plastic traps, with and without insecticide, and soaked-wood killer blocks; which of these are most cost-effective for farmers with different resource availabilities in terms of chemicals, traps and labour, will be studied.

The study will also compare the performance of mixtures of baits and lures relative to one alone, by a series of fully factorialised comparison of possible combinations, as the following treatments: current unconfirmed impressions are that bait and lure may negatively affect each other, but that mixes of multiple baits or of multiple lures may offer advantages, hinted at by some results reported in Appendix II.

Assessment will be by a tier of control assessments for bait and other on-farm controls, progressing in increasing cost, complexity and realism. This process of "industrialising" bait and lure assessment allows the rapid, replicated and systematic evaluation of baits, hopefully permitting "fine tuning" of sensitive variables known to affect effectiveness. It economises by the initial assessment of attractant controls by counting flies which are attracted to, and killed by, a single "killing point". This produces direct information about the effectiveness of individual killing points, and reduces demands for space, as only one point is assessed instead of an entire plot, and time, as the number of killed flies itself comprises the data, instead of the assessment of fruit damage and yield. This method includes insecticide in the full field bait formulation, allowing comparison of not only attractants but also insecticides and deployment methods - comparing, for example bait spots applied to foliage and wood and traps as are used made of coconut shells or ceramics. This research will proceed in a hierarchy of levels of increasing realism with increasing cost and time-consumption, in three stages from laboratory single-killing-point studies to field single-killing-point studies to farm-level studies (with economic and social evaluation forming in a sense a fourth tier). These research strategies have been evaluated by

Imperial College in the past, and three proposed peer-reviewed papers (one at time of writing in press, two in preparation) are appended outlining the history of their use (Appendix IV).

2.1: Laboratory Single-Killing-Point (SKP) Evaluation

This system has been successfully evaluated (Zia *et al.*, 2001; Stonehouse *et al.*, 2002) but may require refinement. The proposed laboratory methodology minimizes uncontrolled effects by assessing baits not individually but as simultaneous comparisons of pairs in choice chambers, so allowing extraneous differences such as time of day, fly age, nutrition and the order of testing to be discounted. Comparisons are made in a series of two-way choices, between two different bait formulations placed at opposite ends of a long cage arena. On the centre line, equidistant between the two treatments, freshly-emerged adult flies are released, and subsequent fall of dead flies recorded on either side of the centre line, to give a relative estimate of the power of each deposit to attract and kill flies. Each cage is 2m long, 0.5m wide and 0.5m high, of a painted wood frame, floor and ceiling, with glass and gauze walls, and contains a dish with a sugar-water wick placed on the centre line. Between the two treatments at the cage extremities, the arenas are filled with untreated potted young plants, to mimic a field in which only a fraction of plants have been treated, and to evaluate realistically the powers of the deposits to attract and kill flies at a distance through a stand of untreated plants.

Cages are checked every day to see if flies remain alive, and then corpses counted by sex and location when all are dead (there is little point in counting flies daily, as this experiment gives little information about deposit decays, as if one decays faster than the other, the second may give a meaningless impression of increasing in potency). The experimental design allows standard assessment of data, on prepared data sheets for entry into standard spreadsheet analysis files by 2-way replicated ANOVAs of treatment and fly sex. Experimentation will begin with some runs to check the validity of the equipment - checking that attractant controls collect more fly casualties than insecticide alone, and that two identical preparations attract equal numbers of flies.

Laboratory SKP Evaluation: Material Requirements:

- 8 wooden cages, built in 2 blocks of four. Each cage 2m long x 05m wide x 0.5m high, allowing each block of four to stand 2m high. Wooden construction, standing on short (10cm) legs to exclude ants.
- An indoor environment to allow the cages to be set up symmetrical to possible disturbances such as heat and light sources, including a maximum-minimum recording thermometer and, to allow experimentation throughout the year, possibly heating in some parts of the country.
- For every replicate in every experimental comparison:
    - 20 freshly emerged adult flies
    - 2 potted plants to be treated and disposed of
    - 10 potted plants, not to be treated, capable of being reused

For food lures, each experiment lasts 5-7 days. For continuous operation, therefore, the replicate needs will be required every week - the required production of flies and plants will be the major outlay.

2.2: Field Single-Killing-Point (SKP) Evaluation

This methodology has been used in Pakistan and Mauritius (Afzal *et al.*, 2001; Zia *et al.*, 2001; Stonehouse *et al.*, in prep. A). The principle is that the flies killed by a single killing point (bait spot or lure block) in a real field situation are collected in a receptacle hanging below it, for counting and thus evaluation of the relative lethality of different killing point types. Killing points hung in plantations or fields are checked and emptied daily or weekly, and fly counts used to assess lethality and the duration of its effects. For reliability of comparisons, it is well to have beneath at least some of the collectors further, precise collectors to allow the assessment of the distribution of dead flies falling outside the main collector, and thus how the main collector represents the total fly mortality attributable to the killing point. Initial comparisons were with a tier of descending and widening collectors to evaluate the curve of corpse catch decay with distance from the killing point. This had drawbacks in (a) the coarse grain of distance catches and (b) the need for correction of catches with the descent of collectors in

tiers. It is proposed to replace this by deploying alongside the main collectors a few (2 per experimental block) "calibration collectors", flat sheets hanging below the killing points at the same height at the treatment collectors, but allowing the precise location of each dead fly to be recorded upon falling. The construction of these remains to be finalised, but the current plan is to use extruded-plastic grille mesh used to support perspex sheets below fluorescent lights in suspended-panel ceilings. This mesh comprises sheets of cells, about 3cm square in plan and with plastic walls about 2cm high. It is already used to form individual-rearing cells for predatory insects by biological control researchers at Gujarat Agricultural University, and may hopefully be put together by combining panels, both alongside and on top of each other, to obtain sheets about 2mx2m square, composed of hundreds of cells, open at the top (to allow flies to fall in) and floored with mesh (to trap flies while allowing rainwater to drain out), 3cm square in plan and about 6cm high (to prevent dead flies from being plucked out by the wind). The study of dead flies in such a grid, below a killing point, will allow the detailed analysis of how dead flies fall, and thus the modelling of how catches in treatment collectors represent total mortality by each killing point. The use of a rectangular grid will allow analysis by vector algebra statistics (Batschelet, 1984).

Field SKP Evaluation: Requirements

- Treatments: - baits, lures, insecticide(s), ethanol solvent, lure blocks, bait applicators, traps
- 50 killing point collectors to be deployed by each research group, in various combinations of numbers of treatments and levels of replication
- Access to field sites of adequate size and number for collectors with bait treatments to be 7.5m apart, those with MAT treatments 15m apart.

2.3: On-Farm Trials

These will be required both for methods not amenable to single-killing-point analysis, such as cover sprays, and for the final economic evaluation of attractant controls identified as promising by smaller-scale studies - the attraction and killing of flies is not the same as obtaining actual control, and should not automatically be taken as a proxy for it. There is often a suspicion that male lures merely kill males without reducing female matedness, and that some recommendations for male trapping may confuse in the farmer's mind its usefulness for population monitoring as opposed to actual control.

Cover sprays, while considered by IPM practitioners the last resort, can and do control flies when applied in a position to do so, and will not be assessable by single-killing-point technology but will require full-field evaluation. The comparison of cover sprays of neem with BAT may be valuable.

Most recommendations to farmers combine at least two control techniques as an integrated package. Full-field-level controls will be needed for assessment of combinations of cultural controls (fruit destruction, ploughing), bait sprays, parapheromone lures, cover sprays *etc*. Only full-field trials will show the fullintegrability of various control techniques.

Fruit samples will be of six fruit on each of five randomly-selected trees in each experimental plot, with two or more experimental plots on each farm (depending on space). Initial results (Stonehouse *et al.*, in prep. B) indicate that six farms or sites will be required for each comparison.

Assessment will be by a standardised suite of records of fruit production, infestation and harvest, initially developed elsewhere (Mahmood *et al.*, 2001; Stonehouse *et al.*, in prep. B), comprising the following.

i - Harvested yield Harvests from all plots will be assessed and recorded by farmers and/or assessors as weights of counts of fruit, at the farmer's convenience. Prevailing price data will also be gathered, along with relevant costs (particularly estimates of control costs) to allow the economic returns to different practices to be compared.

ii - Fruit production Estimates will be made of the numbers of fruit on each of five trees sampled, and the area of ground covered by each tree and its height. Numbers of fruit will be divided by an estimate of tree volume, obtained by multiplying the height by area estimates, to obtain an estimated density per cubic metre of tree canopy. Fruit on the ground will be counted in three randomly-thrown

square-metre quadrats beneath each tree, and the average of these, as a mean value per m2, divided by the tree's estimated height to obtain an estimate of fallen fruit per cubic m of canopy. Differences in the tendency of fruit to fall will be compared by the ratio of fallen to tree fruit per m3 of canopy.

iii - Fruit infestation Infestation of fruit will be assessed by three methods.

1 - Harvested fruit counted and categorised by the farmer into pristine, fly-attacked and not visibly attacked but spoiled by rot or similar.

2 - A formal sample of susceptible fruit taken from the field as late near harvest as possible (a previous one just at the beginning of control implementation may also be done, to allow researchers practice in techniques and to check for non-treatment differences between treated and untreated plots). These will comprise 30 fruit, as six fruit from each of five trees. Fruit will be inspected and classified into those unblemished, apparently oviposited, apparently exit-holed and rotting.

3 - The same fruit are to be kept in field laboratories for the collection of emerging flies. Fruit will be kept in cool rooms (checked by maximum-minimum thermometers), in individual containers, to allow the quantification of larval distribution among fruit and of numbers of fruit infested. These characteristics will be analysed by spreadsheet programmes. Additional to economic differences between treatments, the spreadsheet automatically tests the characteristics of larval distribution as outlined above.

The three approaches complement each other by balancing precision and robustness: the formal samples (2 and 3) are relatively small (30 fruit) and taken not at harvest but before, whereas farmer assessments (1) are of the whole harvest taken as it was gathered; visual damage assessments by farmers (1) and researchers (2) are essentially subjective, and uncertain indicators of fly attack (oviposition punctures can resemble other blemishes; exit-holes can resemble bird and beetle attacks) but the rearing of larvae from fruit (3) while objective and certain, lacks robustness in field conditions where collection, transport and storage may affect larval mortality, for example if rearing laboratory temperature and humidity fluctuate beyond those in the field. These relative advantages are summarised in Table III.2.

Table III.2. Fruit infestation methods scored as to advantageousness by criteria (1=low; 3=high) (adapted from Stonehouse *et al.*, in prep. – Table IV.C.1).

Criterion	Farmer harvest estimate	Sample inspection	Sample Larva rearing
Sample size	3	2	1
Proximity to harvest	3	1	1
Objective certitude	1	2	3
Robustness	3	3	1

Activity 3: Village-Level Trials

Fruit flies are controlled in a coordinated way over large areas in many parts of the world, including Mauritius (where *B. zonata* has been controlled to "very low levels" by area-wide bait sprays, Permalloo *et al.*, 2001), Israel (where 27000Ha are simultaneously treated, reducing medfly infestation of citrus to less than 0.05%, Gazit and Roessler, 2001) and South Africa (where an experimental use of Sterile Insect Technique over a single valley has obtained zero medfly infestation, Barnes, 2001). It is proposed to include a study of the extent to which economies of scale accrue when control is area-wide as opposed to on individual plots, and of how the benefits of area-wide controls may be most efficiently realised by social and economic structures. Economic "externalities" arise when the costs and benefits to the agent of a particular action are not the same as those to society at large: for example if a private trading company raises a navy to protect its ships from pirates, other ships enjoy protection without making a contribution, as "free riders". Such cases require communal action in order effectively and sustainably to share the costs of social action (Mumford and Stonehouse, 1994), ideally through voluntary "bottom-up" cooperation to contribute to shared costs for

general benefit. Socially-cooperative control offers great benefits in cost-effectiveness, but requires full cooperation to attain these (Enkerlin and Mumford, 1997).

3.1: Village-Level Institutional Study

Village-level studies will begin with a survey of village-level institutions which may provide cooperation and concerted action by groups of farmers. This will require social organisation and thus entail a key role for coordinating institutions such as cooperatives, NGOs, government agencies, self-help organisations and traditional institutions such as religious bodies. Sadly, it is often the case that cooperative area-wide controls set up by state bodies, though highly profitable for and enthusiastically welcomed by farmers, are not carried on by individuals and voluntary organisations when state support is withdrawn, as is happening in Mauritius (Permalloo *et al.*, 2001), and so the robustness and commitment of social organisations are critical for the sustainability of area-wide control even when its efficacy is proven. The study will assess how such institutions may productively, reliably and sustainably provide the cohesion required. India, with its particular wealth of social organisations and groupings such as these, offers a particularly promising location for a study of this sort into how exactly such organisations may realise economies of scale in the optimisation of pest management.

The study will take the form of visits to candidate villages, with the establishment of cooperative links with farmers' organisations, sounding out the possibilities of research cooperation in village level control, with the following draft question set for each:

- Nature of organisation
- Extent and budget
- History and development
- Goals, including any statement of principles
- Essential operating philosophy, including any statement of principles
- Extent of inclusiveness - to cover all residents or a specified subset
- Level of success and public perception
- Nature and functionality of relations with other organisations

This may be supplemented by village-level group participatory rural appraisal (PRA) discussions of why and how people might find it profitable, practical and sustainable to carry out controls jointly.

Village-Level Institutional Study: Material Requirements

Access and contacts in candidate villages and organisations. Notebooks.

3.2: Village-Level Trials

It is proposed in the second year of fieldwork to evaluate wide-area control at village level, in liaison with village organisations contacted and evaluated previously, such as extension services, cooperatives, NGOs, *etc*. Due to the difficulties of this research, few quantified studies of the minimum area suitable for area-wide control have been performed, so the current "best guess", possibly awaiting future refinement, is for one square kilometre (suggested by Cunningham, 1989) - roughly a small village and its immediate garden environs. The objective is to implement season-long wide-area village-level control, and to assess its success by evaluating fly populations and damage (as described above) inside and outside the protected area(s). Village-level control will be assessed relative to not only no-treatment but also to farm-level control outside a village-level control context, to assess the added value of cooperative control. It may be that village level of a certain level of intensity will not eradicates flies, and so there may still be room for further improvement by farmers in the protected area carrying out on-farm controls on their own account as well, so that village- and farm-level controls deployed together may obtain superior control to either alone. The current proposal is for a factorial design – at each of the eight experimental centres four villages will be assessed, two with and two without village- level control (to allow two replicates of each full treatment at each of the eight research centres). In each village one farm will receive farm-level control, and another will not. This design is intended to show the relative effectiveness of farm- and village-level control, and of

interaction between them, in a factorial design, as shown in Table III.3. Each village will be monitored by a trap set, as in 1.2.1, and each farm by the on-farm production and infestation monitoring technique set, as in 2.3.

Table III.3. Suggested factorial design for the evaluation of village- and farm-level fruit fly control.

Control		Farm-level	
		No	Yes
Village-level	No	No control	Farm-level control only
	Yes	Village-level control only	Village- and farm-level control

Village-Level Trials: Material Requirements

If possible to be evaluated at four villages per experimental centre.

- baits, lures, insecticide, applicators for control
- trap suites for monitoring, as in 1.2.1, above
- on two farms: fruit production and infestation assessment, as in 2.3 above

3.3: Participatory Rural Appraisal of Village-Level Trials

The evaluation of farmers' and villagers' opinion of the usefulness and practicability of village-level control will be by means of participatory group appraisal (PRA) and group discussion, as well as survey and SSI activities. Discussions will focus in particular on how villagers may see opportunities for organisations and institutions to ensure that area-wide control, if seen as worthwhile, is sustained, with continuing commitment to the resources needed, and not fragmented and lost.

Additional: Focussed Research and Information Gaps

The use of student researchers under academic supervision is intended to leave time and resources for individual research projects to focus on specific problems, either points of interest or information gaps identified by the Knowledge Review. Personnel will have more time for this in the second than the first year of the project and, of their nature, these cannot be predicted at this point, but possible future topics may include:-

- Role of cultural controls such as the ploughing and/or harrowing of soil to destroy pupae and the collection and destruction of fallen fruit. Sadly, both these practices appear too demanding of time and energy to be favoured by all but the keenest farmers. The difficulty with fruit collection is its destruction, as discussed in Appendix II.
- Other cultural controls. In Pakistan, Khan *et al.* (1992) found that in a trial of various techniques the best economic cost:benefit ratios were 1:9 for ash dusting, 1:7.9 for intercropped squashmelon as a trap crop and 1:2.7 for poisoned cut-melon baits. This is a slightly atypical result which may repay further study.
- In general, the value of IPM is inherently difficult to evaluate, as the implication of the value of more than two treatments at once requires the assessment of each individually, as well as of different combinations of some or all, so that the number of evaluation options increases as the factorial of the number of controls deployed, with consequent large demands on research resources for evaluation. As a result, mathematical computer models are often required for the full assessment of IPM, and the development of such a model for fruit fly control may be a worthwhile aim. Mathematical modelling is not part of the project as currently proposed.
- When two or more control techniques are deployed together, their effects may be less than the sum of their parts if, after the action of one control, the action of a second imposes mortality which is positively density-dependent, so that fractional mortality is less than if the first had not been deployed - life table analysis may show if this is the case. Conversely, two or more controls may have an effect

greater than the sum of their parts when the effectiveness of the second is negatively density-dependent, being greater at low densities - this is often the case in fruit fly controls, where those which work by mating interruption by denying females access to males, such as MAT, often function best at low population levels; this too may require some study, particularly of mate-seeking behaviour in males and females.
- For the optimisation of area-wide control, some fundamental questions of fly management biology may be addressed by behavioural studies in the laboratory. For example, in Male Annihilation Technique (MAT), there is a need for studies as to what do mated and unmated females and males do, and in Bait Application Technique (BAT) as to what males and females eat, and to what foods are they attracted, how often they feed and with what intervals relative to inferred satiation, and how food seeking and consumption are affected by age, fedness, matedness *etc*., by laboratory studies of exactly how freshly emerged adult females respond to different requirements (males, sugar, protein) by attraction relative to their tendency to migrate (capturable in the laboratory by frequencies of taking to the wing rather than roosting, feeding *etc.*).
- Similar questions of wide-area control entail studies of fly migration, as this will critically affect their capacity to cross the control barriers which provide the advantages of area-wide control. In Madagascar *Ceratitis malgassa* has a specific pattern of annual migration, including a migratory morph (Raveloson-Ravaomanarivo, 1996). The study of fly migration across barriers may be approached by a variety of methods including mark-release-recapture studies (Stonehouse, Manrakhan and Mumford, in prep.). If all the pupae in an area may be annihilated (by ploughing, soil treatment, or plastic-sheet sterilisation) then all flies subsequently found may be assumed to be immigrants - the scale on which this provides any crop protection will indicate necessary scales for social control (the destruction of pupae at individual farm level, for example, may offer not benefit to the farmer if fly immigration swamps its effects, and so all non-adult controls may require social cooperation at village level or greater).

Synthesis of Outputs and Activities

Table III.4 shows how the key research questions identified as knowledge outputs are each addressed by the research activities. Although no one activity is sufficient alone to address any one question, taken as a whole the research programme addresses them all.

Table III.4. Overview of the relationship between Key Questions (Knowledge Outputs) of the Research Programme and its Activities, "X" signifying an activity to address a question.

KNOWLEDGE OUTPUTS:- Activities	1A: Problem analysis: Fly damage	1B: Problem analysis: Social con-sequences and constraints	2A: Farm-level control: Effective-ness	2B: Farm-level control: Appropriateness	3A: Village level control: Effective-ness	3B: Village-level control: Appropriateness
1.1: Knowledge Review						
1.1.1: Incidence mapping	X					
1.1.2: Damage tabulation	X	X				
1.1.3: Biology review		X	X		X	
1.1.4: Controls tabulation			X		X	
1.2: Survey						
1.2.1: Trapping	X					
1.2.2: Rearing out	X	X				
1.2.3: Key informants		X	X	X		X
1.2.4: SSIs		X	X	X		X
2: Farm-Level Control Experiments						
2.1: Laboratory SKP study			X			
2.2: Field SKP study			X			
2.3: On-farm trials		X	X	X		
3: Village-Level Studies						
3.1: Institutional study						X
3.2: Village-level trials		X			X	
3.3: Village PRA						X

Activity 4: Closing Workshop

Together, the studies proposed will allow the assessment of how realistically and practically farm-level management may be improved from economic, social, environmental and health points of view, while remaining appropriate to farmers and thus able to be actually adopted. This will lead to the final output of this project: first recommendations as to the optimum farm stratagem in every case, categorised by crop, fly species, the financial and time resources available to the farmer, operational scale (from small-plot to village level) and other criteria; second robust and productive village- and local-level plans for the improvement of fly pest management, tailored to the specific ecogeographical, economic and institutional contexts of the particular areas where problems are found.

Several publications will be prepared on socio-economic studies, baits, lures, fly migration and IPM components. It is anticipated that some of these activities, as is normal, will be completed after the end of the project.

Appendix IV. Prior Scientific Papers.

Appendix IV.A. "Single-Killing-Point" Laboratory Assessments of Bait Controls of Fruit Flies (Diptera: Tephritidae) in Pakistan

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Abstract

In the evaluation of insect controls by baits and lures considerable advantages are offered by the assessment of the efficacy of a single "killing point". Modifications of Bait Application Technique (BAT) were evaluated in the laboratory in Pakistan using choice chamber cages for pairwise comparisons of individual spot deposits of bait recipes. In attracting and killing *Bactrocera cucurbitae*, a home-made beef meat broth had 68.7% of the effectiveness per unit volume of commercial protein hydrolysate. The addition of urea and cucumber extract source did not enhance the effectiveness of broth bait. There may be a substantial health risk from the mixing of insecticide with meat broth which is prepared in a way similar to a food product. The methodology developed offers the rapid and reliable assessment of alternative bait mixtures and formulations.

Key words: Pakistan, fruit fly, bait control

Introduction

Tephritid fruit flies cause annual farm-level losses in Pakistan estimated at US$200 million (Stonehouse *et al*., 1998). Bait Application Technique (BAT) offers a control which is reliable, economic and uses a minimum of chemical insecticide. In BAT a mixture of hydrolysed protein and insecticide is applied in spot deposits (Roessler, 1989). Adult fruit flies on eclosion need a protein meal for full maturation, particularly for reproduction, and so before attacking fruit are attracted to these spots, feed on them and die from ingesting the insecticide. Relative to cover sprays, BAT uses lower doses of insecticide, can be applied on foliage, avoiding the fruits themselves, and generally offers superior control. BAT with protein hydrolysate bait has been successfully evaluated in Pakistan (Latif *et al*., 1987).

This research sought ways to make BAT practical, cheap and reliable for farmers in Pakistan, evaluating the potential for substitution of costly, imported protein hydrolysate bait with cheaper, home-made alternatives. Many such studies have evaluated baits made from waste brewer's yeast (Lloyd and Drew, 1997). Pakistan having no substantial brewing industry, this study evaluated boiled meat broth. In Afghanistan the United Nations Food and Agriculture Organisation successfully developed baits for melon farmers consisting of broth made from cheap beef meat, with malathion, fermented cucumber extract as a cucurbit smell source and human or animal urine or urea as an ammonia source (Stride, 1996).

Methods

The assessment of fruit fly controls is generally by conventional field trials, comparing whole plots treated in different ways. Alternatively, BAT may be assessed by counting flies which are attracted to, and killed by, a single "killing point" of a BAT spot. This produces direct information about the effectiveness of individual killing points, allowing more detailed comparisons and information for the optimisation of spot size, spacing and application. It also reduces demands for space, as only one point is assessed instead of an entire plot, and time, as the number of killed flies itself comprises the data, instead of the assessment of fruit damage and yield. A major objective of this research was the development and verification of such assessment techniques, to see whether it is possible to obtain reliable information from such "single-killing-point" assessments, and thus to use these techniques to "industrialise" the comparison of controls, allowing large numbers of options to be reliably assessed with low demands for time, space and labour.

Lloyd and Drew (1997) used a laboratory technique for the assessment of baits against *Bactrocera tryoni* Frogatt, assessing the attraction of flies to baits by counting flies on sponges soaked in candidate baits. Baits were assessed individually, without an insecticide component, and the same flies re-used for successive assessments. The method developed here included insecticide in the full field bait formulation, and aimed to minimize uncontrolled effects by assessing baits not individually but as simultaneous comparisons of pairs in

choice chambers, so allowing extraneous differences, such as time of day, fly age, nutrition and the order of testing, to be discounted.

Comparisons were made in a series of two-way choices, between two potted young melon plants treated with different bait formulations and placed at opposite ends of a long cage arena. On the cage centre line, equidistant between the two treated plants, freshly-emerged adult flies were released, and subsequent fall of dead flies recorded on either side of the centre line, to give a relative estimate of the power of each deposit to attract and kill flies. Each cage was 2m long, 0.5m wide and 0.5m high, with painted wood frame, floor and ceiling, walled with glass on one side and with wire gauze at the other and at either end. Doors in the glass side allowed flies in jars to be placed on the centre line and then released. Each cage contained a dish with a sugar-water wick placed on the centre line. Between the two treated plants at the cage extremities, the arenas were filled with untreated potted young melon plants, to mimic a melon field in which only a fraction of plants have been treated, and to evaluate realistically the powers of the deposits to attract and kill flies at a distance through a stand of untreated plants. Plants were about 15cm high, and were selected and positioned to maximise the symmetry of the stand about the centre line. The arenas were positioned to be symmetrical to light and warmth, and their facing directions adjusted until daily catches by two identical preparations were evenly divided. Six arenas were used as replicates, in three pairs built one on top of the other and standing on legs in dishes of water to prevent ant raids. In each cage pair the two treatments were placed at opposite ends in a Latin square design. The cages are illustrated in a preliminary graphical report elsewhere (Zia *et al*., 2001).

Insects were from a laboratory culture of melon flies, *Bactrocera cucurbitae* Coquillet, from a stock taken near Karachi. Emerged adults from pupae taken from the culture were fed sugar water only until experimental release. Ten males and ten females were released in each run.

Each comparison lasted until no live flies were observed, typically five to ten days. Not all of the 20 flies released in each experiment were always recovered; the missing ones were inferred to have expired in the soil in the melon pots. Records were taken of the maximum and minimum temperatures and of the time elapsed before each experiment ended. Treated melon plants were destroyed; untreated plants were reused, but rotated through the greenhouse to refresh them. The cages were washed with soap and water at the end of each experiment.

The protein dosage was based on an unpublished survey of the literature (Stonehouse, J.M., Mumford, J.D., 1998, *Protein Bait Spray Control of Fruit Flies: A Survey of Recommended Doses and Application Rates*, Imperial College, London, 5pp, available from j.stonehouse@ic.ac.uk). It comprised 30ml of commercial protein hydrolysate (International Pheromone Systems Ltd, Ellesmere Port, South Wirral, CH65 4TY, UK. ips_ltd@btconnect.com) and 3ml of malathion 57% active ingredient emulsifiable concentrate ("Fifinone" obtained locally) made up to 1l with water. The preparation of animal protein was based on that recommended by the FAO Afghanistan Rural Development Programme. It comprised 0.75l of broth made from 300g cheap beef meat, boiled for two hours, stood overnight and skimmed of fat, 0.125l boiled and mashed cucumber filtrate liquid, mixed with 50g of urea and stood to ferment for two days, with 3ml of malathion (Fifinone), made up to 1l with water. In order to ensure homogeneity of non-experimental variables, the preparations of commercial hydrolysate bait, meat preparation bait, cucumber extract, urea and insecticide were made initially in a single batch, and all frozen in compartmented ice cube trays, and then thawed out and mixed with other ingredients when needed. The literature survey found a typical application rate of protein hydrolysate bait to be $7.5 l ha^{-1}$ ($0.75 ml m^{-2}$), repeated every 10 days. Each half of a cage arena was approximately $0.5 m^2$ and so each treated plant was treated with 0.5ml of mixture, applied to the leaves with a pipette in droplets of approximately 1mm diameter.

Six comparisons were performed, between March and July 1999. First were two to test the validity of the method; subsequently, baits were compared to test four questions of crop protection importance.

i - Two identical bait preparations (method check).

Protein hydrolysate with malathion was compared with itself to see if flies confronted with two theoretically equally attractive options fell dead evenly about the centre line.

ii - Bait preparation compared with nothing (method check).

Protein hydrolysate with malathion was compared with an untreated plant to see if larger numbers of dead flies fell on the side of the centre line facing the putatively more effective mixture.

iii - Bait preparation compared with insecticide without bait.

Protein hydrolysate with malathion was compared with a preparation of the same strength of malathion with no bait, to confirm whether bait significantly attracted flies to the deposit.

iv - Commercial and home-made bait preparations.

Protein hydrolysate formulation was compared with standard animal protein formulation, to evaluate the ability of home-made animal protein baits to attract and kill flies as efficiently as commercial preparations.

v - Value of urea component.

Standard meat preparation mix was compared with an identical preparation without urea, to see if the urea may be omitted to simplify and economise the preparation with no severe loss of efficacy.

vi - Value of cucurbit extract component.

Standard meat preparation mix was compared with an identical preparation without cucumber extract, to see if the latter may be omitted.

Results and discussion

The results of the six comparisons are given in *Table IV.A.1*, showing the average numbers, over the six replicates of each comparison, of dead flies found in the half of the arena with each treatment. These were recorded separately for males and females. Analysis for each treatment comparison was by two-way replicated analysis of variance to compare treatment, fly sex and interaction between them. This found sex effects and their interaction with treatments to be insignificant (all twelve *F* ratios were less than unity). As a result, the table shows only the total numbers of dead flies and *F* values for treatment differences.

Table IV.A.1. Results of laboratory assessments of different bait preparations, as numbers of flies out of an initial release of 20 found dead in the end of choice chamber cages containing each treatment, as means and standard deviations (S.D.) from six replicates, and the outcome of an analysis of variance (with in each case 1 and 20 degrees of freedom) to compare them.

Treatments	Mean	S.D.	*F*
Commercial hydrolysate + malathion	9.17	±2.32	0.014
Commercial hydrolysate + malathion	9.33	±2.25	ns
Commercial hydrolysate + malathion	14.17	±1.47	183.253
Nothing	1.17	±0.75	***
Commercial hydrolysate + malathion	14.83	±1.00	240.874
Malathion only	1.00	±1.27	***
Commercial hydrolysate + malathion	11.17	±2.32	7.63
Full home-made mix + malathion	7.67	±1.63	*
Full home-made mix + malathion	9.17	±1.72	0.000
Home-made mix minus urea + malathion	9.17	±1.33	ns
Full home-made mix + malathion	8.83	±0.41	0.031
Home-made mix minus cucumber + malathion	9.00	±1.27	ns

The initial two comparisons provided evidence of the validity of the methodology - the comparison of two identical treatments obtained an even distribution of dead flies between the two, and that of treated and untreated plants obtained many more flies in the treated part of the arena. The third comparison showed that insecticide without bait attracted only a small fraction of the flies of the bait mixture. The fourth showed that the attracting and killing power of the home-made mixture as a fraction of the commercial one was 7.67/11.17=68.7%, with a 95% confidence interval, conventionally derived by parametric methods, between 53.3 and 92.9%. The final two comparisons implied that the urea and cucurbit odour source were not worthwhile additions to the home-made mix.

It was concluded that the home-made broth bait had roughly two-thirds of the efficacy of commercial hydrolysate - potentially a useful effect when its greatly reduced cost is considered. The addition of urea and cucurbit extract did not give a significant improvement.

More generally, the two-treatment comparison of "killing points" appeared able quickly and reliably to compare the effectiveness of bait treatments. The accuracy of the method may be reduced when the lethal agent in the mixture evaluated has a relatively slow knock-down time, with such insecticides as spinosad, fiprinile and insect growth regulators, as the location of the fly corpse may not be a suitable index of attractant efficacy in these cases. In cases where it is feared that cultured flies may lose natural responses to attractants, the technique could be used with wild flies, reared directly from infested hosts.

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Appendix IV.B. "Single-Killing-Point" Field Assessments of Bait and Lure Controls of Fruit Flies (Diptera: Tephritidae) in Pakistan

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Abstract
Variations of Bait Application Technique (BAT) and Male Annihilation Technique (MAT) were evaluated in field studies of the effectiveness of individual "killing points" of food bait spots, or parapheromone lure traps or blocks, by recovering flies attracted and killed, in collectors below the killing points. BAT spots were more effective applied to natural foliage than to cut wood, cloth or plastic. BAT with a home-made meat broth killed 65.7% of the number of flies killed by commercial protein hydrolysate, and application by brushes was as effective as by a sprayer. There may be a health risk from the mixing of insecticide with a meat bait which is prepared in a way similar to a food product. MAT by wooden blocks soaked in lure and insecticide was compared with the plastic lure-baited traps currently used in Pakistan; blocks killed four times more flies than traps, are cheaper and less vulnerable to theft and weather, and require no recharging and replacement. Plywood blocks killed more flies than those of mulberry and poplar wood, though not than acacia. Square and oblong blocks were more effective than round and hexagonal ones. The study showed that "single-killing-point" analysis of alternative fruit fly controls can produce consistent results while being quicker and cheaper than full-field trials.
Key words: Pakistan, fruit fly, *Bactrocera*, on-farm controls, bait, lure

Introduction

Tephritid fruit flies cause annual farm-level losses in Pakistan estimated at US$200 million (Stonehouse *et al*., 1998). This research looked for ways to adapt two successful on-farm control technologies, Bait Application Technique (BAT) and Male Annihilation Technique (MAT), to be as practical, cheap and reliable as possible for farmers.

In BAT a mixture of protein and insecticide is applied in spots (Roessler, 1989). Adult fruit flies on eclosion need a protein meal for full maturation, particularly for reproduction. Before attacking fruit, therefore, adult flies are attracted to these spots, feed on them and die from ingesting the insecticide. Relative to cover sprays, this technique uses lower doses of insecticide, can be applied in spots on leaves and foliage, thus avoiding the fruits themselves, and generally offers superior control. It has been successfully evaluated, though not widely used, in Pakistan (Latif *et al*., 1987; Khan *et al*., 1992; Qureshi and Hussain, 1992). This study sought to find the optimum concentration of protein hydrolysate in BAT sprays, and to evaluate the substitution of commercial components with cheaper, home-made ones - bait of boiled meat broth instead of protein hydrolysate, applied by brushes instead of sprayers. In Afghanistan in 1996 the United Nations Food and Agriculture Organisation developed baits for melon farmers consisting of brush-applied cheap meat broth, and the technology was used successfully by farmers (Stride, 1996).

Control by MAT exploits the attraction of males to parapheromone lures, locally exterminating males so that unmated females do not reproduce (Cunningham, 1989). Most pest fruit fly males in Pakistan are attracted to methyl eugenol, and are controlled by the use of plastic traps, containing wicks soaked in this liquid, which they enter, and then die of overheating inside (Qureshi *et al*., 1976, 1981; Marwat and Baloch, 1986; Marwat *et al*., 1992; Mohyuddin and Mahmood, 1993). These may be replaced by wooden blocks, soaked in parapheromone and insecticide, which attract flies and kill them when they stand or feed on the surface. Compared with the traps, the blocks are cheaper, simpler, last longer and are less likely to be blown down or stolen. This research aimed to evaluate and maximise their effectiveness. Block wood type and block shape may affect performance: some woods and/or shapes may allow more rapid evaporation of the lure mixture and so may attract more flies than other, harder woods, but also deplete their lure load faster and so last less long. In the Seychelles the spongy and fibrous husk of the coconut caught more flies, and lasted longer, than plywood or coconut shell or wood when used with trimedlure against *Ceratitis capitata* (Stravens *et al*., 2001). In Mauritius, the Indian Ocean Regional Fruit Fly Programme found square plywood blocks to be less effective than ones of the same area in the shape of a rectangle twice as long on one side as on the other (Harnaivo Rasamimanana, pers. comm.).

Methods

The assessment of BAT and MAT controls is generally by conventional field trials, comparing plots treated in different ways. An alternative is to retrieve and count the corpses of flies which are attracted to, and killed by, a single "killing point" of a BAT spot or an MAT trap or block. This reduces demands for space, as only one point is assessed instead of an entire plot, and time, as the number of retrieved carcasses itself comprises the data, instead of the assessment of fruit damage and yield, and produces direct information about the effectiveness of individual killing points. A major objective of this research was to develop and verify such "single-killing-point" techniques, to see whether it is possible to obtain reliable information, and thus in future to use these techniques to "industrialise" comparisons of control options, allowing large numbers of variables to be reliably assessed with low demands for time, space and labour. Lloyd and Drew (1997) tested individual BAT spray spots on foliage with $1.5m^2$ groundsheets below, and the National Fruit Fly Programme of Mauritius evaluated killing points with conical cloth bags hung beneath (Indira Seewooruthun, pers. comm.). This study assessed the mortality caused by individual BAT and MAT killing points in fruit trees in farm orchards, approximately 1.66m above the ground, by hanging directly below each a conical cotton collector bag, its circular mouth held rigid with a wire loop.

This study also aimed to evaluate the accuracy of these collectors as estimators of the total mortality caused by the killing point below which they were hung. Collectors will fail to record the deaths of flies which receive a lethal dose at the killing point but, before dying, fly beyond the perimeter of the collector mouth and so fall to the ground outside it. The numbers of these were assessed by placing beneath the central collector two additional, wider collectors to catch those that fell outside the central collector. The use of these additional collectors was intended to model the decay curve of catches with distance, to estimate the total fly mortality caused by the treatment, and to gauge how accurately the catch in the small, central collector may represent the whole mortality caused.

The central collector had a circular mouth of 0.305m radius and was hung 6cm below the killing point (1.6m above the ground). Because of the need to accommodate the body of the central collector, the outer ones' mouths also dropped in height at they stood out from the centre, forming together three tiers of increasingly wider and lower receptacles. The second collector had a circular mouth of 0.610m radius (*i.e.* 0.305m outside the first) and was 0.8m below the first (0.8m above the ground). The third and lowest collector was a square sheet of 1.829m along each side laid on the ground (an area of $3.345m^2$, equivalent to a circle of radius 1.032m, *i.e.* 0.422m outside the second). The calculation of total mortality attributed to a killing point, from the three collector tiers, was as follows.

First, because the central collector was hung close below the killing point (in order to maximise its catch) whereas the other two were regularly spaced to the ground, the three collector mouths were irregularly spaced as to height. This was assumed to affect their ability to catch dying flies falling away from the killing point at an angle: a collector was assumed to catch relatively more flies the wider its mouth was horizontally, but relatively fewer flies the larger was the vertical drop to its mouth rim from the one above, as flies falling at an angle would be likelier to pass over the rim and not be collected. This was corrected by weighting the individual catches of the three receptacles by multiplying them by the ratio between the vertical and horizontal distances between the rim of the receptacle and its upper neighbour (*i.e.* the trigonometric tangent of the angle of declination of the descent from one mouth rim to the next).

Second, the decline in catches with increasing distance from the killing point, corrected as above, was evaluated against an expected model of exponential decay. Catch data were converted to natural logarithms (after the addition of one to forestall the calculation of LN(0)), regressed against distance from the killing point, and the three values predicted by the resulting regression equation compared against the three values found. Comparisons were evaluated in three ways. The first was by visual inspection of graphic plots. The second was the comparison of observed and expected values by Kolmogorov-Smirnov goodness-of-fit tests. The third was by determining whether each observed relationship was more or less extreme or "elbowed" in shape than the model, calculated, from the three observed catch levels (O_1, O_2, O_3) and the three expected levels (E_1, E_2, E_3), as whether the quantity $(O_1\ E_1)-(O_2\ E_2)+(O_3\ E_3)$ was greater than zero, denoting an observed relationship more elbowed than the model, or less than zero, denoting an observed relationship less elbowed than the model (*i.e.* closer to an arithmetic, "straight-line" relationship): the relative frequencies of positive and negative departures were then compared.

Third, total catch was modelled as the area under the fitted exponential decay curve, between the killing point and a cut-off distance of four metres radius and, fourth, the fraction of the total catch represented by the original central collector catch was calculated. Table IV.B.1 gives an example illustration of the complete modelling process. The fraction of total estimated mortality represented by the central collector catch was evaluated for differences between experimental treatments and time elapsed in days or weeks. Because of the importance of the relationship between central collector catch and total estimated mortality, and the dangers of

assuming a constant relationship when there is a risk of a difference, statistical outcomes of these tests are given below even when these were not significant at the 0.05 level.

Table IV.B.1. Example of treatment of a data set (from a plywood MAT block on the third day of its deployment). This data set after weighting did not differ from the exponential decay model (Kolmogorov-Smirnov *D*=0.0491ns), and the weighted observed data were less "elbowed" than the exponential model - $(O_1 E_1)-(O_2 E_2)+(O_3 E_3)=-11.8$. Extension of the modelled catch to four metres from the killing point obtained a total catch estimate of 122.17 flies; the actual central collector catch (115) was 98.2% of this estimated total mortality.

Collector	1	2	3
Rim distance from killing point (m)	0.305	0.61	1.032
Horizontal distance from previous rim (m)	0.305	0.305	0.422
Vertical distance from previous rim (m)	0.06	0.8	0.8
Tangent of angle of declination (ratio)	0.1967	2.6230	1.8957
Original catch (No.)	115	4	1
Multiplied by tangent (No.)	22.623	10.492	1.896
Weighted to original sum (No.)	77.541	35.961	6.498
Exponential model (No.)	83.078	30.073	6.850

The descending tiers of collectors were sometimes damaged or dislodged, and useable data were not obtained in all of the assessments described below. When these data were not obtained this is indicated and the central collector data were analysed alone.

In comparisons of the catching effectiveness of different treatments, data are presented throughout as the total catches over the period of killing point deployment. The evaluation of their crop protection usefulness also requires estimation of how long killing points last before needing to be replaced. Catches were thus compared with days elapsed from first deployment until the experiment ended. All decays of catches in time were compared by least-squares regression to both linear and exponential fitted models and by visual inspection of graphical plots. In no case was the fit of one regression model to the data significantly closer than the other, and the exponential was chosen as the model for use, as considered likeliest to represent the decay in concentrated effectiveness over time. With this model used to estimate the relationship, the value chosen for comparison of treatments' durability was the estimated time it would take for the daily catch per killing point to fall to one fly, a point termed the killing point's "persistence". The use of a regression estimate also allowed data from analogous experiments to be compared when, as often and inevitably happened, they were run for different lengths of time.

Research encountered operational difficulties, such as the vagaries of weather, crop development, field access by bus or bicycle and the theft or destruction of collectors, and as a result comparisons unavoidably varied in duration and level of replication. The analyses below are attempts to provide useful information in spite of these shortcomings.

BAT

BAT studies were carried out (by QZ) in guava orchards between Rawalpindi (33°21'N, 73°6'E) and Haripur (33°41'N, 73°6'E) in the growing seasons of 1998 and 1999. Trees were on experimental stations or farms, and between 2 and 10Ha, interspersed with non-fruit arable crops and without fly controls. Space did not permit the grouping of spot treatments into complete randomized blocks and these were evenly spaced throughout orchards, at least 10m apart and 10m from orchard edges. Protein hydrolysate dosage was based on an unpublished survey of the literature (Stonehouse, JM, Mumford, JD, 1998 *Protein Bait Spray Control of Fruit Flies: A Survey of Recommended Doses and Application Rates*, Imperial College, London, 5pp, available from j.stonehouse@ic.ac.uk). It comprised 30ml of commercial acid-hydrolysed protein hydrolysate (International Pheromone Systems Ltd, Ellesmere Port, South Wirral, CH65 4TY, UK. ips_ltd@btconnect.com), and 3ml of malathion 57%a.i. emulsifiable concentrate ("Fifinone" obtained locally), made up to one litre with water. Each spot was of 12.5ml applied over approximately 0.125m^2 of fruit tree foliage with a hand-operated garden sprayer of 0.5l capacity.

The first experiment compared protein hydrolysate bait spots applied to different substrate surfaces. Farm applications are generally to living leaves and branches of trees, but artificial substrates are quicker and easier to use for both farm control and experimental assessment. Applications to living trees must be done by moving the application equipment all through a field, but discrete artificial surfaces may be treated all together at a convenient point and then carried into the field and hung up. For practical control and also for rapid experimentation, therefore, the relative attractiveness of deposits on natural vegetation and on candidate artificial surfaces must be known. Sprays were applied to living foliage of guava (*Psidium guava*) and to three artificial

surfaces - cotton cloth, plastic sheet and commercial sawn timber (deodar, *Cedrus deodara*) - replicated five times.

The second experiment compared protein hydrolysate doses. The bait strength used, of 30ml.1^{-1} was in fact greater than the most frequent recommendation, of 20ml.l^{-1}. The appropriateness of this was tested by comparing concentrations of 0, 20, 30 and 40ml.l^{-1}, all with the same concentration of insecticide, replicated ten times.

The third comparison was of commercial protein hydrolysate with meat broth protein, and of application by sprayers with that by brushes. The preparation of animal protein was based on recommendations from the FAO Afghanistan Rural Development Programme, developed against *Bactrocera cucurbitae* in Herat (34°22'N, 62°10'E) comprising 0.75l of broth made from 300g of beef meat, boiled for two hours, stood overnight and skimmed of fat, 0.125l boiled and mashed cucumber filtrate liquid, mixed with 50g of urea and stood to ferment for two days, with 3ml of Fifinone malathion, made up to one litre with water. The recommended field application rate (Barry Stride, pers. comm.) is approximately 2.5l.ha^{-1}, at intervals of 10m or 5 plants (whichever is nearer), repeated every 10 days. A first experiment, replicated ten times, compared baits, and a second, replicated five times, compared baits and application techniques.

MAT

MAT treatments were compared (by MA) in farmers' mango, guava and citrus orchards in three locations - Islamabad (33°41'N, 73°6'E), Rawalpindi (33°21'N, 73°6'E) and Bhakkar (31°36'N, 71°4'E) - in the growing seasons of 1998, 1999 and 2000. Orchards were of medium to large size (5 to 20Ha), interspersed with wheat, cotton and vegetable fields and without fly controls in place. All experimental designs were of complete randomised blocks both across and within sites. Treatments were spaced at least 15m apart and 15m from the orchard edge.

Following guidance from the Mauritian National Fruit Fly Programme, square blocks were made of approximately 5×5×1.4cm commercial plywood, soaked in a mixture of 95% ethyl alcohol solvent (obtained locally), technical methyl eugenol (International Pheromone Systems Ltd) and "Fifinone" malathion in a v:v:v ratio of 6:4:1. Blocks were soaked for twelve days and allowed to dry for approximately six.

The first experiment compared the soaked MAT blocks with the plastic traps currently in use, replicated four times in each of the three zones. Traps were standard plastic cylinder traps with cotton swab wicks soaked in methyl eugenol alone, as recommended and practised by farmers. Those flies in traps were considered to represent the total number of flies they attracted and killed; those killed by blocks were modelled from data from the three tiered collectors as described above.

The second experiment compared the doses of the components of the soaking mixture, by adjusting the quantities of each of the three components separately, replicated once in each of the three zones. The third experiment, replicated seven times in two zones, compared blocks of different woods, comparing inexpensive types potentially suitable for farmer use - plywood, acacia, mulberry and poplar. The fourth experiment, replicated 11 times in the three zones, compared plywood blocks of similar surface area but different shapes, as shown in Table IV.B.2.

Table IV.B.2. Dimensions of plywood blocks of different shapes compared for MAT.

Shape	Square	Oblong	Hexagon	Circle
Dimensions (cm)	5×5	7×3.5	5.5 across (face to face)	5.5 diameter
Area (cm^2)	25.00	24.50	26.20	23.76
Edge length (cm)	20.00	21.00	19.05	17.28

BAT research was conducted in the same locality, but MAT research was conducted in a variety of regions, localities, seasons and years, together termed "sites". There were often significant differences between sites separated in time and space, and these were attributed to expected natural variation among locations, seasons and years. The use of complete randomised block experimental designs, with all experimental treatments compared at every site, was intended to allow differences between sites to be disregarded, and these are not itemised or discussed even when significant. (Interaction between sites and treatments, on the other hand, is of importance in implying that treatments work better in some sites than in others; in the event no such interaction was significant).

Results

Data are summarised as single means and standard deviations (S.D.) of all replicates (pooling sites when separate); analysis was by analyses of variance (ANOVA); unplanned comparisons of pairs of means followed the T-method of minimum significant differences (MSD) using studentised ranges (Sokal and Rohlf, 1995).

The decline of catches with distance from the killing point, calculated as in Table IV.B.1, did often depart significantly from the exponential model, but with no clear indication of a better alternative. Deviations from the model were calculable for only four of the experiments below, analysed in every case as total catches added up over the duration of the experiment. In the comparison of BAT with different baits and applicators, of the forty experimental cells none significantly departed from the model; of the comparison of MAT with blocks and with traps, of twelve cells five significantly departed from the model ($P<0.05$), all in the direction of observed as less elbowed than modelled; of the comparison of MAT with different wood substrates, of twenty-eight cells nine departed significantly, eight to more-elbowed and one to less-elbowed distributions; finally of the forty-four cells in the comparison of MAT blocks of different shapes, 29 departed significantly, 23 as more-elbowed and six as less-elbowed. Between only three points, two distributions can only differ in two ways - as more or less "elbowed", and despite the high frequency of significant departures, those in one direction were not convincingly more frequent than in another. Observed differences among zones and experiments may have been due to differences in the vertical spacing of collector rims, and the development of concentric collectors on the same level is a high priority for future development of these techniques.

The analysis of percentages of estimated total catches in the central cone is of central importance to the reliability of the methods and so differences in these are summarised below even when not statistically significant.

BAT

All collectors were checked daily. All flies caught were *Bactrocera dorsalis*. BAT spot catches are much smaller, and of shorter duration, than those by MAT lures. Such small catches provide such thin distributions that the slopes of "decay" from the killing point with both space and time sometimes point upwards, resulting in meaningless estimates of "infinity" for, respectively, total catch and killing point persistence, and to obtain adequate numbers for the estimation of total catch and persistence it was often necessary to pool replicates, days elapsed and/or sexes, allowing the assessment of some differences between treatments and sexes, generally without standard deviations.

Table IV.B.3 gives the catches on the four application substrates assessed. On guava foliage the percentage of total estimate in the central collector was 59.6% of males and 63.0% of females and time until decay to one catch a day was 5.7 for males and 6.1 for females; catches on other substrates were too low to allow either time decays or total catches to be estimated, and comparisons were of central collector catches only.

Table IV.B.3. Total catches (N=5) of *B. dorsalis* by bait sprays, after five days on four substrates. Treatments differed significantly (one-way ANOVA among total means $F=38.7835[3,16]$*); means with different letters differed at $P<0.01$ (MSD=3.6); those with the same did not differ at $P<0.05$ (MSD=2.8). On guava foliage, though not on other substrates, the catch of males was significantly larger than that of females ($t=3.2691[8]$*).**

Surface		Guava foliage	Sawn wood	Cotton cloth	Plastic sheet
Males	Mean (No.)	6.8	0.0	1.2	0.0
	S.D.	±2.8	±0.0	±1.6	±0.0
Females	Mean (No.)	2.2	0.0	0.0	0.0
	S.D.	±1.5	±0.0	±0.0	±0.0
Total	Mean (No.)	9.0a	0.0b	1.2b	0.0b
	S.D	±2.6	±0.0	±1.6	±0.0

Table IV.B.4 gives the average catches by the four bait concentrations assessed, in a comparison with no outer collectors, lasting ten days and with five replicates.

Table IV.B.4. Mean total catches (N=5) of *B. dorsalis* after ten days by differing strengths of protein hydrolysate solution. All treatments differed significantly from each other in total catch (one-way ANOVA F=76.9357[3,15]*; MSD=5.5 at P<0.01). Persistence estimates were analysed omitting those for strength zero.**

		Total catch (No.)				Persistence (days)			
Strength (ml.l^{-1})		40	30	20	0	40	30	20	0
Males	Mean	9.0	15.2	4.4	0.2	9.5	9.7	8.2	-
	S.D.	±2.3	±1.6	±1.6	±0.4	± 0.9	± 0.8	± 0.4	-
Females	Mean	4.6	6.8	2.2	0.0	9.6	9.2	10.9	-
	S.D.	±0.8	±1.2	±0.7	±0.0	± 0.9	± 0.6	± 6.3	-
Total	Mean	13.6a	22.0b	6.6c	0.2d	9.6	9.8	8.4	-
	S.D.	±2.7	±2.4	±2.2	±0.4	± 0.8	± 0.6	± 0.6	-
F	Strength	106.9594[3,32]***				0.0052[2,24]ns			
	Sex	70.4390[1,32]***				0.6661[1,24]ns			
	Interaction	15.0569[3,32]***				0.9772[2,24]ns			

Table IV.B.5 gives the outcome of a first comparison of bait protein sources, with ten replicates over five days, without outer collectors. The attracting and killing power of the home-made mixture as a fraction of the commercial one was 11.9/18.1=65.7% with a 95% confidence range (calculated, as a ratio, between the logarithms of the catch data) between 48.2 and 91.8%.

Table IV.B.5. Mean total catches (N=10) of *B. dorsalis* after five days by commercial and home-made baits, and compared by two-way replicated ANOVA (for persistence data low catch levels led to random pooling of data set pairs).

		Total catch (No.) (N=10)		Persistence (days) (N=5)	
Bait		Commer-cial	Home-made	Commer-cial	Home-made
Males	Mean	11.6	8.1	7.1	8.2
	S.D.	±4.0	±2.6	±0.7	±2.5
Females	Mean	6.5	3.8	6.8	6.8
	S.D.	±2.7	±1.1	±1.2	±2.0
Total	Mean	18.1	11.9	7.7	8.0
	S.D.	±6.2	±3.5	±0.9	±2.1
F	Bait	12.1219[1,36]**		0.5044[1,16]ns	
	Sex	27.8641[1,36]***		1.3164[1,16]ns	
	Interaction	0.2018[1,36]ns		0.5172[1,16]ns	

The final comparison was of protein and application methods together. Estimation of percentages of total mortality represented by the catches in the central collectors required the pooling of data across replicates and days elapsed, as daily catches were too low for analysis. The resulting estimates are given in Table IV.B.6. Overall, there was no indication of differences among treatments or sexes and in the light of this finding, catch data were compared as the catches from the central collector only, and are presented in Table IV.B.7.

Table IV.B.6. Percentages of estimated total mortality within the central cone, among baits, sprayers and catch sex. Each datum is the sum of five replicates over five days. Compared by three-way unreplicated ANOVA no difference or interaction was significant (for baits F=1.1459, for applicators F=2.8543, for sexes F=1.1459, all [1,1]ns)

Application	Bait	Commercial	Home-made
Sprayer	Males	70	70
	Females	63	53
Brush	Males	65	68
	Females	81	54

Table IV.B.7. Total catches (N=5) of *B. dorsalis* after five days under areas treated with commercial and home-made baits (protein hydrolysate and meat broth) and applications (sprayer and brush), analysed by a three-way replicated ANOVA. No interactions were significant.

Application	Flies	Bait	Total catch (No.)		Persistence (days)	
			Comm-ercial	Home-made	Comm-ercial	Home-made
Sprayer	Males	Mean	6.4	5.8	7.1	8.3
		S.D.	±3.4	±2.3	±4.6	±4.8
	Females	Mean	3.0	1.6	5.6	4.6
		S.D.	±2.4	±0.9	±1.7	±1.3
	Total	Mean	9.4	7.4	5.9	6.0
		S.D.	±5.0	±2.8	±1.9	±1.6
Brush	Males	Mean	7.2	5.2	8.6	4.6
		S.D.	±1.5	±2.7	±5.4	±2.7
	Females	Mean	3.2	2.2	5.9	3.7
		S.D.	±1.9	±1.3	±1.9	±1.5
	Total	Mean	10.4	7.4	6.1	6.2
		S.D.	±2.5	±1.9	±1.6	±2.0
F	Bait		3.2808[1,32]ns[1]		0.4539[1,32]ns	
	Application		0.1312[1,32]ns		1.9857[1,32]ns	
	Sex		27.9737[1,32]***		4.3073[1,32]ns	

1: $P<0.1$

The overall average efficiency of the broth bait as a percentage of the hydrolysate was (7.4+7.4)/(9.4+10.4)=74.7%, with 95% confidence intervals (calculated between logarithms) of between 55.0 and 116.5%. This may be compared with 65.7% for the first experiment, and with 68.7% obtained from laboratory assessments of single killing points with *B. cucurbitae* (Stonehouse *et al*., 2002). Overall mean projected persistence was six days, with no significant differences among fly sex or bait or application treatments.

MAT

In the intervals between collections, catch specimens began to decompose in the cotton bags when the weather was wet, and so identification as to species was not always possible. Overall approximately 75% were *Bactrocera zonata*, the remainder *B. dorsalis*. All flies identifiable were male, although females may be caught by methyl-eugenol (Verghese, 1998). The duration of experimental runs varied widely, and some were not long enough to allow persistence to be estimated, as indicated below.

In the first comparison, of traps with blocks, traps and collectors were examined weekly. In each of the three zones the comparison was replicated four times; in two it ran for five weeks and in the third for four. The percentages of total kill estimated by the central collector catches are given in Table IV.B.8. It was concluded that these percentages did not differ between zones nor with time. Table IV.B.9 shows block kill estimates and trap catches as overall totals and days persistence

Table IV.B.8. Percentages of total estimated kill caught by central collectors in the first comparison (with plastic traps) in four replicates at each of three sites. Overall these averaged 49.9% (S.D.=42.6). For each trial, logarithms of percentages were regressed against weeks elapsed; the slopes of these did not significantly differ among the three zones (one-way ANOVA *F*=0.2012[2,9]ns), nor from an expected slope of 0 (two-way replicated ANOVA *F*=0.2603[1,18]ns).

Week	1	2	3	4	5
Mean (%)	40.1	59.6	48.0	52.2	49.4
S.D.	±20.1	±26.4	±20.7	±21.1	±18.4

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Table IV.B.9. Catches over four to five weeks of four plastic traps and four soaked blocks in each of three zones, as total catches and projected persistence until daily catch fell below one fly. Statistical analysis was by two-way replicated ANOVA: blocks were significantly superior to traps in estimated total mortality but not in estimated persistence.

		Sum (No.)		Persistence (days)	
		Trap	Block	Trap	Block
Mean		107.7	448.4	124.4	280.7
S.D.		±30.8	±181.6	±70.1	±366.8
F	Treatments	49.1629[1,18]***		1.9990[1,18]ns	
	Sites	3.1032[2,18]ns		0.4243[2,18]ns	
	Interaction	1.0682[2,18]ns		1.0351[2,18]ns	

The second evaluation, of soaking doses, did not feature lower collectors for calibration. Collectors were emptied daily. Table IV.B.10 shows the mean central collector catches obtained, with variations in the levels of alcohol, methyl eugenol and malathion.

Table IV.B.10. Collector catches in three zones after 27 days by mixes of solvent:lure:insecticide, with original 6:4:1 mixture underlined and individual changed values in *bold italics*. Analysis was by two-way unreplicated ANOVA.

Variable		Total catch (No.)			Persistence (days)		
Solvent	Mixture	***4***:4:1	6:4:1	***8***:4:1	***4***:4:1	6:4:1	***8***:4:1
	Mean	809.7	818.7	849.7	65.5	53.4	62.1
	S.D.	±109.9	±202.1	±23.7	±6.9	±3.1	±2.5
Lure	Mixture	6:***2***:1	6:4:1	6:***6***:1	6:***2***:1	6:4:1	6:***6***:1
	Mean	774.7	818.7	887.3	59.6	53.4	73.5
	S.D.	±40.1	±202.1	±335.2	±2.5	±3.1	±19.0
Insecticide	Mixture	6:4:1	6:4:***2***	6:4:***3***	6:4:1	6:4:***2***	6:4:***3***
	Mean	818.7	785.0	757.0	53.4	65.9	59.6
	S.D.	±202.1	±101.3	±20.8	±3.1	±2.5	±9.0
F	Mixtures	0.3464[6,12]ns			1.5811[6,12]ns		
	Zones	4.0413[2,12]*			0.8421[2,12]ns		

The third evaluation, of blocks of different wood substrates, was run for only four days, and as a result persistence could not be estimated and the four days' data were pooled. Table IV.B.11 gives the percentages of total catch estimates in the central collector for each wood and Table IV.B.12 gives their total kill estimates.

Table IV.B.11. Percentage of total kill estimates in central collectors, from wood substrate experiment, over four days in seven traps in two sites. Overall mean was 79.3% (S.D.=19.5). There was no significant difference among woods (one-way ANOVA *F*=0.2597[3,24]ns).

Wood	Plywood	Acacia	Mulberry	Poplar
Mean (%)	81.0	80.2	79.0	76.8
S.D.	±17.4	±17.6	±19.0	±24.0

Table IV.B.12. Total kill estimates (N=7 in two zones) by blocks of four woods in four days. Among all four woods there was a significant difference (one-way ANOVA *F*=6.0932[3,24]); individual means with different suffix letters were different at *P*<0.05 (MSD=95.6; T-method using studentised range).**

Wood	Plywood	Acacia	Mulberry	Poplar
Mean (No.)	466.8a	406.7ab	346.8b	335.7b
S.D.	±83.3	±76.2	±50.8	±38.5

Finally, block shapes were compared in six separate trials in four different sites, one with six complete randomised block replicates, running for four days, and five with one replicate each, running for 16, 18, 19, 45 and 65 days. Collectors were checked daily. Percentages of total estimated catches in central collectors are summarised in Table IV.B.13. It was concluded that the percentage of total estimated kill represented by the central collector catch did not differ between treatments nor with time elapsed. The total estimated kills and persistence for the four shapes are given in Table IVB.14.

Table IV.B.13. Percentages of total estimated kill caught by central collectors in the fourth comparison (of block shapes) in 11 replicates at four sites. Overall these averaged 78.9% (S.D.=9.0). Averages for each block over all 11 replicates were not significantly different (one-way ANOVA *F*=0.3320[3,40]ns). For five replicates of over four days, the percentages were least-squares-regressed against weeks elapsed and these slopes did not significantly differ between block shapes (one-way ANOVA *F*=0.5216[3,16]ns), nor from an expected slope of 0 (related *t*=0.6320[19]ns).

Shape	Square	Oblong	Hexagon	Circle
Mean (%)	79.9	79.9	79.3	76.5
S.D.	±6.4	±8.6	±8.8	±12.1

Table IV.B.14. Total fly catches and estimated persistence of four blocks of different shapes, in eleven replicates in six experiments, and compared by two-way unreplicated ANOVA of treatments and replications. Means with differing suffix letters differed at *P*=0.05 (MSD=148.0).

Shape	Catch (No.) (N=11)				Persistence (days) (N=5)			
	Square	Oblong	Hexagon	Circle	Square	Oblong	Hexagon	Circle
Mean	968.8a	929.3a	782.5b	733.6b	88.8	79.3	64.8	72.0
S.D.	±816.0	±788.3	±683.4	±642.0	±42.9	±44.0	±25.1	±22.4
F	8.6490[3,30]***				0.8918[3,12]ns			

Discussion and Conclusion

In BAT control males were caught in significantly larger numbers than females. All the artificial substrate surfaces tried - sawn timber, plastic or cotton - were significantly less effective than natural vegetation. The bait concentration of 30ml.l^{-1} was superior to both stronger and weaker alternatives. Brush application was the equal of sprayers - an important finding for small-farmer crop protection, where often access to a sprayer is the limiting factor (Stonehouse, 1995). Home-made bait had 65.7% of the effectiveness of commercial hydrolysate but did not decline to inactivity any faster. This compares with a percentage performance of the same mixtures tested against *B. cucurbitae* in the laboratory of 68.7% (Stonehouse *et al*., 2002). A future study might see whether the same percentage kill as with protein hydrolysate may be obtained by a home-made meat mix by increasing the dose of the latter by 100/70=1.43 times - if so, the resulting recipe may be an attractive control option for on-farm fruit fly control. As a bait, however, meat preparations have drawbacks, particularly poor keeping properties, unacceptability to vegetarians such as in India, the likelihood of attracting non-pest nuisance carrion flies such as muscids and, most serious, the risk of accidental poisoning by a pest management preparation made in a similar way to a food product.

MAT by soaked wooden blocks attracted and killed over four times more male fruit flies than the plastic traps currently in use in Pakistan. The currently recommended soaking mixture was as good as both stronger and weaker alternatives. For block construction, plywood was better than two potential alternative woods. Square and oblong blocks were better than round or hexagonal. There may be a positive association between performance and edge length, as has also been suggested by findings of the Indian Ocean Regional Fruit Fly Programme (Aruna Manrakhan, pers. comm.). If so, this may be because it is from the edges, where the ends of xylem channels open to the air, that most material is emitted. It may be worthwhile in future to assess shapes with longer edge lengths per unit surface area, such as triangles and parallelograms. The roles played in the decline of catches over time by decays in insecticide, lure and actual local fly populations has not been explored by this study but is important - for example blocks whose insecticide has decayed but whose lure remains active may draw pests into a treated field. The relative persistence of the attractant and insecticide components of bait and lure mixtures is a priority for future studies.

More generally, this work has shown that it is possible to “industrialise” field comparisons of bait spots, to allow a large number of different options to be compared quickly and efficiently. This opens the possibility of rapid analysis of large numbers of candidate home-made controls to lower costs for farmers. According to estimates, the central collector caught 50 to 83% of flies killed by MAT and 37% of those killed by BAT, without any systematic bias to control treatment or time elapsed. The lower central collector catch frequencies for BAT than for MAT are attributed to the large area of BAT killing points, as patches of liquid spread on foliage, relative to the compact wood blocks of MAT. Differences among experiments are attributed to local variations in the vertical distances between collector rims. Constancy of the representation of total mortality by central collector catch may not always be assumed: different insecticides, in particular, may have different knock-down speeds and so produce total mortalities represented by different fractional collector catches.

Many improvements may be made to the methods described. First, catching apertures on the same horizontal level will reduce the need for the correction for descending collectors, which is thought to have led to many difficulties in the interpretation of the results above. Second, the lack of species identification is a shortcoming, and the preservation of specimens for identification would be facilitated if collectors had floors of mesh or similar to allow rainwater to drain out. Third, more information about the functional relationship of catch and distance would be obtained by the use of a finer grid of sampling distances (*i.e.* more than three). With these improvements, future studies might assess further options of different lures, baits and applications.

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Appendix IV.C. Farm Field Assessments of Fruit Flies (Diptera: Tephritidae) in Pakistan: Distribution, Damage and Control

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Abstract

The abundance and distribution of fruit fly infestation in melon, guava, jujube and mango were assessed in farmers' fields, under different control regimes, in four areas of Pakistan. Larval distribution was not clustered among trees but was highly clustered among fruit. The mean number of larvae per infested fruit was not constant, and was not significantly less variable than the infestation rate. In comparisons of Bait Application Technique (BAT) with farmer controls, in melon, average season-end fruit infestation was 29% in unprotected fields and 5% in those protected by BAT; in guava infestation was 44% in unprotected orchards and 12% in orchards protected by BAT; in jujube, infestation was 16% in unprotected orchards and 4% in those protected by BAT. Fifteen farmer-managed trials found BAT-treated melon fields yielded 37% more than unprotected and farmers reported considerable satisfaction. Soaked-block Male Annihilation Technique (MAT) was compared with farmer practices of no control: average infestation before harvest was 9% in unprotected plots and 0 in those protected. Additional to differences in infestation rate, protected melon fields produced 17% higher yields of all fruit, and protected guava orchards had 20% more fruit on trees, relative to those fallen, suggesting that fly attack stimulated fruit drop, and loss estimates based on percentage infestation of sampled fruit may be underestimates. If these reductions in infestation are extrapolated to loss estimates for Pakistan as a whole, the gross annual saving inferred is 4915 million Pakistan Rupees or US$144.6 million.

Key words: Pakistan, fruit fly, on-farm controls, BAT, MAT, distribution

Introduction

Fruit flies are estimated to cause annual losses to fruit and vegetable farmers in Pakistan of over US$200 million (Stonehouse *et al*., 1998). This study aimed to evaluate aspects of their distribution, damage and control, using realistic applications in farmers' fields, and to develop for this a suite of assessment techniques sufficiently accurate to quantify fly populations, and sufficiently robust to allow data to be gathered under difficult field conditions.

The study looked at the presence and infestation levels of different species in different crops, and when and how quickly infestation built up. The spatial distribution of infestation among trees and fruit was also studied. If attack is clustered among trees in "hot spots" in the field, as opposed to randomly or evenly distributed, more effort is required to assess infestation, and control efforts may need to be localised. The distribution of larvae among fruits affects the relationship between the infestation rate, which is the frequency of fruits containing one or more larvae (directly affecting economic because any infested fruit is largely unmarketable), and the size of the larval population present, which is the product of the infestation rate and the mean number of larvae per infested fruit. Changes in larval population size may result in changes in either or both of these component quantities.

If the distribution of larvae among fruits is random, a change in the size of the total larval population would involve changes in both the infestation rate and the number of larvae per infested fruit. If, however, the number of larvae per infested fruit is relatively constant (that is, if infestation is clumped), then changes in the total larval population would be a direct function of the infestation rate. The relationship between population size and economic loss depends on which of these two patterns (or intermediates) occurs. If the mean number of larvae per infested fruit remains constant, population control will be directly related to loss reduction. However, if it does not remain constant, and the number of larvae per infested fruit is the major determinant of population size (and infestation rate relatively constant), then changes in density of larvae overall will not correlate well with changes in infestation rate (and therefore economic loss), especially when the mean larval population is above one per fruit. In this case control efforts at high infestation levels will produce relatively poor returns, and the

economic damage per fly will be greater at small population sizes than at large ones. Additionally, several control studies (e.g. Qureshi *et al*., 1981, Marwat *et al*., 1982) have assessed fly control as differences in total emergences of pupae per number or mass of fruit: these values can only be converted into infestation rates, and thus economic losses, if the distribution of larvae among fruit is known.

A check was also made on the ability of parapheromone lure traps to convey information about fruit infestation. Traps allow the quick and cheap monitoring of fly populations, potentially useful both for general population monitoring and for on-farm threshold estimates to deploy controls, but they are difficult to calibrate to infestation ((Nasir Uddin *et al*., 2000b).

Control research focussed on the potential benefits of the use of Bait Application Technique (BAT) and soaked-block Male Annihilation Technique (MAT). Neither of these technique is in farm use in Pakistan.

BAT deploys spots of protein bait mixed with insecticide; adult insects are attracted to these, feed from them and are killed (Rossler, 1989). Per unit surface area, BAT may use less than 10% of the insecticide content of cover sprays, and thus is cheaper and less polluting. Bees and parasitoids are not attracted to the protein, and deposits may be positioned to minimise exposure of humans and domestic animals. BAT has been successfully evaluated in Pakistan (Latif *et al*., 1987) but not widely adopted.

MAT exploits the attraction of male fruit flies to parapheromones to eradicate males so that flies cannot reproduce (Cunningham, 1989). It involves less expense, insecticide and threat to humans and non-target organisms even than BAT. In Pakistan MAT has been shown substantially to reduce fly populations in guava (Marwat *et al*., 1992; Qureshi *et al*., 1981) and mango (Mohyuddin and Mahmood, 1993). It has hitherto used plastic traps containing cotton wicks soaked in lure, which can be expensive, needing regular reloading and emptying, and vulnerable to sunlight, wind and theft; these shortcomings can be remedied if traps are replaced by wooden blocks soaked in lure and insecticide which can be nailed or hung in trees - male flies are attracted to the blocks, feed from their surfaces and are killed. In Mauritius, a block programme has successfully maintained low levels of flies over large areas (Permalloo *et al*., 2001).

Materials and Methods

Fruit and flies were sampled on farms from a variety of zones, farms, years and seasons, together labelled "sites", around Rahim Yar (RY) Khan (28°24'N, 70°19'E, by ZC) and Faisalabad (31°22'N, 73°3'E, by GM), in the Punjab, and Mardan (34°13'N, 72°4'E, by AM) and Dera Ismail (DI) Khan (31°51'N, 70°56'E, by KB), in the North West Frontier Province. The four are spread over an area of over 100 000Km^2.

BAT and MAT were deployed on farms for comparison with farmer controls under field conditions (in fact all no-control, with the sole exception of guavas in Mardan, protected by cover sprays of insecticide). BAT was assessed in guava (*Psidium guajava*; DI Khan, 1998, two farms; RY Khan, 1998, two farms; Mardan, 1998, one farm; fields between one and five Ha), jujube (*Ziziphus jujuba*; DI Khan, 1998, one farm, and 1999, one farm, Faisalabad, 1999, one farm; fields between 0.4 and 4.5Ha) and melon (*Cucumis melo*; RY Khan, 1999, two farms; DI Khan, 1999, two farms; Faisalabad, 1999, one farm; fields between 0.4 and 5.5Ha). Soaked-block MAT was evaluated on mango (*Mangifera indica*) in RY Khan in 1999 on four farms (fields between 2.4 and 6.0Ha). Two other crops - persimmon (*Diospyros virginiana*; Mardan, 1998, one farm) and luffa (*Luffa aegyptiaca*; RY Khan, 1998, two farms) - were evaluated but trials discontinued after late starts and small sample sizes indicated few useful results could be expected.

The study served as both a survey of loss levels and distributions and a comparative trial of control technologies. Fieldwork encountered difficult conditions, relying on public transport for field visits, and at risk to larval mortality in rearing laboratories whose temperature and humidity could not be controlled, and to the loss of crops to other causes such as drought and the theft of fruit (and equipment) from fields. As a result, the data-gathering process was intended to be as robust as possible, with overlapping use of different assessment methods to back each other up. A standardized research data set was developed to allow both the comparison of controls and farm-by-farm evaluation of distribution. Data gathering was facilitated when in 1999 loose data record sheets were replaced with purpose-written comb-bound data books of empty tables for the recording of all variables from one field in one season, together with a manual for filling in the data books, with worked examples. Similarly, data analysis was facilitated by the development of a standard spreadsheet template of statistical operations, laid out to mirror the data sheets, onto which field data could be copied for standardised processing.

Experimental controls were deployed by farmers or researchers. BAT sprays were of a preparation of 3ml of malathion 57% a.i. E.C. ("Fifinone" obtained locally) and 30ml of commercial protein (International Pheromone Systems Ltd, Ellesmere Port, South Wirral, CH65 4TY, UK. ips_ltd@btconnect.com) in 1l of water, applied in discrete spots at a rate of 7.5$l.Ha^{-1}$. Application was by farmers or researchers depending on circumstances, with standard lever-operated knapsack sprayers. Following guidance from the Mauritian National Programme, MAT blocks were of 5x5cm squares of 1.2cm thickness commercial plywood, soaked in a mixture of 95% ethanol solvent obtained locally, technical methyl eugenol (International Pheromone Systems Ltd) and malathion ("Fifinone") in a v:v:v ratio of 6:4:1. Blocks were soaked for approximately twelve days, allowed to dry for

approximately six, and hung in trees. In order to reassure farmers, who pointed out that unlike traps blocks provide no direct evidence of killing flies, cotton bags, their mouths held open by wire rings, were hung below some blocks to demonstrate that they kill flies.

Each farm evaluation was in a single field. Each of these was divided into two halves treated differently, and all analyses were carried out in each half. Sampling was sequential by successive visits to plots to allow assessment of the development of infestation over time. Fruit ripen over a period of time, and are harvested sequentially, with ripe fruit removed at each pass. All fields were assessed once, as close as possible to the main harvest. Some others, as access and resources permitted, were also visited at other points in the harvesting season. Fly records from successive visits were combined to obtain overall values by deriving means of fly damage weighted in each case by the quantity of fruit harvested at that point in time. Some fields, in addition, were sampled very early in the season, to check that the two halves to be treated differently did not differ significantly in their fly populations before treatments started. Each field assessment had several components, as follows.

The first was of the volume of harvested fruit. Relative to the assessment of fruit infestation, quantifications of harvested yield have the disadvantage of being more prone to non-treatment fluctuations in uncontrolled variables (e.g. fertility and water) but the advantage of being most easily converted to farm income and so offering the best indication of likely control impacts on livelihoods. Harvests were assessed and recorded by farmers or researchers as weights or counts of fruit, along with prevailing prices in Pakistan Rupees (Rs).

In 1999 there was also a series of farmer-managed trials, assessed by harvested yield alone, of BAT for melon fly control, to obtain comparisons across a large number of farms, to complement the detailed trials. In the arid area around Kulachi, 40km west of DI Khan, bait mixture and training in its use were given to fifteen farmers for evaluation in protected and unprotected plots, and records made of farmers' estimates of yields and returns.

Second, the density of fruit production was assessed on each of five trees (or, in the case of melons, "clumps" of plants in areas 2mx2m) in each treated field half. Melon density was estimated by three randomly-thrown square-metre quadrats in each clump. Tree fruit numbers were estimated or counted by eye on each of the five trees sampled; for each tree this number was divided by a simple estimate of tree volume, obtained by multiplying its height by the area beneath it, to estimate the density of fruit per cubic metre of canopy. Fruit on the ground were counted in three randomly-thrown square-metre quadrats beneath each tree, and the average of these, as a mean value per m^2, divided by the tree's estimated height to obtain an estimate of fallen fruit per m^3 of canopy. Fruit counts were divided into the simple ordinal classes of 1=formation, 2=growing, 3=ripening and 4=ripe.

Third, two parapheromone lure traps were also deployed in each treated field half.

Fourth, infestation of fruit was assessed by three methods. Formal samples of susceptible fruit were taken from each treated portion of a field at various points in the season, the main sample being as near as possible before the main harvest. Each comprised 30 fruit, as six fruit, ripe enough to be attacked, from each of the five sampled trees or melon clumps, from trees themselves and (except in melons) from the ground beneath. First (method i), fruit were inspected and classified into those unblemished, apparently oviposited, apparently exit-holed and rotting. Subsequently (method ii) the gathered fruit were kept for the collection of emerging flies, in shaded, cool rooms (checked by maximum-minimum thermometers), in individual containers, to allow the quantification of larval distribution among fruit and of numbers of fruit infested. Fruit were placed on sand, which was regularly sieved for emerged pupae, which were then transferred to glass phials stoppered with cotton wool to await the emergence of adults for identification. Adults were fed and watered (to allow colours to develop), then killed, identified and mounted in a permanent collection (C.O. RM). Additionally (method iii), the counts of fruit harvested were categorised into pristine, fly-attacked and not visibly attacked but spoiled by rot.

The three approaches to fruit infestation assessment were intended to complement each other by balancing precision and robustness: the formal samples (i, ii) were relatively small (30 fruit) and taken not at harvest but before, whereas harvest assessments (iii) were of the whole harvest taken as it was gathered; visual damage assessments by farmers (iii) and researchers (i) are essentially subjective, give no identification of fly species, and are uncertain indicators of fly attack (oviposition punctures can resemble other blemishes; exit-holes can resemble bird and beetle attacks) but the rearing of larvae from fruit (ii) while objective and certain, lacks robustness in field conditions where collection, transport and storage may affect larval mortality. These advantages and disadvantages are summarised in Table IV.C.1.

Table IV.C.1. Fruit infestation assessment methods scored by criteria of advantage (1=low; 2=intermediate; 3=high).

Criterion	Sample inspection	Sample larva rearing	Farmer harvest estimate
Sample size	1	1	3
Proximity to harvest	1	1	3
Objectivity	2	3	1
Species identification	0	3	0
Robustness	2	1	3

Results

Throughout, data are summarised as unadjusted means and standard deviations (S.D.); statistical analysis was generally by related *t* test or analysis of variance (ANOVA), after data normalisation by the arcsine transformation in the case of data as frequencies or percentages (Sokal and Rohlf, 1995).

Table IV.C.2 gives infestation levels in unprotected plots, including some where no experimental results were obtained and are not discussed below, together with the overall estimates of Stonehouse *et al*. (1998), with which they seem to be in overall broad agreement. No parasitoid was found in any fruit or trap. Trimedlure traps deployed near Islamabad airport and the main road to the NWFP and Khyber Pass caught no *Ceratitis capitata* or other insect.

Table IV.C.2. Mean percentage infestation of fruit by flies in various zones (by pupal emergence unless specified) in the absence of controls. Species were unknown where larvae emerged but not adults. Also included (as "Survey") are the comparable overall Pakistan loss estimates by Stonehouse *et al*. (1998).

Crop	Location	Year	Species	Infestation (%)
Melon	DI Khan	1999	*Bactrocera cucurbitae*	50
Melon	RY Khan	1999	*Bactrocera cucurbitae*	23
Melon	Faisalabad	1999	None	0
Melon	Kulachi	1999	*Bactrocera cucurbitae*[1]	37[2]
Melon	**Survey**	**Several**	**All**	**35**
Guava (summer)	DI Khan	1998	*Bactrocera zonata*	80
Guava (summer)	RY Khan	1998	*Bactrocera zonata*	11
Guava (summer)	Mardan	1998	*Bactrocera zonata*	14
Guava (winter[3])	RY Khan	1998	None	0
Guava (overall[4])	**Survey**	**Several**	**All**	**35**
Jujube	DI Khan	1998	Unknown	3
Jujube	DI Khan	1999	*Carpomyia vesuviana*	45
Jujube	Faisalabad	1999	None	0
Jujube	**Survey**	**Several**	**All**	**15**
Mango	RY Khan	1999	*Bactrocera zonata*	9
Mango	**Survey**	**Several**	**All**	**15**
Persimmon	Mardan	1998	*Bactrocera zonata*	11
Persimmon	**Survey**	**Several**	**All**	**40**
Luffa	RY Khan	1998	Unknown	>15
Plum	Peshawar	1999	*Bactrocera dorsalis*[1]	23[5]
Plum	**Peshawar**	**Survey**	**All**	**35**

1 Identification inferred from trap catches although no adults were reared.
2 Difference in mean yield weight between treated and untreated plots (Table IV.C.5, below) - not a strict record of infestation.
3 Result from a single winter fruit sample to check the common view that the winter guava crop is largely unattacked.
4 Stonehouse *et al*. (1998) did not distinguish summer and winter guava crops.
5 Figure from another study in this project (Hai, 2001); fruit were not collected, but identified as attacked on the tree.

Sequential samples taken after the development of ripe fruit allowed the assessment of the development of infestation rates through the harvesting period, and the observation of how infestation, as the average of treated and untreated plots, may build up. In two melon plots, when ripening fruit frequency was 46 and 52% of final, infestation was 76% and 186% of final. In four guava plots, when ripening fruit frequency was between 27 and 73% of final, infestation was between 12% and 1467% of final. In two jujube plots, when ripeness was 62 and 68% of final, infestation was 50 and 113% of final. In one mango field, when ripeness was 83% of final, infestation was 50% of final. These data were inadequate for statistical analysis, but are sufficient to show that levels of

attack, at intermediate stages of fruit development, can be highy variable and that it cannot be assumed that attack is restricted to later periods so that, at least in the absence of a monitoring system, protection of fruit should be recommended to begin as soon as attack can begin.

The distribution of fly infestation among trees and melon clumps was not clustered. Nested ANOVAs compared variation in infestation between the five sampled trees (or melon clumps) in each treated half of each field, relative to that among fruit on the same tree or clump (six fruit on each). On-tree and fallen fruit were assessed separately. Of 44 data sets with enough data to be useable, only one (of guavas) showed a significant difference between trees (F=2.8721[4,25]*); among the other 43, 35 F values were unity or less.

Infestation was significantly clustered among fruit. Observed distributions were compared by Kolmogorov-Smirnov tests with Poisson distributions, with on-tree and fallen fruit assessed separately, and the two differently-treated halves of each field pooled to obtain a spread of different infestation levels (N=60 in all cases). In the four mango fields, none of the samples on trees significantly departed from the Poisson (between D=0.0162 and D=0.1592) but all of the samples in fallen fruit did so (between D=0.2666*** and D=0.2780***). Of the 18 useable data sets among the other fruits, two did not depart significantly from the Poisson model (one of guava D=0.1082 and one of jujube D=0.0006) but the other 16 did, 11 of them at the level P<0.001 (between D=0.1897* and D=0.5866***). All departures were to a distribution more clustered than Poisson.

The relative contributions, to the overall larval population, of the infestation rate and the mean number of larvae per infested fruit, was first investigated by seeing if the two values were positively associated. The two values were calculated for each tree (or melon clump) in both treated halves of each field (omitting fallen fruit) and compared by linear least-squares correlation for each field. Of 17 useable data sets one (of guavas) produced a significant association (F=22.3831[1,7]**); among the rest, seven associations were negative. This implies that infestation rate and numbers of larvae per infested fruit were largely independent. Second, the two values were compared for their level of variation: as both are ratio quantities, if one is more variable than the other, it will be the chief determinant of larval population size. The two quantities were compared by their coefficients of variation, among trees in both treated halves of each field but separating on-tree from fallen fruit. These, calculable only for some plots, are given in Table IV.C.3. There is little evidence that infestation level and fly larval population fluctuate together while the average number of larvae per infested fruit remains relatively stable.

Table IV.C.3. Coefficients of variation (CV) among infestation rate (IR) and mean number of larvae per infested fruit (NL). Compared by the nonparametric Wilcoxon test (due to the unconventional nature of CVs as data), there were no significant differences between IR and NL values.

Fruit	Location	Value	Mean (CV)	S.D.
Melon		IR	0.41	±0.10
(N=4)		NL	0.57	±0.20
Guava	Tree	IR	0.51	±0.19
(N=3)		NL	0.23	±0.05
	Ground	IR	0.55	±0.09
		NL	0.44	±0.18
Jujube	Tree	IR	0.18	±0.25
(N=2)		NL	0.10	±0.14
	Ground	IR	0.50	±0.08
		NL	0.21	±0.30
Mango	Tree	IR	0.12	±0.22
(N=3)		NL	0.26	±0.16
	Ground	IR	0.39	±0.05
		NL	0.33	±0.11

In order to evaluate the representation by trap catch data of losses in the same plots, data for trap catches from one time interval were compared with those for emergence of pupae from fruit gathered at the end of the same interval. The larval infestation figure used for comparison was the total number of larvae per tree, obtained by multiplying the volume of fruit recorded on trees and on the ground by the frequencies of pupae emerging in the samples taken at the same times. Analysis was by regression of the 'Total' values for larvae present with the trap catches of adults at the time: these produced no statistically significant relationships and no R^2 value greater than 0.23. There was no indication of a reliable relationship.

In the comparison of plots treated with different crop protection treatments, many cases differences between "sites" (zones, farms, years and seasons) were significant, but the values for sites are not given individually as, since such variation was expected and is attributable to a wide variety of non-experimental

factors (ecoregion, year, season, weather, surrounding vegetation, random fluctuations), these differences are not discussed. The catching bags suspended below some blocks demonstrated that they were indeed killing flies, with up to several hundred dead in each bag at the end of the season.

Generally, harvested yields were recorded by fruit number, weight and value (at local prices) on each plot, per unit area for adjustment to hectares. Differences between treatments were least significant in cash value, attributed to small sale values of attacked fruit for use in pickles, chutneys and similar in some areas. More reliable effects were found among fruit numbers, but most reliable among fruit weights - this latter difference may be due to higher weights of individual fruit in protected plots, although this was not statistically demonstrated. Table IV.C.4 shows the wieght yield of all melons from the five researcher-managed trials. In other fruits harvest volumes did not significantly differ (not all data were obtained from guavas and jujubes).

Table IV.C.4. Yield (Kg.ha^{-1}) of all (pristine and blemished) melons harvested from five researcher-managed comparisons across Pakistan. The difference was statistically significant (related *t*=3.9962[4]*). The mean yield increase attributed to BAT was 17%.

Control	BAT	None
Mean (Kg.ha^{-1})	5646	4832
S.D.	±9586	±823

Table IV.C.5 shows the outcome from the farmer-managed trial at Kulachi. On none of the fifteen farms did the application fail to recover its estimated costs (Mahmood *et al*., 2001), and all farmers expressed themselves favourable to BAT and keen to obtain a source of bait supply. Kulachi is, however, fly-infested and short of water for cover sprays, and thus may be better favoured for BAT use than the country overall.

Table IV.C.5. Yield (Kg.ha^{-1}) of unblemished melons from fifteen farmer-managed comparisons at Kulachi, NWFP. The difference was statistically significant (related *t*=7.2087[14]*). The inferred yield increase by BAT was 37%, totalling 728kg.ha^{-1}, leading with a melon price of Rs8Kg^{-1} and BAT costs of Rs450ha^{-1}, to a net gain of Rs5375ha^{-1} or US$158ha^{-1} at an exchange rate of US$1=Rs34.**

Control	BAT	None
Mean (Kg.ha^{-1})	2738	2010
S.D.	±457	±447

Additional to harvested yield, estimates were made of production of fruit on trees and vines. Density of melons in square-metre quadrats did not significantly differ among treatments (mean in BAT plots was 17.7, in unprotected plots 14.8, with S.D.s of respectively 11.4 and 9.0, related *t*=2.2448[4], *P*=0.088). Absolute levels of production are variable among trees, obscuring differences due to treatments. This problem was addressed by assessing not absolute fruit numbers but the relative abundance of tree fruit and fallen fruit below the same trees, in the hope that the use of this ratio might cancel out tree-tree variability and distinguish trees in their tendency to shed fruit. These ratios are shown in Table IV.C.6, and suggest that the ratio of on-tree fruit to fallen fruit was higher in protected than unprotected orchards, implying that fly attack may stimulate the fall of fruit from trees.

Table IV.C.6. Percentages of all fruit present (on-tree and fallen) represented by those on-tree as opposed to fallen, both per estimated cubic metre of tree canopy. In guavas, though not the others, the ratio was significantly greater in BAT than unprotected plots (related *t*=4.2619*[4]). The increase in guava density attributed to BAT was 20%.

Fruit	Guava (N=5)		Jujube (N=2)		Mango (N=4)	
Protection	BAT	None	BAT	None	MAT	None
Mean (%)	49	40	96	87	56	53
S.D.	±26	±30	±4	±14	±36	±34

Fruit ripening was evaluated by comparing the percentage of all fruit present on trees and vines which fell into the latter two of the four ordinal ripening classes, “ripening” and “ripe”, as shown in Table IV.C.7.

Table IV.C.7. Percentage of all on-tree fruit classed as "ripening" and "ripe". In melons, though not the others, the ratio was significantly greater in BAT than unprotected plots (related *t*=3.4587[3]*).

Fruit	Melon (N=4)		Guava (N=5)		Jujube (N=2)		Mango (N=5)	
Protection	BAT	None	BAT	None	BAT	None	MAT	None
Mean (%)	72	70	69	68	62	69	76	75
S.D.	±30	±31	±26	±26	±19	±15	±28	±30

Parapheromone trap catch data are given in Table IV.C.8. On some plots traps were stolen, and on others plot sizes were too small to allow trap deployment without mutual interference. There were no statistically significant differences due to treatments.

Table IV.C.8. Mean numbers of flies caught in traps among fruit sites. Traps were baited with cue-lure among melons and methyl eugenol elsewhere . There were no significant differences due to treatments.

	Melon (N=2)		Guava (N=5)		Jujube (N=1)		Mango (N=1)	
Protection	BAT	None	BAT	None	BAT	None	MAT	None
Mean (No.)	3	4	708	1708	8	3	15	2
S.D.	±1	±0	±609	±1787	-	-	-	-

Data from assessment by pupal rearing (method i) and by inspection of sampled fruit (ii) are presented in Tables IV.C.9 to IV.C.12. Analysis was by ANOVA (of arcsine-transformed data) in two dimensions (for arable melons, among treatments and sites) or three (for orchard fruits, additionally between fruit on-tree and fallen, called "locations"). (As a check on the economically important category, these incidences were also compared for on-tree fruit alone by related *t* tests; these obtained significance levels similar to the ANOVA results and are not presented). In three of five melon plots, one of five guava plots and one of three jujube plots, an initial assessment, when ripening fruit was less than 5%, was made to check for differences in infestation before treatments began; Fisher exact contingency tests found no significant differences.

Table IV.C.9. Percentage fly infestation of melons shortly before harvest in five sites, with BAT protection and none, and assessed by pupal emergence and fly mark records. The inferred reduction in infestation by BAT was 84%.

	Indicator:	Pupae		Marks	
Output	Protection:	BAT	None	BAT	None
Infestation	Mean	4.7	29.3	26.3	49.3
(%)	S.D.	±5.6	±26.9	±24.9	±28.6
ANOVA *F*	Treatments	10.6262[1,4]*		4.7660[1,4]ns	
	Sites	4.5009[4,4]ns		7.4730[4,4]*	

Table IV.C.10. Infestation of guava fruit from fives sites, as in Table IV.C.9 and among fruit in the "locations" of on the tree and fallen to the ground. No interactions were significant except that between locations and sites by marks (*F*=23.1455[4,4]). The inferred reduction in infestation by BAT was 73%.**

	Indicator:		Pupae		Marks	
Output	Protection:		BAT	None	BAT	None
Infestation	Tree	Mean	11.6	43.7	26.2	53.0
(%)		S.D.	±10.2	±35.0	±9.6	±28.5
	Ground	Mean	16.4	45.5	56.0	75.1
		S.D.	±10.0	±31.8	±21.7	±13.7
ANOVA *F*	Treatments		26.3165[1,4]**		63.6634[1,4]**	
	Locations		0.8965[1,4]ns		79.6435[1,4]***	
	Sites		99.3364[4,4]*		4.2473[4,4]ns	

Table IV.C.11. Infestation of jujube fruit from three sites, as in Table IV.C.10. Among pupae there were significant interactions between treatments and sites (*F*=81.6134[2,2]*) and locations and sites (*F*=54.1577[2,2]*). The inferred decrease in infestation by BAT was 76%.

	Indicator:	Pupae		Marks	
Output	Protection:	BAT	None	BAT	None

Infestation (%)	Tree	Mean	3.9	16.1	30.6	44.4
		S.D.	±4.2	±25.1	±24.3	±36.6
	Ground	Mean	8.9	17.8	33.9	41.7
		S.D.	±10.2	±16.8	±24.3	±24.7
ANOVA *F*	Treatments		81.6134[1,2]*		0.3281[1,2]ns	
	Locations		21.4615[1,2]*		7.2344[1,2]ns	
	Sites		364.8379[2,2]**		7.5350[2,2]***	

Table IV.C.12. Infestation of mango fruit from four sites, as in Table IV.C.10. No interactions were significant. The inferred reduction in infestation by MAT was 100%.

	Indicator:		Pupae		Marks	
Output	Protection:		MAT	None	MAT	None
Infestation (%)	Tree	Mean	0.0	10.0	5.0	17.5
		S.D.	±0.0	±7.2	±1.9	±11.0
	Ground	Mean	4.2	24.2	68.3	73.3
		S.D.	±1.7	±6.3	±6.4	±9.4
ANOVA *F*	Treatments		211.0847[1,3]***		36.9901[1,3]**	
	Locations		92.1408[1,3]**		1047.3419[1,3]***	
	Sites		6.9911[3,3]ns		15.2315[3,3]*	

Estimates of fruit infestation at harvest (method iii, above) were adequate for analysis only in melons and mangoes. The results are given in Table IV.C.13.

Table IV.C.13. Farmer estimates of percentage loss frequencies among harvests on four mango farms and five melon farms. Spoiled mangoes were identified as "fly-attacked", melons as"fly-attacked" and "spoiled but not visibly fly-attacked". The inferred reduction in all spoiled melons by BAT was 63.6%; that by MAT in attacked mangoes was 96%.

Fruit:	Mango		Melon			
Symptom:	Attacked		Attacked		Spoiled	
Protection	MAT	None	BAT	None	BAT	None
Mean (%)	0.3	8.9	0.7	5.3	2.9	4.9
S.D.	±0.1	±5.0	±0.4	±1.8	±1.5	±2.4
Related *t*	5.0533[3]*		6.2755[4]**		6.0701[4]**	

Conclusions

The methodology developed was able to distinguish many important variables. Visible marks were recorded on sampled fruits, as a back-up to the more accurate but less robust (in case of larval mortality before emergence) record of emerged pupae. Visible mark records were inferior to pupal rearing in the detection of infestation differences, but provided some meaningful information, and may be recommended as a back-up when there is a risk of loss of pupal emergence data. Estimates of fruit numbers on trees and on the ground were able to distinguish different levels of production.

The number of sites used was only barely adequate. The greater clarity of conclusions from guava and melon (on five sites) than from mango and jujube (on respectively four and three) strongly suggests that replication levels of at least six plots should be sought in studies of this sort.

Flies were not clustered among trees or bushes within fields, but were clustered among fruit, although the number of larvae per infested fruit was not constant, and not significantly less variable than the infestation rate.

Losses in general were most apparent as infestation levels on trees. There was evidence, however, that fruit with heavier fly attack were likely to be less numerous, possibly because more likely to fall from the tree. This would make loss estimates derived from infestation rates alone too low, by removing from the sample some fruit which are attacked.

Bait sprays were effective in controlling fruit flies on guava, jujube and melon, and are preferable to cover sprays for reasons of cost, safety and environmental contamination. All farmers who hosted trials made favourable comments about BAT regarding its effectiveness and its low demands for water and work.

MAT was able effectively to control fruit flies in mangoes. However, losses may anyway sometimes be too low to justify controls. Both BAT and MAT attained control even on small and medium-sized farm plots (0.2 to 2.0ha).

The potential significance of these results may be estimated by extrapolating the reduction obtained in percentage infestation by flies to the loss estimates Pakistan by Stonehouse *et al*. (1998). This extrapolation is problematical, but if accepted with appropriate caveats can estimate the hypothetical potential benefit of a wider use of BAT and MAT in Pakistan. Table IV.C.14 gives the outcome of this exercise for the fruit assessed. Infestation reductions are taken as the reductions in reared-out larvae obtained in Tables IV.C.9 to IV.C.12. The table shows estimates of annual gross savings (not including control costs) for the four crops of Rs4915 million, or (at the rate of 1US$=Rs34) $144.6 million.

Table IV.C.14. Potential gross savings at farm level in Pakistan from overall reductions in fruit fly losses of the sizes estimated above. Production, prices and losses of melon, guava and mango (rows marked *) are for 1994-6, from Table 4 of Stonehouse *et al*. (1998), and dollar conversion at the then-prevailing rate of Rs34:US$1. Jujube production and prices, with no official statistics, are estimates from Pakistan Ministry of Agriculture personnel, and jujube losses from Stonehouse *et al*. Table 3. Production is taken to be after pest loss, but loss estimates refer to potential production; so if recorded production is 100 units, and loss estimated at 25%, the loss is inferred to be not 25 units but 33.3, *i.e.* potential production is 133.3 units and 25% of this is lost to leave 100. Estimated percentage increases in yield and reductions in infestation are those derived above, in the Tables specified.

Crop	Melon	Guava	Jujube	Mango
Annual production ('000 MT)*	536	402	18	839
Unit price ($Rs.MT^{-1}$)*	5440	7300	5500	9100
Production value (Rs million)*	2916	2935	99	7635
Crop protection	BAT	BAT	BAT	MAT
Experimental yield increase (%)	17	20	0	0
(Source - Table)	(IV.C.4)	(IV.C.6)	(IV.C.6)	(IV.C.6)
Inferred yield increase value (Rs million)	496	587	0	0
Percentage overall loss (%)*	35	35	15	15
Annual loss (Rs million)*	1570	1580	17	1347
Experimental infestation reduction (%)	84	73	76	100
(Source - Table)	(IV.C.9)	(IV.C.10)	(IV.C.11)	(IV.C.12)
Inferred infestation reduction value (Rs million)	1319	1154	13	1347
Total inferred crop protection value (Rs million)	1815	1740	13	1347
Total inferred crop protection value (US$ million)	53.4	51.2	0.4	39.6

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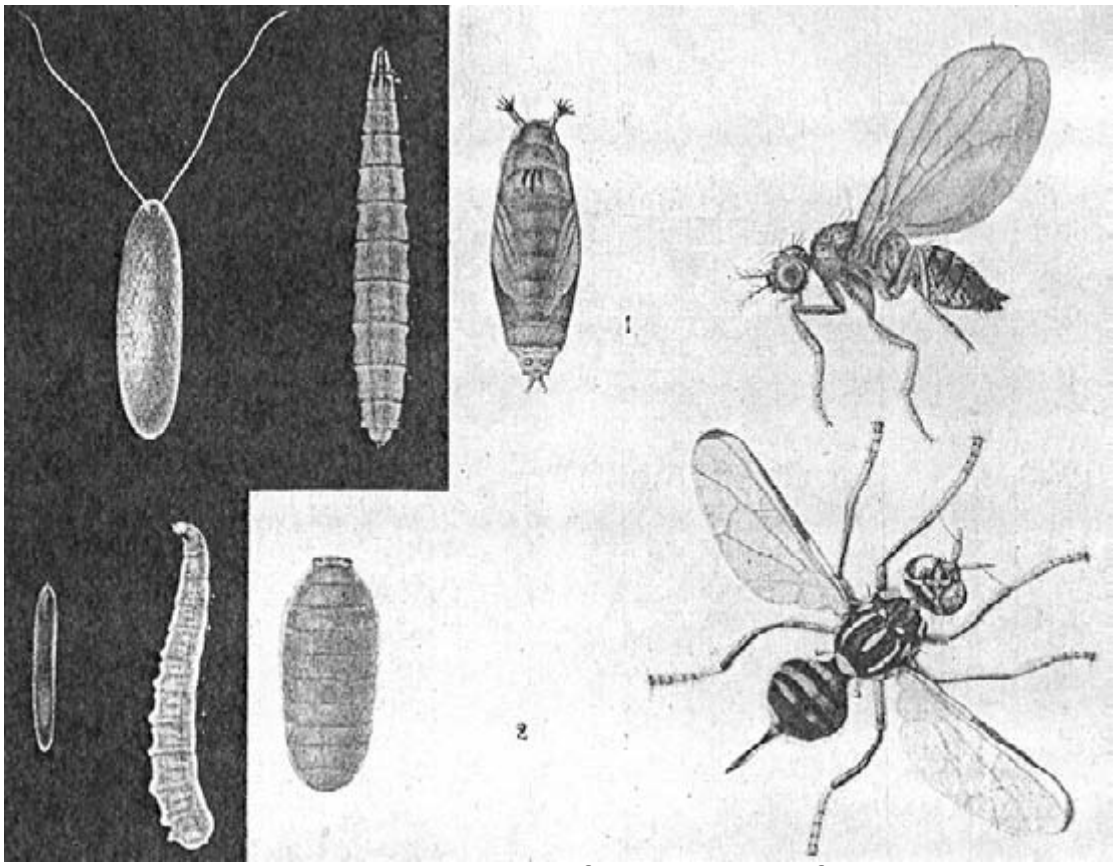
Project *Integrated Management of Fruit Flies in India (IMFFI)* (DFID Project CPPPM210 (Contract R8089)

IMFFI Knowledge Review: Publications on Indian Fruit Fly Ecology, Infestation and Management

August 2004



Frontispiece: Indian Diptera from Maxwell-Lefroy, H:
Indian Insect Life: A Manual of the Insects of the Plains, Tropical India
(Calcutta and Simla: Thacker, Spink, 1909).

This document present summaries of publications about Indian fruit flies located by electronic and manual searches from a base at Pusa, New Delhi. It is not exhaustive. It contains eighteen numbered sections as follows.

1 Host production by state
2 Host production by product
3 Host production trends
4 Species list
5 Host list
6 Species records (qualitative): incidence and distribution, including findings alongside other
7 Loss estimates (quantitative) with and without crop protection
8 Population dynamics, fluctuations, distribution patterns and environmental ecology
9 Preference and survival among different hosts, host resistance and susceptibility
10 Rearing, culture and diet
11 Physiology and biochemistry, including the effects of radiation
12 Natural enemies (multicellular organisms - not those applicable by a sprayer): predators, pa
13 Cultural controls
14 Insecticides assessed for laboratory lethality and as sprays, including botanicals, PGRs and
15 Chemical sterilization
16 Pheromone lures, colours
17 Food baits
18 References

Authors: Singh, A, Sardana, HR, Chaurasia, V, Stonehouse, JM

This document is also available as a spreadsheet computer file, to allow searching and sorting, from j.stonehouse@imperial.ac.uk

Section 1: Indian Fruit and Vegetable Production by area
2001 Data (* - 2000 data)
Source: Indian Horticulture Database, National Horticulture Board, New Delhi

State or Territory	Area ('000 Ha)	Production ('000 MT)	Yield (MT/Ha)		State or Territory	Area ('000 Ha)	Production ('000 MT)	Yield (MT/Ha)
FRUIT					VEGETABLES			
Maharashtra	529.3	8680.8	16.4		West Bengal	1075.0	17779.4	16.5
Andhra Pradesh	448.0	5003.4	11.2		Uttar Pradesh	668.1	13030.4	19.5
Karnataka	326.9	4819.5	14.7		Bihar	707.8	10219.7	14.4
Bihar	268.4	3237.5	12.1		Orissa	702.5	8089.1	11.5
Uttar Pradesh	287.8	2713.0	9.4		Karnataka	343.7	5763.0	16.8
Gujarat	170.9	2268.2	13.3		Maharashtra	409.0	5142.0	12.6
Kerala	234.5	1772.6	7.6		Madhya Pradesh	238.5	3501.9	14.7
Madhya Pradesh	63.2	1740.4	27.5		Andhra Pradesh	249.9	3147.7	12.6
West Bengal	133.7	1656.5	12.4		Gujarat	205.6	3070.8	14.9
Assam	107.0	1293.8	12.1		Assam	238.3	2693.1	11.3
Orissa	215.4	1284.4	6.0		Kerala	114.8	2530.9	22.0
Jammu & Kashmir	140.9	837.3	5.9		Punjab	131.0	2318.0	17.7
Uttranchal	191.8	541.0	2.8		Haryana	141.7	2191.5	15.5
Punjab	35.2	479.7	13.6		Jharkhand	149.8	2109.5	14.1
Tripura	28.9	450.8	15.6		Chhattisgarh	84.2	1146.3	13.6
Himachal Pradesh	213.0	438.3	2.1		Uttranchal	104.8	1138.1	10.9
Rajasthan*	20.0	339.3	17.0		Delhi	114.8	862.7	7.5
Nagaland	24.7	290.4	11.8		Jammu & Kashmir	45.7	757.9	16.6
Jharkhand	20.9	265.1	12.7		Himachal Pradesh	44.8	734.2	16.4
Tamil Nadu	240.4	237.7	1.0		Rajasthan	95.1	386.4	4.1
Haryana	30.7	232.0	7.6		Tripura	31.8	328.1	10.3
Meghalaya	24.1	186.9	7.8		Meghalaya	37.7	303.6	8.1

Chhattisgarh	11.8	154.3	13.1		Nagaland	26.9	253.6	9.4
Arunanchal Pradesh	51.1	123.1	2.4		Arunanchal Pradesh	21.0	83.7	4.0
Manipur	24.7	118.7	4.8		Goa	7.6	76.0	10.0
Goa	10.5	71.5	6.8		Manipur	9.7	67.4	6.9
Mizoram	18.0	66.7	3.7		Sikkim	13.5	59.7	4.4
Pondicherry	1.1	26.7	24.3		Pondicherry	3.7	54.2	14.6
Andaman & Nicobar*	3.7	16.7	4.5		Mizoram	7.9	47.3	6.0
Sikkim	9.4	10.0	1.1		Andaman & Nicobar*	3.1	15.8	5.1
Dadra & Nagar Haveli*	0.7	7.1	10.1		Dadra & Nagar Haveli*	1.5	13.5	9.0
Daman & Diu*	0.4	3.4	8.5		Tamil Nadu	218.6	11.0	0.1
Chandigarh	0.1	1.1	11.0		Chandigarh	0.1	1.7	17.0
Lakshadweep	0.3	1.1	3.7		Daman & Diu*	0.1	1.1	11.0
Delhi	0.1	1.0	10.0		Lakshadweep	0.2	0.2	1.0

Section 2: Indian Production of Fruit and Vegetables by Product

2001

Source: Indian Horticulture Database, National Horticulture Board, New Delhi

Fruit	Area	Production	Yield	Area		Vegetable	Area	Production	Yield	Area
Product	('000 Ha)	('000 MT)	(MT/Ha)	as %		Product	('000 Ha)	('000 MT)	(MT/Ha)	as %
Banana	482.8	16167.0	33.5	12		Potato	1211.3	222242.7	183.5	19
Mango	1522.6	10237.0	6.7	39		Brinjal	472.1	7676.9	16.3	8
Citrus	496.6	4399.5	8.9	13		Tomato	458.7	7277.1	15.9	7
Papaya	70.1	1767.1	25.2	2		Cabbage	245.4	5617.1	22.9	4
Guava	148.2	1631.5	11.0	4		Onion	448.9	4721.1	10.5	7
Apple	239.8	1226.6	5.1	6		Cauliflower	256.3	4694.6	18.3	4
Pineapple	78.2	1221.1	15.6	2		Okra	349.1	3344.6	9.6	6
Grapes	45.2	1056.9	23.4	1		Peas	319.3	3007.6	9.4	5
Sapota	69.2	674.0	9.7	2		Others	2487.4	35339.8	14.2	40
Litchi	53.6	412.0	7.7	1						
Others	680.1	6577.3	9.7	17						
Total	3886.4	45370.0				Total	6248.5	293921.5		

Section 3: Trends in Indian Fruit and Vegetable Production

Source: Report and Data Base of Pilot Scheme on Major Fruits & Vegetables - 1982-83 to 1999-2000, Directorate of Economics & Statistics, New Delhi

Crop estimation survey on fruits and vegetables in 11 States:

(Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu & Uttar Pradesh)

		1999			2000			% change 1991-2000		
		Area	Production		Area	Production		Area	Production	
	#	('000Ha)	('000MT)	(MT/Ha)	('000Ha)	('000MT)	(MT/Ha)	('000Ha)	('000MT)	(MT/Ha)
Mango	1	645	3639	5.6	889	3581	4.0	38	-2	-29
Apple	2	33	342	10.3	86	59	0.7	158	-83	-93
Banana	3	152	5898	38.8	234	9358	40.1	54	59	3
Grapes	4	23	384	16.7	38	941	24.8	65	145	48
Guava	5	28	187	6.8	43	294	6.9	54	58	2
Pineapple	6	1	28	31.6	0	11	32.7	-60	-58	3
Citrus	7	156	965	6.2	281	2305	8.2	80	139	33

1 Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Orissa, Punjab,Tamil Nadu & Uttar Pradesh

2 Himachal Pradesh

3 Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Orissa & Tamil Nadu

4 Haryana, Maharashtra, Karnataka & Tamil Nadu

5 Gujarat, Haryana, Karnataka, Rajasthan, Tamil Nadu & Uttar Pradesh

6 Tamil Nadu

7 Andhra Pradesh, Himachal Pradesh, Karnataka, Maharashtra, Punjab, Rajasthan & Tamil Nadu

Section 4: Fruit Fly Species Reported from India

Source: Kapoor "Fruit Flies of India"

1	Dacus		brachycera	
2	D.		eumenoides	
3	D.		icariiformis	
4	D.		munroi	
5	D.		quadristriata	
6	D.		sphaeroidalis	
7	D.		crabroniformis	
8	Bactrocera	(Polistomimetes)	minax	
9	B.	(Javadacus)	aberrans	pallescentis
10	B.	(Arodacus)	cocciniae	
11	B.	(A.)	trilineata	
12	B.	(Bactrocera)	affinis	
13	B.	(B.)	andamanensis	
14	B.	(B.)	biguttata	
15	B.	(B.)	bangalorensis	
16	B.	(B.)	correcta	
17	B.	(B.)	diaphora	
18	B.	(B.)	parvula	
19	B.	(B.)	occipitalis	
20	B.	(B.)	poonaensis	
21	B.	(B.)	scutellarius	
22	B.	(Polistomimetes)	osciniae	
23	B.	(Paradacus)	pusaensis	
24	B.	(P.)	watersi	
25	B.	(Melanodaeus)	citronellae	
26	B.	(Parazeugodacus)	bipustulata	

27	B.	(Zeugodacus)	duplicata	
28	B.	(Z.)	gavisa	
29	Acanthonevra		dunlopi	
30	A.		formosana	
31	A.		fuscipennis	
32	A.		gravelyi	
33	A.		hemileina	
34	A.		imparata	
35	A.		inermis	
36	A.		vaga	
37	A.		vidua	
38	Diarrhegma		modestum	
39	Hexacinia		radiosa	
40	Phorelliosoma		ambitiosum	
41	Rioxa		parvipunctata	
42	R.		sexmaculata	
43	Themara		maculipennis	
44	Urophora		stylata	
45	Acroceratitis		ceratitina	
46	A.		separata	
47	A.		gladiella	
48	Acrotaeniostola		apiventris	
49	Anoplomus		flexuosus	
50	Callistomyia		pavonina	
51	Carpophthorella		scutellomaculata	
52	Chaetellipsis		atrata	
53	C.		dispilota	
54	C.		paradoxa	
55	Galbifascia		sexpunctata	

56	Gastrozona		balioptera	
57	G.		fasciventris	
58	G.		montana	
59	Phaeospila		varipes	
60	Phaeospilodes		bambusae	
61	Proanoplomus		laqueatus	
62	P.		vittatus	
63	Sophira		phlox	
64	Taeniostola		limbata	
65	T.		vittigera	
66	Xanthorrhachis		annandalei	
67	X.		assamensis	
68	Oxyaciura		monochaeta	
69	Sphaeniscus		quadrincisus	
70	Adrama		apicalis	
71	A.		austeni	
72	A.	determinata	determinata	
73	Meracanthomyia	intermedia	intermedia	
74	M.	hotiensis	hotiensis	
75	M.	maculipennis	maculipennis	
76	Ceratitis	capitata	capitata	
77	Euphranta	(Rhacochlaena)	cassiae	
78	E.	(R.)	crux	
79	E.	(R.)	dissoluta	
80	E.	(R.)	nigripeda	
81	Ichneumonosoma		imitans	
82	Indophranta		humerata	
83	Acidiella		angustifrons	
84	A.		discalis	

85	A.		elythraspis	
86	A.		riaxaeformis	
87	Acidiostigma		apicalis	
88	A.		lucens	
89	Anomoia		immsi	
90	A.		mirabilis	
91	Chetostoma		completa	
92	C.		sarolensis	
93	Chenacidiella		bangaloriensis	
94	Hemilea		cnidella	
95	H.		praestans	
96	Myiopardalis		pardalina	
97	Myoleja		fossata	
98	Pseudacidia		himalayensis	
99	Rhagoletis		bezzianum	
100	Trypeta		buddha	
101	T.		indica	
102	Vidalia		ceratophora	
103	V.		cervicornis	
104	V.		fletcher	
105	V.		melanonotum	
106	V.		triceratops	
107	V.		trigenata	
108	Rhabdochaeta		asteria	
109	R.		bakeri	
110	R.		gladifera	
111	Dictyotrypeta		longiseta	
112	Platensina		amplipennis	
113	P.		fulvifacies	

114	P.		tetrica	
115	Indacilira		basivitta	
116	Isoconia		bifaria	
117	I.		reinhardi	
118	Tephraciura		basimacula	
119	T..		pachmarica	
120	Tephrella		decipiens	
121	T.		variegata	
122	Acanthiophilus		lugubris	
123	Actinoptera		carignaniensis	
124	A.		formosana	
125	A.		montana	
126	Campiglossa		cribellata	
127	C.		kumaonensis	
128	Paratephri.ti.s		abstractus	
129	Paroxyna		gemma	
130	P.		iracunda	
131	P.		lyncea	
132	P.		parvula	
133	Pliomelaena		udhampurensis	
134	Pliomelanena		quadrimaculata	
135	Tephriti.s		atocoptera	
136	T.		darjeelingensis	
137	T.		ludhianaensis	
138	Trupanea		asteria	
139	T.		aucta	
140	T.		augur	
141	T.		cosmia	
142	T.		sirhindiensis	

143	T.		inaequabilis	
144	T.		keralaensis	
145	T.		pteralis	
146	T.		pentadactyla	
147	T.		proovita	
148	T.		stellata	
149	Craspedoxantha		indica	
150	C.		octopunctata	
151	Orellia		tribulicola	
152	Ictericodes		cashmerenisis	

Section 5: Hosts of Tephritid Fruit Flies in India

Source: Kapoor, "Indian Fruit Flies"

Host

	Linnean name	Family	English name	Hindi name	Fly species
1	*Aegle marmelos*	Rutaceae	Bael	Bel	*B. dorsalis and B. zonatus*
2	*Althaea rosea*	Malvaceae	Hollyhock	Gul-khera	*C. octopunctata*
3	*Anacardium occidentale*	Anacardiaceae	Cashew	Kaju	*B. dorsalis*
4	*Annona squamosa*	Annonaceae	Sweet apple	Sharifa: Sitaphal	*B. zonata*
5	*Artemisia absinthium*	Compositae	Wormwood	Vilaiti afsantin	*Trupanea stellata*
6	*Artocarpus altilis*	Moraceae	Bread fruit	-	*B. dorsalis*
7	*Artocarpus heterophullus*	Moraceae	Jack fruit	Katahal	*B. dorsalis ; B. tau*
8	*Bambusa arundinacea*	Bambusaceae	Thorny bamboo	Bans	*Stictaspis ceratitina ; Gastrozona fasciventris; Phaeospilodes bambusae; Galbifascia sexmaculata*
9	*Bambusa burmanica*	Bambusaceae	Wild bamboo		*Chaetellipsis paradoxa; Phaeospilodes bambusae*
10	*Bambusa vulgaris*	Bambusaceae	Feathery bamboo	Bansini	*A. striata*
11	*Barleria alba*	Acanthaceae	Ornamental shrub		*Isoconia bifaria*
12	*Benincasa hispida*	Cucurbitaceae	White gourd	Petha	*D. ciliatus; B. cucurbitae; B. divera; B. tau*
13	*Berberis lycium*	Berberidaceae		Dar- hald	*B. cucurbitae*
14	*Bidens biternata*	Asteraceae	Hairy beggar tick		*Dioxyna sororcula*
15	*Bidens laciniosa*	Cucubitaceae	Bryony		*B.caudata; B.tau*
16	*Blumea lacera*	Compositae		Kakranda	*Rhabdochaeta asteria*
17	*Calendula officinalis*	Compositae	Potmarigold	Zergul	*T. stellata*
18	*Calotropis procera*	Asclepiadaceae	Akund	Safed ak	*D. longistylus*
19	*Camella sinensis*	Theaceae	Tea	Cha	*Adrama determinata*
20	*Capsicum annuum*	Solanaceae	Spanish pepper	Lal Mirch	*D. ciliatus; B. cucurbitae*
21	*Capsicum frutescens*	Solanaceae	Red pepper	Lal Mirch	*B. dorsalis; B. cucurbitae*
24	*Carica papaya*	Coricaceae	Papaya; Papaw	Papita	*B. cucurbitae*
25	*Carissa carandas*	Apocynaceae	Karanda	Karaunda	*B. correcta; B. dorsalis*

26	*Cassia fistula*	Compositae	Safflower	Kusum	*A. helianthi*
27	*Centaurea cyanus*	Compositae	Golden shower	Amaltas	*Euphranta cassiae*
28	*Cerebera manghas*	Apocynaceae	Basket flower		*A. helianthi; C. octopuntata*
29	*Centaurea cyanus*	Compositae	Cornflower		*A. helianthi; C. octopuntata*
30	*Cerebera manghas*	Apocynaceae	Honde fruit		*B. dorsalis; B. diversa*
31	*Chrysanthemum indicum*	Compositae	Japanese chrysanthemum	Gulaudi	*T. amoena*
32	*Chrydophyllum cainito*	Sapotaceae	Star apple		*B.dorsalis*
33	*Cirsium alfocinsus*	Asteraceae	A thistle		*U. stylata; T. serratulae; Tephritis heiseri; T.cardualis*
34	*Cirsium arvense*	Asteraceae	Canada thistle		*U. stylata; E. sonchi*
35	*Cirsium vulgarae*	Asteraceae	Bull thistle		*U. stylata*
36	*Citrullus colocynthis*	Cucubitaceae	Bitter apple		*B. cucurbitae*
37	*Citrullus lanatus*	Cucurbitaceae	Water melon	Tarbooz	*D. ciliatus; B. cucurbitae; B. tau; M. pardalina*
38	*C. lanatus var. fistulossus*	Cucurbitaceae	Roundgourd	Tinda	*B. cucurbitae; D. ciliatus; B. tau*
39	*Citrus aurantifolia var limetta*	Rutaceae	Sweet lime	Meetha nimbu	*B. dorsalis; B. zonata*
40	*Citrus aurantium*	Rutaceae	Sour orange	Khatta	*B. dorsalis; B. zonata; B. diversa*
41	*Citrus decumana*	Rutaceae	Pomelo	Chkotra	*B. caudata*
42	*Citrus grandis*	Rutaceae	Pomelo		*B. tau; B. dorsalis; B. nigrotibialis; B. zonata; B. diversa; B. cucurbitae*
43	*Citrus limon*	Rutaceae	Lemon	Bara nimbu	*B. zonata*
44	*Citrus medica*	Rutaceae	Citron	Bijaura; Galgal	*B. dorsalis; B.zonata*
45	*Citrus nobilis*	Rutaceae	Orange	-	*B. dorsalis; B. zonata*
46	*Citrus reticulata*	Rutaceae	Mandarin	Santra	*B. dorsalis; B. zonata*
47	*Citrus sinensis*	Rutaceae	Sweet orange	Musambi	*B. dorsalis; B. zonata*
48	*Cnicus sp.*	Asteraceae	A thistle	-	*T. serratulae; T. heiseri; U. Stylata*
51	*Coffea canephora*	Rubiaceae	Congo coffee	-	*B. nigrotibialis; B. dorsalis*
52	*Coreopsis baselis*	Compositae	GoldenWave	-	*D. sororcula*
53	*Coreopsis grandiflora*	Compositae	-	-	*D. sororcula*
54	*Cucumis melo*	Cucurbitaceae	Musk melon	Kharbuza	*D. ciliatus; B. cucurbitae; M. pardalina*
55	*Cucumis melo var momordica*	Cucurbitaceae	Snap melon	Phunt; Kachra	*B. cucurbitae; D. ciliatus*

56	*Cucumis melo var. utilissimus*	Cucurbitaceae	Long melon	Kakri	*D. ciliatus; B. cucurbitae; B.zonata*
57	*Cucumis pubescens*	Cucurbitaceae	Wild cucurbit	-	*D. ciliatus; B.cucurbitae*
58	*Cucumis sativus*	Cucurbitaceae	Cucumber	Khira	*D. ciliatus; B. caudata; D. cucurbitae; B. tau; M. pardalina*
59	*Cucumis trigonus*	Cucurbitaceae	Wild cucurbit	-	*B. cucurbitae; M. paradalina*
60	*Cucurbita maxima*	Cucurbitaceae	Red gourd; Red Pumpkin	Sitaphal	*D. ciliatus; B. cucurbitae; B. tau*
61	*Cucurbita moschata*	Cucurbitaceae	Squash	Meetha Kaddu	*B. expandens; B. cucurbitae; B. caudata*
62	*Cucurbita pepo*	Cucurbitaceae	Pumpkin	Vilaiti kaddu	*D. ciliatus; B. diversa; D. cucurbitae*
63	*Cydonia oblonga*	Rosaceae	Quince	Bihi	*B. dorsalis*
64	*Cymbopogon winterianus*	Poaceae	Citronella	-	*B. citronellae*
65	*Dahlia pinnata*	Compositae	Dahlia	-	*D. sororcula*
66	*Dendrocalamus giganteus*	Gramineae	Gaint bamboo	-	*A.striata*
67	*Dendrocalamus stricutus*	Gramineae	Solid bamboo	Bans kaban	*A. ceratitina*
68	*Diospyros sp.*	Ebenaceae	Persimmon	-	*B. dorsalis*
69	*Eclipta alba*	Compositae	-	Bhangra	*Rhabdochaeta asteria*
70	*Elephantopus scaber*	Compositae	-	Gobi	*Tertraluaresta obscuriventris*
71	*Eribotrya japonica*	Rosaceae	Loquat	Lokat	*B. dorsalis*
72	*Eugenis uniflora*	Mrytaceae	Surinam cherry	-	*B.correcta*
73	*Eupatorium trapezoideum*	Asteraceae	Crofton weed	-	*Procecidochares utilis*
74	*Ficus carica*	Moraceae	Fig	Anjir	*B. dorsalis; B. zonata*
75	*Ficus mysorensis*	Moraceae	-	-	*B. dorsalis*
76	*Fortunella japonica*	Rutaceae	Kumbquat	Narange	*B. zonata*
77	*Garcinia cambogia*	Guttiferae	Gamboge tree	Vilaiti imli	*B. expandens*
80	*Gonicaulon glabrum*	Compositae	-	-	*C. octopuntata*
81	*Helianthus annuus*	Compositae	Sunflower	Surajmukhi	*A. helianthi; C. octopunctata*
82	*Hyptis capitata*	Labiatae	-	-	*Sphaleniscus atilius*
83	*Ilex diphyrena*	Aquilfoliaceae	-	-	*Chaetellipsis dispilota*
84	*Inula cappa*	Asteraceae	,-		*Tepherella veriegata*
85	*Juglans regia*	Juglandaceae	Walnut	Akhrot	*Vidalia cervicornis*

86	*Jussiaea sp.*	Onagraceae	-	-	*Platensina acrostacta*
87	*Lactuca sativa*	Compositae	Lettuce	Salad	*Dioxyna sororcula*
88	*Lactuca scariola*	Compositae	Wild lettuce	Kahu	*Trupanea amoena*
89	*Lagenaria siceraria*	Cucurbitaceae	Bottle Gourd	Lauki; Ghia	*B. occipaotalis; D. ciliatus; B. diversa; B. cucurbitae;B. tau; B. zonata*
90	*Lantana camara*	Verbenaceae	Lantana	-	*Eutreta xanhochaeta*
91	*Litchi chinensis*	Sapindaceae	Litchi	Lichi	*B. dorsalis*
92	*Loranthus longiflorus*	Loranthaceae	-	-	*Ceratitella asiatica*
93	*Luffa acutangula*	Cucurbitaceae	Ribbed of Ridge gourd	Kali; toria	*B. zonata; D. ciliatus; B. cucurbitae; D. tau*
94	*Luffa aegyptiaca*	Cucurbitaceae	Smooth loofah	Ghia toria	*B. zonata; D. ciliatus; B. diversa; B. cucurbitae; D. tau*
95	*Lycopersicum lycopersicum*	Solanaceae	Tomato	Tamatar	*B. caudata; B. cucurbitae; B. tau; B. zonata*
96	*Lycopodium clavatum*	Lycopodiaceae	A herb	-	*D. sororcula*
97	*Madhuca indica*	Sapotaceae	Mahua tree	Mohua	*B. zonata*
98	*Malus pumila*	Rosaceae	Apple	Sab	*B. dorsalis; B. zonata*
99	*Mangifera indica*	Anacardiaceae	Mango	Amaltas	*B. correcta; B. dorsalis; B. diversa; B. tau*
100	*Manilkara achras*	Sapotaceae	Sapodilla	Chiku; Sapota	*B. dorsalis;B. zonata; B. caudata; B. tau*
101	*Matricaria chamomilla*	Compositae	Chamomille	Babuna	*T. stellata*
102	*Mimusops elengi*	Sapotaceae	Spanish cherry	Maulsari	*B. dorsalis*
104	*Momordica charantia*	Cucurbitaceae	Bitter gourd	Karela	*D. ciliatus; B. cucurbitae; B. tau*
105	*Momordica cochinchinensis*	Cucurbitaceae	-	Bhat Karela	B. cucurbitae
106	*Morus australis*	Moraceae	Common mulberry	Tut	*B. dorsalis*
107	*Musa paradisiacal*	Musaceae	Plantain; Banana	Kela	*B. dorsalis; B. diversa*
108	*Myristica beddomei*	Myristicaceae	Wild nutmeg	-	*B. diversa*
109	*Myristica fragrans*	Myristicaceae	Nutmeg	Jaiphal	*B. diversa*
110	*Olea europaea*	Oleaceae	Olive	Zaitun	*B. oleae*
113	*Passiflora edulis*	Passifloraceae	Passion fruit	Jhumkalata	*B. dorsalis*
114	*Passiflora palida*	Passifloraceae	-	-	*D. sphaeroidalis*
115	*Persea Americana*	Lauraceae	Avocado	-	*B. dorsalis*
116	*Phaseolus vulgaris*	Papilionaceae	Kidney bean	Vilaiti sem	*B. cucurbitae*
117	*Phoenix dactylifera*	Palmae	Date palm	Pindkhajur	*B. cucurbitae*

118	*Physalis peruviana*	Solanaceae	Cape gooseberry	Rasbari	*B.dorsalis*
119	*Prunus armeniaca*	Rosaceae	Apricot	Khubani	*B. correcta; B.dorsalis*
120	*Prunus avium*	Rosaceae	Sweet cherry	Gilas	*B. dorsalis*
121	*Prunus domestica*	Rosaceae	Plum	Alucha,Alubukhara	*B.dorsalis*
122	*Prunus persica*	Rosaceae	Peach	Aru	*B. dorsalis; B. zonata; B. caudata; B.cucurbitae*
123	*Psidium guajava*	Myrtaceae	Guava	Amrud	*B. dorsalis; B. zonata; B. caudata; B. cucurbitae*
124	*Pulicaria crispa*	Compositae	-	Buhrna	*Trupanea augur*
125	*Pucica granatum*	Punicaceae	Pomegranate	Anar	*B. dorsalis; B. zonata*
126	*Pyrus communis*	Rosaceae	Pear	Nakh	*B.dorsalis; B.zonata*
127	*Raphacus sativus*	Cruciferae	Radish	Muli	*B.diversa*
128	*Ricinus communis*	Euphorbiaceae	Castor seed	Arandi	*Platensina zodiacalis*
129	*Rubus fruticossus*	Rosaceae	Black berry	Vilaiti anchu	*B. dorsalis*

Section 6: Species Records - Incidence and Presence

Fly	Host	Location	Author	Date	Summary
Callantra minax	Orange	Darjeeling, West Bengal	Nath	1973	This is stated to be the first published record of Callantra minax (End.) [RAE/A 9, p.98] damaging orange fruits in India; infestation by the Tephritid was responsible for high pre-harvest drop of ripening fruits in hilly areas of Darjeeling, West Bengal.
B. latifrons	Solanaceae	Bihar	Agarwal	1984	In Bihar B. latiforns is found in solanaceae such as Solanum melongena.
		India	Agarwal et al.	1992	One new species of Tephritis is described from India, and notes are provided on the taxonomy of 2 other species of tephritids. One species is recorded for the 2nd time only from India, and Adrama determinata (a pest of tea elsewhere) and Urophora stylata (a natural enemy of weeds elsewhere) are recorded for the first time from that country.
Bactrocera spp.	Mango	Andhra Pradesh	Babu et al.	2001	Among 18 species of insects that were recorded at various stages of mango crop in an overlapping manner during August 1998 to July 1999 and August 1999 to July 2000 in Chittoor and Cuddapah regions of Andhra Pradesh only five species, Amritodus atkinsone, Idioscopus spp., Procontarinia matteiana, Orthaga exvinacea and Sternochetus mangiferae and Bactrocera spp. attained major status prevailing in a severe form for a long time. Three species, Apoderus tranquebaricus, Coptosoma variegatum and Dasychira mendosa [Olene mendosa], were recorded only as stray pests during crop growth. The remaining ten insect species appeared as minor pests without causing any severe and perceptible damage to the crop.
		Karnataka	Balikai	1999	A field survey was carried out in Ziziphus mauritiana. A total of 22 pests was identified. Of these, B. correcta was found to be major pest, with infestation levels above 51%.
B. tau, Callantra	Snake gourd, ash gourd, bottle gourd, pumpkin	Assam	Borah and Dutta	1997	Infestations by tephritids were studied on ash gourd (Benincasa hispida), bitter gourd (Momordica charantia), bottle gourd (Lagenaria siceraria), cucumber, pumpkin (Cucurbita moschata), ridge gourd (Luffa acutangula) and snake gourd (Trichosanthes cucumerina) in kharif and summer. B. tau and Callantra [B.] sp. were found infesting these vegetables. Snake gourd had the highest fruit infestation (62.62%). Larger proportions of marketable fruits (healthy + lightly infested) were obtained from ash gourd in kharif and bottle gourd in summer. Snake gourd and pumpkin yielded the lowest proportions of marketable fruits.

Bactrocera sp.	*T. dioica*	Mondouri, Nadia, West Bengal	Chintha et al.	2002	In a field study conducted at Mondouri, Nadia, West Bengal, from 1998-99 to 2000-2001, the pests infesting T. dioica cv. Kajli consisted of 16 insect species, Tetranychus cinnabarinus, snails, and rodents. Major pests were Epilachna dodecastigma [E. pusillanima], E. septima, Aulacophora foveicollis, A. lewisii, Diaphania indica, Bemisia tabaci, and T. cinnabarinus while the minor ones were Monolepta signata, Mylabris pustulata, Trichoplusia sp., Aphis gossypii, Bactrocera sp., Solenopsis geminata, snails, and rodents. Haptoncus sp., Pheidole constanceae, and Ponera truncata appeared as pollen, nectar, or honey dew feeders. Coccinella transversalis, Brumus suturalis [Brumoides suturalis], Micraspis discolor, Casnoidia indica, Paederus fuscipes, and Pardosa birmanica comprised the predatory species, with Pardosa birmanica being the most important throughout the cropping season.
B. dorsalis	Mango	Kanpur, Uttar Pradesh	Dwivedi et al.	2003	Investigations were carried out during 1997-98 at Kanpur, Uttar Pradesh, India to monitor the seasonal incidence of insect pests of 20-year-old mango trees in relation to mean temperature and humidity. The population of mealy bug (Drosicha mangiferae) was highest (84.6) at the base of the tree trunk in February and lowest (0.58) in December. Leaf hopper (Amritodus atkinsoni) appeared in March and reached its peak (87.9/10 leaves) in June. The incidence of (Inderbella quadrinatala) ranged from 1.2 (July) to 8.6 ribbons/plant (January). Gall formation by Apsylla cistellata started in July and gradually increased during August, September and October. Fruit fly (Dacus dorsalis [Bactrocera dorsalis]) was first observed in April with 3% infestation, gradually increased in May (8.2%) and June (9.8%) and slightly declined in July (8.3%). The maggots fed on fruit pulp, resulting in premature fruit falling.
		All-Asia	Hardy	1983	Taxonomic information is given, with keys, on 48 species (in 6 genera) of the tribe Euphrantini from Indonesia, New Guinea, the Bismarck Islands and the Solomon Islands. The genus Euphranta contains many fruit-infesting species, including E. japonica (Ito) on cherry in Japan, E. skinneri Hardy on cucurbits in the Philippines, E. cassiae (Munro) on the pods of Cassia fistula in India, besides the species described here from Indonesia and New Guinea, for which the food-plants are not given.

B. correcta		Tamil Nadu	Jalaluddin et al.	1999	B. correcta was recorded for the first time in Tamil Nadu, in 1995, where it caused guava fruit damage ranging from 60 to 80%. The adults laid their eggs in the fruit causing blemishes and discoloration and the larvae bored inside the fruit. The other principle species recorded were B. dorsalis and B. zonata, although they were not as abundant as B. correcta.
			Kapoor et al.	1977	A zoogeographical analysis of species of fruit-flies of the family Tephritidae occurring in India is presented. Only 139 species, of 58 genera, 11 tribes and 4 subfamilies have so far been recorded from India out of a world total of 4000 species. Some 54% of the species are endemic to the country, but none of the genera is endemic. Of the species known from India, 129 are Oriental, 4 Palaearctic, 1 Ethiopian and 5 known throughout the world. The genus mostly widely represented in India is Dacus (Bactrocera?) (31 species).
		India	Kapoor et al.	1981	This monograph from India provides a review of the taxonomy, biology and distribution of the Tephritidae in the Indian subcontinent, where different species are of economic importance as pests of fruit, vegetables and ornamental plants, but are also important as potential or actual agents for the biological control of weeds. The topics dealt with include diagnostic features of the family and affinities with other Diptera; supergeneric categories and taxonomic treatment; methods of collecting, preserving and preparing for study; bionomics; taxonomic terminology; a historical review; a key to the genera in the subcontinent; and an annotated list of the species there, providing information on their distribution and food-plants.
B. dorsalis, B. carambolae		Andaman Islands	Khalid	1999	Variations in the aculeus length and aculeus length to discal cell length ratio in Bactrocera dorsalis (Hendel) in different localities (Hawaii, India and Thailand from Taiwan, type locality) are discussed. Similarly, the variation in Bactrocera carambolae (Drew and Hancock) in different localities (Malaysia, Suriname and Andaman Islands) are also discussed.
Dacus sp.	Mandarin	West Bengal	Konar and Ghosh	1991	The incidence of about 20 insect pests on Citrus reticulata [mandarins] at 11 orchards in West Bengal, India, in June and September 1985 is reported. Phyllocnistis citrella, Anoplophora versteegi, Dacus sp., Rhynchocoris humeralis and Papilio demoleus were among the most abundant pests.

B. cucurbitae	Mogekai	Karnataka	Kumar	2002	A study was conducted in Karnataka during 1996-97 and 1997-98 to record insect pests and their extent of damage and peak period of activity on summer vegetables namely, radish, aubergine, tomato, bhendi (Abelmoschus esculentus) and mogekai. Flea beetle (Phyllotreta downesi) was found feeding on radish leaves. An average of 8.0 beetles/plant with minimum and maximum of 2.0 and 30.0 per plant, respectively, was recorded. The peak beetle incidence was recorded during the month of March. Adults of Monolepta signata were also found feeding on the leaves with very low population levels (1.0-5.0 beetles/plant). The incidence of pumpkin beetle (Aulacophora foveicollis), leaf miner (Liriomyza trifolii), and fruit fly (Bactrocera cucurbitae) was observed on mogekai. Adult activity of the pumpkin beetle was recorded during February-April. About 1-4 adults per vine were found feeding on the leaves. An average of 13% leaf damage was recorded. About 16.7% fruit fly damage was recorded on fruits. The incidence of leafhopper (Amrasca devastans [Amrasca biguttula biguttula]), and shoot and fruit borer (Leucinodes orbonalis) was observed on aubergine. An average of 3.0 leafhoppers/plant and 33.1% of fruit damage was recorded. In tomato, the incidence of serpentine leaf miner (Liriomyza trifolii) and fruit borer (Helicoverpa armigera) was observed. Leaf and shoot infestation was 67.0% and 58.4%, respectively. Fruit damage was 24.5%. Fruit borer (Earias vitella) was observed in bhendi with fruit damage ranging from 8.0 to 14.0%.
B. correcta	Grape	Karnataka	Mani	1992	Fruit flies identified as Bactrocera correcta were recorded on grapevine in Karnataka, India, in 1990 and 1991. This was the first record of this pest on vines in India or elsewhere. No natural enemies were recorded.
B. cucurbitae	Cowpea, yard long bean	Vellanikkara, Kerala	Mathew et al.	1999	B. cucurbitae was found infesting wilted cucumber and bitter gourd [Momordica charantia] vines in Vellanikkara, Kerala, during November to December 1998. It was also found in pods of cowpea and yard long bean [Vigna unguiculata subsp. sesquipedalis]. This is the first report of B. cucurbitae infesting vines of cucumber and bitter gourd and the first report in cowpea pods.

B. dorsalis	*Terminalia procera, T. manii, Artocarpus sp., Syzygium sp.*	North, Middle and South Andaman	Ranganath et al.	1994	Bactrocera dorsalis A was collected for the first time from the islands of North, Middle and South Andaman on guava and mango. B. dorsalis A was also found on Terminalia procera, T. manii, Artocarpus sp. and Syzygium sp. in South Andaman. It was not found on carambola [Averrhoa carambola].
Bactrocera	*Spondias pinnata, Strychnos andamanensis, S. andamanensis*	Andaman and Nicobar Islands	Ranganath et al.	1995	A survey of the fruit fly fauna in the Andaman and Nicobar Islands revealed 11 species belonging to the genus Bactrocera. Three species reared, one each from Spondias pinnata and Strychnos andamanensis, and one from S. andamanensis and several cucurbits, are probably new to science.
B. albistrigata	Guava	Nicobar Islands	Ranganath et al.	1996	Bactrocera albistrigata was collected for the first time in September 1991 in N. Nicobar Islands from a heavily infested guava crop.
B. cucurbitae	Tomato	South Andaman	Ranganath et al.	1996	B. cucurbitae was recently recorded infesting tomato in South Andaman.
B. carambolae	Papaya	South Andaman	Ranganath et al.	1997	Papaya [pawpaw] was recorded as a new host for Bactrocera carambolae in South Andaman, India. The most infested fruit contained 32 larvae.
6 Bactrocera spp.	12 hosts including cloves	Andaman and Nicobar Islands	Ranganath et al.	1999	In the second part of the ongoing survey of the fruit fly fauna of the Andaman and Nicobar islands (June 1993 to January 1996), 6 species of dacines belonging to the genus Bactrocera are added. B. (Bulladacus) mcgregori was reared from Gnetum gnemon, B. (Gymnodacus) calophylli was reared from Calophyllum inophyllum, while B. (Bactrocera) sp. nr. latilineola and B. (Zeugodacus) incisa were obtained by trapping. Of the two undescribed species recorded, one was reared from Momordica cochinchinensis and Trichosanthes tricuspidata (Cucurbitaceae) and the other was caught in methyl eugenol traps. Additional host records of B. (Bactrocera) carambolae (Polyalthia longifolia and Fagraea racemosa) and B. (Bactrocera) albistrigata (Syzygium spp. including cloves, Scolopia spinosa, P. longifolia, C. inophyllum, Guettarda speciosa and Aglaia argentea) were identified. B. albistrigiata was found seriously to attack guavas on Great Nicobar Island.

B. carambolae		Andaman Islands	Ranganath et al.	2000	The fruit fly B. carambolae, known to attack a wide range of tropical fruits, occurs in the Andaman Islands. There is a considerable risk that it will reach mainland India, where it is likely to have little immediate effect on the cultivation of the major fruit crops, although it is possible that it may adapt to them.
B. correcta	Mango, sapota	Gujarat	Shah and Vora	1975	B. correcta (Bez.) was found attacking the fruits of mango and chiku [Achras zapota] in the Bulsar district of Gujarat. This appears to be the first record of the Tephritid in Gujarat and on chiku in India.

Section 7: Estimates of Percentage Losses to Fruit Flies

Given as minimum and maximum values (both the same if only a central estimate given), and mean calculated with an "inserted" value if the estimate was only min or max

"Inserted": When only a lower (or upper) estimate was given, its counterpart upper (or lower) is the mean of itself and 100 (or 0)

"P": protection as N = none, R = resistance, S = cover sprays, M = MAT, B = BAT, I = IPM

When for arable crops dates of sowing but not infestation were given this was taken as one month later.

"Summer" was taken as July. When more than one month cited (eg "in March-June") the last was used

	Actual		Inserted								
Host	Min	Max	Min	Max	Mean	Prot	Location	Month	Author	Date	Fly
Guava	16	16	16	16	16	M	Kashmir	ix	Makhmoor and Singh	1998	
Guava	20		20	60	40	N	Haryana		Rana et al.	1990	*B. zonatus*
Guava	82	82	82	82	82	N	Kashmir	ix	Makhmoor and Singh	1998	
Guava	30	40	30	40	35	N	S. Gujarat	vii-ix	ARS, Gandevi, pers. comm.	2001	
Guava	60	80	60	80	70	N	Tamil Nadu	-	Jalaluddin et al.	1999	
Guava	6	90	6	90	48	N	Tamil Nadu	-	Anon.		
Guava	61	68	61	68	65	N			Mann	1996	*B. dorsalis*
Guava	19	42	19	42	31	N/R	Punjab	vii-ix	Arora et al.	1998	
Guava		10	5	10	8	R	Haryana		Rana et al.	1990	*B. zonatus*
Guava	10	20	10	20	15	R	Haryana		Rana et al.	1990	*B. zonatus*
Guava	16	22	16	22	19	S			Mann	1996	*B. dorsalis*
Jujube	47	47	47	47	47	N	Bawal	-	Dashad et al.	1997	
Jujube	72	72	72	72	72	N	Bawal	I	Dashad et al.	1999	
Jujube	13	13	13	13	13	N	Bawal	xi	Dashad et al.	1999	
Jujube	13.2	13.2	13	13	13	N	Bawal, Haryana	xi	Dashad et al.	1999	
Jujube	71.6	71.6	72	72	72	N	Bawal, Haryana	I	Dashad et al.	1999	
Jujube	13.2	13.2	13	13	13	N	Bawal, Haryana	xi	Dashad et al.	1999	*C. vesuviana*
Jujube	71.6	71.6	72	72	72	N	Bawal, Haryana	I	Dashad et al.	1999	*C. vesuviana*
Jujube	50		50	75	63	N	Delhi	-	Sharma et al.	1998	

Jujube	20		20	60	40	N	Gujarat	xi,xii	Bagle	1992	
Jujube	77	77	77	77	77	N	Gujarat	iii	Patel		
Jujube	32	32	32	32	32	N	Gujarat	-	Patel		
Jujube		75	38	75	56	N	Gujarat	-	GAU pers.comm.	2001	
Jujube	20	20	20	20	20	N	Gujarat	xi	Bagle	1992	
Jujube	56.2	56.2	56	56	56	N	Haryana	X	Lakra and Singh	1983	*Carpomyia vesuviana*
Jujube	46.8	46.8	47	47	47	N	Haryana		Dashad et al.	1999	*Carpomyia vesuviana*
Jujube	51		51	76	63	N	Karnataka		Balikai	1999	*B. correcta*
Jujube	22	22	22	22	22	N	N. Gujarat	iii	Patel		
Jujube	50		50	75	63	N	New Delhi		Sharma et al.	1998	*Carypomyia vesuviana*
Jujube	73	73	73	73	73	N			Singh	1984	*Carpomyia vesuviana*
Jujube	30	40	30	40	35	N/R	Delhi	-	Sharma et al.	1998	
Jujube	22	22	22	22	22	N/R	Gujarat	-	Patel		
Jujube	49	49	49	49	49	R	Abohar		Arora et al.	1999	*Carpomyia vesuviana*
Jujube	40	40	40	40	40	R	Abohar		Arora et al.	1999	*Carpomyia vesuviana*
Jujube	33	33	33	33	33	R	Abohar		Arora et al.	1999	*Carpomyia vesuviana*
Jujube	1	10	1	10	6	R	Delhi	-	Sharma et al.	1998	
Jujube	16	16	16	16	16	R	Gujarat	-	Patel		
Jujube		10	5	10	8	R	New Delhi		Sharma et al.	1998	*Carypomyia vesuviana*
Jujube	40	40	40	40	40	R	Punjab	-	Arora et al.		
Jujube	33	33	33	33	33	R	Punjab	-	Arora et al.	1999	
Jujube	49	49	49	49	49	R	Punjab	-	Arora et al.	1999	
Jujube	13	13	13	13	13	R	Rajasthan	-	Faroda	1996	
Jujube	13	13	13	13	13	R			Faroda	1996	*Carpomyia vesuviana*
Jujube	6.7	6.7	7	7	7	R			Singh	1984	*Carpomyia vesuviana*
Jujube	3	3	3	3	3	S	Bawal	-	Dashad et al.	1999	
Jujube	8.8	8.8	9	9	9	S	Gujarat		Patel et al.	1990	*Carypomyia vesuviana*

Jujube	11.9	11.9	12	12	12	S	Gujarat		Patel et al.	1990	*Carypomyia vesuviana*
Jujube	14.9	14.9	15	15	15	S	Gujarat		Patel et al.	1990	*Carypomyia vesuviana*
Jujube	15	15	15	15	15	S	Gujarat		Patel et al.	1990	*Carypomyia vesuviana*
Jujube	20.5	20.5	21	21	21	S	Gujarat		Patel et al.	1990	*Carypomyia vesuviana*
Jujube	2.9	2.9	3	3	3	S	Haryana		Dashad et al.	1999	*Carpomyia vesuviana*
Jujube		8	4	8	6	S	Hisar	-	Lakra et al.	1991	
Jujube	13.7	13.7	14	14	14	S	New Delhi		Gyi et al.	2003	*Carpomyia vesuviana*
Jujube	15.1	15.1	15	15	15	S	New Delhi		Gyi et al.	2003	*Carpomyia vesuviana*
Jujube	37.3	37.3	37	37	37	S	New Delhi		Gyi et al.	2003	*Carpomyia vesuviana*
Jujube	12.4	12.4	12	12	12	S	New Delhi		Gyi et al.	2003	*Carpomyia vesuviana*
Jujube	11	11	11	11	11	S	New Delhi		Gyi et al.	2003	*Carpomyia vesuviana*
Jujube	4.6	9.3	5	9	7	S	Uttar Pradesh		Singh et al.	2000	*Carpomya vesuviana*
Jujube	6.3	6.3	6	6	6	S	Uttar Pradesh		Singh et al.	2000	*Carpomya vesuviana*
Lemon		61	31	61	46	U	Punjab	viii	Goel *et al.*	1983	*B. dorsalis*
Mango	1	2	1	2	2	I	Karnataka	-	Shukla et al.	1984	
Mango	2	3	2	3	3	I	Karnataka	-	Shukla et al.	1984	
Mango	5	5	5	5	5	I	Karnataka	-	IIHR pers. comm.	2001	
Mango	5	7	5	7	6	I	Karnataka	-	Tandon and Verghese	1996	
Mango		70	35	70	53	N	Bihar	-	Kumar	1995	
Mango	30	50	30	50	40	N	C. Gujarat	-	GAU pers.comm.	2001	
Mango	19	19	19	19	19	N	C. Gujarat	-	Bagle	1996	
Mango	15	15	15	15	15	N	C. Gujarat	-	Bagle	1997	
Mango	27	27	27	27	27	N	C. Gujarat	-	Bagle	1998	
Mango	27	27	27	27	27	N	Gujarat	-	Kumar et al.	1994	
Mango	3	3	3	3	3	N	Kanpur	iv	Dwivedi et al.	2003	
Mango	8.2	8.2	8	8	8	N	Kanpur	V	Dwivedi et al.	2003	

Mango	9.8	9.8	10	10	10	N	Kanpur	vi	Dwivedi et al.	2003	
Mango	8.3	8.3	8	8	8	N	Kanpur	vii	Dwivedi et al.	2003	
Mango	26	31	26	31	29	N	Karnataka	-	Shukla et al.	1984	
Mango	30	80	30	80	55	N	Karnataka	-	IIHR pers. comm.	2001	
Mango	31	86	31	86	59	N	Punjab	-	Mann	1966	
Mango	30	40	30	40	35	N	S. Gujarat	vi, vii	GAU pers.comm.	2001	
Mango	20	35	20	35	28	R	Gujarat	-	GAU pers.comm.	2001	
Mango	4	10	4	10	7	R		-	Singh	1990	
Mango	7	7	7	7	7	S	C. Gujarat	-	Bagle	1996	
Mango	6	6	6	6	6	S	C. Gujarat	-	Bagle	1997	
Mango	13	13	13	13	13	S	C. Gujarat	-	Bagle	1998	
Mango	5	5	5	5	5	S	Gujarat	-	GAU pers.comm.	2001	
Mango	3	3	3	3	3	U	Kanpur, Uttar Pradesh	iv	Dwivedi et al.	2003	*B. dorsalis*
Mango	8.2	8.2	8	8	8	U	Kanpur, Uttar Pradesh	V	Dwivedi et al.	2003	*B. dorsalis*
Mango	9.8	9.8	10	10	10	U	Kanpur, Uttar Pradesh	vi	Dwivedi et al.	2003	*B. dorsalis*
Mango	8.3	8.3	8	8	8	U	Kanpur, Uttar Pradesh	vii	Dwivedi et al.	2003	*B. dorsalis*
Mogekai	16.7	16.7	17	17	17	N	Karnataka	-	Kumar	2003	
Moringa	48	49	48	49	49	N	Coimbatore, Tamil Nadu	ix	Murthy and Regupathy	1995	*Gitona sp.*
Moringa	13	20	13	20	17	N	Coimbatore, Tamil Nadu	xii	Murthy and Regupathy	1995	*Gitona sp.*
Moringa	23.4	23.4	23	23	23	N	Coimbatore, Tamil Nadu	ii	Murthy and Regupathy	1995	*Gitona sp.*
Moringa		23.4	12	23	18	N	Coimbatore, Tamil Nadu	vi	Murthy and Regupathy	1995	*Gitona sp.*
Moringa	23	23	23	23	23	N	Tamil Nadu	iii-vi	Murthy and Regupathy	1992	
Moringa	12	23	12	23	18	N	Tamil Nadu	i, ii	Murthy and Regupathy	1992	
Moringa	13	20	13	20	17	N	Tamil Nadu	xi,xii	Murthy and Regupathy	1992	
Moringa	48	49	48	49	49	N	Tamil Nadu	Viii, ix	Murthy and Regupathy	1992	
Moringa	15	15	15	15	15	N	Tamil Nadu	-	Ragumoorthy et al.	1998	

Moringa	10	10	10	10	10	S	Tamil Nadu	-	Ragumoorthy et al.	1998	
Narangi	24	24	24	24	24	U	Punjab	viii	Goel *et al.*	1983	*B. dorsalis*
Peach	41.7	41.7	42	42	42	N	Himachal Pradesh		Sharma *et al.*	1973	*B. dorsalis, B. cucurbitae, D. ciliatus*
Peach	3.45	3.45	3	3	3	S	Himachal Pradesh		Sharma *et al.*	1973	*B. dorsalis, B. cucurbitae, D. ciliatus*
Peach	8.11	8.11	8	8	8	S	Himachal Pradesh		Sharma *et al.*	1973	*B. dorsalis, B. cucurbitae, D. ciliatus*
Phalsa	64	64	64	64	64	N	Punjab	-	Mann	1994	
Sapota	30	50	30	50	40	N	S. Gujarat	vii-ix	GAU pers.comm.	2001	
Bitter gourd	60	60	60	60	60	N	H. Pradesh	Vii,ix	Gupta et al.	1992	
Bitter gourd	80	80	80	80	80	N	H. Pradesh	vii,viii	Gupta et al.	1992	
Bitter gourd	47	47	47	47	47	N	Kerala	-	Dale and Jiji	1997	
Bitter gourd	31.3	31.3	31	31	31	N			Singh et al.	2000	*B. cucurbitae*
Bitter gourd	87	87	87	87	87	N			Ravindranath and Pillai	1986	*B. cucurbitae*
Bitter gourd	37	53	37	53	45	S			Ravindranath and Pillai	1986	*B. cucurbitae*
Bitter gourd	59	59	59	59	59	S			Ravindranath and Pillai	1986	*B. cucurbitae*
Cucumber	13	13	13	13	13	B	Bangladesh	-	Nasir Uddin et al.	2000	
Cucumber	2	2	2	2	2	M	Bangladesh	-	Nasir Uddin et al.	2000	
Cucumber	20	20	20	20	20	N	Assam	x-iii	Borah	1996	
Cucumber	28	28	28	28	28	N	Assam	vi-x	Borah	1996	
Cucumber	39	39	39	39	39	N	Assam	-	Borah	1996	
Cucumber	27.6	27.6	28	28	28	N	Assam	iv	Borah	1996	*B. cucurbitae*
Cucumber	59.5	59.5	60	60	60	N	Assam	vii	Borah	1996	*B. cucurbitae*
Cucumber	20.3	20.3	20	20	20	N	Assam	ix	Borah	1996	*B. cucurbitae*
Cucumber	22	22	22	22	22	N	Bangladesh	-	Nasir Uddin et al.	2000	
Cucumber	80	80	80	80	80	N	H. Pradesh	vii,viii	Gupta et al.	1992	
Cucumber	53	53	53	53	53	N	Karnataka	-	IIHR pers. comm.	2001	
Cucumber	39	39	39	39	39	N	South Andaman		Ranganath et al.	1997	*B. cucurbitae*
Cucumber	21	21	21	21	21	S	Karnataka	-	IIHR pers. comm.	2001	

Cucumber	6.2	6.2	6	6	6	S	South Andaman		Ranganath et al.	1997	*B. cucurbitae*
Little gourd		100	50	100	75	N	Gujarat	-	Farmer pers.comm.	2001	
Little gourd		63	32	63	47	N	Gujarat	-	Patel	1994	
Little gourd	45	45	45	45	45	N	Gujarat	iii	Patel and Patel	1996	
Little gourd	46	46	46	46	46	N	Gujarat	iv	Patel and Patel	1996	
Little gourd	38	38	38	38	38	N	Gujarat	vi	Patel and Patel	1996	
Little gourd	3	100	3	100	52	N	Gujarat	-	Patel	1996	
Little gourd	5	5	5	5	5	S	Gujarat	-	Farmer pers.comm.	2001	
Little gourd	0	0	0	50	25	S	Gujarat	-	Patel	1994	
Melon	76	100	76	100	88	N	Rajasthan	-	Pareek and Kavadia	1995	
Melon	51	75	51	75	63	R	Rajasthan	-	Pareek and Kavadia	1995	
Musk melon	51	75	51	75	63	N	Rajasthan		Pareek and Kavadia	1995	*B. cucubitae*
Musk melon	76	100	76	100	88	N	than		Pareek and Kavadia	1995	*B. cucubitae*
Pumpkin	26.7	39.3	27	39	33	N		-	Saikia and Nath	2002	
Pumpkin	26.7	39.3	27	39	33	N			Saikia and Nath	2002	
Ridge gourd	0	0	0	50	25	N	Gujarat	-	GAU, pers.comm	2001	
Ridge gourd	0	0	0	50	25	N	Gujarat	-	Farmer, pers.comm	2001	
Ridge gourd	32.9	32.9	33	33	33	N	South Andaman		Ranganath et al.	1997	*B. cucurbitae*
Ridge gourd	9.1	9.5	9	10	9	S	South Andaman		Ranganath et al.	1997	*B. cucurbitae*
Snake gourd	4.9	8.6	5	9	7	B	Bangladesh		Nasiruddin and Karim	1992	*B. cucurbitae*
Snake gourd	63	63	63	63	63	N	Assam	-	Borah and Dutta	1997	
Snake gourd	62.6	62.6	63	63	63	N	Assam		Borah and Dutta	1997	*B. tau, Callantra*
Snake gourd	22.5	22.5	23	23	23	N	Bangladesh		Nasiruddin and Karim	1992	*B. cucurbitae*
Sponge gourd	50	50	50	50	50	N	H. Pradesh	Vii,ix	Gupta et al.	1992	
Watermelon	28.6	28.6	29	29	29	N			Singh et al.	2000	*B. cucurbitae*
Watermelon	38.8	38.8	39	39	39	R	Jabalpur, Madhya Pradesh	vii	Choubey et al.	2002	*B. cucurbitae*
Gen. Cucurbits	75	75	75	75	75	N	Bihar	iv-ix	Farmer, pers.comm	2001	
Gen. Cucurbits	40	80	40	80	60	N	Delhi	vii-x	Pruthi	1941	

Gen. Cucurbits	10	20	10	20	15	N	Orissa	-	CHES pers. comm.	2001	
Gen. Cucurbits	25	30	25	30	28	N	Overall	-	IIHR pers. comm.	2001	
Gen. Cucurbits	10	25	10	25	18	S	Bihar	iv-ix	Farmer, pers.comm	2001	

Section 8: Population Dynamics and Ecology

Fly	Host	Location	Authors	Date	Summary
B. zonata		Northern Bihar	Agarwal and Kumar	1999	Studies on the population dynamics of peach fruit fly, B. zonata, were conducted during April-August 1997 in northern Bihar. Maximum fly populations were observed during the third week of June (357.0 flies/trap), whereas the lowest numbers were observed during the last week of August (14.3 flies/trap). Fly populations showed a positive correlation with maximum and minimum temperatures, rainfall and a negative correlation with relative humidity.
B. cucurbitae			Agarwal et al.	1987	Green, tender fruits are preferred for oviposition and females lay up to 200 eggs. Adults overwinter in November-December and the pest is most active in July-August.
B. dorsalis		Northen Bihar	Agarwal et al.	1995	The effects of maximum and minimum temperature and relative humidity on the population dynamics of B. dorsalis were studied in northern Bihar in 1990-91. The pest population was not affected by relative humidity; however, it was highest when the temperature was between 25 and 38°C, and significant positive correlations were observed between maximum temperature and pest population, and minimum temperature and pest population.
B. dorsalis, B. zonata		Pusa,Bihar	Agarwal et al.	1999	Adult males of B. dorsalis and B. zonata were trapped using the attractant methyl eugenol, bait (protein hydrolysate) and malathion 50 e.c. between April and August 1997, at Pusa, Bihar. The average number of these flies trapped during the experimentation period was 39.94 and 134.92 flies per trap per week, respectively. The average mean population of B. zonata was 3.38 times greater than that of B. dorsalis, which indicated population suppression of B. dorsalis by B. zonata.
C. vesuviana	Jujube	Gujarat	Bagle	1992	The incidence of Carpomyia vesuviana on Ziziphus mauritiana was studied in Gujarat, and attempts were made to determine suitable control measures. Pest attack started around mid-October and increased suddenly in mid-November (average incidence over 20%), continuing until December. Of several insecticides tested, fenvalerate at 0.005% and decamethrin [deltamethrin] at 0.0015% were the most effective and consistent in reducing infestation, followed by monocrotophos and phosphamidon at 0.05%.
B. dorsalis	Mango	Karnataka	Bagle and Prasad	1983	Traps with 100ml of an emulsion containing 0.1% methyl eugenol and 0.255 malathion were used and weekly counts were made. It was found that population was greatest during March, April, May and June with average monthly catches per trap of 1268, 270, 416 and 487 flies, respectively. The lowest catches were made in January, August and December, with average monthly catches per trap of 42, 71 and 72 flies, respectively.

B. cucurbitae			Bhagat and Koul	1999	The seasonal biology of melon fruit fly, *B. cucurbitae,* was studied during pre-monsoon (April-June), monsoon (July-September) and post-monsoon (October-December). Field-collected adults of *B. cucurbitae* were housed in glass tubes with fresh slices of bottle gourd (Lagenaria siceraria), examined after 24h and their eggs collected. Eggs were placed on fresh bottle gourd slices kept on water-soaked filter papers and observed for hatching. Freshly hatched maggots were transferred on bottle gourd slices in glass tubes. At the onset of pupation, the slices were placed in tubes with water-soaked sand 50 mesh layer to facilitate pupation. Results revealed that incubation, larval and pupal periods were lowest during the pre-monsoon (1.00, 4.96 and 6.94 days, respectively) followed by monsoon and post-monsoon periods. Pre-oviposition and oviposition periods were lower in pre-monsoon (11.06 and 12.12 days, respectively) than in monsoon and post-monsoon periods. Adult emergence was highest in the pre-monsoon (80%), followed by monsoon (74.4%) and post-monsoon (62.7%) periods.
B. cucurbitae	Cucumber	Assam	Borah	1996	Field trials showed that the highest yield of cucumber (87.4 q/ha), with 27.6% infestation by B. cucurbitae, was recorded in the summer-sown crop (20 March), followed by the kharif-sown crop (27 June, 59.5 q/ha, 39.1% infestation). In the rabi-sown crop (10 October), the yield was lowest (27.7 q/ha); infestation was 20.3%.
B. tau, Callantra sp.	Snake gourd, ash gourd, bottle gourd, pumpkin	Assam	Borah and Dutta	1997	Infestations by tephritids were studied on ash gourd (Benincasa hispida), bitter gourd (Momordica charantia), bottle gourd (Lagenaria siceraria), cucumber, pumpkin (Cucurbita moschata), ridge gourd (Luffa acutangula) and snake gourd (Trichosanthes cucumerina) in kharif and summer. B. tau and Callantra [B.] sp. were found infesting these vegetables. Snake gourd had the highest fruit infestation (62.62%). Larger proportions of marketable fruits (healthy + lightly infested) were obtained from ash gourd in kharif and bottle gourd in summer. Snake gourd and pumpkin yielded the lowest proportions of marketable fruits.
C. vesuviana	Jujube	Bawal, Haryana	Dashad et al.	1999	The incidence of ber fruitfly, Carpomyia vesuviana on 13-year-old trees of Zizyphus mauritiana cv. Gola in Bawal, Haryana, ranged from 12.0 to 78.5% between 1993/94 and 1995/96. The lowest mean incidence (13.2%) was recorded during the first fortnight of November, while the peak (71.6%) occurred during the first fortnight of January and was synchronized with the ripening of fruits. The intensity of incidence was determined by the surviving fruitfly population in preceding years. Higher fruit fly incidence was recorded when the maximum temperature ranged from 17.0 to 25.0°C and the minimum from 2.3 to 4.8°C. The optimum relative humidity range was 62.0 to 85.5%.

B. dorsalis	Mango	Kanpur, Uttar Pradesh	Dwivedi et al.	2003	Investigations were carried out during 1997-98 at Kanpur, Uttar Pradesh, India to monitor the seasonal incidence of insect pests of 20-year-old mango trees in relation to mean temperature and humidity. The population of mealy bug (Drosicha mangiferae) was highest (84.6) at the base of the tree trunk in February and lowest (0.58) in December. Leaf hopper (Amritodus atkinsoni) appeared in March and reached its peak (87.9/10 leaves) in June. The incidence of (Inderbella quadrinatala) ranged from 1.2 (July) to 8.6 ribbons/plant (January). Gall formation by Apsylla cistellata started in July and gradually increased during August, September and October. Fruit fly (B. dorsalis) was first observed in April with 3% infestation, gradually increased in May (8.2%) and June (9.8%) and slightly declined in July (8.3%). The maggots fed on fruit pulp, resulting in premature fruit falling.
	Mango	Maharastra	Godse and Bhole	2002	Studies on natural incidence of fruit flies on Alphonso mango indicated (at Maharastra) that the fruits harvested before June were free from fruitfly infestation also showed that regular collection and destruction of fallen, ripe or decaying fruits can reduce fruit fly population in orchards as fruitflies preffred the ripening fruits for egg laying.
B. zonata			Grewal and Kapoor	1987	Methyl eugenol used as a bait in a new collapsable fruitfly trap (GK trap) in the field found that the number of flies/catch ranged from 150 to 700. B. zonatus was the dominant sp., accounting for up to 98% of the catch.
B. dorsalis, B. zonata	Mango, guava	Himachal Pradesh	Gupta and Bhatia	2001	The fruit fly (B. dorsalis and B. zonata) population was monitored with the help of bottle traps containing 100 ml aqueous solution of 0.1% methyl eugenol and 0.25% malathion per trap, in mango and guava orchards of submountainous region of Himachal Pradesh. The maximum catch of 98.6 and 62.6 males/trap for mixed population was recorded during 30th and 27th standard weeks in 1992 and 1993, respectively, in mango orchard. The corresponding catch in guava orchard was 427.2 and 517.0 during the 37th and 39th standard weeks. There was a significant positive correlation between the trap catch and maximum and minimum temperatures during both the years for both the hosts. The maximum catch coincided with the ripening period of fruits.

	Mango, guava	Tirupati, Andhra Pradesh	Jalaluddin and Sarada	2001	Experiments on the seasonal abundance and population dynamics of fruit flies (Bactrocera spp.) were conducted in orchards located in Tirupati, Andhra Pradesh, India from September 1999 to March 2000 (guava), and from February to July 2000 (mango). The peak fly population in the mango orchard was observed from May to July, coinciding with the fruit maturity period. The lowest population was recorded in February (34 flies), while the highest population was observed in July 2000 (235 flies). The fly population was positively correlated with minimum temperature and rainfall, and negatively correlated with the relative humidity. In the guava orchard, the highest (223.5 flies) and lowest (11.0 flies) populations were recorded during November 1999 and March 2000, respectively. The fly population in the guava orchard was positively correlated with the relative humidity and rainfall, while it was negatively correlated with the maximum temperature.
B. dorsalis	Mango	Karnataka	Jayanthi and Verghese	1998	Hourly fluctuations in trap catch (baited with methyl eugenol + carbaryl) of B. dorsalis in a mango orchard in Karnataka were monitored. Catches were maximum in the afternoon, with a peak between 16.00 and 17.00h. There were no catches between 19.00 and 06.00h.
B. correcta	Mango, sapota	Gujarat	Kumar et al.	1997	In a field study in 1992-94 in Gujarat in mango and sapota [Manilkara zapota, sapodilla] orchards, the seasonal activity of B. correcta was examined using traps baited with methyl eugenol. B. correcta were trapped throughout the year in the mango and sapota orchards. In mango orchards, trappings peaked during the second fortnight of April (453 fruit flies/trap) and the second fortnight of May (483 fruit flies/trap). Major activity of the pest occurred from March to June, coinciding with the fruiting period. The pest activity was positively correlated with temperature (maximum, minimum and average). Other environmental factors did not have any significant impact. In sapota orchards, the pest activity coincided with the fruiting period during April to September. The trappings peaked during the first fortnight of June (580 fruit flies/trap). The pest activity was positively correlated with temperature (minimum and average), relative humidity (evening and average) and negatively with sunshine hours.

C. vesuviana	Jujube	Haryana	Lakra and Singh	1983	The oviposition behaviour of Carpomyia vesuviana Costa on ber (Ziziphus mauritiana), fruit deformity resulting from infestation and the incidence of the pest were studied in Haryana, India, between 1979 and 1981. Females preferred to oviposit in the distal or central part of the fruit. Oviposition inhibited growth in the surrounding tissues, causing protuberances and/or depressions in the fruit. Deformity was most apparent in young fruits with oviposition holes. Fruits smaller than 9 X 4.5 mm were avoided by females, while almost 50% of fruits measuring 20 X 9 mm contained oviposition holes during October. A maximum of 55.15% of fruits contained a single larva, while 37.16% contained 2 or 3. Only 0.08% of fruits contained 7 or 8 larvae. A total of 45% of fruits was infested by 2-8 larvae at some stage during of their development. Of the infested fruits, 21.83% were collected from the southern side of trees, while only 5.27% were taken from the northern side; the percentages taken from the eastern and western sides were almost equal (14.6 and 14.5, respectively). The pest was most abundant in December and least abundant in March.
C. vesuviana	Jujube	Hisar, Haryana	Lakra and Singh	1985	Field observations in Hisar, Haryana, India, in 1979-81 on the seasonal incidence of Carpomyia vesuviana, an important pest of jujube (Ziziphus spp.), are described. Activity of different stages of the tephritid continued at temperatures of -1.7-46.7°C and relative humidities of 5-100%. Extremes of meteorological conditions had a greater effect on adult activity than on larval activity. An increase in the daily maximum temperature to >40°C, together with a low relative humidity (20-30%) was unfavourable for pest development. A drop in temperature to <5°C prolonged the duration of the immature stages. Intermittent light rainfall of 20-40 mm/week during July-August enhanced adult activity, while moderate to heavy rainfall of 50-120 mm/week curtailed adult activity. Mean weekly minimum and maximum temperature ranges of 10-25 and 25-40°C, respectively, and morning and evening relative humidities of 25-90% were ideal for pest activity. Larval incidence in fruits reached a peak in August-September on Z. nummularia and in July, January and April on Z. mauritiana; peak incidence on the 2 species reached 76.8 and 47.4%, respectively. Parasites of the fly were present only in small numbers.
B. cucurbitae	Cucurbits	Bihar	Lall and Singh	1969	In Bihar studies has been carried out in the field and incidence was recorded that B. cucurbitae was active on various cucurbits from February to November ; From December to mid-February the adults did not breedand were observed clustering under the leaves of guava, citrus, mango and other trees.

B. dorsalis	Mango	Ludhiana, Punjab	Mann	1996	B. dorsalis flies were observed throughout the year in methyl eugenol baited traps in a mango orchard in Ludhiana, Punjab, India. Population counts were low in the winter months from December to February which was thought to be caused by low temperature (below 20°C). Following the warmer season, the flies rebuilt their population throughout the rest of the year. However, low catches in July may be due to the after-effects of high temperatures in June (31.93°C) or due to high rainfall (223 mm/month). Afterwards, increases in fruit fly catches may be attributed to conducive temperature (24-29°C) and abundant supply of host fruits. The fruit fly counts on the mango fruits during July were greatest at 1100 h and 1200 h. Fruit fly infestation was 30.77, 65 and 85.50% in cultivars Dusheri, Sucking and Chausa, respectively.
B. dorsalis	Sand pear	Punjab	Mann	1997	Studies on the incidence of B. dorsalis on sand pear (Pyrus pyrifolia) in isolated and mixed orchards in Indian Punjab revealed that there were 3.73 and 14.89 times more insects in fruits and pupal counts per kilogram fruits in mixed orchards than in isolated orchards. Similarly, adult counts in methyl eugenol baited traps were higher (16.63 times) in mixed orchards than in isolated orchards. Based on egg punctures and pupal counts, isolated orchards were more profitable than mixed orchards.
B. dorsalis	Peach	Punjab	Mann and Bindra	1977	Field incidence of B. dorsalis Hendel on different cultivars of peach (Prunus persica) at Ludhiana (Punjab)studies over two years with eleven varieties, Florida Sun had the lowest average infestation; generally, infestation was related to earliness of fruiting, the earlier the variety the lower the infestation, except in the midearly variety Sun Red, in which infestation was heavy, possibly because the fruit lack hairs.
Gitona sp.	Moringa	Coimbatore, Tamil Nadu	Murthy and Regupathy	1995	The population dynamics of Gitona sp. on annual moringa [Moringa oleifera] were investigated in Coimbatore, Tamil Nadu, in 1984-85. The annual form of this popular vegetable had recently been introduced to cultivation in southern India and Gitona sp., previously regarded as a minor pest, had become more important. Gitona sp.-damaged fruits were recognised in the initial stages of infestation by the presence of gummy exudates, in association with eggs laid in the grooves between the ridges of the fruits, and by drying of the fruits in later stages. Gummy exudates were also observed following feeding by Oxycetonia versicolor and Anatona stillata. Gitona sp. were most numerous in August-September 1984, when 48-49% of fruit were damaged. Incidence decreased to 13-20% in November-December. A slight increase in January-February 1985, when 23.4% of fruits were damaged, was followed by another decrease in March-June. Incidence of Gitona sp. was negatively correlated with maximum temperature and hours of sunshine, and positively correlated with relative humidity and sunshine of the previous month.

Meridarchis scyrodes, Carpomyia vesuviana	Jujube	Bijapur, Karnataka	Nandihalli et al.	1996	In a field study in 1995-96 at Bijapur, Karnataka, in Zizyphus mauritiana orchards, Meridarchis scyrodes and Carpomyia vesuviana were prevalent from first fortnight of December to first fortnight of February. The relationship between pest incidence and temperature was positive while negative relationship of the incidence of the pests was found with relative humidity, wind speed and cloud cover. M. scyrodes was more damaging than C. vesuviana in all the cultivars evaluated. Cv. Ilaichi and Chhuhara fruits recorded lowest pest infestation (1 larva/fruit).
Dacus ciliatus		Gujarat	Patel and Patel	1998	Laboratory studies showed that most adults of Dacus ciliatus emerged between 08.00 and 10.00h. Very few adults emerged at other times.
D. ciliatus		Gujarat	Patel and Patel	1998	A study on the number of generations found that it took 34 to 79 days for completion of one generation; seven generation took a year when reared on bitter gourd fruits.
B. cucurbitae	Bitter gourd	Maharastra	Pawar *et al.*	1991	Monitoring by using traps baited with the sex attractant tephrit lure. Result showed that the numbers caught reached a peak in early October.
B. correcta	Guava	Haryana	Rana *et al.*	1993	The influence of temperature and relative humidity on incidence of guava fruit fly infesting guava fruits in Haryana were studied and was found that the greatest infestations were recorded in the orchard when the temperature and relative humidity were 26-30°C and 70-75%, resp.
	Pumpkin		Saikia and Nath	2002	Pumpkins (local variety) were grown at 2-week intervals from 1 September 1996 to 15 January 1997 under field conditions. The incidence of fruit fly was determined. The fruit fly damage on different sowing dates was significant. The fruit fly infestation varied between 26.7 and 39.3%. Lowest infestation was in crops sown on October 15, followed by those sown on November 1.
B. dorsalis	Guava	Punjab	Sandhu *et al.*	1979	The incidence of B. dorsalis and Dichocrocis punctiferalis on the fruit was determined in 9 guava cvs. The former ranged from very low in the cvs Red Flesh and Seedless to very high in the cv. Apple and the latter from very low in the cvs Guinea and Red Flesh to very high in the cv. Seedless
C. vesuviana			Sangwan and Lakra	1992	In the laboratory, the optimum temperature for pupal development in the tephritid Carpomyia vesuviana, a pest of Ziziphus mauritiana, was 30°C, leading to high adult emergence (74%) and short pupal duration (average 15.65 days). At 10, 16 and 40°C, no adult emergence occurred in 50 days. The ideal depth for pupation was 3-6 cm below the soil surface, at which adult emergence was 82%. Only 15% adult emergence took place at a depth of 45 cm.

B. correcta	Guava	Tamil Nadu	Sarada et al.	2001	Studies of population fluctuations of the guava fruit fly, B. correcta, were conducted in guava orchards in Tamil Nadu from May 1994 to September 1995 using methyl eugenol traps. A distinct population peak, which coincided with the ripening, was recorded from July to August in both years. Abiotic factors played an important role in regulating B. correcta population. Data on weekly catch when correlated with weather parameters showed significant positive correlation with mean maximum temperature (r=0.3314), minimum temperature (r=0.3610), day-degrees (thermal units) (r=0.3692), morning relative humidity (r=0.4369) and rainfall (r=0.2364). Weekly mean sunshine hours had low negative correlation with the catch.
B. dorsalis, B. correcta, B. zonata	Mango	Tirupati, Andhra Pradesh	Sarada et al.	2001	An experiment was conducted in a mango orchard to evaluate the different coloured plastic open pan traps viz., yellow, white, blue, orange, red and green as attractants for fruit flies such as B. dorsalis, B. correcta and B. zonata in three replications at Tirupati, Andhra Pradesh, during 2000. During the same year another two experiments were conducted with these open pan traps by placing them at different heights (0, 1.0, 1.5 and 2.0 metres) above the ground and at different locations in the orchard. An open pan of 60 cm diameter with 7.5 cm depth, along with 0.1% methyl eugenol attractant was used for the purpose. Significantly more flies were attracted to white (16.953 flies/trap) and yellow (15.317 flies/trap) coloured traps followed by green, orange, red and blue, respectively. Lowest number of flies were attracted to blue colour. Traps placed on the ground caught significantly most flies (12.433 flies/trap), followed by 1.0m, 2.0m and 1.5m, respectively. Traps in the periphery of the orchard attracted more flies (945 flies) than traps in the centre (561 flies).
B. dorsalis	Guava	Karnataka	Shukla and Prasad	1985	Abiotic factors played an important role in regulating the fly population. Trap catches were significantly and positively correlated with maximum and minimum temperatures day degrees and maximum relative humidity.Trap catches were significantly and negatively correlated with minimum relative humidity.
B. dorsalis	Mango	Pantnagar, Uttar Pradesh	Singh *et al.*	1997	Methyl eugenol (0.2%) was used to bait 4 traps/acre for 18 weeks (2nd April to 30th July). The largest trap catches of 233 males/week occurred between 18 June and 25 June.
B. cucurbitae			Sood and Nath	1998	An analysis of the seasonal variation in adult sex ratios in a population of B. cucurbitae indicated that the ratios were female biased (1:1.23, 1.15 and 1.29) during the spring, autumn and winter seasons, respectively, but not during summer. However, Chi-square analysis did not indicate any significant departure from a 1:1 ratio during different seasons. Possible reasons for a deviation of the sex ratio from the expected 1:1 are also discussed.

B. cucurbitae	Bitter gourd		Thakur *et al.*	1994	Stability analysis for economic traits and infestation of melon fruit-fly (B. *cucurbitae*) in bittergourd (*Momordica charantia*) were studied. 10 cultivars were sown out of which C96 was the most stable for fruits/plant and had the lowest incidence of fruit fly infestation. NDBT1 had the most stable resistance to B*. cucurbitae.*

Section 9: Oviposition, Preference and Survival among Hosts

Fly	Host	Location	Authors	Date	Summary
B. cucurbitae			Agarwal et al.	1987	Green, tender fruits are preferred for oviposition and females lay up to 200 eggs. Adults overwinter in November-December and the pest is most active in July-August.
Carpomyia vesuviana	Jujube	Abohar	Arora et al.	1999	Physicochemical characteristics of fruits of eight ber (Ziziphus mauritiana) varieties, Chhuhara, Gola, Elaichi, Kaithli, Nazuk, Sanaur 2, Umran and ZG-2 in relation to fruit fly infestation were studied at Abohar. Fruit fly (Carpomyia vesuviana) infestation was positively correlated with fruit weight, pulp-stone ratio, total soluble solids (TSS) and total sugars, whereas, it was negatively correlated to acidity, vitamin C [ascorbic acid] and total phenols. The varieties high in pulp content, TSS, total sugars, low acidity, vitamin C and total phenols were highly susceptible to fruit fly attack. The most resistance varieties were Umran (49% incidence), Gola (40%) and ZG-2 (33%).
B. tau, Callantra	Snake gourd, ash gourd, bottle gourd, pumpkin	Assam	Borah and Dutta	1997	Infestations by tephritids were studied on ash gourd (Benincasa hispida), bitter gourd (Momordica charantia), bottle gourd (Lagenaria siceraria), cucumber, pumpkin (Cucurbita moschata), ridge gourd (Luffa acutangula) and snake gourd (Trichosanthes cucumerina) in kharif and summer. B. tau and Callantra [B.] sp. were found infesting these vegetables. Snake gourd had the highest fruit infestation (62.62%). Larger proportions of marketable fruits (healthy + lightly infested) were obtained from ash gourd in kharif and bottle gourd in summer. Snake gourd and pumpkin yielded the lowest proportions of marketable fruits.
B. dorsalis	Guava		Bose and Mehrotra	1986	The maximum pressure exerted by the ovipositor of the tephritid B. dorsalis, attacking guava fruits, was more than 180 kg/ cm2. Soft fruit samples were infested more than hard fruits.
B. cucurbitae	Musk melon, snake gourd, ribbed gourd		Chelliah	1970	The fruits of three cucurbits plants were investigated for their suitability as media for the mass culture of B. cucurbitae Coq. in the laboratory. Muskmelon (Cucumis melo) proved the most suitable, snake gourd (Trichosanthes anguina) the least so and ribbed gourd (Luffa acutangula) intermediate.
Bc?	C melo, C callosus		Chelliah and Sambandam	1971	Resistance in C. callosus, which was compared with the susceptible C. melo varieties Delta Gold and Smith Perfect, and the susceptible F1 C. callosus X Delta Gold, appeared to be determined by rind toughness, which was associated with high silica content.
Bc?	C melo, C callosus		Chelliah and Sambandam	1972	The resistance of the parents and F1, F2 and back-cross progenies of a cross between Cucumis melo and C. callosus was investigated. The results indicated that susceptibility is controlled by two complementary dominant genes.

B. cucurbitae	C melo, C callosus		Chelliah and Sambandam	1973	Varieties of C. melo, which are highly susceptible to D. cucurbitae, had a higher number of aminoacids than resistant, wild C. callosus. Cystine and tyrosine were present in C. melo but not in C. callosus, and histidine, glycine, threonine and leucine were present in higher proportions in C. melo. It is concluded that antibiosis in C. callosus may be due to low concentrations or imbalance of essential aminoacids.
B. cucurbitae	Melon, wild melon		Chelliah and Sambandam	1974	Laboratory studies were carried out on the resistance mechanism of antibiosis to B. cucurbitae Coq. in the wild melon Cucumis callosus; the highly susceptible muskmelon cultivars Delta Gold and Smith Perfect, and the hybrid C. callosus X Delta Gold were used for comparison. When reared on resistant fruit, larval survival, growth index, pupal size and weight, the ratio of adult females to males, fecundity and adult life-span were lower, the larval period was longer, and there was little effect on the pupal period.
B. cucurbitae	Melon, wild melon		Chelliah and Sambandam	1974	The highly susceptible C. melo variety Delta Gold and its hybrid with C. callosus were used in tests in the laboratory to determine the resistance mechanism to B. cucurbitae in C. callosus. Variation in the number of eggs laid in the different fruit types revealed that nonpreference for C. callosus resulted from the combined influence of a tough rind and the biochemical properties of the fruit.
B. cucurbitae	Melon, wild melon		Chelliah and Sambandam	1974	Of 69 muskmelon accessions screened, 9 were resistant, 7 susceptible and the remainder highly susceptible to fruit fly. The wild C. callosus, however, was highly resistant, and since it will hybridize with muskmelon it is likely to be of value in breeding.
B. cucurbitae	Watermelon	Jabalpur, Madhya Pradesh	Choubey et al.	2002	An experiment was conducted in Jabalpur, Madhya Pradesh, India during the 1991 summer season to evaluate the varietal response of watermelon cultivars MHW-11, Arka Jyoti, MHW-4, MHWHM-101, MHW-6, MHW-5, and Madhu, against melon fruit fly (B. cucurbitae). Arka Jyoti was the least susceptible (38.81%) under Jabalpur conditions.
	Mango		Dan et al.	1989	The hybrids Totapuri X Alphonso (T X A) and Totapuri X Mulgoa (T X M) gave larger fruits with smaller stones than their parents. Hybrid T X A had a high fibre content, which made it suitable only for juice production, but was more susceptible to fruit fly than its parents. Quality of juice was rated in the order Alphonso > T X A > T X M > Totapuri > Mulgoa. Both hybrids had lower sugar:acid ratios than their parents. The hybrid Banganpalli X Alphonso was suitable for canned slice production and was rated as superior to Banganpalli and only slightly inferior to Alphonso, which has smaller fruits with larger stones than the hybrid.

B. dorsalis, B. cucurbitae	Mango, guava, sapota, pumpkin, bitter gourd, squash gourd		Doharey	1985	Preference of B. dorsalis on fruits of mango, guava and sapota [Manilkara achras] and of D. cucurbitae on pumpkin, bitter gourd (Momordica charantia) and squash gourd (Citrullus vulgaris var. fistulosus) was studied, D. dorsalis preferred mango, followed by guava and sapota and D. cucurbitae preferred bitter gourd.
Carpomyia vesuviana	Jujube		Faroda	1996	The ber [Ziziphus mauritiana] cultivar Seb was crossed with a local cultivar, Tikadi, resistant to fruit fly (Carpomyia vesuviana) in order to develop a pest resistant cultivar. The F1, although 90% resistant, had poor fruit quality. By backcrossing to Seb, a BC1 line with 87-90% resistance and desirable fruit characters was obtained. A mean of 13% fruit fly infestation was observed in this line, along with a high level of antibiosis. Fruits weighed around 16 g (4.5 g in the F1) and Brix value was 24°.
B. cucurbitae	Pumpkin, tinda	New Delhi	Garg et al.	1979	Comparative suitability of tinda (squash melon) and pumpkin as larval diet for the development of melon fly (B.c.) has been carried out with regard to oviposition preference and larval development. No preference between the 2 fruits was shown by ovipositing females, but the rates of pupation and adult emergence, together with the pupal weights of larvae reared on them, indicated that tinda was more favourable to growth and development.
B. tau	Peach	Punjab	Grewal and Malhi	1987	Damage to peaches by the tephritid B. zonatus was studied in Punjab. The cultivar Sharbati, which is considered to be suitable for the plains of northern India, was highly susceptible to attack by D. zonatus. Up to 89.50% of fruit was damaged by B. zonatus.
B. cucurbitae	Bitter gourd, sponge gourd, cucumber		Gupta and Verma	1995	The tephritid B. cucurbitae, when reared on 3 cucurbit food plants, namely bitter gourd (Momordica charantia), cucumber and sponge gourd (Luffa sp.), showed slight variations in the duration of the egg (1.1-1.8 days) and pupal (7.7-9.4 days) stages, but it varied notably in the larval stage, being 6 days on Luffa sp. and 3 days on the 2 other hosts. The highest mortality occurred during the egg stage (maximum 20%) on Luffa sp.
B. cucurbitae	Bitter gourd, sponge gourd, cucumber		Gupta and Verma	1995	The tephritid B. cucurbitae, when reared on 3 cucurbit food plants, namely bitter gourd (Momordica charantia), cucumber and sponge gourd (Luffa sp.), showedthe shortest mean generation time (T = 25.8 days) and highest net reproductive rate (Ro = 55.8) had the highest intrinsic rate of increase (0.16) on cucumber.
B. cucurbitae	Bitter gourd, sponge gourd, cucumber		Gupta and Verma	1995	The tephritid Bactrocera cucurbitae, when reared on 3 cucurbit food plants - bitter gourd (Momordica charantia), cucumber and sponge gourd (Luffa sp.) - showed slight variations in the duration of the egg (1.1-1.8 days) and pupal (7.7-9.4 days) stages, but it varied notably in the larval stage, being 6 days on Luffa sp. and 3 days on the 2 other hosts.

B. correcta	Guava		Jalaluddin and Sadakathulla	1999	The effect of guava cultivars AC10, Chittidar, Lucknow-46 and Lucknow-49 on B. correcta larval survival, adult eclosion and size were investigated. There was significant variation in larval and pupal periods between cultivars, but no significant difference in pupation rates. Percentage adult emergence was higher (90.6%) on the susceptible Chittidar cultivar and lower (59.0%) on the resistant cultivar Lucknow-46. Chittidar yielded the largest adult (>2.17 mm head width). High levels of Vitamin C, total soluble solids and total phenol in the fruits were factors contributing to guava resistance to B. correcta.
B. dorsalis			Jayanthi et al.	2001	A study was conducted to determine whether resource limitation for oviposition affects pupal recovery, adult emergence and sex ratio in mango fruit fly, B. dorsalis. The results revealed that pupal recovery depended on duration of oviposition time and it increased with increased exposure to adult flies. However, by 48h, the per cent increase in pupae declined in 89.34% of 24h and drastically fell to 23.28% of 48h exposure after 72h. The percentage of adult emergence was highest (71.09) when fruits were exposed for 48h, followed by 24h (67.16%). The percentage of adult emergence was least (43.09) with 72h exposure. Exposure time did not affect the sex ratio.
B. cucurbitae	94 watermelons	Rajasthan	Khandelwal and Nath	1979	Field tests were carried out in Jobner, Rajasthan, India, in 1967-72 to evaluate the resistance of 94 cultivars of watermelon from India, USSR, USA and Japan to B. cucurbitae Coq. The cultivars J 18-1 (from Uttar Pradesh) and J 56-1 (from Rajasthan) were both found to be resistant to the fruit fly.
B. correcta	Mango	Paria, Gujarat	Kumar et al.	1994	Four promising mango varieties namely, Alphonso, Rajapuri, Kesar and Dashehari were evaluated during 1990-93 for their susceptibility to B. correcta in Paria, Gujarat. Fruit infestation, larval population in infested fruit and loss were considered for varietal screening. TSS, total sugars, acidity, pulp and peel of different varieties were correlated with fruit fly infestation. Cv. Alphonso suffered the most significant damage and recorded 26.7% fruit infestation, (2.7 larvae/fruit). The weight loss was greatest (17.2 kg/tree) in cv.Kesar, but on a par with cv. Alphonso (16 kg/tree). In terms of monetary loss, cv. Alphonso ranked first (Rs 120/tree), followed by cv. Kesar. Cv. Dashehari suffered the least with respect to all the parameters studied. Total sugars showed significant positive correlation with fruit fly infestation (r = 0.8190), but the cumulative impact of all the chemical factors on fruit fly infestation was non-significant.
B. dorsalis, B. correcta	Mango		Kumar et al.	2002	Twenty mango hybrids evaluated for multiple pest resistance to tree fruit fly (B. dorsalis, B. correcta) revealed that 10 hybrids (viz., Nedgoa, A.U. Rumani, Mehmood Bahar, Neleshan-Gujarat, Arka Punit, Sindhu, Manjira, Sangam, HY-165 and Neeluddin) showed multiple resistance to the test insects. GMH-1 (a promising hybrid from Gujarat) and Neleshan showed moderate to susceptible reaction to most of the insect pests. Neeleshwari was less susceptible to these insect pests.

Carpomyia vesuviana	Jujube	Haryana	Lakra and Singh	1983	The oviposition behaviour of Carpomyia vesuviana Costa on ber (Ziziphus mauritiana), fruit deformity resulting from infestation and the incidence of the pest were studied in Haryana, India, between 1979 and 1981. Females preferred to oviposit in the distal or central part of the fruit. Oviposition inhibited growth in the surrounding tissues, causing protuberances and/or depressions in the fruit. Deformity was most apparent in young fruits with oviposition holes. Fruits smaller than 9 X 4.5 mm were avoided by females, while almost 50% of fruits measuring 20 X 9 mm contained oviposition holes during October. A maximum of 55.15% of fruits contained a single larva, while 37.16% contained 2 or 3. Only 0.08% of fruits contained 7 or 8 larvae. A total of 45% of fruits was infested by 2-8 larvae at some stage during of their development. Of the infested fruits, 21.83% were collected from the southern side of trees, while only 5.27% were taken from the northern side; the percentages taken from the eastern and western sides were almost equal (14.6 and 14.5, respectively). The pest was most abundant in December and least abundant in March.
Bc?	29 cucurbits		Lall and Sinha	1974	The percentage of infested fruit was assessed weekly over a four-week period for six bittergourd (Momordica charantia), six pumpkin (Cucurbita pepo), five sponge-gourd (Luffa cylindrica), five bottle-gourd (Lagenaria siceraria) and seven cucumber (Cucumis sativus) cultivars. The cultivars exhibiting most resistance for the five species respectively were Short Green Kareli, Small Sugar, Pilibhit Padmini, Sutton's Long White and Improved Long Green.
B. dorsalis	Mango	Ludhiana, Punjab	Mann	1996	B. dorsalis flies were observed throughout the year in methyl eugenol baited traps in a mango orchard in Ludhiana, Punjab, India. Population counts were low in the winter months from December to February which was thought to be caused by low temperature (below 20°C). Following the warmer season, the flies rebuilt their population throughout the rest of the year. However, low catches in July may be due to the after-effects of high temperatures in June (31.93°C) or due to high rainfall (223 mm/month). Afterwards, increases in fruit fly catches may be attributed to conducive temperature (24-29°C) and abundant supply of host fruits. The fruit fly counts on the mango fruits during July were greatest at 1100 h and 1200 h. Fruit fly infestation was 30.77, 65 and 85.50% in cultivars Dusheri, Sucking and Chausa, respectively.
B. dorsalis	Peach	Punjab	Mann and Bindra	1977	Field incidence of B. dorsalis Hendel on different cultivars of peach (Prunus persica) at Ludhiana (Punjab)studies over two years with eleven varieties, Florida Sun had the lowest average infestation; generally, infestation was related to earliness of fruiting, the earlier the variety the lower the infestation, except in the midearly variety Sun Red, in which infestation was heavy, possibly because the fruit lack hairs.
Meridarchis scyrodes, Carpomyia vesuviana	Jujube	Bijapur, Karnataka	Nandihalli et al.	1996	In a field study in 1995-96 at Bijapur, Karnataka, in Zizyphus mauritiana orchards, Meridarchis scyrodes and Carpomyia vesuviana were prevalent from first fortnight of December to first fortnight of February. The relationship between pest incidence and temperature was positive while negative relationship of the incidence of the pests was found with relative humidity, wind speed and cloud cover. M. scyrodes was more damaging than C. vesuviana in all the cultivars evaluated. Cv. Ilaichi and Chhuhara fruits recorded lowest pest infestation (1 larva/fruit).

B. cucurbitae	82 cucurbits		Nath et al.	1976	Eighty-two lines belonging to Cucurbita maxima and C. moschata were screened for resistance to B. cucurbitae. C. maxima 'IHR79-2' was found to have high resistance combined with a high yield in both wet and dry seasons.
B. cucurbitae	Arka		Nath et al.	1976	Data from the F1, F2 and BC1 of Arka Suryamukhi (resistant to B. curcurbitae) X IHR (susceptible) and their reciprocal indicated that resistance is controlled by a single dominant gene designated Fr.
	Peach		Nijjar	1991	TA-170 is a new cultivar of peach (Prunus persica), introduced from Florida and released in Punjab for general cultivation in December 1990. Fruits are medium large. Fruit flesh is firm and yellow with red colouration, semi-free and ripens 7 days earlier (76 days) than the standard Flordasun. Although there was no difference in yield and fruit weight, the trees of TA-170 were more vigorous. It is superior in respect of titratable soluble solids (TSS) and TSS/acid ratio, has better storage and shipping quality and is free from attack by fruit fly.
B. cucubitae	Musk melon		Pal et al.	1983	Of 50 Cucumis melo accessions from India and elsewhere screened for resistance to B. cucurbitae in the field over 4 years, 6 (all from India or Afghanistan) were characterized as resistant or immune (0-10% fruit damage). The resistant accessions were similar to the commercial variety Arka Jeet in many respects, but low in total soluble sugar contents. Data from a cross between Arka Jeet and the resistant wild species C. callosus indicated that resistance may be dominant.
B. cucubitae	Musk melon	Rajasthan	Pareek and Kavadia	1995	In a field trial at 2 sites in Rajasthan, 17 musk melon cultivars were evaluated for their susceptibility to B. cucurbitae. The cultivars were either susceptible (51-75% fruits damaged) or highly susceptible (76-100%).
B. cucubitae	10 cucurbits	Udaipur and Jobner, Rajasthan	Pareeka and kavadia	1994	The relative preference of B. cucurbitae for 10 cucurbits grown in one field under semi-humid (Udaipur) and semi-arid (Jobner) agro-climatic conditions studied. The studies indicated the highest preference for musk melon and round gourd followed by bitter gourd and long melon, whereas water melon was only moderately preferred. Ridge gourd, sponge gourd, cucumber, bottle gourd and pumpkin were the least preferred hosts.
Dacus ciliatus	Cucurbits	Gujarat	Patel and Patel	1998	The ovipositional preference of D. ciliatus on number of eggs laid in fruits found as (1) Little gourd > (2) Cucumber > (3) Bitter gourd > (4) Bottle gourd > (5) Smooth gourd > (6) Ridge gourd.
Dacus ciliatus	Cucurbits	Gujarat	Patel and Patel	1998	Little gourd appeared to be the most preferred host for the development of maggots showing highest growth index of all the hosts tested .
Dacus ciliatus	Little gourd	Gujarat	Patel and Patel	1998	Laboratory observations showed that smaller sized fruits of little gourd [Coccinia grandis] were preferred over larger ones for oviposition
B. spp.			Pillai et al.	1983	Obtained from gamma-irradiated (75 kR) seed of selection H160, this variety gave better yields in trials than either its parent or the common variety Co1. It is tolerant to B. spp.

B. zonata	Guava	Haryana	Rana et al.	1990	Among 20 guava cultivars tested in the field in Haryana, Nasik and China Surkha were relatively least susceptible to B. zonata, having <10% infestation; Strawberry, Chakaiya Rahmannagar, Supreme and Smooth Grren had 10-20% infestation, and the remainder >20%.
Carpomyia vesuviana	Jujube	Jodhpur, Rajasthan	Sachan	1984	Damage to the fruits of 4 improved varieties of ber (Ziziphus jujuba [Z. mauritiana]), namely Seb, Jogia, Gola and Mundia-Marhera, by the tephritid Carpomyia vesuviana was assessed at harvest in the 1973-74 season at Jodhpur, Rajasthan, India, where the fruit fly is a serious pest. The results showed that 3.75, 7.68, 16.60 and 19.6% of the fruits of these varieties were damaged, respectively. Observations on 20 varieties that had received 3 applications of sprays containing 0.02% parathion in the 1st and 4th weeks of November and in the 3rd week of December (0.5 to 7 ml insecticide/tree 5 years old) indicated 98-100% protection of fruits against damage by the fruit fly.
B. dorsalis, Dichocrocis punctiferalis	Guava	Punjab	Sandhu et al.	1979	The incidence of B. dorsalis and Dichocrocis punctiferalis on the fruit was determined in 9 guava cvs. The former ranged from very low in the cvs Red Flesh and Seedless to very high in the cv. Apple and the latter from very low in the cvs Guinea and Red Flesh to very high in the cv. Seedless
Carypomyia vesuviana	Jujube	New Delhi	Sharma et al.	1998	Thirty varieties of ber (Zizyphus mauritiana) were screened for varietal resistance against Carpomyia vesuviana in 1989-91 in New Delhi. Regular observations to record the fruit infestation were continued till harvesting. The cultivars were categorised into different grades of susceptibility, considering the per cent fruits damaged on the basis of number and weight. The categories were: totally immune, highly resistant 1-10%, resistant 11-20%, moderately resistant 21-30%, moderately susceptible 31-40%, susceptible 41-50%, and highly susceptible >50%. None of the cultivars was immune to the pest. However, cv. Tikdi and Illaichi were highly resistant in both the years. Cv. Umran, Tas Bataso, Deshi Alwar, Kishmis, were resistant or moderately resistant. The fruit of cultivars with high infestation and graded highly susceptible included Akhrota, Bagwadi, Gola, Katha Rajasthan, Dandan, Seo and Laddu.
Carpomyia vesuviana	Jujube		Singh	1984	Data are presented on the extent and severity of fruit infestation by Carpomyia vesuviana on 25 Zizyphus [Ziziphus] mauritiana cultivars, averaged over 3 years. The extent of infestation varied among cultivars (from 6.7% in Tikadi to 73%), indicating that flies prefer certain cultivars for egg-laying. Eggs/fruit did not vary significantly, but the percentage of larvae hatched varied among cultivars, indicating varying degrees of antibiosis. There was a positive correlation between percentage fruit infestation and percentage hatching (r = 0.9038).
Carpomyia vesuviana	Jujube	Rajasthan	Singh and Vashishtha	1985	Field trials were carried out in Rajasthan, India, in 1979-82 to assess the resistance of some cultivars of ber (Ziziphus mauritiana) to attack by the tephritid Carpomyia vesuviana. The most susceptible varieties were Dandan Gola, Gola Gurgaon No. 3, Kaithli Hissar and Kakro Gola, while Ilaichi was moderately resistant and Tikadi was resistant

B. cucurbitae			Singh et al.	2000	The host preferences of the red pumpkin beetle, Aulacophora foveicollis, and the melon fruit fly, B. cucurbitae, were studied using different cucurbits during the summer.The percentage of fruit damage by the melon fruit fly was under 50% in all cases. However, percentage damage was significantly highest on watermelon (28.55%) and bitter gourd (31.27%).
B. cucurbitae	Melon?		Tewatia and Dhankhar	1996	Inheritance of resistance to melon fruitfly was studied in 2 crosses of resistant Faizabad 17 X susceptible Pusa do Mausami and susceptible Arka Harit X resistant Kerala 1. Data on the percentage of infested fruits were recorded in parent lines, F1, F2, BC1 and BC2. Results indicated that resistance is dominant over susceptibility, and both additive and dominance gene effects were important in inheritance of resistance. However, a duplicate type of epistasis was noted. For further genetic improvement, reciprocal recurrent selection is suggested.
B. cucurbitae	Bitter gourd		Thakur et al.	1994	Stability analysis for economic traits and infestation of melon fruit-fly (B. cucurbitae) in bittergourd (Momordica charantia) were studied. 10 cultivars were sown out of which C96 was the most stable for fruits/plant and had the lowest incidence of fruit fly infestation. NDBT1 had the most stable resistance to B. cucurbitae.
B. cucubitae	Bitter gourd	Ludhiana, Punjab	Thakur et al.	1996	Information on yield correlations is derived from data on 7 characters (including fruit fly B. cucurbitae infection and total yield) in 10 Momordica charantia varieties (BG14, Arka Harit, Kalyanpur Sona, ARU41, NDBT1, Pusa Do Mausmi, Priya, Pusa Vishesh, Pusa Hybrid-1 and C96) grown at Ludhiana (Punjab). B. cucurbitae infection was negatively correlated with fruits/plant and total marketable yield. BG14 was the most promising variety with respect to yield components and B. cucurbitae resistance

Section 10: Rearing, Culture and Diet

Fly	Host	Location	Author	Date	Summary
B. cucurbitae			Anand and Anand	1990	In experiments to determine the dietary effects of D-isomers of 10 essential amino acids on larvae of the tephritid B. cucurbitae, incorporating phenylalanine and tryptophan into a casein-based diet gave the best growth increase, followed by threonine, methionine and lysine. Arginine produced the maximum inhibition of growth and reduced survival.
B. tau			Bala	1987	The preoviposition period of the tephritid B. tau was determined on natural (fruit of Luffa spp.) and synthetic diets . Flies with a diet consisting of natural food, extra protein hydrolysate, vitamins, minerals and carbohydrates had the shortest preoviposition period (9 days). Tephritids fed on protinex and glucose had the longest preoviposition period (25 days).
B. cucurbitae			Bhagat and Koul	1999	The seasonal biology of melon fruit fly, B. cucurbitae, was studied during pre-monsoon (April-June), monsoon (July-September) and post-monsoon (October-December). Field-collected adults of B. cucurbitae were housed in glass tubes with fresh slices of bottle gourd (Lagenaria siceraria), examined after 24h and their eggs collected. Eggs were placed on fresh bottle gourd slices kept on water-soaked filter papers and observed for hatching. Freshly hatched maggots were transferred on bottle gourd slices in glass tubes. At the onset of pupation, the slices were placed in tubes with water-soaked sand 50 mesh layer to facilitate pupation. Results revealed that incubation, larval and pupal periods were lowest during the pre-monsoon (1.00, 4.96 and 6.94 days, respectively) followed by monsoon and post-monsoon periods. Pre-oviposition and oviposition periods were lower in pre-monsoon (11.06 and 12.12 days, respectively) than in monsoon and post-monsoon periods. Adult emergence was highest in the pre-monsoon (80%), followed by monsoon (74.4%) and post-monsoon (62.7%) periods.
B. cucurbitae			Boush et al.	1977	Attempts were made to develop a chemically defined diet, for studying the nutritional requirements of this pest. Hydrolysed yeast was successfully replaced by a mixture of sucrose, 9 essential amino acids (arginine, histidine, isoleucine, lysine, methionine, phenylalanine, tryptophan, threonine and valine), McCollum's salt mixture, and 10 vitamins of the B complex.
B. cucurbitae	Muskmelon, snake gourd, ribbed gourd		Chelliah	1970	The fruits of three cucurbits plants were investigated for their suitability as media for the mass culture of B. cucurbitae Coq. in the laboratory. Muskmelon (Cucumis melo) proved the most suitable, snake gourd (Trichosanthes anguina) the least so and ribbed gourd (Luffa acutangula) intermediate.

B. cucurbitae			Gowda et al.	1979	An improved method developed in India for mass rearing of B. cucurbitae Coq. based on Protinex (protein hydrolysate with vitamins) and 20% honey solution instead of the previously used yeast hydrolysate and sugar crystals. The method was used for rearing D. cucurbitae for 5-6 generations, and pupal recoveries were in the range of 90-95%. The period between the egg stage and adult emergence was 11-16 days at 28 plus or minus 2 deg C and 75% RH.
B. cucurbitae			Gupta and Anand	1994	When different doses of boric acid, molybdic acid and cobalt chloride were tested for their effects on growth and development of larvae, there was a significant adverse effect on growth.
B. cucurbitae			Gupta and Anand	1994	Salt mixture 185 used in the larval diet does not have any trace elements. When FeCl3 was added in addition to salt mixture 185 in the diet, there was a significant improvement in the growth of the larvae but when the same concn of FeCl3 was added to a diet with HMW salt mixture there was no significant improvement in growth index.
B. cucurbitae			Gupta and Anand	2002	The salt compositions of Wesson's salt mixture, i.e. calcium carbonate (21.00%), tricalcium phosphate (14.90%), copper sulfate (0.039%), ferric phosphate (1.47%), manganese sulfate (0.02%), magnesium sulfate (9.00%), potash (0.009%), potassium dihydrogen phosphate (31.00%), potassium chloride (12.00%), potassium iodide (0.005%), sodium chloride (10.5%) and sodium fluoride (0.057%), in a casein-based artificial diet were removed individually. One treatment had all the salts and the treatment with no salts was taken as the control. Single omissions of ferric sulfate and manganese sulfate improved the diet over the treatment with complete salts. The absence of these 2 salts not only improved the oviposition and fertility but also the longevity of B. cucurbitae. The absence of copper sulfate also affected the fecundity but its effect was more pronounced on longevity and egg viability. The absence of calcium salts had no effect on longevity and oviposition period but did not favour peak attainment and viability. Removal of magnesium, potassium and sodium salts individually delayed the sexual maturity of the flies and reduced significantly the oviposition period, longevity, fecundity and fertility.
Bactocera cucurbitae			Gupta and Anand	2003	Different constituent salts of Wesson's salt mixture having the same anion were detected one by one in a casein artificial diet and their effect on various parameters of reproductive potential of Bactrocera cucurbitae was observed. Six anions - carbonate, phosphate, chloride, iodide, sulfate and fluoride - were removed from the diets one at a time. In the absence of fluoride anion, the flies improved their oviposition, longevity as well as fertility, but the improvement was less when carbonate, phosphate, chloride and sulfate anions were removed. The absence of iodide produced a positive effect on all the parameters.

B. cucurbitae			Gupta and Verma	1995	The tephritid B. cucurbitae, when reared on 3 cucurbit food plants, namely bitter gourd (Momordica charantia), cucumber and sponge gourd (Luffa sp.), showed slight variations in the duration of the egg (1.1-1.8 days) and pupal (7.7-9.4 days) stages, but it varied notably in the larval stage, being 6 days on Luffa sp. and 3 days on the 2 other hosts. The highest mortality occurred during the egg stage (maximum 20%) on Luffa sp. The shortest mean generation time (25.8 days), highest net reproductive rate (Ro = 55.8) and highest intrinsic rate of increase (0.16) were on cucumber.
B. cucurbitae			Gupta et al.	1994	The effect of addition of 3 trace metal salts at various concn were tested on larvae. No significant effects were observed when MnCl2 was added, but when ZnSo4 and Cuso4 were added individually to the diets there was a significant adverse effect on larval growth.
B. cucurbitae			Kaur and Srivastava	1991	The effect of the B vitamins, folic acid and boitin, individually and together on reproduction by was studied y at 27°C and 75% RH. The omission of all B vitamins resulted in a reduction of the oviposition period, longevity, total oviposition and egg viability. These parameters were also reduced when only one B vitamin was omitted.
B. cucurbitae			Kaur and Srivastava	1994	The effect of amino acids on reproduction was studied at 27°C and 75% RH. The 10 essential amino acids were indispensable together and individually, and without them the flies failed to attain sexual maturity.The omission of the non-essential amino acids as a group resulted in reduced longevity, total oviposition and egg viability.
B. cucurbitae			Kaur and Srivastava	1994	The effect of alpha-tocopherol at 0, 2.5, 5.0, 7.5 and 10.00 mg in the diet on the reproductive potential of adults was studied. In the absence of alpha-tocopherol, the cyclic rhythm of oviposition was impaired. The oviposition period, total oviposition, egg viability and longevity were also adversely affected and were reduced by 46.60 days, 3356 eggs/20 females, 55.57% and 41.70 days, resp. Optimum total oviposition, egg viability and longevity were observed with 5 mg of alpha-tocopherol in the diet.
B. cucurbitae			Kaur and Srivastava	1995	The effect of ascorbic acid in various quantities (0.5, 1.00 (control), 1.50 and 2.00mg/ml) in the diet on the various parameters of reproductive potential were studied in adults and found that a dietary concn of 1.00mg/ml diet was optimal. Lower quantities of ascorbic acid (0.50mg/ml of diet) proved to be detrimental and could not support normal life and reproduction, whereas higher quantities (1.50 and 2.00mg/ml of diet), although not very harmful, were either ineffective or slightly detrimental.
B. cucurbitae			Kaur and Srivastava	1995	The effect of the presence or absence of cholesterol in the diet on various parameters of reproductive potential was studied. The absence of cholesterol shortened the peak oviposition period, which also occurred earlier than in the diet with cholesterol; it also resulted in a reduced oviposition period, and a lower oviposition rate and egg viability. It is concluded from the results that cholesterol promotes oogenesis and is therefore an essential component of the diet of B. cucurbitae.

B. cucurbitae			Kaur and Srivastava	1995	The effect of different amounts of sucrose (0, 250, 500, 750, 1000 (control), 1250, 1500, 1750 and 2000 mg/ml diet) on various parameters of the reproductive potential was studied. In absence of sucrose the flies died within 3 days and for adults of B. cucurbitae the optimal dietary level of sucrose is 66.67 per (dry wt.) for optimum longevity, total oviposition and egg viability.
B. cucurbitae			Kaur and Srivastava	1995	The effects of dietary water, sucrose and yeast hydrolysate on oviposition and longevity were studied by eliminating each component one at a time. Water was essential for the survival of adults, which died if kept without water for more than 24h. Without sucrose, adults died within 3 days. When adults were kept on a diet without protein, females failed to oviposit, although adults lived longer (113 days) than those fed on a diet containing all components (101.6) days.
B. cucurbitae			Kaur and Srivastava	1995	The effects of minerals on the reproductive potential of B. cucurbitae was studied. In the absence of minerals from the diet, oviposition period, longevity, egg deposition, number of oviposition peaks and egg viability were drastically reduced (by 34.00 days, 24.70 days, 2987.70 eggs (two-thirds), 4.33 peaks and 21.13%, resp.), leading to a considerable reduction in the reproductive potential of the pest. Thus, minerals are extremely important for normal reproduction of B. cucurbitae
B. cucurbitae			Kaur and Srivastava	1995	Three different artificial diets, yeast hydrolysate based, casein based and amino acid based, were evaluated for their effects on various parameters of the reproductive potential . When all the parameters were assessed together, the yeast hydrolysate based diet containing bulk nutrient was found to be most suitable as it supported maximum reproductive potential. It was followed by the casein based and amino acid based diets.
B. cucurbitae			Kaur and Srivastava	1996	In two artificial oviposition receptacles (a paraffin dome and a plastic, lemon-shaped receptacle) for B. cucurbitae tested for comparison with pumpkin fruits, average oviposition per 20 females per day was 2.80 and 17.20, respectively, compared with 150.20 in pumpkin fruits.
B. cucurbitae			Lall and Singh	1969	In laboratory rearing, adults were kept in breeding cages with slices of cucumber; slices containing eggs were removed to glass troughs containing a layer of sand and more cucumber, in which the larval stage was passed; the pupae were transferred to petri dishes of moist sand to prevent desiccation, and the ensuing adults were returned to the breeding cages. Under these conditions 9-10 generations were reared, each lasting 12.56-33.61 days according to the time of year.
B. dorsalis			Pant et al.	1990	The effect of the pH of artificial diet on the growth and development of B. dorsalis was studied under aseptic conditions. The optimum pH was 5, with 87.5% of larvae developing to the pupal stage and a growth index of 3.88. Growth and development were adversely affected when the pH was below 4.5 or above 5.5.

B. cucurbitae			Paripurna and Srivastava	1987	Experiments were carried out to determine the optimum quantity of water in an artificial diet for B. cucurbitae. The quantities of distilled water tested were 10, 20, 30, 40, 50, 75 and 100 ml. The diet containing 50 ml of water provided the maximum growth and development of larvae of B. curcurbitae.
B. cucurbitae			Paripurna and Srivastava	1990	The optimum amounts of sucrose and glucose for larval growth and development of B. cucurbitae on an artificial diet were found to be 2000 and 500 mg, resp., per 50 ml diet.
B. cucurbitae			Srivastava et al.	1977	Qualitative studies were carried out on the requirement of larvae of B. cucurbitae Coq. for vitamins of the B complex. Only thiamin, riboflavin, nicotinic acid, pantothenic acid, pyridoxin and choline chloride were found to be essential for growth and development.
B. cucurbitae			Srivastava et al.	1978	Laboratory experiments were carried out to determine the effect of ascorbic acid on larvae of B. cucurbitae Coq. reared on an artificial diet. Added to the diet at a rate of 0.2 mg/ml, it was found to be suitable for normal growth and development of the larvae. The vitamin was effective only if it was added after the rest of the diet was autoclaved. When added before autoclaving, the ascorbic acid probably lost its effectiveness because of its thermolabile nature.
B. cucurbitae			Srivastava et al.	1980	An artificial diet developed for rearing larvae of B. cucurbitae Coq. the diet contains 3.0g casein, 1.0g sucrose AR, 0.040g cholesterol, 0.100g McCollum's salt mixture No.185, 0.100g ribonucleic acid, 0.025g methyl 4-hydroxybenzoate, 1000 mu g thiamin, 1000 mu g riboflavin, 1000 mu g nicotinic acid, 1000 mu g pantothenic acid, 1000 mu g pyridoxine, 0.100g chloramphenicol, 0.4ml potassium hydroxide 10%, 1.0g agar, 50.0ml distilled water, 1000 mu g 4-aminobenzoic acid, 1000 mu g inositol, 20 000 mu g choline chloride, 100 mu g biotin and 250 mu g folic acid. The pH of the diet was found to be a crucial factor, and at pHs above or below 5.4 the larvae failed to grow.
B. cucurbitae			Srivastava et al.	1980	The addition of yeast, its 2 fractions (water soluble and insoluble) and yeast ash to the artificial diet of B. cucurbitae Coq. was studied in relation to its effects on the growth and development of the pest. The larvae could only develop if yeast was included in the diet, and this was found to be due to the change in pH from 4.4 to 5.4 caused by the yeast. Raising the pH to 5.4 by the addition of 10% KOH to the diet enabled the yeast to be eliminated, and it was established that a pH of between 5.4 and 7 was most suitable for the growth of B.c. larvae in aseptic conditions.
B. cucurbitae			Srivastava et al.	1983	The effects of the antimicrobial compounds methyl 4-hydroxybenzoate at 0.04%, sorbic acid at 0.04% and propionic acid [propanoic acid] at 0.2% in the artificial diet on the growth and development of B. cucurbitae were studied. The addition of sorbic acid and propanoic acid to the diet was lethal to the larvae, while in the presence of methyl 4-hydroxybenzoate 50% of the larvae pupated within about 10 days. The optimum concentration range of the compound for protection against fungal infection without adversely affecting larval survival was shown to be 0.4-0.8 mg/ml diet, and the minimum effective dosage 0.4 mg/ml diet.

B. dorsalis			Srivastava et al.	1989	The composition of an aseptic diet to rear larvae of the tephritid B. dorsalis was developed. The diet (in g) consists of vitamin-free casein (3.5), sucrose 2.0), cholesterol (0.04), Mc-collum salt mixture No. 185 (0.1), ribonucleic acid (0.1), methyl parahydroxy benzoate (0.1), chloramphenicol (0.1), 10% potassium hydroxide (0.4) ml, agar (1.0), distilled water (10 ml) and (in mg) the vitamins thiamine 1, riboflavin 1, nicotinic acid, pantothenic acid (1), p-aminobenzoic acid (1), inositol (10), choline chloride (2), biotin (0.1), folic acid (0.25 and PII (5.4).
B. cucurbitae			Srivastava et al.	1995	A casein hydrolysate-based diet was shown to be as effective as one containing imported yeast hydrolysate for use in rearing.

Section 11: Physiology and Biochemistry

Fly	Authors	Date	Location	Summary
B. cucurbitae	Kaur and Srivastava	1995		The effect of minerals on the reproductive potential *of Bactrocera cucurbitae* was studied. In the absence of minerals from the diet, oviposition period, longevity, egg deposition, number of oviposition peaks and egg viability were drastically reduced (by 34.00 days, 24.70 days, 2987.70 eggs (two-thirds), 4.33 peaks and 21.13%, resp.), leading to a considerable reduction in the reproductive potential of the pest. Thus, minerals are extremely important for normal reproduction of *B. cucurbitae.*
B. dorsalis	Prasad and Sethi	1980		The effects of various doses of gamma-irradiation on the haemolymph protein content of adults of B. dorsalis Hend. were studied in Laboratory. It was found that irradiation with doses up to 15 kR did not appreciably change the haemolymph protein content; but irradiation with 24 kR resulted in an increase in protein content from 3.116 to 3.661 g/100 ml haemolymph in males and from 2.826 to 3.995 g/100 ml haemolymph in females 4 days after treatment, and the content increased further to 3.773 g in males and 4.215 g in females when analysed 10 days after treatment. This increase in the concentration of haemolym ph protein indicated that there was no degradation of the protein in adults of D. dorsalis treated with high doses of radiation.
B. dorsalis	Prasad and Sethi	1980		The effects of various doses of gamma-irradiation on peroxidase activity in adults of B. dorsalis Hend. were studied in the laboratory in India. It was found that there was little difference in enzyme activity between untreated insects and those irradiated with 10 kR. However, a slight reduction was observed 30 days after treatment with 15 kR in the fore-gut region and 20 days after treatment in the mid-gut region. A significant reduction in peroxidase activity was observed after treatment with 20 kR in all regions of the gut in both sexes of D. dorsalis.
B. dorsalis	Prasad and Sethi	1980		A laboratory study was carried out to determine the effect of gamma -irradiation on lipase activity in adults of B. dorsalis Hend. The insects were treated with 10, 15 and 20 kR and it was found that the lowest dose had no significant effect on the activity of the enzyme, whereas the 2 higher doses resulted in considerable reductions in activity in all regions of the gut, the maximum reduction being observed 10 days after treatment. The pattern of lipase activity was almost identical in males and females, except that in females the enzyme was initially slightly more active than in males in all the gut regions.
B. dorsalis	Prasad and Sethi	1980		Studies carried out in the laboratory on the effect of gamma-radiation doses between 1 and 20 kR on third-instar larvae and mature pupae of B. dorsalis Hend. revealed that the treatment had a pronounced effect on the development of these stages, the effect being dose-dependent. Irradiation of larvae and pupae with the highest dose (20 kR) of gamma -radiation resulted in 31.50 and 64% adult emergence, respectively.

B. dorsalis	Prasad and Sethi	1981		The activity of some important digestive enzymes in the various parts of the alimentary canal was studied in normal adults of B. dorsalis Hend. as well as in adults treated with gamma -radiation at 10, 15 and 20 krad in the laboratory. There was no significant difference in the activity of amylase, invertase, lactase, maltase and trypsin in the fore-gut and hind-gut or between normal insects and those treated at 10 krad, except in the case of lactase that declined sharply in the fore-gut of irradiated flies. Enzyme activity in all parts of the gut was considerably reduced by radiation doses of 15 or 20 krad, the greatest reduction occurring 10 days after treatment at 20 krad.
B. dorsalis	Prasad and Sethi	1983		The effects of gamma-irradiation on the important amino acids of B. dorsalis was studied in the laboratory in India by taking whole body extracts of the pest in various developmental stages and analysing them chromatographically. Tissue extracts of untreated larvae, pupae and adults showed the presence of almost all the essential amino acids; the acids identified were alanine, arginine, aspartic acid, cystine, glutamic acid, glycine, methionine, phenylalanine, proline and valine. At dosages of 15 and 20 kR, the intensity of amino acids in all stages was reduced, and phenylalanine and proline were not detected in insects treated with these dosages. In addition, treatment with 20 kR reduced the amino acid content and resulted in the loss of aspartic acid and valine in all the developmental stages as well as cystine in adults 10 days after irradiation.
B. dorsalis	Prasad et al.	1980		The structure of the mid-gut of normal adults of B. dorsalis Hend. and the histological damage associated with radiation exposure were investigated in the laboratory. The results indicated that the epithelial lining of the mid-gut was highly sensitive to gamma -radiation. The regenerative cells and mid-gut epithelium were damaged at 15 kR, while at 20 kR the effect was much greater, the entire mid-gut epithelium being destroyed. No radiation damage was observed after treatment at 10 kR.
B. dorsalis	Sethi et al.	1981		Third-instar larvae of B. dorsalis Hend. were allowed to feed in the laboratory for 24 h on mango and guava fruits to which radioactive phosphorus or radioactive sulfur had been applied. They were then thoroughly washed to remove surface contamination and were assayed for radioactivity. The initial level of radioactivity (counts/100 s) in newly emerged adults to which the larvae fed on 32P gave rise was 1822-57 980 for males and 7364-19 782 for females. The corresponding counts for adults from the 35S treatment were 2320-4760 for males and 986-2920 for females. It was calculated that the half-life of the 32P labelling was 44.77 days for females and 66.07 for males, and for 35S it was 10.87 days for females and 14.12 days for males.
B. cucurbitae	Shukla and Srivastava	1980		The distribution and kinetics of acetylcholinesterase in B. cucurbitae Coq. Acetylcholinesterase activity was found to be highest in the head (140 plus or minus 2.0nM ATCh mg protein-1 min-1), followed by the thorax (40 plus or minus 1.52 nM ATCh mg protein-1 min-1), and was lowest in the abdomen (12 +/- 0.32nM ATCh mg protein-1 min-1). The protein content was highest in the abdomen, lower in the thorax and lowest in the head.
B. cucurbitae	Shukla and Srivastava	1980		The activity of acetylcholinesterase preparations from heads of B. cucurbitae Coq. was inhibited by 5 organophosphorus and carbamate insecticides (malathion, chlorfenvinphos, dicrotophos, carbaryl and eserine). All of the compounds except malathion were strong inhibitors of the enzyme.

B. cucurbitae	Srivastava et al.	1977		Qualitative studies were carried out on the requirement of larvae of B. cucurbitae Coq. for vitamins of the B complex. Only thiamin, riboflavin, nicotinic acid, pantothenic acid, pyridoxin and choline chloride were found to be essential for growth and development.
B. dorsalis, B. cucurbitae	Thomas and Rahalkar	1975		Experiments were carried out determine whether irradiation at the low dose (25 krad) used to delay ripening in mango fruits could prevent adult emergence in two mango pests, B. dorsalis Hend. and D. cucurbitae Coq., and also to determine the susceptibility of these fruit-flies to radiation at different stages of their life-cycle. Eggs, larvae 3-4 days old and pupae 2-3 days old were exposed to 15, 25, 40 or 100 krad gamma-radiation from a 60Co source and afterwards the eggs and larvae were transferred to pieces of mango or pumpkin and the pupae to moist sand. All stages of both species exposed to the 2 higher doses ceased development, except for 30-50% of the larvae treated at 40 krad, which pupated but did not give rise to adults. Exposure of eggs to 15 or 25 krad permitted 40-50 and 25-30% hatch, respectively, as compared with 70-80% for no treatment, but the ensuing larvae had reduced mobility, delayed growth and not more than 50% pupation rate, and there was no survival to the adult stage. Exposed larvae were likewise slow in growth and movement, and although 60-70 and 50% pupated, respectively, no adults emerged. No adults emerged from pupae irradiated at any dose.

Section 12: Natural Enemies

Host	Enemy	Nature	Location	Author	Date	Summary
D. ciliatus	*O. longicaudatus*	Parasitoid	Coimbatore, South India	Vadivelu et al.	1976	Parasite on some South Indian crop pests out of which Biosteres longicaudatus Ashm. (Opius longicaudatus) on Dacus ciliatus Lw. (brevistylus Bez.) has been newly recorded.
B. zonata, Chetostoma completum	*Opius sp., Torymoides kiesenwetteri*	Parasitoid	North India	Agarwal and Kapoor	1989	The torymid Dimeromicrus kiesenwetteri [Torymoides kiesenwetteri] was found parasitizing pupae of the tephritid Chetostoma completum, a pest of Centaurea cyanus in India. A species of the braconid genus Opius was found parasitizing pupae of the tephritid Bactrocera zonata.
		Parasitoid	Northern India	Agarwal and Kapoor	1989	A species of the braconid genus Opius was found parasitizing pupae of the tephritid Bactrocera zonata.
B. dorsalis	*Opius incisi*	Parasitoid	Burrdwan, West Bengal	Banerjee	1990	During light-trapping the braconid parasitoid Opius incisi, a parasitoid of Bactrocera dorsalis, showed well defined nocturnal activity. Larger numbers of the parasitoid were present in March and August, which was probably due to host distribution and favourable weather conditions prevailing in these 2 months.
		Natural enemies		Cavalloro et al.	1983	Over 30 species of hymenopterous parasites of tephritids are reported mainly from India. The hosts include the beneficial tephritids Ensina sonchi (L.), which destroys the weeds Cirsium arvense and Sonchus arvensis and was parasitised by a species of Pteromalus , and Procecidochares utilis Stone (a promising biological control agent against crofton weed (Eupatorium adenophorum), which was parasitised by Dimeromicrus vibidia (Wlk.) in Nepal. The other hosts are in the genera Dacus, Carpomyia, Acanthiophilus and Chetostoma, and include some well-known pests.
A. helianthi	*Menochilus sexmaculatus*	Predator	Madhya Pradesh	Chaudhary et al.	1983	Discovered a coccinellid, Menochilus sexmaculatus feeding on the larvae of the capsule fruit flies, A. helianthi .
		Predator		Jalaluddin et al.	1998	In India during 1994-95, the carabid Pheropsophus sobrinus desbordesi [P. hilaris sobrinus] was observed preying on larvae and pupae of B. correcta that fell to the ground. The carabid population peaked in July and August.
B. dorsalis, B. zonata		4 spp		Kumar and Monga	1996	In a laboratory study, Zygoballus indica, Lyssomanes sikkimensis, Myrmarachne bengalensis and Lycosa mackenziei showed high preference for Idioscopus sp. and Drosicha mangifera, and moderate preference for Bactrocera dorsalis and B. zonata.

D. latifrons	*Opius sp., O. incisi, Biosteres sp*	Parasitoid	Karnataka	Udayagiri	1987	In Karnataka B. latifrons was reared in the laboratory from berries of Solanum viarum collected in the field. Three braconid parasitoids were recovered from the pupae: these were subsequently identified as Opius sp., O. incisi and Biosteres sp. This was the first record of O. incisi and Biosteres sp. parasitizing D. latifrons.

Section 13: Cultural Controls

Fly	Host	Location	Authors	Date	Summary
B. zonata			Butani *et al.*	1976	*B. zonata* (Saund.), a polyphagous pest that is controlled by destroying all damaged and fallen fruits and by ploughing round the trees in January and February to kill the pupae.
	Mango	Maharastra	Godse and Bhole	2002	Studies on natural incidence of fruit flies on Alphonso mango indicated (at Maharastra) that the fruits harvested before June were free from fruitfly infestation also showed that regular collection and destruction of fallen, ripe or decaying fruits can reduce fruit fly population in orchards as fruitflies preffred the ripening fruits for egg laying.
B. dorsalis	Guava		Makhmoor and Singh	1999	The effects of soil type, hoeing frequency, depth of pupation and irrigation frequency on pupal mortality and adult emergence of guava fruit fly, *Bactrocera dorsalis*, were determined in field studies in guava orchards in India. Maximum (93.3%) pupal mortality was recorded at the surface and minimum (13.3%) at a depth of 10cm which was significantly less than all other treatments. Increased pupal mortality was observed with an increase in the frequency of irrigation and ranged from 20.0 to 96.6%.
B. cucurbitae			Pandey and Mishra	1999	Vertical and horizontal movement of *Bactrocera cucurbitae* larvae for pupation was studied, and it was observed that larvae had a thrust movement for a maximum distance of 30cm, while the vertical movement was up to 15cm in depth. The larvae usually preferred the texture of medium soil to medium sand for pupation. It appeared that the available soil conditions governed the movement of larvae for pupation.
		Gujarat	Patel	1994	Infested fruit must be buried to a depth of at least 15 cm to prevent adult emergence.
C. vesuviana			Sangwan and Lakra	1992	In the laboratory, the optimum temperature for pupal development in the tephritid Carpomyia vesuviana was 30°C, leading to high adult emergence (74%) and short pupal duration (average 15.65 days). At 10, 16 and 40°C, no adult emergence occurred in 50 days. The ideal depth for pupation was 3-6 cm below the soil surface, at which adult emergence was 82%. Only 15% adult emergence took place at a depth of 45 cm.
C. vesuviana	Jujube	Uttar Pradesh	Singh et al.	2000	A field experiment was conducted in Uttar Pradesh in 1997 to evaluate the efficacy of the following control schedules on ber fruit fly (Carpomya vesuviana) infestation and yield of Ziziphus mauritiana: deep raking soil (T1); radial application of phorate as Thimet 10G (118 g/tree) (T2); cypermethrin, endosulfan [application rates not given] (T3); phosphamidon (0.05%), chlorpyrifos (0.04%) (T4); monocrotophos (0.05%), malathion (0.05%) (T5); dimethoate, econeem [application rates not given] (T6); methyl-O-demeton [demeton-O-methyl] (0.03%), sukrina (1.0%) (T7); and an untreated control (T8). All treatments reduced ber fruit fly infestation compared to the untreated trees. The T5 schedule resulted in the lowest percentage of fruit infestation at 15 days after the 1st, 2nd and 3rd sprayings (9.30%, 7.30% and 4.60%, respectively) and the highest mean yield of 10.43 kg/picking (compared to 6.58 kg/picking in T8), followed by T4 with 6.3% fruit infestation at 15 days after the 3rd spray and a mean yield of 10.26 kg/picking.

Section 14: Insecticides - Active Ingredient Lethality and Effects of Cover Sprays

Fly	Host	Location	Authors	Date	Summary
B. dorsalis, B. cucurbitae, D. ciliatus	Peach	Himachal Pradesh	Sharma et al.	1973	Two spray treatments 4 and 2 weeks before fruit harvest. Fenthion and Fenitrothion each at 2.5 ml a.i./ tree. Percentage infestation was reduced to 3.45 and 8.11 respectively, compared to 41.65 in the untreated control.
B. cucurbitae	Cucurbits	Bihar	Agarwal et al.	1987	Fenthion, dichlorvos, phosphamidon and endosulfan recommended.
B. dorsalis	Mango (alphanso)	Maharastra	Anand and Rama Chandani	1984	Fumigation with ethylene dibromide at dosages of 20, 28 and 36 g/m3 gave 100% mortality after an exposure period of 2h. On the basis of results lowest dosage (20g/m3) of ethylene dibromide is recommended.
B. cucurbitae	Watermelon		Babu et al.	2002	A field experiment was carried out from January to March 1999, to evaluate the bioefficacy of test insecticides: neem (3 and 5 ml/litre), triazophos (700 g a.i./ha), chlorpyriphos [chlorpyrifos] (400 g a.i./ha), monocrotophos (700 g a.i./ha), abamectin (15 and 20 g a.i./ha), SIL-942 (60 and 100 g a.i./ha) and beta-cyfluthrin (12.5 and 18.75 g a.i./ha) on insect pests of watermelon. Abamectin exerted superior control of aphids (Aphis gossypii; 96.19%), thrips (Thrips tabaci; 81.14%) and also desirable suppression of leaf miner (Liriomyza trifolii; 30.95%). Beta-cyfluthrin was effective against red pumpkin beetle (A. foveicollis; 6.86% damaged leaves per plant). Monocrotophos offered good control of aphids (94.92%) and thrips (63.94%). Triazophos reduced aphid population to an extent of 94.56%. Chlorpyriphos achieved good control of thrips (72.54%). Neem recorded 27.18 and 70.55% reduction of leaf miner and fruitfly (B. cucurbitae), respectively.
Carypomyia vesuviana	Jujube	Gujarat	Bagle	1992	The incidence of Carpomyia vesuviana on Ziziphus mauritiana was studied in Gujarat, and attempts were made to determine suitable control measures. Pest attack started around mid-October and increased suddenly in mid-November (average incidence over 20%), continuing until December. Of several insecticides tested, fenvalerate at 0.005% and decamethrin [deltamethrin] at 0.0015% were the most effective and consistent in reducing infestation, followed by monocrotophos and phosphamidon at 0.05%.
C. vesuviana	Jujube	Punjab	Bal	1992	Spray 500ml of rogor 30EC (Dimethoate) in 300 litres of water during Feb-March. Stop spraying at least 15 days before fruit picking.
C. vesuviana	Jujube	South India	Basha	1952	Four triweekly sprays of 0.05 per cent BHC and 0.1 per cent DDT. (Both BHC and DDT are now banned in India).

B. cucurbitae			Bhagat and Koul	1999	The seasonal biology of melon fruit fly, B. cucurbitae, was studied during pre-monsoon (April-June), monsoon (July-September) and post-monsoon (October-December). Field-collected adults of B. cucurbitae were housed in glass tubes with fresh slices of bottle gourd (Lagenaria siceraria), examined after 24h and their eggs collected. Eggs were placed on fresh bottle gourd slices kept on water-soaked filter papers and observed for hatching. Freshly hatched maggots were transferred on bottle gourd slices in glass tubes. At the onset of pupation, the slices were placed in tubes with water-soaked sand 50 mesh layer to facilitate pupation. Results revealed that incubation, larval and pupal periods were lowest during the pre-monsoon (1.00, 4.96 and 6.94 days, respectively) followed by monsoon and post-monsoon periods. Pre-oviposition and oviposition periods were lower in pre-monsoon (11.06 and 12.12 days, respectively) than in monsoon and post-monsoon periods. Adult emergence was highest in the pre-monsoon (80%), followed by monsoon (74.4%) and post-monsoon (62.7%) periods.
B. cucurbitae	Bottle and sponge gourd, ridge gourd	Rajasthan	Bhatnagar and Yadav	1992	In field studies conducted in Rajasthan, malathion 50 EC (0.5%) was the most effective insecticide at reducing numbers of B. cucurbitae infesting bottle and sponge gourd [Lagenaria siceraria] and ridge gourd [Luffa acutangula], followed by carbaryl 50 WP (0.2%) and quinalphos 25 EC (0.2%).
B. cucurbitae	Cucurbits	Himachal Pradesh	Bhatt and Bhalla	1978	The toxicity of films of spray residues of 7 insecticides to adults of the cucurbit pest B. cucurbitae Coq. at 0, 24, 48, 72 and 168 h after application was determined in laboratory tests. Mortality 24 h after exposure showed that fenthion was consistently more toxic than the other compounds. Initial toxicity showed that, after fenthion, malathion was the most effective, followed by tetrachlorvinphos, trichlorphon and endosulfan. Carbaryl and DDT (banned in India) were almost ineffective.
B. dorsalis	Guava	Ludhiana, Punjab	Bindra and Mann	1971	High volume spray contains 0.2% Acephate, 0.1% Malathion and 0.1 and 0.25 % Fenthion applied at weekly interval. Dipping the fruit into a 0.06% dimethoate emulsion.
B. dorsalis	Guava		Bindra and Mann	1979	Laboratory and field experiments were carried out to test the effectiveness of several insecticides as dips, foliar sprays and soil sprays against the guava pest B. dorsalis Hend. Dipping the fruits into a 0.06% dimethoate emulsion was effective against larvae inside fruit, but spraying guava trees with 2% of the same was ineffective. High-volume weekly sprays of 0.2% acephate, 0.1% malathion and 0.1 and 0.2% fenthion were promising, assessed by percentages of fruits with oviposition holes and numbers of oviposition holes. Spray applications of aldrin and HCH (BHC) to the soil were promising in reducing the emergence of adult B dorsalis.
B. cucurbitae	Pumpkin	Assam	Borah	1993	Carbofuran at 1.5 Kg a.i./ha applied 15 days after germination.
B. cucurbitae	Cucumber	Assam	Borah	1997	Spray of deltamethrin, cypermethrin and fenvalerate gave acceptable level of control.

B. cucurbitae	Pumpkin	Assam	Borah	1998	Various insecticidal schedules were tested against B. cucurbitae on pumpkin. The most effective in terms of lowest pest incidence and highest yield was carbofuran at 1.5kg a.i./Ha applied 15 days after germination.
A. helianthi	Safflower	Madhya Pradesh	Chaudhary et al.	1983	0.03 per cent Quinalphos (best), dimethoate, formothion, demeton-s-methyl (Metasystox) and Phosphamidon. 0.04 per cent monocrotophos & phosalone and 0.075 per cent endosulfan gave good result.
B. cucurbitae	Momordica charantia	Vellayani, Kerala	Das et al.	1968	0.1% Carbaryl and trichlorophos (Dipterex) and 0.05% malathion, four times as cover sprays beginning at flowering times.
Carpomyia vesuviana	Jujube	Haryana	Dashad et al.	1999	In a field experiment in 1993-97 in Haryana with Ziziphus mauritiana, Carpomyia vesuviana was most effectively controlled by applying monocrotophos 0.03%, fenthion 0.05% and carbaryl XLR 0.01% consecutively at an interval of 15 days. This treatment resulted in the lowest fruit infestation level (2.92%) compared to 46.83% in the untreated control. Application of these insecticides resulted in 90.31-95.03% reduction in fruitfly infestation.
B. dorsalis, B. cucurbitae			Doharey	1985	The effectiveness of 5 insecticides applied in baits against B. dorsalis and B. cucurbitae was studied in the laboratory. Fenitrothion was the most effective compound, resulting in 100% mortality of both species 24h after treatment with the lowest concentration (0.03%). All 3 concentrations of decamethrin [deltamethrin] (0.003, 0.004 and 0.005%) gave 100% mortality of B. dorsalis within 48h and of B. cucurbitae within 72h at 0.004 and 0.005% and 96 h at 0.003%. The lowest concentration of carbaryl (0.05%) gave 100% mortality of B. dorsalis within 72h and of D. cucurbitae within 48h.
B. dorsalis, B. cucurbitae	Mango, guava, sapota, pumpkin, squash, bitter gourd		Doharey and Butani	1986	Two tephritids were studied in the laboratory at 27°C. The toxicity of 0.03, 0.04 or 0.05% endosulfan, dimethoate or fenitrothion, 0.05, 0.1 or 0.15% carbaryl and 0.003, 0.004 or 0.005% decamethrin [deltamethrin] against both species was assessed. Fenitrothion was the most effective insecticide against both species, giving 100% mortality within 24 h at each dose. Deltamethrin was more toxic to B. dorsalis than to B. cucurbitae while the reverse was found with carbaryl.
B. spp.	Peach		Gupta and Joshi	1977	In 2-year trials against B. spp. on peach trees, fenthion at 0.075% applied twice in June at 10-day intervals gave good control.
B. cucurbitae	Bitter gourd	Haryana	Gupta and Verma	1978	Soil treatment with 105 aldrin at a rate equivalent to 25 kg dust/ha.

B. cucurbitae	Bitter gourd		Gupta and Verma	1979	Laboratory experiments were carried out to test 13 insecticides against adults of B. cucurbitae Coq., reared from naturally infested bitter gourd (Momordica charantia) and fed on pumpkin, using malathion as the standard. On the basis of the LC50s, determined by the dry film technique, fenitrothion was 106.9 times, tetrachlorvinphos was 101.3 times, phosalone was 31.5 times, chlorpyrifos was 22.1 times, carbaryl was 17.8 times, fenthion was 13.8 times, quinalphos was 9.1 times, parathion-methyl was 8.8 times, trichlorphon was 6.7 times, diazinon was 1.5 times, gamma -BHC (lindane) was 0.7 times and endosulfan was 0.8 times as toxic as malathion, for which the LC50 was 0.01009%.
B. cucurbitae	Momordica charantia	Haryana	Gupta and Verma	1982	0.025% fenitrothion better than malathion.
Carpomyia vesuviana	Jujube	New Delhi	Gyi et al.	2003	Field experiments were conducted during 2000/01 and 2001/02 in New Delhi on 15-year-old ber cv. Gola to study the effects of lambda-cyhalothrin and beta-cyfluthrin residues. The bio-efficacy of lambda-cyhalothrin and beta-cyfluthrin against the fruit fly Carpomyia vesuviana was also studied. The treatments comprised 8 sprays at 15 day intervals of 0.25 mg lambda-cyhalothrin and 18.75 mg beta-cyfluthrin/litre. The residues declined to non-detectable levels (< 0.007 mg/kg) in 14 days. The initial deposits of beta-cyfluthrin varied from 0.56 to 0.76 mg/kg from both the years. beta-Cyfluthrin was not detectable after 7 days of the third spray in the first year and after 10 days in the second year. lambda-Cyhalothrin (12.38 and 11.02% of fruits damaged) was the most effective against C. vesuviana.
Carpomyia vesuviana	Jujube	New Delhi	Gyi et al.	2003	Two field trials were conducted in New Delhi during 2000/01 and 2001/02 to evaluate the efficacy of endosulfan (0.07%), lambda-cyhalothrin (0.0025%), beta-cyfluthrin (0.00187%), cartap hydrochloride (0.05%), nimbecidine [azadirachtin] (5 ml/litre), Neemazal F (1 ml/litre), and alternate sprays of endosulfan and Neemazal against Carpomya vesuviana infesting ber [Ziziphus mauritiana] (cv. Gola). Eight sprays of insecticides were given at 15-day intervals, commencing from the appearance of infestation. Infestation was recorded at harvest. The lowest mean C. vesuviana infestation (13.7%) was recorded with lambda-cyhalothrin treatment in the 2000/01 cropping season, followed by beta-cyfluthrin (15.1%). The highest mean infestation (37.3%) was recorded with nimbecidine treatment. Similar observations were recorded in 2001/02.
B. cucurbitae	Cucumber	Himachal Pradesh	Hameed and Kashyap	1980	0.05 fenthion, parathion-methyl, malathion, trichlorphos and fenitrothion with waiting period of five, seven, two and nine days, respectively.
B. cucurbitae			Hameed et al.	1980	Toxicity and persistence of residues of some organophosphorous insecticides applied for the control of B. cucurbitae Coquillet on the fruits of cucumber. In the laboratory, fenitrothion and parathion-methyl were found to be highly toxic to newly hatched larvae of B. cucurbitae Coq. Malathion and trichlorphon were intermediate, and fenthion was the least toxic of the compounds tested.

B. cucurbitae			Hameed et al.	1980	The safety periods or some of some organphosphorus insecticides applied for the control of B. cucurbitae on the fruits of cucumber following treatment were 2 days for malathion, 12 days for trichlorphon, 7 days for parathion-methyl, 9 days for fenitrothion, and about 5 days for fenthion.
B. zonata	Peach, apple	Palampur, Himachal Pradesh	Hameed et al.	1983	Sprays of malathion were applied at the currently recommended concentration of 0.05% to the point of run-off to apple and peach trees in studies. Laboratory tests showed that the spray residues were more toxic to the crawlers of Quadraspidiotus perniciosus (Comst.) than to newly hatched larvae of B. cucurbitae Coq. The half-life and effective life values of the residues were 2-3 and 5-6 days, respectively, on apple, and 1 and 2 days on peach. The period after treatment needed for the residue levels on fruit to fall below the tolerance limit (8.00 p.p.m. for apple and 6.00 p.p.m. for peach) was 1 day for apple and 1.5 days for peach. The residue levels were within the acceptable limits at harvest. (B. zonata wrongly mentioned as B. cucurbitae?).
B. zonata	Apple, peach	Solan, Himachal Pradesh	Hameed et al.	1985	Residues of fenitrothion in apple and peach fruits were studied by biochemical and chemical assay following application to trees, at 0.05%. The half-life and effective life (period of protection) were higher on apple (5-6 and 23-27 days, respectively) than on peach (3 and 10-11 days). The waiting period before the fruit could be safely consumed was 19-22 days for apple and 14-16 days for peach. The intrinsic toxicity of the deposits was greater to crawlers of the diaspidid Quadraspidiotus perniciosus than to newly hatched tephritid larvae. (B. zonata wrongly mentioned as B. cucurbitae?).
A. helianthi	Safflower	Madhya Pradesh	Jakhmola and Yadav	1983	Monocrotophos applied four times at intervals of 10 days from breeding stage - then two applications, each of phosphamidon, endosulfan, parathion, Vamidothion, Demeton-methyl, malathion or fentrothion.
B. correcta		Tamil Nadu	Jalaluddin et al.	2000	The potential of gibberellic acid for reducing the susceptibility of guava fruit to B. correcta was tested in Tamil Nadu, India. Gibberellic acid was applied before fruit colour break at 0, 10 20 and 50 p.p.m. to the cultivars Lucknow 16, AC 10, Lucknow 49 and Chittidar. Infestation was significantly reduced for all 4 cultivars with the highest concentration. These effects were most pronounced on Chittidar and Lucknow-49. The progression of fruit colour from green to yellow was negatively correlated with acceptability and suitablility of fruit to fly attack and development.
Carypomyia vesuviana	Jujube	Rajasthan	Joshi and Shinde	1972	Carpomyia vesuviana Costa is a serious pest of ber (Ziziphus jujuba) in Rajasthan, damaging up to 90-100% of the fruits. A spray programme involving applications of (1) 0.1% methyl-demeton in November, (2) 0.25% DDT or a mixture of 0.12% DDT and 0.048% methyl-parathion in December, and (3) 0.05% malathion in January was the best of nine programmes evaluated against the Tephritid in the field.
B. dorsalis	Mango		Kalid	1995	In the laboratory, Endosulfan 35% EC, cypermethrin 25% EC, methyl parathion [parathion-methyl] 50% EC and monocrotophos 36% WSC were tested at 0.001, 0.003 and 0.005% against B. dorsalis. On the basis of mortality at 24h after treatment and number of oviposition punctures in mango fruits, cypermethrin and parathion-methyl were the most effective insecticides (at 0.003 and 0.005%), followed by monocrotophos.

B. zonata	Peach	Himachal Pradesh	Kashyap and Hameed	1982	A study was carried out to determine the residues of sprays containing fenitrothion, fenthion, malathion, parathion-methyl and trichlorphon, applied to peach trees at 0.05% against B. cucurbitae Coq., in peach fruits at harvest. The safety intervals between treatment and consumption of fruit were 14-16 days for fenitrothion, 11-13 days for trichlorphon, 10-12 days for fenthion, 9 days for parathion-methyl and 1-2 days for malathion. All the residues had fallen within acceptable limits by the time of harvest. (B. zonata wrongly mentioned as B. cucurbitae).
B. cucurbitae	Peach	Himachal Pradesh	Kashyap and Hameed	1982	Assessment of toxicity and persistence of 5 insecticides applied in sprays at a concentration of 0.05% and dosage of 400 g/ha against newly hatched larvae of B. cucurbitae Coq. Fenitrothion and parathion-methyl were highly toxic, followed by fenthion and malathion, while trichlorphon was the least toxic. Fenitrothion was highly persistent (12 days), followed by parathion-methyl (7 days). All the residues were within acceptable limits at the time of harvest.
B. zonata	Peach	Solan, Himachal Pradesh	Kashyap and Hameed	1986	The toxicities of fenitrothion, fenthion, malathion, methyl parathion [parathion-methyl] and trichlorfon deposits on fruits against the neonate larvae of D. cucurbitae were tested in the laboratory. Fenitrothion was most toxic to the larvae followed by methyl parathion, and both can be recommended for application in the orchard. Trichlorfon was the least toxic compound. (B. zonata wrongly mentioned as B. cucurbitae).
B. cucurbitae			Kaur and Rup	1999	Gibberellic acid (GA) at 0, 25, 125, 625, 3125 ppm was applied to eggs, larval instars and pupae of melon fruit fly B. cucurbitae, which were reared on fresh pumpkin (Cucurbita moschata). GA resulted in significant elongation of the developmental period of the insect. This inhibition in growth was directly related to the increasing GA concentration. GA inhibited pupation percentage and adult emergence. The number of pupae and adults with aberrations also increased with increasing GA concentration. Low GA concentrations (25 and 125 ppm) increased the body weight of emerged flies, but high concentrations reduced body weight and length.
B. cucurbitae			Kaur and Rup	2002	The topical treatment given to freshly emerged (0- to 1-day-old) male and female adults of B. cucurbitae, with 25, 125, 625 and 3125ppm concentrations of gibberellic acid (GA3), IAA, kinetin and coumarin showed a significant adverse influence on the reproductive potential of this fruit fly. The assessment for reproductive potential was made on the basis of reduction in fecundity and fertility of laid eggs and measured as sterility in females and shortening of the longevity, i.e. ovipositional phase. The strongest influence was with kinetin, followed closely by coumarin, then GA3 and lastly with IAA treatments. It was concluded that although these compounds demonstrate their activities differently in plants and might be following a different mode of action in insects, they ultimately influence the reproductive potential of this insect.

B. cucurbitae			Kaur and Rup	2003	The effects of four plant growth regulators (PGRs), namely, coumarin, kinetin, gibberellic acid (GA3) and indole-3-acetic acid (IAA), at 25, 125, 625 or 3125 µg/ml on the development of the melon fruit fly, B. cucurbitae. All four compounds exerted growth- and development-inhibitory effects on the fly. Coumarin was the most potent, followed by kinetin, GA3 and IAA. The first and second instars of the fly were more sensitive than the third instar. Treatment with the PGRs also prolonged the developmental period, reduced the percentage emergence, and increased percentage of abnormal flies emerging. At higher concentrations (125, 625 and 3125 µg/ml), coumarin, kinetin and GA3 caused 100% mortality in the first instar.
B. cucurbitae	Long melon	Rajasthan	Kavadia et al.	1977	The effects of malathion and carbaryl with or without the attractant gur were evaluated. Carbaryl was found to be superior to malathion in reducing infestation. Mixing gur with the insecticides increased infestation.
			Kumar and Singh	1993	Preharvest sprays of GA3 (50 or 75 p.p.m.) or Ethrel [ethephon] (500 p.p.m.) brought forward fruit maturity by 8-11 days and ripening by 10-14 days compared with controls, significantly improved fruit quality (TSS content, sugar, ascorbic acid and beta-carotene concentrations) and reduced spoilage losses during storage, without causing a marked increase in preharvest fruit drop. There was virtually no fruit fly damage with plant growth regulator treatment.
Carypomyia vesuviana	Jujube		Lakra et al.	1991	Laboratory and field studies were carried out in India on the effectiveness of some insecticides against Carpomyia vesuviana on Ziziphus spp. Of 17 insecticides tested as prophylactic sprays, 0.03% oxydemeton-methyl or dimethoate, applied twice, in late October-early November and again 45 days later, kept the incidence of the pest below 8% on Z. mauritiana. During ripening of fruits, sprays of either 0.075% endosulfan followed by 0.1% carbaryl, or 0.1% carbaryl followed by 0.05% malathion + 1% sugar solution, at an interval of 10 days, proved effective against the pest. Soil application of fenitrothion, BHC [HCH] or quinalphos dust, each at 25 kg/ha, under the canopy of trees resulted in a reduction in adult emergence of 80-95%.
B. dorsalis	Guava		Mann	1996	Fogging of guava trees with fenvalerate at 450ml a.i./ ha by using Van fog machine was tested against B. dorsalis. Six insecticidal applications during the active season of the pest reduced the infestation of fruits from 61-68 to 16-22 per cent. It increased the yield of uninfested fruits by 55-58 q/ha. The net gain and the cost:benefit ratio were Rs11,000/ ha and 1:3.4 respectively.
B. dorsalis	Guava	Punjab	Mann	1996	The efficacy of 3 insecticide schedules (5, 3 and 2 sprays) with or without protein hydrolysate bait spray at intervals of 7, 14 and 21 days were evaluated against B. dorsalis infesting guava in the Punjab. Fenvalerate (0.05%) with protein hydrolysate (Protinex 0.15%), and fenthion (0.1%) with or without protein hydrolysate were most effective in controlling fruit fly incidence at all spray intervals. The incidence was lower in 5-spray schedule given at weekly intervals as compared to 3-spray schedule at 14-day and 2-spray schedule at 21-day intervals.

B. cucurbitae	Bitter gourd		Mote	1975	Spraying 3 times at an interval of 15 days starting from fruit setting at the rate of 550l/ha of spray liquid. Tetrachlorvinphos at 0.1%, 0.03% Fenthion, 0.1% Carbaryl.
B. cucurbitae	Snake gourd	Tamil Nadu	Nagappan et al.	1971	In control trials with 8 insecticides for 3 seasons the best results were achieved with 3 applications of fenthion 0.1 % or dimethoate 0.1 % at three-week intervals from the time of flowering.
B. cucurbitae			Nair and Thomas	1999	The effect of extracts of Acorus calamus on the longevity of B. cucurbitae was studied in the laboratory. The longevity of adults fed continuously on sugar treated with 0.15% at 1 ml/g sugar was 26.6 days, compared with 119.2 days for untreated flies.
B. cucurbitae			Nair and Thomas	2000	Toxicity of A. calamus extracts to various stages of B. cucurbitae were evaluated in a laboratory study. The various stages were treated with the extracts and mortalities determined after required intervals of time. The mortality values were subjected to Probit Analysis to work out the LC50 values. The aqueous extracts were not found to be toxic to any stage, up to 10% concentration. The solvent (methanol) extract was found to be 0.03% for eggs and 0.07% for adults. LT50 values were also calculated for a range of concentrations.
B. cucurbitae			Nair and Thomas	2001	Laboratory experiments were conducted to assess oviposition deterrence effect of A. calamus extracts to the melon fly, B. cucurbitae. Laboratory reared flies of uniform age were provided with substrates (2.5 cm3 pumpkin pieces) treated with the extracts for oviposition and observations were taken on the mean number of ovipunctures and mean fecundity. Both aqueous and solvent extracts showed the deterrent effect, the latter being more effective. The mean numbers of ovipunctures, as well as the mean fecundity were inversely proportional to the increase in concentration of the extracts.
C. vesuviana	Jujube	India	Narayana and Batra	1960	Spray ber trees with 0.1 per cent BHC (now banned in India) after middle of October.
B. cucurbitae	Musk melon	Rajasthan	Pareek and Kavadia	1988	Four spray spplications of 0.2% carbaryl (3,5,9 and 11 weeks after sowing) proved the most effective control.
B. zonata	C. vulgaris	Jobner, Rajasthan	Pareek and Kavadia	1990	0.2 per cent carbaryl, 0.07 per cent endosulfan, 0.03 per cent dimethoate and 0.035 per cent phosalone. Waiting periods seven, five, three and three days, respectively. (B. zonata wrongly mentioned as B. cucurbitae).
B. cucurbitae	Bitter gourd	Junagadh, Gujarat	Patel and Vyas	1981	Laboratory studies were made on the effectiveness of insecticides in sprays against this species on bitter gourd (Momordica charantia). The compounds that gave the highest rates of adult mortality after 8 h were 0.07% malathion, 0.1% fenthion and 0.05% endosulfan, dichlorvos, fenitrothion, quinalphos and leptophos (Phosvel), all of which were significantly superior to 2 formulations of 0.1% carbaryl (1 with molasses as Sevimol).

C. vesuviana	Jujube	Gujarat	Patel et al.	1989	Of various insecticides tested against Carpomyia vesuviana on Ziziphus mauritiana in Gujarat, fenthion at 0.1% applied 3 times was the most effective against the pest, followed by endosulfan at 0.07%, also applied 3 times. Fenthion also resulted in the highest yields, followed by endosulfan and 0.04% malathion. The most economical treatments comprised 2 sprays of endosulfan or malathion.
C. vesuviana	Jujube	Gujarat	Patel et al.	1990	The efficacy of the insecticides fenthion, methyl-o-demeton [demeton-o-methyl], monocrotophos, formothion, methyl parathion [parathion-methyl], phosphamidon, dimethoate and thiometon (all 0.03%), malathion 0.07%, quinalphos, phenthoate and phosalone (all 0.05%) and decamethrin [deltamethrin] 0.00125% to control Carpomyia vesuviana infesting fruit orchards in Gujarat was determined. Dimethoate, fenthion, phosphamidon and deltamethrin were the most effective insecticides and infestation levels after treatment were 8.83, 11.86, 14.90 and 14.95%, respectively, and endosulfan was least effective (20.50%).
B. cucurbitae	Musk melon	South India	Pawar et al.	1984	Of 6 insecticides used in trials with the cv. Pusa Sarbati, monocrotophos 40 e.c. gave the best result at 0.05% of B. cucurbitae. However, the highest yields (5240.7 kg/ha) were obtained from plants treated with permethrin 20 e.c. at 0.1%. The yields under other treatments ranged from 3638.8 to 5101.7 kg/ha, with 3018.5 kg/ha in the control.
C. vesuviana	Jujube	Haryana	Popli et al.	1980	0.05 per cent malathion - waiting period two days before harvesting fruits for human consumption; washing for 30 seconds rendered fruit fit even on the day of treatment. Treated leaves can be safely fed to sheep and goats 14 days after application.
Carypomyia vesuviana	Jujube	Tamil Nadu	Ragumoorthi and Arumugam	1992	When 6 insecticides were tested in Tamil Nadu in 1989 and 1990 against Carpomyia vesuviana on ber (Ziziphus mauritiana), 2 applications (at the pea stage of the fruits and 15 days later) of 0.1% dichlorvos gave the best results (in terms of reduced fruit infestation), followed by 0.036% monocrotophos, 0.05% malathion and 0.07% phosalone.
Carypomyia vesuviana	Jujube	Tamil Nadu	Ragumoorthi and Arumugam	1992	Five chemical insecticides and 3 plant extracts were tested against 2 pests on Moringa oleifera grown as a vegetable crop in Tamil Nadu in 1988-89. All treatments against Gitona sp. (in which the pesticides were applied in sprays at 3 litres/tree during 50% fruit set) caused significant reductions in the percentage of fruits infested and the mean number of larvae per fruit, as compared with the untreated control. Treatment against Noorda blitealis took place during the early vegetative stage and flowering, and all treatments caused significant reductions in larval populations up to 21 days after treatment, as compared with the control. The best results against the 2 pests were obtained with 0.04% dichlorvos and fenthion and 1% neem cake extract and neem oil.

B. cucurbitae	Ccumber, ridge gourd	South Andaman	Ranganath et al.	1997	A number of botanical and chemical insecticides were tested against B. cucurbitae on cucumber [Cucumis sativus] and ridge gourd [Luffa acutangula] in South Andaman, India, in June-August 1996. Neem oil at 1.2% was the most effective treatment in reducing damage to cucumber (mean percentage damage 6.2%, as compared with 39.0% in the control), while neem cake at 4.0% and DDVP [dichlorvos] at 0.2% were the most effective against the pest on ridge gourd, reducing damage to 9.1-9.5% as compared with 32.9% in the control.
Carpomyia vesuviana	Jujube	Hyderabad	Rao et al.	1995	In field trials carried out in Hyderabad, Andhra Pradesh, during 1992, monocrotophos (0.05%) was the most effective out of 9 insecticides tested against Carpomyia vesuviana in ber [Ziziphus mauritiana].
B. cucurbitae	Bitter gourd	South India	Ravindranath and Pillai	1986	Bitter gourd (Momordica charantia) cultivar MC23 was sprayed with one of 4 pyrethroid insecticides or malathion at 48, 78 and 102 days after sowing for control of the tephritid B. cucurbitae. Fruit set was not affected by the treatments. Permethrin, fenvalerate, cypermethrin (all at 100 g a.i./ha) and deltamethrin at 15 g a.i./ha were all more effective in reducing damage than the standard malathion at 500 g a.i./ha up to 16 days after the first and second sprays. By the third spray, all 5 insecticides exerted a similar degree of control. There was no significant variation among the treatments in the number of female flowers formed and fruits set; on average over the whole season, 37-53 % of fruits were damaged under pyrethroid treatments, 59% with malathion and 87% in unsprayed plots.
B. cucurbitae	Bitter gourd	Rajandranagar, Andhra Pradesh	Reddy	1997	In a field experiment, 8 insecticides were sprayed on bitter gourd (Momordica charantia) against B. cucurbitae at fortnightly intervals between 30 and 90 days after sowing. Triazophos was the most effective insecticide against the pest.
Zaprionus paravittiger [Z. indianus]			Rup and Bangla	1995	Larvae (68- to 72-h-old) of Zaprionus paravittiger [Z. indianus] were fed on methoprene or precocene II incorporated in diets at 100 and 500 p.p.m. for 24- and 48-h intervals at 25±2°C and 60-70% RH and LD 9:15. The quantitative estimation for protein revealed that feeding of larvae on low concn (100 p.p.m.) of methoprene for 24 h increased the protein content, whereas higher concn (500 p.p.m.) or longer feeding intervals at both concn decreased the protein content. The protein content was reduced with both concn and feeding intervals for precocene II treatment. Methoprene treatment increased the glycogen content at both concn, except for 500 p.p.m. with longer exposure, while precocene II decreased glycogen content. Both growth regulators suppressed the trehalose content.
Zaprionus paravittiger [Z. indiana]			Rup et al.	1996	The second-instar larvae of Zaprionus paravittiger [Z. indiana] were treated with diflubenzuron using 2 concentrations (100, 1000 ppm) at 24 and 48h intervals. Analysis for the hydrolytic enzymes revealed an increase in esterase and alkaline phosphatase activity after 24h of feeding, but a decline in enzyme activity was observed with prolongation of the exposure interval to 48h compared with that in the control. Nevertheless, the acid phosphatase activity was suppressed with diflubenzuron treatment at both time intervals.

Z. paravittiger			Rup et al.	1998	The influence of gibberellic acid (GA3), a plant growth regulator (PGR), on the protein, total lipid, total carbohydrate, glycogen and trehalose contents of Z. paravittiger, was investigated by feeding 63-h-old larvae on artificial diet containing 1000, 2000 and 4000 p.p.m. GA3, for 30 and 50 h. The maximum increase in the protein content was recorded for the 1000 p.p.m. GA3 treatment. Significant decreases in the total lipid and total carbohydrate contents were recorded at 1000 and 2000 p.p.m. while the 4000 p.p.m. treatment significantly increased their levels. Glycogen content was significantly decreased by all the tested GA3 concentrations. The possible reasons for the observed changes in these biochemical components are discussed.
B. tau	Ridge gourd	Jorhat, Assam	Saikia and Dutta	1997	Fenvalerate at 0.02% with 1% molasses was the best of 15 treatments tested against B. tau on ridge gourd (Luffa acutangula). The plant products Multineem [a preparation from Azadirachta indica] and Polygonum hydropiper leaf extract at different doses were less effective than fenvalerate, cypermethrin and malathion. Multineem, however, proved to be superior to P. hydropiper in suppressing attack by the pest. The treatments with molasses were more effective than those without molasses.
B. cucurbitae			Samalo et al.	1995	Soil incorporation of 10% aldrin dust at 0.6 g/kg soil caused 66.6% pupal mortality closely followed by granular carbofuran (60.0%) at the same rate.
B. cucurbitae			Samalo et al.	1995	In laboratory conditions, baiting with dichlorvos, monocrotophos or quinalphos at a concentration of 0.025% killed 100% of adults within 6h, as compared with 6.6% mortality in a 10% sugar solution.
B. cucurbitae	Musk melon		Sarode et al.	1983	In field studies, sprays of fenthion were applied at concentrations of 0.5 and 1.0% (0.5 and 1.0 kg a.i./ha) to a musk-melon crop just prior to harvest for the control of B. cucurbitae Coq. Samples of fruit were taken 0, 3, 5 and 7 days after treatment, and the residue levels in them determined. Initial residue levels following treatment at the 2 concentrations were 0.96 and 1.4 p.p.m., respectively, in the whole fruit and 0.35 and 0.6 p.p.m. in the pulp. The levels (in both whole fruit and pulp) fell below the tolerance limit (0.2 p.p.m.) after 5 and 7 days for the 2 treatments, respectively. Half-life values in the whole fruit and pulp were 1.31 and 1.38 days, respectively, for the lower dosage and 1.61 and 1.85 days for the higher dosage. Sufficient waiting periods following treatment were considered to be about 1-3 days for the pulp and 3.8-4.7 days for the whole fruit. Washing fruits in water resulted in 43.5-74.2 and 38.0-52.0% reductions in the residue levels in the whole fruit and pulp, respectively.
C. vesuviana	Jujube	Madhya Pradesh	Saxena	1969	Three to four sprays at triweekly interval from last week of November - first two with 0.1 per cent lindane before ripening of fruits; third with malathion (0.06 percent emulsion) during ripening of fruits; fourth (if necessary) from last week of November or, in early-ripening variety, from first week of November.

Zaprionus paravittiger [Z. indianus]			Sharma et al.	1995	Newly emerged adults of Zaprionus paravittiger [Z. indianus] were transferred to vials containing test medium with the cytokinin plant growth regulator kinetin at 25, 125, 625 and 3125 ppm. Treatment with 25 or 125 ppm prolonged adult lifespan by 20%, and slowed development of the larvae and pupae of the next generation (also raised on the test medium) by 18%.
B. spp.	Peach		Sharma et al.	1973	Two sprays of Fenthion followed by Fenithothion.
B. cucurbitae	Watermelon	Maharastra	Shivarkar and Dumbre	1985	Spray of 0.03% Endosulfan and Fenitrothion and 0.1% Permethrin were most effective.
B. cucurbitae	Water melon	Maharastra	Shivarkar and Dumbre	1985	0.05 per cent monocrotophos.
B. cucurbitae			Shukla and Srivastava	1980	The activity of acetylcholinesterase preparations from heads of B. cucurbitae Coq. was inhibited by 5 organophosphorus and carbamate insecticides (malathion, chlorfenvinphos, dicrotophos, carbaryl and eserine). All of the compounds except malathion were strong inhibitors of the enzyme.
B. dorsalis	Mango (alphanso)		Shukla et al.	1984	In 2-year trials with the mango cv. Alphonso, 7 insecticides were applied in early April and mid April, and twice more at 15-day intervals. In both years deltamethrin at 0.0025% gave the best control followed by fenthion (0.05%), carbaryl (0.1%) and dimethoate (0.03%).
B. cucurbitae, B. dorsalis			Singh and Singh	1998	Neem (Azadirachta indica) seed kernel extracts, (seed kernel aqueous suspension, ethanolic extract of seed kernel, hexane extract of seed kernel, ethanolic extract of the hexane extract and acetone extract of deoiled seed kernel powder) at 1.25-20%, and pure azadirachtin at 1.25-10ppm were evaluated as oviposition deterrents to B. cucurbitae and B. dorsalis on pumpkin and guava, respectively, in the laboratory at 27°C and 65% RH. Neem seed kernel aqueous suspension at >=5% in choice tests, and at all concentrations (>=1.25%) in no-choice tests significantly deterred oviposition in both species. Similarly, the ethanolic extract was significantly active at all the concentrations tested for both species in choice and no-choice tests. However, with neem oil and its ethanolic extract sensitivities of the two species differed considerably. Both extracts deterred oviposition by B. cucurbitae at all the concentrations tested under both choice and no-choice test conditions. However, with B. dorsalis, neem oil was significantly deterrent only at 20% in both tests, and at 5 and 20% for oil ethanolic extract in choice and no-choice tests, respectively. The acetone extract of deoiled kernel powder significantly deterred oviposition by both species at all concentrations tested. Azadirachtin failed to deter oviposition in either species.
B. cucurbitae			Singh et al.	1974	The effectiveness of sprays containing the parasitic nematode Neoaplectana carpocapsae (DD-136 strain) against some injurious insects was studied. T+F18he only test species in which the nematode did not multiply were the Tephritid B. cucurbitae Coq.

		Sabour, Bihar	Singh et al.	1995	In an experiment at Sabour in Bihar, GA3 and Ethrel [ethephon] were sprayed on the fruits in the first week of June 1990 to enhance the ripening and improve the storage life of Amrapalli mango fruits. GA3 at 75 and 50 ppm improved the quality and shelf life of fruits. Ethrel at 500 ppm was very effective in enhancing the ripening and improving the quality in terms of TSS, total sugar, ascorbic acid and B carotene content. Treated fruits also escaped attack by fruit flies. Ethrel at 750 ppm improved the quality of fruits but enhanced fruit drop.
B. dorsalis	Mango	Uttar Pradesh	Singh et al.	1997	Two high volume sprays of deltamethrin (0.002%) gave an 83.3% reduction in the damageof physiologically mature and 78.80% in dropped fruit.
C. vesuviana	Jujube	Uttar Pradesh	Singh et al.	2000	A field experiment was conducted in Uttar Pradesh in 1997 to evaluate the efficacy of the following control schedules on ber fruit fly (Carpomya vesuviana) infestation and yield of Ziziphus mauritiana: deep raking soil (T1); radial application of phorate as Thimet 10G (118 g/tree) (T2); cypermethrin, endosulfan [application rates not given] (T3); phosphamidon (0.05%), chlorpyrifos (0.04%) (T4); monocrotophos (0.05%), malathion (0.05%) (T5); dimethoate, econeem [application rates not given] (T6); methyl-O-demeton [demeton-O-methyl] (0.03%), sukrina (1.0%) (T7); and an untreated control (T8). All treatments reduced ber fruit fly infestation compared to the untreated trees. The T5 schedule resulted in the lowest percentage of fruit infestation at 15 days after the 1st, 2nd and 3rd sprayings (9.30%, 7.30% and 4.60%, respectively) and the highest mean yield of 10.43 kg/picking (compared to 6.58 kg/picking in T8), followed by T4 with 6.3% fruit infestation at 15 days after the 3rd spray and a mean yield of 10.26 kg/picking.
B. cucurbitae			Sinha and Sharma	1999	The culture filtrate of Rhizoctonia solani, Trichoderma viride and Gliocladium virens adversely affected the oviposition and development of Bactrocera cucurbitae.
B. dorsalis	Mango		Tandon et al.	1974	Four sprays of Carbaryl 0.2% or 0.06% dimethoate. The Ist sprays were applied 30 days apart and the last 2 sprays 2 weeks apart.
B. cucurbitae	Musk melon		Tewari	2001	The effect of different extracts from six plant species (Pongamia pinnata, Catharanthus roseus, Vitex negundo, Ocimum sanctum [O. tenuifolium], Psoralea corylifolia and Azadirachta indica) on the transmission of cucumber mosaic virus (CMV) by B. cucurbitae in Cucumis melo cultivars Arkajeet and Arkarajhans was investigated. All plant extracts significantly reduced the vector population and virus incidence compared with the untreated and water spray controls. V. negundo and Catharanthus roseus completely inhibited the fruit fly population and the incidence of CMV, while A. indica, Psoralea corylifolia, Pongamia pinnata and O. sanctum reduced transmission to 10.3, 15.2, 18.3 and 20.5%, respectively.

B. zonata	Apple, peach	Solan, Himachal Pradesh	Thakur and Kashyap	1986	Fenitrothion, methyl parathion [parathion-methyl] and malathion were applied to run-off at 0.05% concentration to apple (cv. Red Delicious) and peach (cv. Babcock) trees when the fruits were 3-4cm in diameter. Thresholds of toxic effectiveness against crawlers of San Jose scale (Quadraspidiotus perniciosus) on apple and larvae of peach fruit fly (B. zonata, wrongly described as cucurbitae) were then determined. The threshold level was lowest with parathion-methyl, closely followed by fenitrothion, on both fruits, and these compounds gave protection against the target pests for more than 15 days. Residues of all 3 insecticides were below the tolerance limits at the time of harvest. (B. zonata wrongly mentioned as B. cucurbitae).
B. cucurbitae	Bitter gourd	Kerala	Thomas and Jacob	1990	Granular carbofuran applied to the soil at 1.5 kg a.i./ha at the time of sowing, vining and flowering afforded 83.35% protection against the tephritid B. cucurbitae on bittergourd (Momordica charantia), but residues were above the permitted limits. Application at the vining stage and later is not desirable.
A. helianthi	Safflower	Jabalpur, Madhya Pradesh	Vaishampayan	1970	Dichlorovos, about two weeks before flowering of safflower (Carthamus tinctorius).
B. cucurbitae			Verma and Pandey	1980	A laboratory study was carried out to determine the relative toxicities of 9 insecticides to the pumpkin pest B. cucurbitae Coq., on the basis of their LC50s and with malathion as unity, using the dry film technique. The results showed that tetrachlorvinphos was 100.9 times, phosphamidon was 31.6 times, dichlorvos (dichlorophos) was 22.21 times, carbaryl was 17.02 times, quinalphos was 9.18 times, parathion-methyl was 8.08 times, parathion (ethyl parathion) was 6.18 times and diazinon was 1.05 times as toxic as malathion.
C. vesuviana	Jujube	India	Wadhi and Batra	1964	Triweekly sprays with 0.2 per cent DDT or BHC (now banned).
B. cucurbitae			Wadhwani and Khan	1983	In the laboratory adults were fed on baits containing sodium arsenite, sodium arsenate or malathion: these gave significant increase in the preoviposition period and a reduction in fecundity.
B. cucurbitae	Bitter gourd		Yadav and Kathpal	1983	To control B. cucurbitae on the Momordica charantia cv. Pusa-do-Mosami, fenitrothion at 0.05% was applied at 10-day intervals starting at 70 days after seed emergence. Fenitrothion residues decreased to below the permissible level (0.3 p.p.m.) within 3 days of treatment and below the detectable level within 7-10 days.
C. vesuviana	Jujube	Haryana	Yadav et al.	1986	0.03 per cent dimethoate (2.4g a.i./tree) and oxydimetonmethyl (2.8g a.i./tree) - first spray in the first week of November and the second in mid-December. In five to seven days reached undetectable levels. Washing of fruit recommended to further reduce residue level by about 22 per cent of oxy-dimetonmethyl on days of treatment and 10 per cent on the third day of treatment.

Section 15: Chemical Sterilization

Fly	Location	Authors	Year	Summary
B. cucurbitae		Adhami	1980	The effects of the chemosterilants apholate, thiotepa and hemel on the sexual vigour and mating competitiveness of males were determined by caging groups of 25 sixteen days old virgin females with sterilised and normal males in various ratios. It was found that males that had been treated with apholate and thiotepa were sexually more competitive than normal males, whereas those treated with hemel were less competitive.
B. cucurbitae		Ansari and Wadhwani	1972	The mating competitiveness of males of B. cucurbitae Coq. sterilised with 1% hempa in sugar was studied by allowing treated and untreated males to pair with virgin females of the same age. There was no indication that mating vigour and sexual competitiveness were reduced by the treatment with hempa. In a test in which the ratio of normal to treated males was 2:1, the average net sterility was 38.4%, as compared with an expected 33.3%.
B. cucurbitae		Bodhade et al.	1985	Studies were carried out to determine the sterilant activity of petroleum ether and alcohol extracts of ripe pea seeds and the powdered berries of Melia azedarach against B. cucurbitae. The extracts were added to the larval diet at doses of 10, 20, 30, 40 or 50 mg/1.5 g glucose.There was a linear relationship between the dose of the extracts (up to 40 mg) and the reduction in egg viability. Higher doses of alcohol extracts of both plants reduced egg hatch; that of pea did not affect fecundity.
B. cucurbitae		Kaur and Rup	2002	The topical treatment given to freshly emerged (0- to 1-day-old) male and female adults of B. cucurbitae, a serious pest of cucurbit crops in tropical countries, with 25, 125, 625 and 3125ppm concentrations of gibberellic acid (GA3), IAA, kinetin and coumarin showed a significant adverse influence on the reproductive potential of this fruit fly. The assessment for reproductive potential was made on the basis of reduction in fecundity and fertility of laid eggs and measured as sterility in females and shortening of the longevity, i.e. ovipositional phase. The strongest influence was with kinetin, followed closely by coumarin, then GA3 and lastly with IAA treatments. It was concluded that although these compounds demonstrate their activities differently in plants and might be following a different mode of action in insects, they ultimately influence the reproductive potential of this insect.
B. cucurbitae		Khan	1976	The effects of three chemosterilants on B. cucurbitae Coq. are described from reciprocal crossing experiments in the laboratory with treated and untreated adults. Hempa reduced the fecundity of females, and at a concentration of 0.5% no eggs were laid.
B. cucurbitae		Khan	1976	The oviposition period of females treated with tepa, metepa and hempa (especially hempa) was reduced. The degree of sterility was increased when both sexes were treated with chemosterilant.

B. cucurbitae		Khan and Khan	1977	The effectivenesss of tepa, metepa and hempa, applied in different ways, as chemosterilants was evaluated in laboratory tests . Tepa was the most effective material, followed by metepa and hempa in that order. Net sterility was 100% when 0.125% tepa or 0.25% metepa was fed to adults on sugar.
B. cucurbitae		Nair and Thomas	2001	Laboratory studies on the chemosterilant effect of A. calamus extracts on B. cucurbitae were conducted. Results revealed remarkable changes in the size and morphology of the reproductive organs of adult flies. The extracts were administered to the flies through food at dosages of 0.1-0.01% from the day of emergence. No signs of mating or courtship were observed in the treated flies even up to the 25th day after emergence, after which the flies died. After the normal pre-oviposition period, the treated flies were dissected. Considerable reduction in size of the reproductive organs was noticed in the treated flies compared to the normal ones. Due to a combined effect of mating inhibition, reproductive suppression and low survival, fecundity realization was not possible.
B. cucurbitae		Sankaranarayanan and Jayaraj	1975	When five antibiotics (oxytetracycline (Terramycin), sulphanilamide, penicillin, streptomycin and or ampicillin) were applied to adults by three methods, oral administration had more effect on fecundity, duration of adult life, and size and weight than topical application or the exposure of the fruit flies to the compounds in films.
B. dorsalis		Thakur and Kumar	1984	Topical applications of diflubenzuron or penfluron at a dose of 5µg/fly to newly emerged adults of B dorsalis resulted in complete sterility of both sexes.
B. dorsalis		Thakur and Kumar	1984	In mixed populations of untreated flies and adults that had been sterilised by the topical application of 1 µl 0.5% thiotepa, treated flies of either sex were found to be sexually more vigorous than untreated ones. However, when the mating competitiveness of either sex was determined separately by using various methods, treated males were found not to differ significantly in sexual competitiveness from untreated flies.
B. dorsalis		Thakur and Kumar	1984	3-Indoleacetic acid [IAA], applied topically to adults of B. dorsalis 1-24 h old induced significant sterility in both sexes. No effects were observed when flies 13-16 days old were treated. Treatment of immature females at a concentration of 5% caused a significant increase in fecundity. The corrected percentage sterility was dose-dependent and increased from 5.03 to 48.82 with increase of concentration from 0.2 to 5%.
B. dorsalis		Thakur and Kumar	1986	Thiotepa was found to be an effective sterilant for both sexes when applied topically to newly emerged (0-24-h-old) flies at a dose of 1 µl/fly. No eggs were deposited when treated females were mated with untreated males, while when untreated females were mated with treated males, the fecundity of the females was significantly reduced.

B. dorsalis		Thakur and Kumar	1987	Adults were treated with 5, 3, 2, 0.5 or 0.1% thiotepa. Treatment reduced the insemination capacity of males, based on the presence of sperm in the spermathecae of females, by 50%. There was no effect on the male accessory gland fluid. It is suggested that thiotepa has no adverse effect on normal mating behaviour in this species
B. dorsalis	Himachal Pradesh	Thakur and Kumar	1988	The sterilant effects of ethyl methanesulfonate (EMS) on B. dorsalis were studied in the laboratory, using insects collected from the field in Himachal Pradesh. Aqueous and acetone solutions both induced significant sterility in both sexes, but the aqueous solution was most effective.
B. dorsalis		Thakur and Kumar	1988	Newly emerged females topically treated with thiotepa at 0.5 and 1.0% had smaller ovaries than untreated flies. The reduction in size, however, was not dose dependent. Histological examinations showed that thiotepa caused contraction, vacuolization and degeneration of the ooplasm leading the arrest of yolk formation and subsequent immaturation of the oocytes.
B. dorsalis		Thakur and Kumar	1988	The chemosterilant thiotepa caused significant reduction in testis size when applied topically to newly emerged adult males of the tephritid B. dorsalis [B. dorsalis] at s a dose of 1 mul per fly and a concn. of 0.1 or 0.5%. The reduction in testis size was not dose-dependent, and was increasingly apparent as days after treatment increased.
B. cucurbitae		Wadhwani and Khan	1983	Studies were carried out to determine the effects of sublethal doses of toxic baits on the reproductive potential of B. cucurbitae Coq. There was a significant increase in the preoviposition period and a reduction in fecundity when adults were fed on baits containing sodium arsenite, sodium arsenate or malathion. With baits containing dieldrin or carbaryl (Sevin), pesticidal stress was apparent in 3rd-generation adults.

Section 16: Pheromone and Colour Lures

Fly	Host	Location	Authors	Date	Summary
B. zonata	Mango	Pusa, Bihar	Agarwal and Kumar	1999	Eight poisonous bait and attractant combinations were used in steiner types traps for the annililation of adult peach fruit flies. Of these the treatment comprising methyl eugenol (2ml) mango pulp (20g) and malathion 50EC (1ml) resulted in maximum trapping of flies.
B. zonata		North Bihar	Agarwal et al.	1995	Three different combinations of the attractant methyl eugenol, bait (protein hydrolysate) and malathion 50 EC were used in trapping males. Methyl eugenol mixed with bait and malathion was significantly superior for trapping males as compared with other combinations, i.e. methyl eugenol & malathion and bait & malathion.
B. dorsalis	Plum, mandarin orange	Tamil Nadu	Balasubramanium et al.	1972	Use of traps baited with 1% methyl eugenol and containing 0.5% malathion reduced D. dorsalis infestation in a plum orchard from 23 to 3% in 36 months. In a mandarin orange orchard infestation was reduced from 14.3 to 0.5% in 15 months.
B. cucurbitae	Bitter gourd	Vellayani (Andhra Pradesh)	Dale and Jiji	1997	Studies on pheromone trapping for the management of melon fly showed negative correlation between melon flies trapped and the percentages of damaged bitter gourd fruits.
B. spp.	Ridge gourd	Maharastra	Desmukh and Patil	1996	The fruit fly trap (Trap-F) with methyl eugenol @ 3 ml/trap and baited with 0.05% cent dichlorvos (DDVP) was found the most effective and economical treatment against fruit flies (B. spp.) with the lowest percentage of fruit infestation, maximum yield and net returns/ha and greatest cost benefit ratio (1:47.8).
B. dorsalis	Mango	Tamil Nadu	Lakshmanan et al.	1973	Methyl eugenol used at 1% with 0.1% carbaryl and the traps replenished monthly gave effective control in a mango orchard.
B. dorsalis	Guava	Jammu and Kashmir	Makhmoor and Singh	1998	Concentration of 1% methyl eugenol was the most effective with dichlorvos.
B. zonata, B. dorsalis, B. correcta	Sapota	Gujarat	Patel and Patel	1998	A trap consisting of a plastic jar, a plastic funnel and a cotton swab impregnated with 5 drops of methyl eugenol as attractant in a glass Petri dish caught a total of 49.36 male fruit flies in a sapota [Manilkara zapota, sapodilla] orchard in Gujarat. They belonged to the species B. zonata, B. dorsata and B. correcta.
B. ciliatus	Sapota	Southern Gujrat	Patel and Patel	1995	Efficacy of a modified trap (Methyl eugenol alone) with the conventional bait trap (Methyl eugenol + DDNP) for trapping fruit flies was evaluated. The modified trap proved to be equally effective in trapping the fruit flies without extra cost; also the trap involves no use of insecticide so it is ecofriendly too.
B. ciliatus, B. zonata, B. dorasta	Little gourd	Gujarat	Patel and Patel	1998	Study on efficacy of methyl eugenol trap against fruit flies were carried out and found that methyl eugenol was not effective to attract Dacus ciliatus. On the other hand large number of adults of B. zonata and dorsalis were attracted tomethyl eugenol.

B. dorsalis			Patel et al.	1996	Two experiments were conducted to identify the optimum dose of methyl eugenol required per trap to attract B. dorsalis.
B. cucurbitae	Bitter gourd	Maharastra	Pawar et al.	1991	Monitoring by using traps baited with the sex attractant tephrit lure. Result showed that cue-lure was a more effective attractant than tephrit lure.
		Kerala	Reghunath and Indira*	2000	Holy basil (Ocium sanctum, a known methyl eugenol source) is used in Kerala (20g of crushed leaves with 0.5g each of citric acid and of cabofuran 3G in 100ml of water) at four traps/ha as bait.
B. dorsalis, B. correcta, B. zonata	Mango	Tirupati, Andhra Pradesh	Sarada et al.	2001	An experiment was conducted in a mango orchard to evaluate the different coloured plastic open pan traps viz., yellow, white, blue, orange, red and green as attractants for fruit flies such as B. dorsalis, B. correcta and B. zonata in three replications at Tirupati, Andhra Pradesh, during 2000. During the same year another two experiments were conducted with these open pan traps by placing them at different heights (0, 1.0, 1.5 and 2.0 metres) above the ground and at different locations in the orchard. An open pan of 60 cm diameter with 7.5 cm depth, along with 0.1% methyl eugenol attractant was used for the purpose. Significantly more flies were attracted to white (16.953 flies/trap) and yellow (15.317 flies/trap) coloured traps followed by green, orange, red and blue, respectively. Lowest number of flies were attracted to blue colour. Traps placed on the ground caught significantly most flies (12.433 flies/trap), followed by 1.0m, 2.0m and 1.5m, respectively. Traps in the periphery of the orchard attracted more flies (945 flies) than traps in the centre (561 flies).
B. correcta	Mango	Southern Gujrat	Shah and patel	1976	Tulsi plant (Ocimum sanctum) used as male attractant. Chemical analysis showed that 40% of the essential oil content of this plant consisted of methyl eugenol.
B. correcta	Mango	Sourthern Gujarat	Shah and Patel	1976	During studies in southern Gujarat in India on the extent and timing of attacks by B. correcta (Bez.) on mango, this fruit-fly was found for the first time on an aromatic plant, Ocimum sanctum (tulsi plant), but only males were attracted to it.
B. cucurbitae, B dorsalis	Mango, guava	Karnataka	Shukla and Prasad	1985	Benzyl acetate is used to attract B. cucurbitae and B. dorsalis.
B. dorsalis, B. cucurbitae			Singh and Seghal	2001	Five fractions from distilled A. calamus oil, obtained after column chromatography, were analysed. Fractions that were attractive to B. cucurbitae and B. dorsalis, i.e. FI, FII and FV, were further purified and tested on flies, B. dorsalis and B. cucurbitae, under laboratory conditions. All fractions were attractive to both flies. FI (beta-asarone) was highly attractive to the males of B. dorsalis. FII (acoragermacrone) was attractive to female B. cucurbitae, but was only slightly attractive to male flies of the same species. FV (unidentified) was attractive only to female B. dorsalis. No fraction showed equal attractiveness to both sexes of either species or to the same sex of both species.

B. dorsalis	Mango	Pantnagar Uttar Pradesh	Singh et al.	1997	Methyl eugenol (0.2%) was used to bait 4 traps/acre for 18 weeks (2nd April to 30th July) and resulted in a reduction in damage of 71.11% in physiologically mature fruits (var. Dashehari) and 71.15% in damage of fully ripe dropped fruits.
B. dorsalis	Guava	Kapaa Hawaii	Stark and Vargas	1992	The response of male oriental fruit fly to colored plastic bucket traps baited with methyl eugenol was determined. White and yellow traps caught the largest numbers of flies. The results suggest that the attractiveness of traps is due primarily to intensity of refelected light.
B. dorsalis	Mango	Bangalore	Verghese	1998	Methyl eugenol, which is categorized as a bait for male tephritids, was also found to attract a small number of females of B. dorsalis during the active breeding time in a mango orchard at Bangalore, Karnataka, India, in May-June 1998. At the time of harvest, numbers of males and females trapped were in almost equal proportions. The potential of these findings for avoiding post-harvest mango losses due to B. dorsalis is noted.
B. spp.		Bangalore	Verghese et al.	2001	A trap for B. spp. was developed using soaked wooden blocks with methyl eugenol. In an evaluation in Bangalore, Karnataka, these traps attracted B. dorsalis, B. zonata, B. correcta and B. affinis for a period of one month. The collected flies were dry, which facilitated easy taxonomic identification.

Section 17: Baits

Fly	Host	Location	Authors	Year	Summary
B. cucurbitae	Bitter gourd	Bihar	Lall and Singh	1969	In tests of bait-traps, in which various combinations of fermented palm juice, sugar, dried mango juice and oil of citronella were mixed with 10% diazinon, the catches of flies were highest with mixtures of either citronella oil, dried mango juice, palm juice and diazinon or sugar, palm juice and diazinon.
B. zonata	Mango	Pusa, Bihar	Agarwal and Kumar	1999	Eight poisonous bait and attractant combinations were used in steiner types traps for the annililation of adult peach fruit flies. Of these the treatment comprising methyl eugenol (2ml) mango pulp (20g) and malathion 50EC (1ml) resulted in maximum trapping of flies.
B. zonata		North Bihar	Agarwal et al.	1995	Three different combinations of the attractant methyl eugenol, bait (protein hydrolysate) and malathion 50 EC were used in trapping males. Methyl eugenol mixed with bait and malathion was significantly superior for trapping males as compared with other combinations, i.e. methyl eugenol & malathion and bait & malathion.
B. dorsalis, B. cucurbitae			Doharey	1983	Fenithothion applied in bait was the most effective compound, resulting in 100% mortality of both species 24h after treatment with the lower concentration (0.03%).
B. cucurbitae	Bitter gourd	Haryana	Gupta and Verma	1982	Spray of Fenitrothion in combination with protein hydrolysate or molasses gave the most effective control.
B. cucurbitae	Long melon	Rajasthan	Kavadia *et al*.	1977	The effects of malathion and carbaryl with or without the attractant gur were evaluated. Carbaryl was found to be superior to malathion in reducing infestation. Mixing gur with the insecticides increased infestation.
B. dorsalis		Pusa, Bihar	Kumar and Agarwal	1998	Out of different bait combinations the maximum number of male flies was trapped by 20ml ripe mango pulp + Methyl eugenol (2ml) + Malathion 50EC (1ml) followed by 20 ml fermented palm juice + methyl eugenal (2ml) + Malathion 50EC (1ml).
B. cucurbitae			Kumar *et al.*	1976	A mixture of jackfruit pulp, citronella oil and malathion was the most effective bait.
B. dorsalis	Guava	Punjab	Mann	1996	The efficacy of 3 insecticide schedules (5, 3 and 2 sprays) with or without protein hydrolysate bait spray at intervals of 7, 14 and 21 days was evaluated against B. dorsalis infesting guava in the Punjab, India. Fenvalerate (0.05%) with protein hydrolysate (Protinex 0.15%), and fenthion (0.1%) with or without protein hydrolysate were most effective in controlling fruit fly incidence at all spray intervals. The incidence was lower in the 5-spray schedule given at weekly intervals as compared to 3-spray schedule at 14-day and 2-spray schedule at 21-day intervals.

B. cucurbitae	Snake gourd	Bangladesh	Nasiruddin and Karim	1992	A bait trap (0.5g Dipterex 80SP per 100g sweet gourd flesh), an insecticide spray (0.1% Dipterex 80SP + 100g molasses per litre of water) offered stastically similar levels of control of the fruit fly attacking snake gourd and kept the pest infestation within 4.9-8.6% as compared to 22.5% in the untreated control in farmers field. The catches of fruit fly in bait traps were of 1.6 times more females than males.
B. cucurbitae	Gourd	Thrivandrum	Pillai et al.	1991	Palayankodan banana fruit impregnated with carbofuran at the cut surface was found very effective in trapping and can be used as a good tool for management systems at a lesser cost.
B. tau	Ridge gourd	Jorhat, Assam	Saikia and Dutta	1997	Fenvalerate at 0.02% with 1% molasses was the best of 15 treatments tested against B. tau on ridge gourd (Luffa acutangula). The plant products Multineem [a preparation from Azadirachta indica] and Polygonum hydropiper leaf extract at different doses were less effective than fenvalerate, cypermethrin and malathion. Multineem, however, proved to be superior to P. hydropiper in suppressing attack by the pest. The treatments with molasses were more effective than those without molasses.
			Sasidharan *et al*.*	1991	In bait plantain fruit was found superior to jaggery, honey and molases.
B. cucurbitae			Satpathy and Rai	2002	Efficiency of indigenous food baits for attracting the adults of B. cucurbitae infesting bitter gourd, Momordica charantia, was assessed under field conditions. The bait containing pulp of overripe banana (1kg) + Furadan [carbofuran] (10g) + citric acid (1g) was best in luring the fruit fly adults during peak activity period of the pest. However, addition of sweet basil [Ocimum basilicum] leaf extract reduced the attractiveness of the bait. The bait remained effective up to 10 days after installation in the field.
B. dorsalis	Mango	Pantnagar, Uttar Pradesh	Singh *et al.*	1997	In trials of bait traps, mango juice (5%) was the most effective bait in reducing damage to fruits (36.6% in physiologically mature and 17% in dropped fruits).
B. tau			Sunandita and Gupta	2001	The attractant-bait mixture containing boric acid-borax (3:1) as toxicant, protein hydrolysate (4%) as attractant in water, when fed to five-day-old adults of fruit fly, B. tau, kept in rearing cages in the laboratory, caused 40-98.3 per cent mortality after 24h of exposure with different concentrations (1-12%) of the toxicant. The LC50 value was calculated to be 1.95. The bait mixture remained effective up to a week and when sprayed on tomato plants caused phytotoxicity, above 2 per cent concentration of the toxicant, within 24h.
B. cucurbitae	Bitter gourd		Verma and Sinha	1977	50 g/l sugar was added to the insecticide sprays used for controlling fruit fly. Endosulfan and carbaryl were the most effective insecticides.

Section 18: References

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Anon.			2002	Evaluation of guava accessions for resistance to the fruit fly, Bactrocera dorsalis (Hendel) in relation to certain fruit morphological characters	Pest Man. Hort. Ecosyst.	8(1)	27-32
Anon.			2002	Factors influencing infestation of fruit-fly (Carpomyia vesuviana) in ndian jujube (Zizyphus mauritiana)	Indian J. Agri. Sci.	72(9)	543-547
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