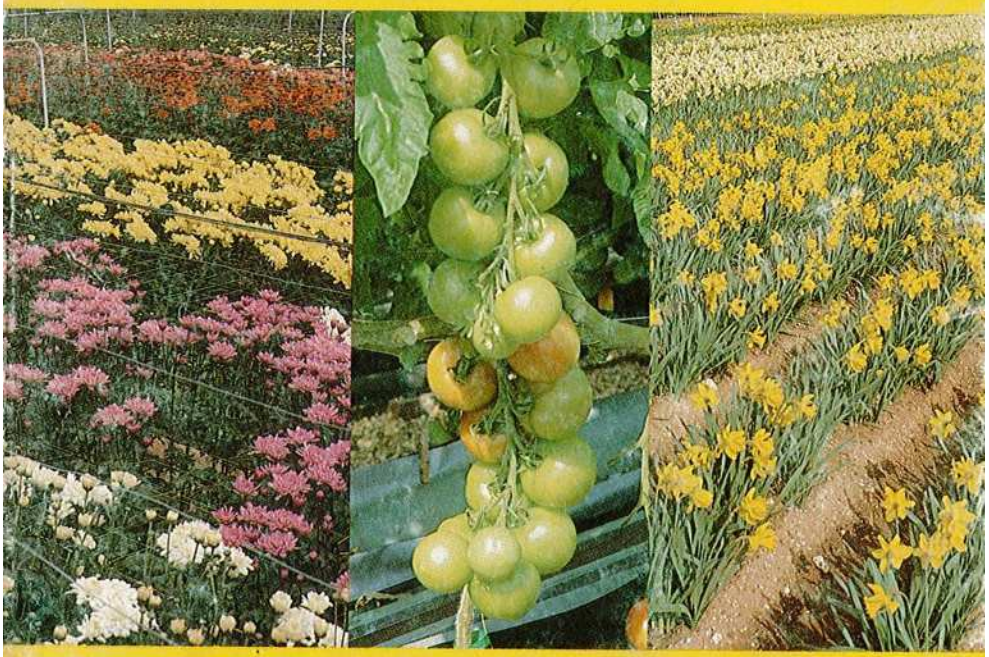
PEST AND DISEASE CONTROL OF PROTECTED CROPS OUTDOOR BULBS AND CORMS



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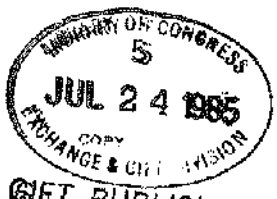
Exclusive Distributor
ISBS, Inc.
P.O. Box 1632
Beaverton, OR 97075

ISBN 0 901436 82 8



Printed in Great Britain by
The Lavenham Press Limited
Lavenham, Suffolk

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Introduction

As the economic pressures on both agriculture and horticulture steadily increase with land at a premium, intense production of high quality crops becomes annually more important. As a result crop production must react rapidly to these changes if it is to remain viable. New varieties, specialised monoculture and fertilisers are essential to maximise yield, while pests and diseases are becoming a serious limiting factor.

Many pests and diseases have the genetic ability to overcome any resistance harnessed by the plant breeder, while pesticides become less effective as they induce resistance in the organisms themselves. There is, unfortunately, no going back to the "good old days"—predictable control with chemicals is possible only with a limited range of materials, while the effective lifespan of new products, costing millions of pounds to develop is, at most, only a few years.

This state of affairs cannot continue *ad infinitum*. Research into integrated pest and disease control is an essential development for the future to ensure that the present armoury of pesticides is used to best effect if we are to continue to produce sufficient quality products.

New spraying technologies such as ULV and electrostatic spraying are continuously under development and must be evaluated for efficacy, and, perhaps more important, for their effects on the ecosystem, a both time-consuming and costly process.

It is against this background that the Pest and Disease Control Handbook is published. The British Crop Protection Council is attempting to meet the challenge of the next 20 years; the need for accurate up-to-date information is paramount.

Two chapters (Pest and Diseases of Protected Crops and Pests and Diseases of Outdoor Bulbs and Corms) have been bound together from the 1983 edition of the Pest and Disease Control Handbook.

It is designed to make the wealth of information about pest and disease control easily available to growers, advisors and students, indeed everybody concerned with crop production.

The simple format has been designed for easy reading and where possible Tables are used to guide pesticide usage. Further information may be obtained from the 'key' references to many important pests and diseases included at the end of the Chapter.

The production of separate crop-orientated booklets will facilitate future revisions so that control practices can be updated when necessary.

David Price
Glasshouse Crops Research Institute

Notes for readers

Dose rates

Unless stated, pesticide rates refer to active ingredient.

To convert active ingredient to amount of product:—

Multiply rate of use (active ingredient) by multiplication factor for the % active ingredient in the product, e.g. suppose rate is [*6 g/ha*] and product to be used contains 15% active ingredient use 6 × 6·67 g = 40·02 g product/ha.

% active ingredient	*multiplication factor*
5	20·00
10	10·00
15	6·67
20	5·00
25	4·00
30	3·33
35	2·86
40	2·50
45	2·20
50	2·00
55	1·82
60	1·67
70	1·43
80	1·25
90	1·11

Publications

The Ministry of Agriculture, Fisheries and Food (MAFF) produce a wide range of booklets many of which are mentioned in the text. These include:—

Booklet (B)
Horticultural Enterprise (HE)
Leaflet (L)
Reference Book (RB)
Short Term Leaflet (STL)
Technical Bulletin (T.Bull.)

They may be obtained from the MAFF Publications Department, Lion House, Willowburn Trading Estate, Alnwick, Northumberland NE66 2PF.

Changes in the reference numbering of MAFF publications may be confusing to people with older issues so the changes are detailed below.

Booklets are numbered 2001-4000 and include former Horticultural Enterprise booklets. "Car number plate" reference numbers are rapidly disappearing.

Where appropriate, some former Short Term Leaflets are now being absorbed into the Booklet series.

Leaflets are numbered 1-2000 and adopt the number of the Advisory Leaflet they replace. Thus AL 580 becomes L 580. Where appropriate, some former Short Term Leaflets are now being absorbed into the Leaflet series.

Reference Books comprise former Bulletins and Technical Bulletins. These are HMSO publications. The series also includes selected Ministry publications. Old numbers are retained where possible: Bulletin 161 becomes RB 161. In the case of Technical Bulletins a prefix of 4 has been added to distinguish from former Bulletin numbering, so that Technical Bulletin 27 is now known as RB 427.

Abbreviations

The following abbreviations have been used:

ACAS	MAFF Agricultural Chemicals Approval Scheme
ADAS	MAFF Agricultural Development and Advisory Service
Arb. L	Forestry Commission Arboricultural Leaflet
BSC	British Sugar Corporation
BTG	British Technology Group
c.	*circa* (approximately)
CDA	controlled droplet application
cm	centimetre(s)
col	colloidal
cv	cultivar(s)
DAFS	Department of Agriculture and Fisheries for Scotland
e.c.	emulsifiable concentrate
EEC	European Economic Community
FC Bull.	Forestry Commission Bulletin
FCL	Forestry Commission Leaflet
FC Record	Forestry Commission Forest Record
FCR & D	Forestry Commission Research and Development Paper
f.sp.	*forma specialis* (distinct race within sp.)
g	gram(s)
GS	growth stage
ha	hectare(s)
HE	MAFF Horticultural Enterprise*
hr	hour(s)
kg	kilogram(s)
km	kilometre(s)
l	litre(s)
L	MAFF Leaflet*
m	metre(s)

m^2	square metre
m^3	cubic metre
MAFF	Ministry of Agriculture, Fisheries and Food
MC	moisture content
mg	milligrams(s)
ml	millilitre(s)
mm	millimetre(s)
NFT	nutrient film technique
NIAB	National Institute for Agricultural Botany
NRDC	National Research and Development Corporation (now BTG)
p.	page
Pa	Pascal
PMB	Potato Marketing Board
pp.	pages
PSPS	Pesticides Safety Precautions Scheme
pv.	pathovar
rev.	revolutions
r.h.	relative humidity
sp.	species
spp.	species (plural)
STL	MAFF Short Term Leaflet*
T. Bull	MAFF Technical Bulletin
w.g.	water gauge
w.p.	wettable powder
°C	degrees centigrade
μm	micrometre (micron)
<	less than
>	more than

*Single copies of these leaflets are available free of charge.

Chapter 12
Pests and diseases of protected crops

by Dr R. J. Penna, Dr W. M. Morgan and M. S. Ledieu

Introduction

The control of pests and diseases on crops under glass and plastic structures is profoundly influenced by the fact that the crop is enclosed.

Rotation cannot normally be practised in greenhouses and because a high level of expertise is required for commercial success, the same crop or crops are grown from one year to the next. Thus, there is a danger that pests and diseases may be carried over from one crop to the next. This is particularly true of pests and pathogenic fungi which persist in soil and on the structure of the house and therefore soil sterilisation and hygiene measures between crops must be regular and thorough.

The complex control systems of modern greenhouses must be used to maintain an economic and physiologically optimum environment for the crop. Often the conditions which promote growth of the crop also promote the growth of pathogens and pests. Many UK greenhouse crops are either subtropical species, which will not survive or are not efficient outdoors, or they are native plants grown at steady and elevated temperatures for increased productivity or uniformity. However, the greenhouse also provides a protected and favourable environment for pests and pathogenic organisms. They may be more prolific on, and cause more damage to, their hosts under glass than in their natural habitat.

Greenhouses also give shelter from rain and wind which may influence pest and disease control. Many fungal pathogens need moisture, particularly at certain stages of their life cycles, e.g. spore germination, and if this is unavailable they will not multiply. Watering should therefore be managed so that moisture does not persist on plant surfaces, and ventilation and heating used to dispel pockets of humid air within the crop. The stability of the environment in greenhouses allows natural enemies of pests to be used as an effective means of control.

Crops grown within structures which can be more or less sealed may be treated with pesticides using methods of application which take advantage of this. Chemicals may be applied in fogs, smokes and as vapours, often with considerable savings in labour. Although methods of application are dealt with in detail in Chapter 3, fogs and smokes, which are almost exclusively used in the greenhouse, are described in more detail in this chapter.

Because the value of crops grown in greenhouses is usually high, expensive chemicals and methods of application, such as soil drenching, may still be economic in achieving the high standards of pest and disease control necessary. Generally, greater care is necessary in the use of particular pesticides on greenhouse crops, and in the method of their application to avoid unsightly deposits on, or damage to the harvested products, which must be of high quality.

As advanced methods of growing plants are introduced, so the approach to pest and disease control must change. A number of radically new techniques of growing plants have recently been introduced: the nutrient-film system, in which plants grow with their roots directly immersed in a thin film of flowing nutrient (NFT); mineral wool systems where roots grow into a mineral wool block and peat bag culture, where the roots are contained within a polythene sack. When the method of growing is changed, so pest and disease organisms are exposed to a new ecosystem which may in turn require changes to be made in the traditional methods of control. Pests and pathogens can become a nuisance where they were innocuous before. This may be the case with stem rot of tomato which appears to be more prevalent in crops grown in soil-less systems. The use of peat block for the establishment of lettuce seedlings may have contributed to the increase in downy mildew over the last decade because peat blocks require more watering after planting out than do transplanted seedlings. Soil-less systems tend to be more prone to phycomycete attack (*Pythium* spp. and *Phytophthora* spp.), and to be free of typical soil-borne diseases and pests such as Rhizoctonia, brown and corky root rot and nematodes.

Often soil-less methods of growing are introduced to avoid the need to sterilise the soil. This may allow the crop to be exposed to a huge reservoir of pests and disease organisms in the unsterilised soil which may contaminate the nutrient film technique (NFT) gullies, peat bags, cucumber or carnation beds, or pot plants, even where the border soil has been covered with polythene sheets. Losses have been encountered in nutrient film (NFT) grown tomatoes, where roots have become colonised with *Phytophthora* spp. possibly arising from contamination of the solution with soil or water splash from the soil surface.

The traditional methods of controlling pests and diseases, with chemicals and with resistant cultivars, must never be thought of as infallible. In the same way that changes in the ecology of pest and disease organisms can be caused by changes in growing technique, so the introduction of new pesticides and disease resistant cultivars presents new opportunities for change in the pest organisms. Therefore, a multi-faceted approach to greenhouse crop protection, in which chemical, biological, environmental and genetic control of pests and diseases can be integrated, will be more successful and make adaptive changes in the pest or pathogen less likely.

It is important to bear in mind that the approaches to the control of pests and diseases are fundamentally different. Pests can often be seen on crops and, with chemicals, it is possible for a grower to destroy them before much damage is caused. On the other hand, damage is the first sign of disease and the organism

responsible may not be seen until later, if indeed it is visible to the naked eye at all. Thus, the insidious action of pathogens means that prevention is more likely to be successful than cure.

The use of site specific insecticides and acaricides on greenhouse crops has long been associated with the development of resistance in pests to these materials. Over the last 10 years most new fungicides have also been site specific and have superseded the traditional broad spectrum materials. Resistant disease organisms have emerged and in addition the specific materials which often only kill particular species or groups of species have encouraged the emergence of new problems e.g. the extensive use of benomyl on tomatoes in the past decade led to *Stemphyllium* sp. and *Alternaria* sp. being troublesome in some situations. There is much debate on the best way to avoid resistance. The use of mixed sprays or an alternating programme of materials that act on different sites is advocated. At this time there is little evidence to suggest which of these is best. As a general rule where routine pesticide application is necessary and where a site specific material has to be used then a programme of mixed or alternating application must be made. Chemical manufacturers are now taking a more responsible attitude to resistance and some are including advice on labels or in literature. Growers, through experience of resistance, are now more sympathetic to the use of these programmes.

There are many accounts published elsewhere of the life histories and classifications of the organisms responsible for crop loss in the greenhouse. A brief description of the pests and of the symptoms of the important diseases will be given for each of the crops grown widely in protected cultivation.

Control of virus diseases of greenhouse crops

Virus diseases can cause severe losses in many kinds of horticultural crops and cannot be controlled with chemicals. Crops grown under glass or equivalent protective structures, however, suffer from fewer virus diseases than do the same crops grown outdoors. Under glass, the use of sterilised composts in raised beds or containers avoids the danger of soil-borne virus infection, whether transmitted by nematodes, chytrid fungi or (as with tomato mosaic in tomatoes) resulting from gross contamination of the soil from the previous crop. Insect vectors are also more easily controlled under glass than outdoors, and the traffic of viruliferous aphids or other insects from infected crops or weed hosts is greatly diminished.

Many greenhouse crops are vegetatively propagated, and any virus infection in the stock will be perpetuated. Virus-free stocks of the important vegetatively propagated greenhouse crops are now available through the appropriate Nuclear Stocks Associations, and provide the most effective means of avoiding virus disease problems. Virus-free stocks should never be grown in the same greenhouse as ordinary stock which may well be infected. The working life of a virus-free stock will also depend upon a good standard of hygiene being maintained in the nursery.

Soil sterilisation (MAFF Bull. 22). See Tables 12.2 (p. 380 and 381).

Border soils

Soil-borne pathogens and pests can be partially eliminated by 'steaming' well-worked greenhouse border soils: complete eradication by steam is seldom accomplished because heat does not penetrate to a sufficient depth.

Chemical soil sterilants can be used as substitutes for steaming but there are disadvantages. They are more specific in their biocidal action than heat; a long period is required between treatment and planting to ensure the release of phytotoxic vapours from treated soils; there is a risk of phytotoxicity to crops in adjoining greenhouses; soils with a high organic content or heavy soils which cannot be broken down to a fine tilth may be unsuitable for treatment by chemicals due to excessive retention in the former and poor penetration in the latter. Methyl bromide, however, rapidly diffuses into and from treated soil. Although methyl bromide is the best chemical sterilant under most conditions, inconsistent results are more likely than with steam. With all chemical sterilants the conditions of the soil during treatment, soil temperature, the application technique and state of the pathogenic organisms all significantly affect the success of these treatments.

Soils must be moist and be thoroughly worked before treatment. When chemicals are mixed into soil by rotary cultivation, L-shaped tines should be used with a rotor speed of 120-150 rev/minute and a forward speed not exceeding 4-6 m/minute. After treatment, the soil surface should be sealed by compacting and wetting, or should be covered with polythene sheeting where the active ingredient is volatile. Because the speed of sterilisation and release of the chemical is faster at higher soil temperatures, chemical sterilisation should not be used during the winter and only when soil temperatures are high during the late autumn. In unheated houses, release will be hastened by forking or rotary cultivation to a depth of 250-300 mm.

When using the following chemicals it is essential to obey the manufacturer's instructions with respect to the interval between treatment and planting.

Chloropicrin, or chloropicrin with dichloropropane-dichloropropene/methyl isothiocyanate mixture. These must be applied when soil temperatures are above 13°C and by trained operators following the 'Code of practice for the fumigation of soil with chloropicrin' (MAFF). Chloropicrin [*630 kg/ha*] is injected at a depth of 150 mm and at spacings of 300 mm. The soil surface should be sealed immediately with polythene sheet of at least 150 gauge for not less than 4 days. The absence of hazardous contamination should be decided by trained operators. It is important to test for phytotoxic residues with cress seed (see dazomet).

Dazomet. This should only be used on light to medium soils with less than 5% organic matter. Evenly incorporate the prill [*330 kg/ha*] to a depth of 180-200 mm. The surface of the soil should be sealed with an anchored polythene sheet for 14 days, then cultivated and ventilated. Test the soil using the cress germination

Table 12.1 Relative sensitivities to methyl bromide of organisms found in glasshouse soils

Organism and effective gas concentration (CTP) in decreasing order of sensitivity →

Decreasing sensitivity ↓

HIGHER PLANTS (100-400)	INSECTS AND MITES (150-400)	NEMATODES (200-600)	FUNGI (800-5 000)		BACTERIA (500-5 000)
Germinating seeds	Active larvae Active adults	Active larvae Active adults	*Pythium* spp. *Phytophthora* spp.		Active cells
Seedlings			*Sclerotinia* spp. (mycelium) *Rhizoctonia* spp. *Botrytis cinerea*		
Mature plants		Inactive stages	*Didymella* spp. *Pyrenochaeta lycopersici* *Verticillium albo-atrum*		
Small thin-coated seeds			*Phialophora cinerescens* *Phomopsis sclerotioides* *Fusarium* spp.		
Large oily thick-coated seeds	Inactive insect stages	Eggs Dry cysts	*Colletotrichum coccodes* *Verticillium dahliae* *Sclerotinia sclerotiorum*	sclerotia	Resting spores

Source of information: Glasshouse Crops Research Institute, Littlehampton

Table 12.2 Some chemical soil sterilants which can be applied by growers.

Type of formulation	*Active ingredient*	*Minimum interval between treatment and planting*	*Problems controlled or partially controlled*
GRANULES	dazomet	4–8 weeks	Soilborne fungal diseases causing damping-off, root rots, foot rots and vascular wilts.
LIQUID	metham-sodium	10 weeks	Potato cyst, root-knot and free-living migratory nematodes. Soil pests such as millepedes, slugs, symphylids and woodlice.
,,	methyl isothiocyanate with dichloropropene-dichloropropane	6 weeks	Many annual and some perennial weeds
,,	dichloropropene	6 weeks	Potato cyst, root-knot and free-living migratory nematodes
	dichloropropene with dichloropropane		
,,	formaldehyde	7–21 days	Suppression of soilborne fungi
SOLUBLE POWDER	nabam	3–14 days	

Source of information: M.A.F.F./Guernsey Horticultural Advisory Service

method: half fill a jar with a representative 1·00 kg sample of moistened soil, and scatter cress seeds on the surface and seal the jar. If the seed germinates normally the soil is safe for use, but it is advisable to flood the treated soil before cultivating and planting.

Dichloropropane-dichloropropene/methyl isothiocyanate mixture. This should be used between April and October, when the soil temperature is at least 5°C, but not on heavy clay or highly organic soils. Inject [*610 l (product)/ha*] at 300 mm spacings and to a depth of 200 mm. Cover the soil with a polythene sheet for 7 days or compact and lightly wet the soil surface. Allow the vapour to escape by ventilation and rotary cultivation over the next 6 weeks. Test with cress seed before final cultivation.

Dichloropropene. This is applied [*225 l (product)/ha*] under the same conditions as dichloropropane-dichloropropene mixture.

Formaldehyde. Spray the soil surface [*800 g/100 l*] using 30 l/m² and keep the greenhouse closed for 3 days. Allow vapour to disperse before planting or laying polythene sheets for soil-less culture.

Metham-sodium. Water the soil with metham-sodium [*317 g/100 l*] using 15 l/m². In summer, keep the soil surface sealed by spraying with water, cultivate after 7 days and repeat a number of times at 4-day intervals. Test for residues with cress seed 4 weeks after application. In autumn, allow 7-10 weeks for treatment which must be completed by the end of October. After application, close the greenhouse for 14 days, then ventilate and fork to 300 mm. Leave the soil for 2-3 weeks and fork again. Test with cress seed 7 weeks after application and if the seed germinates normally, the first crop (carnation, tomato or lettuce) may be planted.

Methyl bromide[1,2]. This is widely used for the control of pathogenic fungi and nematodes in greenhouse soils when the soil temperature is 10°C or above. It has a high mammalian toxicity and special equipment is required. Therefore it must only be applied by approved operators* and according to the 'Code of practice'. Methyl bromide has the advantage of rapid diffusion into and from soil and consequently, the interval between treatment and planting is short (6-8 days). In addition to the use for border soil sterilisation, methyl bromide is also used to sterilise peat in troughs, growing bags, or loose piles. In the case of bags or piles of loose peat, they are usually placed on a sheet of polythene and a gas tight envelope made by bringing up the sides of the sheet and sealing the two edges together.

Nabam. Spray the soil surface [*100 g/100 l*] using 2700 l/100 m². This material is useful where a material that does not produce phytotoxic fumes and has a short waiting period before planting is necessary, as in greenhouses where several different crops are planted. In winter up to 14 days must elapse from treatment to planting but in summer this can be only 3 days.

Propagating and potting soil

Dazomet. Incorporate the prill [*70 g/m²*] into warm, moist loam to a depth of 250 mm, sheet and leave for 3 weeks. Finally, turn the loam 4 weeks before it is required and test with cress seed before use. The fumes are phytotoxic and will affect nearby plants.

Formaldehyde. This should be applied [*800 g/100 l*] to saturate the soil in 15 cm layers as a heap is built. Cover for 2 days, then turn the heap. Allow 4-6 weeks before use.

Metham-sodium. This is watered on to potting compost [*312 g/100 l*] as a heap is built. Leave for 2 weeks, then aerate by turning frequently to release phytotoxic fumes. Test with cress seed before use.

*An up-to-date list of approved contractors may be obtained from the Ministry of Agriculture, Fisheries and Food, The Harpenden Laboratory, Harpenden, Herts.

Greenhouse hygiene

Strict attention to hygiene is most important in reducing the incidence of pests and diseases in greenhouses. When diseases have occurred, the internal structure of greenhouses and mushroom houses, staging and the soil surface should be treated with formaldehyde before and after the removal of crop debris.

There are 3 methods of application: use high pressure sprays [*800 g/100 l*] or a pulse-jet fogging machine [*400 ml* (product)*/100 m*^{3}] or fumigate by adding potassium permanganate to formaldehyde [*100 g + 200 g*] in a container of at least 10 l capacity, using one such container for every 100 m^3 of greenhouse. The ensuing reaction is violent, so the permanganate should be measured out and placed close to each container. Addition of permanganate to the formaldehyde should begin with those containers furthest from the door. Close the house for at least 24 hr after applying formaldehyde.

Protective clothing should be worn for all methods of application. When fumigating, a respirator must be worn and may be necessary for comfort when spraying. Fogging machines should only be operated from outside the greenhouse.

Boxes, pots etc. may be disinfected with steam, boiling water, formaldehyde or 8-hydroxyquinoline [*42 g/100 l*].

Methods of application

Sprays, dusts, granules and prills

See chapter 3, p. 33.

Fogs and smokes

The most common design of fogging machines produces a stream of hot gas from a petrol-driven pulse-jet engine. Metered by a valve, pesticide is pumped into the jet stream and broken up into airborne particles (5-100 μm diam).

The distribution of the pesticide may be very limited but, nevertheless, satisfactory disease control has been obtained in practice. Most of the deposit arrives at leaf surfaces by sedimenting from the air and, therefore, the deposit on the undersurface will be small. Chemicals with a systemic or vapour action will overcome irregularities in vertical distribution. In trials it has been found that the limit of 'throw' of a fogging machine may be as little as 10-15 m. Thus, it is necessary to carry the machine through the crop and to fog strips of 20 m width. Horizontal distribution is improved when the fog is directed over the top of the crop.

Fogs should only be applied during calm conditions and preferably in the evening.

The Pesticides Safety Precautions Scheme (PSPS) has only given clearance for the application of chemicals which have been specially formulated for use in fogging machines.

The distribution of a chemical applied as a smoke formulation will probably be similar to that of a fog but there is no means of directing the flow of smoke. The dose is regulated by the size of canister which is recommended by the manufacturer for a given volume of greenhouse.

Soil drenches

Soil drenches are generally applied as an occasional substitute for watering with a hosepipe or a calibrated dispenser connected to a tank containing the diluted chemical. Automatic irrigation systems may become blocked if pesticide formulations, such as wettable powders, are added to nutrient solutions. Systemic pesticides applied as soil drenches will generally use more chemical, but will protect the plants for longer than the same compound applied to the foliage. Soil drenches will be more effective if the drench reaches actively growing roots. This is less likely to occur with mature plants growing in border soil. However, plants in pots or peat bags or seedlings in boxes may be very effectively treated by this method.

Nutrient film culture solution additives

Locally-high phytotoxic concentrations of chemicals in the nutrient solution are damaging. Wettable powder formulations are particularly prone to this fault and may, therefore, have to be dissolved in hot water (see manufactuer's instructions) before pouring into the reservoir. The pesticide should be applied gradually during the period required for complete recirculation of the total volume of solution.

Biological and integrated control[3,4,5,6]

In biological control, living organisms are used in place of chemical pesticides. Predators may eat the pest, or parasites living inside the pest may prevent it from reproducing, or microorganisms may cause diseases which kill the pest. These 'natural enemies' generally only attack one type of pest and will certainly not harm the crop.

Insecticides or fungicides used to control other pests and diseases may reduce the efficiency of a natural enemy. This is often overlooked. Therefore, a grower using natural enemies is committed to 'integrated control' in which all aspects of crop husbandry, particularly the use of pesticides, must be harmonised intelligently. For crops in which biological control is practised, guidelines on the effect of pesticides on natural enemies, based on laboratory tests, are given in the relevant tables (see also p. 462).

The predator *Phytoseiulus persimilis* and the parasite *Encarsia formosa* which control red spider mite and whitefly, respectively, are currently used on tomato and cucumber. The methods of using these natural enemies in integrated pro-

grammes are fully explored in the references given above. A parasite of the aphid *Myzus persicae* and a parasite of leaf miners are also available.

Recently a fungal parasite *(Verticillium lecanii)* of whitefly and aphids has been produced commercially and there is a possibility that strains of this fungus may be used to control certain fungal diseases.

Weeds

Weeds around the outside of greenhouses can harbour pests and some diseases. Whitefly and aphids in particular are commonly found on weeds and act as a reservoir for reinfestation after control measures have been carried out on the crop. With biological control the influx of flying pests from outside the greenhouse can upset a low level interaction between pest and predator or parasite in the crop. An area of mown grass or weed-free soil 3 m wide should surround greenhouses, particularly greenhouses where access is often easier than with polythene structures. Paraquat, simazine and glyphosate have been used successfully close to greenhouses, but careful consideration must be given before application of any weedkiller close to the greenhouses, as there are no label recommendations for this use.

Pesticide use on minor crops

Throughout agriculture there is an increasing problem of the availability of pesticides with safety clearance and recommendations for minor crops. The problem is probably most serious in the protected crops section. The reluctance of manufacturers to enter high risk, small markets is understandable and the need to maintain a high standard of safety clearance requirements is obvious. The present situation however encourages the widespread misuse of products. The grower is often placed in a situation where experimental results (or the practical experience of other growers) and economic pressures encourage him to use products without safety clearance or label recommendations for a specific use, where these are significantly more effective than the officially recommended alternatives. Growers have unfortunately earned a reputation for being quick to claim compensation from manufacturers for crop damage associated with the use of pesticides and this has reinforced the manufacturers' reluctance to develop recommendations for relatively uneconomic uses. The establishment of an arrangement where the manufacturer is exonerated from responsibility for crop damage i.e. an effective growers' risk use, for the use of a product on a minor crop would seem at present to be the only way that they may be encouraged to seek safety clearance for the extension of use of an established product onto a minor crop. Growers and manufacturers may take heart from official scrutiny that this serious problem is now receiving.

Table 12.3 Ornamentals—aphid, red spider mite, whitefly, thrips and leaf miner

N.B. Before using compounds listed in this table, consult the product label for information on species/cultivars which should not be treated.

See Integration, p. 462

Compound	Application rate	Active against: Aphid	Red spider mite	Whitefly	Thrips	Leaf miner	Effect (where known) on: Phytoseiulus Eggs	Phytoseiulus Adults	Encarsia Pupae	Encarsia Adults
1. HV sprays	*g/100 l*									
carbaryl	77	—	—	Yes	Yes	—	—	H>12	H	H>11
cyhexatin	12·5‖	—	Yes	—	—	—	H	H	S	S
deltamethrin	1·75	Yes	—	Yes∅	Yes	—	H	H	H	H
demeton-S-methyl†	22	Yes*	Yes*	—	—	—	H	H	S	H7
diazinon	16	Yes*	Yes*	Yes*ʃ	Yes	Yes*	—	H	H	H7
dicofol/tetradifon	40/12·5	—	Yes*	—	—	—	I	I	—	I
dienochlor	30	—	Yes	—	—	—	I	H	S	S
dimethoate†	30-34	Yes*	Yes*	—	—	Yes	H	H	H	H>7
fenbutatin oxide	25	—	Yes	—	—	—	S	S	S	S
fenpropathrin	5	—	Yes	—	—	—	—	H>21	—	—
gamma-HCH	12·5	Yes	—	Yes	Yes	Yes*	H	H<4	H	I<4
heptenophos†	41	Yes	—	—	—	—	H	H<3	S	I<4
malathion	114	Yes*	—	Yes*ʃ	Yes	Yes	H	H10	H	H10
nicotine	112	Yes	—	—	—	—	—	I<4	S	H<4
oxydemeton-methyl†	22	Yes*	Yes*	—	—	—	—	H	S	—
parathion	10	Yes*	Yes*	—	—	Yes	H	H14	H14	H
permethrin	‡	Yes	—	Yes∅	Yes	Yes§	—	H	S	H
permethrin/thiram + gamma-HCH	4+25+13	—	—	—	—	Yes	—	—	—	—
petroleum emulsion	‡	—	Yes	—	—	—	S	I	I	I
pirimicarb	25	Yes	—	—	—	—	S	S	S	I
pyrethrum/resmethrin	‡	Yes	Yes	Yes	—	—	H	H<4	—	H<4
rotenone	6·25	Yes	Yes	—	—	—	I	H	S	H1
tetradifon	12·5	—	Yes*	—	—	—	S	S	S	S

2. Atomisations										
dimethoate†	‡	Yes*	—	—	—	—	—	—	—	H
gamma-HCH	‡	Yes	—	—	Yes	—	—	—	—	—
permethrin	‡	Yes	—	Yes	—	—	H	H28	H	H21
pyrethrum/resmethrin	‡	Yes	Yes	Yes∫	—	—	H	H	S	—
resmethrin	‡	Yes	—	Yesø	—	—	—	—	—	—
3. Smokes (S) and fogs (F)	*g/100 m³*									
dicofol (S)	‡	—	Yes*	—	—	—	—	—	—	—
gamma-HCH (S)	‡	Yes	—	Yes*∫	Yes	Yes*	S	H	—	—
nicotine (shreds)	16	Yes	—	—	Yes	Yes	S	S	S	H
permethrin (F)	‡	—	—	Yesø	—	Yes	—	H	—	H>15
permethrin (S)	‡	—	—	Yes	—	—	—	—	—	—
pirimicarb (S)	‡	Yes	—	—	—	—	—	—	—	—
pirimiphos-methyl (S)	‡	Yes	—	Yes∫	—	—	—	—	—	—
pirimophos-methyl (F)	‡	Yes	Yes	Yesø	Yes	—	—	H	H	H16
propoxur (S)	‡	Yes	—	Yes∫	—	—	—	H8	S	—
pyrethrum/resmethrin (F)	‡	Yes	—	Yes∫	—	—	—	H	I	H
tecnazene/gamma-HCH (S)	‡	Yes	—	Yes∫	Yes	Yes	—	—	—	—
4. Compost treatments—drenches (D) and granules (G)	*g/100 l*									
aldicarb (G)†	‡	Yes*	Yes*	Yes	—	Yes	—	H	—	—
demeton-S-methyl (D)†	15	Yes*	Yes*	—	—	—	—	H	—	H70
formothion (D)†	113	Yes*	—	—	—	—	—	—	—	—
oxydemeton-methyl (D)†	14	Yes*	Yes*	—	—	—	—	—	—	—

* — resistant insects may be encountered.
† — systemic compound.
‡ — see product label.
§ — *Liriomyza trifolii*; use 6 g/100 l (see p. 414).
‖ — use 25 g/100 l on roses.
∫ — kills adults only.
ø — kills adults and larvae.

H — harmful (>7—harmfulness persists for more than 7 days).
I — intermediate.
S — safe.

Anemone

Diseases

Downy mildew *(Peronospora ficariae).* This is a soil-borne disease and is uncommon in protected crops unless anemone crops have been grown frequently in the same soil without sterilisation. Affected plants have dull grey-yellow leaves which are usually down-curled. Plants are often stunted with affected areas of plants developing in the most humid part of the house first. Zineb [*140-225 g/100 l*] will probably give some protection to plants although there is no reference to its use for downy mildew control in protected crops.

Grey mould *(Botrytis cinerea).* Grey mould often colonises old senescing leaves especially in the autumn. Plants growing rapidly, sometimes because of excessive nitrogen, under shortening days seem particularly susceptible. Losses caused by plant death, infection of young growth and flower spotting may have a significant effect on the production of marketable blooms. Avoid producing too soft a plant by restricting the amount of nitrogen given and avoid excessive damage during picking. Trimming plants to remove senescing leaves may be necessary. Routine applications of one of the fungicides in Table 12.5 (p. 392) should be made starting in early autumn or at the first signs of the disease.

Leaf curl *(Colletotrichum acutatum* or possibly *C. gloeosporioides).* The disease has become serious recently due to dissemination in infected corm stocks. The most obvious symptoms are twisting, curling and distortion of leaves and flower stalks. Salmon pink spoting areas are sometimes seen, initially on leaf and flower primordia, at the centre of affected plants. The disease is favoured by temperatures over 20°C and spread by water splash and probably wind and on pickers' hands and clothes.

Affected plants should be removed and destroyed as soon as they become evident. In experiments plants have been protected by high volume drenching sprays of captafol [*200 g/100 l*] using 100 ml/plant applied every 2 weeks. In Holland a corm dip has been suggested which is given immediately before planting. This consists of captafol or captan with either benomyl or carbendazim, but there is little evidence that these are effective treatments. The disease is soil-borne and anemones should not follow an affected crop unless the soil is to be sterilised. The St. Piran strain of corm anemones is recognised as having consistently low levels of the disease or to be disease free and should be used in preference to other commonly infected strains.

Plum rust *(Tranzschelia pruni-spinosae).* This is an unusual disease but where it does occur on protected crops the source is usually infected corms rather than plum trees. Affected plants have a stiff upright habit and may be taller than healthy plants. These plants may cease to produce further flowers. Leaf margins are down-curled and yellow pustules may be evident on their undersurfaces. Affected plants should be destroyed. Protective sprays of zineb [*140-225 g/100 l*] and oxycarboxin [*37·5 g/100 l*] have been used.

Powdery mildew *(Erysiphe ranunculi).* This disease occasionally occurs on greenhouse crops but is not usually a problem. Typical white powdery patches appear on leaves and bracts. The disease occurs during the summer and autumn and disappears with the onset of cool weather. At the first sign of symptoms a fungicide should be applied. Benomyl [*25 g/100 l*], or carbendazim [*25 g/100 l*] should give satisfactory control.

Arum (Calla) lily

Pests

Aphids. *Myzus persicae, Macrosiphum euphorbiae, Aphis gossypii,* and occasionally other species, cause stunting and disfiguration of the young growth and severe spotting of the flower spathes. Control before the flowers open with one of the compounds listed in Table 12.3 (p. 386).

Red spider mite *(Tetranychus urticae)* (L 224). This may be a serious pest. For control measures see Table 12.3 (p. 386).

Thrips *(Heliothrips femoralis, H. haemorrhoidalis, Thrips tabaci)*[7]. Thrips breed on the foliage and flowers causing pale, whitish spots on the leaves and brown spots on the flowers. For control see Table 12.3 (p. 386).

Diseases

Corm rot *(Erwinia carotovora (Pectobacterium carotovorum)).* Corm rot is a serious bacterial disease. Plants are attacked at the collar and the 'corms' are rotted causing yellowing and death of the foliage. Badly diseases 'corms' should be destroyed. Others may be saved by washing away all the soil when they are dormant, cutting out all diseased tissue and steeping for 2 hr in formaldehyde [*8 g/l*]. Pot into sterilised soil without delay. Disinfect the greenhouse with formaldehyde when vacant, see p. 382.

Root rot *(Phytophthora richardiae).* Infected leaves first become yellowish and streaky, then gradually turn brown and die. Flowers become brown at their tips and may be deformed. Sterilise potting soil to prevent the spread of this soil-borne disease. Etridiazole or fosetyl-aluminium or propamocarb should give control of this disease. They should be applied either as a soil drench or by incorporation into the compost (Table 12.4, p. 390).

Asparagus fern *(Asparagus plumosus, A. sprengeri)*

Pests

Caterpillars. Foliage-eating caterpillars may be controlled as for Carnation—tortrix (p. 406), but do not use products containing malathion.

Table 12.4 Ornamentals—*Phytophthora* and *Pythium* root rots
N.B. Before using compounds listed in this table, consult the product label for information on species/cultivars which should not be treated.

Compound	*Application rate*		*Remarks*
	g/100 l	*l/m²*	
1. Compost (C), pot (P) and soil (S) drenches			
drazoxolon (C, P)	21	—	Drench seed tray with 420–560 ml. Pelargonium and *Primula obconica* should be drenched every 3–4 weeks.
etridiazole (C, P)	17·5–35	5	Drench is less effective than incorporation. Up to 10 l/m² may be used for rooted cuttings, transplants or established plants in pots to obtain run-through if concentration is reduced proportionately. Do not use on *Gloxinia*.
fosetyl-aluminium (C)	200	—	Use to water compost for pricking-out.
fosetyl-aluminium (P, S)	80	5	For established plants; repeat after 4–6 weeks, if necessary.
8-hydroxyquinoline (C)	42	2·7	For control of Pythium apply 7 days before planting†.
8-hydroxyquinoline (CS)	14	2·7–5·4	Apply lower dose before or after sowing or planting, for control of other root-rotting fungi and bacteria. Higher dose may be applied every 7–10 days to eradicate infection by Pythium and other rots†.

propamocarb (C)	144	5	For seed-sowing, pricking-out, potting-on.
propamocarb (C, S)	108	10	For rooting of cuttings.
propamocarb (P)	108	—	Drench after potting and at intervals of 21 days thereafter.
2. Dip			
8-hydroxyquinoline	10·5	—	Dip carnation cuttings for 6-8 hr. Do not use for Pelargonium†
propamocarb	216	—	For bulbs.
3. Incorporation into compost (C), soil (s)‡	*g/m³*		
etridiazole (C)	14-26·3	—	Use lower rate mixed into soil-less composts for seedlings; use higher rate for loam composts or for rooted cuttings and transplants. Do not use for Gloxinia.
etridiazole/chlorothalonil mixture	100*	—	Controls other soil-borne diseases.
propamocarb (S)	505-1011 g/ 100 m²	—	For bulbs.

* — rate is g (product)/m³.
† — may damage seedlings of Begonia, Petunia, Gloxinia.
‡ — see product label.

Table 12.5 Ornamentals—grey mould and powdery mildew
N.B. Before using compounds listed in this table, consult the product label for information on species/cultivars which should not be treated.
For Rose—powdery mildew see Table 12.6 (p. 446)

Compound	Application rate for: Grey mould	Application rate for: Powdery mildew	Usual interval between applications	Remarks	See Integration, p. 462 — Effect (where known) on: Phytoseiulus: Eggs	Phytoseiulus: Adults	Encarsia: Pupae	Encarsia: Adults
1. HV sprays	*(g/100 l)*		*days*					
benomyl*	25	25	21-28	First 2 sprays with a chemical other than carbendazim or thiophanate-methyl then alternate in subsequent applications.	H	H	S	—
bupirimate	—	17·5	10-14	Chrysanthemum only.	I	S	—	—
bupirimate	—	100	14	Gerbera only.	I	S	—	—
carbendazim*	25	25	14		—	I	S	—
chlorothalonil	110	—	7-14		—	S	S	S
dinocap	—	6·5	10-14	Some cv. of Begonia and Chrysanthemum are susceptible to damage.	—	S	—	H
fenarimol	—	4§	10-14	Use initially on a small area only.	—	—	—	—
imazalil	—	10	7-10	Damages open Begonia flowers.	I	S	—	I
iprodione	50	—	21	On Saintpaulia use tepid water, do not spray flowers.	S	S	—	S
pyrazophos	—	15	10-14	Do not use on Aquilegia or Scorzonera.	H	I	—	H

thiophanate-methyl*	50	50	14		H	S	—	S
thiram	160-320	—	10-14	Hydrangea susceptible to damage.	—	—	—	S
thiram/petroleum oil/ permethrin	1 l†	1 l†	7-14	Asparagus fern, Fuchsia and Pelargonium susceptible to damage. Also controls capsids red spider mite and caterpillar	—	—	—	—
triforine	—	25	10-14		S	S	—	S
vinclozolin	50	—	10-14		—	S	—	S
2. Dust	*(g/100 m²)*							
thriam	34-94	—	10-14	See thiram HV above.	—	—	—	—
3. Smoke								
tecnazene	‡	—	14-21	Use only on established plants. May damage asparagus fern.	—	—	—	—
4. Soil drench	*g/100 l*							
benomyl*	25	25	14	Recommended for pot plants, apply in place of watering.	I	I	S	S
carbendazim*	25	25	14		—	—	—	—
thiophanate-methyl*	50	50	14		—	—	—	—

* — insensitive races of *Sphaerotheca pannosa* occur.
† — rate is (product)/100 l.
‡ — see product label.
§ — new recommendation—should be checked.

H = harmful (>7 = harmfulness persists for more than 7 days)
I = intermediate
S = safe

Red spider mite *(Tetranychus urticae)* (L 224). This is a serious pest which causes browning and abscission of leaflets. For control see Table 12.3 (p. 386).

Thrips *(Thrips tabaci)*[7]. Severe attacks cause a silvering of the leaflets. For control see Table 12.3 (p. 386), but do not use products containing malathion.

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 422). For control see Table 12.3 (p. 386), but do not use products containing malathion or propoxur.

Diseases

Basal rot *(Pythium* spp.*)*. The fungus attacks the stems near soil level, so sterilise the soil with steam.. It is possible that drenching the soil with drazoxolon or etridiazole or propamocarb (Table 12.4, p. 390) will check the spread of this disease.

Root rot *(Fusarium oxysporum* f. sp. *asparagi)*[8]. Branches become yellow and are finally dessicated, while basal shoots wither and roots decay. To prevent recurrence, sterilise the soil by steaming. It is possible that benomyl or carbendazim or thiophanate-methyl drenches (Table 12.5, p. 392) will give control.

Aubergine

Pests

Broad mite *(Hemitarsonemus latus)*. Broad mite can cause distortion of flowers and bronzing of the lower leaf surfaces. For other symptoms and control measures see Sweet pepper, p. 449.

Diseases

Grey mould *(Botrytis cinerea)*. Attacks of this disease can be troublesome particularly on fruit. This probably results from infected flowers adhering to the developing fruit. It often occurs at the end of the season during cold humid weather. Regular protective fungicide applications are necessary especially for cold house crops. Vinclozolin [*25-50 g/100 l*] may be used with a 7 day harvest interval, or benomyl [*50 g/100 l*], or use carbendazim [*50 g/100 l*] with a O day harvest interval where the strain of the fungus is not resistant to these chemicals.

Sclerotinia rot *(Sclerotinia sclerotiorum)*. This is a very damaging disease which usually affects mature plants during the summer. All parts of the plant can be affected, but the light brown lesions typical of the disease are usually found on leaf scars in the axils of leaves. Under suitable conditions the lesions extend rapidly often causing the death of the affected shoot. Dense white fluffy mycelial growth develops on these lesions under humid conditions and the large black sclerotia of the fungus develop under this.

Careful removal and destruction of infected debris to avoid sclerotia falling on the soil, combined with thorough soil sterilisation with steam or methyl bromide will reduce the risk of subsequent crop infection. Regular high volume sprays of iprodione [*50 g/100 l*], or a benizimidazole type fungicide will give some protection to healthy plants.

Wilt *(Verticillium dahliae).* Wilt is sometimes found in crops, particularly those where soil sterilisation is infrequent. Affected plants initially show yellow lower leaves and plants may be stunted. As the disease progresses staining of the vascular system, one sided wilting and leaf death will usually precede death of the plant. Sterilise the soil with steam or methyl bromide. Benzimidazole fungicides applied as drenches as for tomato wilt (Table 12.19, p. 458), will reduce the effects of the disease if applied in the early stages of infection.

Azalea

Pests

Red spider mites *(Tetranychus urticae, T. cinnabarinus)* (L 224). This may be a problem if plants for forcing are placed in houses containing hibernating *T. urticae* or mite-infested plants. For control see Table 12.3 (p. 386).

Tarsonemid (cyclamen) mite *(Steneotarsonemus pallidus).* These mites can become a problem especially where azaleas are intensively produced. Twisting and distortion of shoots and leaves and distortion of flowers are symptoms of this pest. For control see Cyclamen—tarsonemid mite, p. 427.

Thrips *(Heliothrips haemorrhoidalis)*[7]. This pest causes silvery or whitish patches with reddish-brown spotting on the undersides of the leaves and on flower petals. Attacks almost invariably result from existing infestations within the greenhouse and are rare in commercial houses. For control see Table 12.3 (p. 386).

Diseases

Grey mould *(Botrytis cinerea).* Flowers rot in humid conditions, so ample ventilation and prompt removal of all diseased flowers will usually prevent the disease from spreading. However, it is advisable, especially in unheated houses, to apply one of the fungicides shown in Table 12.5 (p. 392).

Leaf spot *(Septoria azaleae).* The fungus causes angular, brown leaf lesions sometimes with yellow margins, and plants may later become defoliated after infected leaves wither. Because pycnidia in the lesions exude spores when wet, it is important to reduce the humidity in the greenhouse and burn fallen infected leaves. HV sprays of chlorothalonil or iprodione (Table 12.5, p. 392) have given control of the disease in trials.

Bean (french and climbing french) (HE 3)

Pests

Aphids. Control measures and minimum harvest intervals are listed in Table 12.12 (p. 433).

Red spider mites *(Tetranychus urticae, T. cinnabarinus)* (L 224). Red spider mite is a serious pest. Control using compounds listed in Table 12.18 (p. 454).

Symphylids (L 484). For description see Tomato—symphylids (p. 456). Control using compounds listed in Table 12.20 (p. 463).

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 423). Control using the rates and harvest intervals given in Table 12.18 (p. 454).

Wireworms (L 199). For description see Lettuce—wireworms (p. 433). Control using compounds listed in Table 12.20 (p. 463).

Begonia

Begonia flowers are particularly susceptible to injury by many pesticides, especially when applied as sprays. Do not spray plants in bright sunshine or humid conditions.

Pests

Aphids. A number of species, including *Myzus persicae, Aulocorthum solani* and *Aphis gossypii*, breed on begonias and may cause serious damage to foliage and flowers. Control with treatments listed in Table 12.3 (p. 386). Products containing formothion should not be used and some cultivars of begonia, e.g. Gloire de Lorraine, are damaged by aldicarb at the recommended rate [*45 g/100 m²*]. Fogs of pyrethrum/resmethrin do not damage flowering *B. semperflorens* or non-flowering *B. fimbriata*. Insecticides used as HV sprays may also be used as plant dips.

Mealybugs *(Planococcus citri, P. adonidum).* Mealybugs are uncommon in commercial greenhouses. They are aphid-like insects which, when adult, are covered by a white, mealy protective wax. Control with aldicarb [*45 g/100 m²*] (see aphids), or treat with HV sprays or dips of deltamethrin [*1·75 g/100 l*], or diazinon [*16 g/100 l*], or malathion [*114 g/100 l*], or parathion [*10 g/100 l*], or petroleum emulsion [*1 l* (product)*/100 l*], or fumigate with nicotine shreds [*16 g/100 m³*] several times at 10–14 day intervals.

Mites (L 588). The tarsonemid (cyclamen) mite *(Steneotarsonemus pallidus)* and the broad mite *(Hemitarsonemus latus)* cause stunting, crinkling and curling of the leaves and malformed flowers. Control both mites as for Cyclamen—tarsonemid mite (p. 427), but some chemicals are phytotoxic—see aphids.

Thrips[7]. Several species, e.g. greenhouse thrips *(Heliothrips haemorrhoidalis)*, banded greenhouse thrips *(Hercinothrips femoralis)* and onion thrips *(Thrips tabaci)* cause irregular brownish-red streaks on the upper surface of leaves and roughened brownish spots on the underside. Thrips should be controlled before flowering using compounds listed in Table 12.3 (p. 386), but some chemicals are phytotoxic—see aphids.

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 423). For control see Table 12.3 (p. 386), but some compounds are phytotoxic—see aphids.

Diseases

Grey mould or Blotch *(Botrytis cinerea)*. Foliage, stems and flowers may be attacked by this fungus if plants are grown in humid conditions. Spray at the first sign of attack with one of the fungicides shown in Table 12.5 (p. 392).

Powdery mildews *(Oidium begoniae, Microsphaera begoniae)*. A typical white powdery mould forms on young leaves, stems and flower buds and when severely attacked, tissues may become desiccated. The disease is usually associated with large fluctuations in humidity and temperature. Control with chemicals is difficult to obtain because of phytotoxicity. Vaporise sulphur [*0·5 g/100 m*^{3}] nightly for 5-10 days or use HV sprays (Table 12.5, p. 392). Some cultivars may be damaged by dinocap. Use appropriate wetting agents with benomyl and thiophanate-methyl.

Root and stem rots. Several fungi including *Rhizoctonia solani (Thanatephorus cucumeris)*, *Thielaviopsis basicola* and *Pythium* spp., cause the roots, tubers or stems to rot, particularly when plants are frequently overwatered. Prevent infection by using sterilised composts but if the disease is suspected use one of the drench or incorporation treatments shown in Table 12.4 (p. 390). Do not apply 8-hydroxyquinoline over seedlings. Etridiazole/chlorothalonil mixture should give some control of all three root rot pathogens listed above, but the other compounds in Table 12.4 (p. 390) will only control Pythium root rot.

Bulbs (forced)

Many pest and disease problems occur as a result of 'housing' infested bulbs. It is very important to select only sound, healthy bulbs for forcing and to apply preventive treatments before planting into sterilised soil.

Bulbs (forced)—hyacinth

Pests

Stem nematode *(Ditylenchus dipsaci)*. This pest reduces the vigour and productivity of bulbs. The symptoms are similar to those seen when this nematode

attacks narcissus but leaf 'spickels' are not produced. There is no chemical control measures so the selection of clean stock is vital.

Diseases[9]

Soft rot *(Erwinia carotovora* pv. *carotovora).* This bacterial disease results in the complete breakdown of the tissue of the bulb. The first signs of rotting are a stunting of growth and yellowing of leaf tips. Flower buds often fall off. Rotting of the flower stem at soil level may result in the collapse of the whole plant. It is a bulb- or soil-borne disease. Remove and destroy affected bulbs. Drenches of copper oxychloride [*100 g/100 l*] may reduce the spread of the disease if it appears early in the life of the crop.

Yellow disease *(Xanthomonas hyacinthi).* This is a bacterial disease which *totally* rots the bulbs before or soon after planting. Slightly diseased bulbs, when cut across, show small, yellow spots arranged in concentric rings. Diseased bulbs should be removed very carefully and great care taken with watering to avoid splashing the bacteria about. There is no effective chemical treatment.

Bulbs (forced)—iris

Pest

Bulb mite *(Rhizoglyphus echinopus).* Bulb mite occasionally causes damage to iris bulbs during storage. See Freesias—bulb mites (p. 428).

Diseases[9]

Botrytis rot *(Botrytis cinerea).* The disease causes plants to topple with a rot at the base of the stem and top of the bulb. The fungus sometimes causes flower spotting and often results in dieback of leaves due to tip infection. It is only a problem in unheated crops where conditions can sometimes favour the development of the disease. High volume sprays of iprodione [*50 g/100 l*], or vinclozolin [*50 g/100 l*] should be used if necessary.

Fusarium basal rot *(Fusarium oxysporum* f. sp. *gladioli).* Fusarium basal rot is usually considered to be mainly a bulb-borne disease although it can result from contaminated soil. Affected plants are stunted and have a characteristic one sided growth which leads to the shoot growing at an angle of 45° to the ground. These plants have a dark brown rot of the base plate and disintegrated roots. Death follows the complete rotting of the bulbs.

Pre-planting bulb dips with benomyl [*100 g/100 l*] have been found to give some control. Post-planting soil drenches of benomyl [*25 g/100 l*], or carbendazim [*25 g/100 l*] are sometimes used. Soil should be sterilised with steam or methyl bromide.

Leaf spot *(Mycosphaerella macrospora).* This disease affects leaves and spathes and although not usually a problem in protected crops, under some circumstances it can cause serious losses of marketable blooms. The first signs of the disease are small brown spots in the centre of a water soaked area. The lesion turns pale grey, then the tissue dries to a light grey-brown. They are typicaly elliptical in shape being restricted laterally by the veins and up to 10 mm in length and about 5 mm wide. They may coalesce to form larger lesions. Under suitable conditions of high humidity, particularly when plants are alternately wet and then dry, the centres of the spots turn dark grey and the fungus produces tufts on which spores are produced. Spores are dispersed by air movement and splashing. The disease perennates on debris.

Control can be achieved by keeping the foliage dry, especially during the autumn and winter, and reducing humidity by ventilation where possible. Destroy infected debris from previous crops. Protective sprays of chlorothalonil [*100 g/100 l*], or mancozeb [*17·6 g/100 l*] have been found to be effective.

Penicillium rot or bulb rot *(Penicillium corymbiferum).* The disease usually only causes a problem during storage or while bulbs are being transported. Under suitable conditions the pathogen can penetrate through wounds caused by handling and natural wounds such as those caused by emergence of root initials. The disease produces a rot which is often only noticeable by peeling the outer scales from the bulbs. It is typically blue-green in colour. Slightly affected bulbs grow normally. Adverse growing conditions favour the development of the disease or invasion and rotting by secondary organisms which may lead to poor growth or death of the bulb.

Careful handling and storage will reduce the subsequent development of the disease. Pre-planting dips with maneb [*750 g/100 l*] are used and give some control.

Pythium root rot *(Pythium irregulare).* Pythium root rot is a serious root rot of iris. Affected plants stop growing and the root tips are found to be yellow and rotted. The disease develops in clearly defined areas of the crop in which plants are stunted and fail to flower. Cold wet conditions encourage the development of the disease. It can be serious especially where iris are monocropped and soil sterilisation is infrequent. A bulb dip of propamocarb [*216 g/100 l*] for 20 minutes combined with preplanting soil treatment with etridiazole [*175-245 g/100 m²*], or propamocarb [*505 g-1·01 kg/100 m²*] is effective but soil incorporation must be thorough. Post-planting soil drenches with etridiazole are used but are less effective than pre-planting treatments. Sterilise soil with steam or methyl bromide between crops.

Rhizoctonia *(Rhizoctonia solani).* The disease can be bulb- or soil-borne. It causes a root or neck rot of the bulbs. Affected plants are stunted and foliage yellows. Symptoms on the bulbs are of a soft brown rot. Spread can be rapid under conditions of high soil temperature and can result in significant losses.

Sterilise the soil with steam of methyl bromide. Treat soil with quintozene [*500 g/100 m²*] before planting.

Bulbs (forced)—lily

Pests

Aphids *(Myzus ascalonicus, Aulacorthum circumflexum, Dysaphis tulipae).* Aphids attacking the foliage of plants should be controlled with HV sprays of systemic aphicides such as demeton-S-methyl, or dimethoate, or pirimicarb if the plants are in bloom, using the rates given in Table 12.3 (p. 386). The dry outer scales of bulbs may harbour *Dysaphis tulipae*, so care must be taken when selecting stock.

Diseases[9]

Foot rot *(Phytophthora* spp.*).* Affected plants may topple over and die. The bulbs of such plants will be found to be in an advanced state of rotting. The disease is worse in poorly drained soils under wet conditions. The effects of the disease can be reduced by using pre-planting soil incorporation of etridiazole [*175-245 g/100 m²*], or propamocarb [*505 g-1·01 kg/100 m²*], or drenches of etridiazole [*175 g/100 m²*] after planting, or pre-planting bulb dips of propamocarb [*216 g/100 l*] for 20 minutes.

Fusarium scale rot *(Fusarium oxysporum* f. sp. *lilii).* This disease causes plants to wilt slightly and although bulb scales may appear healthy, roots turn red. Eventually the scales become infected and rot away. Sterilise soil with steam or chloropicrin. A blub dip or soil drench as shown in Table 12.6 (p. 402) may give some control.

Leaf spot *(Botrytis elliptica).* This fungus causes leaf spots that enlarge rapidly in humid conditions. Keep the leaves as dry as possible when watering. In spring, spray new growth with one of the compounds shown in Table 12.6 (p. 402).

Pythium root rot *(Pythium* spp.*).* Tips of roots show the first signs of the disease which gradually spreads to affect whole roots. All roots normally become infected and rot. This often leads to the disintegration of the bulb. Above ground the plant at first becomes stunted and then foliage becomes chlorotic and dies. It is a soil-borne disease but may be spread in non-mains water. Some control may be effected by pre-planting incorporation of etridiazole [*175-245 g/100 m²*], or propamocarb [*505 g-1·01 kg/100 m²*], or post-planting drenches of etridiazole [*175 g/100/100 m²*], or combine soil treatment with a bulb dip immediately before planting of propamocarb [*216 g/100 l*] for 20 minutes.

Stump rot *(Phytophthora nicotiana).* A watersoaked area appears in the centre of the rosette or at the base of the leaves soon after emergence of the shoot through the soil. This may lead to the entire shoot being killed in which case unaffected laterals are often produced and these remain healthy. Where the disease appears later in the season and under dry conditions, only tips of shoots and flower buds may be affected. The disease is encouraged by wet soil conditions and the use of a contaminated water supply. Pre-planting soil incorporation of etridiazole [*175-245 g/100 m²*], or propamocarb [*505 g-1·01 kg/100 m²*], or

drenches of etridiazole [*175 g/100 m²*] at the first signs of the disease, will give some control. Bulb dips of propamocarb [*216 g/100 l*] for 20 minutes are also recommended.

Bulbs (forced)—narcissus (HE 7)

Pests

Bulb scale mite *(Steneotarsonemus laticeps)* (L 456). This microscopic mite feeds between the bulb scales. On cutting open the bulb and parting the scales, elongated brown streaks can be seen on the surface of the scales. During forcing, the leaves are abnormally green with yellow streaks and the flowers may be distorted or buds killed. Control by drenching with endosulfan [*100 g/100 l*] after overnight frosting of the boxed bulbs.

Stem and bulb nematode *(Ditylenchus dipsaci)* (L 460). This nematode infests the bulbs and upper growth, causing a delay in flowering. Infested leaves are characterised by small swellings (spickels) produced by the nematodes. The spickels vary in colour from green to yellow to brown necrotic tissue depending on the severity of the attack. There is no chemical control measure so it is important to select clean stock.

Diseases[9]

Basal rot *(Fusarium oxysporum* f. sp. *narcissi)*. Bulb infection takes place in the summer, and a formaldehyde dip treatment—the only means of control—should have been carried out by the producer soon after lifting. By planting time, diseased bulbs are soft and frequently have a pink mass of spores on the root plate. Infected bulbs should be removed and contaminated soil must be sterilised before it is used again. It is important to distinguish between basal rot (a uniform chocolate-brown rot) and eelworm (brown concentric rings from the base upwards) which is becoming prevalent and can cause serious damage. Forced bulbs should not be recovered for forcing if there are appreciable amounts of basal rot, or eelworm, or bulb scale mite.

Bulbs (forced)—tulip (HE 8)

Pests

Aphids *(Dysaphis tulipae, Myzus persicae, Macrosiphum euphorbiae)*—see Lily—aphids (p. 400). Cut flowers may be cleaned up with fogs of pyrethrum/resmethrin.

Stem and bulb nematode *(Ditylenchus dipsaci)*—see Narcissus, stem and bulb nematode (above). Control by dipping clean dry bulbs in thionazin [*240 ml/100 l*], though this may retard growth and affect flowering in some varieties.

Table 12.6 Bulbs—Tulip and Lily—diseases

		Tulip			*Lily*	
Compound	*Application rate*	*Fusarium bulb rot*	*Root rot*	*Tulip fire*	*Fusarium scale rot*	*Leaf spot*
1. HV sprays	*(g/100 l)*					
benomyl	5·5*	—	—	Yes†§	—	—
captan	94	—	—	—	—	Yes
carbendazim	5·6*	—	—	Yes†	—	—
dichlofluanid	150	—	—	Yes	—	—
iprodione	50	—	—	Yes	—	—
maneb	13·4-17·9*	—	—	Yes	—	Yes
manganese, zinc, iron, dithiocarbamate complex	14·5-38·3*	—	—	Yes	—	Yes
thiophanate-methyl	22·5*	—	—	Yes†	—	—
thiram	320-560	—	—	Yes	—	—
vinclozolin	50	—	—	Yes	—	—
zineb	140-225	—	—	Yes	—	Yes
2. LV sprays	*(g/100 m²)*					
maneb	13·4-17·9	—	—	Yes	—	Yes
manganese, zinc, iron, dithiocarbamate complex	14·5-38·3	—	—	Yes	—	Yes
3. Dusts						
quintozene	500‖	Yes	—	Yes	—	—

4. Dips	*(g/100 l)*					
benomyl	100	Yes†	—	Yes†	Yes†	—
carbendazim	100	Yes†	—	Yes†	—	—
etridiazole	70	—	Yes	—	—	—
maneb	640	Yes	—	Yes	Yes	—
propamocarb	217	—	Yes	—	—	—
thiabendazole	‡	Yes†	—	Yes	—	—
thiophanate-methyl	200	Yes†	—	Yes	—	—
5. Soil drenches						
captan	117	—	—	—	Yes	—
drazoxolon	330	—	Yes	—	—	—
etridiazole	175	—	Yes	—	—	—
fosetyl-aluminium	80	—	Yes	—	—	—
8-hydroxyquinoline	14	—	Yes	—	—	—
quintozene	‡	—	—	—	Yes	—
6. Soil incorporation	*(g/100 m²)*					
etridiazole	175-245	—	Yes	—	—	—
propamocarb	505-1011	—	Yes	—	—	—
quintozene	700-1400	Yes	—	—	Yes	—
7. Atomisation						
maneb	‡	—	—	Yes	—	—

* — g/100 m².
† — races of the fungus may be insensitive to these chemicals.
‡ — see product label.
§ — alternate sprays with a chemical other than those marked †.
‖ — g/tonne of bulbs.

Diseases[9]

Fire *(Botrytis tulipae)* (L 536). This fungus can be seen on outer and fleshy bulb scales as small, black sclerotia (similar in size to onion seed) which may be associated with brown-margined lesions. Before planting, the fungus may be controlled by dipping the bulbs for 30 minutes in a suspension of one or more of the chemicals shown in Table 12.6 (p. 402). A mixed dip (e.g. benomyl plus maneb) may prevent attack by isolates of *B. tulipae* or *Fusarium oxysporum* which are insensitive to one of the fungicides. A mixture may broaden the spectrum of activity of the dip to cover root rot (e.g. benomyl + etridiazole). Always check chemical compatiblity before mixing. Primary infections occur on emerging shoots, which produce masses of olive-grey spores. These can cause secondary infection or spotting on other leaves and flowers. Cut off all infected shoots below the soil surface, avoid splashing foliage when watering and use one of the HV or LV sprays shown in Table 12.6 (p. 402).

Fusarium bulb rot *(Fusarium oxysporum* f. sp. *tulipae).* Bulb infection usually occurs in the summer before forcing, and diseased bulbs may become soft and a pinkish-white fungal mat may develop on the shrivelling bulb. If infected blubs are planted, ethylene gas produced by rotting tissues can cause damage to the embryonic flowers of nearby bulbs. As a preventive measure dip the bulbs before planting as described for Tulip—fire.

Grey bulb rot *(Rhizoctonia tuliparum).* The fungus attacks the bulb causing it to rot, usually from the neck downwards, and often entirely preventing the growth of the shoot. The disease is soil-borne and if plants become affected after emergence the new foliage is often distorted and poorly developed, and the plants frequently fail to flower. Inspection of affected bulbs shows a dry grey to purplish rot. Scales stay firm unless secondarily attacked by soft rotting organisms. Soil often adheres to the neck of bulbs by a profuse development of white mycelium. In this mycelium large (5–7 mm) white, later almost black, sclerotia may be seen. Use clean growing media and forcing boxes. Dip bulbs in carbendazim [*200 g/100 l*], or dust them with quintozene [*500 g/l*]. Treat soil with quintozene [*700 g–1·40 kg/100 m²*] pre-planting, or incorporate in compost [*18·0 kg/100 m²*].

Root rot *(Pythium* spp.*).* This disease has become more prevalent since bulbs for forcing have been planted direct into greenhouse border soil instead of boxes. Root rot causes patches of weak, yellowish plants with poor root systems. Dip bulbs for 20 min in a suspension of propamocarb [*216 g/100 l*] or use one of the soil incorporation or soil drench treatments in Table 12.6 (p. 402). Bulbs should be planted in steam sterilised soil.

Shanking *(Phytophthora cryptogea* or *P. erythroseptica).* Affected plants usually develop the first symptoms when flower buds are well developed. Buds often shrivel and leaf tips turn yellow. The roots of these plants will be poorly developed and often rot. The rot may extend into the base plate. It is a soil-borne disease. Use clean substrate and forcing boxes. A bulb dip immediately before

planting with propamocarb [*216 g/100 l*] for 20 minutes should be used in conjunction with the treatments of the soil or compost shown in Table 12.6, p. 402.

Calceolaria

Sprays must not be applied in bright sunshine or to plants dry at the roots.

Pests

Aphids. *Aulacorthum circumflexum* (mottle arum aphid), *A. solani, Myzus persicae* and occasionally other species, breed on calceolaria. They may be controlled with the materials listed in Table 12.3 (p. 386), although ULV sprays of permethrin, pyrethrum/resmethrin or resmethrin should not be used on red calceolaria. Products containing gamma-HCH alone will not be effective against the mottled arum aphid.

Leafhopper *(Zygina pallidifrons)*[16]. The feeding of these insects on the underside of leaves causes mottling or bleached spotting. Control with HV sprays of carbaryl [*77 g/100 l*], or gamma-HCH [*12·5 g/100 l*], or malathion [*114 g/100 l*]; or use ULV sprays of malathion [*see label*] or use nicotine shreds [*16 g/100 m³*].

Whitefly *(Trialeurodes vaporariorum)* (L. 86). Calceolarias are often badly checked in growth and soiled by whitefly. Control with one of the compounds listed in Table 12.3 (p. 386), but do not use ULV sprays of pyrethrum/resmethrin on red calceolaria.

Diseases

Root and stem rots. Calceolarias are susceptible to several soil-borne fungal diseases. Seed and potting composts should be made with sterilised soil and if disease is suspected, a broad spectrum fungicide, such as etridiazole/chlorothalonil mixture should be used. See Table 12.4 (p. 390).

Carnation (MAFF Bull. 151)

Pests

Aphids. The peach potato aphid *(Myzus persicae)* and the glasshouse potato aphid *(Aulacorthum solani)* are pale to dark yellowish-green when wingless and mainly live on the young leaves. The young feed within the growing tip which shelters them from contact insecticides. Therefore, systemic insecticides are more likely to be effective. Control measures, which should be effected before flowers begin to open, are listed in Table 12.3 (p. 386).

Earwig *(Forficula auricularia).* Earwigs are only occasionally found on indoor crops and are often associated with debris which has not been cleared away. They feed on flowers, giving them a ragged appearance. The damage may be confused with that due to caterpillars, so check for the presence of caterpillar frass. Earwigs may be controlled with compounds listed in Table 12.20 (p. 463). Where HV sprays are undesirable, e.g. where grey mould is present, use atomised diazinon [*see label*]; or use smokes of gamma-HCH [*see label*], or tecnazene/gamma-HCH [*see label*]. Repeat at 14-day intervals as necessary.

Red spider mite *(Tetranychus cinnabarinus)* (L 224). This serious pest is a reddish-brown mite which initially causes small whitish spots on the leaves; as the infestation increases, the leaves become pale, stippled and desiccated. The mites breed on carnations throughout the year. Occasionally *T. urticae* causes similar damage. Mites may be controlled with one of the compounds listed in Table 12.3 (p. 386). The organophosphorus compounds do not kill the eggs, so a further treatment will be required 7-10 days later. Complete coverage of the foliage is required with sprays of contact acaricides. Control should be effected before flowering.

Thrips *(Thrips tabaci, Taeniothrips atratus)*[7]. Thrips are slender, small insects. The adults are brownish-black and very active but the younger stages are yellowish and less active. They feed on petals causing silvery streaks and sometimes distortion, and they often invade greenhouses in the summer. They may be controlled with one of the compounds listed in Table 12.3 (p. 386). Thrips should not be a problem where the soil has been sterilised before planting.

Tortrix *(Cacoecimorpha pronubana).* The yellowish to olive-green caterpillars feed on the upper leaves, tying them together with silken threads, and later enter the flower buds and destroy the blooms. They may be controlled by HV sprays of the bacterial pesticides *Bacillus thuringiensis* [*see label*], or carbaryl [*77 g/100 l*, or dichlorvos [*50 g/100 l*], or diflubenzuron [*12·5 g/100 l*] or pyrethrum/resmethrin [*see label*]; or atomised dichlorvos [*see label*]; or ULV sprays of pyrethrum/resmethrin, or fogs of permethrin. Apply immediately the pest is seen and repeat after 14 days.

Wireworms (L 199). They should not be a problem where the soil has been sterilised before planting. Control with one of the compounds listed in Table 12.20 (p. 463).

Woodlice. They should not be a problem where the soil has been sterilised before planting. Control using one of the compounds listed in Table 12.20 (p. 463).

Diseases

Bacterial wilt or stem crack *(Pseudomonas caryophylli).* This is an uncommon bacterial disease which slowly progresses until the plant collapses. Foliage turns grey-green, the vascular tissue becomes discoloured and longitudinal cracks appear on the stem between lower nodes. The disease is usually associated with infected cuttings. Destroy affected plants and steam sterilise the soil between crops.

Basal rots *(Pythium* spp. *Phytophthora* spp. *Rhizoctonia solani, Fusarium culmorum* and *Alternaria dianthi).* All these fungi are individually capable of causing stem lesions at or just above soil level, and usually within six weeks of planting. It is usually necessary to use microscopic examination to identify the pathogen. Affected plants wilt and often die. Routine high volume sprays of captan [*94 g/100 l*], or mancozeb [*140 g/100 l*] are sometimes used to reduce the risk of occurrence of these diseases. Iprodione [*50 g/100 l*], or chlorothalonil [*81 g/100 l*] may be effective against Alternaria and Rhizoctonia. Sterilise the soil between crops.

Bud rot *(Fusarium poae).* This disease results in rotting of buds before the flower opens. On open blooms petals may be distorted. The fungus is spread by the mite *Siteroptes graminum.* Remove affected buds. Control of mites with acaricides recommended for red spider mite control in Table 12.3 (p. 386) is usually sufficient to control the spread of the disease.

Fusarium wilt *(Fusarium oxysporum* f. sp. *dianthi).* This wilt has become more prevalent in recent years and is the most damaging disease of carnation. The pathogen invades vascular tissues, which appear pale brown and separated into strands, and causes all or part of the plant to wilt.

If the amount of inoculum in soil is kept low by prompt and careful removal of wilted plants and spot treatment of the affected area with a fungicide drench, thorough soil sterilisation with steam and attention to hygiene between crops will give control of the disease. Sterilisation needs to be effective because carnation is a 2-year crop. Although substantial losses have occurred in first year crops, wilt may not begin to spread rapidly until the second year. Metham-sodium (see Introduction), applied before steaming, can give improved control but results have been variable. It is difficult to eradicate the disease once soil inoculum levels have become high and, consequently, peat bags on polythene sheets are increasingly used. Sterilisation of the soil beneath the sheet is still advisable because the peat in the bag can become contaminated with the pathogen, but growing in bags will limit the spread of the disease.

Soil drenches of benomyl [*75 g/100 l*] or carbendazim [*75 g/100 l*] using 5·5 l/m² may be applied 14 days after planting and then every 1-3 months; early treatment of infections is more likely to be successful. Insensitive strains of the pathogen or microbial breakdown of the fungicide may occur with repeated use of these chemicals.

Greasy blotch *(Zygophiala jamaicensis).* This disease is rare but appears on leaves as green fibrillate patches which may extend and join to give the leaves an oily appearance. Avoid high humidity which encourages the disease. HV sprays of captan [*94 g/100 l*] every 7-10 days may give control.

Grey mould *(Botrytis cinerea).* This fungus causes spotting and rotting of buds and flowers and may be serious if lesions become established on old, yellowing leaves which provide inoculum for the infection of flowers. Greenhouse ventilation and heating should be regulated to prevent high humidity which favours the disease. For fungicidal treatments see Table 12.5 (p. 392).

Leafy gall *(Corynebacterium fasciens).* The disease typically causes multiple development of grass-like short leaves at the nodes giving a tufted appearance. Destroying affected plants will usually limit the spread of the disease to a few plants.

Leaf spot or Alternaria blight *(Alternaria dianthi).* This disease is common on cold-stored cuttings. Small purple spots enlarge into brown-black sporulating patches with purple edges. The fungus may also infect stems. Spray HV with captan [*94 g/100 l*], or chlorothalonil or iprodione as in Table 12.5 (p. 392), or zineb [*150 g/100 l*].

Phialophora wilt or Verticillium wilt *(Phialophora cinerescens (Verticillium cinerescens)).* This wilt is less important than Fusarium wilt. A rapid wilting occurs, often starting on one side of the plant; the foliage turns grey-green and the stem xylem turns dark brown. For control measures see Fusarium wilt; soil drenches of benomyl, or carbendazim are very effective against this wilt disease.

Powdery mildew *(Oidium* spp.*).* This fungus may cover the leaves and occasionally the calyces. It is controlled by dinocap, as in Table 12.5 (p. 392), or with sulphur dust [*280 g/100 m²*] applied every 7 days.

Ring spot or fairy ring spot *(Mycosphaerella dianthi).* The disease is worst in winter under humid conditions when it is difficult to control. Lesions appear on leaves, stems and calyces. When it appears on calyces it makes the affected blooms unmarketable. These lesions are typically dark brown with a purple edge and up to 5 mm in diameter. Spores are produced in concentric rings on the spots. The disease is often brought in on cuttings. Avoid conditions of high humidity. Zineb dust [*17·5 g/100 m²*] at weekly intervals, or high volume sprays of mancozeb or zineb [*140 g/100 l*], or chlorothalonil [*81 g/100 l*] have been used and give some control but fortnightly applications are necessary particularly during the winter months.

Rust *(Uromyces dianthi)*[11]. Rust causes small blisters on the lower leaves and stem, which rupture releasing brown, powdery spores. The disease develops when the foliage remains wet or dew forms overnight; the humidity within the greenhouse should be reduced as much as possible. It is difficult to wet the waxy leaf surface, but one of the compounds listed in Table 12.7 (p. 409) should give some control of rust. Cut open blooms before applying HV sprays and check for phytotoxicity by spraying a few plants before treating the remainder.

Drenches of the systemic fungicide oxycarboxin, applied to plants grown in peat bags are effective.

Septoria leaf spot *(Septoria dianthi).* This is an uncommon disease which is usually introduced on cuttings. The symptoms are similar to leaf spot but it tends to be found on lower leaves. The purple margin is not so obvious and the centre of the spots have minute black specks rather than the powdery black appearance of Alternaria. Fungicide application is not usually necessary. Control can be achieved by avoiding high humidity or wetting of foliage. Where this is not effective the fungicides and rates suggested for leaf spot (p. 408) should give control.

Table 12.7 Carnation—rust
N.B. Before using compounds listed in this table, consult the product label for cultivars which should not be treated.

Compound	*Application rate*	*Frequency of applications (days)*	*Remarks*
1. HV Sprays	*(g/100 l)*		
chlorothalonil	110	7-14	
oxycarboxin	37·5	7-10	Spray cuttings after striking and 3 further sprays every 10-14 days.
thiram	320-560	10-14	
zineb	140-225	10-14	
2. Drench			
oxycarboxin	50	—	Peat module culture only; use 4 litres/module every 6 months.
3. Fog	*(g/100 m³)*		
oxycarboxin	12·5	7-14	
4. Dust			
zineb	17·5	7-14	
5. Atomisations			
mancozeb/zineb mixture maneb zineb	Follow manufacturer's instructions.		

Slow wilt *(Erwinia chrysanthemi).* This is a rare, systemic bacterial disease, causing plants to wilt slowly. Characteristic root rotting is not found in the two fungal wilt diseases. Plant clean, rooted cuttings in steamed soil as no chemical treatment is yet available. Stock plants should be tested for the disease if there is any suspicion of infected cuttings being introduced.

Stem rot and die-back *(Fusarium culmorum (F. roseum)).* The fungus can occur as a soil saprophyte both within and outside the greenhouse. It rots the base of the stem and sometimes branch stems. Woody tissues are not extensively discoloured. The pathogen often invades the stumps left when shoots are removed or flowers cut at an internode, causing die-back in the stem: the stem should therefore be cut at the node. A basal rot of cuttings may occur if they are taken from contaminated plants. Spray stock plants with captan [*94 g/100 l*] before and after cuttings are taken, propagate in sterile rooting media and plant in steam-

sterilised soil. Routine sprays may be applied every 10-14 days. If established plants are attacked, remove infected shoots and spray with captan every 7-10 days.

Celery (self blanching) (STL 169)

Pests

Aphids. These insects may infest the crop at all stages of development. Attacks early in the crop may be controlled with HV sprays of diazinon, or gamma-HCH or ULV sprays of dimethoate. Later in the season use HV sprays of malathion, or heptenophos or pyrethrum/resmethrin; or ULV sprays or fogs of pyrethrum/resmethrin; or smokes of gamma-HCH or nicotine shreds. Rates and harvest intervals are as shown in Table 12.18 (p. 454).

Carrot fly *(Psilla rosae)* (L 68). The larvae feed on the roots and young plants may be stunted or killed. Control with soil drenches of diazinon [*50 g/100 l*] using 130 ml/plant, or gamma-HCH [*50 g/100 l*] using 140 ml/plant, within a week of planting out.

Celery fly *(Philophylla heraclei)* (L 87). This pest is also known as celery leaf miner. The larvae feed in the leaves causing large blisters. Control with HV sprays of gamma-HCH [*25 g/100 l*], or malathion [*282 ml/100 l*], or trichlorphon [*400 g/ha*] with harvest intervals of 14, 4 and 2 days respectively. Alternatively, ULV sprays of malathion [*see label*] can be used with a 2-day harvest interval.

Slugs (L 115). Control using one of the compounds listed in Table 12.20 (p. 463).

Diseases

Damping-off *(Artotrogus hydrosporus (Pythium artotrogus), Pythium* spp., *Rhizoctonia solani (Thanatephorus cucumeris)).* This is the main disease of seedlings. Patches of seedlings collapse and are easily pulled out to reveal shrivelled and sometimes reddish-brown roots. Propagate in sterilised compost and avoid overwatering. Chlorothalonil/etridiazole mixture [*see label*], or etridiazole [*14-26 g/m²*] may be incorporated into seed compost, or seedlings may be drenched with etridiazole [*175 g/100 m²*], or cupric ammonium carbonate [*10·5 g/100 l*], or zineb [*105 g/100 l*].

Grey mould *(Botrytis cinerea).* The fungus colonises damaged petioles and covers them with clusters of grey spores. Infected tissue rots and eventually the leaf stalk collapses. High humidity encourages the disease. For control spray with benomyl or carbendazim every 14 days, as in Table 12.8 (p. 411), unless the fungus becomes insensitive to these compounds, when chlorothalonil or thiram [*320 g/100 l*] may give some control.

Leaf spot *(Septoria apiicola)* (L 241)[12]. This disease causes brown spots on leaves and stems and can be damaging if left unchecked, especially if overhead

Table 12.8 Celery—leaf spot

Compound	*Application rate*	*Minimum harvest interval*
1. HV Sprays	*(g/100 l)**	*days*
benomyl†	5·5 *g/100 m²*	0
carbendazim	50	0
chlorothalonil	15 *g/100 m²*	7
copper oxychloride	250	0
cupric ammonium carbonate	50–80	0
zineb	140–150	2
2. LV Sprays		
benomyl†	5·5 *g/100 m²*	0
carbendazim	5·6 *g/100 m²*	0
3. Atomisations		
copper oxychloride	see manufacturer's instructions	0
mancozeb/zineb mixture		2
zineb		2

* — unless otherwise stated.

† — first 2 sprays with an alternative chemical (not carbendazim) then alternate in subsequent applications.

damping is used. Infected seeds are the primary source of inoculum and spores, splashed from pycnidia in leaf lesions, spread the infection within the crop. The best method of control is to use seeds which have been soaked for 24 hr in an agitated suspension of thiram [*250 g/100 l*] maintained at 30°C. After treatment the seeds should be dried.

Also, for continued protection use one of the compounds listed in Table 12.8 (p. 411) every 14 days.

Root and crown rot *(Phoma apicola).* This is a root rot of seedlings which may occasionally cause losses of the same order as damping off diseases. The disease typically causes a wilting of outer leaves which sometimes progresses to kill the plant. Brown or black lesions are found at the base of the stem. The disease can be seed- or debris-borne and is spread by water splash. Use thiram soaked seed. Good hygiene particularly in the disposal of old crop debris and sterilisation of the soil are the most effective means of avoiding the disease. There are no pesticides with recommendations for this disease.

Sclerotinia rot or pink rot *(Sclerotinia sclerotiorum)* (L. 265). The first symptoms of this important disease are usually seen as pink lesions at the base of leaf stalks. The lesions become covered with a white, fluffy growth within which the black sclerotia (resting bodies) are formed. These sclerotia can remain viable

Table 12.9 Information on the effect of some insecticides on certain varieties of chrysanthemum.

Insecticide	*Method of application*	*Remarks*
carbaryl	HV	Not on Delmarvel. Care on other varieties.
diazinon	HV	Not on Fred Shoesmith.
dicofol	Smoke	Not on Bluechip
dichlorvos	HV or Atomisation	Not on Bonnie Jean, Dawn Star, Iceberg, Pink Champagne, Shasta, Taffeta, Vanguard, William Row. Do not use on open blooms
dicofol/tetradifon	Atomisation	Not on Fandango, Red Fandango.
dimethoate	HV or Atomisation	Not on most varieties.
formothion	HV	Not on most varieties.
malathion	HV	Do not use on open blooms.
malathion	Atomisation	Do not use on plants in bud or bloom.
pirimiphos-ethyl	Granules	Safe on Golden Anne, Gay Anne, White Anne, Wedgewood and Garland.
propoxur	Smoke	Safe on Hurricane, Yellow Hurricane, Bluechip, Rosechip, Promise, White Hope Valley, Princess Anne and sports, Aramis, Woking Scarlet, Louise, Polaris, Fandango, Heyday, BGA Tuneful.

in the soil for several years and it is important to remove and destroy all infected plant debris and sterilise the soil by steam or methyl bromide (see Introduction) after an infected crop. Fortnighly high volume sprays of benomyl, carbendazim or chlorothalonil as for celery leaf spot, Table 12.8 (p. 411) will give some protection.

Chinese cabbage

Disease

Bacterial rot *(Erwinia carotovora* pv. *atroseptica).* The disease usually results from water stress. Outer leaves that wilt because of water shortage can become infected and develop water soaked lesions followed by a light brown slimy rot. Whole plants may become affected leading to wilting and collapse. Heart leaves may develop glassiness as a result of excess or insufficient water. Bacterial invasion of this tissue can lead to necrosis which often progresses to a complete heart rot. Other unknown factors may also influence the onset of bacterial rotting.

Attention to watering, avoiding high temperatures and humidity, will help to reduce the risk of infection. Careful disposal of debris will reduce the source of infection.

Chrysanthemum (MAFF Bull. 92)[13]

There are marked differences in the susceptibility of chrysanthemum varieties to pests and diseases, and in their tolerance to pesticides (see Table 12.9, p. 412). When there is any uncertainty, e.g. with a new variety or new pesticide, always check for phytotoxicity on a small batch of plants before extensive use.

Integrated control

Aldicarb resistance in aphids and red spider mites reduces the value of this pesticide as a simple means of controlling chrysanthemum pests. Growers seeking an alternative should consider integrated control. Advice may be obtained through ADAS.

Pests (STL 122)

Angleshades moth *(Phlogophora meticulosa).* Moths are often attracted by the supplementary lighting used in chrysanthemum culture. They lay eggs on the plants and the caterpillars of this and other Noctuid moths feed on foliage and flowers. For control measures see Carnation—tortrix, p. 406. *Bacillus thuringiensis* and diflubenzuron are ideal for integration with biological control since they will not harm natural enemies. See also Table 12.9 (p. 412).

Aphids. These insects are common on chrysanthemums and are probably the most injurious pest; not only do they secrete honeydew, on which sooty moulds develop, and reduce plant vigour by sucking the sap but they may also transmit virus disease. Greenhouse chrysanthemums are attacked by several species of aphid. The most important is the peach-potato aphid *(Myzus persicae)* whose wingless form is green to greenish-yellow. Others include the mottled arum aphid *(Aulacorthum circumflexum)*, which is yellowish-green with a well-defined, dark, horseshoe-shaped mark on the abdomen; the chrysanthemum stem aphid *(Macrosiphoniella sanborni)* which is a shiny mahogany coloured species; and the leaf-curling plum aphid *(Brachycaudus helichrysi)* which is dark green and lives in the crown of the plant. Recently a dark green to black aphid, possibly *Aphis gossypii* or *A. fabae*, has become prominent.

Control measures may be complicated by varying patterns of resistance in *M. persicae* and, where this aphid is a problem, biological control using the parasite *Aphidius matricariae* can be very effective (see p. 385). Chemical control methods are listed in Table 12.3 (p. 386) (see also Table 12.9, p. 412) and treatments should be applied before buds open. Systemic compounds give the most persistent

protection to the foliage but compounds with good contact or fumigant action are needed to control aphids on flower buds. Demeton-S-methyl drenches have given better control than drenches of oxydemeton-methyl. Mottle arum aphid is resistant to gamma-HCH. The aphid which has recently caused problems (possibly *Aphis gossypii* or *A. fabae*) is resistant to carbamates but may be controlled with fogs or smokes of pirimiphos-methyl, or smokes of nicotine shreds as in Table 12.3 (p. 384). Tests with heptenophos [*38 g/100 l*] have proved effective against this aphid.

Broad mite *(Polyphagotarsonemus latus)*. Distortion of flowers and other symptoms are caused by this pest (see Sweet pepper, p. 449). Dicofol [*30 g/100 l*] will control the pest, but some cultivars may be sensitive.

Capsid (Tarnished plant bug) *(Lygus rugulipennis)*. Capsids are only occasionally found on greenhouse chrysanthemums, though they are becoming more common where biological control is practised. The bugs feed on stems, leaves and flowers causing puckered, mis-shapen leaves, distorted stems and small, malformed flowers. Very occasionally *Lygocoris pabulinus* and *Calocoris norvegicus* cause similar damage. Control with HV sprays of diazinon [*16 g/100 l*], or gamma-HCH [*12·5 g/100 l*], or permethrin/thiram [*4 g + 25 g/100 l*]; or use ULV sprays of gamma-HCH; or use smokes of gamma-HCH, or tecnazene/gamma-HCH following the manufacturer's labels; or treat the soil with aldicarb [*45 g/100 m²*]. See also Table 12.9 (p. 412).

Earwig *(Forficula auricularia)*. For description see Carnation—earwig (p. 406). Control using one of the compounds listed in Table 12.20 (p. 463).

Leaf and bud nematode *(Aphelenchoides ritzemabosi)* (L 339, L 379). This pest is very rare now that clean stock plants are widely used. The first sign of attack is yellowish-green or purple blotching on the basal leaves, often delineated by veins. Later these blotches darken and become desiccated.

Plants should be propagated from nematode-free stock. Stool beds can be treated with aldicarb granules [*56 g/100 m²*] at the onset of a flush of new cuttings. Allow 14 days after treatment before taking cuttings.

Leaf miner *(Phytomyza syngenesiae)* (L 550). This is often a troublesome pest because resistance to insecticides is widespread. The larvae of this small fly disfigure the leaves by eating tunnels (mines) in the leaves. Control with the compounds listed in Table 12.3 (p. 350) and see Table 12.9 (p. 412). Strains resistant to diazinon and gamma-HCH have been observed. Alternatively, treat the soil with aldicarb [*56 g/100 m²*].

Another species of leaf miner *(Liriomyza trifolii)* may become troublesome in the UK where it is a notifiable pest. Unlike *P. syngenesiae*, this species will feed on several crops, including tomatoes, and is resistant to many pesticides. Apply HV sprays of permethrin [*see product label*] 3 times at 4-day intervals, followed by further sprays every 6 days until the miners are controlled.

Red spider mite *(Tetranychus urticae)* (L 224). Red spider mite is a frequent and troublesome pest made more serious by the use of supplementary lighting which inhibits the normal winter diapause. For a description see Cucumber—red

spider mite (p. 420). The mites remain on the underside of leaves then migrate up to the opening buds which they damage. Therefore, mites should be controlled before the buds open using compounds listed in Table 12.3 (p. 350) (but also see Table 12.9, p. 412) or with HV sprays of petroleum emulsion [*1 l* (product)*/100 l*], or ULV sprays of dicofol [*see label*], or dicofol/tetradifon [*see label*]. Organophosphorus compounds do not kill eggs so re-treat 7-10 days later. Complete coverage of the leaves must be obtained when using contact acaricides. Biological control using the predatory mite *Phytoseiulus persimillis* is now a more attractive alternative to aldicarb because of widespread resistance (see p. 384).

Slugs (L 115). These may only be a problem in greenhouses where regular hygiene measures have been neglected or where slugs have gained entry from uncultivated land adjoining greenhouses. See Table 12.20 (p. 463).

Stool miner *(Psilla nigricornis)*[14]. This pest is rare now that clean stock plants are widely used. The larvae tunnel into the stools and reduce cutting production. They may be controlled by thorough sprays of gamma-HCH [*10 g/100 l*] or diazinon [*16 g/100 l*] in early May and again in early September. See Table 12.9 (p. 412).

Symphylid *(Scutigerella immaculata)* (L 484). For description see Tomato—symphylid (p. 456). Control using one of the compounds listed in Table 12.20 (p. 463).

Thrips[7]. For description see Carnation—thrips (p. 404). Control measures are listed in table 12.3 (p. 350), but see also Table 12.9 (p. 412).

Whitefly *(Trialeurodes vaporariorum)* (MAFF Bull. 86). This is rarely a serious pest since it does not breed well on chrysanthemums. For description see Cucumber—whitefly (p. 423). Chemical control is complicated by resistance of whitefly strains to many insecticides. The frequency of application must be related to the kill of various stages of this pest. Thus, if adults only are killed, treatments should ideally be repeated more frequently (every 3 days) than if larvae are also killed. Treatments are listed in Table 12.3 (p. 350), but see also Table 12.9 (p. 412).

Diseases

Blotch *(Septoria chrysanthemella)*[15]. Blotch is an uncommon disease causing circular, grey-brown leaf spots on older leaves. In severe cases, leaves may turn yellow and fall. To control, increase ventilation and HV spray with zineb [*140 g/100 l*].

Brown rust *(Puccinia chrysanthemi)*[19]. Rust is an uncommon disease which attacks the leaves under humid conditions causing yellowish spots on the upper surfaces and, later, rusty, spore-bearing pustules on the undersides. Apply oxycarboxin [*56-94 g/100 l*] as a fine spray to, but not beyond run-off, or as a fog [*14 g/100 m*^{3}], or thiram [*320 g/100 l*] or zineb [*140 g/100 l*] as HV sprays. Zineb may also be applied as a dust [*17·5 g/100 m*^{3}] or atomised according to the manufacturer's instructions. These treatments should be applied when the disease first appears and repeated every 10-14 days. Formulations containing thiram,

with petroleum oil and permethrin are also effective and give simultaneous control of capsids, caterpillars, powdery mildew and red spider mite.

Crown gall *(Agrobacterium tumefaciens).* Tumours may be found on the roots or above ground but more commonly large developments of callous-like tissue are found at the base of the stem at soil level. Affected plants may be stunted. The bacterium can survive for long periods in debris. Destroy affected plants, taking cuttings only from healthy mother stock plants. Use sterilised soil and pay attention to hygiene particularly in the disposal of debris.

Damping-off *(Pythium* spp., *Phytophthora* spp. and *Rhizoctonia solani (Thanatephorus cucumeris)).* This disease of young plants is associated with poor hygiene and failure to sterilise the soil. Beds and compost must be steam sterilised after an infected crop. Incorporate into compost or drench soil with etridiazole or etridiazole + chlorothalonil mixture or fosetyl-aluminium or propamocarb as shown in Table 12.4 (p. 390), to control Pythium. If damping-off is caused by Rhizoctonia, incorporate quintozene [*150 g/m*^{3}] into compost, or soil surface.

Grey mould *(Botrytis cinerea).* This fungus causes spotting and rotting of buds and flowers especially if dew is allowed to form on the plants. Losses may also be serious due to infection of leaves and stems, especially in bench-propagated cuttings and in stock plants after cuttings have been taken. Botrytis flower-rot may be distinguished from petal blight and ray blight by masses of grey spores. In humid weather, at bud burst, apply one of the materials in Table 12.5 (p. 392), as a fine mist. If infection has already occurred, remove diseased plants promptly and apply one of the spray, dust or smoke treatments in Table 12.5 (p. 392) and repeat if humid conditions persist. Stock plants should be similarly treated before cuttings are taken to reduce infection during propagation. Cuttings may be drenched or dipped before striking in compost with benomyl or carbendazim or thiophanate-methyl unless insensitive *Botrytis cinerea* is known to be present on the nursery. Alternatively, cuttings and the surface of the rooting medium may be drenched with thiram, or dicloran may be incorporated into compost as in Table 12.5 (p. 392).

Leaf gall *(Corynebacterium fasciens).* Affected plants have a proliferation of short thickened shoots at the stem base. It is an infectious disease which is easily spread during propagation. Mother stocks can be infected by hands when taking cuttings. In the cropping beds water splash is probably the main means of spread. Use healthy mother stock plants. Remove and destroy infected plants carefully. Sterilise the soil with steam or methyl bromide between crops.

Petal blight *(Itersonilia perplexans)*[16,17]. This disease is rare on heated crops and is associated with high humidity and water films which persist on petals overnight. Coalescing, reddish-brown spots usually appear on the tips of the petals and a rot gradually extends inwards to affect the whole bloom. The sporulating fungus appears as a dull, white sheen on the rotted petals. Control is best achieved by ventilating and heating because flowers are sensitive to chemicals. Alternatively, spray tank-mixed zineb [*125 g* zinc sulphate + *176 g* nabam (93%)*/100 l*], or with maneb [*160 g/100 l*], or zineb [*140 g/100 l*] as a fine

mist, or spray LV with zineb [*67·5 g/l*], or dust with zineb [*17·5 g/100 m³*]; chlorothalonil [*108 g/100 l*] has also given useful results. In humid conditions, repeat applications every 7 days.

Phoma root rot *(Phoma chrysanthemicola).* The plants are stunted or killed by severe rotting of roots and, ultimately, of the base of the stem. Lower leaves show chlorotic and necrotic areas. Cultivars differ markedly in susceptibility. Soil sterilisation with steam will avoid the disease. Soil drenches with 8-hydroxyquinoline [*14 g/100 l*] or nabam [*see label*] may give some control.

Powdery mildew *(Oidium chrysanthemi).* This disease is first seen as whitish patches on the upper sides of young leaves and progresses in severe cases to cover and disfigure upper and lower leaf surfaces and even stems. Apply an appropriate spray from Table 12.5 (p. 392), or vapourise (without risk of ignition) pure sulphur [*14 g/100 m³*] every 7–14 days, or every night [*1·7–3·5 g/100 m³*].

Ray blight *(Didymella chrysanthemi (Mycosphaerella ligulicola))*[18]. Infections occasionally arise on flowers, stems or lower leaves. In contrast to petal blight, the inner florets are attacked first; the infection spreads outwards to distort the flower and causes a dark brown rot. More commonly, stems and lower leaves of cuttings and young plants may become stunted with black-brown lesions. Cultivars vary markedly in susceptibility. Remove infected plants and keep the remainder as dry as possible. Spray HV every 7–10 days with captan [*94 g/100 l*] or chlorothalonil [*110 g/100 l*] or zineb [*140 g/100 l*] or apply captan as an LV spray [*46 g/l*] or atomise a mancozeb/zineb mixture or zineb according to the manufacturer's instructions. Benomyl, applied as a dip [*50 g/100 l*], may also give some control of the disease. Sterilise the soil by steaming following an infected crop.

Sclerotinia rot *(Sclerotinia sclerotiorum).* Light brown lesions occur on the stem usually about 10–20 cm above soil level. These lesions often rapidly develop, girdling the stem and causing the plant to wilt. Under humid conditions a dense white fluffy mould develops. Large (0·5–2 cm in diameter) irregularly shaped sclerotia develop in this mould or more frequently in the pith. Remove affected plants carefully to avoid dropping sclerotia. High volume sprays of vinclozolin [*50 g/100 l*], or iprodione [*50 g/100 l*], or chlorothalonil [*81 g/100 l*] or a benzimidazole fungicide may give some protection to plants. Hygiene may need to be improved if the disease regularly occurs on a nursery. Sterilise soil with steam or methyl bromide.

White rust *(Puccinia horiana)*[20]. This disease is endemic in other parts of Europe but not in the UK. Recently, many outbreaks have occurred in the UK and strict measures have been taken to eradicate the disease.

Small, white blisters appear on the underside of leaves 2–4 weeks after infection and erupt to release light brown spores. The rust is favoured by periods of high humidity and the greatest danger of infection is in March–April and September–October; any factor which tends to increase humidity, such as the use of overhead spray lines or tightly-sealed thermal screens/blackouts should be avoided, particularly during these danger periods.

In periods of high risk, or if an outbreak has occurred nearby, apply oxycarboxin as HV sprays [*56-94 g/100 l*], or fogs [*14 g/100 m²*], or zineb HV [*140-25 g/100 l*] every 10-14 days until the threat ceases. Chemicals may cause damage so sprays should be applied as described for brown rust. Atomised mancozeb/zineb mixtures [*see label*], applied to control ray blight, will also give some protection against white rust.

If white rust infection is confirmed, the MAFF Plant Health and Seed Inspectors must be informed: *in situ* destruction of plants or marketing restrictions may be necessary.

Verticillium wilt *(Verticillium albo-atrum).* This only occurs very rarely if soil sterilisation has been effective, but it may be introduced on infected cuttings. The lower leaves turn yellowish-brown and discolouration of foliage progresses upwards; the plants are stunted and woody and in severe cases wilting occurs. Routine soil sterilisation is essential for control. If infection occurs, completely remove infected plants and drench the surrounding soil with benomyl, carbendazim or thiophanate-methyl as in Table 12.5 (p. 392).

Cineraria

Pests

Aphids *(Myzus persicae, Aulacorthum circumflexum, A. solani* and *Aphis gossypii).* Control using compounds listed in Table 12.3 (p. 386) but do not use products containing formothion. Do not exceed the dose for aldicarb. Drenches of demeton-S-methyl or oxydemeton-methyl have been successfully applied to cinerarias but should be used with care and not in hot bright weather. *Aulacorthum circumflexum* is resistant to gamma-HCH.

Leaf miner *(Phytomyza syngenesiae)* (L 550)—see Chrysanthemum—leaf miner (p. 414). Do not exceed the dose for aldicarb.

Whitefly *(Trialeurodes vaporariorum)* (L 86). Use compounds listed in Table 12.3 (p. 386). Do not exceed the dose for aldicarb.

Diseases

Grey mould *(Botrytis cinerea).* The fungus attacks flowers, leaves and stems; for control measures see Table 12.5 (p. 392).

Powdery mildew *(Sphaerotheca fuliginea).* For control measures see Table 12.5 (p. 392), avoiding, if possible, applications during hot, bright weather.

Courgette and marrow

Diseases

Grey mould *(Botrytis cinerea).* Extensive losses can be caused by this fungus under suitable conditions of high humidity and cool weather. The disease usually

attacks the flowers and developing fruit causing flower abortion and fruit rotting. It may also attack stems and leaves and may cause the collapse of whole plants if lesions are low down the stem. Avoid high humidity, if possible by heat and ventilation, and reduce damage to the plants during picking and trimming. Although there are no fungicides with recommendations for control of the disease on these crops imazilil, as used for control of powdery mildew, will also give some control of grey mould.

Powdery mildew *(Erysiphe cichoracearum).* In the warm humid conditions of late summer and the autumn the disease can spread rapidly causing loss of photosynthetic leaf area and premature death of plants. Spots of white powdery mould are first seen and these soon coalesce to completely cover the leaf surface. Affected leaves desiccate and hang dead on the plants. High volume sprays of quinomethionate [*12·5 g/100 l*], or bupirimate [*25 g/100 l*], or imazalil [*10 g/100 l*] should be used at 10-14 day intervals as soon as the disease is seen. Lower humidity if possible. Destroy affected debris at the end of the crop.

Cucumber and melon

Pests

Aphid *(Aphis gossypii).* This aphid varies in colour from yellowish-green to black and feeds on foliage causing yellowing, and on fruitlets which become distorted or fail to develop. Suitable control measures (Table 12.10, p. 420) depend on the stage of growth and season. Malathion may damage soft plants.

Clover mite *(Bryobia* spp.*)* (L 305). Clover mites sometimes invade cucumber houses from clover and grasses in February and March and cause damage to foliage and fruit. Control using products containing dicofol, see Table 12.10 (p. 420).

French-fly *(Tyrophagus longior).* This is a glistening-white globular, sluggish mite with prominent bristles, commonly occurring in straw and undecomposed horse manure. It is, therefore, only troublesome when traditional methods of culture are used. It migrates from beds and feeds on and within the leaves of the shoot tips of young plants, causing irregular perforations in the leaves, distortion and sometimes blindness of the shoots. It does not reproduce on cucumbers.

To control, spray the plants, especially growing tips, with pirimiphos-methyl [*25 g/100 l*] as soon as damage is seen and not later than 3 weeks before cutting.

Fungus gnats (root maggots) *(Sciara* spp.*)* (STL 110). The larvae are about 6 mm long with black heads and creamy translucent bodies. They are common in beds containing horse manure, and occasionally attack the large roots and stem bases of cucumbers in beds, especially if the beds become too dry. They also destroy young plants in pots. To control, use one of the compounds listed in Table 12.10 (p. 420).

Leafhopper *(Zygina pallidifrons).* For a description of this pest see Tomato-leafhopper (p. 453). Control with HV sprays of carbaryl [*77 g/100 l*], or

Table 12.10 Cucumber—aphid, red spider mite, thrips and whitefly

See Integration, p. 462

Compound	Application rate	Minimum harvest interval	Active against				Effect (where known) on			
							Phytoseiulus		Encarsia	
			Aphid	Red spider mite	Thrips	Whitefly	Eggs	Adults	Pupae	Adults
1. HV Sprays	*g/100 l*	*days*								
deltamethrin	1·75	0	Yes	—	Yes	Yes◇	H	H	H	H
demeton-S-methyl†△	22	21	Yes*	Yes*	—	—	H	H	S	H7
diazinon	16	14	Yes*	Yes*	Yes	Yes*ø	—	H	H	H7
dicofol	9·3	2	—	Yes*	—	—	—	H	S	S
dicofol/tetradifon‖	40/12·5	2	—	Yes*	—	—	I	I	—	I
dimethoate	34	7	Yes*	Yes*	—	—	H	H	H	H>7
fenbutatin oxide	25	3	—	Yes	—	—	S	S	S	S
malathion	114	1	Yes*	—	—	Yes*ø	H	H10	H	H10
nicotine	112	2	Yes	—	—	—	—	I<4	S	H<4
oxydemeton-methyl†△	22	21	Yes*	Yes*	—	—	—	H	—	—
parathion§△	10	28	Yes*	Yes*	—	—	H	H14	H14	H
permethrin∫△	‡	0	—	—	Yes	Yes◇	—	H	S	H
permethrin/thiram	4/25	0	Yes	—	Yes	Yes	—	—	—	—
petroleum emulsion	‡	0	—	Yes	—	—	S	I	I	I
pirimicarb△	25	2	Yes	—	—	—	S	S	S	I
propargite	43	1	—	Yes	—	—	H	—	I	I
pyrethrum/resmethrin∫	‡	0	Yes	Yes	—	Yes◇	H	H<4	—	H<4
rotenone	6·25	1	Yes	Yes	—	—	I	H	S	H1
tetradifon∫	10	0	—	Yes*	—	—	S	S	S	S

2. Atomisation										
dicofol‖	‡	2	—	Yes*	—	—	H2	S	S	S
dicofol/tetradifon	‡	2	—	Yes*	—	—	H2	S	S	S
dimethoate†	‡	7	Yes*	—	—	—	H	H24	I	H14
permethrin	‡	0	Yes	—	—	Yes	H	H28	H	H21
pyrethrum/resmethrin	‡	0	Yes	Yes	—	Yesø	H	H7	S	H3
resmethrin∆	‡	0	Yes	—	—	Yesº	H	H7	S	H3
3. Smokes (S) and Fogs (F)	*g/100 m³*									
dicofol (S)	‡	0	—	Yes*	—	—	—	—	—	—
nicotine (S)	16	0	Yes	—	Yes	—	S	S	S	H
permethrin (F)	‡	0	—	—	—	Yesº	—	H	—	H>15
permethrin (S)	‡	0	—	—	—	Yes	—	—	—	—
pirimicarb (S)	‡	0	Yes	—	—	—	—	—	—	—
pirimiphos-methyl (S)	‡	0	Yes	—	—	Yesø	—	—	—	—
pirimiphos-methyl (F)	‡	0	Yes	Yes	Yes	Yesº	—	H	H	H16
propoxur (S)	‡	2	Yes	—	—	Yesø	—	H8	S	—
pyrethrum/resmethrin (F)	‡	0	Yes	—	—	Yesø	—	—	—	H

* — possibility of encountering resistant insects.
† — systemic compound.
‡ — see product label.
§ — max. 3 applications/season.
‖ — treat during summer only.
∫ — risk of hardening young plants; spray infested leaves only.
ø — kills adults only.
º — kills adults and larvae.
∆ — young plants may be treated.
H — harmful (>7—harmfulness persists for more than 7 days).
I — intermediate.
S — safe.

malathion; or with nicotine shreds [*16 g/100 m*³]. Malathion may damage soft plants.

Millepede (glasshouse) *(Oxidus gracilis)* (L 150). The glasshouse millepede is common in cucumber houses, and when numerous, destroys plants by feeding on the soft tissue of the stem base and larger roots. It is unlikely to be a problem where the soil has been sterilised before planting or where a soil-less method of culture is used. To control this pest, see Table 12.20 (p. 463).

Red spider mite *(Tetranychus urticae)* (L 224). This is a serious pest. Adult mites of this species hibernate within the greenhouse and emerge in spring as the temperature increases. They feed on the undersides of leaves and lay eggs which hatch within a few days producing whitish-pink globular larvae (with three pairs of legs) which pass through 3 nymphal stages to become greenish oval adults. The complete life cycle takes 24 days at 15°C or 6½ days at 30°C.

In autumn, mites tend to migrate towards the greenhouse structure as the plants become too hard for them to feed on. Therefore, prevent or reduce the hibernation of adult mites by removing old crops before mid September (while the mites are still on them) together with all weeds.

Strains of mites resistant to acaricides occur more frequently on infested cucumbers than on other crops. Therefore it is advisable to vary the type of chemical used and to spray HV to cover upper and lower leaf surfaces. Alternatively, use biological control.

Suitable chemical control measures (Table 12.10, p. 420) depend on the age of the plants and season. Organophosphorus compounds do not kill the eggs and further treatments may be required at intervals of 5-10 days.

Root-knot nematodes *(Meloidogyne hapla* and *M. incognita)* (L 307). These nematodes cause swollen, gall-like growths on the roots which reduce the vigour of the plants and greatly decrease cropping. Attacks are most serious at high temperatures in light soils and, for control, the borders should be steam-sterilised or treated with dichloropropene or methyl bromide (see Introduction, p. 376). When the attack is endemic on young plants, drench the soil once with parathion [*6 g/100 l*] (*500 ml/plant*), allowing 4 weeks between treatment and harvest.

Springtails *(Collembola* spp.)[121]. The adults of the species in cucumber beds are about 3 mm long and dark grey: often the young stages are lighter in colour. They occasionally occur in large numbers in beds and may injure plants by feeding on the roots. They are unlikely to be a problem where soil-less culture is used. To control, use one of the compounds listed in Table 12.20 (p. 463).

Symphylid *(Scutigerila immaculata)* (L 484). This insect occasionally attacks cucumbers checking growth and making the roots susceptible to fungal attack. It is unlikely to cause problems where soil-less culture is used. If uninfested soil is used for beds, gamma-HCH [*12·5 g/100 l*] (1·5 l/m² bed) is likely to insure against invasion. If infestation occurs, control using one of the compounds listed in Table 12.20 (p. 463). Symphylids are unlikely to be a problem where soil has been sterilised before planting.

Thrips *(Thrips tabaci* and *T. fuscipennis)*[7]. Thrips are increasingly important

pests of cucumber. They damage plants by feeding on leaves and flowers and are detected by small irregular white marks on the leaves. Control using compounds listed in Table 12.10 (p. 420). When biological control is practiced, soil drenches (5 l/m run) of diazinon [*30 g/100 l*] or gamma-HCH [*12·5 g/100 l*] may be used but diazinon may damage soft plants, and gamma-HCH should not be used in conjunction with biological control of whitefly early in the season, when ventilation is insufficient to allow harmful vapours of this pesticide to disperse. Allow 2 days between diazinon treatment and harvest but no interval is necessary with gamma-HCH. Thrips are less likely to be a problem where the soil has been sterilised before planting or where a soil-less method of culture is used. Spraying polythene covered floors between rows of plants with deltamethrin in polybutene has been successful in combating the pest.

Whitefly *(Trialeurodes vaporariorum)* (L 86). These small (4 mm) white, moth-like insects are serious pests which normally rest on the undersides of leaves where the conical eggs are laid erect. The larvae are scale-like and after two days, immobile. Sooty moulds grow on the honeydew secreted by all whitefly stages. With large whitefly populations, the mould disfigures the fruit. Many whitefly strains have developed resistance to pesticides and therefore biological control (see p. 384) or different insecticides must be used. Treatments are listed in Table 12.10 (p. 420) but note that malathion may damage soft plants. The frequency of application must be related to the kill of the various stages of the pest. Thus, if adults only are killed, treatments should be repeated more frequently (every 3 days) than when larvae are also killed. Whitefly adults may multiply or overwinter on weeds outside the greenhouse, so site hygiene can be an important factor in whitefly control.

Woodlice *(Armadillidium* spp., *Oniscus* spp., *Porcellio* spp., *Trichoniscus* spp.*)*. Woodlice damage cucumbers by gnawing stems and lower leaves. Control using one of the compounds listed in Table 12.20 (p. 463). Methiocarb granules have also been used successfully [*2·2 g/100 m²*] (harvest interval 7 days). Applications should be made to the bales, to the crevices between the greenhouse structure and the soil in which woodlice hide, and beneath the polythene sheeting used in soil-less culture systems. Woodlice should not be a problem where soil has been sterilised before planting.

Diseases

Anthracnose *(Colletotrichum lagenarium)*. This disease results in pale green or reddish-brown spots which enlarge until the whole leaf withers. The fungus also attacks stems and causes pink depressions which develop into black spots. Spray HV with wettable or colloidal sulphur [*150 g/100 l*], or dust with sulphur [*220 g/100 m²*].

Basal stem rot *(Erwinia carotovora)*. This is a slimy soft-rot of the stem occurring at soil level. To control, apply copper dust heavily to the stems at soil

Table 12.11 Cucumber—grey mould and powdery mildew

Compound	Application rate: Grey mould	Application rate: Powdery mildew	Minimum harvest interval	Approximate frequency of application	Remarks	See Integration, p. 462 Effect (where known) on: Phytoseiulus: Eggs	Phytoseiulus: Adults	Encarsia: Pupae	Encarsia: Adults
1. HV Sprays	*(g/100 l)*		*days*	*days*					
benomyl*	25	25	0	28	First 2 sprays with a chemical other than carbendazim or thiophanate-methyl then alternate in subsequent applications.	H	H	—	S
bupirimate	—	50	2	14		—	I	—	S
carbendazim*	25	25	0	14-28	Commence 3 weeks after planting.	—	I	—	S
chlorothalonil	110	—	0·5	7-14		—	S	S	S
cupric ammonium carbonate	—	21	0	14	Copper fungicides can be added petroleum emulsion dilution. See Table 12.10.	—	S	—	I
dinocap	—	12·5	2	10-14	Slightly incompatible with petroleum oil.	—	S	—	H
fenarimol	—	1·1-2·2	2	7-14	Preventative treatment—lower rate every 14 days. If disease occurs spray twice at 7-day intervals using higher rate.	—	—	—	—

imazalil	—	10	1	7-14	Do not spray in full sunshine.	I	S	—	I
iprodione	50	—	2	14		S	S	—	S
pyrazophos	—	15	3	10-14		H	I	—	H
thiophanate-methyl*	—	100	0	28		H	S	—	S
2. LV Spray	*(g/l)*								
dinocap	—	12·5	2	10	Slightly incompatible with petroleum oil.	—	—	—	—
3. Smoke									
dicloran	†	—	2	†	Use only on established plants	—	—	—	—
4. Atomisation									
copper oxychloride	—	†	0	10-14		—	—	—	—
5. Drench	*(g/100 l)*								
carbendazim*	18·8-25	18·8-25	0	14-28	Apply 570 ml/plant in place of watering.	—	—	—	—
thiophanate-methyl*	—	100	0	28	First application 3 weeks after planting; 500 ml/plant.	—	—	—	—

* — races of the pathogen insensitive to these fungicides may occur.
† — see product label.

H — harmful (>7—harmfulness persists for more than 7 days).
I — intermediate.
S — safe.

level. 8-hydroxyquinoline applied as a soil drench [*14 g/100 l*] may have some effect. Keep the base of the stem dry, especially with melons.

Black root rot *(Phomopsis sclerotioides)*[22]. This is a very common root disease which rots smaller roots, followed by the tap root and hypocotyl. Similar symptoms are less commonly caused by Fusarium and Pythium, but Phomopsis attack is characterised by black spotting on small roots and black lesions on larger roots and hypocotyls below ground. Typically the stem base thickens and occasionally, greyish lesions extend above ground level. In cold soil, where root growth is slow, rotting may be severe and black lesions may not develop. Regular steaming of the border soil is the most effective control; methyl bromide fumigation is only effective if soil temperatures are above 15°C and the soil not too wet. Soil drenches of carbendazim [*17·5 g/100 l*] can slow the spread of the disease but only roots within the zone penetrated by the drench appear to be protected.

Damping-off *(Pythium* spp.*)*. Within a few days of germination, the stems of seedlings may become constricted at soil level and collapse. Recently established plants may also be affected by a rot at soil level and *Pythium* spp. are also responsible for root and stem rots. Steam sterilise border and propagating soil and, if the disease is troublesome, incorporate etridiazole [*14-26 g/m*^{3}] into seed-sowing compost. If infection arises after planting, drench with etridiazole [*17·5 g/100 l*] (allow 3 days between application and harvesting) or with propamocarb [*144 g/100 l*].

Grey mould *(Botrytis cinerea)*. This disease is encouraged by high humidity and failure to remove damaged and yellowing foliage which is readily colonised by the fungus. For chemical control measures see Table 12.11 (p. 424). Painting with carbendazim or iprodione in Actipron oil may also be expected to give some control of stem lesions.

Gummosis *(Cladosporium cucumerinum)*. Gummosis is now less important because of resistance bred into modern cultivars. It causes sunken, scab-like depressions on fruit from which the sap exudes to form an amber gum. Fruits are often distorted, especially if infected when young. Remove all diseased fruits and reduce humidity, if possible, by heating. Spray with chlorothalonil [*110 g/100 l*], or zineb [*140 g/100 l*] and repeat at intervals of 10 days while the disease persists, or dust at intervals of 7 days with zineb [*17·5 g/100 m*^{3}]. Allow 12 hours after chlorothalonil or 2 days after zineb application before cutting.

Powdery mildew *(Sphaerotheca fuliginea)*. This is the most important fungal disease of cucumber. A white, powdery mould forms on both surfaces of the leaves causing chlorotic spots which spread and desiccate the leaf tissue. Spores produced on cucumber are viable for only 10 days but overlapping crops provide a continuous supply of inoculum. Weeds, which may also become infected, should be removed from the greenhouse and its neighbourhood. The conditions which govern infection and spread of the disease are poorly understood. At the first sign of the disease, apply one of the treatments listed in Table 12.11 (p. 424).

Stem and fruit rot *(Didymella bryoniae (Mycosphaerella melonis))*[23]. This

disease can be damaging on some cultivars. Lesions develop on the stem, leaves and fruit. Stem lesions usually originate at pruning wounds or from infections of male flowers; fruit are infected from the blossom-end or from contact with an infected stem or leaf. On leaves, spreading, light brown patches later collapse and rot. Black pycnidia develop on the lesions and exude pinkish spore masses. Spray HV with benomyl, or chlorothalonil as in Table 12.11 (p. 424). Iprodione, applied as an HV spray, has given good results in trials.

Root rot *(Fusarium* spp.*).* Roots, especially in unsterilised compost or wet beds, are attacked causing the plant to wilt and die. To control the disease, steam the border and propagating soil and drench with carbendazim or thiophanate-methyl as in Table 12.11 (p. 424).

Verticillium wilt *(Verticillium albo-atrum).* The plants wilt and the leaves become yellow and desiccated, from the base upwards. Control is as for root rot.

Cyclamen

Pests

Aphids. *Aulacorthum circumflexum*, the mottled arum aphid, and other species which are occasionally troublesome, may be controlled with treatments listed in Table 12.3 (p. 386), but do not use products containing parathion or propoxur; *A. circumflexum* is resistant to gamma-HCH.

Broad mite *(Hemitarsonemus latus).* The mite causes distortion of flowers and bronzing of the lower leaf surfaces. For other symptoms and control measures see Sweet pepper—broad mite (p. 449).

Tarsonemid (cyclamen) mite *(Polyphagotarsonemus pallidus)* (L 558). The minute, waxy, white-brown mites feed on developing foliage causing it to become puckered, distorted, stunted and brittle. When flower buds are infested, they are either distorted or fail to open. Control with HV sprays of endosulfan [*40 g/100 l*] or dicofol/tetradifon [*40 + 12·5 g/100 l*]. Repeat applications once or twice at intervals of 28 days. Alternatively use aldicarb [*45 g/100 m²*] after potting and shortly before spacing out.

Thrips *(Thrips tabaci, T. fuscipennis, Heliothrips haemorrhoidalis)*[7]. Thrips damage foliage and flowers. Control with compounds listed in Table 12.3 (p. 386), but do not use products containing parathion.

Vine weevil *(Otiorhynchus sulcatus)*[24]. The whitish, wrinkled, legless grubs usually lie curled in the soil, and feed on the corms and roots. Prevent attack by using one of the compounds listed in Table 12.20 (p. 463).

Diseases

Grey mould *(Botrytis cinerea).* To prevent this disease avoid high humidity; plant in soil sterilised with steam or formaldehyde and at the first sign of infection apply one of the control measures listed in Table 12.5 (p. 390).

Root rots *(Thielaviopsis basicola, Cylindrocarpon destructans).* Propagate and pot using sterilised soil. Drench soil or potting compost with benomyl or carbendazim or thiophanate-methyl (Table 12.5, p. 392). Alternatively, control Thielaviopsis with captan drenches [*125 g/100 l*] after each repotting and 21 days after final potting; control Cylindrocarpon in unsterilised composts by incorporating chlorothalonil/etridiazole mixture [*see label*] or zineb [*832 g/m³*] or drenching with zineb [*140 g/100 l*].

Freesia

Pests

Aphids *(Aulacorthum circumflexum, Macrosiphum euphorbiae, Myzus persicae).* These aphids cause yellow marks on the leaves and stunt growth. *M. euphorbiae* is also a vector of freesia mosaic virus. Control with demeton-S-methyl, or diazinon, or dimethoate, or formothion, or gamma-HCH (will not control *A. circuflexum*), or malathion, or nicotine, or oxydemeton-methyl, or permethrin, or pirimicarb as described in Table 12.3 (p. 386).

Bean seed fly *(Delia platura).* This pest is occasionally serious in Guernsey. The larvae of the insect enter and feed on the embryo corm, causing the seedlings to lack vigour and develop a bluish tinge. Control with thorough drenches of gamma-HCH [*25 g/100 l*] at the first sign of damage.

Bulb mites *(Rhizoglyphus echinopus).* Bulb mites do not appear to initiate damage but gain entry on mechanically damaged or diseased tissue where they multiply rapidly. Symptoms develop after lifting mainly under warm storage conditions. Soft areas of brown loose tissue become evident and extend rapidly, sometimes to the whole of the corm. Unusually the pest causes serious damage to a stock, more typically a low percentage of corms is destroyed. Removing damaged and rotting corms in the store will reduce the risk of spread. Empty stores should be thoroughly cleaned before restocking.

Red spider mite *(Tetranychus urticae)* (L 224). This pest is rarely found on freesias and may be controlled with compounds listed in Table 12.3 (p. 386).

Slugs (L 115). Control as for Tomato—slugs (p. 453).

Diseases

Fusarium yellows *(Fusarium moniliforme, F. oxysporum).* Both pathogens invade freesia roots from the soil and cause pinkish superficial lesions and a reddish-brown rot in the vascular tissues of the corm. Foliage from infected corms becomes yellow and may die. *F. moniliforme* is also seed-borne and may contaminate healthy seeds during 'chitting' and kill seedlings.

Sterilise seed-sowing and greenhouse soils and use a captan or thiram seed dressing. With crops raised from seed, drench the soil with benomyl [*12·5 g/*

100 l], or captan [*100 g/100 l*] every 4-6 weeks from the 4-leaf stage. Infection of corms may be controlled by dipping in benomyl [*100 g/100 l*], or carbendazim [*100 g/100 l*] for 15-30 minutes. Alternatively corms may be soaked in formaldehyde [*8 g/l*] for 30 minutes.

Grey mould *(Botrytis cinerea)*. This fungus attacks the stems, leaves and flowers of densely grown freesias under humid conditions. Flower spotting may develop after boxing blooms for market and is a common cause of downgrading. Apply an HV spray or dust treatment from Table 12.5 (p. 392), every 10-14 days during autumn and winter to prevent the build-up of the disease.

Fuchsia

Pests

Aphids *(Myzus persicae)*. Control as indicated in Table 12.3 (p. 386). Beware when using products containing diazinon and do not use ULV sprays of malathion.

Broad mite *(Hemitarsonemus latus)*. Broad mite can cause distortion of flowers and bronzing of the lower leaf surfaces. For other symptoms and control measures see under Sweet pepper—broad mite, p. 449.

Red spider mite *(Tetranychus urticae)* (L 224). This is an occasional pest. Control as in Table 12.3 (p. 386), but some chemicals may be phytotoxic—see aphids.

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 423). This pest may cause serious damage by covering plants with honeydew and sooty mould and by making the leaves fall prematurely. Control as in Table 12.3 (p. 386), but some chemicals may be phytotoxic—see aphids.

Diseases

Grey mould *(Botrytis cinerea)*. This fungus may attack flowers under very humid conditions. For control select a suitable treatment from Table 12.5 (p. 392).

Geranium—see Pelargonium

Gerbera

Pests

Broad mite *(Polyphagotarsonemus latus)*. The mite can cause distortion of flowers and bronzing of the lower leaf surfaces. For other symptoms and control measures see under Sweet pepper—broad mite, p. 449.

Leaf miner *(Liriomyza* sp.). The crop is very prone to this pest and high populations of larvae can build up in the leaves. Premature death or secondary infection with leaf rotting fungi can follow an attack. Dimethoate, dichlorvos, diazinon, deltamethrin and permethrin are used but care is necessary as flowers are easily damaged. (For rates see Table 12.3, p. 386).

Diseases

Foot and root rot *(Phytophthora cryptogea).* Gerberas are very susceptible to this disease and serious losses can occur at any stage of growth, particularly within the first 6 months after planting. The main symptom of the disease is a slow but progressive wilt which often results in the death of the plant. Leaves become red-violet and then necrotic areas develop. The crown below soil level and roots rot sometimes leaving the outer cortex loosely attached to the steele. The disease is soil-borne but may be introduced on the plants or in contaminated water.

Plant healthy plants into sterilised soil. Pre-planting soil incorporation of etridiazole [*175-245 g/100 m*^{3}], or propamocarb [*505 g-1·01 kg/100 m*^{3}] may be useful. Any plants showing symptoms should be removed with surrounding soil. Little can be done however once the disease becomes established.

Powdery mildew *(Erysiphe cichoracearum).* Typical powdery mildew symptoms are produced on leaves as well as flowers and flower stems. Can be damaging if left unchecked leading to the death of leaves and loss of marketable blooms. Bupirimate [*100 g/100 l*] sprayed at the first sign of the disease and at intervals of 3 weeks will give satisfactory control.

Grapevine

Pests

Brown scale *(Parthenolecanium corni)* (L 88). The adult stage is protected in a hard reddish-brown scale beneath which the eggs are laid. Young scale insects are active and, because they come out from under the scale, are much more readily killed. The stems bear the brunt of infestations which may be controlled with diazinon [*32 g/100 l*], or malathion [*190 g/100 l*], or tar-oil, or petroleum emulsion as for mealybug. Repeat every 21 days until the bunches are thinned.

Mealybugs *(Planococcus* spp.). These aphid-like insects, when adult, are covered by a white, mealy protective wax. They feed on the stems, berries and leaves and secrete honeydew, on which a sooty mould grows. Control by scraping dormant rods and spraying in December with tar-oil winter wash [*4 l* (product)/100 l HV], conforming to the MAFF specification. In spring, use HV sprays of diazinon [*16 g/100 l*], or malathion [*114 g/100 l*], or petroleum emulsion [*1 l* (product)/*100 l*], repeating every 14 days until thinning. Adequate wetting agent must be added to thoroughly wet the waxy insects.

Red spider mite *(Tetranychus urticae)* (L 224). For description see Cucumber—red spider mite (p. 420). This is a serious pest which can be controlled with HV sprays of diazinon, or petroleum emulsion, or tetradifon at the rates given in Table 12.3 (p. 386). Repeat, if necessary, every 7-14 days, but only tetradifon may be used after thinning.

Diseases

Grey mould *(Botrytis cinerea).* Under warm, very humid conditions, the fungus may attack ripening berries, causing rapid rotting. Dust bunches with sulphur at the first sign of the disease and repeat every 7-10 days. Vapourised sulphur will also give control. Alternatively, apply HV sprays of benomyl [*25 g/100 l*]. Races of the pathogen insensitive to benomyl may occur.

Powdery mildew *(Uncinula necator).* This disease is more common than grey mould and attacks leaves, young shoots, flowers and fruits. Control by vapourising sulphur as for Chrysanthemum—powdery mildew (p. 414), or spray HV with dinocap [*12·5 g/100 l*], or colloidal or wettable sulphur [*200-300 g/100 l*] during shoot growth; repeat when flowers open and again when the berries have set, but not after thinning.

Hippeastrum

Pests

Bulb scale mite *(Steneotarsonemus laticeps)* (L 456). This mite causes dark reddish spots on the leaves, flower stalks and bulb scales, accompanied by distortion. Hot water treatment of dry, dormant bulbs for 1·5 hr at 43°C followed by gradual cooling will kill the mites. Infested plants should be treated with HV sprays of endosulfan [*40 g/100 l*], or dicofol/tetradifon [*40 + 12·5 g/100 l*].

Mealybug *(Planococcus citri).* To control this pest treat as for Begonia—mealybug (p. 396) but do not use petroleum emulsion.

Red spider mite *(Tetranychus urticae)* (L 224). This is a pest of minor importance. Control as for Ornamentals—red spider mite, Table 12.3 (p. 386).

Diseases

Red spot *(Stagonospora curtisii)*[26]. Symptoms of this disease may be seen on all parts of the plant. The fungus survives in dormant bulbs and, under warm, humid conditions, causes watery, red or red-brown lesions on the bulbs, leaves and flower stalks, making them deformed. Reddish scabs may also form on the outer scales of the bulbs and the roots may be discoloured. Spray emerging foliage and buds at the first appearance of the disease with Bordeaux mixture [*100 g* (copper)/*100 l*] and repeat every month. Some cultivars are susceptible to copper. Alternatively, HV spray with mancozeb [*125 g/100 l*], or zineb [*140 g/100 l*] and repeat every 2-3 weeks.

Hydrangea

Hydrangeas are very susceptible to damage by sprays applied in sunshine or if the plants are dry at their roots.

Pests

Leatherjackets *(Tipula* spp.*).* Leatherjackets are occasionally troublesome feeding on the roots of potted plants. Plants are stunted and may wilt especially where plants are being forced into flower and several larvae are present in a pot. Where leatherjackets are known to be a problem, gamma-HCH [*12·5 g/100 m²*] applied as a dust or spray to the surface on which plants are to be stood will give satisfactory protection without damaging plants. Methiocarb pellets [*2·2 g/100 m²*] sprinkled between plants will also give some control. These treatments are generally effective because during non-feeding times the pest is often outside the pot, usually underneath.

Red spider mite *(Tetranychus urticae)* (L 224). Control this serious pest as for Ornamentals—red spider mite in Table 12.3 (p. 386).

Diseases

Grey mould *(Botrytis cinerea).* This disease may occur on dense flower clusters when plants are grown under excessively humid conditions. For control select a suitable compound from Table 12.5 (p. 392).

Powdery mildew *(Microsphaera polonica).* Mildew develops on the leaves as a white coating. Select a suitable compound from Table 12.5 (p. 392).

Lettuce (HE 2)

Pests

Aphids (L 392). Several species attack lettuce, of which *Myzus persicae, Nasanovia ribisnigri* and *Aulacorthum solani* are the most prevalent. Losses are usually due to planting infested seedlings, or planting in houses where aphids are present on plants or weeds. Hence, for control, raise plants in isolation or ensure neighbouring plants are free of aphids. Clean up the houses 7–10 days before planting, with smokes listed in Table 12.12 (p. 433), if aphids are present. For attacks after planting out, use one of the compounds in Table 12.12 (p. 433).

Slugs (L 115). Slugs should not be a problem where soil was sterilised prior to planting. For control see Table 12.20 (p. 463).

Springtails[21]. For description see Cucumber—springtails (p. 422). Control using one of the compounds listed in Table 12.20 (p. 463).

Symphilids (L 484). For description see Tomato—symphylid (p. 456). Control

Table 12.12 Lettuce—aphids

Compound	*Application rate*	*Minimum harvest interval*
1. HV Sprays	*(g/100 l)*	*days*
demeton-S-methyl*†	19§	21
diazinon*	16	14
dichlorvos*	50	1
dimethoate*	34	7
formothion*†	416 g/ha‖	7
gamma-HCH∫	12·5	14
heptenophos†	41	1
malathion*	114	1
nicotine	112	2
oxydemeton-methyl*†	18§	21
pirimicarb	25	14
rotenone	6·25	1
2. Atomisation		
dichlorvos	ǂ	1
dimethoate*†	ǂ	7
gamma-HCH	ǂ	2
resmethrin	ǂ	0
3. Smokes (S) and fogs (F)	*(g/100 m³)*	
gamma-HCH (S)	ǂ	2
nicotine (S)	16	1
pirimicarb (S)	ǂ	14
tecnazene/gamma-HCH (S)	ǂ	2

* — possibility of encountering resistant insects.
† — systemic compound.
ǂ — see product label.
§ — use in 136 ml/m².
‖ — in 180–445 l.
∫ — on established transplants only.

using one of the compounds listed in Table 12.20 (p. 463). Symphylids should not be a problem where the soil has been sterilised.

Wireworm *(Agriotes obscurus)* (L 199). Wireworms usually occur only in the first 3–4 years after greenhouses have been built on grassland, but may enter under the walls from heavily infested land and attack adjacent plants. Control as for Lettuce—symphylids (see above) but repeat the treatment 3 weeks later. Wireworms should not be a problem where the soil has been sterilised.

Diseases

Big vein. This disease is caused by a virus-like organism and is spread by the common soil fungus *Olpidium brassicae*. The disease is most damaging when

plants become infected pre-planting and can cause serious losses in winter grown crops. Symptoms only become visible 4–5 weeks after infection. Puckering of the leaves, clearing of areas along the veins, reduced growth rate and in extreme cases stunting and the production of unmarketable plants may result. If the disease becomes established in NFT systems it is difficult to eradicate and spreads easily causing serious losses to winter production.

Regular sterilisation of soil with steam or methyl bromide is necessary to maintain the vector at a low level. The main way of avoiding the disease is to only plant healthy plants. This can be achieved in part by making sure plants are raised in systems which are isolated from the soil. Carbendazim incorporated into the blocking compost [*0·01 g/block*] will protect young plants. No chemicals are available for control although the use of non-ionic wetting agents in the circulating solution has given promising results in restricting the spread of the organism in NFT systems. Agral added to the NFT solution [*20 ppm product*] twice a week is recommended.

Bottom rots

There are 3 diseases that cause rotting of the stem and leaf bases (Grey mould, Rhizoctonia rot and Sclerotinia rot). Infected plants may be killed or require excessive trimming at cutting.

Grey mould *(Botrytis cinerea)* (L 559). This fungus can cause severe losses especially in crops sown in autumn and winter. *B. cinerea* is a weak pathogen and damage due to handling at planting, slugs and other fungi predispose the plant to attack. Propagation in peat blocks eliminates handling and reduces the risk of infection in seedling hypocotyls. In plants approaching maturity, red-brown lesions are often seen on the outer leaves close to the soil surface and at the stem base. Sudden wilting and characteristic masses of grey spores accompany extensive rotting. Remove debris from the soil surface and treat with formaldehyde (see Introduction, p. 382) 3 weeks before planting.

Chemical control measures are shown in Table 12.13 (p. 436). HV sprays and dusts containing thiram, mancozeb or zineb must be applied at the times shown in Table 12.14 (p. 437) to avoid high residues at cutting.

Rhizoctonia rot *(Rhizoctonia solani (Thanetephorus cucumeris))*[27]. This disease is common but only occasionally severe. The fungus can cause a damping-off of seedlings or a superficial slimy rot of the stem and petiole bases beneath an apparently healthy head. Red flecks on petioles and fine, mycelial strands may be associated with the rot and small brown sclerotia are sometimes present. Sterilise compost and border soil. To control damping-off of seedlings, dress seed with captan or thiram. Spray or dust quintozene [*700 g/100 m²*] on to the surface of the seed beds and soil or incorporate into composts [*150 g/m³*] 3–4 days before sowing or planting out. Do not apply quintozene to the growing crop. Where attacks occur, remove debris; drenches of thiram [*150 g/ha*], or zineb [*140 g/100 l*] applied to the surrounding soil may reduce inoculum. Benomyl, or

carbendazim, or iprodione, or thiophanate-methyl, applied to control grey mould, may suppress Rhizoctonia.

Sclerotinia rot *(Sclerotinia sclerotiorum)* (L 265). Outbreaks of the disease are erratic and probably less common than the other bottom rots but may cause severe losses especially in warm weather. Lower leaves and stem bases develop a soft rot and become covered with a dense, white mycelium, which may contain large, black sclerotia. The plant wilts progressively. Remove infected debris and the surrounding soil because sclerotia can infect the next crop. Sterilise soil and flame the surface of affected areas. Do not dump infected debris from lettuce or other crops close to greenhouses because wind-blown ascospores can cause infections. HV sprays for grey mould control (Table 12.13, p. 436) are likely to reduce the incidence of this rot.

Downy mildew *(Bremia lactucae)* (L 577)[28]. This disease has increased over the last decade and is the most important fungal disease. It is first noticed on lower leaves as pale, angular areas bounded by the veins. Masses of white spores form on the undersides. Free water on the leaf surface is essential for infection by spores and checks to growth also predispose the plant to infection. Thus good management of watering and conditions in the greenhouse will aid control. Exclusion of the disease during propagation and immediately after planting by regular spraying are also essential. Resistant lettuce varieties are available but should still be subject to routine chemical measures because the fungus may mutate and overcome this resistance.

The most effective means of chemical control is to spray HV with metalaxyl/mancozeb [*see label*] at 100% seedling emergence then at intervals of 14 days until planting. Applications after planting are subject to the restrictions shown in Table 12.14 (p. 437). Alternatively, apply sprays of mancozeb/zineb mixture [*180 g* product*/100 l*], or thiram [*320 g/100 l*], or zineb [*140 g/100 l*], or dust with zineb [*34 g/100 l*] at the times shown in Table 12.14 (p. 437), or atomise zineb or a mancozeb/zineb mixture according to manufacturer's instructions. Allow at least 14 days between the last application of atomised zineb, or mancozeb/zineb and cutting.

Mushroom

Disinfection of mushroom houses

To destroy spores of pathogenic and competing fungi on walls, floors, woodwork, etc., the cropping houses should be treated with a fungicide after the diseased crop has been removed, even though the old compost has been 'cooked out' by heating to 57-71°C or fumigated with methyl bromide. Suitable for this purpose are fogs or HV sprays of formaldehyde (see pp. 381, 382), or sprays of emulsified cresylic acid [*2 l cresols/100 l* HV], or DNOC-sodium [*100 g/100* HV]

Table 12.13 Lettuce—grey mould

Compound	*Application rate*	*Frequency of application*	*Minimum harvest interval*	*Remarks*
1. HV Sprays	*(g/100 l)*	*days*	*days*	
benomyl*‡	25	14	0	
carbendazim*	50-60	10-14	0	
iprodione	25	14	7	
thiophanate-methyl*	50	14	0	
thiram	320	See Table 12.12 (p. 433)		
vinclozolin	25	10-14	14	Maximum of 4 applications after transplanting
2. LV Sprays	*(g/100 m²)*			
iprodione	2·5	14	7	
3. Dusts	*(g/100 m²)*			
thiram	34-94	See Table 12.12 (p. 433)		May be applied to soil surface before planting.
4. Atomisations (A) and Smokes (S)				
dicloran (S)	†	†	14	
dicloran/thiram mixture (A)	†	7	4	First application 10 days after planting. Do not use on seedlings.
iprodione (A)	†	14	7	First application at planting. Maximum of 7 applications in winter-sown, 4 in spring-sown crops.
tecnazene (S)	†	21	2	Do not use earlier than 1 month after planting.

* — when insensitive strains of *Botrytis cinerea* occur, these compounds will not give control.
† — see manufacturer's instructions.
‡ — use alternately with another chemical not marked *.

(for safety regulations where DNOC-sodium is used see product label). Timber cropping trays should be dipped in sodium pentachlorophenolate [*1 kg/100 l*].

Many of these disinfectant treatments have the added advantage that they will also discourage the carry-over of pests from one crop to the next.

Table 12.14 Lettuce—grey mould and downy mildew*

	Total number of applications	*Interval between planting and last application*	*Minimum harvest interval*
Summer		*days*	*days*
thiram	2	14	21
maneb mancozeb† zineb	2	14	21
Winter			
thiram	3	21	21
maneb mancozeb† zineb	2	14	21

* — there is no restriction on spray or dust applications made before planting out or of atomisable formulations.

† — this restriction also applies to formulations of mancozeb with metalaxyl.

Pests

Flies

Flies from 3 families, Cecidomyiidae, Phoridae and Sciaridae, are common pests of mushrooms. The life history and behaviour of each group differs and they are dealt with separately.

Cecid midges *(Heteropeza pygmaea, Mycophila speyeri, M. Barnesi).* The larvae are white or orange and distinguishable from other mushroom maggots by a pair of dark 'eye spots' on the body just behind the minute head. They are paedogenetic, giving birth to daughter larvae and, as this process may continue for a long time, the small delicate adult midges are rarely seen. With heavy infestations larvae climb the mushroom stems, spoiling their appearance.

Peak-heating of the compost at 55–60°C will give control at this stage, but strict attention must still be paid to hygiene because larvae can be reintroduced. Chemicals are unlikely to give complete control of larvae and may damage the crop. Treat by mixing diazinon [*5 g/100 kg*] or thionazin [*1·9 g/100 kg*] into the compost at spawning. Gamma-HCH [*5 g/100 kg (Heteropeza* sp.*), 1 g/100 kg (Mycophila* sp.*)*], incorporated into the casing before cropping, acts as a barrier to larval migration and reduces infestation of the mushrooms.

Phorid flies *(Megaselia halterata, M. nigra).* These are small, dark, stout-bodied flies, the maggots of which are white and lack the black head of sciarid larvae. The maggots of *M. halterata* feed on mycelium in the compost and those

of *M. nigra* by tunnelling in mushrooms. Their attacks are most frequent in summer and autumn and come mainly from flies entering spawn-running rooms: keep doors closed and ventilators screened.

To prevent infestation, incorporate one of the following into compost: pirimiphos-ethyl [*5 g/100 kg*] immediately before the last turn on the yard, or diazinon [*2 g/100 kg*], or pirimiphos-ethyl [*5 g/100 kg*], or thionazin [*1·9 g/100 kg*] at spawning. Fumigate with dichlorvos [*21 g/100 m³*] twice every day during spawn-run and in the first week after casing, or water non-alkaline floors every week with a solution of dichlorvos [*100 g/100 m³*] (in 16 l). Success depends upon conditions in the spawn-running room because dichlorvos may be inactivated by high humidity.

Atomised dichlorvos [*21 g/100 m³*], or fogs of pirimiphos-methyl [*4 g/100 m³*], or pyrethrum/resmethrin [*15 g/100 m³*] will control adults during cropping. Allow 24 hours (dichlorvos) between last application and cutting.

Sciarid flies *(Lycoriella auripila* and others). Maggots are white with black heads. They tunnel in stalks and caps of mushrooms and can thereby kill buttons. The flies are small, dark, 'leggy' insects, with a tendency to run rather than fly, and can carry bacterial, nematode, and fungal pathogens. Peak-heating at 55-60°C will kill sciarids but flies are attracted to the compost as it cools, and they later congregate in the casing layer.

To prevent establishment of larvae, one of the following may be admixed into the compost at spawning:— chlorfenvinphos [*3 g/100 kg*], or diazinon [*5 g/100 kg*], or pirimiphos-ethyl [*5 g/100 kg*], or thionazin [*1·9 g/100 kg*].

Infestations may also be controlled before cropping by incorporating chlorfenvinphos [*3 g/100 kg*] or pirimiphos-ethyl [*5 g/100 kg*] into the casing. Malathion drenches can be used during cropping [*200 g/100 m²*] in 200 l, allowing 24 hours before cutting.

Strains of sciarids resistant to the above organophosphorous insecticides can be controlled with diflubenzuron [*3 g/100 kg*] incorporated into the casing before cropping, or drenched [*100 g/100 m²*] in 20 l during cropping.

Treat infestations of flies during cropping with the same methods and rates as for phorids.

Mite *(Tarsonemus myceliophagus).* This scarcely visible mite causes a chestnut-brown discolouration and rounding of the base of the mushroom stalk. Control with gamma-HCH [*5 g/100 kg*] incorporated into the casing before cropping. Strict hygiene is still essential and buildings and equipment should be cleaned thoroughly as described under Disinfection of mushroom houses (p. 435).

Nematodes *(Ditylenchus myceliophagus, Aphelenchoides composticola).* These and other species feed on mycelium causing it to disappear in patches. Where they are numerous the compost may become dark, overmoist and stinking. Nematodes can survive for at least two years in dry compost and woodwork, and can be carried from place to place on tools, boxes, or by flies.

There is no acceptable method of controlling nematodes in spawned or cropping compost; in unspawned compost, peak-heating is effective, while

Table 12.15 Mushroom—cobweb, dry bubble, gill-mildew, red geotrichum and wet bubble

Compound	*Application rate (g/100 m²)*					*Minimum harvest interval*	*Remarks*
	Cobweb	*Dry bubble*	*Gill mildew*	*Red geotrichum*	*Wet bubble*		
1. Post casing spray/ drench						*(days)*	
benomyl*	120	120†	120	—	120	0	Use 100-200 l/m², instead of first watering.
carbendazim*	125	125†	125	—	125	0	
chlorothalonil	—	110	110	—	110	1	Apply after casing and 2 weeks later, if necessary.
thiabendazole	—	†‡	—	—	‡	0	
zineb	35-38	35-38	35-38	—	30-38	2	Apply 50 l/100 m² three times before watering: shortly after casing; between 1st and 2nd flushes; between 2nd and 3rd flushes.
Dust							
zineb	30	30	30	30	30	2	After casing, then every 3 weeks.
2. Casing incorporation							
benomyl*	120	120†	120	—	120	0	
carbendazim*	125	125†	125	—	125	0	

* — may be strongly absorbed or made ineffective by casing.
† — insensitive strains of Verticillium are widespread.
‡ — see manufacturer's instructions.

structures and spent compost may be disinfected by cooking-out or with methyl bromide. The fumigation is effective above 21°C and should only be applied by approved operators. Clean woodwork and structures thoroughly as described in Disinfection of mushroom houses (p. 435).

Thionazin [*1·9 g/100 kg*] incorporated into the compost at spawning is effective against fungal-feeding, but not other, nematodes.

Slugs. These only cause damage in structures which permit their entry. They may be controlled with metaldehyde baits as for Tomato—slugs (p. 453), but keep bait off the beds.

Woodlice. These are likely to occur when mushrooms are grown in floor beds in greenhouses. Before cropping begins, apply methiocarb granules to the floor and near crevices which harbour woodlice.

Diseases

Mushroom yields are reduced by parasitic organisms and by 'weed' fungi which compete for nutrients in the compost. Such competitive fungi may indicate that the compost is unsuitable for mushroom cultivation. Losses can be avoided or minimised by strict attention to hygiene, correct compost fermentation and adequate pasteurisation before spawning. There are no satisfactory control measures for several pathogenic and competitive fungi.

Bacterial blotch *(Pseudomonas tolaasi).* This is a common disease, particularly during the summer, in warm, humid weather. It appears on the caps as slightly sunken yellowish-brown blotches and spots, which spread and become brown and sticky if the caps are wet. Reduce the relative humidity, if possible to below 80%, by ventilating well after watering. If the disease appears, routine watering with sodium hypochlorite [*16 g available chlorine/100 l*] or with chlorinated water [*160 ppm available chlorine*] will reduce losses.

Bacterial pit[29]. This disease is relatively uncommon and rarely severe. Its cause is unknown but bacteria appear to be associated with the symptoms. It starts as small cavities in the cap beneath the skin, which eventually collapses to leave open pits. Treatment as for bacterial blotch has reduced its incidence.

Cobweb *(Hypomyces rosellus (Dactylium dendroides)* and *Hypomyces* sp. *(Cladobotryum* sp.*)).* The disease is uncommon but can cause severe losses. The fungus envelops entire mushrooms with pinkish-white, loose, cobweb-like mycelium which spreads in the surrounding casing. Apply one of the compounds in Table 12.15 (p. 439).

Dry bubble (Verticillium) *(Verticillium fungicola* and *V. psalliotae)*[30,31]. Outbreaks are most frequent during the summer. It is one of the two most common fungal diseases of mushrooms; wet bubble is the other. The initial light brown blotches on the caps may be confused with bacterial blotch. As the disease progresses, mushrooms become infected increasingly earlier and are severely distorted with bulbous stalks and small caps, or with no recognisable cap and stalk. Mushrooms become covered with grey-white mould but do not usually

decay or produce the offensive odour associated with wet bubble. *V. psalliotae* is very rare on the common cultivated mushroom, *Agaricus bisporus*, but has been reported on *A. bitorquis* more frequently. Apply one of the compounds in Table 12.15 (p. 439).

Gill mildew *(Cephalosporium lamellicola).* This disease is rare and causes symptoms similar to a mild attack of dry bubble but the blotches are darker. The gills may become covered with a fine mycelial growth. Apply one of the compounds in Table 12.15 (p. 439).

Red geotrichum *(Sporendonema purpurascens).* This occurs occasionally and is a competing fungus which grows in the compost and casing. Young mycelium is white but when sporulating, the fungus turns buff and then bright pink. It is favoured by poor ventilation and high temperatures, and may be avoided by using steamed casing and better control of humidity and temperature during spawn run. Use zineb dust as in Table 0.00 (p. 000).

Truffle (false truffle) *(Diehliomyces microsporus).* Although less common than in the past, this competitor can cause very serious crop losses. The cream-coloured mycelium grows rapidly in compost, making it dark and soggy. Mushroom mycelium disappears from affected areas and does not recolonise. Fruiting bodies of the weed fungus are cream-coloured, with a convoluted surface ('calves' brains'), up to 25 mm in diameter and are produced in the compost and casing. Spores are resistant to disinfectants and can survive pasteurisation and 'cook-out' but are killed if maintained at 70°C for 3 hr. If the fungus develops in shelf beds, carefully remove the compost to form a trench extending at least 600 cm beyond the visible limit of the fungus.

Wet bubble (white mould) *(Mycogone perniciosa).* The disease is common during the summer months, especially when the temperature is high. Mildly infected mushrooms usually have wavy gills covered by a white, velvety fungal growth. More severely attacked mushrooms are deformed, covered by the white mould and exude drops of a clear, golden liquid. Later, the mushrooms turn brown, wet and foul smelling. The fungus naturally inhabits soil, and strict hygiene must be observed. Apply one of the compounds shown in Table 12.15 (p. 439).

Orchid

After the application of sprays to orchids with sheath-type leaves the accumulated spray should be drained from the leaf axils. Apply sprays under quick drying conditions, but not in bright sunshine.

Pests

Aphids. Several species of aphid including *Aulacorthum circumflexum, Cerataphis lataniae* and *Myzus persicae* breed on orchids. *C. lataniae* is reddish-

brown and scale-like when wingless. *A. circumflexum* is resistant to gamma-HCH. Control aphids with smokes listed in Table 12.3 (p. 386), HV sprays of gamma-HCH, or pirimicarb, as in Table 12.3 (p. 386) may also be used.

Cattleya fly *(Eurytoma orchidearium)*, **Cattleya midge** *(Parallelodiplosis cattleyae)*, **Cattleya weevil** *(Cholus cattleyae)* and several other less important pests have almost been eliminated from orchid houses by insecticides used for other pests. Should they occur, control with HV sprays of gamma-HCH [*12·5 g/100 l*].

Mealybugs *(Planococcus* spp.*)*. For description see Begonia—mealybugs (p. 396). Control with HV sprays of diazinon [*32 g/100 l*], repeated several times at intervals of 14-21 days.

Red spider mite *(Tetranychus urticae)* (L 224). The mites are a frequent pest on orchids but may be controlled with atomised diazinon, or with HV sprays of dicofol/tetradifon, or tetradifon, or with ULV sprays of dicofol/tetradifon at the rates given in Table 12.3 (p. 386). Biological control, using *Phytoseiulus persimilis*, has given good results.

Scale insects. Many species occur on orchids, most of which have been introduced on imported plants. Control with HV sprays of diazinon [*32 g/100 l*] repeating 2-3 times at 14-21 day intervals.

Thrips *(Heliothrips haemorrhoidalis, Hercinothrips femoralis* and *Anaphothrips orchidaceus)*[5]. Control as for scale insects, above.

Vine weevil[24]. Control using one of the compounds listed in Table 12.20 (p. 463).

Woodlice. Control by drenching the compost sparingly with parathion [*25 g/100 l*], or apply methiocarb baits [*2·2 g/100 m²*]. See Table 12.20 (p. 463).

Diseases

Anthracnose. Two fungi cause diseases commonly called anthracnose: *Glomerella cincta* is responsible for dark, decayed areas on the leaves, usually starting at the tips; *Glocosporium* spp. cause light brown spots which later turn yellow, soft and sunken. Spray HV with copper oxychloride [*38-50 g* copper*/100 l*] every 10-14 days.

Bacterial soft rot *(Erwinia carotovora (Pectobacterium carotovorum))*. This results in a slimy rot of the pseudo-bulbs and basal stems. Plants may be saved by cutting out all the diseased tissue and thoroughly dusting the wounds and surrounding areas with a copper dust. Drenches of 8-hydroxyquinoline [*14 g/100 l*] may give some control.

Black rots *(Pythium* spp.*)*. The fungus causes damping-off of seedlings or it may invade the roots of older plants and cause pseudo-bulbs to shrivel. Leaves may also be attacked if the humidity is high. Apply one of the compounds in Table 12.4 (p. 390). Alternatively, seedlings may be immersed in captan [*3 g/l*] after removal from the culture flasks. To prevent attack on leaves, reduce humidity and spray as for anthracnose.

Pelargonium

Pests

Aphids *(Myzus persicae, Aulacorthum solani).* Control as for Ornamentals—aphids, Table 12.3 (p. 386) but only use soil drenches of demeton-S-methyl, or dimethoate, or formothion, or oxydemeton-methyl on zonal pelargonium flowers of which may also be damaged (speckled) by fogs of pyrethrum/resmethrin.

Leafhopper *(Zygina pallidifrons)*[10]. See Calceolaria—leafhopper (p. 405).

Mealybug *(Planococcus citri).* See Begonia—mealybug (p. 396).

Mites. The Tarsonemid (cyclamen) mite *(Steneotarsonemus pallidus)* (L 588) and the broad mite *(Polyphagotarsonemus latus)* may cause infestations. Control as for Cyclamen—tarsonemid mite (p. 427).

Vine weevil *(Otiorhynchus sulcatus)*[24]. The larvae of this beetle occasionally feed on the roots. They may be introduced in unsterilised compost or hatch from eggs laid by adults within the greenhouse. For control use one of the compounds listed in Table 12.20 (p. 463).

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 421). Control as for Ornamentals—whitefly, Table 12.3 (p. 386).

Diseases

Grey mould *(Botrytis cinerea).* Leaves, flowers and stems are susceptible to rotting under humid conditions. 'Soft' plants are particularly vulnerable, especially if debris, such as dead flowers, is allowed to remain on the plant. For control, see Table 12.5 (p. 392).

Leaf spot *(Alternaria tenuis).* Small water-soaked spots with a central necrotic fleck form on the undersides of the leaves. The lesions increase in diameter to about 3 mm and become necrotic. Spray with thiram [*320 g/100 l*], or zineb [*140 g/100 l*], or some control may be expected from applications of chlorothalonil [*110 g/100 l*], or iprodione [*50 g/100 l*].

Root and stem rots. Pelargoniums are susceptible to several soil-borne diseases, *Xanthomonas pelargonii* causes Bacterial (Black) stem rot. Fungi such as *Sclerotinia* spp., *Rhizoctonia solani (Thanatephorus cucumeris), Fusarium* spp., *Thielaviopsis basicola* and *Pythium* spp. are also responsible for the death of plants from root or stem decay. Sterilised soil should be used in cutting and potting composts and propagation made from healthy stock. Some control may be expected from the use of a drench treatment from Table 12.5 (p. 392): those in Table 12.4 (p. 390) will control Pythium; 8-hydroxyquinoline will also give some control of Xanthomonas; etridiazole/chlorothalonil mixture will also control Rhizoctonia; those in Table 12.5 (p. 392) will give control of Fusarium and Thielaviopsis rots. Treatments in Table 12.4 (p. 390) should be applied to a few plants first to check for phytotoxicity.

Rust *(Puccinia pelargonii-zonalis*[32]. The fungus attacks zonal pelargonium

cuttings and plants. Reddish-brown spores erupt from the undersides of leaves in concentric rings and corresponding yellow areas appear on the upper surface. Apply HV sprays of chlorothalonil [*110 g/100 l*], or oxycarboxin [*37·5-75 g/100 l*], or zineb [*140 g/100 l*] every 10-14 days. Alternatively, atomise mancozeb/zineb according to the manufacturer's instructions or fog with oxycarboxin [*9·5 g/100 m³*].

Poinsettia

The bracts of poinsettia are very susceptible to injury by pesticides from the time they begin to colour.

Pests

Mealybugs *(Pseudococcus citri, P. adonidum).* These pests may infest poinsettia, particularly when grown with other host plants. For control see Begonia—mealybug (p. 396) but do not use dips of HV sprays of petroleum emulsion.

Red spider mite *(Tetranychus urticae)* (L 224). Red spider mite may occasionally cause problems on this crop. For control see Ornamentals—red spider mite, Table 12.3 (p. 386). However, fogs of pirimifos-methyl may cause some bract discolouration. Do not use parathion.

Scale insects *(Coccus hesperidum, Aspidiotus hederae).* See mealyugs.

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 423). For control see Table 12.3 (p. 386). Fogs of permethrin or pirimiphos-methyl may cause some bract discolouration.

Diseases

Damping-off *(Pythium* spp.*).* Use sterilised compost and an appropriate compound from Table 12.4 (p. 390), but check for phytotoxicity by applying to a few plants in the first instance.

Grey mould *(Botrytis cinerea).* This fungus attacks leaves and bracts under moist conditions. If control is not achieved by removing the diseased parts and increasing ventilation, apply one of the fungicides listed in Table 12.5 (p. 392).

Root rots *(Rhizoctonia solani (Thanatephorus cucumeris), Fusarium* spp., *Thielaviopsis basicola).* Use a soil drench from Table 12.5 (p. 392) in place of the first watering after planting.

Primula *(Primula malacoides, P. obconica)*

Pests

Aphids *(Aulacorthum circumflexum, Myzus persicae).* Sprays or smokes of gamma-HCH will only control *M. persicae*; malathion sprays, or pirimicarb

sprays or smokes, or aldicarb will control both species. Use if possible before flowering, at the rates given in Table 12.3 (p. 386). Some cultivars may be sensitive to systemic organophosphorus compounds but demeton-S-methyl, formothion and oxydemeton-methyl have been used successfully as sprays and drenches on several cultivars of both species.

Leafhopper *(Zygina pallidifrons)*[10]. An active, yellowish-green insect which feeds on the undersides of the leaves causing chlorotic spotting of the upper surfaces. Control as for Calceolaria—leafhopper (p. 405).

Red spider mite *(Tetranychus urticae)* (L 224). Red spider mite may occasionally be troublesome on this crop. Control as in Table 12.3 (p. 386) but do not use products containing tetradifon or dimethoate. Some organophosphorus compounds may be phytotoxic—see aphids.

Vine weevil *(Otiorhynchus sulcatus)*[24]. For description see Cyclamen—vine weevil (p. 427). Control using one of the compounds listed in Table 12.20 (p. 463).

Diseases

Grey mould *(Botrytis cinerea)*. For control measures see Table 12.5 (p. 392).

Root rots *(Phytophthora* spp., *Pythium* spp., *Thielaviopsis basicola)*. For control see Begonia—root rot (p. 397).

Powdery mildew *(Oidium* sp.*)*. Apply one of the compounds listed in Table 12.5 (p. 392).

Radish

Disease

Damping off and crater rot *(Rhizoctonia solani)*. These diseases can occur at any stage of plant growth, particularly when growing conditions are unfavourable and the plants are not growing normally. Seedlings may damp off or develop the 'wirestem' symptom. Black sunken lesions may develop on the hypocotyl. Sometimes the brown mycelium of the fungus can be seen on the plant and soil surface, and sclerotia are occasionally also seen. Old crop debris should be destroyed and the seed bed sterilised with steam or methyl bromide. The seed bed should be well prepared and kept moist to encourage good growth. Quintozene [*700 g/100 m²*] incorporated into the soil pre-sowing will give reasonable control.

Rose

Systemic compounds may not be effective when applied as soil drenches to old, woody plants; best results will be obtained during active vegetative growth.

Pests

Aphids. *Macrosiphum rosae* is the most troublesome of several species. Control by using treatments listed in Table 12.3 (p. 386). ULV sprays of dimethoate, permethrin, and smokes of gamma-HCH may be phytotoxic. In general, ULV sprays cause more damage to foliage than HV.

Caterpillars. Several species damage leaves, shoots and buds; some tortrix larvae spin leaves together. Control as for Carnation—tortrix (p. 406).

Leafhopper[10]. For description and control see Tomato—leafhopper (p. 453).

Mealybug. For description and control see Grapevine—mealybugs (p. 430).

Red spider mite *(Tetranychus urticae)* (L 224). For description see Cucumber—red spider mite (p. 422). Control with treatments listed in Table 12.3 (p. 386), but some chemicals are phytotoxic, see aphids.

Table 12.16 Rose—powdery mildew

N.B. Before using compounds listed in this table, consult the product label for information on cultivars which should not be treated.

Compound	*Application rate (g/100 l)*	*Interval between sprays (days)*	*Remarks*
1. HV Sprays			
benomyl*	25	7-10	
bupirimate	62·5-95	21-28	Alternate with drazoxolon‡. Use higher rate for first spray if mildew present.
carbendazim*	25	14	
dichlofluanid	250-375	14	Apply higher rate in first 2 sprays.
dinocap	6·5	10-14	Some cv. are susceptible to damage.
dodemorph	100-150	5-14	Use higher rate on established infections.
drazoxolon	93	21-28	Alternate with bupirimate‡.
fenarimol§	4	10-14	Use initially on a small area.
imazalil	30	7-14	*Do not use on* cv. Dr. A. J. Verhage.
sulphur/nitrothal-isopropyl mixture	150†	7-14	Only use on out-of-flush crop.
thiophanate-methyl*	50	14	
triforine	25	10-14	Some cv. are susceptible to damage.

* — insensitive races of *Sphaerotheca pannosa* occur.
† — rate is g (product)/100 l.
‡ — see product label.
§ — new recommendation—check with manufacturer.

Rose (scurfy) scale *(Aulacaspis rosae).* The older branches become covered with a scurfy mass of scales and colonies of young yellowish-white scales may appear on shoots and leaves. Control as for Grapevine—brown scale (p. 430), but aldicarb [*112 g/100 m²*] may also be used.

Diseases

Black spot *(Diplocarpon rosae)*[33]. This disease occasionally occurs on roses in greenhouses when black or purple spots develop on upper surfaces of leaves and leaflets drop prematurely. Spray HV at the first sign of infection with captan [*91 g/100 l*], or carbendazim [*25 g/100 l*], or chlorothalonil [*110 g/100 l*], or dichlofluanid [*100 g/100 l*], or maneb [*120-250 g/100 l*] and repeat at intervals of 10-14 days. Sprays of imazalil as shown in Table 12.16 (p. 446) may also give some control. Alternatively, atomise copper oxychloride or maneb according to the manufacturer's instructions.

Crown gall *(Agrobacterium tumefaciens).* Galls, which are whitish at first and later brown-black, may be found on roots or stems but more commonly at the base of the stem just below soil level. Large galls completely surrounding the stem may be found, although these do not usually cause an obvious effect on the plant. Occasionally plants may be stunted and die where the galls become secondarily infected with soft rotting organisms. Remove infected plants.

Coniothyrium die back *(Leptosphaeria coniothyrium (Coniothyrium fuckelii)).* The disease results in the death of old wood often by infection through a pruning scar. Affected stems become light brown or silvery grey in colour. Black pycnidia (0·5 mm in diameter) of the fungus are often clearly seen on its tissue. The first obvious symptom of the disease may be the wilting of young lateral shoots on the affected stem. High volume sprays of maneb [*64-120 g/100 l*] or mancozeb [*140 g/100 l*] used immediately after pruning have given some reduction in the occurrence of the disease.

Downy (black) mildew *(Peronospora sparsa).* This fungus produces irregular yellow-green or purplish spots on leaves and occasionally on flower stems. Whitish-grey downy fungal growth appears on the undersides of leaves which fall prematurely. Spray at 14-day intervals with chlorothalonil [*110 g/100 l*] or a copper/petroleum emulsion mixture [*60 g* copper + *500 ml* emulsion/*100 l*] or cupric ammonium carbonate [*10·5 g/100 l*] or wettable sulphur at the rate given on the label or zineb [*140 g/100 l*] or atomise copper oxychloride [*see label*].

Grey mould *(Botrytis cinerea).* Under excessively humid conditions, flowers and occasionally stems may be attacked. Germinating spores may produce spotting of the petals leading to rotting of the flowers. The fungus can also invade stem wounds causing die-back of woody tissue. To control the disease remove infected blooms and decrease the humidity. Vapourise sulphur as for Chrysanthemum—powdery mildew (p. 416) or apply a suitable treatment from Table 12.16 (p. 446).

Powdery mildew *(Sphaerotheca pannosa).* An important disease which disfigures young leaves, stems, buds and petals by distorting, dwarfing and covering them with a typical powdery mould. To control the disease, spray with one of the chemicals listed in Table 12.16 (p. 446) but take precautions to avoid phytotoxicity on sensitive cultivars. Sulphur may also be vapourised as for Chrysanthemum—powdery mildew (p. 416) but some cultivars are sensitive to this treatment.

Rust *(Phragmidium mucronatum)*[34]. Rust causes orange-coloured pustules on the leaves in summer and, in autumn, dark brown ones often on the same spots. The fungus can perennate as spores on fallen leaves, or, as mycelium in the wood, from which it emerges as easily-overlooked infections of young shoots and buds. Burn all infected debris and apply HV sprays of chlorothalonil [*110 g/100 l*], or maneb [*320 g/100 l*], or oxycarboxin [*37·5–94 g/100 l*], or zineb [*140 g/100 l*] every 10–14 days or fog with oxycarboxin [*9·5 g/100 m³*]. Check cultivar sensitivity before using any pesticide on a large area.

Saintpaulia (African violet)

Do not apply sprays or dips in bright sunshine or under humid, slow drying conditions, or if the compost is dry. Use tepid water for sprays and preferably drain the plants on their sides.

Pests

Aphid *(Myzus persicae).* Control with compounds listed in Table 12.3 (p. 386) but fogs of pyrethrum/resmethrin may cause flower speckling. Do not use aldicarb at rates higher than [*45 g/100 m²*] as damage may occur.

Mealybug *(Planococcus citri).* Control as for Begonia—mealybugs (p. 396).

Mites—broad mite *(Polyphagotarsonemus latus)*, **tarsonemid (Cyclamen) mite** *(Steneotarsonemus pallidus)* (L 588), and *Tarsonemus confusus.* These mites cause stunting, leaf twisting and distorting of buds and flowers. Control as for Cyclamen—tarsonemid mite (p. 427), but do not use dicofol/tetradifon more frequently than at 28 day intevals. Do not exceed the rate for aldicarb.

Diseases

Grey mould *(Botrytis cinerea).* The conditions conducive to attack are similar to those described for Azalea—grey mould (p. 395). For control measures, see Table 12.5 (p. 392).

Stocks

Diseases

Downy mildew *(Peronospora parasitica).* The leaves develop yellow blotches with a greyish furry coating on the underside; growth of the plant may be checked.

Reduce the humidity and keep the leaves as dry as possible during watering. Apply HV sprays of chlorothalonil [*110 g/100 l*], or zineb [*140 g/100 l*], or compost drenches of propamocarb [*145 g/100 l*], or atomise copper oxychloride, or mancozeb/zineb mixture according to the manufacturer's instructions.

Sweet Pepper *(Capsicum annuum)* (STL 181)

Pests

Aphid *(Myzus persicae)*. For control see Table 12.17 (p. 450).

Broad mite *(Polyphagotarsonemus latus)*. This is an occasional pest of sweet peppers but it can cause severe damage and loss of yield. The mites are not visible to the naked eye but they cause distinct symptoms. They feed on young tissue at the growing point. Growth is stunted, and leaves and fruit may be distorted and russetted. In extreme cases extensive necrosis of young buds can develop which leads to a complete cessation of growth. Dicofol [*30 g/100 l*] applied two to three times at intervals of 2-3 weeks will give reasonable control.

Leaf miner. For description see Tomato—leaf miner (p. 452). For control see Table 12.17 (p. 450).

Red spider mite *(Tetranychus urticae)* (L 224). Red spider mite may occasionally be troublesome on this crop. For description see Cucumber—red spider mite (p. 422). For control see Table 12.17 (p. 450). The predatory mite *Phytoseiulus persimilis* has given good control of red spider mite on sweet pepper, using the same methods as for Cucumber[3].

Thrips *(Thrips tabaci)*[7]. For control see Table 12.17 (p. 450).

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 421). For control see Table 12.17 (p. 450). In trials, successful biological control of whitefly has been obtained with the parasitic wasp *Encarsia formosa* as used for Cucumbers[3].

Woodlice. For description see Cucumber—woodlice (p. 423) (Control using one of compounds listed in Table 12.20 (p. 463).

Diseases

Damping-off and Foot rot *(Pythium* spp., *Phytophthora* spp. and *Rhizoctonia solani (Thanatephorus cucumeris))*. These soil-borne fungi kill seedlings before or after emergence and cause foot rot of young plants or root rot of mature plants. Peppers are very slow to root and are predisposed to attack if sown or planted too deeply, in compost below 15°C, or over-watered. Crops should be grown in sterilised soil or compost. If Pythium or Phytophthora infection does occur, remove diseased plants and drench the remainder with copper oxychloride or cupric ammonium carbonate or zineb or (for transplanted seedlings only) etridiazole; see Tomato—foot rot in Table 12.19 (p. 458). Seedling infection may be

Table 12.17 Sweet pepper—aphid, red spider mite, whitefly, thrips and leaf miner

See Integration, p. 462

			Active against					*Effect (where known) on*			
								Phytoseiulus		Encarsia	
Compound	*Application rate*	*Minimum harvest interval*	*Aphids*	*Red spider mite*	*Whitefly*	*Thrips*	*Leaf miner*	*Eggs*	*Adults*	*Pupae*	*Adults*
1. HV Sprays	*(g/100 l)*	*days*									
cypermethrin	100-150	0	—	—	Yes	—	Yes	—	—	—	—
deltamethrin	1·75	0	Yes	—	Yes‖	Yes	—	H	H	H	H
gamma-HCH	12·5	14	Yes	—	Yes	Yes	Yes*	H	H<4	H	I<4
malathion	114	4	Yes*	—	Yes*§	Yes	Yes	H	H10	H	H10
permethrin	12·5	0	Yes	—	Yes‖	Yes	Yes*f*	—	H	S	H
permethrin/thiram	4/25	0	Yes	—	Yes	Yes	Yes	—	—	—	—
pirimicarb†	25	2	Yes	—	—	—	—	S	S	S	I
pyrethrum/resmethrin	‡	0	Yes	Yes	Yes‖	—	—	H	H<4	—	H<4
tetradifon	12·5	0	—	Yes*	—	—	—	S	S	S	S

2. Atomisation											
permethrin	‡	0	Yes	—	Yes	—	—	H	H28	H	H21
pyrethrum/resmethrin	‡	0	Yes	Yes	Yes§	—	—	H	H7	S	H3
resmethrin	‡	0	Yes	—	Yes	—	—	H	H7	S	H3
3. Smokes (S) and Fogs (F)	*(g/100 m³)*										
gamma-HCH (S)	‡	2	Yes	—	Yes*§	Yes	Yes*	S	H	—	—
nicotine (S)	16	1	Yes	—	—	Yes	Yes	S	S	S	H
permethrin (F)	‡	0	—	—	Yes‖	—	Yes	—	H	—	H>15
permethrin (S)	‡	0	—	—	Yes	—	—	—	—	—	—
pirimicarb (S)	‡	0	Yes	—	—	—	—	—	—	—	—
pirimiphos-methyl (S)	‡	0	Yes	—	Yes§	Yes	Yes	—	—	—	—
pirimiphos-methyl (F)	‡	0	Yes	Yes	Yes‖	Yes	—	—	H	H	H16

* — resistant insects may be encountered.
† — systemic compound.
‡ — see product label.
§ — kills adults only.
‖ — kills adults and larvae.
ʃ — *Liriomyza trifolii*: use 6 g/100 l (see p. 414).
H — harmful (H>7—harmfulness persists for more than 7 days).
I — intermediate.
S — safe.

controlled by compost incorporation of etridiazole for control of Phytophthora and Pythium or quintozene for control of *Rhizoctonia* as shown in Table 12.19 (p. 458).

Grey mould *(Botrytis cinerea).* For description see Tomato—grey mould (p. 460). To prevent attack regulate heating, ventilation and watering to avoid high humidity in the crop. Apply HV sprays of chlorothalonil, or iprodione, or thiram every 7-14 days as shown in Table 12.19 (p. 458). Allow 7 days between the last application of iprodione and picking. Fortnightly HV sprays of benomyl, or carbendazim, or thiophanate-methyl as in Table 12.19 (p. 458) may be used but not with biological control of pests or if insensitive races of *B. cinerea* are known to be present in the crop.

Sclerotinia rot *(Sclerotinia sclerotiorum).* This fungus can cause damping-off of seedlings or, if airborne spores infect petioles, drooping leaves may be the first sign of attack. A fluffy white growth develops on infected tissue and black sclerotia form in the pith cavity. For control measures see Celery—Sclerotinia rot (p. 411).

Tomato (STL 38)

Pests

Aphids. The glasshouse potato aphid *Aulocorthum solani* is the most common. On foliage it causes yellowing and increases susceptibility to grey mould; on immature fruit it causes raised pale areas which remain yellow when the fruit ripens. Control with the treatments listed in Table 12.18 (p. 454) and repeat, if necessary, after 10-14 days. Propoxur smokes should not be used until after the third truss has set.

Leaf miner *(Liriomyza bryoniae)*[35]. The larvae tunnel in cotyledons and stems of seedlings early in the year, often killing them. Later generations sometimes mine the leaves of established plants sufficiently to warrant chemical control. The larvae pupate and overwinter in the soil. The first indications of attack are small rounded pits on the leaves caused by adult flies feeding. Do not propagate tomatoes in houses where the previous crop was infested, unless the soil has been thoroughly sterilised. Control using compounds listed in Table 12.18 (p. 454). HV sprays of permethrin [*6 g/100 l*] may be used against the recently introduced American serpentine leaf miner *(Liriomyza trifolii)*, repeating twice at 4-day intervals, followed by further sprays at 6-day intervals until it is controlled. **NB—This is a notifiable pest in the UK.** Overwintering leaf miner populations will be reduced where soil has been thoroughly sterilised before planting. Where the soil surface is to be covered with polythene and an isolated growing technique use gamma-HCH applied to the soil surface [*20 g/100 m²*] will give effective control of soil infestations; deltamethrin in polybutene has given good results in trials when applied to the polythene.

Leafhopper *(Zygina pallidifrons)*[10]. This yellowish-green, active insect may attack young foliage, causing chlorotic spotting of the upper surfaces. It is rarely a problem but is sometimes present in crops where biological control is being used. Control measures are usually unnecessary but if they are, pesticides used to control whitefly (Table 12.18, p. 454) will generally be effective.

Potato cyst nematode *(Globodera rostochiensis)* (L 284). This nematode will retard plant growth and cause the leaves to become dark green with purplish undersurfaces. Plants wilt during hot, bright weather and their roots may become invaded by fungi and then rot. Propagate in steamed soil and avoid introducing eelworm into greenhouses. Greenhouse soils should be sterilised (see p. 379). Alternatively, apply oxamyl [*56 g/100 m²*] to the soil surface 3–4 days before planting and incorporate by rotovation to a depth of 10 cm, or use an isolated growing technique.

Red spider mite *(Tetranychus urticae)* (L 224). Red spider mite is a serious pest of tomatoes. For description see Cucumber—red spider mite (p. 422). Control with compounds listed in Table 12.18 (p. 454). Infestations early in the season may be controlled with a mixture of deltamethrin [*1·75 g/100 l*], or permethrin [*6·25 g/100 l*] with malathion [*114 g/100 l*] but these materials cannot be used with biological control. Treatments may need to be repeated. Fruit less than 1·3 cm diameter may be blemished by cyhexatin.

Another species of red spider mite has caused concern in both England and Guernsey recently. This may be *Tetranychus cinnabarinus*. Because the characteristic feeding marks associated with red spider mites are not always evident in the case of this pest, symptoms of attack have sometimes been mistaken for manganese toxicity or magnesium deficiency. Bright yellow patches usually develop on older leaflets and gradually coalesce, with the result that the leaf and petiole wither and die. The stem, however, is not affected. Control with products containing dicofol (Table 12.18, p. 454).

Root-knot nematodes *(Meloidogyne* spp.*)* (L 307). Where tomatoes have to be planted in soil known to be infested by root-knot nematode, watering with parathion [*38 g/100 l*] using 5 l/m² within 3 days of planting will protect plants from early attacks and increase their yields. In view of the relatively high concentration of parathion used, the greenhouse must be well ventilated during application. Rubber boots must be worn when entering the greenhouse, and rubber gloves worn when handling the soil for 14 days after application; these precautions are additional to other statutory requirements. Alternatively, the soil should be sterilised as outlined for Tomato—potato cyst nematode (above) or use an isolated growing technique.

Slugs (L 115). These may occasionally enter houses in dung, or from weedy land outside and are controlled by baiting with pellets of metaldehyde [*9·4 g/100 m²*], or methiocarb [*2·2 g/100 m²*]. Allow a harvest interval of 7 days for methiocarb.

Springtails[21]. For description see Cucumber—springtails (p. 422). Control with one of the compounds listed in Table 12.20 (p. 463).

Table 12.18 Tomato—aphid, red spider mite, whitefly and leaf miner

See Integration, p. 462

Compound	Application rate	Minimum harvest interval	Active against: Aphids	Red spider mite	Whitefly	Thrips	Leaf miner	Effect (where known) on: Phytoseiulus Eggs	Phytoseiulus Adults	Encarsia Pupae	Encarsia Adults
1. HV Sprays	*(g/100 l)*	*days*									
carbaryl	77	7	—	—	—	Yes	—	—	H>12	H	H>11
cyhexatin□	25	2	—	Yes	—	—	—	—	H	S	S
cypermethrin ◇	100-150	0	—	—	Yes	Yes	Yes	—	—	—	—
deltamethrin	1·75	0	Yes	—	Yes○	—	—	H	H	H	H
demeton-S-methyl†△	22	21	Yes*	Yes*	—	—	—	H	H	S	H?
diazinon	16	14	Yes*	Yes*	Yes*ø	Yes	Yes*	—	H	H	H?
dichlorvos	50	1	Yes	Yes	Yes*ø	Yes	—	—	H	H	H?
dicofol	11·5	2	—	Yes*	—	—	—	—	H	S	S
dicofol/tetradifon	40/12·5	2	—	Yes*	—	—	—	I	I	—	I
dimethoate†	30-34	7	Yes*	Yes*	—	—	—	H	H	H	H>7
fenbutatin oxide	25	3	—	Yes	—	—	—	S	S	S	S
gamma-HCH	12·5	14	Yes	—	Yes	Yes	Yes*	H	H<4	H	I<4
heptenophos†	41	1	Yes	—	—	—	—	—	H<3	S	I<4
malathion	114	1	Yes*	—	Yes*ø	Yes	Yes	H	H10	H	H10
nicotine	112	2	Yes	—	—	Yes	Yes∫	—	I<4	S	H<4
oxydemeton-methyl†△	22	21	Yes*	Yes*	—	—	—	—	H	—	—
parathion§△	10	28	Yes*	Yes*	—	—	Yes	H	H14	H14	H
permethrin	‡	0	Yes	—	Yes○	Yes	Yes‖	—	H	S	H
permethrin/thiram	4/25	0	Yes	—	Yes	Yes	Yes	—	—	—	—
petroleum emulsion	‡	7	—	Yes	—	—	—	S	I	I	I
pirimicarb△	25	3	Yes	—	—	—	—	S	S	S	I
propargite	57	1	—	Yes	—	—	—	H	—	I	I
pyrethrum/resmethrin△	‡	0	Yes	Yes	Yes○	—	—	H	H<4	—	H<4
tetradifon△	12·5	0	—	Yes*	—	—	—	S	S	S	S

dichlorvos	‡	1	Yes	Yes	Yes*ø	Yes	—	—	—	—	—
dicofol▽	‡	2	—	Yes	—	—	—	H2	S	S	S
dicofol/tetradifon	‡	2	—	Yes	—	—	—	H2	S	S	S
gamma-HCH	‡	2	Yes	—	—	—	Yes*	—	—	—	—
malathion	‡	1	Yes	—	Yes*ø	Yes	—	—	—	—	—
permethrin	‡	0	Yes	—	Yes	—	—	H	H28	H	H21
pyrethrum/resmethrin	‡	0	Yes	Yes	Yesø	—	—	H	H7	S	H3
resmethrin△	‡	0	Yes	—	Yes°	—	—	H	H7	S	H3
3. Smokes (S) and Fogs (F)	*(g/100 m³)*										
dicofol (S)	‡	0	—	Yes	—	—	—	—	—	—	—
dicofol/tetradifon (F)	‡	2	—	Yes	—	—	—	—	—	—	—
gamma-HCH (S)	‡	2	Yes	—	Yes*ø	Yes	Yes*	S	H	—	—
nicotine (S)	16	1	Yes	—	—	Yes	Yes	S	S	S	H
permethrin (F)	‡	0	—	—	Yes°	—	Yesø	—	H	—	H>15
permethrin (S)	‡	0	—	—	Yes	—	—	—	—	—	—
pirimicarb (S)△	‡	0	Yes	—	—	—	—	—	—	—	—
pirimiphos-methyl (S)△	‡	0	Yes	—	Yesø	—	—	—	—	—	—
pirimiphos-methyl (F)	‡	0	Yes	Yes	Yes°	Yes	—	—	H	H	H16
propoxur (S)	‡	2	Yes	—	Yesø	—	—	—	H8	S	—
pyrethrum/resmethrin (F)△	‡	0	Yes	—	Yesø	—	—	—	—	—	H
tecnazene/gamma-HCH (S)	‡	2	Yes	—	Yesø	Yes	Yes	—	—	—	—
4. Granules	*(g/plant)*										
aldicarb†	0·1	42	Yes	Yes	Yes	—	Yes	—	H	—	—
oxamyl†	0·1	14	Yes	Yes	Yes	—	Yes	—	S	—	—

* — possibility of encountering resistant insects.
† — systemic compound.
‡ — see product label.
§ — max. 3 applications/season.
‖ — *Liriomyza trifolii*; use 6 g/100 l.
ʃ — use 154 ml/100 l.
ø — kills adults only.
° — kill adults and larvae.
△ — young plants may be treated.
▽ — treat during summer only.
□ — avoid spraying fruit <½ inch diameter.
◇ — limited clearance, not for general use at present.
H — harmful (H>7—harmfulness persists for more than 7 days).
I — intermediate.
S — safe.

Symphylid *(Scutigerella immaculata)* (L 484). These pests are active, white, centipede-like organisms which live too deep in the soil to be destroyed by soil sterilisation in autumn and winter, but return to the surface in spring and stunt the growth of plants by damaging young roots. Control using one of the compounds listed in Table 12.20 (p. 463). Alternatively gamma-HCH may be used [*60 g/100 l*], watering each planting hole with 280 ml, 2-3 days before planting.

Thrips *(Thrips tabaci)*[7]. Thrips seldom cause direct damage but are vectors of spotted wilt virus and are thus important where different species of plants are grown together. Control using one of the compounds listed in Table 12.18 (p. 454).

Tomato moth *(Lacanobia oleracea).* This pest has largely been controlled by chemicals applied for other pests. Where biological control is used (with fewer pesticide sprays) it may reappear. The young green or brown caterpillars of this moth will reduce leaves to a vascular skeleton. When larger, they eat foliage, fruit and stems. Control with HV sprays of the bacterial pathogen *Bacillus thuringiensis* [*see label*] which can be used safely with biological control agents; or use HV sprays of carbaryl [*77 g/100 l*], or deltamethrin [*1·75 g/100 l*], or dichlorvos [*50 g/100 l*], or permethrin [*see label*], or pyrethrum/resmethrin [*see label*]; or use ULV sprays of dichlorvos, or permethrin, or pyrethrum/resmethrin; or use fogs of permethrin as directed on the labels. The harvest intervals are given in Table 12.18 (p. 454).

Whitefly *(Trialeurodes vaporariorum)* (L 86). For description see Cucumber—whitefly (p. 423). Many whitefly strains have developed resistance to pesticides and either biological control (see p. 384) or different insecticide types must be used. Control measures are listed in Table 12.18 (p. 454); application frequency must be related to the kill of the various stages of the pest. If adults only are killed, treatments should be repeated more frequently (every 3 days) than when larvae are also killed. Propoxur smokes should not be used until after the third truss has set. Control of adult whitefly on seedlings and very young plants can be safely achieved with pyrethrum/resmethrin as a fog [*see label*].

The fungus *Verticillium lecanii* is parasitic on whitefly and will give good control of all stages, provided humidity remains above 85% for at least 10 hours. *V. lecanii* is compatible with *Encarsia formosa.*

Wireworm *(Agriotes obscurus)* (L 199). For description see Lettuce—wireworms (p. 433). This pest should not be a problem where soil has been sterilised before planting, or where peat bag or nutrient film culture is practised. Control using one of the compounds listed in Table 12.20 (p. 463).

Woodlice. For description see Cucumber—woodlice (p. 423). Attacks can usually be prevented by attention to hygiene, and this pest should not be a problem where soil has been sterilised before planting. The soil underneath polythene sheeting used for soil-less culture systems can harbour woodlice. Control using one of the compounds listed in Table 12.20 (p. 463).

Diseases

Bacterial canker *(Corynebacterium michiganense)* (L 793). Bacterial canker is a

serious, though at present uncommon, disease causing loss of vigour, unmarketable spotted and disfigured fruit and premature plant death. Symptoms are very variable. Early in the season, bird's eye spotting on fruit, mealiness on the stems and white spotting on leaves may be found in crops where spraying has been regularly carried out. Later symptoms associated with blocking of the vascular tissue are typical and include one sided wilting of leaves, fruit marbling and dropping, and straw-coloured, yellow-staining of tissue surrounding the vascular bundles, particularly in the petioles. Plant death usually follows the onset of high summer temperatures.

The disease can be contained by strict isolation of infected plants and preventing spore spread by any form of water splash. Copper sprays (eg copper oxychloride [*150 g/100 l*]) are used and may give some reduction in spread during the early part of the season. A high standard of hygiene, both within the greenhouse and in the disposal of crop debris is necessary to prevent re-infection of the next tomato crop.

Brown root rot—see Root rots (p. 461).

Buck-eye rot *(Phytophthora nicotianae).* This disease is less common where watering is by drip lines. The lower fruits show grey and red-brown patches with concentric dark rings. Infection is caused by water-splash from, or contact with, contaminated soil. Tie trusses out of contact with soil and avoid splashing when watering. Containers, propagating and border soil should be sterilised with steam to reduce contamination. Where the disease occurs, apply one of the HV sprays shown in Table 12.19 (p. 458) to the lower part of the plant and the surface of the soil. Symptoms of buck-eye rot may be confused with blossom-end rot and other ripening disorders which are described in Growers' Bulletin No. 4, obtainable from the Glasshouse Crops Research Institute, Littlehampton.

Calyptella root rot *(Calyptella campanula)*[36]. This disease has recently been identified, although it has probably been present in tomato crops for several years. It has only been found in soil-grown crops where it can cause significant losses. The first signs of the disease are wilting on bright days which usually coincides with the commencement of picking. Plants recover turgor at night but as the disease progresses plants wilt for longer periods until they eventually do not recover, and die. Examination of the root system of affected plants reveals rusty brown lesions on all sizes of root. These are similar to brown and corky root rot lesions but there is no sign of the corkiness typically found on thick roots with brown and corky root rot.

Fruiting bodies of the fungus are sometimes produced on the surface of the soil in clusters near the base of the plant. They are lemon yellow to white in colour, saucer shaped, 2-4 mm in diameter on a stalk 2-4 mm long. Incubation of roots with extensive Calyptella lesions in a moist chamber will sometimes induce the production of these fruiting bodies directly on the root tissue which makes diagnosis easy.

There is a close association between high soil moisture content and the incidence and severity of the disease. It seems that where the soil is sufficiently

Table 12.19 Tomato—buck-eye rot, foot rot and damping off, grey mould, late blight, leaf mould, root rot, stem rot, wilt

See Integration, p. 462

Compound	Application rate: Buck-eye rot	Foot rot & damping-off	Grey mould	Late blight	Leaf mould	Root rot	Stem rot	Wilt	Minimum harvest inverval	Effect (where known) on: Phytoseiulus Eggs	Phytoseiulus Adults	Encarsia Pupae	Encarsia Adults
1. HV Sprays *(g/100 l)*									*(days)*				
benomyl	—	—	50*‡	—	50*‡	—	50	—	0	H	H	—	S
captan	—	—	—	—	—	—	*250*	—	*0*	—	*H*	—	S
carbendazim	—	—	50*	—	50*	—	50	—	0	—	I	—	S
chlorothalonil	110	—	110	110	110	—	—	—	0.5	—	S	S	S
copper oxychloride	150	—	—	150	—	—	—	—	0	S	S	—	S
cupric ammonium carbonate	10·5	—	—	—	21	—	—	—	0	—	S	—	I
dichlofluanid	—	—	50	—	50	—	—	—	3	—	S	S	S
iprodione	—	—	50	—	—	—	—	—	2	S	S	—	S
maneb	—	—	—	136-176	136-176	—	64-120	—	2	—	S	—	*I*
thiophanate-methyl	—	—	100*	—	100*	—	—	—	0	H	S	—	S
thiram	—	—	320	—	—	—	—	—	7	—	—	—	S
vinclozolin	—	—	37·5	—	—	—	—	—	1	—	S	—	S
zineb	140-150	—	—	140-150	140-150	—	—	—	2	—	S	—	S
2. LV Sprays *(g/100 m²)*													
maneb	—	—	—	13-18	13-18	—	—	—	2	—	—	—	—
thiram	—	—	56-90	—	—	—	—	—	7	—	—	—	—
zineb	—	—	—	34	34-90	—	—	—	2	—	—	—	—
3. Dust *(g/100 m²)*													
thiram	—	—	34-47	—	—	—	—	—	7	—	—	—	—
zineb	—	—	—	18	18-36	—	—	—	2	—	—	—	—
4. Paints *(g/l)*													
benomyl + 'Actipron'	—	—	—	—	—	—	330	—	0	—	—	—	—
captan	—	—	—	—	—	—	13·3	—	0	—	—	—	—
iprodione + 'Actipron'	—	—	333	—	—	—	333	—	0	—	—	—	—
maneb	—	—	—	—	—	—	10	—	0	—	—	—	—

5. Atomisations (A), Smokes (S), Vapourisations (V) *(g/100 m³)*													
copper oxychloride (A)	—	—	—	†	†	—	—	—	0	—	—	—	—
iprodione (A)	—	—	†	—	—	—	—	—	2	—	—	—	—
tecnazene (S, V)	—	—	†	—	†	—	—	—	2	—	—	—	—
zineb (A)	—	—	—	†	†	—	—	—	2	—	—	—	—
6. Incorporation into Compost (C), Soil (S), Nutrient film solution (NF) *(g/m²)*													
etridiazole (C)	—	14-26·3	—	—	—	—	—	—	0	—	—	—	—
etridiazole (NF)	—	2§	—	—	—	—	—	—	1	—	—	—	—
quintozene (C)	—	100-150	—	—	—	150	—	—	0	—	—	—	—
quintozene (S)	—	7	—	—	—	7	—	—	0	—	—	—	—
propamocarb (C)	—	288	—	—	—	—	—	—	14	—	—	—	—
7. Soil drenches *(g/100 l)*													
benomyl	—	—	25*	—	25*	—	25	25*	0	I	I	S	S
carbendazim	—	—	25*	—	25*	—	25	25*	0	—	—	—	—
copper oxychloride	—	75	—	—	—	—	—	—	0	—	—	—	—
cupric ammonium carbonate	—	10·5	—	—	—	—	—	—	0	—	—	—	—
etridiazole	—	35	—	—	—	—	—	—	3	—	—	—	—
propamocarb	—	144	—	—	—	—	—	—	14	—	—	—	—
thiophanate-methyl	—	—	100*	—	100*	—	100	100*	0	—	—	—	—
zineb	—	140-150	—	—	—	140-150	—	—	2	—	—	—	—

* — races of the fungus may be insensitive to these chemicals, use soil drenches where biological control is in practice.
† — see manufacturer's instructions.
‡ — first 2 sprays of an alternative chemical not marked *; then alternate in subsequent applications.
§ — rate is *g/100 l*.

H — harmful (H>7—harmfulness persists for more than 7 days).
I — intermediate.
S — safe.

moist to support the growth of moss on the surface then the conditions are suitable for the disease, especially where the watering system creates this condition near the base of the plant, as with a drip system. The disease does not appear to spread easily from house to house but rather to spread gradually within a house, possibly over a number of years.

Conventional soil sterilisation techniques do not appear to give effective control. Avoiding prolonged periods of excessively wet soil conditions offers the best means of reducing the effects of the disease. Reducing the quantity and frequency of watering and, with drip systems, moving the drip outlet from the plant base to about 20 cm away, will help. Experimental work has shown that a captan drench [*100 g/100 l*] using 500 ml/plant applied when the disease is first seen and again 3 weeks later will give some control. In houses with a history of the disease a first drench 2-3 weeks after planting at the rate recommended for Didymella [*50 g/100 l*] has been suggested.

Colletotrichum root rot—see Root rots (p. 461).

Corky root—see Root rots (p. 461).

Foot rot and Damping-off *(Phytophthora nicotianae, P. cryptogea, Rhizoctonia solani (Thanatephorus cucumeris)* and *Pythium* spp.*).* These fungi may cause damping-off of seedlings or foot rot of plants in propagation or soon after planting out. Infection arises from the soil or from contaminated boxes, pots or water. Attack by *Phytophthora* sp. is associated with cold, wet soils and is less likely in heated greenhouses. Sterilise propagating soil, as for buck-eye rot. Use one of the soil drenches or incorporation treatments shown in Table 12.19 (p. 458) at seed sowing, potting or planting out. All doubtful plants must be rejected when potting or planting.

In nutrient film culture, species of Phytophthora and Pythium can cause extensive wilting with associated suppressed root regeneration. Protect plants by the addition of etridiazole mixed into reservoirs as directed on the product label; do not over-dose. Heating the solution to 20-22°C and avoiding checks to growth will reduce the risk of root rotting due to infection with the organisms.

Grey mould *(Botrytis cinerea)*[SY]. The disease is common, especially when the weather is wet and cool. The fungus can invade all parts of the plant above soil level and is characterised by the masses of grey spores produced on infected tissues. Lesions in the stem are caused by the spread of infection from damaged or senescent leaves, petiole stumps or deleafing wounds; in layered cultivation, lesions may spread from stem to stem by contact. Stem lesions are particularly damaging because, if they become aggressive, they destroy the structural and conducting tissue and kill the plant. Air-borne Botrytis spores can cause a reaction in matt-surfaced, immature fruit which persists to disfigure the ripe fruit with 'ghost-spots'. Fruit are lost when flowers become infected before setting or the calyx or corolla may be colonised after the fruit has set and cause premature drop.

To control the disease, reduce humidity. Remove all plant debris from borders, and decaying leaves and fruits from plants. Allow circulation of air through the lower parts of the plants by removing leaves and shoots cleanly. Grey mould

lesions on stems should be painted with a paste of iprodione as in Table 12.19 (p. 458).

To protect foliage and fruit from infection, use one of the HV or LV sprays or dust treatments shown in Table 12.19 (p. 458) every 14 days or apply an appropriate soil drench every month. Iprodione and vinclozolin have been very effective in practice, but better control of ghost spot is given by dichlofluanid or chlorothalonil.

Late blight *(Phytophthora infestans).* Crops in unheated or well-sealed or insulated greenhouses are at risk during wet weather in August, when the disease is very common on potato crops, and considerable loss can occur due to attack on leaves and fruit. On the leaves, large brown spots with pale margins and a downy, white fungal growth on the underside, spread rapidly in humid conditions. Stems may show dark lesions, and green fruit are disfigured with large, hard, brown patches. High temperatures or low humidity will control the disease, but in unheated crops near potato fields a routine spray application may be worthwhile. Otherwise sprays may begin when blight, or weather suitable for its development, is forecast. Apply one of the compounds shown in Table 12.19 (p. 458) for late blight control. Young plants raised in late autumn may also be affected, but the disease rarely spreads after plants are spaced out in the cropping houses and no action other than removing affected tissue is usually necessary.

Leaf mould *(Fulvia fulva (Cladosporium fulvum))* (L 263)[38]. This disease is favoured by warm weather and high overnight humidities and is common in mid-summer. Yield loss, presumably due to a reduction in effective leaf area, only occurs some weeks after the disease has become established. Older leaves show pale yellow patches which on the undersurface become covered with a pale grey mould which darkens to brownish violet. The disease is often controlled by ventilation or by growing resistant varieties. In some varieties, resistance has been overcome by the fungus. Use one of the methods of treatment shown in Table 12.19 (p. 458). Alternatively, when petroleum oil is used to control red spider mite, copper fungicides may be added [*63·95 g* (copper)*/100 l* diluted emulsion] to control leaf mould.

Root rots[39,40]. Tomato roots are commonly attacked and rotted by several fungi, the most important are *Pyrenochaeta lycopersici*, which is responsible for brown root rot and for corky root, and *Colletotrichum coccodes* which destroys the cortex of the roots and stem below soil level. The effect of these fungi is to reduce plant vigour and crop production, and plants tend to wilt in bright, hot weather. The severity of root rot is correlated with pre-planting soil treatment. For the control of root-rotting fungi, sterilise the soil (p. 399). Other methods of treatment are to incorporate quintozene into composts or soil or to drench with zineb as shown in Table 12.19 (p. 458).

Stem rot *(Didymella lycopersici)* (L 560)[41]. This disease has become more frequent particularly in crops in soil-less cultivation. The potential for loss is considerable and, once established, the disease is difficult to eradicate. Dark brown, sunken, girdling lesions are found at the base of stems. Pinhead-sized

pycnidia which exude spores when wet, are often found embedded in the soft and rotting tissues of the lesion. The lower leaves become yellow and plants wilt and die. Stem rot lesions are also found in the upper part of the stem and on fruit. They may be distinguished from grey mould lesions by the absence of grey spores and mycelium. Young and wounded tissues are most susceptible to infection in wet conditions and when the temperature is 15-20°C. Inoculum survives in debris, in soil and on the greenhouse structure and wires. It spreads in the crop by splash dispersal and on implements, hands and clothes.

Hygiene is vital to the exclusion and control of the disease. When infection occurs, completely enclose infected plants in an air-tight bag before prompt and clean removal from the crop. Alternatively, lesions should be treated with benomyl or iprodione paint shown in Table 12.19 (p. 458) for stem rot; do *not* cut out stem rot lesions. Treat other plants with HV sprays, as shown in Table 12.19 (p. 458), at weekly intervals if the disease is severe. Benomyl or carbendazim can be used as soil drenches every month, but they are likely to be less effective. At the end of the crop, fumigate or fog with formaldehyde. Dispose of all debris and used peat bags safely so that there is no risk of spread or reinfection. Wash down all structures and implements with 2% formaldehyde.

On nurseries with a history of stem rot, border soil should be sterilised with steam or methyl bromide even if soil-less cultivation is to be used. Using the rates shown in Table 12.19 (p. 458), protect with HV sprays or soil drenches of benomyl or carbendazim. Or captan may be drenched at the stem base (85 ml/plant) 2 days after planting, repeating 2-3 weeks later (110-140 ml/plant).

Wilt diseases *(Verticillium albo-atrum, V. dahliae, Fusarium oxysporum)* (L 53). Isolation and sterile culture is required to identify the organism responsible for wilting because the diseases are not easily distinguished by symptoms. Fusarium wilt is more serious at higher temperatures.

The first symptoms of wilt are usually yellowing and temporary wilting of lower leaves, often on one side of the plant. The woody stem tissues become brown and the discolouration can be extensive or limited to the lower stem region.

Most modern cultivars are resistant to both pathogens but soil sterilisation should not be neglected since races of Fusarium occur which can overcome the resistance. Where Verticillium wilt occurs, symptoms may be suppressed by raising the greenhouse temperature to 25°C, shading lightly and/or overhead damping.

Soil drenches as shown in Table 12.19 (p. 458) may give some control.

Integration of pesticides with natural enemies

The information in some of the Tables about the possible effects of pesticides on natural enemies is based mainly on laboratory investigations where pesticides were applied very efficiently under ideal conditions. Consequently, the results may not exactly reflect the situation in commercial greenhouses, but they do offer useful guidelines.

Compound	Application rate	Harvest interval (days)	Pest: Cutworm	Earwig	Leatherjacket	Millepede	Sciarid	Slug	Springtail	Symphylid	Vine weevil	Wireworm	Woodlouse
1. Drenches	*(g/100 l)*												
Carbaryl	‡	7	Yes	Yes*	Yes	—	—	—	Yes	—	—	—	Yes
diazinon	10	▵	—	—	—	—	Yes	—	Yes	Yes	—	—	—
diflubenzuron‖	11	—	—	—	—	—	Yes	—	—	—	—	—	—
gamma-HCH∫	12·5	14	Yes	Yes	Yes	—	—	—	Yes	Yes	Yes	Yes	—
parathion	13†	28	—	—	—	Yes	—	—	—	Yes	—	—	Yes§
permethrin/thiram	4 + 25	0	—	Yes	—	—	—	—	—	—	—	—	—
2. Granules	*(g/100 m²)*												
metaldehyde	9·4	0	—	—	—	—	—	Yes	—	—	—	—	—
methiocarb	2·2	7	Some	—	Some	—	—	Yes	—	—	—	—	Yes
3. Compost incorporation	*(g/m²)*												
aldrin	20‖	—	—	—	—	—	—	—	—	—	Yes	—	—
diflubenzuron	10‖	—	—	—	—	—	Yes	—	—	—	—	—	—
pirimiphos-ethyl	50‖	—	—	—	—	—	Yes	—	—	—	—	—	—

* — resistant strains may be encountered.

† — on cucumber use maximum one application/season *6·25 g/100 l*; on tomato use maximum one application/season *37·5 g/100 l*; OR three applications/season *15·6 g/100 l*. Do not use on other edible crops.

‡ — See product label.

§ — for woodlouse on ornamentals, use *27 g/100 l*.

‖ — use on ornamentals only.

∫ — vapours may be harmful to *Phytoseiulus* if insufficient ventilation.

▵ — on tomato 14 day harvest interval; on cucumber 2 day harvest interval.

The following steps should be used in interpreting the information given:—

1. Decide which natural enemies you are or *may be* using; *always think ahead.*
2. Make a short-list of pesticides which can be used for a given pest or disease.
3. Beside each chemical in the short-list write in the effects on natural enemies as given in the Table.
4. Err on the side of caution and assume that, where no information is available, the pesticide is Harmful, unless there is good evidence to the contrary. Where a pesticide is Safe to adult *Encarsia formosa* it will almost certainly be Safe to pupae as well. Add all this information to the short-list.
5. One of the pesticides may now stand out as the safest alternative. If not:—
6. Use the persistence data (e.g. Harmful for 7 days) to find the pesticide which is least persistent. Where no information is given the 'minimum interval to be observed between application and harvesting', given in the ACAS handbook of Approved Products for Farmers and Growers, may be substituted.

The following points should also be noted:—

1. Pesticides applied soon after the introduction of natural enemies will be more harmful than when applied after natural enemies are well established.
2. The method of application can influence the effect of a pesticide on natural enemies. Benomyl (Table 12.5, p. 392) is less harmful to *Phytoseiulus persimilis* when applied as a soil drench than as an HV spray.
3. One way of minimising any harmful effect of a pesticide is to use 'spot-treatments' to areas where the pest or disease occurs, so that natural enemies are unharmed elsewhere.
4. 'Once-off' sprays will be less harmful than routine programmes.

List of Latin names

Pests

Agriotes obscurus	wireworm
Anaphothrips orchidaceus	orchid thrips
Aphelenchoides composticola	mushroom nematode
Aphelenchoides ritzemabosi	chrysanthemum nematode
Aphidius matricariae	(a parasite of the peach-potato aphid)
Aphis fabae	black bean aphid
Aphis gossypii	melon and cotton aphid
Armadillidium spp.	woodlouse
Aspidiotus hederae	oleander scale
Aulacaspis rosae	scurfy rose scale
Aulacorthum circumflexum	mottled arum aphid
Aulacorthum solani	glasshouse-potato aphid
Bacillus thuringiensis	(a bacterial pesticide)
Brachycaudus helichrysi	leaf-curling plum aphid
Bryobia spp.	clover mite
Cacoecimorpha pronubana	carnation tortrix
Calocoris norvegicus	potato capsid

Cerataphis lataniae	aphid
Coccus hesperidum	soft scale
Collembola spp.	springtail
Cholus cattleyae	cattleya weevil
Delia platura	bean seed fly or freesia maggot
Ditylenchus dipsaci	stem and bulb nematode
Ditylenchus myceliophagus	mushroom spawn nematode
Dysaphis tulipae	tulip bulb aphid
Encarsia formosa	(a parasite of glasshouse whitefly)
Eumerus strigatus	small narcissus fly
Eumerus tuberculatus	small narcissus fly
Eurytoma orchidearum	cattleya fly
Forficula auricularia	common earwig
Globodera rostochiensis	potato cyst nematode
Heliothrips femoralis	thrips
Heliothrips haemorrhoidalis	glasshouse thrips
Hercinothrips femoralis	banded glasshouse thrips
Heteropeza pygmaea	white cecid
Lacanobia oleracea	tomato moth
Liriomyza bryoniae	tomato leaf miner
Liriomyza trifolii	american serpentine leaf miner
Lycoriella auripila	mushroom sciarid
Lygocoris pabulinus	common green capsid
Lygus rugulipennis	tarnished plant bug or bishop bug
Macrosiphoniella sanborni	chrysanthemum aphid
Macrosiphum euphorbiae	potato aphid
Macrosiphum rosae	rose aphid
Megaselia halterata	worthing phorid
Megaselia nigra	black phorid
Meloidogyne hapla	root-knot nematode
Meloidogyne incognita	root-knot nematode
Merodon equestris	large narcissus fly
Mycophila speyeri	orange cecid
Myzus ascalonicus	shallot aphid
Myzus persicae	peach-potato aphid
Nasanovia ribisnigri	lettuce aphid
Oniscus spp.	woodlouse
Otiorhynchus sulcatus	black vine weevil
Oxidus gracilis	glasshouse millepede
Parallelodiplosis cattleyae	cattleya midge
Parthenolecanium corni	peach scale
Philophylla heraclei	celery fly
Phlogophora meticulosa	angleshades moth
Phytomyza syngenesiae	chrysanthemum leaf miner
Phytoseiulus persimilis	(a predator of glasshouse red spider mite)
Planococcus citri	greenhouse mealybug
Polyphagotarsonemus latus	broad mite
Porcellio spp.	woodlouse

Pratylenchus spp.	root-lesion nematode
Prodenia litura	mediterranean climbing cutworm
Pseudococcus adonidum	long-tailed mealybug
Psilla nigricornis	chrysanthemum stool miner
Psilla rosae	carrot fly
Rhizoglyphus echinopus	bulb mite
Sciara spp.	sciarid fly
Scutigerella immaculata	glasshouse symphilid
Spodoptera littoralis	mediterranean climbing cutworm
Steneotarsonemus laticeps	bulb scale mite
Steneotarsonemus pallidus	cyclamen mite or strawberry mite
Taeniothrips atratus	carnation thrips
Tarsonemus confusus	—
Tarsonemus mycelophagus	mushroom spawn mite
Tetranychus cinnabarinus	red spider mite
Tetranychus urticae	glasshouse red spider mite
Thrips tabaci	onion thrips
Tipula spp.	leatherjackets
Trialeurodes vaporariorum	glasshouse whitefly
Trichoniscus spp.	woodlouse
Tryophagus longior	*french fly*
Zygina pallidifrons	glasshouse leafhopper
Diseases	
Agrobacterium tumefaciens	crown gall
Alternaria dianthi	basal rot of carnation
Alternaria dianthi	leaf spot of carnation
Alternaria tenuis	leaf spot of pelargonium
Artotrogus hydrosporus	damping-off of celery
Botrytis cinerea	grey mould
Botrytis elliptica	leaf spot of bulbs—lily
Botrytis tulipae	fire of bulbs—tulip
Bremia lactucae	downy mildew of lettuce
Calyptella campanula	root rot of tomato
Cephalosporium lamellicola	gill mildew of mushroom
Cladobotryum sp. (see *Hypomyces* sp.)	
Cladosporium cucumerinum	gummosis of cucumber
Cladosporium fulvum (see *Fulvia fulva*)	
Colletotrichum coccodes	root rot of tomato
Colletotrichum gloeosporioides	leaf curl of anemone
Colletotrichum scutatum	leaf curl of anemone
Colletotrichum lagenarium	anthracnose of cucumber
Coniothyrium fuckelii	Coniothyrium rot of rose
Corynebacterium fascians	leafy gall
Corynebacterium michiganense	bacterial canker of tomato
Cylindrocarpon destructans	root rot of cyclamen
Dactylium dendroides (see *Hypomyces rosellus*)	
Didymella bryoniae	stem and fruit rot of cucumber

Didymella chrysanthemi	ray blight of chrysanthemum
Didymella lycopersici	stem rot of tomato
Diehliomyces microsporus	truffle on mushroom beds
Diplocarpon rosae	black spot of rose
Erwinia carotovora	basal stem rot of cucumber
Erwinia carotovora	corm rot of arum lily
Erwinia carotovora pv. *atroseptica*	bacterial rot of chinese cabbage
Erwinia carotovora pv. *carotovora*	soft rot of hyacinth
Erwinia chrysanthemi	slow wilt of carnation
Erysiphe cichoracearum	powdery mildew of courgettes and marrow
Erysiphe ranunculi	powdery mildew of anemone
Fulvia fulva	leaf mould of tomato
Fusarium culmorum	stem rot of carnation
Fusarium culmorum	basal rot of carnation
Fusarium moniliforme	Fusarium yellows of freesia
Fusarium oxysporum f. sp. *asparagi*	root rot of asparagus fern
Fusarium oxysporum f. sp. *dianthi*	Fusarium wilt of carnation
Fusarium oxysporum f. sp. *gladioli*	Fusarium basal rot of iris
Fusarium oxysporum f. sp. *lilii*	Fusarium scale rot of bulbs—lily
Fusarium oxysporum f. sp. *narcissi*	basal rot of bulbs—narcissus
Fusarium oxysporum f. sp. *tulipae*	Fusarium bulb rot of bulbs—tulip
Fusarium oxysporum	Fusarium yellows of freesia
Fusarium oxysporum	wilt of tomato
Fusarium poae	bud rot of carnation
Fusarium roseum (see *F. culmorum*)	
Fusarium spp.	root rot
Gloeosporium spp.	anthracnose of orchid
Glomerella cincta	anthracnose of orchid
Hypomyces roseilus	cobweb of mushroom
Hypomyces sp.	cobweb of mushroom
Itersonilia perplexans	petal blight of chrysanthemum
Leptosphaeria coniothyrium	Coniothyrium rot of rose
Microsphaera begoniae	powdery mildew of begonia
Microsphaera polonica	powdery mildew of hydrangea
Mycogone perniciosa	wet bubble of mushroom
Mycosphaerella dianthi	ring spot or fairy ring spot of carnation
Mycosphaerella ligulicola (see *Didymella chrysanthemi*)	
Mycosphaerella mucrospora	leaf spot of iris
Mycosphaerella melonis (see *Didymella bryoniae*)	
Oidium begoniae	powdery mildew of begonia
Oidium chrysanthemi	powdery mildew of chrysanthemum
Oidium sp.	powdery mildew of carnation
Oidium sp.	powdery mildew of primula
Olpidium brassicae	vector of lettuce big vein
Pectobacterium carotovorum (see *Erwinia carotovora*)	

Penicillium corymbiferum	bulb rot of iris
Peronospora ficariae	downy mildew of anemone
Peronospora parasitica	downy mildew of stocks
Peronospora sparsa	downy mildew of rose
Phialophora cinerescens	Phialophora wilt of carnation
Phoma apicola	root and crown rot of celery
Phoma chrysanthemicola	Phoma root rot of chrysanthemum
Phomopsis sclerotioides	black root rot of cucumber
Phragmidium mucronatum	rust of rose
Phytophthora cryptogea	foot rot of tomato
Phytophthora cryptogea	shanking of tulip
Phytophthora erythroseptica	shanking of tulip
Phytophthora infestans	late blight of tomato
Phytophthora nicotianae	stump rot of lily
Phytophthora nicotianae	buck-eye rot of tomato
Phytophthora nicotianae	foot rot of tomato
Phytophthora richardiae	root rot of arum lily
Phytophthora spp.	basal rot of carnation
Phytophthora spp.	foot rot of lily
Phytophthora spp.	damping-off of sweet pepper
Phytophthora spp.	root rots of primula
Pseudomonas caryophylli	bacterial wilt or stem crack of carnation
Pseudomonas tolaasi	bacterial blotch of mushroom
Puccinia chrysanthemi	rust of chrysanthemum
Puccinia horiana	white rust of chrysanthemum
Puccinia pelargonii-zonalis	rust of palargonium
Pyrenochaeta lycopersici	brown root rot of tomato
Pythium artotrogus	damping off of celery
Pythium irregulare	root rot of iris
Pythium spp.	basal rot of asparagus fern
,, ,,	black rot of orchid
,, ,,	basal rot of carnation
,, ,,	root rot of lily
,, ,,	damping-off of celery
,, ,,	damping-off of chrysanthemum
,, ,,	damping-off of cucumber
,, ,,	damping-off of poinsettia
,, ,,	damping-off of sweet pepper
,, ,,	foot rot of tomato
,, ,,	root rots of begonia
,, ,,	root and stem rots of pelargonium
,, ,,	root rots of primula
,, ,,	root rot of bulbs—tulip
Rhizoctonia solani	basal rot of carnation
,, ,,	damping-off of celery
,, ,,	damping-off of chrysanthemum
,, ,,	damping-off of sweet pepper
,, ,,	damping-off of radish

Rhizoctonia solani	foot rot of tomato
,, ,,	rot of iris
,, ,,	Rhizoctonia rot of lettuce
,, ,,	root rots of begonia
,, ,,	root and stem rots of pelargonium
,, ,,	root rots of poinsettia
Rhizoctonia tuliparum	grey rot of tulip
Sclerotinia sclerotiorum	Sclerotinia rot of aubergine
Sclerotinia sclerotiorum	Sclerotinia rot of celery
Sclerotinia sclerotiorum	Sclerotinia rot of chrysanthemums
Sclerotinia sclerotiorum	Sclerotinia rot of lettuce
Sclerotinia sclerotiorum	Sclerotinia rot of sweet pepper
Sclerotinia spp.	root and stem rots of pelargonium
Septoria apiicola	leaf spot of celery
Septoria azaleae	leaf spot of azalea
Septoria chrysanthemella	blotch of chrysanthemum
Septoria dianthi	Septoria leaf spot of carnation
Sphaerotheca fuliginea	powdery mildew of cineraria
Sphaerotheca fuliginea	powery mildew of cucumber
Sphaerotheca pannosa	powdery mildew of rose
Sporendonema purpurascens	red geotrichum of mushroom
Stagonospora curtisii	leaf scorch of hippeastrum
Thanatephorus cucumeris (see *Rhizoctonia solani*)	
Thielaviopsis basicola	root rots of begonia
Thielaviopsis basicola	root rots of cyclamen
Thielaviopsis basicola	root and stem rots of pelargonium
Thielaviopsis basicola	root rots of poinsettia
Thielaviopsis basicola	root rots of primula
Tranzschelia pruni-spinosae	plum rust on anemones
Uncinula necator	powdery mildew of grapevine
Uromyces dianthi	rust of carnation
Verticillium albo-atrum	Verticillium wilt of chrysanthemum
Verticillium albo-atrum	Verticillium wilt of cucumber
Verticillium albo-atrum	wilts of tomato
Verticillium cinerescens (see *Phialophora cinerescens*)	
Verticillium dahliae	wilt of aubergine
Verticillium dahliae	wilt of tomato
Verticillium fungicola	dry bubble of mushroom
Verticillium psalliotae	dry bubble of mushroom
Xanthomonas hyacinthi	yellow disease of bulbs—hyacinth
Xanthomonas pelargoni	root and stem rots of pelargonium
Zygophiala jamaicensis	greasy blotch of carnation

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Chapter 14
Pests and diseases of outdoor bulbs and corms

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Introduction

The UK bulb industry produces dry bulbs for sale together with cut flowers from both the field and the greenhouse. About 4000 ha of bulbs were planted in 1981 of which some 3000 ha were down to narcissus, our most important bulb crop. Approximately 400 ha of tulips are grown with much smaller areas of anemone, gladiolus, iris and lily. There is some local interest in the production of the smaller bulbs such as crocus, muscari and snowdrop but most stocks are imported for flower production and the remainder for garden and amenity use.

An increasing export trade of narcissus in particular, has resulted in the need to grow bulb stocks substantially free from pests and diseases in order to meet the strict phytosanitary requirements of importing countries.

The fungal and viral diseases of bulbs are given in detail in RB 117 'Diseases of Bulbs', available from MAFF publications.

Anemone

Pests

Aphids. The peach-potato aphid *(Myzus persicae),* mottled arum aphid *(Aulacorthum circumflexum)* and other species cause direct damage by feeding

on the flower bracts and petals and also transmit virus diseases. As soon as aphids are seen spray with demeton-S-methyl [*22 g/100 l*], or dimethoate [*34 g/100 l*], or gamma-HCH [*13 g/100 l*] (not effective against the mottled arum aphid), or malathion [*112 g/100 l*], or oxydemeton-methyl [*22 g/100 l*], or pirimicarb [*25 g/100 l*].

Caterpillars. The caterpillars of several moth species including the angle shades moth *(Phlogophora meticulosa)* eat the flowers and foliage. Spray with deltamethrin [*1·7 g/100 l*], or gamma-HCH [*13 g/100 l*], or trichlorphon [*800 g/ha*].

Cutworms (L 225). These are the caterpillars of certain noctuid moths, e.g. the turnip moth *(Agrotis segetum)* and the garden dart moth *(Euxoa nigricans)* which feed at or just below ground level and are most troublesome in July and August in hot, dry summers. They do most damage to seedlings but the leaves and flower buds on established plants are also attacked. Cutworms are more readily killed when they are small and still feeding at ground level. To control, use a drenching spray of DDT [*50 g/100 l*] at the first signs of damage. Information is limited on the value of alternative insecticides but trichlorphon [*12·0 kg/ha*] has been used on other crops with some success.

Slugs (L 115). These occasionally damage leaves, stems and flowers and are controlled by baiting with pellets of methiocarb [*220 g/ha*], or metaldehyde [*940 g/ha*] when the slugs are active on the soil surface.

Symphylids (L 484). The open ground symphylids *(Symphylella* spp.*)* and occasionally the glasshouse symphylid *(Scutigerella immaculata)* will feed on the roots, corms and underground stems resulting in patchy growth. Some control can be achieved by drenching with diazinon [*40 g/100 l*], or gamma-HCH [*13 g/100 l*]. Where damage occurs regularly, spray the soil with gamma-HCH [*1·12 kg/ha*] and lightly incorporate before drilling the seed or planting corms.

Diseases

Downy mildew *(Plasmopara* spp. and *Peronospora* spp.*)*. These fungi cause leaves to turn a dull greyish-yellow. Often, leaves curl downwards (not to be confused with anemone leaf curl) which makes plants look stunted. Large numbers of spores are produced on the undersides of leaves, and these are easily dispersed in wet and windy weather. Resting spores are produced which infest soil and remain viable for several years.

Foliar sprays are usually uneconomic and a long crop rotation is the usual method of control. If this is not possible soil sterilants such as metham-sodium [*150 l/ha*], or dazomet [*380 kg* formulated prill/*ha*] will kill many of the resting spores.

Grey mould *(Botrytis cinerea)*. This is essentially a disease of either poorly grown plants or a result of bad weather damage and is common after severe gales in the south-west of England. The fungus establishes in the crown of plants and kills them. Spores form prolifically on the dead tissue and are splashed by rain on to nearby plants.

Several fungicides give good control of the disease; dithiocarbamates [*14·5-33·8 l/100 m²*], and iprodione [*50 g/100 l*] are likely to give good control.

Leaf curl *(Colletotrichum* spp.). This is a new disease reported in the last few years. A leaf curling symptom appears reminiscent of hormone damage. As yet there is no satisfactory method of control.

Plum rust *(Tranzschelia discolor).* This disease sometimes affects anemones in the south west of England. The plants are distinguished by their thickened and more upright appearance. The undersides of the leaves display aecidia and cluster-cups, these latter producing the spores which infect plum trees later in the year. Spores from leaves of infected plum trees in the vicinity of anemones may in turn cause infection. The plants may be protected by spraying in the winter months with oxycarboxin [*37·5 g/100 l*].

Powdery mildew *(Erysiphe ranunculi).* This is a common mildew in conditions when day temperatures are high and there are heavy dews at night. Leaves appear whitish and occasionally small black bodies (cleistothecia) are formed in the white superficial fungus. These are probably of lesser importance than the masses of dry powdery spores that are blown from the leaves on to nearby plants.

Occurrence of this disease is rarely frequent enough for control measures to be tested but chemicals used to control other powdery mildews should be effective.

Crocus

Pests

Gladiolus thrips *(Thrips simplex)* (L 766). These will feed on crocus corms in store producing yellowish-brown discolorations beneath the skin; attacked corms make poor growth. Control as for Gladiolus—thrips (p. 562).

Tulip bulb aphid *(Dysaphis tulipae).* For description and control see Tulip—tulip bulb aphid (p. 570).

Diseases

There is a growing commercial interest in the smaller decorative bulbs and of these crocus is the most popular. Many of the diseases, for example, grey mould, dry rot and Fusarium rot, have similar development patterns and control methods to corresponding diseases of the bigger bulbs; tulip fire, gladiolus dry rot and narcissus basal rot, respectively.

Gladiolus

Pests

Aphids. Several species, e.g. the potato aphid *(Macrosiphum euphorbiae)* the peach-potato aphid *(Myzus persicae)* and the shallot aphid *(Myzus ascalonicus)*

all infest the foliage and also transmit virus diseases. Control as for Anemone—aphids (p. 559). The tulip bulb aphid *(Dysaphis tulipae)* attacks the dry corms in store, control as for Tulip—*tulip bulb aphid* (p. 570).

Caterpillars. Foliage feeding caterpillars of the cabbage moth *(Mamestra brassicae)* and the angle shades moth *(Phlogophora meticulosa)* are occasionally troublesome. For control see Anemone—caterpillars (p. 560).

Gladiolus thrips *(Thrips simplex)* (L 766). These very small elongate insects, yellow when immature and dark brown in the adult stage, suck the sap of the stems and leaves causing pale yellow or silvery streaks. They will also feed on flowers producing small white flecks on the petals. Thrips overwinter in store on the corms, feeding under the scales; they continue to breed at temperatures above 10°C. Infested corms have rough, greyish-brown patches on the surface. Control infestations in the field by sprays of gamma-HCH [*13 g/100 l*], or malathion [*112 g/100 l*] as soon as thrips are found. To prevent a build-up of the pest in store fumigate regularly with dichlorvos [*see label*], or gamma-HCH smokes [*see label*] then reduce the store temperature to about 10°C to limit further breeding.

Slugs (L 115). These sometimes graze the emerging foliage during wet periods and are controlled as for Anemone—slugs (p. 560).

Diseases

Botrytis rot *(Sclerotinia draytoni).* This causes spotting of flowers but the origin of this goes back to corm infection. Small sunken lesions, with a cavity beneath the brown rot, may be seen in corms. If corms are stored in damp conditions these lesions will enlarge and develop into a brown spongy mass. Black sclerotia (resting bodies) may form. Shoots from infected bulbs may become infected and once above ground the fungus forms spores which are spread to nearby plants, principally by water splash. Secondary leaf spotting then develops which will eventually maintain the disease until the flowers become infected. The disease is perpetuated by short crop rotations and infection passing from the parent to the daughter corms.

Control involves several practices. Corms should be lifted and dried rapidly which induces a wound reaction and effectively prevents lesions from enlarging. Corm dips are effective (but see Fusarium yellows). A cold dip for 30 minutes should be adequate.

Leaf infection may be prevented or controlled by routine cyclic spraying of carbendazim [*5·5-6·6 g/l*], or iprodione [*50 g/100l*], or dithiocarbamate [*14·5-33·8 g/100 m²*]. Captan [*94 g/100 l*], daconil [*0·75 l/100 l*] or dichloran have also been used successfully in America.

Dry rot *(Stromatinia gladioli).* This is the most common and serious disease of gladioli in this country. Shoots emerge apparently healthy but at any time during growth infected ones turn yellow then brown and finally die in the space of one or two weeks. Such shoots are easily pulled away from the corm and at the base

many thousands of minute black sclerotia may be seen. These sclerotia infest soil to such an extent that it becomes 'sick' and remains unsuitable for many years. The fungus also causes a dry rot of corms in store.

There is no effective treatment of the growing plant. Corm infection may be controlled by treating corms with hot water containing formalin [*0·2% commercial formaldehyde*].

Soil sterilisation is effective with methyl bromide being the favoured chemical.

The fungus also attacks Acidanthera, Crocus, Freesia, Galanthus, Lepeirousia, Montbretia and Narcissus.

Fusarium yellows *(Fusarium oxysporum f. sp. gladioli).* This is in many countries the most serious disease but, probably because of lower soil temperatures in the UK it remains as a potential threat. The first symptom is leaf tip yellowing followed by die-back which is similar to dry rot. However, there are some fundamental differences between the two diseases. With yellows the stem base will appear clean and is free from the minute sclerotia. The roots of plants with yellows are usually brown or absent, unlike those with dry rot which look healthy. Yellows disease usually coincides with hot weather and high soil temperatures.

Corms frequently rot away in the ground, although in store they often mummify.

The disease is controlled by hot water treatment with added formalin [*0·2% commercial formeldehyde*] and thiabendazole [*see makers recommendation*].

Storage rot *(Penicillium gladioli).* This is a storage disease associated with damaged corms or when corms are stored badly. Rotted corms appear brown and are soft and wet to the touch. Treatment with thibendazole [*see makers recommenation*], used to control other diseases, will also control this rot.

Hyacinth

Pests

Large narcissus fly *(Merodon equestris)* (L 183). Attacks occasionally develop on hyacinth bulbs; for description and control measures see Narcissus—large narcissus fly (p. 566).

Stem nematode *(Ditylenchus dipsaci).* Symptoms of damage are similar to those seen on Narcissus (p. 567) except that definite leaf 'spickels' do not develop. Hot-water treatment of infested bulbs for four hours at 45°C, which is based on the Dutch recommendation, is the only effective control measure available.

Diseases

Yellow disease *(Xanthomonas hyacinthi).* Although almost all the hyacinths used in the forced flower trade are imported there is no especial reason why bulbs

should not be produced out of doors in the UK. There are several diseases that attack hyacinths but the limiting one is yellow disease. Control of this bacterial disease is largely by using good cultural methods, especially during storage.

Iris

Pests

Aphids. Species infesting the foliage include the potato aphid *(Macrosiphum euphorbiae)* and the peach-potato aphid *(Myzus persicae)*. The tulip bulb aphid *(Dysaphis tulipae)* is occasionally found on bulbs in store. For control see Anemone—aphids (p. 559) and Tulip—tulip bulb aphid (p. 570).

Potato tuber nematode *(Ditylenchus destructor)* (L 372). This nematode, which closely resembles the stem nematode in size and shape, attack bulbous iris producing damaging symptoms only on the bulb. Attacked bulbs show dark, reddish-brown streaks on the scales extending upwards from the base plate. The emerging foliage generally lacks vigour and bulb yields are depressed. Hot-water treatment for three hours at 44·4°C preceded by warm storage and a pre-soak, is the only effective control measure available.

Slugs (L 115). These will attack the bulbs, or graze the foliage and occasionally feed on the flowers. For control see Anemone—slugs (p. 560).

Thrips. The iris thrips *(Frankliniella iridis)* and the gladiolus thrips *(Thrips simplex)* feed on the foliage causing silvering. They will also attack flowers producing white flecks on the petals. For control see Gladiolus—thrips (p. 562).

Diseases

Blue mould *(Penicillium corymbiferum)*. This fungus is to be found on almost all bulbous irises and is able to attack bulbs through small wounds. Even with great care at lifting and during grading some damage is done. If these bulbs are subsequently stored in high humidities, rotting will start. This may extend throughout the bulb which becomes hard and chalky; sometimes, however, other organisms turn the bulb into a wet rotten mass.

Post-lifting dips in thiram [*320 g/100 l*] will give adequate control, but careful handling is the most important measure.

Fusarium basal rot *(Fusarium oxysporum* f. sp. *gladioli)*. This is not common in the UK, probably because of the cool climate, but represents a serious threat. The disease symptoms resemble narcissus basal rot, and infected plants are stunted with yellowing leaves. Bulbs have either no roots or brown rotting ones and bulbs, when split, will show degrees of browning extending from the root plate.

Control is obtained by dipping bulbs in warm water suspension (20-30°C) of carbendazim [*100-120 g/100 l*], or thiabendazole fungicide [*see makers' recommendation*] as soon after lifting as possible.

Ink disease *(Drechslera iridis)*. This disease takes its name from the inky markings it causes on *I. reticulata*. It also attacks Dutch iris and causes a severe leaf disease which reduces both flower quality and bulb yield. The spots themselves are typically black but leaves also turn yellow and die prematurely.

Regular spraying with dithiocarbamate fungicides [*14·5-33·8 g/100 m²*] gives good control.

Leaf spot *(Mycosphaerella macrospora)*. This is the most common and most serious leaf disease. Brown spotting of the leaves distinguishes it from ink disease and these spots will coalesce and cause premature leaf death. Flower quality is affected by spotting in any one season but premature leaf senescence will affect flower quality and yield in the subsequent season.

The fungus attacks and enters the leaves several weeks before any spotting is seen. Because of this it is important to begin spraying soon after emergence. Although dithiocarbamate fungicides [*14·5-33·8 g/100m²*] are effective, good results have been obtained with a flowable formulation of chlorothalonil [*100-150 g/100 l*].

Lily

Pests

Aphids. The tulip bulb aphid *(Dysaphis tulipae)* can be troublesome on the bulbs in store and, together with other species, e.g. the peach-potato aphid *(Myzus persicae)* and the shallot aphid *(Myzus ascalonicus)*, will infest the foliage and transmit virus diseases. For control see Anemone—aphids (p. 559) and Tulip—tulip bulb aphid (p. 570).

Lily beetle *(Lilioceris lilii)*. A bright red beetle with black legs found locally in southern England. The larvae are orange in colour but frequently covered with a black, slimy accumulation of faeces. Both the adults and larvae feed on the leaves, flowers and seed pods. To control, spray with gamma-HCH [*13 g/100 l*].

Lily thrips *(Liothrips vaneeckei)*. These feed on the bulbs in store resulting in light brown patches on the scales which are often invaded by fungal rots. Control as for Gladiolus—thrips (p. 562).

Slugs. Lily bulbs are very susceptible to slug damage. Control as for Anemone—slugs (p. 560).

Diseases (see under Bulbs (forced)—lily, p. 400).

Narcissus

Narcissus is the most important of the bulb crops grown in the UK which is the world's largest producer, growing about half of the global acreage. Some 60% of

the crop is forced for flowers, 25% sold as dry bulbs on the home market and 15% exported. Bulb production and forcing are predominant in eastern England and outdoor flower production most important in the south-west.

Pests

Bulb mite *(Rhizoglyphus echinops).*[1] These shiny, yellowish-white, globular mites infest bulbs already damaged by pests, diseases etc. They extend the original damage and prevent recovery from minor cuts and bruising. The mites are easily controlled by routine hot-water treatments.

Bulb scale mite *(Steneotarsonemus laticeps)*[2] (L 456). These are very small, slow moving translucent brown mites which feed between the bulb scales. Infested bulbs show brown streaks extending down to the base plate as long, narrow scars. In the field, infested bulbs rarely show symptoms of mite damage but such bulbs gradually lose vigour and yields may be reduced.

Routine hot-water treatment for stem nematode control (see p. 567) will eradicate the mites in bulb stocks. Alternatively, fumigate the bulbs with methyl bromide at concentration-time products between 200 and 250 mg.hr/l at 18-20°C.

Large narcissus fly *(Merodon equestris)*[3] (L 183). The yellowish-white maggot tunnels into the centre of the bulb destroying much of the tissue. The maggot, usually one per bulb, enters through the base plate after eggs hatch in May and June but damage is not obvious until September or October. When fully grown the maggot is about 18 mm long and leaves the bulb in March to pupate. Infested bulbs are softer than usual, especially around the neck and, if replanted, will probably not flower but throw up a clump of abnormally narrow leaves 'grass' or may not grow at all.

The maggots are easily killed by routine hot-water treatment but if this cannot be used a three hour cold dip in gamma-HCH [*50 g/100 l plus wetter*] is reasonably effective. In areas where large narcissus fly is a problem, attacks can be largely prevented by either soaking the bulbs in aldrin [*188 g/100 l*] before planting or by spraying the open furrow with aldrin [*2·20 kg/ha*] while planting.

Root-lesion nematodes *(Pratylenchus* spp.*).* These very small nematodes feed on the roots making small, brown or black lesions which allow entry of fungal rots. The attacked roots eventually decay and the bulbs make poor growth, damage usually occuring in patches. Attacks are mainly confined to the Isles of Scilly and Cornwall. Control measures must be directed against the nematode in the soil and the fumigant nematicide dichloropropene [*207 l/ha*] or the soil sterilant metham-sodium [*153 l/ha*] are recommended where root-lesion nematodes are a problem.

Small narcissus flies *(Eumerus strigatus* and *E. tuberculatus)* (L 183). These greyish-white maggots up to 9 mm long frequently infest bulbs damaged

mechanically or attacked by diseases and other pests. They are secondary pests, merely extending damage already done and control measures taken against the primary pests and diseases will reduce small narcissus fly infestations.

Stem nematode *(Ditylenchus dipsaci)*[4,5] (L 460). This is the most important pest of narcissus producing damaging symptoms on the foliage and in the bulb. The leaves of attacked plants are usually pale, stunted and distorted with characteristic pale-yellow localised swellings ('spickels'). Infested bulbs often flower late or may rot in the ground if the infestation is severe. Attacked bulbs are soft and, when cut across, show rings of brown tissue where the nematodes have been feeding on the scales.

All narcissus stocks should be closely inspected during the growing season and infested plants and bulbs removed and destroyed. After lifting, discard all soft or suspect bulbs and hot-water treat the stock for three hours at 44·4°C with formalin [*0·2% commercial formaldehyde*] and wetter.

Whether or not stem nematode was found during the growing season, it is advisable to hot-water treat all narcissus bulbs as a routine in the period between lifting and replanting.

Where the outdoor flower crop is required, hot-water treatment damage can be minimised by warm storing the bulbs for seven days at 30°C and then soaking in cold water for three hours before hot-water treating for three hours at 46·7°C.

On nematode-infested land the interval between bulb crops should be at least five years after groundkeepers have been removed and no other susceptible host plant (e.g. bluebell, onion, snowdrops and strawberries) has been grown in the interval. It may be considered worthwhile sterilising small areas of infested land with dichloropropene [*207 l/ha*], or metham-sodium [*153 l/ha*].

Diseases

Basal rot *(Fusarium oxysporum* f. sp. *narcissi)*[6,7] (L 783). This is the most serious and limiting disease of narcissus. The fungus is active all the year round but most infection takes place from early summer until autumn when soil temperatures are at their highest. The fungus penetrates the bulbs either through roots or directly into the root plate. Infected bulbs, when split, have a chocolate brown appearance and are soft. In store the fungus may produce masses of pinkish spores on the root plate, and in handling these spores will easily be dislodged to infect other bulbs. In the field, infection is less easy to see but leaf tip yellowing or early senescence are the most common symptoms. Although Golden Harvest and Carlton are the most susceptible cultivars the fungus is often found on other cultivars. Control is difficult and rests upon a series of good husbandry measures (long rotation, rapid drying after lifting, minimal handling damage, good storage) supported by formalin with or without additional fungicide in the hot water treatment tank. Of the added fungicides thiabendazole [*see label*] is probably the most effective.

Fire *(Sclerotinia polyblastis).* This is less common than in previous years because flowers are cut before they open. The fungus survives on trash from the previous season and in the soil. In spring, fruiting bodies discharge spores which cause a splitting of the delicate floral parts. Tazetta daffodils are particularly susceptible.

Control is achieved by spraying but many formulations leave unsightly deposits. Two cycles of a dithiocarbamate [*14·5-33·8 g/100 m²*] at flowering should be sufficient.

Leaf scorch *(Stagonospora curtissii).* This disease is common in the south-west. It is most usually seen as a leaf tip necrosis. The life cycle is very similar to that of the fungus causing smoulder, but the leaf lesions are usually lighter in colour. Although the lesions occur anywhere on leaves, and suggest secondary spread from the leaf tip, the infection more usually arises as the shoot passes through the neck of the bulb. The fungus survives in the dry papery scales and does not usually rot bulbs.

Control is best achieved using an oil-based tank-mixed zineb; the oil formulation gives great tenacity which is needed in the south-western climate, but good results have been achieved with a flowable formulation of chlorothalonil [*100-150 g/100 l*]. Hot water treatment itself lessens the number of primary infectors which is also affected by storage temperatures.

Smoulder *(Sclerotinia narcissicola)*[5,9]. This disease causes a leaf and flower spot which, in some years, reaches epidemic proportions. The fungus survives from one season to another in the form of small black resting bodies in soil, as well as in and on the outer scales of bulbs. These begin to grow in the autumn and may infect the shoots which emerge on 'primaries'. Spores develop on these and are distributed by wind and water splash to nearby plants to cause further secondary spotting. Sometimes shoots of infected bulbs escape infection but the fungus develops in the mother bulb and infects the developing daughter bulbs. It is unusual for the disease to appear in the first year of a crop but it is frequent in the second year especially where the ridges were reformed in autumn (because infected trash is buried near the emerging shoots).

A good measure of control is obtained from hot water treatment but in biennial cropping, spraying with dithiocarbamates [*14·5-33·8 g/100 m²*] may be necessary.

White mould *(Ramularia vallisumbrosae).* This leaf disease is largely confined to the south-west. It usually appears early in the year as small sunken spots or streaks on leaves. These are usually grey-green or yellowish. In moist weather they enlarge and coalesce to affect large areas of leaf. On the underside of these leaves a white powdery mass of spores may form.

Many cultivars are attacked but usually it is the late flowering ones such as Cheerfulness and Double White that are most susceptible. The disease usually only assumes serious proportions in bulbs that are kept planted for several years. It is rare in the first season and not at all common in the second. Spraying with an oil-based tank-mixed zineb is probably the most suitable treatment, especially on the mid- and late-season cultivars.

Snowdrop

Until recently the supply of snowdrops has been by the removal of rich stands of bulbs in private woodlands for immediate sale. However, the practice must soon decline in favour of a more controlled crop husbandry.

Pests

Stem nematode *(Ditylenchus dipsaci)*. Infested plants develop leaf 'spickels', are stunted and distorted, and when cut across, the bulbs show brown rings of damage. There are no recommendations for chemical or hot-water treatment so the destruction of infested stocks is advised.

Tulip bulb aphid *(Dysaphis tulipae)*. See Tulip—tulip bulb aphid (p. 570).

Diseases

Grey mould *(Botrytis galanthina)*. This disease has been known for over a century. It is first seen as infected shoots appear above ground, turning grey as thousands of fungal spores develop. The fungal rot will extend to the bulb but spores are spread by water splash on to other plants. The life-cycle of the fungus may be assumed to be similar to that of *B. tulipae*. Snowdrops are frequently sold 'green' soon after flowering and disease control is difficult. However, dormant bulbs may be treated in a dip of a carbendazim fungicide [*100–120 ml/100 l*] for 30 minutes which should give reasonable control. The growing crop should be protected with dithiocarbamate [*14·5–33·8 g/100 m²*] sprays.

Tulip

Pests

Stem nematode *(Ditylenchus dipsaci)*[10,11] (L 461). The strain or race of stem nematode which damages tulips is particularly virulent and has a wide host range including narcissus.

Infested tulips show fine cracks and purplish streaks on the stems below the flower head. When the attack is severe, the stem is distorted and cracked, the flower head bent over and the outer petals often fail to colour. Infested bulbs have glossy, greyish or brownish patches on the side above the base plate but when cut across, the bulbs seldom show distinct rings of damage as with narcissus.

As slight infestations are difficult to detect in the dormant bulbs, tulip stocks should be examined for signs of stem nematode attack at flowering time. Infested plants and their bulbs should be removed and destroyed and, after lifting, the bulbs dipped for two hours in a cold solution of thionazin [*230 g/100 l*]. It may be

worthwhile sterilising infested soils before replanting with other bulbs. For control see Narcissus—stem nematode (p. 567). Thorough rogueing, strict attention to hygiene and close examination of newly acquired stocks will help to limit stem nematode attacks.

Tulip bulb aphid *(Dysaphis tulipae).* This aphid is a common pest of tulip and other bulbs in store where it feeds in colonies beneath the outer scales.

When infested bulbs are planted the aphids feed on and damage the emerging shoots distorting and checking growth. Regular fumigation of bulb stores with smokes of gamma-HCH [*see label*], or nicotine [*see label*], or pirimicarb [*see label*] will prevent a build-up of aphids.

Other species including the peach-potato aphid *(Myzus persicae)* and the black bean aphid *(Aphis fabae)* occasionally infest tulips in the field. They rarely cause direct damage but will transmit virus diseases; for control see Anemone—aphids (p. 559).

Diseases

Fire *(Botrytis tulipae)* (L 536)[12,13,14]. Tulip fire has become far less significant in the past decade. 'Primaries' (infected shoots) appear above ground and spores from these cause secondary leaf spotting which in wet conditions develop into aggressive lesions. Small leaf spots do not enlarge and are unimportant but aggressive ones lead to such losses of leaf that flower quality is poor and subsequent yield of bulbs is much reduced. The fungus lives on bulbs and some shoots escape infection with the result that daughter bulbs develop normally. However, as they enlarge and as the mother bulb scales rot, the fungus moves on to the daughter bulb. Small black resting bodies form on the tunic and on the base of the flower stalk which perpetuate the disease. A few bulbs have lesions on the fleshy scales underneath the tunic.

Control is largely achieved by dipping the bulbs during storage for 30 mins in a carbendazim [*100-120 ml/100 l*] fungicide and iprodione [*50 g/100 l*] (but not if a benzimidazole tolerant Fusarium causing sour is present in the stock). Good rogueing for primaries and several foliar sprays of dithiocarbamate [*14·5-33·8 g/100 m²*] or iprodione [*50 g/100 g*] fungicides will prevent leaf infection. It is important not to use benzimidazole formulations as foliar sprays because tolerance by Botrytis would remove the excellent control gained in the annual dip.

Fusarium bulb rot or sour *(Fusarium oxysporum* f. sp. *tulipae)*[15,16] (L 624). This disease became important principally as a rot of Darwin hybrid tulips. Extensive work in Holland has shown that there are two serious effects of the disease. First, bulbs rot but in addition some of these bulbs produce ethylene which in store causes a flower bud blast which is not seen until flowering time. Although dipping in fungicides such as thiabendazole [*see makers' recommendations*] should give some control, attention to aspects of crop husbandry are very important. Bulbs are less susceptible when lifted before the tunic is membraneous. The bulbs should be handled carefully to lessen physical damage and planting should be delayed until soil temperatures have fallen below 15°C.

Pythium root rot *(Pythium* sp.*)*. This is principally a disease of forced tulips. Both in boxes and border soil, areas of bulbs of stunted growth suggest Pythium attack, especially if such bulbs have virtually no root yet the bulb itself is seemingly sound. Sometimes apparently healthy roots will have red lesions which develop into a complete rot in which only the outer cylinder of tissue is left. Prevention is the only means of control. Boxing and border soil should not be allowed to become too wet. A pre-planting drench of etridiazole or etridiazole incorporated into the boxing soil is usually very effective.

Yellow pock *(Corynebacterium flaccum fasciens* pv. *oortii)*. This bacterial disease occurs from time to time in imported tulip bulbs. Yellow spots occur on the bulb in store and severely infected bulbs will die without producing a shoot. In the growing plant leaf splitting which looks similar to frost damage is seen. However, if the tissues are examined and the stem split carefully, yellow spots may be seen in the conducting vessels. Eventually these plants wither and die.

List of Latin names

Pests

Agrotis segetum	turnip moth
Aphis fabae	black bean aphid
Aulacorthum circumflexum	mottled arum aphid
Ditylenchus destructor	potato tuber nematode
Ditylenchus dipsaci	stem nematode
Dysaphis tulipae	tulip bulb aphid
Emerus strigatus & E. tuberculatus	small narcissus flies
Euxoa nigricans	garden dart moth
Franklinlella iridis	iris thrips
Liliocerls lilii	lily beetle
Liothrips vaneecki	lily thrips
Macrosiphum euphorbiae	potato aphid
Mamestra brassicae	cabbage moth
Merodon equestris	large narcissus fly
Myzus ascalonicus	shallot aphid
Myzus persicae	peach-potato aphid
Phlogophora meticulosa	angle shades moth
Pratylenchus spp.	root lesion nematodes
Rhizoglyphus echinops	bulb mite
Scutigerella immaculata	glasshouse symphylid
Steneotarsonemus laticeps	bulb scale mite
Symphylella spp.	symphylids
Thrips simplex	gladiolus thrips

Diseases

Botrytis cinerea	grey mould
Botrytis galanthina	grey mould
Botrytis tulipae	fire
Colletotrichum spp.	leaf curl
Corynebacterium flaccumfasciens pv. *oortii*	yellow pock
Drechslera iridis	ink disease
Erysiphe ranunculi	powdery mildew
Fusarium oxysporum f. sp. *gladioli*	Fusarium basal rot
Fusarium oxysporum f. sp. *gladioli*	Fusarium yellows
Fusarium oxysporum f. sp. *narcissi*	basal rot
Fusarium oxysporum f. sp. *tulipae*	Fusarium bulb rot or sour
Mycosphaerella macrospora	leaf spot
Penicillium corymbiferum	blue mould
Peronospora spp.	downy mildew
Plasmopara spp.	downy mildew
Pythium sp.	Pythium root rot
Ramularia vallisumbrosae	white mould
Sclerotinia draytoni	Botrytis rot
Sclerotinia narcissicola	smoulder
Sclerotinia polyblastis	fire
Stagonospora curtisii	leaf scorch
Stromatinia gladioli	dry rot
Transzchelia discolor	plum rust
Xanthomonas hyacinthi	yellow disease

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