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OKRA

OKRA

Common name : Okra, Bhindi, Lady's finger, Gumbo.

Botanical name : *Abelmoschus esculentus*

Family : Malvaceae

Chromosome no. : 2n=130

INTRODUCTION :

Okra is fast growing annual herb the young seed pods of which are commonly used as vegetable.

- It is an important fruit vegetable crop of the tropical and subtropical regions of the world.
- It is commonly grown through the warmer parts of temperate Asia, Southern Europe, Northern Africa, the United States and in all parts of the tropics.
- It is adopted to climates with relatively short rainy seasons, hence its special acceptance in North-east Brazil.
- India ranks first in world in okra production.
- In India, okra is commercially grown in the states of Gujarat, Maharashtra, Assam, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, West Bengal, Assam, Rajasthan, Tamil Nadu, Karnataka, Haryana and Punjab.

ORIGIN:

- According to Zeven and Zhukovsky (1975),okra is believed to have originated in the Hindustani Centre of Origin, chiefly India, Pakistan and Burma.
- However according to some other authors, okra originated in India (Masters,1875), Ethiopia(de Candole, 1883,Vavilov,1951), West Africa(Chevalier, 1940, Murdock, 1959) and Tropical Asia (Grubben, 1977)

TAXONOMY:

- The genus *Abelmoschus* is small and consists least 6 species (Borssum Waalkes,1966)
- These are native to the Hindustani Centre or to south-east Asia, and are closely related to each other.
- West African okras are characterised by many morphological and physiological differences from the normal okra.

- West African okra’s have less epicalyx segments, very red leaf veins, late flowering when planted in the summer, pods mounted at right angles to the stem, and large numbers of seeds per pod.
- In addition, pods of the East African type tend to be short, with a relatively long sterile tip.

BOTANY

- Okra is a erect, herbaceous annual.
- Stem : green with or without reddish tinge.
- Leaves : alternate, 3-7 lobed palmate, hirsute and serrate.
- flowers: solitary, axillary having epicalyx (up to 10)
- There are five yellow patterns with crimson spot on claw.
- Staminal column consist of numerous stamens which are united to the base of petal.
- Stigma is 5-9 lobed.
- Fruit is capsule.
- Flowering starts below to upwards.
- Dehiscence: occurs around 8-10 am, about 20minutes after anthesis.
- Flowers remain open for shorter duration and wither in afternoon.
- Stigma receptivity: during anthesis hence pollination is not very successful at bud stage.

The species of *Abelmoschus* L. (Martin, 1982)

Sr. No.	SPECIES	SPECIAL CHARACTRISTICS	CHROMOSOME NUMBER
1.	*A angulosus*	Epicalyx bracts 4-8 and persisting,as long as capsule	-
2.	*A crinitus*	Epicalyx bracts 10-16 and 25-50 mm long, capsule usually shorter, mature capsule fusiform.	-
3.	*A esculentus*	Epicalyx bracts 6-10 , lanceolate	72,124, 130
4.	*A ficulneus*	Epicalyx bracts 4-8 , lanceolate, ovoid capsule	72
5.	*A.glutino-textile*	Combines characteristics of *A.esculentus and A.manihot*	-
6	*A manihot*	Epicalyx bracts 4-8 free, much shorter than capsule.	60,68
7	*A moschatus*	Epicalyx bracts 6-10, lanceolate , capsule ovoid to oblong	72
8	*A speciest*	Epicalyx bracts 5-8 , free, broad	194
9	*A tetraphyllus*	Epicalyx bracts , soft hairs	130
10	*A tuberculatus*	Fruit with bristly hairs from a tubercular base	58
11	*A tubercular esculentus*	Combined characterstics of A. tuberculatus and A. esculentus	182

BREEDING OBJECTIVES:

- High pod yield.
- Dark green , tender, thin, medium long, smooth, 4-5 ridged pods at marketable stage
- Pods free from conspicuous hair. Seed bulging and yellow ring at base.
- Early and prolonged harvest.
- Short plant with more number of nodes , short internodes.
- Optimum seed yielding ability.
- Pods suitable for processing industry and export market.
- Resistance to diseases like yellow vein mosaic viruse, fusarium wilt, cercospora leaf spot.
- Resistance and tolerance to insect like fruit and shoot borer, jassids and whitefly.
- Tolerance to abiotic stresses like low temperature, excessive rains, saline and alkaline soils.

Inheritance of principal characteristics of okra

Characteristics	Inheritance
Plant height	Height heritability (79%) Medium heritability (49%), Non-additive gene action
Internode length	Height heritability (79%)
Dark red stem	Simple inheritance, purple dominant over green
Pubescence of foliage	Incomplete dominance
Light red petiole	Simple inheritance
Degree of leaf lobing	Simple inheritance Incomplete dominance
Resistance to yellow vein mosaic	Height heritability (70%)
Earliness	Simple inheritance
Days to flowering	Height heritability (65%) Non-additive gene action

Calyx colour	Simple inheritance (dominance)
Petal blotch	Simple inheritance (dominance)
Outer side, petal colour	Simple inheritance (dominance)
Base colour	Simple inheritance (dominance)
Petal venation colour	Simple inheritance (dominance)
Pod colour	Simple inheritance (multiple alleles), Two genes, dominant
Pubescence of pod	Complex/simple inheritance, complete dominance
Length of fruit	High heritability (84%)
Diameter of fruit	High heritability
Weight of fruit	Average heritability (48%)
Vitamin C content of fruit	High heritability
Fiber content of fruit	High heritability
Pods/plant	Additive gene action, average heritability (40%)
Seeds/pod	Very high heritability (94%)
Seed weight	High heritability (77%)
Yield	High heritability (63%)

Selfing and crossing

Selfing

Cover unopened bud with half length white pollination paper bag and staple or clip the bag securely along peduncle. Put a thread ring at the peduncle. The pod will come out piercing through the bag. The thread ring acts as identification mark for selfed pods during harvesting.

Tie circular thread around pedicel and put a knot around the unopened flower petals with the same piece of thread .the petals shall bulge out below the tied thread during the flower opening and the stigma inside remain protected from unwanted pollen grains. The thread tied at pedicel is the identification mark for selfed pod at harvesting

Emasculation

The flower in okra start from below to upwards.

Dehiscence of anthers about 20 minute after anthesis flower remain open for the 3-4 day and wither in the afternoon. Stigma receptive during anthesis hence pollination is not very successful at bud stage.

Emasculation is done in the late afternoon. Big size unopened flower is selected. Two long and opposite silts are made on the calyx with forceps. Both the halves of sepal are pulled downward and removed. Now entire corolla and anthers are removed and the emasculated bud is covered with paper bag which is secured with U clip on the pedicel.

Pollination:

Flower just to open fully are collected. Calyx and corolla are removed and the dehiscing anthers are brushed over stigma of the buds emasculated on perceeding afternoon. One male flower can be used to pollinate 3-4 flower . After pollination the buds are again covered with pollination paper bag and a label having name of male parent along with date of pollination is tied at the pedicel of the pollinated flower bud.

Breeding Methods:

Okra is considered both as self pollinated and as an often cross pollinated vegetable due to protogyny and male sterility in a few varieties.

INTRODUCTION:

A cultivar from Africa known as *Abelmoschus manihot* spp *manihot* introduced into India has been successfully used as source of resistance to YVMV in breeding of Prabhani and Punjab Padmani

Clemon Spineless

Perkin Long Green.

PURE LINE SELECTION:

An elite single plant is identified from the population based on the desirable characters. Controlled selfing is done to ensure self pollination.

Variety develop through this method:

- Pusa Makhmali
- CO-1 from Red Wonder
- Gujarat Bhendi 1

Mass selection

This method is follow only to purify the existing variety. Sometime only one generation of mass selection would purify variety, if variation in the original population is due to physical mixture or similar reasons.

BACKCROSS METHOD

This is followed to transfer a few gene to a desirable variety lacking the particular gene. The receptor parent may be a popular variety and the donor parent may be another variety , breeding line or wild related species.

Pedigree method

This method is applicable to the segregating generation after hybridization between desirable promising donors. The individual plant selection starts in F2 and continue till F5. or F6.

VARITY DEVELOPED BY THIS METHOD

Pusa Sawani
Varsha Uphar
Hisar Unnat
Azad kranti
Punjab Padmani
Prabhani Kranti
P 7
Arka Anamika
Arka Abhaya

Company name	variety
mahyco	MH 10, MH 64
Nunhems	Sonal
Syngenta	Syn 16, 152
Bioseeds	avantika
Krishdahan seeds	Hyb 215 and 577

Mutation breeding

This has been employed to evolve early yielding varieties.
Gamma radiation affected qualitative and quantitaive character of interspecific hybrids and thus created wide variability.
Variety developed by mutation;
MDU1
MDU2

POLYPLOIDY BREEDING

Colchicine induced polyploids have showed samller , thicker , darker leave than untreated control . Plyploids has inhibited growth and retard flowering. A few fruit formed were small and irregular. Amphidiploid were obtained from interspecific crossing with related wild species.amphidiploid was resistant to yellow vein mosaic viruse . Amphidiploid was highly fertile due to its meiotic stability and hybrid could exist as a new synthetic species.

INTERSPECIFIC HYBRIDIZATION

It is resorted to transfer disease resistance gene from related species to A. esculentus

Interspecific hybridization in Abelmoschus

Cross	Results
A. esculentus x A. tuberculatus 2n = 130 x 2n = 58	Positive
A. esculentus x A. manihot 2n = 72 x 2n =60	Positive
A. esculentus x A. manihot 2n = 130 x 2n =66	Positive
A. esculentus x A. feculneus 2n = 130 x 2n = 72	Negative
A. esculentus x A. moschatus 2n = 130 x 2n =138	Negative
A. esculentus x A. tetraphyllus 2n = 130 x 2n =138	Positive
A. esculentus x A. tetraphyllus 2n = 72 x 2n = 130	Positive
A. esculentus x okra from Ghana 2n = 130 x 2n = 194	Positive

Interspecific hybrids in okra

- A. esculentus x A. manihot var. medicus
- A. esculentus x A. manihot var. adotachtylus
- A. esculentus x A. tetraphyllus
- A. esculentus x A. manihot var. manihot
- A. esculentus x A. manihot sp. tetraphyllus

Vegetable crop varieties developed by hybridization and selection from advanced generations

Variety	Organization	Parents	Feature
Punjab Padmini	PAU, Ludhiana	A. esculentus x A. manihot sp. manihot	It is resistant to YVMV, jassids and cotton ball worm.
Parbhani Kranti	MAU, Parbhani	A. esculentus cv. Pusa sawani x A. manihot sp.	It is resistant to YVMV.
Arka Anamika	IIHR, Bangalore	A. esculentus (IIHR 20-31) x A. tetraphyllus	Average yield is 11 t/ha. It is resistant to YVMV.
Varsha Uphar	CCSHAU, Hisar	Lam Selection-1 x Parbhani Kranti	Average yield is 10 t/ha. It is resistant to YVMV and leafhopper.
Hissar Unnat	CCSHAU, Hisar	Selection 2-2 x Parbhani Krani	It is tolerant to YVMV and leafhopper. Average yield is 14 t/ha.

F_1 hybrids in Okra

F_1 hybrids	Features
Hybrids from crosses between Pusa Sawani and Pusa Makhmali (male parent) and H 398 (female parent)	Early flowering, early maturity, higher fruit weight and yield
Local 5 (Malaysian) x Emerald (American) , Local 7 (Malaysian) x Gold Coast (American) , Local 5 (Malaysian) x Gold Coast (American), Local 7 (Malaysian) x Emerald (American)	Higher germination, early flowering, more plant height and higher yield
Pusa Sawani x Smooth Long Green	More fruits/plant and higher yield
American seven Ohari x Pusa Sawani	More plant height and higher yield
New Selection x AE 91	Heterosis for yield
Balady x Gold Coast	Heterosis for plant height, fruits/plant and fruit weight
Seven Leaves x Pusa Sawani	Yield and fruits/plant

DISEASE RESISTANT BREEDING

YELLOW VEIN MOSAIC (Gemini virus)

- Most devastating disease of okra.
- First reported by C. S Kulkarni in 1924 followed by B.N Uppal, P.M Verma and S.P Capoor and P.M Verma in 1950
- Transmitted by white fly (*Bemisia tabaci*)
- Arka Anamika, Arka Abhay and Prabhani Kranti were initially highly tolerant.
- *Abelmoscus manihot* accession have shown resistance to YVMV.

Crosses of cultivated okra with *A. manihot* under BC2/BC3 followed by pedigree method of breeding are expected to give YVMV resistant segregants.

ENATION LEAF CURL OF OKRA

- First observed at IIHR hessarghatta Bangalore in 1924 by S.J Singh and 1986 by S.J Singh and O.P Dutta.
- Virus transmission is by grafting, natural transmission by white fly.
- No resistant source is reported.

Sources of resistance

Disease/Insect	Resistance donors
Yellow vein mosaic	IC 1542, *A. manihot*, *A. manihot sp. manihot*, Parbhani Kranti, Punjab Padmini
Damping off, *Rhizoctonia solani*	Red Ghana, Sel. 7-1, BH 27, IC 12096, IC 17252
Powdery mildew	Nigeria (R), EC 32598, IC 8248
Cercospora blight	Sel. 7-1, Round Selection, EC 32598, IC 10238, IC 8248, IC 1542
Fusarium wilt	IS 9273, IS 9857, IS 6653, Pusa Sawani, Pusa Makhmali
Nematode	Long green Smooth
Jassid	IIHR 21, AE 15, AE 30, IC 7194, IC 8899,Crimson Smooth Long, IC 7194, IC 8899, *A. manihot sp. manihot*
Fruit/shoot borer	Red I, Red II, Red Wonder I, Red Wonder II, *A. manihot*, Pusa Sawani, Long Green

IMPORTANT VARIETIES

1. **Pusa Makhmali**

- Developed by H.B. Singh and S.M. Sikka in 1955 as a result of selection from the local material collected from West Bengal.
- It is an early variety; Pods smooth, straight, 5-edged, attractive, light green, slender, 15-20 cm long.
- Yield potential is 100 q/ha.

2. **Pusa Sawani**

- Bred by H.B. Singh (1957-58), derived from a cross of IC-1542 (field resistance to YVMV) and Pusa Makhmali.
- Plants are 120-180 cm tall in rainy season; Pods smooth, 5-edged,dark green and 18-20 cm long.
- It is distinguished by the presence of a purple patch at the base of the yellow petal on both the sides whereas in most okra varieties the patch is present only in inner side.
- At present it has found to be susceptible to YVMV; yield potential is 150 q/ha.

3. MDU 1

- Evolved by TNAU, Coimbatore in 1978. It is an induced mutant, isolated from 'Pusa Sawani' .
- On an average there are 13 nodes/plants; fruiting begins from4-5th node.
- It takes 33 days to first flowering and 43 days to first picking, fruits are light green about 20 cm long.
- It has been notified by the central seed committee in 1985.

4. Punjab Padmini

- Evolved by B.R.Sharma at the PAU, Ludhiana from a cross between *Abelmoschus esculentus* and *A. manihot* ssp. *Manihot*.
- F1 plant of a cross *A. esculentus* cv. '*Reshmi*' x *A. manihot* ssp. *manihot* cv. Ghana was hybridized with an F2 (OP) plant of a cross *A. esculentus* cv. Pusa Sawani x *A. manihot* ssp. *manihot* cv. Ghana.
- Continuous selection for resistance to YVMV and desirable horticultural traits in the subsequent generations led to the isolation of Ludhiana Sel-1 in the F8 generation which was later named as 'Punjab Padmini'.
- It has field resistance to YVMV and tolerance to jassids and cotton boll worm.
- yield potential is 100-125/ha q green pods and 12.5 q/ha seeds.

5. Harbhajan

- The original ‘Perkins Long Green’ or Sel-6 has been named as Harbhajan in memory of Dr. Harbhajan Singh of Iari by T.A. Thomas and R. Prasad.
- Plants are very tall, thick and prolific bearer. Leaves are large, moderately lobed with rough surface and prominent veins.
- Fruits are long tapered, bright green, spineless and mostly 8-edged.
- Notified by the central variety release committee.

6. Parbhani Kranti

- It is a YVM resistant variety evolved by N.D. Jambhale and Y.S. Nerkar in 1985 from an interspecific cross between *A. esculentus* cv. ‘Pusa Sawani’ and *A.manihot*, an African soecies carrying resistance to YMV.
- BC2 with Pusa Sawani was subjected to selfing and selection upto F8.
- Plants are tall, leaves are deeply lobed; first fruit borne on 5-6th node.
- Marketable fruit size (8-9 cm) is attained 7-8 days after anthesis.
- On an average green fruit yield is 85-90 q/ha during summer and 115 q/ha during rainy season.
- Seed yield of 10 q/ha from rainy season crop and 5-6 q/a from summer crop is possible.

7. Sel 10 (Arka Anamika)

- It is YVM virus resistant variety, an interspecific origin between *A. esculentus* and a wild species *A.manihot* ssp. *tetraphyllus*.
- Plants are medium tall (about 100 cm), leaces are green, small; fruits are medium green, rough. 5-ridged and start after 5-6th node onwards.
- Yield potential is 115 q/ha of green pods.

8. EMS-8 (Punjab 8)

- It is an induced mutant derived from Pusa Sawani treated with 1% EMS. The final selection was made in the M8 generation.
- Plants are tall. Stem, petioles have splashes of purple pigmentation.
- It has field resistance to YVMV and tolerance to fruit borer
- On an average, it gives 95 q/ha marketable yield of green pods.

9. Arka Abhay (Sel 4)

- Released by IIHR, Bangalore as resistant to YVMV.
- It is a sister line of Arka Anamika.
- The plants resemble Arka Anamika in appearance as well as YVMV resistance.
- It carries tolerance to fruit borer and may suit pruning for a ratoon crop.

SALIENT BREEDING ACHIEVEMENTS

- Variety Pusa Sawani a selection from Pusa Makhmali X IC1542 was first YVMV resistant variety released in India.
- High yielding variety Lam Selection , Sel 2 , Vaishati Vadhu , Lam hybrid , R 7 , EMS 8, CO 1, Beltes
- *A.manihot* var. *pungens*, *A.crinitus*, *A.panduraeformis* and *A. vitifolius* and variety Sel 4 and Arka Anamika and Arka Abhay were observed resistant to YVMV.
- Kiran and Salkeerthi are light green types and Aruna is a red fruited type variety Long Green show resistance to nematode.
- Line AE22, AE79, Red wonder II , Red I, Red II and AE52 have shown resistance to fruit borer and lines IC 18960, IC15055, Round selection Walgaon, EC41292 to leaf spot.
- CO3 is high yielding F1 hybrid (Prabhani Kranti X MDU 1) from TNAU 16-18t/ha, Azad Bhindi 1 (Pusa Sawani X Prabhani Kranti) exhibit higher yield 10-12.5t/ha. F1 hybrid Vijay, Varsha, Panchali, Ever Green, Karishma developed by private seed companies.

Prospectus

The yellow vein mosaic disease is the most serious disease in okra. There is a need for combination breeding program to evolve resistant lines. Cultivation of okra during summer has been problematic and less economic so there is need to evolve resistant and suitable variety for summer cultivation. Recombination DNA technology needs to be employed for evolving stable YVMV resistant types. Hybrid technology in okra needs to be popularized.

Recent Advances in Production of Tomato *(Solanum lycopersicum* L.*)*

Tomato

- Botanical name : *Solanum lycopersicum L.*
- Family : Solanaceae
- Origin : Mexico
- Chromosome no : 2n=2x=24
- Breeding system : Self-pollinated

SYSTEMATIC CLASSIFICATION

KINGDOM: Plantae

PHYLLUM: Angiosperms

DIVISION: Eudicots

CLASS: Asterids

ORDER: Solanales

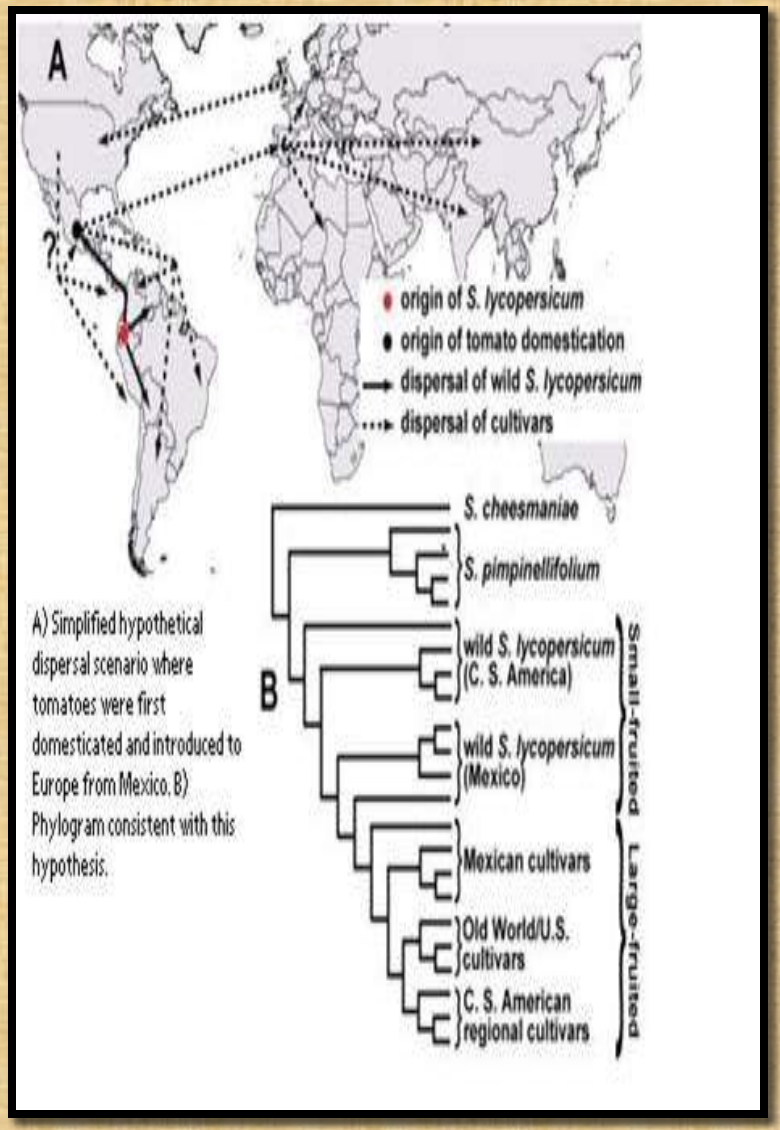
FAMILY: Solanaceae

GENUS: *Solanum*

SPECIES: *lycopersicum*

ORIGIN

- Originated in the Andes mountain region of South America (Peru, Equador and Bolivia) on the basis of availability of numerous wild and cultivated relatives(Vavilov,1951).
- From its centre of origin, it was first domesticated in Mexico.
- From Mexico, it arrived in Europe somewhere around in 1554.
- First introduced in America in 1710.By 1830,tomato became popular in the USA.
- Britishers believed to have introduced tomato in India in 1828 through the Royal Agri-Horticultural Society, Calcutta and afterwards it spreads to others parts of the country.



EVOLUTION OF TOMATO

- Was considered poisonous until 1700s.
- In 1820, farmer R. G. Johansson was the first to eat tomato.

Ancestor of Tomato
(Solanum lycopersicum var. *cerasiforme)*

Cultivated form of tomato
(*Solanum lycopersicum* L.)

CLASSIFICATION

Miller(1788) -*Solanum lycopersicum* (cultivated form)
Solanum pimpinellifolium (wild form)

Muller (1940) & Luckwill (1943) - two sub-genera

i. *Eulycopersicon* (true lycopersicon)

ii. *Eriopersicon*

Eulycopersicon

- annual, edible fruit and red coloured with carotenoid pigment and self compatible.
- *Solanum lycopersicum L.*(cultivated tomato)
- *Solanum pimpinellifolium. (*Wild form)

Eriopersicon

- Green fruited, self incompatible.
- *S. peruvianum, S. hirsutum, S. glandulosum, S. cheesmani, S. chilense, S. pennellii, S. parviflorum, S. chmielewskii*

Bailey,1949: Classified tomato (*Solanum lycopersicum* L.) according to their fruit shape and plant spread.

BOTANICAL VARIETY	COMMON NAME
Var. *commune*	Common Tomato
Var. *grandifolium*	Large Leafed Tomato
Var. *validium*	Upright Tomato
Var. *cerasiformae*	Cherry Tomato
Var. *pyriformae*	Pear tomato

Based on growth habit, tomato plant is characterized into :

i. **Determinate type** – Inflorescence occurs at almost every internode. Terminal bud ends in floral bud and vegetative growth is checked.

ii. **Indeterminate type-** Inflorescence cluster occurs at every third internode and the main axis continues to grow indefinitely. Terminal bud ends in leafy bud and there is continuous vegetative growth.

AREA AND PRODUCTION

IN INDIA BY NHB, NEW DELHI(2012-13)

AREA : 0.884 MILLION HECTARE

PRODUCTION :1.78 MILLION TONNES

IN H.P. BY NHB, NEW DELHI(2012-13)

AREA : 10,000 HA

PRODUCTION : 0.4 MILLION TONNES

BOTANICAL FEATURES

Habit : Herbaceous perennial but cultivated as annual. Tap root system with numerous lateral roots.

Stem : Green coloured, highly pubescent, round in cross section

Leaf : Leaves are pinnate green in colour, petiole-pubescent and long, Tip is blunt.

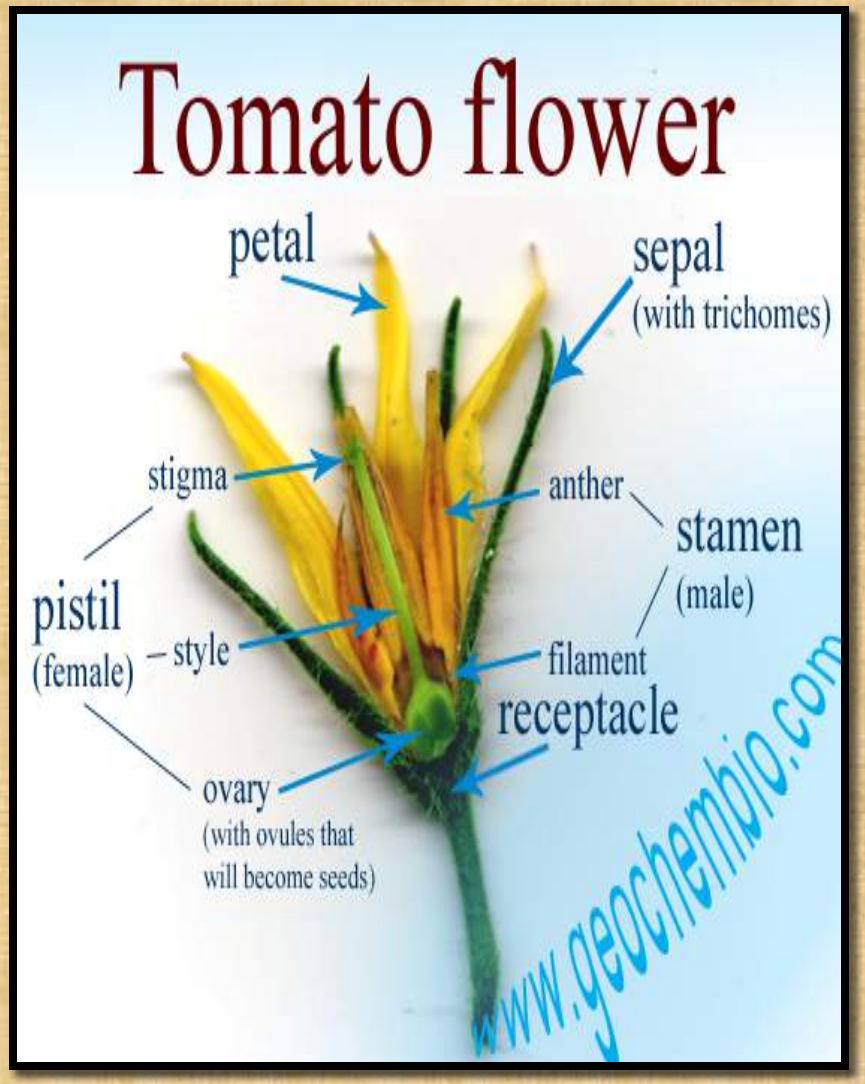
Flowers: Yellow in colour, borne in cluster, extra axillary in position, the flower cluster appears like racemose cyme . The flower cluster is called a truss.

Calyx: Grey in colour, 5-7 sepals, alternate with petals, persistent, valvate aestivation.

Corolla: Bright yellow in colour with 5-7 petals, alternate sepals, valvate aestivation.

Androecium: Stamens 5, greenish yellow, free at the base and united at the top. The anthers dehisce longitudinally.

Gynoecium: Multicolored, syncarpous with numerous ovules in each locules; style pale green and present within the anthredial cone.



NUTRITIONAL AND MEDICINAL VALUE

- Rich source of mineral particularly potassium, vitamins and organic acids particularly citric and maleic acid.
- Ascorbic acid content ranges from 16-75 mg/100 g of fruit weight
- Tomato is also rich in medicinal value.
- The pulp and juice are digestible, mild aparient is parameter of gastric secretion and blood purifier.
- It is said to be useful in mouth cancer and sore mouth etc.
- It is one of the richest vegetables, which keeps our stomach and intestine in good condition.

NUTRITION

RED TOMATOES, RAW	
NUTRITIONAL VALUE PER 100 G (3.5 OZ)	
Energy	74 kJ (18 kcal)
Carbohydrates	3.9 g
- Sugars	2.6 g
- Dietary fiber	1.2 g
Fat	0.2 g
Protein	0.9 g
Water	94.5 g

Vitamin A equiv.	42 µg (5%)
- beta-carotene	449 µg (4%)
- lutein and zeaxanthin	123 µg
Thiamine (vit. B_1)	0.037 mg (3%)
Niacin (vit. B_3)	0.594 mg (4%)
Vitamin B_6	0.08 mg (6%)
Vitamin C	14 mg (17%)
Vitamin E	0.54 mg (4%)
Vitamin K	7.9 µg (8%)
Magnesium	11 mg (3%)
Manganese	0.114 mg (5%)
Phosphorus	24 mg (3%)
Potassium	237 mg (5%)
Lycopene	2573 µg

IMPORTANCE AND USES

- Rank 2nd most important vegetable.(Potato being 1st)
- Tomato is basically a warm season crop and has the potential to grow all the year round in mild climate condition.
- It is a day neutral plant and mainly self pollinated but cross pollination may occur to some extent.
- It is universally treated as 'protective food' and provide almost all types of Vitamins and Minerals.
- Fruit is consumed as fresh or in processed form.
- Its ripe fruits are utilized on a large scale in the preparation of variety of products such as puree, paste, powder, ketchup, sauce, syrup, juice and canned whole peeled fruits.
- Red colour is due to the presence of 'lycopene'(20-50mg/100g of edible portion) which is regarded as the powerful antioxidant.

CLIMATIC REQUIREMENT

- Warm season crop
- Optimum daily mean temperature 21-24°C.
- Lycopene development is highest at 21-24°C and drops off rapidly above 27°C.
- Night temperature is critical for fruit set. Optimum range 15-20°C. Do not set fruit when night temperature is either below 13°C or above 20°C.
- Seed germination occurs maximum at 24^{o}C.
- Tomato is susceptible to cold winds, frost and highly water logging conditions.

SOIL REQUIREMENT

- Well drained fertile organic matter rich soils are ideal.
- For early crop:- Sandy loam soil.
- For higher yield:-Clay loam soil.
- **Ideal soil pH:- 6-7**
- Can tolerate little soil acidity upto pH- 5.5, not below it.

LAND PREPARATION

- 4-5 repeated ploughings
- All stubbles, weeds etc. are removed & levelling of land.
- Addition of well rotten FYM or compost @ 20 -25 tonnes/ha
- Level the land properly

NURSERY RAISING

- Tomato is a transplanted crop.
- Seeds sown on raised nursery beds of 1.0 m width and 15-20 cm height and convenient length.

- **SEED RATE:**
- **Hybrids: 125-175g/ha**
- **Open Pollinated Varieties: 400-500 g/ha**

- After sowing beds are covered with straw or long dry grass till seed germination.
- Sprinkle water regularly.

  Hardening of seedling by withholding water at least 4-6 days before transplanting

Nursery of Tomato can also be raised in plug trays under protected conditions.

Nursery of Tomato can also be raised under protected conditions in poly tunnels.

- Polytunnels can be used to provide a higher temperature and/or humidity than that which is available in the environment but can also protect crops from intense heat, bright sunlight, strong winds, hailstones and cold waves. Every factor influencing a crop can be controlled in a polytunnel. Polytunnels are often used for nursery raising.

SOWING TIME

It can be grown almost throughout the year in the country. However the number of crops grown varies from region to region. In Northern plains, generally two crops, autumn and spring crop are grown.

State/Region	Sowing	Transplanting	Harvesting
Northern plains: • Autumn Crop • Spring-Summer Crop	July-August November	August– September 2nd fortnight of January	October-December April-May
Hills of H.P. and Uttaranchal	March-April	April-May	July-August
Karnataka & Maharashtra	May-June October-December	July-August November-January	September-October March-May

SPACING:

- Indeterminate – 90 x 30 cm
- Determinate – 60 x 45 cm

TRANSPLANTING

- About 28-35 days old healthy seedlings of 12-15 cm height having 3-4 leaves are ideal for transplanting.
- Transplanted in the evening.
- Irrigated immediately after
- transplanting.

MANURES AND FERTILIZER

- Apply 15-20 tonnes of FYM , 100-125 kg N, 50-60 kg P_2O_5 , 50-60 kg K_2O /ha.
- For Hybrid:- 200 kg N, 100 kg P_2O_5 and 100 kg K_2O /ha
- Excess N may delay maturity and decrease fruit size.
- ½ of N and full dose of P and K is applied as basal and remaining dose of N is top dressed into two equal parts i.e. 30 and 45 days after transplanting.

IRRIGATION

- 1st irrigation is applied as soon as transplanting.
- Subsequent irrigations are made at 8-10 days intervals or as per the requirement of the crop.
- In winter, plants are not irrigated during ripening of fruits to retard the process but they are irrigated during summer to promote the process of ripening.

Methods of Irrigation commonly practiced in tomato cultivation

Most adopted method : Furrow irrigation

Furrow Method

Drip Irrigation

Sprinkler Irrigation

INTERCULTURE OPERATIONS & WEED CONTROL

- For raising a successful crop, gap filling, hoeing, earthing up, staking, pruning and mulching are required.

Earthing up

Plastic Mulch

Straw mulch

WEED CONTROL

- Critical period for checking weeds is 35-40 days after transplanting.
- Two hand hoeings at 1st and 3rd fortnight after transplanting and earthing up at 2nd fortnight after transplanting.
- Chemical control:-
- Pre-transplant surface application of Alachlor (1-1.25 kg/ha) or Oxadiazon (1.0 kg/ha) or Fluchloralin (1.25 kg/ha) and post-transplant spraying of Metribuzin (0.5 kg/ha) control the weeds very effectively.

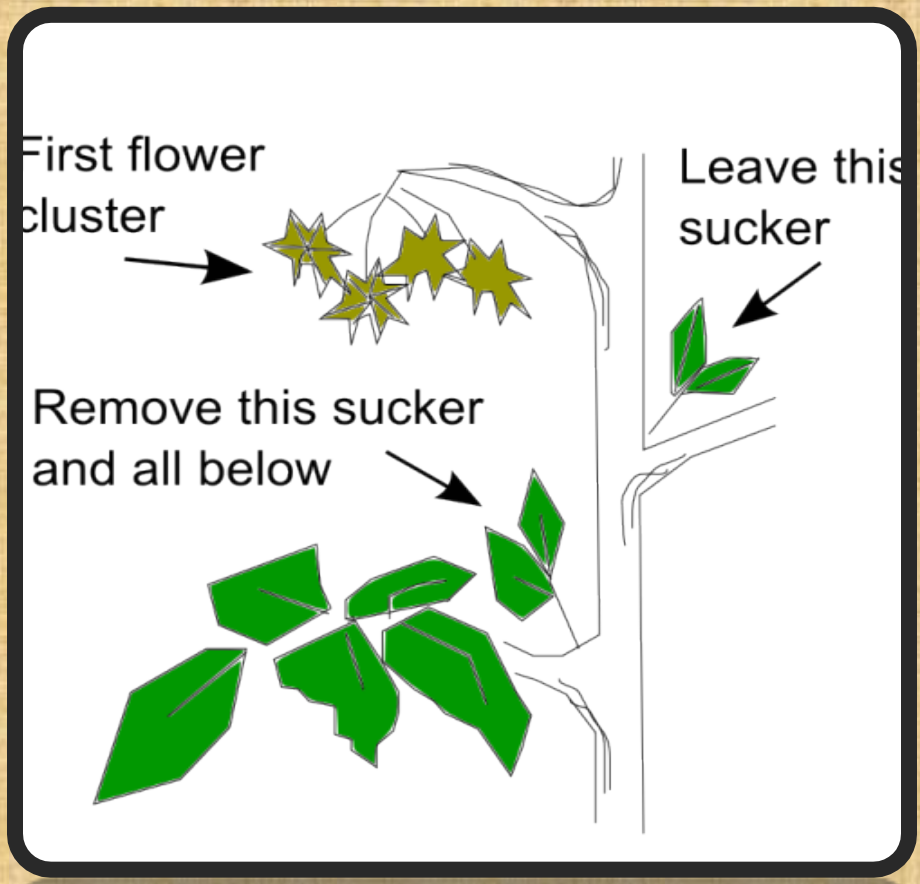
STAKING AND TRAINING

Stake and weaved tomato plants

cage

Trellis

PRUNING


First flower cluster
Leave this sucker
Remove this sucker and all below

USE OF PGR

Beneficial for early yield, increased fruit set at extreme temperature

PURPOSE	GROWTH REGULATOR	MODE OF APPLICATION
High Yield	GA @ 5-25 ppm	Seed treatment
	PCPA @ 10-20 ppm	Seed treatment
Increased Fruit Set	NAA @ .1ppm	Seed soaking for 24 hours
Increased Fruit Set during summer	IAA @ 50 ppm	Seed soaking for 24 hours
Increased fruit set at lower temperature	PCPA @ 50-100 ppm	Foliar spray at flower cluster
Ripening of fruits	Etherel @ 1000 ppm	Whole plant spray at the initiation of fruit ripening

HARVESTING

- Crop start yielding 70 days after transplanting.
- Tomato fruits are harvested at different stages of maturity depending on the distance of market and purpose.
- Harvested
- Twice in : Summer
- Weekly: Winter and Rainy season.

HARVESTING STAGES

Green / Stage 1

"Green" means that the surface of the tomato is completely green in color. The shade of green may vary from light to dark.

Breakers / Stage 2

"Breakers" means there is a definite "break" in color from green to tannish-yellow, pink or red on not more than 10% of the surface.

Turning / Stage 3

"Turning" means that more than 10%, but not more than 30%, of the surface, in the aggregate, shows a definite change in color from green to tannish-yellow, pink, red, or a combination thereof.

Pink / Stage 4

"Pink" means that more than 30%, but not more than 60%, of the surface, in the aggregate, shows pink or red in color.

Light Red / Stage 5

"Light red" means that more than 60% of the surface, in the aggregate, shows pinkish-red or red, provided that not

Red / Stage 6

"Red" means that more than 90% of the surface, in the aggregate, is red.

- Pink stage - Suitable for distant marketing.
- Little Red stage - Suitable for local marketing and processing.
- Red Stage - Suitable for processing purpose

YIELD

- Yield of tomato depends on many factors like soil, variety, season and management practices followed.
- However an average open pollinated varieties yields 300 – 500 q/ha and hybrids yields 500 – 600 q/ha.

DISEASES OF TOMATO (Fungal Diseases)

Name of the Disease	Symptoms	Control Measures	Image
Buckeye rot *Phytophthora nicotianae* var. *parasitica*	Pale brown, concentric rings resembling slightly the markings on a buckeye, usually appear on young and green fruits	Spray metalaxyl + mancozeb (.25 %) Followed by spray of either mancozeb (.25%) or copper oxychloride (.3%) @ 7-10 days interval	
Alternaria Leaf Spots *Alternaria solani* *A.Alternata* *A.a*.f.sp.*lycopersici*	*A.solani*- Dark Brown Spot with concentric rings, target board effect. *A.Alternata*- small, circular, dark brown. *A.a.f.sp.lycopersici* Small, angular, light brown not surrounded by hallow	Treat seed with captan (.3%), Copper oxychloride (.3%) or mancogeb (.25%) @ 10-14 days interval	

Septoria leaf spot *Septoria lycopersici*	**Small, water soaked, more or less circular spots in outline and show brown margins with grey centers**	**Spray carbendazim (.1%) or mancogeb (.25%) or copper oxychloride (.3%) repeat at 10-14 days interval.**	
Powdery mildew *Leveillula taurica Erysiphe cichoracearum*	L.taurica- white talcum like covering on lower surface of leaves upper surface turns yellow E. cichoracearum- white lesions on upper surface of leaves	Spray wettable sulphur (.2%) or dinocap(0.05) or carbendazim (0.05) or hexaconazole (0.05) or difenoconazole (0.05%)	
Fusarium wilt *Fusarium oxysporum* f sp. *lycopersici.*	Clearing of vein lets and drooping of the petioles. Browning of vascular bundles, entire plant wilt	Resistant varieties - Marglobe . Treat seed with T. viride , Streptomyces griseus or Bacillus subtilis or with Carbendazim (.2%)	

Bacterial Diseases **Bacterial spot** ***Xanthomonas campestris* p.v. *vesicatoria***	**Spots on leaves and stems are water soaked ,dark, not surrounded by hallow, later give scorched appearance**	**Dip seed in streptocycline (100ppm) for 30 min. Spray Streptocycline (100ppm) followed by copper oxy chloride(.3%)**
Bacterial Wilt *Ralstonia solanacearum*	Sudden drooping of leaves without yellowing accompained by rotting of the stem	Soil solarization, apply bleaching powder 15 kg/ha before transplanting Use resistant hybrids like Sun seed 7711.
Bacterial Canker *Clavibacter michiganensis* sub sp. *michiganensis*	Lower leaves wilts, on stem brown streaks and canker develop, on fruit scaby lesions surrounded by white hallow	Spray Streptocycline (100ppm) followed by copper oxy chloride(.3%) Dip seed in streptocycline (100ppm) for 1 hrs.

Tomato mosaic	**Virus causes a light and dark green mosaic mottled with raised dark green areas and distorted and crinkled younger leaves. The virus is seed borne**	**Voulenteer plants and weeds should be removed and diseased plants rogued and destroyed**	
Tomato spotted wilt virus	Pale red or yellow areas of 1.2 cm diameter with concentric circular markings in the normal red skin of the ripe tomato are formed	For the control of insect vector spray dimethoate @ 0.03% at 10 days interval	
Root Knot	Knots are formed first in lateral roots followed by primary root	Apply DBCP at 20-40 litre per ha in soil	

INSECT PESTS OF TOMATO

Fruit borer: *Helicoverpa armigera*

Serpentine leaf miner: *Liriomyza trifolii*

Leaf eating caterpillar: *Spodoptera litura*

Whitefly: ***Bemisia tabaci***

POST HARVEST HANDLING AND STORAGE

- Precooling of tomato after harvest at 12-13°C on the farm prolongs their storage life.
- Store well at 4-5°c and 85-90 % RH for 7 days in cold storage.

PHYSIOLOGICAL DISORDERS/PRODUCTION CONSTRAINTS

BLOSSOM END ROT:

- Caused due to high soil moisture, high temperature, deficiency of Ca, increase in N application.
- Controlled by growing resistant varieties, light and frequent irrigations and recommended dose of N. Spray $CaCl_2$ at fruit development stage.

Blossom End Rot

CRACKING

- Caused due to moisture stress conditions because of irregular irrigations, fluctuation between temperatures, Bo deficiency.
- Controlled by growing resistant varieties, maintaining optimum soil moisture and spray borax 2-3 times.

Cracking

Puffiness

- Caused due to abortion of embryo after fertilization, necrosis in tissues of fruits, high temperature and soil moisture, high dose of N.
- Controlled by avoiding over watering to the resistant varieticrop, growing es and recommended dose of N.

Cat Face

- Caused by high or low temperature during fruit setting, faulty pollination and fertilization, time of N application.
- Controlled by delaying pruning, balancing nutrient application, regulating temperature and use of PGR's

Puffiness

Cat Face

Sun Scald

- Caused by exposure to intense sunlight especially during hot/dry weather.
- Controlled by growing varieties with abundant foliage, avoiding training and pruning during summer months.

Green Shoulder

- This disorder is mainly genetic but brought specially in condition of high light and temperature.
- Controlled by growing varieties free from this disorder and cultivating tomato in normal growing conditions.

Sun Scald

Green shoulder

PROTECTED CULTIVATION OF TOMATO

- Average temperature requirement for cultivation under protected environment is 18-24° C
- Main Varieties Grown are :-Naveen 2000+, Amisha, BSS-366.
- Spacing : 70 × 30 cm
- Training and Pruning
- Single stem
- Double stem

Single Stem System


Double Stem System

TOMATO IN MODIFIED NATURALLY VENTILATED MEDIUM TECH POLYHOUSE

FERTIGATION

- Fertigation in polyhouse is usually done with the help of drip and the rate of fertilizer application is controlled by venturii system.
- Water soluble fertilizers like Samadhan (N:P:K ::19:19:19) are used in drip based fertigation system to prevent choking of drip lines.
- Urea 21.5 gram, SSP 62.5 gram and MOP 16.5 g per meter square for soil application.

ENHANCING OUT-OF-SEASON PRODUCTION OF TOMATOES USING HIGH TUNNELS

Low cost structure for high-value crops.
Wind (and sun) protection.
Water control.
Season extension (early and late crops possible.

Case Study: Yield and Soil Quality under Transitional Organic High Tunnel Tomatoes

Yields , fruit quality, and soil quality in transition organic and conventional tomatoes were measured over the course of three growing season. N was applied at 112,168 and 224kg total N/ha in the form of chicken manure (for organic treatment) and a polymer coated slow release urea fertilizer in the conventional treatments. Study revealed that combination of compost and high N, low P organic fertilizers are needed for optimum maintenance fertility strategy for organic tunnel house production.

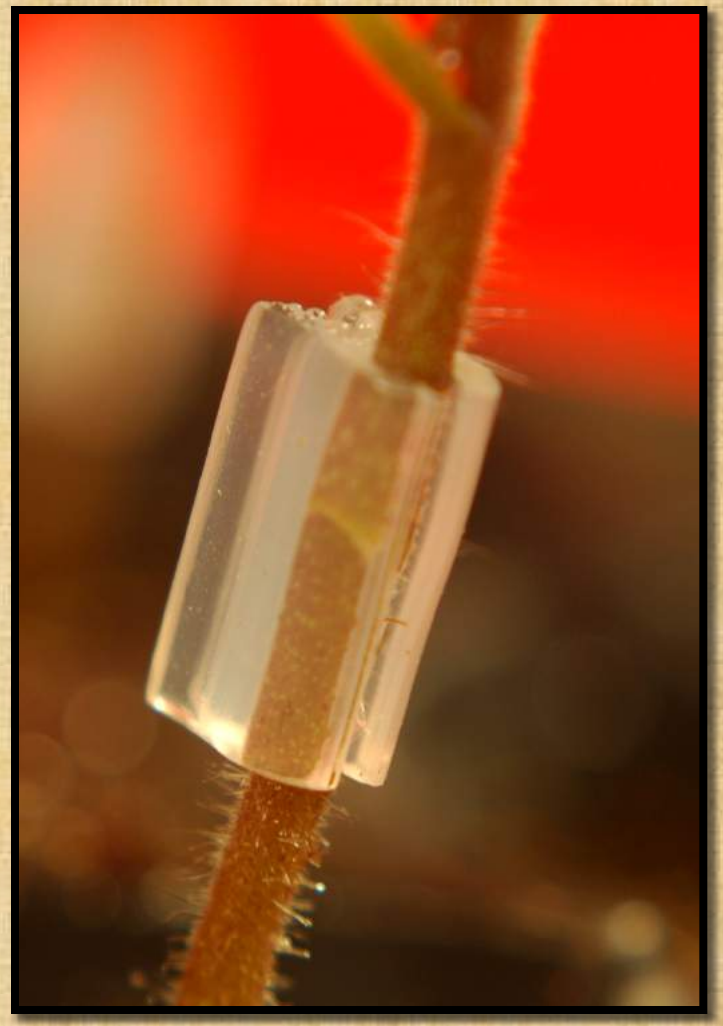
Reeve Jennifer and Drost Dan. 2012

TOMATO GRAFTING

- First reports of vegetable grafting occurred in Asia in the 1920's.
  - Fusarium wilt of melon
- Popularized in Japan and Korea
  - Tunnel and Greenhouse production

TUBE GRAFTING

- The advent of “tube-grafting” or “Japanese top-grafting” has become the most popular for tomato.
  - Seedlings are grafted at 2-4 leaf stage.



Case study: Evaluation of Grafting Using Hybrid Rootstocks for Management of Bacterial Wilt in Field Tomato Production

- Seven hybrid tomato rootstock with possible resistance to Bacterial Wilt and a known resistant cultivar were tested as grafting rootstocks to impart resistance to bacterial wilt susceptible cultivar, BHN 602. Grafted entries consistently exhibited the least bacterial wilt incidence compared with the control; the self-graft and non- grafted entries. Over all the trials, tomato plants grafted onto 'Cheong Gang', 'BHN 1054' and 'BHN 998' displayed the least incidence. Fields studies show that grafting holds promise for decreasing the impact of bacterial wilt as well as increasing the overall productivity of tomato cultivars.

Theodore McAvoy, Joshua H. Freeman, and Steven L. Rideout. 2012

Important hybrids available in tomato in public and private sector

Public Sector	
IARI (New Delhi)	KT-4, Pusa Hybrid-1, Pusa Hybrid-2, Pusa Hybrid-4, Pusa Divya
IIHR (Bangalore)	Arka Vardhan, Arka Vishal, Arka Shreshtha, Arka Abhijit
GBPUAT (Pantnagar)	Pant Hybrid-1, Pant Hybrid-2
NDUAT (Faizabad)	NDTH-1, NDTH-2, NDTH-6
UHF (Solan)	Solan Shagun, Solan Garima, Solan Sindhur

Private Sector

Ankur	ARTH-3, ARTH-4
Century	Century-12, Maitri, Rishi
Indo American	Karnataka, Mangla, Vaishali, Rupali, Naveen, Rashmi, Sheetal
Mahyco	MTH-1, MTH-2, MTH-6, MTH-15, MTH-16, S-28, Sonali
Namdhari	NS-386, NS-815, Summerset, Cross B, Gotya
Nath	NA-501, NA-601
Nijjar	NH-15, NH-25, NH-38
Pioneer	LIHB-230
Sandoz	Learika, Rasika, Avinash 11
Sungrow	Arjuna, Krishna, Bhim
Sutton	Sutton Grom, Prolific
Beejo Sheetal	BSS-39, BSS-20, BSS-40, BSS-90

IARI ACHIEVEMENTS IN TOMATO BREEDING

Achievement for specific purpose	Varieties/hybrids
Varieties for fresh market	Pusa Early Dwarf, Pusa Ruby
Varieties for long distance transport	Pusa Gaurav
Varieties for processing industry	Pusa Gaurav, Pusa Uphar
Low temperature tolerance	Pusa Sheetal (8˚C)
High temperature tolerance	Pusa Hybrid-1 (28-30˚C)
High and low temperature tolerance	Pusa Sadabahar (8-30˚C)

IIHR achievements in tomato breeding

Achievement for specific purpose	Varieties/hybrids
Specific purpose	
Fresh market hybrid	Arka Ananya
Fresh market and processing	Arka Samrat, Arka Rakshak
Biotic and Abiotic stress	
Bacterial wilt resistant hybrid	Arka Alok, Arka Abha, Arka Abhijit, Arka Shreshta
Nematode resistant hybrids	Arka Vardhan, Arka Vishal
Moisture stress tolerance varieties	Arka Meghali
Multiple disease resistant hybrids (TLCV and BW)	Arka Ananya
Multiple disease resistant hybrids (TLCV BW and Early blight)	Arka Samrat, Arka Rakshak

Kashi Hemant	**This has been developed through pedigree selection from a cross Sel-18 x Flora Dade. The plants are determinate, yield 400-420 q/ha**
Kashi Abhiman	Kashi Abhiman is a determinate tomato hybrid High yield potential of 87 t/ha and 93 t/ha has been recorded at HARP, Ranchi and CITH, Srinagar , ideal for long distance transportation

RESISTANCE BREEDING IN TOMATO

DISEASE	RESISTANCE SOURCE	RESISTANT VARIETIES
Buckeye rot	*S. pimpinellifolium*	Early Selection,KT-10, KT-15, Flat Large Red, Red Cherry
Fusarium Wilt	*S. hirsutum* f. *glabratum, S. hirsutum, S. peruvianum, S. pimpinellifolium*	Pant Bahar, BSS-20, Roma, Meenakshi, Roza, HS-110, Pan American for race1 and Walter for race2
Leaf Curl Virus	*S. hirsutum* f. *glabratum*, , *S. peruvianum, S. pimpinellifolium, S. glandulosum*	H-24, H-36,Hissar Gaurav, Hissar Anmol
Spotted Wilt Virus	*S. hirsutum* f. *glabratum*, , *S. peruvianum, S. pimpinellifolium*	Pearl Harbour, Red Currant
Early Blight	*S. hirsutum* f. *glabratum, S.hirsutum, S. peruvianum, S. pimpinellifolium*	H-22, H-25, Kalyanpur No.1
Late Blight	*S. pimpinellifolium, S. esculentum* var. *cerasifolrme*	Ottawa 30, Ottawa 31, Red Cherry, Early Market

Cont'd...

Verticillium Blight	***S. pimpinellifolium***	**Pant Bahar**
Fruit Borer	*S. hirsutum f. glabratum, S.hirsutum*	Pusa Uphar
Bacterial Wilt	*S. pimpinellifolium*	BT-1, BT-10, Arka Abhijit, Arka Shresha, BWR-1, BWR-5, Arka Alok, Arka Abha, Arka Vardhan
Root Knot Nematode	*S. peruvianum*	Hissar Lalit, Pusa 120 (Sel 120), Nematex, Arka Vardhan

BREEDING FOR ABIOTIC STRESSES

- Include environmental conditions such as:
  - Low and high temperature
  - Drought conditions
  - Flooding
  - moisture stress
  - Soil salinity
  - Water logging conditions etc.

Solanum species	Environmental stress tolerance
S. Cheesamanii	Salt tolerance, heat tolerance for fruit set
S. Pimpinellifolium	Heat tolerance for fruit set, drought tolerance
S. Chilense	Drought tolerance, cold resistance
S. Hirsutum	Cold tolerance, chilling tolerance, salt tolerance
S. Pennelii	Drought tolerance, salt tolerance
Solanum lycopersicoides	Cold tolerance

Tomato varieties resistant to abiotic stresses

Variety	Abiotic stress tolerance
Pusa Sheetal	Fruit set upto 8^{o}C (Low) night temperature
Pusa hybrid-1	Fruit set upto 28^{o}C (high) night temperature
Pusa Sadabahar	Fruit set at both low (6^{o}C) and high (30^{o}C) night temperature
Sabour Suphala	Salt tolerant at seed germination stage
Arka Vikas	Tolerant to moisture stress
Solan Vajr	Tolerant to drought
HS-101 , HS-102	Resistant to high temperature
Pusa Ruby	Resistant to salinity

STATUS OF TOMATO BREEDING AT UHF NAUNI

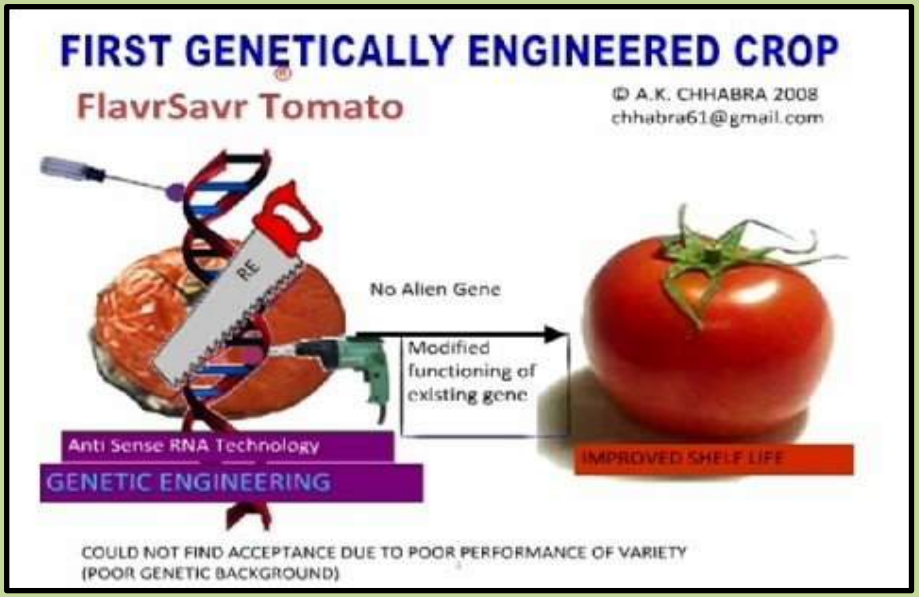
- Solan Gola - oldest variety, single plant selection.
- Solan Vajr - Selection from Solan Gola released in 2001.
- Yashwant –An open pollinated variety.
- Solan Sagun- Hybrid variety.
- Solan Garima – Hybrid variety developed by crossing UHF-55 (Female) and UHF-22 (Male) in 2007.
- Solan Sindhur- Hybrid variety developed by crossing UHF-55 (Female) and UHF-40(Male) in 2007.

Variety	Characteristic Features
Solan Gola	Indeterminate, fruit medium round, suitable for long transportation, fist harvesing after 75 days, average yield 375 q/ hac
Yashwant	Indeterminate, fruit flat with uniform ripening, resistant to Buckeye rot (5%), average yield 500 q/ hac
Solan Vajr	High yielding and drought resistant ,fruit wt. 70gm, ready in 70-75 days, average yield 425-475 q/ hac
Solan Sagun	Suitable for long transportation, average fruit wt. 65gm, resistant to Alternaria and Buckeye incidence , Average yield 500 q/ hac
Solan Garima	Plant indeterminate, 3-4 fruits/ cluster, average fruit wt. 85 gm, round, long distance transportable, average yield 660 q/ hac
Solan Sindhur	Plant indeterminate, 3-4 fruits / cluster, average fruit wt. 60 gm, round, long distance transportable, average yield 650 q/ hac.

Package of practices, 2012

FLAvrSavr (Longer Lasting Tomato)

- In tomato, enzymes poly galacturonase degrades pectin which is the major component of fruit cell wall. This leads to the softening of fruit and a deterioration in fruit quality. Transgenic tomatoes have been produced , which contain antisense construct of the gene encoding PG. These transgenics shows a drastically reduced expression of PG and markedly slower fruit softening; these tomatoes have about 2 weeks longer shelf-life than normal tomatoes. Such tomatoes were approved for marketing in U.S.A. under the name FlavrSavr. Slow Fruit Softening Tomato(1994).



THANK YOU

Series of Crop Specific Biology Documents

BIOLOGY OF BRINJAL

सत्यमेव जयते

Ministry of Environment and Forests
Government of India

Department of Biotechnology
Ministry of Science & Technology
Government of India

CONTENTS

BIOLOGY OF BRINJAL

1. GENERAL DESCRIPTION

Brinjal or eggplant (*Solanum melongena* L.) is an important solanaceous crop of sub-tropics and tropics. The name brinjal is popular in Indian subcontinents and is derived from Arabic and Sanskrit whereas the name eggplant has been derived from the shape of the fruit of some varieties, which are white and resemble in shape to chicken eggs. It is also called aubergine (French word) in Europe.

The brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and the Philippines. It is also popular in Egypt, France, Italy and United States. In India, it is one of the most common, popular and principal vegetable crops grown throughout the country except higher altitudes. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. It is a perennial but grown commercially as an annual crop. A number of cultivars are grown in India, consumer preference being dependent upon fruit color, size and shape.

The varieties of *Solanum melongena* L. display a wide range of fruit shapes and colours, ranging from oval or egg-shaped to long club-shaped; and from white, yellow, green through degrees of purple pigmentation to almost black. Most of the commercially important varieties have been selected from the long established types of the tropical India and China.

Brinjal fruit (unripe) is primarily consumed as cooked vegetable in various ways and dried shoots are used as fuel in rural areas. It is low in calories and fats, contains mostly water, some protein, fibre and carbohydrates. It is a good source of minerals and vitamins and is rich in total water soluble sugars, free reducing sugars, amide proteins among other nutrients. The composition of edible portion of brinjal is given in table 1.

Table 1: Composition per 100 g of edible portion

Calories	24.0	Sodium (mg)	3.0
Moisture content (%)	92.7	Copper (mg)	0.12
Carbohydrates (%)	4.0	Potassium (mg)	2.0
Protein (g)	1.4	Sulphur (mg)	44.0
Fat (g)	0.3	Chlorine (mg)	52.0
Fiber (g)	1.3	Vitamin A (I.U.)	124.0
Oxalic acid (mg)	18.0	Folic Acid (µg)	34.0
Calcium (mg)	18.0	Thiamine (mg)	0.04
Magnesium (mg)	15.0	Riboflavin (mg)	0.11
Phosphorus (mg)	47.0	B-carotene (µg)	0.74
Iron (mg)	0.38	Vitamin C (mg)	12.0
Zinc (mg)	0.22	Amino Acids	0.22

Source: *National Institute of Nutrition, 2007*

It has been reported that on an average, the oblong-fruited eggplant cultivars are rich in total soluble sugars, whereas the long-fruited cultivars contain a higher content of free reducing sugars, anthocyanin, phenols, glycoalkaloids (such as solasodine), dry matter, and amide proteins (Bajaj *et al.*, 1979). A high anthocyanin content and a low glycoalkaloid content are considered essential, regardless of how the fruit is to be used. For processing purposes, the fruit should have a high dry matter content and a low level of phenolics. Bitterness in eggplant is due to the presence of glycoalkaloids which are of wide occurrence in plants of *Solanaceae* family. The glycoalkaloid contents in the Indian commercial cultivars vary from 0.37 mg/100 g fresh weight to 4.83 mg) (Bajaj *et al.*, 1981). Generally, the high content of glycoalkaloids (20mg/100 g fresh weight) produce a bitter taste and off flavor. The discoloration in eggplant fruit is attributed to high polyphenol oxidase activity. The cultivars which are least susceptible to discoloration are considered suitable for processing purposes.

Brinjal is known to have ayurvedic medicinal properties and is good for diabetic patients. It has also been recommended as an excellent remedy for those suffering from liver complaints (Shukla and Naik 1993).

Brinjal has been cultivated in India for the last 4,000 years, although it is often thought of as a Mediterranean or mid-Eastern vegetable. The global area under brinjal cultivation has been estimated at 1.85 million ha with total production of brinjal fruit of about 32 million MTs (FAO data, 2005, http://faostat.fao.org/). India accounts for about 8.7 million MTs with an area of 0.53 million hectares under cultivation. Brinjal is also exported in the fresh or frozen form. In 2007-08, 34 million kg worth of Rs. 19 million was exported mainly to UK, Netherland, Saudi Arabia and Middle East countries (DGCIS, 2008)

2. TAXONOMY AND GEOGRAPHIC ORIGIN

2.1 Taxonomy

Brinjal belongs to the family *Solanaceae* and is known under the botanical name *Solanum melongena* L. The family contains 75 genera and over 2000 species, out of which, about 150-200 are tuber bearing and belong to section Tuberarium. The majority of species (about 1800) are non tuber bearing. Cytological studies have indicated that basic chromosomal number 2n = 24 is same in almost all the varieties and species.

There are 3 main botanical varieties under the species *melongena* (Choudhury, 1976a). The common brinjal, to which large, round or egg-shaped fruited forms belong, are grouped under var. *esculentum*. The long, slender types are included under var. *serpentinum* and the dwarf brinjal plants are put under var. *depressum*.

Name	Cotton
Kingdom	Plantae
Class	Magnoliopsida
Subclass	Asteridae
Order	Solanales
Family	Solanaceae
Genus	*Solanum*
Species:	*S.melongena*

2.2 Geographic origin and distribution

Brinjal is considered a native to India where the major domestication of large fruited cultivars occurred. In "Origin of cultivated plants" published in 1886 De Candolle, stated that the species *S. melongena* has been known in India from ancient times and regarded it as a native of Asia. Vavilov (1928) was of the opinion that its centre of origin was in the Indo-Burma region.

Various forms, colours and shapes of brinjal are found throughout South-East Asia, suggesting that this area is an important centre of variation. A centre of diversity is believed to be in the region of Bangladesh and Myanmar (Former India-Burma border). Evidence to this was given by Isshiki et al (1994) based on the isoenzyme and morphological variation noticed in large germplasm collection from India.

According to Zeven and Zhukovsky (1975), it originated in India but spread eastward and by the 5th century B.C. was in China, which became a secondary centre of variation. Thus, it has been known for the last 1500 years in China. Arabic traders were responsible for subsequent movement to Africa and Spain. Brinjal cultivation in the Mediterranean region is relatively recent. Portuguese colonies took it to Brazil. It is now widely cultivated for its fruits in the tropical, subtropical and warm temperate zones, especially in Southern Europe and the Southern United States. Sampson (1936) suggested the African origin of this crop, but there is no evidence that *S. melongena* is native there though there are spiny African brinjal plants.

2.3 Genomic Evolution

As regards affinities and origin of *S. melongena L.*, hybridization experiments between *S. melongena* and other species of *Solanum* have been performed only in few cases and definite conclusions are not available. Efforts have been initiated for studying evolutionary relationship and discerning varieties within crop germplasm (Doganlar Sami, 2002 and Singh *et al,* 2006)

3. REPRODUCTIVE BIOLOGY

3.1 Growth and development

Brinjal is usually transplanted rather than direct seeded in the field as it provides the best means of establishing a uniform and complete stand of plants. Brinjal seeds germinate one to two weeks after sowing. Seedlings grown in containers are ideal because they allow field planting without disturbing the root system. A main stem with 6-10 leaves develop before the appearance of first flower. Depending on whether the sowing period corresponds to more or less favourable agro climatic conditions, the first flower appears one and a half to three months after sowing. At the level of each flower, there is dichotomous branching that grows more or less regularly, depending on the species and variety. The sympodia generally consist of two leaves and the axillary bud of the leaf below each flower frequently gives rise to a new branch. Growth and flowering are continuous throughout the life of the plant.

Taking into account the competition between the vegetative growth and fruit production, brinjal is capable of indefinite production..

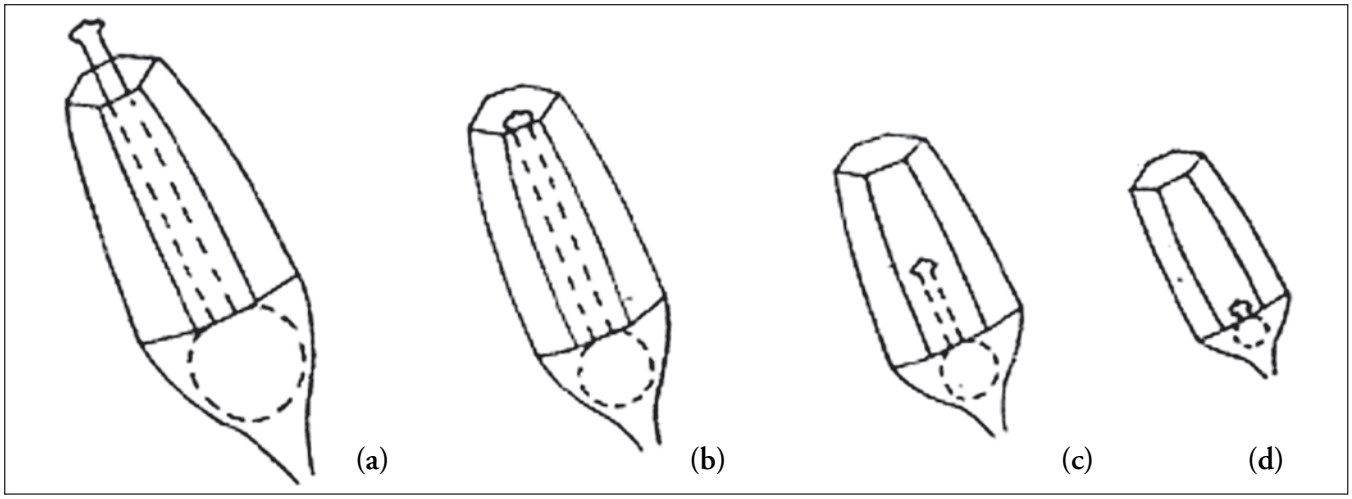
The botanical features of *S. melongena* along with charateristics of three common varieties viz. *esculentum*, *serpentinum* and *depressum* are placed at Annexure- I

3.2 Floral biology

Brinjal flowers are large, violet coloured and solitary or in clusters of two or more. Flower consists of calyx: sepals 5, united, persistent; corolla: petals 5, united, usually cup shaped; Androecium : stamens 5, alternate with corolla; Gynoecium: carpels are united, ovary superior. The hypogynus gynoecium is syncarp located obliquely in relation to the median. In most varieties the perfect flowers are borne singly and opposite the leaves.

In brinjal, heterostyly is a common feature. Four types of flowers have been reported depending on the length of styles, viz. (i) long-styled with large ovary, (ii) medium-styled with medium size ovary, (iii) Pseudoshort-styled with rudimentary ovary and (iv) true short-styled with very rudimentary ovary (Figure 1) (Krishnamurthi and Subramaniam, 1954) .

Figure 1: Types of brinjal flowers on the basis of length of styles



a. long-styled (big ovary), *b. medium-styled (medium ovary),*
c. pseudoshort-styled (rudimentary ovary), *d. true short-styled (very rudimentary ovary).*

It has been reported that long and medium-styled flowers produce fruits whereas pseudo-short and short-styled flowers do not set any fruits. Further, chances of cross pollination are more in long style flowers. The percentage of long and medium styled flowers is a varietal character. Fruit setting of long-styled flowers varies from 70% to 86.7% in different varieties. In medium styled flowers, fruit set ranges from 12.5% to 55.6%. All varieties have flowers with different style length. The position of the stigma in relation to stamens varies with the cultivars and can also vary in different flowers of same cultivar. Stigmas are either found above, on the same level as or below the stamens and the highest

percentage of fruit set is found where the stigma is above the stamens. In short-styled flowers the androecium is fertile but the stigma is smaller with underdeveloped papillae and lower sugar content than that in long-styled flowers. There is no pollen germination on the stigma or penetration of pollen tube into short styles (Rylski *et. al.* 1984).

3.3 Pollination

Brinjal is usually self-pollinated, but the extent of cross-pollination has been reported as high as 48% and hence it is classified as cross-pollinated crop. The cone-like formation of anthers favors self-pollination; but since the stigma ultimately projects beyond the anthers, there is an ample opportunity for cross-pollination. The rates of natural cross-pollination may vary depending on genotype, location, and insect activity. The extent of outcrossing has been reported from 3 to7% in China and from 0 to 8.2% (with a mean of 2.7%) at Asian Vegetable Research Development Centre (Chen, 2000); however the Indian researchers have reported 2 to 48% outcrossing in brinjal varieties in India as indicated in Table 2. Outcrossing primarily takes place with the help of insects.

Table 2: Reported cross-pollination in brinjal in India

% Cross pollination	Reference
0.00-48.00%	Agrawal, R.L. (1980)
6.00-20.00%	Choudhary, B. (1971)
6.70%	Sambandam, C.N. (1964)
30.00-40.00%	Daskalov *et. Al.* (1937)
0.14-1.99%	Choudhary *et. al.* (1970)

Flowers generally emerge 40-45 days after transplanting. The anthesis and dehiscence in brinjal are mainly influenced by the daylight, temperature and humidity and therefore the exact timing for every area should be determined by observation and experience. Usually anthesis starts from 6 to 7.30 AM and continues up to 11 AM Peak time for anthesis is 8.30 to 10.30 AM The pollen dehiscence starts from 9.30 to 10 AM Stigma receptivity is highest during anthesis. The receptivity of the stigma could be observed from the plump and sticky appearance which gradually turns brown with the loss of receptivity. The stamens dehisce at the same time stigma is receptive so that self pollination is a rule, although there is some cross pollination by insects also. The period of effective receptivity ranges from a day prior to flower opening. Pollen is most fertile immediately after the anther dehiscence. Pollen remains viable for a day. Opening of anthers is mostly by pore or slit at or near the apex. Repeated pollination and pollen from different plants increases both fruit and seed set.

There is variation in the size of pollen grains also (Prasad *et. al.* 1968). Popova (1958) reported that pollen remained viable for 7-10 days and stigma remained receptive for 6-8 days. Maximum fruit set was observed when stigma received pollen from many different plants.

The extent of cross pollination has been reported as high as 48% and depends on the presence of pollinating insects such as bumblebees (*Bombus* sp.), wild bees *(Exomalopsis* sp., *Xylocopa* sp., *Anthophora* sp.) and domestic bees*(Apis* sp.).

Pal and Osvald (1967) observed that the fruit set of insect pollinated plants is much higher then that of self pollinated ones. Flower abortion is favoured by natural day light reduction and high (30°C) night temperature as reported by Saito and Ito (1973). Pal and Taller (1969) opined that the number of seeds per fruit is closely related with the type of pollination. It is highest with the free pollination, lower in selfed plants and lowest in exclusively artificially crossed plants.

3.4 Method of reproductive isolation

Since there is considerable amount of cross pollination in eggplant, isolation is essential for seed production in case of brinjal. As per Indian minimum seed certification standards, an isolation distance of 300 meters is required for production of foundation seeds of varieties/hybrids in case of brinjal (Tunwar and Singh, 1988). Accordingly requirements of 300 meters as the isolation distance has been adopted for conducting confined field trial of genetically engineered brinjal varieties/hybrids.

4. CROSSABILITY BETWEEN SOLANUM SPECIES AND HYBRIDISATION

Solanum is a very large genus. It includes both tuberous and non tuberous group of species. The chromosome number of many species under non tuberous group is fairly stable as 2 x = n = 24. There are 38 asian species which include 22 Indian species (listed in Box 1). There is a group of 5 related ones, namely *S. melongena L., S. incanum L,* (often considered synonymous to *S. coagulans L..), S. xanthocarpum, S. indicum L.* and *S. maccani*. (Choudhury, 1976b).

Box 1

1.	*Solanum aethiopicum L.*
2.	*Solanum americanum Miller*
3.	*Solanum anguivi Lam.*
4.	*Solanum blumei Nees*
5.	*Solanum dulcamara L.*
6.	*Solanum ferox L.*
7.	*Solanum incanum L.*
8.	*Solanum indicum L.*
9.	*Solanum lasiocarpum Dunal*
10.	*Solanum macrocarpon L.*
11.	*Solanum mammosum L.*

12.	*Solanum marginatum L*
13.	*Solanum melongena L.*
14.	*Solanum nigrum L.*
15.	*Solanum sisymbriifolium Lam.*
16.	*Solanum stramonifolium L.*
17.	*Solanum torvum Swartz*
18.	*Solanum trilobatum L.*
19.	*Solanum undatum Jacq. non Lam.*
20.	*Solanum viarum L*
21.	*Solanum violaceum Ortega*
22.	*Solanum xanthocarpum* Schrad. et Wendl

Source: *Indian Institute of Vegetable Research (IIVR), 2009. Personal communication*

Crossability among some of the important species has been reviewed by Rao, 1979. He studied crossability among ten species and reported that *S. melongena* cultivar as female parent hybridized with *S. melongena* variety *S. insanum, S. incanum, S. integrifolium* and *S. gilo* and resulted in viable seeds. It produced only shrunken seeds with *S. khasianum* and did not hybridize with *S. indicum S. zuccagnianum* and *S. sisymbrifolium*. *S. melongena* as male parent hybridized with *S. indicum* and produced a number of hybrids. Rajasekharan (1969) studied the interrelationship of some common Solanum species occurring in South India. Eight *Solanum* spp. were crossed in all possible combinations out of which *S. indicum* x *S. melongena*; *S. xanthocarpum* x *S. trilobatum* crosses were successful. Schaff et al. (1980) produced interspecific hybrids in reciprocal crosses by using 11 *S. melongena* types and an African accession of *S. macrocarpon*. Nishio et al (1984) classified 11 *Solanum* species into three groups on the basis of their inter specific compatability: (1) *S. melongena*, *S. incanum*, and *S. macrocarpon*; (2) *S. integrifolium*, *S. gilo* and *S. nodiflorum*; and (3) *S. indicum*, *S. mammosum*, *S. toryum*, *S. sisymbriifollium*, and *S. toxicarium*. Crosses were compatible within and between the first and second groups, but were otherwise incompatible. From various reports, it appears that *S. melongena* is more closely related to *S. incanum* than to any other species.

5. ECOLOGICAL INTERACTIONS

5.1 Organisation of species complexes and gene flow

The species of *S.melongena, S. aethiopicum* and *S.macrocarpon* are interfertile with their respective wild ancestors (Lester and Niakan, 1986; Hasan, 1989; Daunay *et al.*, 1991). For each of these, the wild ancestor constitutes the primary gene pool according to Harlan and de Wet (1971). In nature, the morphological continuum observed between the primitive forms of each cultivated species, its semi-

cultivated forms and the wild species indicates spontaneous gene exchanges. However, these exchanges, which are frequent between primitive forms of each cultivated species and wild species, are much less frequent between advanced forms and wild species.

5.2 Potential for gene transfer from brinjal

5.2.1 *Gene transfer between different brinjal species*

Based on the available information on crossability and different species and subtropics of brinjal, it could be concluded that as such there is no natural crossing among cultivated and wild species of brinjal. Further under forced crossing situations, even if crossing was possible, the viability and subsequent development stable crosses have not been successful.

5.2.2 *Gene transfer from brinjal to other plants*

There are no reports of any gene transfer from brinjal to unrelated plant species. Further it may be noted that such a transfer of any gene is highly improbable because of pre-and post-zygotic genetic incompatibility barriers that are well documented for distantly related plant groups. No evidence for transfer of genes from brinjal to other plant taxa has been identified.

5.2.3 *Gene transfer from brinjal to other organisms*

Horizontal gene transfer from plants to animals (including humans) or microorganisms is extremely unlikely No evidence has been identified for any mechanism by which brinjal genes could be transferred to humans or animals, nor any evidence that such gene transfer has occurred for any plant species during evolutionary history, despite animals and humans eating large quantities of plant DNA. The likelihood of brinjal genes transferring to humans and other animals is therefore effectively zero. Similarly gene transfer from brinjal, or any other plant, to microorganisms is extremely unlikely. Horizontal gene transfer from plants to bacteria has not been demonstrated experimentally under natural conditions (Nielsen *et al*., 1997; Nielsen et al., 1998; Syvanen 1999) and deliberate attempts to induce such transfers have so far failed (Schlüter *et al,*. 1995; Coghlan 2000).

5.3 Seed dormancy

Some wild species of brinjal germinate much slower than cultivated species.. Seed dormancy is sometimes observed, which varies according to cultivars and harvest conditions. Storage for a few months at an ambient temperature, or a few weeks at chilled conditions lessens this dormancy (Daunay *et al.*). Seed dormancy was reported in some of the cultivated brinjal species also. Yogeesha *et al.*, (2006) have reported seed dormancy in fresh seeds of eggplant cultivars. The germination of two month old seeds of two brinjals varieties cv. Arka Keshav and Arka Neelkanth was 0 % and 2 % respectively, revealing the presence of dormancy. However there was a gradual decline in the seed dormancy with the ageing of seeds under ambient conditions and complete breakdown of dormancy occurred after 12 months of storage.

5.4 Free living populations of Brinjal

5.4 Free living populations of Brinjal

The term "free living" is assigned to plant pollutants that are able to survive, without direct human assistance, over long term in competition with the native flora. This is a general ecological category that includes plants that colonize open, disturbed prime habitat that is either under human control (weedy populations) or natural disturbed areas such as river banks and sand bars(wild populations). There are no such free living populations of brinjal in India.

5.5 Weediness of brinjal

No reports of weedy species of *Solanum melongena* are available.

6. HUMAN HEALTH CONSIDERATIONS

In Brinjal no endogenous toxins or significant levels of antinutritional factors have been found till date. It is so not considered a pathogen and is not capable of causing any disease in humans, animals or plants.

7. BRINJAL CULTIVATION IN INDIA

7.1 Climatic and soil requirements

Brinjal is a warm season vegetable and susceptible to severe frost. Climatic conditions especially low temperature during the cool season cause abnormal development of the ovary (splitting) in flower buds which then differentiate and develop into deformed fruits during that season (Nothmann and Koller, 1973). The optimum temperature for growth and fruit set is 20-30°C. However the high night and day temperature condition of 22-24°C to 33-35°C markedly reduce fruit set and yield (Kalloo *et al*, 1990; Kumar *et al.*, 2000; Mohanty and Prusty, 2000; Thapa, 2002). Many of the round varieties set fruits at slightly lower temperature but are highly susceptible to frost. The long fruited varieties set fruit at higher temperature and show tolerance to frost. The growth of the crop is severely affected when temperature falls below 17°C. It can be successfully grown as a rainy season and summer season crop.

The brinjal can be grown practically on all soils from light sandy to heavy clay. Light soils are good for an early crop, while clay loam and silt-loam are well suited for high yield. Generally, silt-loam and clay-loam soils are preferred for brinjal cultivation. The soil should be deep, fertile and well-drained. The soil pH should not be more than 5.5 to 6.0 for its better growth and development. It is moderately tolerant to acidic soil. Several cultivars are grown successfully under high pH level with a rich application of farmyard manure or green manuring practiced before transplanting.

7.2 Varietal testing system

As brinjal is grown all over India and round the year, like other similar vegetable crops, brinjal is tested in the All India Coordinated Vegetable Improvement Programme (AICVIP), spread in selected location

in the country. State Universities and Research stations test the locally preferred varieties in the jurisdiction. The AICVIP promotes R&D and breeding of improved varieties of vegetable crops including brinjal. Vegetable growing states in India are classified into eight different zones, mainly on the basis of agro-climatic conditions and these are listed below:

Zone I: Jammu & Kashmir, Himachal Pradesh and Uttarakhand
Zone II: West Bengal and Assam
Zone III: North East States and Andaman and Nicobar Islands
Zone IV: Punjab, Uttar Pradesh, Bihar and Jharkhand
Zone V: Chhattisgarh, Orissa and Andhra Pradesh
Zone VI: Rajasthan, Gujarat, Haryana and Delhi
Zone VII: Madhya Pradesh and Maharashtra
Zone VIII: Karnataka, Tamil Nadu and Kerala

7.3 Pests and diseases of brinjal

Insect pests infestation is one of the most limiting factors for accelerating yield potential of brinjal. The crop is prone to damage by various insects, although there is wide variability in their degree of infestation. Some of the important insects are fruit and shoot borer, jassids, mites, etc. The brinjal is also subjected to the attack of many diseases affecting roots, leaves, stems and fruits. The severity in any particular disease depends on the season and the region in which the crop is growth. Many of the diseases have caused damage only in exception years, but a few are prevalent in many areas each year and cause varying levels of damage. The major insect/pests, disease and predators of brinjal in India are detailed in Annexure 2 to 4.

7.4 Breeding objectives

Breeding activities in brinjal have been targeted at the development of high-yielding, early, better quality and disease resistant varieties. The color of the fruit and size and shape, the proportion of seeds to pulp, short cooking time and lower solanine levels are important traits in assessing quality. As brinjal is susceptible to several pests and diseases such as wilt, *Phomopsis* , little leaf and root-knot nematodes and to insects such as shoot and fruit borer, jassids, epilachna beetle, etc. the development of pest resistant varieties is a major challenges. Plants are susceptible to both low and high temperature; therefore attempts are being made to develop chilling or frost- tolerant and heat-tolerant varieties. (Singh and Kumar, 2005)

Specific breeding objectives in brinjal in Indian context are: :

i. Exploitation of heterosis for increasing productivity
ii. Incorporation of resistance against insect pests including fruit and shoot borer
iii. Breeding wilt and other disease resistance-host plant resistance

iv. Development of cultivars of better quality and yield
v. Development of locally preferred cultivars which are distinct in appearance

7.5 Importance of heterosis breeding

Brinjal continues to be a choice of breeders for exploitation of heterosis due to hardy nature of crop, comparatively large size of flowers and large number of seeds in a single act of pollination. Highly varied consumer acceptance from region to region also demands for development of a large number of high yielding F_1 hybrids. Exploitation of hybrid vigor has become a potential tool for improvement in brinjal (Pal and Singh 1949, Mishra 1961, Samandam 1962, Dhankar *et. al*. 1980, Chadha and Sidhu 1982).

In India, several reports are available on hybrid vigor in brinjal. Pal and Singh (1949) reported that hybrid in brinjal showed 48.8-56.6% increased yields over the better parent. Mishra (1961) also observed increased yields in brinjal hybrids. The cost of hybrid seed production is not high as compared to other vegetables and this can be further reduced by the use of male sterile lines.

Among the related wild species, S.*sisymbriifolium* and S. *torvum*are particularly interesting on account of their resistance to three of the most serious eggplant diseases (bacterial wilt, *Verticillium* wilt and nematodes). Unfortunately these two species do not give fertile progenies when crossed with S. *melongena*. However the *b*iotechnological tools could be useful in overcoming the crossability barrier between the *Solanum melongena & Solanum tuberarium*

Keeping in view the above, the main objective of inter specific hybridization has been to transfer resistance characteristic(s) of wild species to commercial varieties. The related species of *S. melongena* L. have been used in breeding for insect and disease resistance. Two other species, *S. khasianum* and *S. aviculare*, having the same chromosome number, have gained importance as sources of solasodine used for synthesis of steroid hormones (Choudhury, 1976b).

7.6 Status of brinjal cultivation:

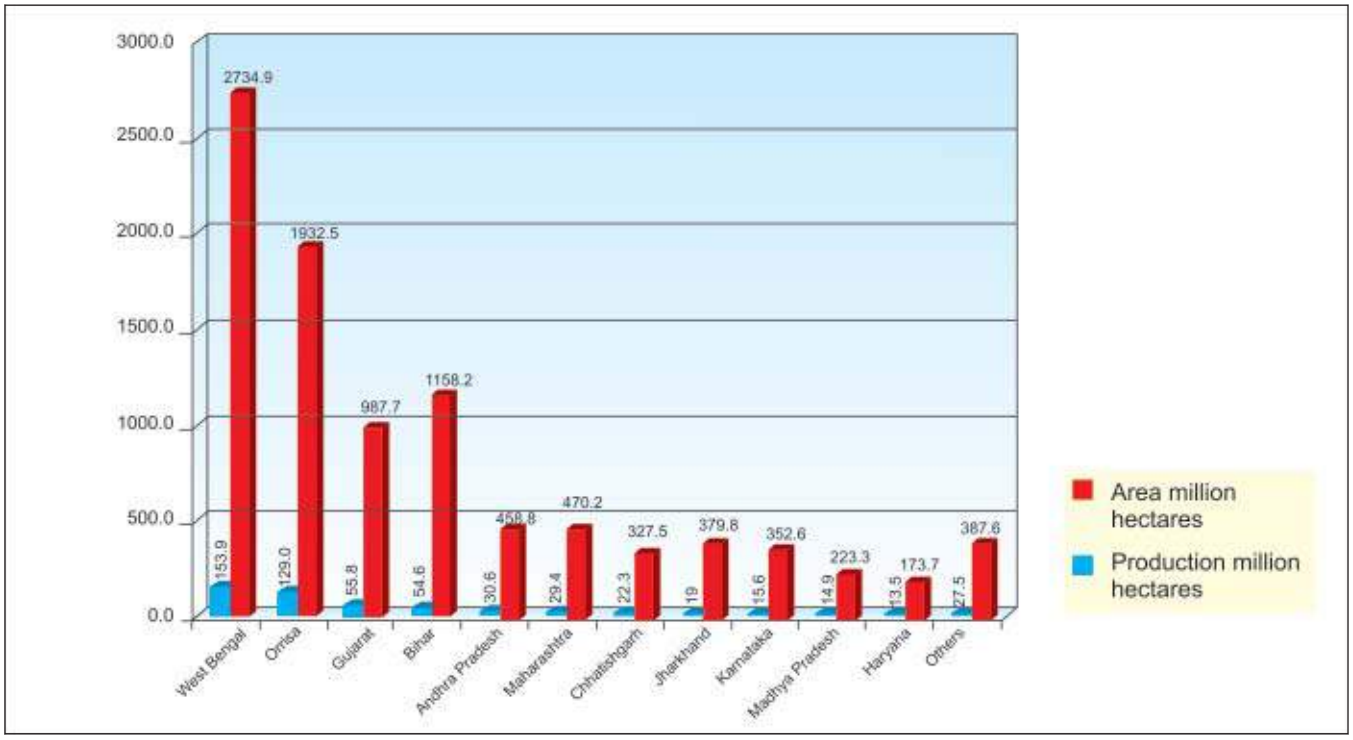
As mentioned earlier, brinjal can be grown in almost all parts of India except higher altitudes all the year round. A number of cultivars are grown throughout the country depending on the yield, consumer's preference about the colour, size and shapes of the various cultivars. There is huge diversity in Indian germplasm ranging from long to round fruits; white fruited to black fruited, thorny to non thorny and bushy plant habit to erect plant habit. It is a versatile crop adapted to different agro-climatic regions

Brinjal cultivation in India is estimated to cover about 8.14% vegetable area with a contribution of 9% to total vegetable production. The crop is largely grown in small plots or as inter crop both for cash and domestic consumption by farmers all over India. The major brinjal producing states are West Bengal, Orissa, Bihar, Gujarat, Maharashtra, Karnataka, Uttar Pradesh and Andhra Pradesh. A map of India showing brinjal cultivation area is placed in Figure 2. Area and production data in major brinjal growing states in 2007-08 is placed in Figure 3.

Figure 2. Map of India showing brinjal cultivation area

Solid shading indicates a traditional brinjal growing area while light feathering indicates sparsely spread area under brinjal.

Figure 3: State wise area and production of brinjal for they year 2007-08



Source: National Horticulture Board

7.7 Status of biotechnological interventions

Fruits and shoot borer i.e. *Leucinodes orbonalis* being the most destructive pest in brinjal crop, efforts have been made to develop insect resistance brinjal varieties by incorporating *cry1Ac* gene in brinjal from a bacterium mainly *Bacillus thuringiensis*, commonly known as Bt brinjal. The Bt brinjal developed by M/s Maharashtra Hybrid Seeds Company Limited containing *cry1Ac* gene (Event EE1) is in the advanced stages of large scale field evaluation. MAHYCO has also transferred Bt brinjal technology to public sector institutions viz. Tamil Nadu Agricultural University (TNAU), Coimbatore, University of Agricultural Sciences (UAS), Dharwad and Indian Institute of Vegetable Research (IIVR), Varanasi, who have successfully backcrossed Event EE1 into locally adopted open pollinated brinjal varieties. The technology has been also transferred to Institute of Plant Breeding of the University of Philippines, in the Philippines and Bangladesh Agricultural Research Institute and East West Seeds Limited in Bangladesh. National Research Centre on Plant Biotechnology (NRCPB), New Delhi has also developed Bt brinjal by incorporating *cry1Fa1* gene into brinjal and transferred to the same to few seed companies for further biosafety studies and field evaluation. The Indian Institute of Horticultural Research (IIHR), Bangalore is also developing Bt brinjal using *cry1Ab* gene construct in two important brinjal varieties.

ANNEXURE - 1

BOTANICAL FEATURES

Brinjal or eggplant is a herbaceous annual with erect or semi spreading habits. It is a perennial plant but cultivated as annual. It develops into bushy plants with large, fuzzy leaves that grow to a height of about 60 to 120 centimeters. The plant is erect, compact, and well branched. It has a rather fibrous or lignified root system. The leaves are large, simple, lobed and alternate on the stems. The stems, leaves, and calyx of some cultivars are spined.

The botanical features of various plants parts of brinjal are as under:

Leaves

The leaf pattern is mostly opposite, large, single lobed and the underside of the most cultivars is covered with dense wool like hairs. The leaves may be with or without spines at the midrib portions. The leaf blade and tip angle is very acute to very obtuse. Inflorescence is often solitary but sometimes it constitutes a cluster of 2 - 5 flowers. This character is dependent on the variety or hybrid.

Flower

The flowers are large, violet-colored and either solitary or in clusters of two or more (Lawande and Chavan 1998). Flower is complete, actinomorphic and hermaphrodite. Calyx is five lobed, gamosepalous and persistent with or without spines depending on the cultivar types. It forms a cup like structure at the base. Corolla is five lobed gamopetalous with margins of lobes incurved. There are five stamens which are free and inserted at the throat of corolla. Anthers are cone shaped, free and with apical dehiscence. Ovary is hypogynous, bicarpellary, sycarpous and with basal placentation.

Four types of flowers have been reported depending on the length of styles, viz. (i) long styled with big ovary, (ii) medium styled with medium sized ovary, (iii) pseudoshort styled with rudimentary ovary and (iv) true short styled with very rudimentary ovary.

Fruit

he fruit is pendent and is fleshy berry borne signally or in clusters. The shape of fruit varies from ovoid, oblong, obovoid, or long cylindrical. The colour of the mature fruit varies from mono-coloured purple, purple black, yellowish, white, green and variegated types of purple with white stripes, green with light green / white stripes or even combination of three colours.

Seeds

The seeds are borne on the fleshy placenta and the placentae with the seeds completely fill the locular cavity. The number of seeds per fruit varies from few (50) to many. The seed color is white, light yellow, brownish yellow, brown to black brown for different varieties.

ANNEXURE - 2

KEY INSECT/PEST OF BRINJAL

Brinjal is attacked by a number of insect pests and nematodes during various stages of crop growth in most of the tropical countries including India. The extent of losses caused by these pests depends on season, variety, soil and other factors (Dhamdhare *et al*., 1995; Roy and Pande, 1995). Some of the important ones are briefly described below.

i) Brinjal fruit and shoot borer (*Leucinodes orbonalis*)

Fruit and shoot borer *(Leucinodes orbonalis)* is the most destructive pest of brinjal. It is widely distributed in the Indian sub-continent and also in Thailand, Laos, South Africa, Congo and Malaysia. It also damages potato and other solanaceous crops. This pest is active through out the year at places having moderate climate but it is adversely affected by severe cold (To improve this paragraph).

The damage by this insect starts soon after transplanting of the seedlings and continues till harvest of fruits. Eggs are laid singly on ventral surface of leaves, shoots, and flower-buds and occasionally on fruits. In young plants, appearance of wilted drooping shoots is the typical symptom of damage by this pest; these affected shoots ultimately wither and die away.

Plant showing shoots damage (Drooping Shoot) and insect inside the shoot

At later stage, the caterpillars bore into flower buds and fruits, entering from under the calyx, they have no visible sign of infestation, but the caterpillars feed inside. The damage flower buds shed without blossoming whereas the fruits show circular exit holes. Such fruits, being partially unfit for human consumption, lose their market value considerably.

Plant showing shoots damage (Drooping Shoot) and insect inside the shoot

2. Brinjal Fruit Borer (*Helicoverpa armigera*)

The pest is polyphagous in nature. The full grown larvae are greenish with dark broken grey lines along the side of body. They measure about 35-45 mm long. The moth is large and brown with V-shaped speck and dull black border on the hind wings. The larvae are feed first on leaves and fruiting bodies and later on, they bore into the fruits, completely eating away the internal contents.

3. Brinjal Stem Borer (*Euzophera perticella*)

Full grown caterpillars are creamy white with a few bristly hairs and measure about 20-22 mm in length. The moth is small having pale straw yellow fore wings and whitish hind wings. The moth measure about 32 mm across the spread wings. The caterpillar causes the damage and feed exclusively in the main stem. It enters the main stem and make tunnel which results either in stunting of growth or withering of plants. Its infestation is seen usually in the later stage of crop.

4. Hadda Beetle (*Epilachna vigintiopunctata*)

The grubs are almost 6 mm long, yellowish in colour and have six rows of long branched spines. Beetles are 8-9 mm in length and 5.5 mm in width. Beetles are deep red and usually have 7-14 black spots on each elytra whose tip is somewhat pointed. The damage is caused by the beetles as well as by the grubs by feeding on the upper surface of leaves. The leaves are eaten between the veins, sometimes being completely stripped to mid-rib. The leaves present a lace like appearance; turn brown, dry up and fall off. Thus, the plant is completely skeletonzed.

Beetle

Grub

5. Sucking Pests

a. Aphids (Lipaphis erysimi)

The nymphs and adults are louse like and pale greenish in colour. This pest is very active from December to March when various cruciferous and vegetable crops are available in the fields. The damage is caused by nymphs and adults by sucking cell sap from leaves, stems, inflorescence or the developing plants. They are seen feeding in large numbers, often covering the entire surface. Owing to feeding on cell sap, the vitality of plants is greatly reduced. The leaves acquire a curly appearance.

Adults

Nypmhs

b. Jassids (*Amrasca bigutella*)

The nymphs and adults are very agile and more briskly forward the side ways. Adults are about 3 mm long and greenish yellow during summer, acquiring a reddish tinge in the winter. Nymphs and adults remain in large numbers and suck the sap from the undersurface of the leaves. While feeding, they inject the toxin saliva into the plant tissues. The leaves shows symptoms of hopper burn such as yellowing upward curling, bronzing and even drying of leaves. The crop becomes stunted and often in highly susceptible varieties it cause complete mortality of the plants.

Nypmhs

Adults

c. White Fly (*Bemisia tabaci*)

Winged nymphs are 1.0-1.5 mm long and their yellowish bodies are slightly dusted with a white waxy power. They have two pairs of pure white wings and have prominent long hind wings. The nymph on emergence, look elliptical and soon fix their mouthparts in the plant tissues. They feed on cell sap causing damage in two ways: (a) the vitality of plant is lowered through the loss of cell sap, and (b) normal photosynthesis is interfered with due to the growth of a sooty mould on the honey dew excreted by the insect. From a distance the attacked crop gives a sickly, black appearance.

Adults

Nypmhs

6. Root Knot Nematodes

These are the most common plant parasitic nematodes (*Meloidogyne* spp.i.e., *incognita, javanica*) in India and infestation of these nematodes is common in brinjal. The root knot nematode damage is more harmful to seedling than to older plants. These nematodes infest the roots and cause root galls. The affected plant becomes stunted and the leaves show chlorotic symptoms. Infestation of these nematodes greatly hampers the yield of the crop.

7. Red Spider Mites (*Tetranychus urticae*)

It is minor and irregular non insect pest of the crop. The nymph and adults are red in color. Its infestation is severe in dry and warm atmosphere. The nymph and adult suck the cell saps from under surface of the leaf. The leaf dried and dropped away incase of severe infestation. Colonies of red mites are found feeding on ventral surface of leaves under protective cover of fine silken webs, resulting in yellow spots on dorsal surface of leaves.

ANNEXURE - 3

MAJOR DISEASES OF BRINJAL

Important fungal and bacterial diseases affecting the brinjal crop in India are as follows:

FUNGAL DISEASES OF BRINJAL

1. Alternaria Blight (*Alternaria spp.)*

Causes characteristic spot on the leaf with concentric rings. Affected leaves may drop off. It may also infect fruits that turn yellow and may drop off prematurely.

2. Late Blight *(Phythophthora spp.)*

Symptoms appears as small watersoaked lesions on the fruit to later enlarge in size considerably skin of infected fruit turn brown and develops whit cottony growth.

3. Fusarium Wilt (*Fusarium solani*)

In *Fusarium* wilt, the underground stems become dry and brown as a result of cortical decay while roots may have soft and water soaked appearance. Stunted growth, withering of immature fruits, yellowing of lower leaves, drooping of the apical portion, browning of vascular bundles and ultimate drying of the whole plant. Wilting of seedlings is also a common characteristics of the diseases.

4. Phomopsis Wilt (*Phomopsis vexan)*

A serious disease infecting the foliage and the fruits. The infected leaves show small circular spots which later become grey to brown with irregular blackish margins. Dark brown lesions on stem and branches and pale sunken spots on fruits which later merge to form rotten areas. The flesh of severely infected fruits rots.

5. Damping Off: (*Pythium* spp., *Phytophthora* spp., *Rhizoctonia* spp., *Sclerotium* spp., *Sclerotinia* spp.)

Both the Pre-emergence and Post-emergence damping-off symtopms are seen in diseased state. The germinating seeds are infected by fungi at the initial stages. The infection later spreads to hypocotyls basal stem and developing roots. The Post-emergence damping off phase is characterized by infection of the young, juvenile tissues of the collar at the ground level. The affected seedlings become pale green and brownish lesions are found at the collar region, resulting in botting and topple over of seedlings.

6. *Cercospora* Leaf Spot (*Cercospora egenula*)

The disease is favoured by high relative humidity. The leaf spots are characterized by chlorotic lesions, angular to irregular in shape, later turning grayish brown with profuse sporulation at the centre of the spot. Severely infected leaves drop off prematurely.

Leaf spot symptoms

BACTERIAL DISEASES OF BRINJAL

1. Bacterial Wilt (*Pseudomonas solanacearum)*

The characteristic symptoms include wilting of the foliage followed by collapse of the entire plant. The wilting is characterized by dropping and slight yellowing of leaves and vascular discolouration. Drying of he palnts at the time of flowering and fruiting are also characteristic to the disease condition. The infected cut stems pieces when dipped in water, a white milky stream ofbacterial oozes coming out which is the diagnostic symptom for bacterial wilt.

MYCOPLASMAL DISEASES OF BRINJAL

1. Little Leaf of Brinjal(*Phytoplasma)*

A serious viral disease of brinjal, transmitted by leaf hopper (*Hishimonus phycitis*) and *Amrasca biguttula biguttula*). The infected leaves show a reduction in size and are malformed into tiny chlorotic structure

The flower buds take an upright position instead of being pendulous. All the flowers become phylloid, leaves become smaller. In severe cases, excessive crowding of short branches and production of smaller leaves give plant a rosette appearance. The infected plants generally do not bear any fruit or either the fruit becomes hard and tough.

ANNEXURE - 4

NATURALLY OCCURRING PREDATORS

Naturally occurring predators that offer control of pests in brinjal crop are spiders, dragonfly and ladybirds as indicated below.

Dragonfly

Ladybird larva

Ladybird adult

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Lecture 8. Origin, area, production, economic importance and description of varieties and hybrids of Brinjal

- Area and production.
- Economic importance and uses.
- Description of popular varieties and hybrids.
- Long varieties.
- Round varieties.

BRINJAL

Botanical name : *Solanum melongena*
Family : Solanaceae
Chromosome No. : 2n = 24

Origin : India

Common name : Eggplant, Aubergine

Area and production

In India it is well distributed in Orissa, Bihar, Karnataka, West Bengal, Andhra Pradesh, and Maharashtra and UP. Brinjal covers 8.14% of total vegetable area and produces 9 per cent of the total production.

Table: Area, production and productivity of brinjal in India

Year	Area (000'ha)	Production (000'MT)	Productivity (MT/ha)
2001-02	**502.4**	**8347.7**	**16.6**
2002-03	**507.3**	**8001.2**	**15.8**
2003-04	**516.4**	**8477.3**	**16.4**
2004-05	**526.5**	**8600.8**	**16.3**
2005-06	**553.3**	**9136.3**	**16.5**
2006-07	**568**	**9453**	**16.64**
2007-08	**561**	**9678**	**17.25**
2008-09	**600**	**10378**	**17.30**
2009-10	**612**	**10563**	**17.26**

Source: APEDA, Ministry of commerce and Industry

Economic importance and uses

It is an annual crop cultivated all over India.. The fruits are available practically throughout the year. Brinjal fruits are a good source of calcium, phosphorus, iron and vitamins particularly 'B' group. Analysis of 100 g of edible fruit contains 91.5g of water, 6.4 g of Carbohydrates, 1.3g of Protein, 0.3g of fat and 0.5g of mineral matters. Its green leaves are the main source of vitamin C (38-104.7mg/100g).

Dark purple brinjal has more vitamin C than those with white skin. Bitterness in brinjal is due to presence of glycoalkaloids. Generally, high amount of glycoalkaloids (20mg/100g) produces a bitter taste and off flavour.

Brinjal is reported to stimulate the intrapeptic metabolism of blood cholesterol. Leaf and fruit, fresh or dry produce had marked drop in blood cholesterol level. The de-cholestrolising action is attributed to the presence of poly unsaturated fatty acids (linoleic and linolenic) which are present in flesh and seeds of fruit in higher amount (65.1%). The presence of Mg and K salts also helps in de-cholestrolising action. Dry fruit is reported to contain goitrogenic principles. Aqueous extracts of fruit inhibit choline esterase activity of human plasma.

Brinjal has got much potential as raw material in pickle making and dehydration industries. It is supposed to contain certain medicinal properties and white brinjal is said to be good for diabetic patients. The fruits are employed as a cure for toothache. It is also an excellent remedy for those who suffering from liver complaints. It is very popular in southern Europe, France and Italy and USA.

Description of popular varieties and hybrids

In brinjal a large variation in plant types, fruit colour, shape and size are available. Two main types namely round and long are cultivated throughout India. The following are important cultivars grown in India.

I. Long varieties

Pusa Purple Long:

It is a selection from a local variety 'Batia' grown in Punjab, Delhi and western UP. It is early maturing cultivar becoming ready for picking in 100 to 110 days. Fruits are glossy, light purple in colour, 25-30 cm long, smooth and tender. The average yield varies from 250-275quintals/ha. It is moderately resistant to shoot borer and little leaf disease.

Pusa Purple Long **Pusa Purple Cluster** **Pusa Kranti**

Pusa Purple Cluster:

It is a very early maturing cultivar becoming ready for picking in 75 days after transplanting. Fruits are small, dark purple in colour and borne in clusters. On an average, each fruit weigh about 21 g with bearing of 50 fruits per plant. This cultivar is resistant to bacterial wilt and little leaf disease.

Pusa Kranti:

This cultivar is dwarf and spreading habit. Fruits are oblong with attractive purple colour. This cultivar is good for both spring and autumn planting under north Indian conditions. The average yield varies from 25-30 t/ha.

Krishnanagar Green long: It is a very popular variety in south India. Fruits are long, green and fleshy with scanty seeds. The average yield varies from 25-30 t/ha.

Arka Sheel: The fruits are medium long, with deep shining purple colour. The duration of this is 150 to 160 days. The yield varies from 35 to 40 t/ha.

Arka Nidhi **Arka Shirish** **Arka Kusumakar**

Arka Kusumakar*:* The finger shaped fruits are borne in clusters. Plants are dwarf in stature. Fruits are small, light green in colour and yield is 45 t/ha in 110-120 days.

Arka Neelkanth

Arka Keshav

Arka Anand

Arka Navneeth

Arka Anand :It is a high yielding F1 hybrid with resistance to Bacterial wilt. Suitable for Kharif and Rabi. Avg fruit weight is 50-55 gm. Yields 60-65 t/ha in 140-150 days.

Arka Keshav (BWR-21) :Derivative of the cross Dingrass Multiple Purple X Arka Sheel through pedigree method.Tall & branched plants bearing long fruits in clusters. Red purple glossy fruit skin with green calyx. Green leaves with purple leaf base and purple veins when young. Light purple green stem. Fruits tender with slow seed maturity with no bitter principles.Resistant to bacterial wilt. Duration 150 days. Yield 45 t/ha.A

Arka Navneeth: A F1 hybrid between IIHR 22-1 and Supreme Green angular leaves. Large oval fruits with deep purple shining skin. Calyx green, thick and fleshy. Average fruit weight 450gm.

Free from bitter principles with very good cooking qualities. Duration 150-160 days.

Arka Neelkanth (BWR-54) .Derivative of the cross Dingrass Multiple Purple X Arka Sheel through pedigree method. Tall & compact plants Bearing small fruits in clusters. Violet blue glossy fruit skin with green purple calyx. Dark green leaves with purple leaf base and purple veins when young. Purple green stem Fruits tender with slow seed maturity with no bitter principles. Resistant to bacterial wilt. Duration 150 days. Yield 43 t/ha.

Arka Nidhi(BWR-12) Derivative of the cross Dingrass Multiple Purple X Arka Sheel through pedigree method. Tall & compact plants Bearing medium long fruits in clusters, Blue

black flossy fruit skin with green purple calyx. Dark green leaves with purple leaf base and purple veins, when young. Deep purple green stem. Fruits tender with slow seed maturity with no bitter principles. Resistant to bacterial wilt. Duration 150 days. Yield 48.5 t/ha.

Arka Shirish (IIHR 194-1) Pure line selection from IIHR 194-1, a local collection from Karnataka Tall plants, green leaves with white flowers Fruits green, extra long. solitary bearing habit. Duration 140-150 days. Yield 39 t/ha.

H -4: It has been released from HAU, Hissar. The fruits are long, thick with deep shining purple in colour. The average yield is 25 t/ha.

Punjab Barsati: It is released from PAU, Ludhiana. Fruits are 18-20 cm long and 4-6 cm in diameter. The average yield 350-400q/ha.

Pant Smart: Released from GBPUAT, Pantnagar. Plants are tall and vigorous, medium long fruits borne in clusters. Purple green in colour, resistant to bacterial wilt and tolerant to shoot and fruit borer.

Azad Kranti: Erect plant, narrow leaf, long fruits, dark purple in colour and fruit weighs 62g. The average yield is 30t/ha.

II. Round varieties

Pant Rituraj: Semi erect plant. Fruits are round, dark purple in colour. Resistant to bacterial wilt and yields 40t/ha.

Pusa Purple Round: Fruits are purple in colour and each fruit weighing about 400-500g. It is highly resistant to little leaf virus diseases. Average yield varies from 25 to 30 t/ha.

Manjri : It is a selection from a local material recommended by the Department of Agriculture, Maharashtra state. The fruits are medium sized, round with purple colour. Average yield 27.5-30 t/ha.

Krishnanagar Purple Round: The fruits are large sized, round and dark purple in colour. Average yield varies from 250-30 t/ha.

Punjab Bahar: The fruits are round with deep shining purple colour. The average fruit weighs 200-300g and yield varies from 35-40t /ha.

Hybrids:

Pusa Anmol: It is a hybrid cultivar evolved from a cross between Pusa Purple Long and Hyderpur at IARI. It produces early and increased yield of about 80% over Pusa Purple Long.

Pusa Hybrid-5: Plants vigorous, fruits long, glossy, attractive, dark purple in colour. Fruit weighs about 100g. Average yield is about 52t/ha.

Pusa Hybrid-6: plants semi erect, vigorous, glossy, attractive purple colour.

Azad hybrid: Iti is cross between Azad B1 and Kalyanpur-3. Plants semi erect, branched, early fruiting and round, yields about 45 tonnes/ha. Less prone to shoot and fruit borer infestation.

Hisar Shyamal (H-8): Aushey X BR112. Plants erect, early, round fruits, tolerant to bacterial wilt.

Arka Navneet: IIHR221XSupreme. Fruits round to slightly oval in shape. Big size (400 to 500g). Yields about 65-75t/ha.

F1 hybrids: Commercially marketed by IAHS in India are Long 13, Suphal and Round 14. Some of the F1 hybrids released by MAHYCO Seed Company are MHB-1, MHB-9 and MHB-20 (Kalpatharu).

Vijay hybrid: It has been released from Vegetable Research Station, Kalyanpur. The fruits are long, thick and deep purple in colour. It takes about 102 days for harvesting the edible matured fruit. The average yield is 400 q/ha.

Pusa Kranti: (Pusa Purple Long X Hyderpur) X WG (Wynad Gaint). It is a medium duration variety, fruits are long, dark purple in colour and bears 35t/ha.

Pusa Bhairav: PPL X 11a-12-2-1. Fruits are long, purple in colour and bears in clusters. Average yield is 30 tonnes/ha. Resistant to phomopsis blight and fruit rot.

Questionnqire

I. MULTIPLE CHOICE QUESTIONS

1. Bitter taste in brinjal fruit is due to ----------

a. Anti Vitamin E factor b. CN glycosides c. Solasodine d. Trypsin inhibitors

2. Brinjal belongs to the species

a. Khasianum b. Sisymbrifolium c. Melongena d. None of the above

3. Brinjal is a native of ----------

a. Africa b. South America c. India d. Korea

4. Brinjal variety MDV 1 was evolved by ----------

a. X-rays b. Gamma rays c. EMS d. MMS

5. Flower in brinjal may be

a. Long styled b. Medium styled c. Pseudo –short-styled d. All of the above

6. Flowers in Brinjal are

a. Hermaphrodite b. Staminate c. Pistillate d. Solitary and hermophrodite

7. ---------- is also known as Egg plant

a. Tomato b. Brinjal c. Chilli d. Okra

8. Brinjal borne ---------- types of flower on the basis of length of style

a. 4 b. 5 c. 3 d. 6

9. ----------colour Brinjal is good for diabetic plant

a. Purple b. Green c. White d. Black

10. Basic chromosome number in Brinjal is ----------

a. 12 b. 8 c. 10 d. 12

11. ---------- is variety of Brinjal resistant to phomopsis blight

a. Pusa purple long b. Pusa bhairav c. Pant Rituraj d. Pant Samarat

II. Say true or false.

1. Three types of flowers have been described in Brinjal

Ans: False

2 Bitterness of brinjal is due the presence of Glucoalkaloides.

Ans: True.

3. Pusa purple long is a selection from local variety Batia. grown in Punjab.

Ans: True

4. Arka Neelkanth is resistant little disease.

Ans: False

5. Pant Samarat is resistant to Bacterial wilt disease and tolerant to shoot and fruit borer pest.

Ans: True

Lecture 9. Climate, soil requirement, seed rate, preparation of field, nursery practices, transplanting, spacing, planting systems, irrigation, growth regulators, nutrition and weed management, physiological disorders, harvest, post harvest handling, storage, marketing and seed production of brinjal

- Climate and soil.
- Seasons.
- Seed rate.
- Nursery.
- Preparation of field.
- Spacing and transplanting.
- Nutrition.
- Irrigation.
- Weed control.
- Mulching
- Use of growth regulators and chemicals.
- Physiological disorders /constraints.
- Harvesting and yield.
- Marketing.
- Storage and post harvest handling.
- Seed production

Climate and soil

Brinjal is susceptible to severe frost. A long and warm growing season with temperature range of 21-27^{0}C is most favourable for its successful production. Climatic conditions especially low temperature during the cool season cause abnormal development of the ovary (Splitting) in flower buds which then differentiate and develop into deformed fruits during that season. Late cultivars, however, withstand mild frost and continue to bear some fruits. The brinjal grown in warm season shows luxurious growth and starts bearing

from the initial flowers, while in cool season its growth is poor and slow and fruit size, quality and production are adversely affected.

Soil

The brinjal can be grown practically on all soils from light sandy to heavy clay loam soils are good for an early crop, while clay loam and silt loam are well suited for higher yield. Generally silt loam and clay loam soils are preferred for brinjal cultivation. The soil should be deep, fertile and well drained. The soil pH should not be more than 5.5 to 6.0 for its better growth and development.

Seasons

Brinjal can grow under a wide range of climatic conditions. The sowing and transplanting time varies according to agro climatic condition of the region. Under the harsh climate of North India two sowings are normally done 1. June-July for autumn- winter crop 2. November for spring summer crop. Sowing time in other parts of the country is from June-September and again in December-January. In hilly regions sowing of seed is done from March- April and seedlings are transplanted in May.

Nursery

Raised beds should be prepared (7.5×1.2×10-15cm) and seeds are sown in rows of 7.5 to 10cm apart. The beds are prepared well and levelled and one centimetre thick layer of farm yard manure is to applied and mixed properly. The seeds should be covered properly by a mixture of FYM and soil. As soon as the sowing is completed the bed should be covered with a thin layer of dry grass and kept moist till the seeds germinate. To avoid fungal diseases, the seeds should be treated with captan or thiram at the rate of 2g/kg of seed. For safe guarding, the seedlings should also be sprayed with mancozeb at a concentration of 2g/litre. About 250-375 g seed is sufficient to cover one hectare of land with 30,000-45,000 seedlings. The seedlings are ready for transplanting in about 4-5 weeks.

Preparation of land

Soil is prepared to fine tilth by giving 4-5 ploughings. Well rotten organic manure (25t/ha) is incorporated into the soil well before the final preparation.

Spacing and transplanting

The planting distance depends on the fertility status of the soil, growing season and cultivar. Usually, the spacing for the bushy, non spreading type should be 50 to 60 cm in both ways and for spreading cultivars row to row distance should be 75 to 90 cm and that for plant to plant 60 to 70 cm either in flat beds or ridges. Three spacing's are generally recommended i.e. 60×45, 75×60cm and 75×75 cm depending upon the size and spread of the plant besides duration of bearing period. Highly vigorous bushy and late bearing cultivars are given, wider spacing as compared to dwarf upright and early types. Stocky, healthy seedlings which are free of disease and shoot and fruit borer infestation and have attained a height of 10-12cm with 3-4 leaves are to be selected and transplanted. A light irrigation should be given immediately after transplanting.

Nutrition.

It is a heavy feeder of nutrients and requires more nutrients for better yield and quality. It removes 0.29, 0.08 and 0.50 Kg NPK for every 100 Kg fruit yield. As already mentioned 25 tonnes of FYM should be added 25 to 30 days before transplanting. NPK application is done in the form of inorganic fertilizers. Apply 25% of nitrogen as in the form of top dressing 6 weeks after transplanting and the remaining 25% N should be added in to soil 10 weeks after transplanting.

Table 1. Recommendations of NPK levels in some states of India

State	NPK (kg)
Andra pradesh	100-60-60
Madhya pradesh	100-60-25
Orrissa	125-80-110
Punjab	125-62-30
Karnataka1	125-10-50
Tamil Nadu	100-50-30
Uttar pradesh	100-50-50
West Bengal	120-50-50

Micronutrients

The deficiency of micronutrients in brinjal has not been noticed in field. But some workers have studied the effect of their application. The application of minor elements had no effect on vegetative growth of the plant. However, Cu increased the number of flowers and fruits, Zn improved the weight of fruits and Mn showed similar but less pronounced effect on flowering and fruiting.

Irrigation

It requires several irrigation for successful cultivation. Timely irrigation is essential for fruit set and its development. Usually the crop is irrigated weekly once for higher yield. Proper drainage facilities should be provided in rainy season to remove excess of water from the field. Drip irrigation is beneficial for decreasing water use and weed control.

Weed control

It is essential to keep weeds under control from the initial growth itself. Shallow inter cultivation is given to remove the weeds. Three to four hoeings are normally followed for effective control of weeds, proper aeration and good growth of the plants. Orabanche is one of the serious weed affecting solanaceous crops in some areas. It is a root parasite and should be controlled effectively. A pre-planting treatment of 1.0 kg ai/ha of fluchloralin followed by one hand weeding at 30 days after transplanting is effective.

Mulching

The most beneficial effect of mulching is that it conserves soil moisture and controls weeds. Mulching in brinjal crop with black polyethylene film reduces weed growth, accelerates crop growth, induces early bearing and increases yield.

Use of growth regulators and chemicals.

Application of 2, 4-D (2ppm) at flowering induces parthenocarpy, increases fruit set, advances fruit maturation and significantly increases total yield. Spraying of 4 CPA(Para-chlorophenoxy acetic acid)(20ppm) and N-metatolyphthalamic acid (0.5%) promotes fruit set in brinjal. NAA (60ppm) alone or in combination with BA(30ppm) applied on open flowers improved fruit set and ascorbic acid, GA_3, IAA and thiourea advances the flowering by 4-5 days. Spray of mixtalol (long chain C24-C34 aliphatic alcohols) on Cv. Arka Navneet has given beneficial effect with single spray of 4 ppm solution.

PHYSIOLOGICAL DISORDER/CONSTRAINTS

1. Calyx withering

This disorder occurs between mid-February and mid - April. The affected fruits become reddish brown in colour and lacking in normal luster and thus marketability of fruits is hampered. The affected fruits have much higher calcium and nitrate content than healthy ones.

2. Poor fruit set

In brinjal, four types of flower, according to length of style, are recognized irrespective of the variety namely, long styled, medium styled, pseudo short styled and short styled. Pseudo short and short styled flowers do not normally set fruit but their numbers in a plant are normally higher than long and medium styled of lower which produce fruits.

In brinjal, flowers are normally borne solitarily as well as in clusters. The solitary flowers are mostly long or medium styled whereas mixtures of short styled, pseudo short-styled and medium /long styled flowers are found in the cluster. Obviously ratio of short styled flowers to long/medium styled flowers in cluster in much high (3-4:1). So, fruit set depends on the plant. Natural drop is also a problem in brinjal which may be as high as 50% in medium styled flower and 30% in long styled flower.

Control: True short styled flowers are actually sterile flowers which cannot be induced to set fruits. However, application of growth substances on pseudo short styled, medium styled and long styled flowers produce higher percentage of fruit set.

1. Spraying the plant with 2 ppm 2, 4,-D at flowering stage when few flower clusters appear.
2. Spraying with 60 ppm NAA or 500 ppm PCPA (Parachloroacetic acid) at full bloom stage.

Harvesting and yield

Brinjal fruits are harvested when they have developed a good colour and marketable size, are still immature, tender and have not lost culinary qualities. The fruits are harvested with stalk at joint where they are attached to the branch. Normally the plucking can be done at 7 to 10 days depending upon the variety. Yield of brinjal vary according to the region,

cultivar and duration of the crop. Early crop normally yields 20-30 t/ha. While long duration crop yields 35-40 t/ha. Many F1 hybrids yield about 40-80t/ha.

Marketing

After harvest, the fruits are kept in shade and diseased and damaged fruits are sorted out. In early stage the size of fruit will be small and hence the fruits can be packed in baskets and taken to the market, but during later stage or at peak of the pickings, the fruits are packed in gunny bags and taken to the market. The attractive bright, glossy appearance having freshness and optimum size of the fruit are qualities for good market price.

Storage and post harvest handling

Brinjal green fruits had longest shelf life of 4 weeks based on the PLW discoloration, spoilage and CO_2 injury during storage at 8-10^{0}C under controlled atmosphere with initial concentration of 5% CO_2 . The fruits can also be stored for 7-10 days in fairly good condition at 7.2-10^{0}C with 85-95% RH.

Seed production

An isolation distance of 100 to 200m for certified and foundation seed plots respectively should be maintained between two cultivars. During crop period at least 3 times plants should be rouged off. First rouging should be done before flowering and on the basis of foliage characters, the off types has to be removed. Second rouging is done at the time of flowering on the basis of flower characters and off types are to be removed. Final rouging is to be done at the fruiting on the basis of fruit characters and off types.

At all the stages disease/pest affected plants should be removed. At ripening, the fruits become light yellow in colour and at this stage they are harvested and seeds are extracted properly. The fruits are cut into pieces and washed in clean water and the seeds settled down in the bottom of the pot are collected. The seeds should be dried completely and kept in cool place.

Questionnaire

I. MULTIPLE CHOICE QUESTIONS

1. Optimum temperature requirement for successful production of brinjal should be

a. 15 -20^0 C b.21- 27^0 C c. 30-35^0 C d. 10-15^0 C

2. Ideal soil PH for growth and development of brinjal is

a. 5-5.5 b. 5.5-6 c. 6-6.5 d. 6.5-7

3. Seed requirement for raising one hectare crop of brinjal

a. 250-375g b. 400-500g c. 500-750g d. 750-1000g

4. Brinjal seedlings are transplanted at a spacing of

a. 60x30-45 b. 75-90x60-70cm c. 50-60x50-60cm d. None of the above

5. Average yield of brinjal is _____ t/ha in F1 hybrids.

a. 10-20 b. 20-30 c. 40-80 d. 50-60

6. Chemical used for controlling root knot nematodes in brinjal is

a. Aldrin b. Nemagon c. Chloropyriphos d. None of the above

7. NPK requirement of brinjal is _____kg/ha.

a. 100:50 :50 b. 200:100:100 c. 125:19:50 d. None of the above

8. Spraying of _____ controls poor fruit set in brinjal.

a. GA3 b. MH c. CCC d. 2,4-D

9. _____ method is followed for extraction of seeds

a. Fermentation b.Acid c. Alkali d. None of these

10. Little leaf of Brinjal is due to

a. Fungus b. Bacteria c. Mycoplasma d. Root knot nematode

11. Little leaf disease of Brinjal is transmitted by an insect vector

a. Aphid b. leaf hopper c. butterfly d. None of the above

II. Say true or false.

1. Orabanche is the serious weed in cultivation of brinjal

Ans: True

2 .Flochloralin weedicide is used for control of weeds in brinjal cultivation.

Ans: True

3. Isolation requirement for brinjal 500 & 800 Meters for breeder seed and certified seed respectively.

Ans: False.

4. Average yield of open pollinated varieties is 50 tons per hectare.

Ans: False.

5. Application of NAA induces parthenocarpy in brinjal.

Ans: False.

Cucurbits

•Cucurbits form an important and a big group of vegetable crops cultivated extensively in the sub- tropical and tropical countries.

•This group consist of wide range of vegetable, either used as salad, or for cooking, or for pickling or as dessert fruits or candied or preserved.

• Cucurbits have been used in many traditional medicines of India different parts of the plant are used to relieve diabetes, hypertension, as a stomachic, laxative, antibilious, emetic, antihelmintic agent, for the treatment of cough, respiratory diseases, skin diseases, wounds, ulcer, gout and rheumatism.

• The bitter flavour of bitter gourd is due to the alkaloid momordicine produced in fruits and leaves

Characteristic features of cucurbits

- Viny growth habit (except summer squash)
- Annuals (except pointed gourd, ivy gourd, *kakrol* and chayote)
- Frost-sensitive
- Monoecious (except pointed gourd, ivy gourd and *kakrol*)
- Cross-pollinated
- Propagated by seed (except pointed gourd, ivy gourd and *kakrol*)
- Multi seeded fruit (except chayote*****)
- Mainly fruit *i.e,* 'pepo' is the edible part (exceptions: chayote all plant parts edible, pumpkin besides immature and mature fruit, flower is also edible)
- Mostly old world origin (except squashes, pumpkin and chayote)

*****(***viviparous : single seed /fruit & the seed germinates inside the fruit***)

List of cultivated cucurbits

S.No.	Common Name	Hindi Name	Botanical Sp.	Chromosome number(2n)
1.	Bitter gourd	*Karela*	*Mormordica charantia* L.	22
2.	Spine gourd	*Kakrol*	*Momordica dioica* Roxb.	28
3.	Sweet gourd of Assam	*Kheksa*	*Momordica cochinchinensis* Spreng	22
4.	Bottle Gourd	*Louki*	*Lagenaria siceraria* (Mol.) Standl.	22
5.	Cucumber	*Khira*	*Cucumis sativus* L.	14
6.	Indian squash	*Tinda*	*Praecitrullus fistulosus* Pang.	24
7.	Musk melon	*Kharbuza*	*Cucumis melo* L.	24
8.	Snap melon	*Phoot*	Cucumis melo var. *momordica*	24
9.	Long or serpent melon	*Kakri*	*Cucumis melo* var. *utilissimus*	24
10.	Pumpkin	*Sitaphal/ kasiphal*	*Cucurbita moschata* Duch ex Poir.	40
11.	Squash or pumpkin or winter	*Kaddu*	*Cucurbita maxima* Duch	40

14.	**Sponge gourd**	***Ghia tori***	***Luffa cylindrica* Roem (syn. *L. aegyptiaca*)**	**26**
15.	Snake gourd	*Chinchinda*	*Tricosanthes cucumerina*(syn. *T. anguina* L.)	24
16.	Pointed gourd	*Parwal*	*Trichosanthes dioica* Roxb.	24
17.	Water melon	*Tarbuz*	*Citrullus lanatus* (Thunb.) (syn. *C. vulgaris* Schrad)	22
18.	Wax or ash gourd	*Petha*	*Benincasa hispida* (Thunb.) Cogn.	24
19.	Ivy gourd	*Kundsru or Tondli*	*Coccinia cordifolia* (Voigt)L. (syn. *C. indica* W. and A)	24
20.	Chow- chow or chayote		*Sechium edule* (Jack) Sw.	28
21.		*Meetha Karela*	*Cyclanthera pedata* Schrad.	32

Bitter gourd is rich in vitamin C

Pumpkin contain high carotenoid pigments

Kakrol is high in protein

Chow- chow is fairly high in calcium

- **Bitter gourd**

- **Spine gourd**

- **Sweet gourd of Assam**

- **Bitter gourd**

- **Spine gourd**

- **Sweet gourd of Assam**

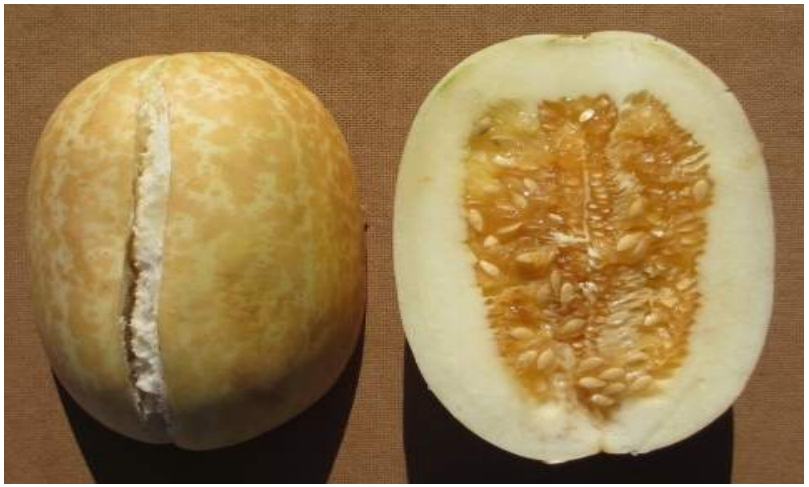
- **Bottle gourd**

- **Cucumber**

- **Indian squash**

- **Musk melon**

- **Snap melon**



- **Long and serpent melon**

- **Pumpkin**

- **Squash or pumpkin or winter squash**

- **Sponge gourd**

- **Snake gourd**

- **Pointed gourd**

- **Water melon**

- **Wax or ash gourd**

- **Ivy gourd**

- **Chow – chow or Chayote**

- ***Meetha Karela***

S.No.	Crop	Center of origin
1.	Bottle gourd	Central Africa, India
2.	Bitter gourd or Balsam Pear	China, Malaysia, India
3.	Small gourd	East India
4.	Ridge gourd	Tropical Asia, India
5.	Sponge gourd	Tropical Asia, India
6.	Snake gourd	India
7.	Pointed gourd	South east Asia, India, Burma
8.	Ivy gourd **or** Scarlet gourd	India
9.	Ash or Wax gourd	South East Asia , India , China, Malaysia
10.	Sweet gourd	South America

11.	Cucumber	Africa, Asia,
12.	Gherkin or Pickling Cucumber	Africa
13.	Muskmelon	Hot of valley of Iran, Persia, India, ,
14.	Snap melon	Iran, India
15.	Long melon **or** Serpent melon	India
16.	Watermelon	Kalahari Dessert, Africa
17.	Round melon	India
18.	Pumpkin	Central America
19.	Winter squash	South America, Argentina
20.	Summer squash	Central Mexico
21.	Cucumber	South Mexico and Central America

Crop	Institute	Variety
Cucumber	IARI, Delhi	Pusa Uday, Pusa Barkha
	YSP UHF, Nauni	Khira 75, Khira 90
Bottle gourd	IARI, Delhi	Pusa Samridhi, Pusa Santushti, Pusa Summer Prolific Long , Pusa Summer Prolific Round, Pusa Sandesh, Pusa Naveen, Pusa Hybrid 3
	IIHR, Bangalore	Arka Bahar
	IIVR , Varanasi	Kashi Bahar , Kashi Ganga
Bitter gourd	IARI, Delhi	Pusa Do Mausami , Pusa Vishesh, Pusa Hybrid -2, Pusa Aushadhi(hybrid), Pusa Rasdar and Pusa Purvi
	YSP UHF, Nauni	Solan Hara , Solan Safed
	IIHR, Bangalore	Arka Anupam , Arka Harit
Ash gourd	IARI, Delhi	Pusa Ujwal
	IIVR , Varanasi	Kaski Ujwal, Kashi Surbhi, Kashi Dhawal
Sponge gourd	IARI, Delhi	Pusa Sneha, Pusa Chikni, Pusa Supriya
	IIVR , Varanasi	Kashi Divya
Ridge gourd	IARI, Delhi	Pusa Nutan, Pusa Nasdar , Kashi Khushi
	IIHR, Bangalore	Arka Sumeet, Arka Sujata
Snap melon	IARI, Delhi	Pusa Shandar

Crop	Institute	Variety
Pumpkin	IARI, Delhi	Pusa Viswas, Pusa Vikas, Pusa Hybrid 1
	IIVR , Varanasi	Kashi Harit
	IIHR, Bangalore	Arka Chandan
	YSP UHF, Nauni	Solan Badami
Musk melon	IARI, Delhi	Pusa Madhuras , Pusa Sharbati, Pusa Madhurima
	IIVR , Varanasi	Kashi Madhu
Water melon	IARI, Delhi	Sugar Baby
	IIHR, Bangalore	Arka Manik, Arka Akash , Arka Madhuras, Arka Rasraj, Arka Aishwarya
Pointed gourd	IIVR , Varanasi	Kashi Alankar, Kashi Suphal
Summer squash	IIVR , Varanasi	Kashi Shubhangi
Round melon	IIHR, Bangalore	Arka Tinda
	IARI, Delhi	Pusa Raunak
Long melon	IARI, Delhi	Pusa Utkarsh

Climate

- Warm season crop
- Does not withstand even light frost and strong winds
- Cucumber tolerates a slightly cooler weather than melons.
- Seed does not germinate at a temperature as low as 11°C.
- Seed give satisfactory germination at 18°C and speed of germination increases with increase in temperature till 30°C.
- Grows best at temperature between 18 and 24°C.
- Abundance of sunshine and low humidity are ideal for the production of cucumber.
- Cucurbits grow well at day temperature 25-35°C.
- Maximum temperature 40 °C and minimum 20-25°C.
- Germination of seed when day temperature is above 25°C.
- Melons prefer tropical climate with high temperature during fruit development.
- Day temperature of 35-40°C, cool nights and warm days give better quality fruits in melons.

Seed rate and plating distance

Crop	Seed rate (kg/ha)	Row to row (m)	Hill to hill (cm)
Watermelon	3.5 to 5.0	2.5 to 3.5	90 to 120
Round melon	3.5 to 5.0	1.5 to 2.0	60 to 120
Muskmelon	3.0 to 7.0	1.5 to 2.5	60 to 120
Long melon	2.5 to 3.5	1.5 to 2.5	60 to 120
Cucumber	2.5 to 3.5	1.5 to 2.5	60 to 120
Bottle Gourd	3.0 to 6.0	1.5 to 2.5	60 to 120
Bitter Gourd	4.5 to 6.0	1.5 to 2.5	60 to 120
Ridge Gourd	3.5 to 5.0	1.5 to 2.5	60 to 120
Sponge Gourd	2.5 to 3.5	1.5 to 2.5	60 to 120
Snake Gourd	5.0 to 6.0	1.5 to 2.5	60 to 120
Ash Gourd	5.0 to 7.0	1.5 to 2.5	60 to 120
Pumpkin	6.0 to 8.0	2.5 to3.0	100 to 150
Squash	8.0 to 10.0	0.6 to 0.75	45to 60

Crop	Planting time	FYM t/ha	N:P:K	Yield kg/ha
cucumber	Summer season- January end to February Rainy season – June July Hills- April	25-30	55:45:85	8000-10000
Muskmelon	Summer season – November to march North India – February onwards	15	60:18:110	10000-12000
Watermelon	November to march	30	75-80:50:50	
Bottle gourd	Same as cucumber	50-60	50:60	15000-20000
Bitter gourd	Summer – January march Rainy – June July	50-60	50:60	8000-14000
Pumpkin and squashes	Summer season :January- march Rainy season : June- July	30	75:50:50	25000
Apply whole FYM, P and K at time of sowing , one half of N at vining stage and rest 10-15 days after.				
In river bed cultivation sowing is done in November December and the plants are protected from cold by planting wind breaks in north India				

Soil – a well drained loamy soil is preferred for cucurbits. In riverbeds alluvial substrata and subterranean moisture of river stream support the crop

Climate – maximum temperature is 30-35°C while minimum is20-25°C. Cucumber prefers slightly lower temperature. Cool nights and warm days are ideal for sugar accumulation in fruits.

Planting methods :

1. Hill method – hills are prepared at proper spacing by adding well rotten organic manure and a number of seeds are sown on each hill.
2. Furrow method – furrows are made at proper spacing which are kept from row to row and seeds are some on the edge of the furrows either on one or both sides of the furrow . Irrigation water flows through the furrows.
3. Ridge method – planting is done on ridges .
4. Bed system – sowing is done on raised beds in high rainfall areas to avoid spoilage of fruits by water.
5. Pit system- practiced during rainy season and vines are trained over trellises, arbours or *pandals* .

Irrigation- in spring summer irrigation is very important while in rainy season no irrigation is required. Too frequent irrigations are said to spoil the quality of melons .

Weed control - a combination of hand weeding , chemical weed control and mulching can be utilized for proper weed control in cucurbits

Harvesting : harvesting stage for cucurbits whose immature fruit is utilized like bottle gourd , Cucumber, sponge gourd, bitter gourd, ridge gourd , parwal etc are harvested when the have attained full size and are still immature , harvesting should be done before seed formation .

Pumpkin and ash gourd are harvested at full maturity. Maturity of ash gourd ig judged by appearance of white ash like substance on fruit surface .

Maturity indices of watermelon include browning of tendrils, ground spot yellowing and dull thumping sound produced on tapping the fruit instead of metallic sound.

Muskmelon is climatric and its maturity is determined by slip stages . For local market musk melon is harvested when on removal of fruit from vine a deep smooth scar is formed at the place of attachment of fruit to vine , this is called full slip stage . When only half portion of the scar produced is smooth this is called half slip stage and this is used for distant market. Cantaloupes type of must melon like Hara Madhu do not produce slip stage and the maturity is judged by netting.

Storage – pumpkin and ash gourd have long storage life and are stored easily. cucumber is stored at 12.5 °C .

Varieties for cultivation in H.P.

Crop	Institute	Varieties
Cucumber	IARI, Delhi	Poinsette
	UHF, Solan	Khira -75 ,Khira - 90
Bitter gourd	UHF, Solan	Solan Hara, Solan Safed
Pumpkin	UHF, Solan	Solan Badami
Sarda melon		Selection 1, selection 9

Cultivation in Himachal Pradesh

Crop	Seed rate kg/ha	Planting time	Spacing	FYM t/ha	N:P:K kg/ha
Cucumber	3.75-4.35	Low hills- February-march , June Mid hills- march-may High hills- April	250 - 125 cm between hills and 1 -2 plant per hill	10	100:50:55
Bitter gourd	5	Same as cucumber	90 cm apart in hills	10	100:50:55
Pumpkin	4	Same as cucumber	240 cm apart in hills	10	90:60:55
Sarda melon	1-1.5	High hills – may	100 X 100cm	10	60:60:60

Apply whole FYM ,P,K and half N at the time of sowing , apply rest N in two splits first one month after planting and second at the time of flowering.

Harvesting

- Harvesting of crop at right time is very important in cucurbits as in most cases, seed development is undesirable.
- Harvest cucumber, bottle gourd, bitter gourd, snake gourd, ridge gourd and sponge gourd when they are still young, tender and having soft seeds inside.
- Harvest before change in fruit colour from green to yellow.
- Musk melon: Climacteric fruit which ripe during transit & storage hence harvested before fully ripe

✓ Full slip stage *i.e.* a crack develops around the peduncle at the base of the fruit and when fully ripe the fruit slips easily from the stem.

✓ Half slip stage: Only a portion of the disc is removed when the fruit is pulled out. The scar on the fruit is smaller than the full slip stage

✓ Water melon: fully ripe stage Maturity signs are withering of tendril, change in belly color or ground spot to yellow and thumping test which gives dull sound on maturity as metallic sound in unripe fruits.

Sex forms in cucurbits

- **Hermaphrodite**: Primitive form where only bisexual or perfect flowers are produced. As for example 'Satputia' cultivar of ridge gourd, cucumber and muskmelon.
- **Monoecious**: Where staminate and pistillate flowers are separately produced in the same plant. As found in cucumber, bottle gourd, bitter gourd, watermelon, pumpkin, squash, ash gourd, ridge gourd, sponge gourd, snake gourd *etc.*
- **Andromonoecious**: Staminate and perfect flowers produced separately in the same plant. For example, watermelon (in some cultivars), muskmelon (dessert type).
- **Gynomonoecious**: Where pistillate and perfect flowers are produced separately in the same plant. As found in cucumber.
- **Gynoecious**: Where only pistillate flowers are produced in a plant. Example, genetic stock of cucumber, it has been evolved from gynomonoecious sex.
- **Trimonoecious or gynoandromonoecious**: Where staminate, pistillate and perfect flowers are produced in the same plant in varying proportion (genetic stock of bitter gourd).
- **Androecious**: Where only staminate flowers are produced (pointed gourd).

- **Dioecious**: Where staminate and pistillate flowers are produced in separate plants, *e.g.,* pointed gourd, ivy gourd and *kakrol* (*Momordica dioica*) among cultivated cucurbits.

Bitter Principles in Cucurbits

- Most cucurbit species have bitter compounds due to presence of oxygenated tetra cyclic triterpene compounds namely *Cucurbita*cins in their foliage.
- *Cucurbita*cins are thought to be toxins produced by these plants as a defense against insects and herbivores.
- The cucurbit cultivars have been selected by plant breeders to have low *Cucurbita*cin content in the fruits except for ornamental gourds where higher level of *Cucurbita*cin is desirable.
- Bitter fruits in cucumber are occasionally produced when plants are exposed to drought during fruiting.
- Another way of producing bitter fruit is when bitter pollen grains

(*Cucumis hardwickii*) fertilize the non-bitter ovule, the resulting fruit will be bitter in taste because the gene *Bt* (bitter fruit) is dominant over *bi* (bitter free) gene and the phenomenon is known as **METAXENIA.**

River Bed Cultivation

Cucurbits have following salient features which make them fit for river bed cultivation:

- ✓ **Long tap root system which makes use of subterranean moisture.**
- ✓ **These are more space planted crops, less number of plants per unit area are to be managed.**
- ✓ **Hot & dry weather with maximum sunshine prevails right from March-June/July which is an essential requirement for melons.**

It is kind of vegetable forcing being used in India where cucurbits are sown during winter season in the river beds. Method of cultivation is as under:

- **Pits or trenches are made during October-November.**
- **They are of convenient length, 30 cm wide and 60 cm deep or to a depth at which the sand is moist.**
- **Between the trenches a distance of nearly 2-3 m is kept.**
- **Normally, 3-4 pre-germinated seeds are planted/hill in pits or trenches.**
- **Before sowing, the trenches are manured with FYM.**
- **Sprouted seeds are carefully sown.**
- **Protection from low temperature/chilling winds during Dec-Jan (1-2°C) is provided probably with the leaves of *Saccharum* spp. on the northern side of the pit.**

Application of *Saccharum* species on the north of a trench/pit serves following purposes:

- ✓ **Checks the sand drifting from dug up trenches.**
- ✓ **Provide protection against chilly winds.**
- ✓ **This grass spread over the sand and later on vines spread over this grass.**
- ✓ **Sand does not blow off in hot months.**
- ✓ **Spot watering during the initial stages.**
- ✓ **Fruits from river bed are available 30-50 days before then the normal field sown crop.**

Problems

- ✓ Leaching of nutrients,
- ✓ If floods due to winter rains occur
- ✓ Occurrence of diseases &
- ✓ Fruits having undesirable quality.

Production of Triploids

♀ 4X x 2X ♂

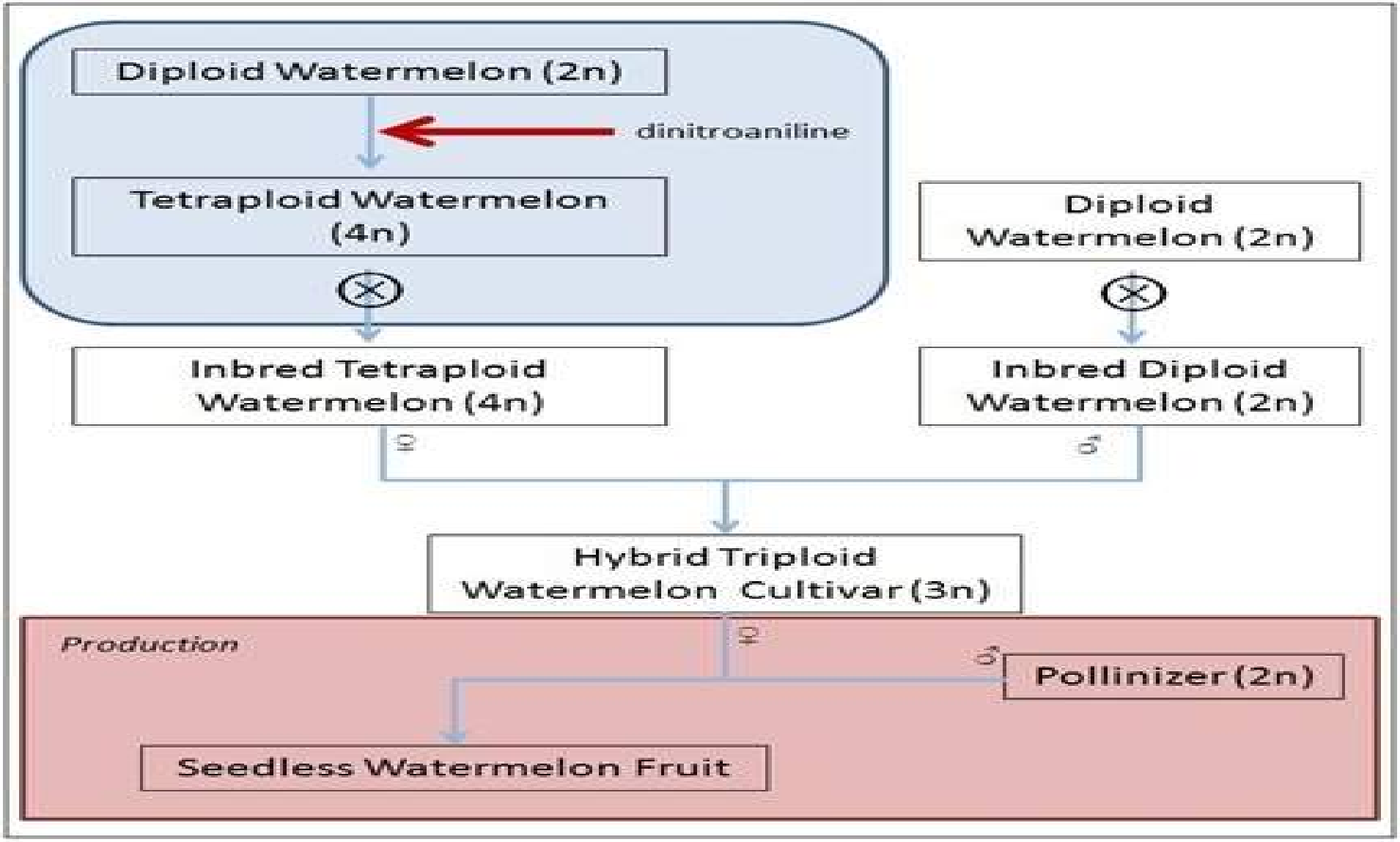
↓

3X

- It is done by hand pollinating the female flowers of tetraploid line with pollen from the male flowers of diploid parent

or

- by pinching the all male flowers from the tetraploid line and then allow for insect/natural cross pollination, where 4X and 2X plants are grown in the same plot at the ratio of 4:1.



The seedless trait of triploids has been desirable especially in fruits. Commercial use of triploid fruits can be found in crops such as watermelons and are produced artificially by first developing tetraploids which are then crossed with diploid watermelon. In order to set fruit, the triploid watermelon is crossed with a desirable diploid pollen donor

Diseases		
Powdery mildew	*Erysiphe cichoracearum* powdery fungal growth is present on leaves stem and fruits	Spray hexaconazol @ .25 %
Downey mildew	*Pseudoperonospora cubensis* yellow to reddish brown spots appear on upper surface of leaves while on lower surface purplish spores appear .	Spray zineb@.5%
Anthracnose	*Colletotrichum lagenarium* small yellow water soaked areas which enlarge and turn brown appear on leaves .later symptom also appears on fruits .	Crop rotation Weed eradication Seed treatment with corrosive sublimate solution 2.5ml/40l
Bacterial wilt	Caused by *Erwinia trachephila* Carried by striped cucumber beetle plant wilts from tip to downwards and stem shows ooze on cutting.	Spray malathion to control the vector
Angular leaf spot	*Pseudomonas lachrymans* water soaked lesions on fruits and leaves which later turn grey or tan .	Spray streptomycin at 400 ppm
Fusarium wilt	*Fusarium sp*. leaves turn yellow and wilt. Vascular system is discolored. Also called sudden wilt	Treat the seed with bavistin Ensure proper drainage
Cucumber mosaic	Plants show mottled mosaic leaf pattern fruiting is less and deformed	Grow resistant varieties
Phylloidy	Caused by mycoplasma like organisms . Internodes and leaf size is greatly reduced and floral parts are converted to leaf like green structures	Destroy affected plants Control vector
Cucurbits are sensitive to sulphur so never use sulphur based fungicide on cucurbits		

Insect - Pests		
Red pumpkin beetle	Most serious pest of cucurbits. Grubs and adults eat away interveinal leaf tissue , and flowers.	Soil application of carbofuran or phorate @ 10 kg /ha
Aphids	Nymphs and adults suck the cell sap	Spray malathion @ .1%
Fruit fly	Adults puncture the fruit and lay eggs , eggs hatch and larvae feed inside the pulp leading to rotting of fruits.	Spray attractant bait i.e. gur and malathion Use fruit fly traps
Nematodes	Cause formation of galls on roots above ground symptom appear as poor growth and stunted plants	Follow crop rotation Apply nemagon
Mites	Mites suck cell sap and the leaf eventually dries up . It is a very serious pest of protected cultivation	Spray dicofol @ 2.5 kg/h

Botanical Name : *Phaseolus vulgaris L.*

Family : Leguminosae

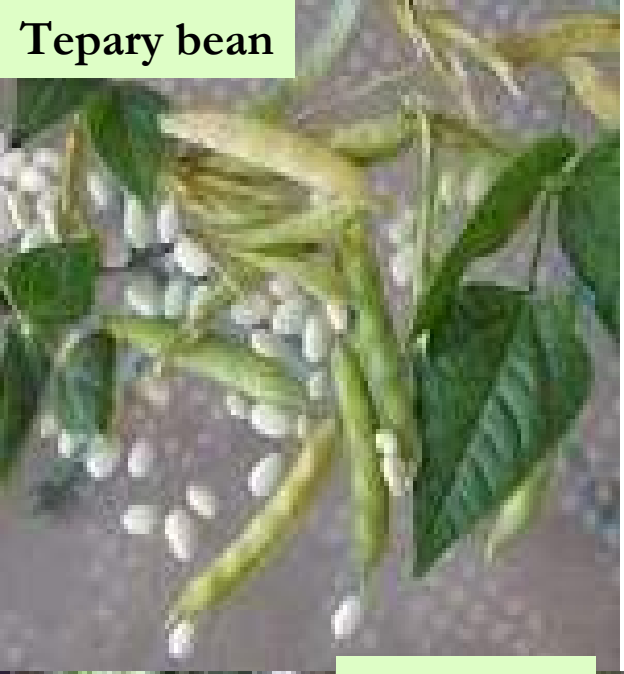
Chr. Number : 2n=22

Origin : South and central America

- **There are at least 18 types of cultivated beans covering about eight different genera.**
- **All beans belong to family Leguminosae**
- **French bean, cowpea, cluster bean and dolichos bean are of economic importance**
- **They have an ability to fix atmospheric N through root nodules.**
- **Used as green vegetables or green shelled or dry as pulses, according to the stage at which they are harvested.**
- **All beans are a valuable source of protein, Ca, Fe and vitamins**
- **All beans except broad bean are susceptible to frost and are grown as a summer crop.**

Bean type	Botanical name	Chr. no.
French bean	*Phaseolus vulgaris*	2n = 22
Cowpea	*Vigna unguiculata*	2n = 22
Asparagus bean or Yard long bean	*Vigna unguiculata* var. *sesquuipedalis*	2n = 22
Cluster bean	*Cyamopsis tetragonoloba*	2n = 14
Hyacinth bean	*Dolichos lablab*	2n = 22
Scarlet runner bean	*P. coccineus*	2n = 22
Tepary bean	*P. acutifolius*	2n = 22
Moong bean	*V. radiata*	2n = 22
Moth bean	*V. aconitifolia*	2n = 22
Lima bean	*P. lunatus*	2n = 22
Winged bean	*Psophocarpus tetragonolobus*	2n = 18
Sword bean	*Canavalia gladiata (tall)* *C. ensiformis (dwarf/jack bean)*	2n = 22
Broad bean	*Vicia faba*	2n = 12


Winged bean
Asparagus bean
Hyacinth bean
Cowpea
Cluster bean
Scarlet runner bean


Tepary bean


Moong bean


Moth bean


Lima bean


Sword bean


Broad bean

Green shelled beans are somewhat fleshier - walled pods with less fibre in the younger stage while pulse type are more fibrous and bear parchment layer which protect shattering of seeds on drying of pods

Varieties of French bean are classified into two categories

On the basis of fibre

1.	**Stringy type**	**Pods contain fiber. The indigenous beans are stringy.**
2.	**Stringless type**	**Pods are free from fiber.**

On the basis of growth habit

1.	Pole type	• Varieties are tall, indeterminate in growth, larger internodes but the number of nodes is dependent upon the length of growing season. • Requires support • Main shoot goes on putting growth. • Branching is unlimited.
2.	Bush type	• Plants are dwarf /short & bushy in their growth habit. • Plants are short, have erect stem with the main axis consisting of 4-8 shortened internodes. • Popular because of compactness, easy harvest & short duration. • Each vegetable stem terminates or ends in the form of terminal inflorescence.
3.	Semi-pole or summer type	• Plants have 4-8 internodes which are longer than those in bush type. • Inflorescence is terminal but appear somewhat late & give vinal growth. • Require staking for better growth.

Varieties recommended in India

Dwarf varieties	Pole type varieties
Contender	Kentucky Wonder
Falguni	SVM-1
Palam Mridula	Luxmi
Solan Naina	Pusa Himlata
Arka Suvidha	VL-Lata bean-12
Arka Komal	VL-Lata bean-17
Premier	Pusa Swarnlata
Pusa Parvati	HAFB-3
Pant Anupama	HAFB-4
Pant Bean-2	RCMFB-1
Arka Anoop	
Phule Surekha	
IVRFB-1	
VL Bauni 1	
IVFB-2	

Institiute	Variety	Characters
IARI, Delhi	Pusa Parvati	Bush type variety evolved by mutation, resistant to mosaic and powdery mildew.
	Pusa Himlata	Pole type
	Pusa Swarnlata	Pole type
IIVR, Varanasi	Kashi Param	
	Kashi Sampann	Bush type tolerant to GYMV and high temperature
IIHR, Bangalore	Arka Sharath	
	Arka Suman	
	Arka Komal	
	Arka Suvidha	
	Arka Anoop	
YSP UHF, Nauni	SVM 1	Pole type resistant to angular leaf spot.
	Lakshmi (P-37)	Pole type, stringless
CSK HPKV, Palampur	Palam Mridula	
GBP AU, Pantnagar	Pant Anupama	Bush type
	Pant Bean 2	

Cultivars recommended for growing in Himachal Pradesh

Bush type: Contender, Palam Mridula, Solan Naina, Arka Komal, VL Bauni-1, Pusa Parvati, and Arka Suvidha

Pole type: Kentucky wonder, SVM-1 and Luxmi

- Ready to harvest in 45 days of sowing
- Stringless, tender, curved pods
- Average yield-75-100q/ha

Stingless- tender variety with straight pods
About one week late than Contender.
Ready to harvest with in 50 days of sowing
High yielding average yield is around 120q/ha

SOLAN NAINA

It is a short duration, bush type cultivar of french bean (vegetable type), flower colour white to cream, bears 40-45 pods/plant, meaty, dark green in colour and straight. The pods mature in about 45 days and the seed colour is white. Suitable for spring-summer and autumn- winter production in low and mid hills of the state. The average yield is 125-140 q/ha.

Pole type beans

SOIL

A well drained, fertile and sandy loam soils

The most suitable pH range is 5.5 and 6.0

CLIMATE

A warm season crop, sensitive to frost and very high temperature.

No seed germination below 16°C. Seed germination takes place between 16-29°C but congenial temperature is 16-21°C.

Blossoms/ pods drop under very hot or rainy weather

The best pod setting occurs at 15-25°C

Planting methods

Flat bed method: Followed in spring-summer and autumn-winter crop.

Hill method:

i. Followed in high rainfall areas as this method facilitates drainage
ii. 5-6 seeds per hill are sown but later on only 3 plants per hill are retained.
iii. Row to row distance is maintained between the hills.

Sowing time	Seed rate	spacing	FYM	N:P:K
Rainy season - July September	Bush type- 85-90 kg	60-70 X 15 cm	25 t/ha	75:30:60 kg/ha
Early spring – January February	Pole type- 25-30 kg/ha	1.5-2 X 15 cm		

The fertilizer should be placed in bands about 7-8cm to the side of the seed and placed deeper than the seed.

Weed control – hand hoeing is necessary to control weeds . Pre emergence weedicides like pendimethalin can also be used for effective weed control.

Irrigation – beans are shallow rooted crop and sensitive to an over supply of water. Application of water is just prior to blooming followed by another irrigation at time of pod formation. Additional irrigation are given as per requirement.

Harvesting – green pods are harvested before they are fully grown and while the seeds are small ,pods are ready to harvest after two to three weeks of first bloom. Average yield is 3000 – 4000 kg / ha .

Recommended practices for Himachal Pradesh

Sowing time	**Seed rate**	**Spacing**	**FYM**	**N:P:K**	**Yield**
Low hills- February march and August	Dwarf – 75 kg/ha	45 X 15 cm	10 t / ha	45:100:30 kg /ha	10-12 q/ha
Mid hills May – July	Pole – 30 kg /ha	90 X 15 cm			12-18 q/ha
High hills- April –June					
175 kg CAN , 625 kg SSP and 50 kg MOP can be used for fertilization. Apply FYM , SSP, MOP and half of CAN before sowing . The rest of the can can be applied as top dressing at the time of earthing up.					

Problems associated with French bean cultivation

Spring- summer season

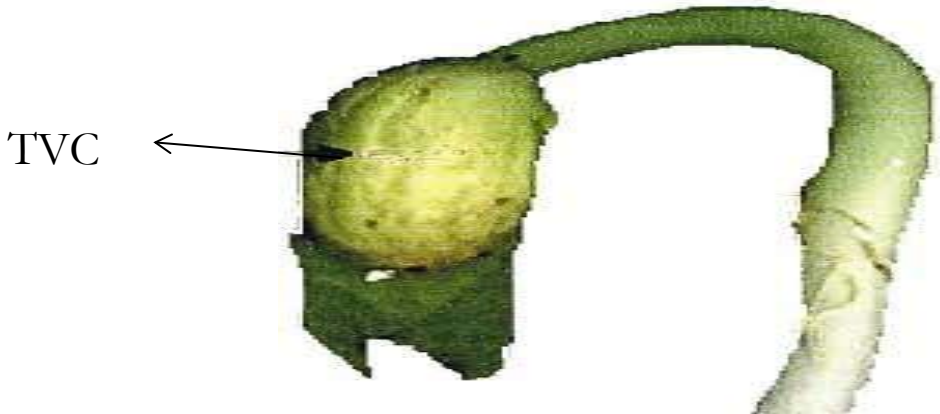
i. The poor crop stand on account of low seed germination due to prevailing low temperature
ii. Incidence of dry root rots especially in the month of March due to dry weather and high temperature
iii. *Rhizoctonia* become more serious resulting in rotting of plant and root system.
iv. Optimum temperature for pod set and development remains for limited time

Autumn – winter crop

i. Poor crop stand due to root rot as a result of high temperature and humidity at early growth stage.
ii. More incidence of viral diseases on account of more insect activity.
iii. Limited fruiting period on account of low temperatures from October onwards.

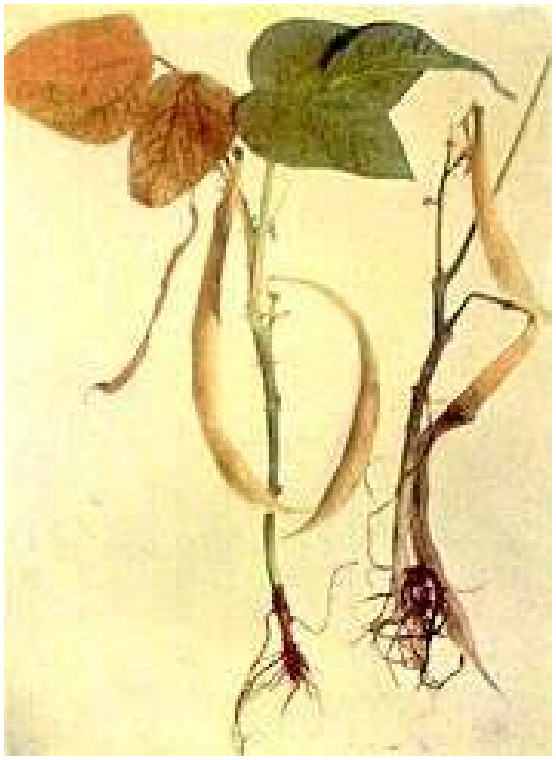
Transverse Cotyledon Cracking

Major disorder in French bean.
White seeded varieties are more prone
It is enhanced by planting dry seeds in wet soil.
Hard seed coat is essential for resistance to this disorder
Seed containing 12% moisture has better germination.



Hypocotyl necrosis

i. Death of hypocotyl tissues occur.
ii. It is associated with low Ca and Mg content in the seed.



Ca deficiency

Mg deficiency

COLD TOLERANCE

- **Beans are generally susceptible to low temperature injury at all stages of growth.**

- **Temperature of 10^{o}C or below during imbibition and germination result in permanent injury and vigour reduction, while prolonged temperature at or below 15-16^{o}C can result in stunted plants with no crop.**

- **The characters contributing towards cold tolerance are large embryonic axis, rapid hypocotyl elongation, rapid mobilization of cotyledonary reserves, leaf area and production of surplus photosynthate.**

HEAT TOLERANCE

- **Heat stress particularly affects the development of reproductive organs.**
- **At high temperature, blossom abscission may be due to inability of pollen grains to germinate.**
- **Pod yield of French bean is severely depressed under a high temperature condition.**
- **It is determined by the number of pods, which is a product of the number of flowers and pod-set-ratio.**
- **Since pod-set-ratio is strongly affected by pollen fertility under high temperature condition, pod yield deterioration in the summer cropping might be due to decrease of pollen fertility.**

DROUGHT TOLERANCE

- The water stress during flowering and grain filling reduces the seed yield and seed weight and accelerates the maturity of bean.
- Reduction in yield during flowering is the result of both fewer pods and seeds per pod.

SALINITY TOLERANCE

- The common bean is a salt sensitive species.

- Salinity impairs seed germination, reduces nodule formation, retards plant development and reduces crop yield.

Diseases

Disease	Management
Anthracnose	• Seed treatment. • Spray Bavistin or Dithane-M-45. • Use resistant varieties (Tweed wonder)
Leaf spot	• Spray of Bavistin or Dithane-M-45
Powdery mildew	• Spray Karathane or Sulphur fungicides.
Ashy stem blight	• Seed treatment.
Rust	• Spray Bavistin/ DM-45
Web blight	• Crop rotation • Spray Bavistin/Dithane-M-45
Bacterial blight	• Use disease free seed • Soak the seed in a mixture of Streptocyclin (1g) & Hexacap (25g) in 10 lt. of water for 4 hrs before sowing.
Common bean mosaic	• Vector: Aphids
French bean yellow & golden mosaic	• Vector: White fly

Insect-Pests

Insects	Management
Aphids	Dimethoate (0.03%), Methyl demeton (0.025%) or fenvalerate (0.01%) before flower initiation stage.
Jassids	-do-
Pod borer	Carbaryl (0.2%) or Endosulfan (0.05%) at 15 days interval.
Bean beetle and Bean bugs	Endosulfan or Nuvan
Hairy catterpiller	Endosulfan
Bean Weevil	Storage pest. Put 1-2 tablets of Celphos/tonnes of material.
RED SPIDER MITE	Azadiractin (0.03%) or Malathion (0.05%) or Dicofol (0.04%). Repeat sprays at 10 day intervals

Disease Resistant Cultivars of French bean In India

Disease	Resistant Cultivar
Powdery mildew	Contender, Pusa Parvati
Wilt	Jampa
Rust	Pant Anupama, VL Boni-1, Arka Bold, Pant Bean 2, Kentucky Wonder
Angular leaf spot	Lakshmi, SVM1, Pant Anupama
Common bean mosaic	Pant Anupama (moderately resistant) Pant Bean 2 (moderately resistant)

COW PEA (*Vigna unguiculata)*

Origin	**Africa**
Climate	**•A warm season crop, suitable for humid tropics and subtropical zones. •Tolerates hot and dry conditions but intolerant to frost. •Thrives best between 21 and 35^{0}C. •Different varieties respond differently to temperature and day length. Rainy season varieties if sown during summer, may give only vegetative growth.**
Soil	**Grown in all types of well drained soil with pH 5.5 to 6.5**
Cultivars	**Pusa Phalguni, Pusa Barsati, Pusa Dofasli, Pusa Komal, Pusa Rituraj,Pusa Sukomal Arka Samridhi, Arka Garima, Arka Suman, Bidhan Barbati-1, Bidhan Barbati-2, Kashi Shyamal, Kashi Kanchan, Kashi Sudha, Kashi Nidhi, Kashi Gauri, Kashi Unnati, Pusa Sukomal**
Sowing time	**Spring-summer crop: February-March, Rainy season: June- July South India: December-January for spring-summer crop.**
Seed rate:	**12.5-20 kg / hectare.**
Spacing	**45-60 cm X 10-15 cm (bush type), 75 cm X 20-25 cm (indeterminate types)**
Nutrition Requirement	**50:80:80 kg NPK /ha, Band fertilizer 7-10 cm deep & 5-7 cm away from the seed is good practice.**
Irr. and inter culture	**As frenchbean**
Harvesting	**At three different stages of maturity: green snaps, green mature and dry.**
Yield	**50-80 q**
Diseases	**Anthracnose, Die back, Ashy stem blight, Powdery mildew, Bacterial blight, Mosaic**
Insects	**Aphids, Jassids, Pod Borer, Bean Weevil**

CLUSTER BEAN / GUAR

Importance	The mucilagenous seed flour is valued as a guar gum (glactomannan) and used in textile, paper, cosmetic and oil industries. It is a useful absorbent for explosives.
Origin	Africa
Climate	•Its typical tropical crop which prefer warm climate, though its grown in subtropics during summers. • Guar requires long day conditions for vegetative growth and short day conditions for induction of flowering. •Average Temp in the range 30-40^{0}C is congenial for growth and development.
Soil	•Guar can tolerate saline and moderately alkaline soils with pH 7.5 and 8. •Prefers well-drained sandy loam soils.
Cultivars	Pusa Mausami, Pusa sadabahar, Pusa Navbahar, Sharad Bahar, Goma Manjari
Sowing time	NI: June- August South India: Through out year
Seed rate:	15-40 kg / hectare.
Spacing	45-60cm X 10-15 cm
Nutrition Requiremen t	10-20: 50-70:50-70 kg NPK/ha

Lablab bean or Dolichos bean or Hyacinth bean or *Sem Phali*

Cultivars	**Pusa Early Prolific, Co-1, Co.2, Co.10, Hebbal Avare 3, Hebbal Avare 4, Deepaliwal, Kashi Haritima, Arka Ajay,Arka Vijay**
Sowing time	**NI: July- August** **South India: Through out year**
Seed rate:	**20-30 kg / hectare.**
Spacing	**60 × 30cm (bush) and 100 × 75 cm (tall)**
Nutrition Requirement	**10-20: 50-70:50-70 kg NPK/ha**
	Rest practices are same as other beans

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR CLUSTER BEAN

(*Cyamopsis tetragonoloba* L.) (2n = 14)

(Hindi: Guar)

Cluster bean is a drought tolerant warm season crop grown for its tender fruits for use as vegetable. Fruits are rich in food value and each 100 g contains 10.8 g carbohydrate, 3.2 protein, 1.4 g minerals, 316 IU vitamin-A and 47 mg vitamin-C. It is also sued as a nutritious fodder for livestock. Mucilaginous seed flour is used for making guar gum (galactomannan) utilized in textile, paper, cosmetic and oil industries throughout the world.

Origin and botany

Diverse opinion on exact origin of cluster bean is still prevailing. Dry regions of West Africa as well as India are treated as centres of origin of cluster bean by various workers. African species, *Cyamopsis senegalensis* is the ancestor of cluster bean.

Botany

Cluster bean is an erect annual, growing to a height of up to 3 in with stiff erect branches. Stem is angled and leaves are trifoliate. Small white or purple flowers are borne on axillary racemes. Fruits are compressed, erect and 4-10 cm long. Each fruit has 5 to 12 white to grey or black coloured seeds.

Varieties

Varieties grown in India differ in height of plants. Cultivars grown in South India are vegetable types while those in North-West India are grown for seeds. There are giant and dwarf types in cluster bean. Vegetable types are mostly dwarf types with smooth appearance. Fodder types are mostly hairy.

Some of the improved varieties developed at IARI, New Delhi are :

- **Pusa Domausami -** Suitable for rainy season. Late and branching variety with 80 days to first picking. Pods smooth, light green and 10-13 cm long.
- **Pusa Sadabahar –** Suitable for summer and rainy season, non branching type. Pods green and 12-13 cm long.
- **Pusa Navbahar** – Non branching variety with pod quality of Pusa Mausmi. Developed by crossisng Pusa Domausami and Pusa Sadabahar.

Sharad Bahar is a branching variety developed at NBPGR. It produces 12-14 branches with an average yield of 133 pods / plant.

Climate and soil

This hardy and drought tolerant crop comes up well during summer and rainy season in well-drained sandy loam. It cannot tolerate shade and prefers long day condition for vegetative growth and short day condition for flowering.

Land preparation and sowing

Main rainy season crop is sown during June-July and extended up to September-October. Summer crop is raised by sowing during February-March. Field is prepared to a fine tilth by ploughing and harrowing. Seeds are either broadcasted or dibbled behind country plough at a distance of 25-30 cm. Seeds are also dibbled at specified spacing of 45-60 cm x 15 cm. Seed requirement is 25-30 kg/ha.

Manure and fertilizers

Though a hardy legume, cluster bean responds to fertilizer application. In addition to 25 t. of farmyard manure, a fertilizer dose of 50:60:60 kg NPK / ha is recommended. Half N, full P and K are applied as basal dose and remaining N, 25-30 days after.

Application of fertilizers in Tamil Nadu

Apply FYM 25 t, Azospirillum 2 kg and *Phosphobacteria* 2 kg / ha, N 25, P 50 and K 25 kg/ha as basal and 25 kg N/ha 30 days after sowing.

Intercultural

The field is kept free of weeds during initial stages. Though a hardy crop, irrigation increases yield. Irrigation at flowering and fruiting stages is the most critical. For getting high yield in vegetable types, irrigation may be done at 7-10 days interval.

Stacking is also necessary to avoid lodging in tall varieties.

Harvesting and yield

Harvesting starts 40 days after sowing and pods are harvested at tender stage. A vegetable yield of 5-8 tonnes and seed yield of 0.6 to 1.0 t/ha are expected within crop duration of 120 days.

Pests and Diseases

Most of pests affecting other legume crops also attack cluster bean. Fusarium wilt, bacterial blight, powdery mildew and anthracnose are major diseases affecting the crop.

****

1. Among the peas and beans _____is a hardy crop.

   a. Peas b. Cluster bean c. Lablab beans d. French bean

2. Gaur gum is a product of _____.

3. Cluster bean is a _____ rooted crop.

4. Spraying of _____@ 2000 ppm would increase the yield of cluster bean.

   a. GA b. CCC c. IAA d. NAA

5. Other name for cluster bean is _____.

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR COW PEA

(Syn: Southern pea, Black eyed pea, Yard long bean)

(*Vigna uniguiculata*) (2n = 22, 24)

(Hindi: *Lobia, Chouli*)

Cowpea is a typical warm season crop adapted to tropics. The crop is used in a variety of ways. Tender pods are used as vegetable and dry beans as pulse. Due to its nutritive value and soil improving properties, it is also used as a fodder, green manure and cover crop. Being a legume crop, cowpea fits well in inter-cropping system. In Kerala, it is grown as a floor crop in coconut gardens, as an inter-crop in tapioca, fringe crop in rice fields and in garden lands. The crop is an integral part of sustainable agriculture. 100 g of green tender pods contain 4.3 g protein, 2.0 g fibre, 8.0 g carbohydrates, 74 mg phosphorus, 2.5 mg iron, 13.0 mg vitamin-C, 0.9 mg minerals, etc. (Africa is considered as primary centre of origin of cowpea). Confusion prevailed in the taxonomy of cultivated cowpea and related wild species was solved to a great extent by Summerfield *et. al* . (1974) and Ng and Marechal (1985).

Taxonomy and botany

Three cultivated sub-species have been identified under the species *Vigna unguiculata* to which cowpea belongs:

1. *V. unguiculata* ssp. *Unguiculata* (dual purpose type)
2. *V. unguiculata* ssp. *Cylindrical* (Syn: *V. Unguiculata* ssp. *Catjang, V. Sinensis* ssp. *Catjang*((grain type)
3. *V. Unguiculata* var. *Sesquipedalis* (vegetable type).

Vigna unguiculata ssp. *cylindrical*

Vigna unguiculata var. *sesquipedalis*

Some do not agree on the distinct subspecies status to each of the above three. Ng and Marechal (1985) renamed subspecies *unguiculata, cylidrica* and *sesquipedalis* as cultigroups. *Unguiculata, Biflora* and *Sesquipedalis* respectively under V.*unguiculata.*

Cultigroup *unguiculata* is most diverse of cultivated *V. unguiculata* and is widely distributed. It is commonly known as cowpea. This is prostrate, semi-erect, erect or climbing. Pods are linear, in axillary racemes. Seeds are small and kidney shaped.

Sesquipedalis, known as yard long bean or asparagus bean is used as vegetable. It is climbing or trailing. Pods are 30-90 cm long, pendulous, fleshy and tending to shrink when dry. Seeds are elongated and kidney shaped.

All the three cross each other. In a cross between *V. unguiculata* spp. *Unguiculata* (2n=22) and *V. Unguiculata* var. *Sesquipedalis* (2n=24), F_1, had 2n=23.

Botany

Cowpea is a diploid with 2n=2x=22. It is a vigorously growing annual herb with strong tap root system. Growth habit ranges from erect to climbing with profuse branching. Stem is cylindrical and twisting. Inflorescence is an un-branched axillary raceme bearing several flowers at terminal end of peduncles. Length of peduncle varies from 5-60 cm.

Anthesis takes place early in morning between 6.30 and 9.00 a.m. The process of opening corolla takes 45-60 minutes. Dehiscence of anthers is much earlier and it varies from 10.0 p.m. to 00.45 a.m. For hybridization purpose, emasculation is to be done 20 hours before flower opening. Safest time for emasculation is morning hours preceding day of anthesis. Stigma becomes receptive from 12 hours before blooming to 6 hours after anthesis.

Climate

Cowpea is a warm season crop and comes up well between 21-35^{o}C. Grain types and dual purpose types are tolerant to hardy conditions including high temperature, drought and poor soil. The climbing yard long bean prefers mild climate than grain types. Performance of varieties varies with day length, rainfall and temperature. Hence, specific varieties are to be selected for each season.

Even though, cowpea can be grown in any soil, fertile loose soil rich in humus is required for a prolonged harvest.

Varieties

Varieties and cultivars respond differently to photoperiod. Brief descriptions of improved varieties are given below:

Developing institution	Variety	Special features
IIHR, Bangalore.	IIHR 16	Developed through pedigree selection from Arka Garima x Pusa Komal. Plants erect bushy, 70-75 cm tall, photo insensitive. Pods

		green and medium long (15-18 cm). Yield 19 t/ha in 70-75 days.
	Arka Garima* (Sel 61-B)	Derived through back cross and pure line selection from TUV 762 x *V. unguiculate* var. *sesquipedalis.* Plants vigorous, bushy, with purple flowers. Pods round and thick, fleshy and stringless.Tolerant to heat and drought. Yield 18 t/ha in 90 days.
	Arka Suman	Bushy photo insensitive variety with medium long pods. Yield 15 t/ha.
	Arka Samrudhi	Bushy photo insensitive variety with medium long pods. Yield 15 t/ha.
IARI, New Delhi.	Pusa Komal * (Sel 1552)	Plants bushy, flowers in 45 days. Pods light green, 25-30 cm long. Resistant to bacterial blight. Yield 10 t/ha.
	Pusa Phalguni	Dwarf variety that matures in 60 days. Suitable for February-March sowing. Yield 5-10 t/ha.
	Pusa Barsati	Suitable for rainy season. Yield 9-9.5 t/ha.
	Pusa Dofasli	Photo insensitive. Yield 7.5-8 t/ha.
	Pusa Rituraj	Bushy variety with 22-25 cm long and thin pods. Yield 8-10 t/ha.
Kerala Agricultural University	Vyjayanthi	Trailing growth habit, long wine red coloured pods, brown seeds; Av. Length of pod 50.62 cm: Av. Fruit weight 16.17 g; No. of seeds / pod 20-22; Productivity 12.6 t/ha.
	Lola	Trailing growth habit, smooth and extra long pods; glossy light green coloured long pods with purple tip, black seeds; Av. Length of pod 53.38 cm; Av. Pod weight 22 g; No. of seeds / pod 20-22; Productivity 20.0 t/ha.
	KMV 1	Trailing growth habit, long light green pods with brown tip, Immature seeds light green, Av. Length of pod 38 cm; No. of seeds / pod 19;

		Productivity 14.2 t/ha.
	Bhagyalakshmi	Early flowering, bushy growth habit, light green medium sized pods, mottled seeds; Av. Length of pod 27.0 cm; Av. Pod weight 7.13 g; Days to first harvest 48 days; Productivity 6.48 t/ha.
	Kanakamani	Semi trailing growth habit, pod-dark green, bold seeded and medium long, reddish brown seeds; Av. Pod length 17.8 cm; Av. Pod weight 2.0 g; Seeds / pod 17; Productivity 7.0 t/ha.
	Kairali	Resistant to mosaic disease, semi trailing growth habit, pink coloured medium long pods, reddish brown seeds; Av. Length of pod 22.78 cm; Av. Pod weight 7.08 g; Days to first harvest 50, Productivity 7.13 t/ha.
	Anaswara	Semi trailing, pods-light green, bold seeded and medium long, purple flowers; Av. Pod length 28.13 cm; Av. Pod weight 12.5 g. Seeds / pod 19; Productivity 12.5 t/ha.
	Varun	Tolerant to mosaic, semi trailing growth habit, pink coloured medium long pods, reddish. Tolerant to mosaic, semi trailing growth habit, pink coloured medium long pods, reddish brown seeds; Av. Length of pod 27 cm; Av. Pod weight 11 g; Days to first harvest 50; Productivity 8.4 t/ha.
Tamil Nadu Agrl. University	CO.2	A semi spreading variety with 26 cm long pods having less fibre. Yield 9.4 t/ha.
	Vamban	Variety with long green pods. Yield 10.6 t/ha.
NDAU&T, Faizabad, UP.	Sel-2-1*	Plants 70-75 cm tall. Pods green, 25-30 cm long, black seeded. Susceptible to cercospora leaf spot and viruses.
Punjab Agrl. University,	Sel-263*	Early maturing dwarf variety with green thick and fleshy pods of 20 cm length. Resistant to

Ludhiana		mosaic and golden mosaic virus.
BCKVV, Kalyani	Bidhan Barati-1	Bushy variety resistant to cowpea mosaic and golden mosaic virus. Flowers white. Pods green, medium long (25.2 cm) borne on long stout peduncle. Yield 13.4 t/ha.
	Bidhan Barati-2	Semi determinate variety with purple flowers. Pods light green, thick medium long (25.8 cm) borne on short peduncle. Yield 15.9 t/ha.

Season

In areas where winter is mild, cowpea can be grown throughout the year. In North Indian plains, it is sown during February-March as a summer crop. In Kerala cowpea is grown throughout the year and June-July, September-October and December-January are main seasons.

Land preparation and sowing

Land is prepared to a fine tilth by 2-3 ploughing and harrowing. Field is divided into plots of convenient size and seeds of bushy varieties are dibbled at a spacing of 30 x 15 cm with 1-2 seeds per hole. For semi-trailing varieties provide a spacing of 45 x 30 cm. During rainy season, seeds are sown at the above spacing in raised beds of 90 cm width. Trailing varieties are sown at the above spacing in raised beds of 90 cm width. Trailing varieties are sown in pits of 45-60 cm diameter and 30-45 cm depth at a spacing of 2m x 2m with 3 plants / pit for trailing on bower. Trailing varieties are also grown on trellis by sowing seeds in channels at 1.50 x 0.45 spacing.

Seed rate required for various types are :

	Seed rate	**Spacing**
Bushy vegetable tyeps	20-25 kg/ha	30 x 15 cm
Semi-trailing vegetable types	20-25 kg/ha	45 x 30 cm
Trailing vegetable tyeps	4-5 kg/ha	2.0 x 2.0 m
Dual purpsoe (broadcasting)	60-65 kg/ha	-
Dual purpose (dibbling)	40-60 kg/ha	45 x 30 cm

In land, where cowpea is cultivated for the first time, inoculate seeds with *Rhizobium* for quick nodulation on roots and for fixing atmospheric nitrogen.

Manures and fertilizers

Kerala Agricultural University recommended a fertilizer dose of 20:30:10 kg NPK / ha along with 20 t. of farmyard manure for cowpea. Yard long bean responds well to application of fertilizers. Hence, a higher dose of 25:75:60 kg NPK/ha is also recommended in some other states. Half of N along with entire dose of P and K should be applied at the time of final land preparation. Apply remaining 15-20 days after sowing along with weeding and earthing up.

For yard long bean, apply fertilizers in several split doses at fortnightly interval for protected fruiting. Drenching cow dung slurry in basins of plants and spraying cow dung supernatant liquid is also highly beneficial for trailing types.

Apply 250 kg lime or 400 kg dolomite / ha in acidic soils at the time of land preparation.

Irrigation

Cowpea, in general, is sensitive to water logging and requires less moisture compared to other vegetables. Grain types require only 2-3 protective irrigations at flowering and pod development stages. Water requirement of vegetable types with protracted and long fruiting phase is more than that of grain types. Irrigate trailing vegetable types at 4-15 days interval depending on soil during pre-flowering phase. Hardening of plants by restricting irrigation during pre-flowering stage is advantageous for avoiding excess vegetative growth and will induce early flowering. Once plant starts flowering, provide frequent but light irrigation. Excess irrigation and frequent rains during fruiting period induces vegetative phase at the expense of fruiting.

Interculture

Climbing types are usually trailed to bowers or trellis made of bamboo poles and coir or plastic wire for harvesting maximum yield. Erect supports with wooden sticks for training plants to the bower when plants start vining. To reduce cost of production, stretching of jute wires from base to bower is also a viable practice.

Shallow cultivation and earthing up is necessary during early stages of crop to check weed growth. Fluchloralin (2 litres /ha) will effectively check weed growth for 20-25 days. Once crop is covered, weeds will naturally be under control.

Light earthing up along with fertilizer application is also highly advantageous for better growth of plants. This facilitates better root growth and prevents lodging of young seedlings.

Nipping of excess vegetative growth is a common practice for inducing flowering and fruiting in bush and semi-trailing cowpea varieties especially when there is rain during flowering and fruiting phase.

Plant growth regulators

Plant growth regulators are effective for specific purposes in yard long bean. Spraying of NAA (15 ppm), 15 and 30 days after sowing is beneficial for inducing fruit set. CCC is reported to induce tolerance to mosaic disease.

Harvesting and yield

Tender fruits are harvested after attaining full size but before they become fibrous. Yard long been is usually harvested in alternate days and harvesting period extends up to 45 days under good management practices. In bush varieties 2-5 harvests are possible.

Yield

Bush varieties	-	4-5 t/ha
Semi-trailing varieties	-	7-8 t/ha.
Yard long bean varieties	-	15-18 t/ha

Seed yield

Bush varieties	-	750-1250 kg/ha
Semi-trailing varieties	-	1000-1500 kg/ha.
Yard long bean varieties	-	450-600 kg/ha

Pests and diseases

Vegetable cowpea varieties especially those belonging to succulent yard long bean are susceptible to a number of pests and diseases. Pea aphids, serpentine leaf miner, stem fly, thrips, pod borers, leaf roller, hairy caterpillar etc. are major pests and fusarium wilt, rhizoctonia wilt, anthracnose, powdery mildew and mosaic are serious diseases affecting cowpea.

****

1. Botanical name for cowpea is _____.
2. Origin of cowpea is _____.

   a. Central Africa b. India c. Europe d. Japan

3. The green pod yield of cowpea is _____ q/ha.
4. Anthracnose of cowpea is transmitted by _____.
5. The vector for cowpea mosaic virus is _____.

   a. Thrips b. Water c. Aphids d. Jassids

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR HYACINTH BEAN

(Syn: Indian bean) *Lablab purpureus* L.

(Syn: *Dolichos lablab, D. purpureus*) (2n = 22, 24)

(Hindi: *Sem*)

Hyacinth bean, also known as field bean or dolichos bean, is grown throughout tropical regions of Asia, Africa and America. In India, it is grown as a field crop in Tamil Nadu., Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra. In Kerala, the photo sensitive pole types are grown in homesteads by trailing to bower for its tender fruits which are used as cooked vegetable. Dry beans are also sued in various vegetable preparations; 100 g of green pods contain 6.7 g carbohydrates, 3.8g carbohydrates, 3.8 proteins, 1.8 g fibre, 210 mg calcium, 68.0 mg phosphorus, 1.7 mg iron etc.

Origin, taxonomy and botany

Hyacinth bean originated in India. Two cultivated type's viz., *Lablab purpureosu* var. *typicus* and *L. purpureus* var. *lignosus* were reported by Sivasankar et al. (1971). Former is vegetable type cultivated for its soft and edible pods and latter is the field bean cultivated for dry seeds as pulse. Both varieties are cross compatible.

L. purpureus var typicus

L. purpureus var lignosus

Hyacinth bean is a perennial herbaceous plant often grown as an annual. Pole types are photosensitive. Leaves are alternate and trifoliate. Flowers are borne in axillary racemes and are typically papilionaceous and are self-pollinated.

Flowering takes place under short day periods irrespective of planting time. Anthesis occurs from 9 a.m. to 5 p.m. (Pokle and Deshmukh, 1971). Anther dehiscence is from 5.00 a.m. to 2.00 p.m. Stigma is receptive on the day of anthesis.

Varieties

A brief description of the improved varieties is given :

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Jay	Photo-insensitive bush variety developed by selection at F7 from Hebbal Avare 3 (Bush) x IIHR 99(Pole-recurrent parent). Pods long, light green slightly curved. Yield 1w t/ha in 75-80 days.
	Arka Vijay	Photo-insensitive bush variety developed by selection at F7 from Hebbal Avare 3(Bush) x Pusa Early Prolific (Pole). Pods short, dark green with characteristic aroma. Yield 12 t/ha in 75-80 days.
UAS, Bangalore.	Hebbal Avare-1	Bush and photo insensitive variety. Pods small and soft. Yield 0.8 t/ha in 90-100 days.
	Hebbal Avare-3	Bush and photo insensitive variety. Flowers white. Pods green, 2-3 seeded. Seeds brown, round and small. Yield 8-10 t/ha in 90-100 days.
	Hebbal Avare-4	Bush and photo insensitive variety. Pods soft and harvested in 5 pickings. Yield 6 t/ha.
IARI, New Delhi.	Pusa Early Prolific	Pole type. Pods flat, green, narrow, cycle shaped. Pod length 9.3 cm, width 1.5 cm, weight 3.5 g. Yield 14 t/ha in 200-215 days.
	Pusa Sem 2	Pole type. Pods semi-flat, dark green, fleshy and stringless. Pod length 15-17 cm. Yield 13-22 t/ha in 200-215 days. Tolerant to anthracnose, yellow bean mosaic virus, aphids, pod borers and frost.
	Pusa Sem 3	Pole type. Pods flat, green, fleshy and stringless. Pod length 15 cm. Yield 17-27 t/ha in 200-215 days. Tolerant to anthracnose,

		yellow bean mosaic virus, aphids, pod borers and frost.
KKVP, Dapoli	Wal Konkan 1	Bushy, photo-insensitive, resistant to yellow mosaic virus. Yield 9-10 t/ha in 110-115 days.
	Konkan Bhushan (DPLD 1)	Bushy, photo-insensitive, resistant to yellow mosaic virus. Yield 9-10 t/ha in 110-115 days.
Tamil Nadu Agricultural University	CO.1	Pole type. Pods green, fleshy with slow fibre development. Pod weight 9.7 g. Yield 18-20 t/ha in 160-180 days.
	CO.2	Pole type. Pods, flat, green with purple margin. Pod length 9.3 cm, width 2.1 cm, weight 6.17 g. Yield 11.8 t/ha in 210-220 days.
	CO.3	Pole type. Pods fleshy, green with purple tinge. Pod length 10.6 cm, width 4.8 cm, weight 11.77 g. Seeds black. Yield 10.0 t/ha in 230 days.
	CO.4	Pole type. Pods deep purple throughout and fleshy. Pod length 10.2 cm, width 3.3 cm, weight 7.43 g. Seeds black. Yield 13.5 t/ha in 215-220 days.
	CO.5	Pole type. Pods long, narrow, light green to white in colour, tubular, curved with serrated margin. Pod length 13.4 cm, breadth 1.5 cm, weight 5.26 g. Seeds chocolate brown. Yield 6-7 t/ha in 235 days.
	CO.6	Bush variety. Selected from DL 3169 x CO.5. Pods slightly curved and bloated. Yield 12 t/ha in 240 days.
	CO.7	Bush variety. Selected form DL 3169 x CO.5. Pods long, succulent, flat, greenish white and broad. Yield 12 t/ha in 240 days.
	CO.8	Bush variety. Pods green tubular and fleshy.

		Yield 6-8 t/ha in 120 days.
	CO.9	Bush variety. Pods and grains are used. Yield 7-8 t/ha in 120 days.
	CO.10	Bush variety. Induced mutant from CO.6 by gamma ray (24 krad). Pods greenish white, tubular and curved. Yield 5-6 t/ha in 120 days.
	CO.11	Bush variety. Hybrid derivative of CO.9 x a pandal type. Compact plant type. Pods flat and light green with purple margin. Yield 9-10 t/ha.
	CO.12	Bush variety. Hybrid derivative of CO.9 x CO.4. Pods deep purple. Yield 10-12 t/ha in 110 days.
	CO.13	Bush variety. Hybrid derivative of Co.9 x a training type. Pods long green. Yield 10t/ha in 110-120 days
CSAUA&T, Kanpur.	Rajani	Pole type. Pods narrow oval in cross section, shining green. Pod length 10.4 cm, width 1.2 cm, weight 1.78 g. Yield 7-8 t/ha in 200-210 days.
	KDB 403	Pole type. Pods long, narrow, shining green. Pod length 12.9 cm, width 1.2 cm, weight 2.0 g. Yield 5-6 t/ha in 180-210 days.
	KDB 405	Pole type. Pods medium long, narrow, dark green band in the middle and boarders light green. Pod length 9.6 cm, width 1.3 cm, weight 1.1 g. Yield 3-4 t/ha in 180-200 days.
MPKV, Akola	Dasarawal	Pole type. Pods dirty green with purple tinge at both boarders. Pod length 7.8 cm, width 2.0 cm, weight 3.2 g. Yield 7-8 t/ha.
	Deepaliwal	Pole type. Pods extra long (18.4 cm), white, not smooth due to bulging at each seed. Pod width 2.7 cm, weight 1.5 g. Yield 6-8 t/ha in 200-210

		days.
JNKV, Jabalpur.	JDL. 79	Pole type. Pods flat, broad, whitish green with parrot green boarder along the line of seed attachment. Pod length 11.8 cm, width 3.6 cm, weight 1.5 g. Yield 5.6 t/ha in 200 days.
	JDL 53	Pole type. Pods flat, small, narrow, dull whitish green with purple tinge along the boarder. Pod length 7.2 cm, width 1.8 cm, weight 3.75 g. Yield 10-12 t/ha in 200-220 days.

Cultivation practices

Prepare land to fine tilth, and sow seeds during July-August with onset of monsoon. In South and Central India, it is grown as a mixed crop with ragi and sorghum. Seeds are dibbled at a spacing of 1.0 m in between ragi or sorghum. After harvest of ear heads of ragi of sorghum, dolichos bean plants are allowed to twine and spread on their stalk. Plants start flowering and fruiting by November-December and continue up to late spring. Later vines are cut along with sorghum straw and given to cattle as a nutritious feed. As a pure crop, dolichos bean is sown at a spacing of 1.0 x 0.75 m @ 3-4 seeds / hill and later thinning is done retaining only 2 plants. Seed rate for pure crop is 50-60 kg/ha.

Pole types are usually sown in backyards of homesteads. Take pits of 45-60 cm diameter during June-July and full with green leaves and wet cow dung. Allow manure to decompose properly for 2-3 weeks. Cover pits with top soil and sow 3-4 seeds in a pit. Erect a bower with bamboo poles over an area of 4.0 x 4.0 m keeping pit at the centre. Allow plants to climb on bower by erecting one or two long twigs in pits. Apply organic manure around plants and earth up with laterite or loan soil. After cessation of rains, make a circular basin 30-35 cm away from base of plants for irrigation. Provide light irrigation daily in basin. Plants start yielding after 3 months once short days start. Thereafter daily watering and fortnightly application of organic manure are essential for protracted flowering and harvest of stringless pods over a long period.

Harvesting and yield

In bush varieties harvesting starts 50-60 days after sowing. In pole types flowering starts around three months after sowing during short days. Harvesting starts from November – December and extends up to middle of March in Kerala. Pods are harvested at tender stage before it becomes fibrous. Green pod yield varies from 5 to 8 t/ha.

Pests and Diseases

Aphids, pod borer and leaf eating caterpillar are the major pests affecting dolichos bean. Among the diseases, *Cercospora* leaf spot and *Rhizoctoni* wilt are most serious.

Lab Lab or Dolichos bean

Application of fertilizers

(a) Basal dressing for bush type

Manures and fertilizers	Irrigated	Dry
FYM	12.5 t/ha	12.5 t/ha
N	25 kg/ha	12.5 kg/ha
P	50 kg/ha	25 kg/ha
K	-	-

(b) For pandal type

Apply 10 kg FYM per pit (20 t/ha) 100 g of NPK 6:12:12 mixture as basal and 10 g N per pit after 30 days. Apply 2 kg each *Azospirillum* and *Phosphobacteria* per ha at the time of sowing.

****

1. _____types of lablab bean or hyacinth beans are photoinsensitive in nature.

a. Pole types b. Bush types c. Both a & b d. None

2. _____variety of lablab bean bears pods in bunches.

a. CO 1 b. CO 2 c. Pusa early prolific d. CO 10

3. The centre of origin for lablab bean is----------.

a. China b. India c. Mexico d. Europe

4. Chromosome number of lablab bean is

a. 22 b. 24 c. Both d. None

5. Lablab yellow mosaic is transmitted by----------.

a. Aphids b. Whitefly c. Jassids d. Mites

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR FRENCH BEANS

(Syn: Snap bean, String bean, Kidney bean, Haricot bean, Fresh bean)

(*Phaseolus vulgaris* L.) (2n = 22)

(Hindi: *Vilaiti sem*)

French bean is an important cool season legume vegetable grown for its tender pods, shelled green beans and dry beans (*Rajmah beans*). In western countries, processed pod consumption is quite high. 100 g of green pods contain 1.7g protein, 4.5 g carbohydrates, 221 I.U. vitamin - A, 11 mg vitamin-C, 50 mg calcium etc. Dry beans are rich in protein.

Origin and Taxonomy

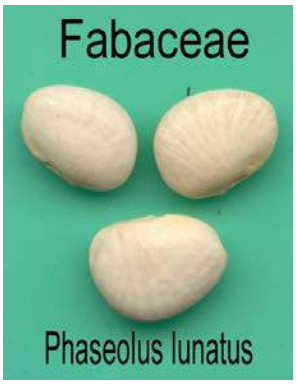
Genus *Phaseolus* originated in New World. Following four species are under cultivation in New World:

1. *Phaseolus vulgaris* – French bean
2. *P. coccineus* – Runner or Scarlet bean
3. *P. lunatus* – Lima bean, Butter bean or Madagascar bean
4. *P. acutifolius* var. *latifolius* – Tapery bean

All the given species are diploids with 2n=22 and self-pollinated except *P. coccineus,* which is cross-pollinated. French bean, the most important species under Phaseolus, is originated in central and South America (Kaplen, 1981).

P.vulgaris ***Phaseolus coccineus***

Phaseolus lunatus



White Tepary Beans

Phaseolus acutifolius

Botany

French bean has tap root system with poor nodule formation. Leaves are trifoliate. Though a self-pollinated crop, French bean offers wide variability for plant growth (bushy / climbing), colour of pod (green / waxy coloured), cross section of pod (flat / oval / round), pliability (stringed / string less) etc.

Varieties

There are specific varieties for snap bean purpose, dry bean purpose and for processing. Processing varieties are very popular in the USA. A brief description of improved varieties is given below:

Developing institution	Variety	Special features
IIHR, Bangalore.	Arka Komal*	Introduced bushy variety from Afghanistan. Pods straight, flat, and green with large brown seeds. Good transport and keeping quality. Yield 19 t/ha and 3 t/ha seed in 65-70 days.
	Arka Subidha* (IIHR 909)	Plants bushy and photosensitive. Pods straight and oval, light green, stringless and fleshy. Yield 19 t/ha in 70 days.
IARI Regional Station, Katrain	Contender	Plants bushy with pink flowers. Pods green, round long and stringless. Tolerant to mosaic and powdery mildew. Yield 20 t/ha.
	Pusa Parvati	Developed through irradiation followed by selection from wax podded variety EC 1906. Plants bushy with pink flowers. Pod green, round long. Resistant to mosaic and powdery mildew. Yield 22-25 t/ha.
	Pusa Himalatha	Pole variety with medium sized (14 cm long) round, meaty, stringless pods with an average yield of 26 t/ha.
VPKAS, Almora	VL Boni 1*	Dwarf variety with white flowers. Pods round, light green, stringless and fleshy. First harvest 45-60 DAS. Yield 10-11 t/ha.
Tamil Nadu Agricultural University	Ooty-1	Moderately resistant to leaf spot, anthracnose and pod borer. Yield 10-11 t/ha.
	TKD1	A pole type suitable for growing in hills. Pods long, flat with low fibre. Yield 5-6 t/ha in 90-100 days.

	KKL 1 Moringa bean	A pole type suitable for growing in hills. Pods long (28 cm) with low fibre. Seeds white and flat. Yield 7 t of pods and 3 t. of grains/ha.
	YCD1	Bushy dual purpose variety suitable for *kharif* season. Pods slightly flat, 15 cm long. Seeds dark purple. Tolerant to root rot, rust, yellow mosaic and anthracnose. Yield 9.75 t. of pods or 6.3 of grains / ha in 105 days.
NDAU&T, Faizabad, UP.	NDVP 8*	Mid season variety with 10 t/ha
	NDVP 10*	Mid season variety with 10 t/ha.
CBPUA&T, Pantnagar	Pant Anupama* (UPF 191)	Plants bushy and dwarf with concentrated fruiting. Moderately resistant to bean mosaic and angular leaf spot. Yield 9 t/ha.
MPKV, Rahuri	Phule Surekha	Pods 9-10 cm long, flat, light green. Tolerant to anthracnose, yellow mosaic and wilt disease. Yield 15 t/ha.

* Varieties released / identified by AICRP (Vegetables)

In addition to the above improved varieties, cultivars like Kentucky Wonder (pole type with long, flat and stringless pods), Premier, Giant Stringless, Bountiful etc. are also very popular among farmers.

Climate

French bean is a day neutral cool season vegetable and tolerates high temperature better than peas. Optimum monthly temperature for cultivation of French bean is 15-25^{o}C compared to 10-18^{o}C for peas. It is sensitive to high rainfall, frost and high temperature. Pole types tolerate high rainfall better than bushy varieties

Soil

Soil requirements are same as that of pea. Ideal soil pH for growth of French bean is 5.5 – 6.0

Season

In plains of North India, French bean is sown during two seasons viz., July-September and January-February. In hills, sowing is done from March to May.

Land preparation and sowing

Land is ploughed to a fine tilth and divided into plots of convenient size. Ridges and furrows are prepared by ploughing after a basal dose application of farmyard manure. Field is irrigated once and seeds are sown under optimum moisture condition on side of ridges 2-3 days after irrigation. Spacing and seed rate vary with varieties. Early varieties are sown at a spacing of 45-60 cm x 10-15 cm and seed rate required is 80-90 kg / ha. Pole types are sown at 1.0 m apart in hills @ 3-4 plants / hill and seed rate is much less (25-30 kg/ha.).

Manure and fertilizers

French bean responds well to application of lime and fertilizers. In addition to 20-25 t. of farmyard manure, 50 kg N, 75 kg, P_2O_5 and 75 kg K_2O are recommended. Half of N along with full P and K should be applied as basal dose at the time of making ridges and furrows or one or two weeks after germination. Apply remaining dose of N, one month after first application.

Application of fertilizers in Tamil Nadu

Apply FYM 25 t/ha at the last ploughing. N 90 kg and P 125 kg/ha should be applied on one side of the ridges. For rainfed conditions of Shevaroy hills, apply as a basal dose of 62.5 kg/ha of Phosphorous as super phosphate and with another half of 62.5 kg/ha Phosphorous as FYM enriched super phosphate.

Intercultural operations

French bean is a shallow rooted crop and only light inter-cultural operations are practiced. During early stages of crop, weeding followed by fertilizer application and earthing up can be synchronized. A pre-sowing application of Fluchloralin @ 2.1 /ha checks weed growth for 20-25 days.

Water stress influences yield of French bean and crop is most sensitive at flowering and fruiting stages. 6-7 irrigations are required during growing season.

Staking is an important operation for pole types and bamboo sticks or any locally available materials should be erected when plants start vining. Individual vertical stakes and horizontal canes at 40 cm distance are erected for encouraging growth and spread of plants.

Application of plant growth regulators like PCPA (2 ppm) and NAA (5-25 ppm) has favourable effect on fruit set and yield.

Harvesting and yield

Pods are harvested at full grown stage but immature and tender. Pods are ready for harvest 7-12 days after flowering depending on varieties. In bush varieties, 2-3 harvests and in pole types 3-5 harvests are made. Quality of beans varies with harvests and best quality fruits

are obtained in initial harvests compared to later harvests. Loss of crispness during storage and in last harvest is attributed to loss of water and increase in water soluble pectin.

Seed weight is a major indicator of green bean harvest maturity. Yield of tender pods varies from 8-10 t/ha in bush varieties and 12-15 t/ha in pole types. Dry beans are harvested when majority of pods are fully ripe and colour turns yellow. Seed yield varies from 1250 to 1500 kg / ha.

Pests and diseases

Crop is affected by pests like stem fly, thrips, mites, bean beetle, bean weevil, aphids etc. Yellow mosaic, anthracnose, powdery mildew, rust, root rot and wilt and leaf spot are common diseases affecting French bean.

LIMA BEAN

(Syn: Double Bean) (*Phaseolus lunatus* L.) (2n = 22)

(Hindi : *Lobia*)

Dixie Speckled Butter Peas - *Phaseolus lunatus*

Christmas Lima Beans - *Phaseolus lunatus*

Hopi Yellow Lima Beans - "Sikyahatiko" - ***Phaseolus lunatus***

Lime bean is a cool season vegetable requiring dry and cool climate with an average rainfall of 50-62.5 cm. Compared to other legumes, it is a long duration crop and is retained in field for 9 months. Lima bean is an important crop in Maharashtra.

Cultivation practices

In Maharashtra, crop is grown after sugarcane. After harvest of sugarcane, land is ploughed to fine tilth and seeds are sown in hills @ 2-3 seeds / hill at a distance of 180 x 120 cm during July. Seed rate required is 8-10 kg/ha.

When plants start vining, they are trained to trellis made with vertical bamboo poles with horizontals tied at a distance of 45 cm. Height of trellis is up to 150 cm and they are usually erected along direction of wind.

Lima bean responds well to manuring and fertilizer application. Irrigation and other timely inter-cultural operations required are same as that of other legume vegetables.

Harvesting

Plants start flowering 80-85 days after sowing and pod formation takes place one month alter. First harvest is obtained four months after sowing, i.e., by November and it extends up to March. On an average, 12-14 harvests are possible at an interval of 15-16 days. Yield varies from 8-12 t/ha.

BROAD BEAN

(*Vicia faba* L.) (2n = 12, 14)

(Hindi: *Bakla)*

Broad bean, also known as faba bean or horse bean, is the only bean, sown in autumn and is grown as a winter crop in high elevations. It is a hardy plant and withstands low temperature as low as 4^{o}C. The crop is widely cultivated in Latin America and is grown in India in a limited scale in northern states having low temperature. It tolerates salinity to a certain

extent. Broad bean is sued as tender bean, green shelled bean, and dry bean and as cattle feed.

Plants are more or less vine like and grow erect without branching to a height of 60-125 cm. Stem is square in cross section and flowers are pollinated by insects. Pods are borne in upright clusters of 5 or more in axils of leaves. Green pods grow parallel to stem. It is about 15 cm long and 2 cm wide with slightly round in cross section with 5 or more beans.

Varieties

Masterpiece White Long Pod, Masterpiece Green Long Pod, Imperial White Windsor and Imperial Green Windsor are some of the introduced varieties. Jawahar Selection 73-31 is an improved selection from Madhya Pradesh. A few selections made at Bihar are BR-1 (black seeded) and BR-2 (yellow seeded). M/s.Suttan Seeds developed a dwarf type 'Suttan White Seeded'.

Cultivation

Broad bean requires low temperature for its cultivation. Crop is tolerant to water stress due to protein accumulation. It tolerates water-logging and salinity. Seeds @ 70-100 kg/ha are sown in shallow channels spaced at 75 cm. In each channel, seeds are sown in double rows at spacing of 25 cm. Cultivation practices are similar to that of pole type pea. Plants are stacked with wooden sticks.

Tender pods are harvested at green shell stage, 3-4 months after sowing. Under favourable conditions, crop yield is 7-10 t. of green pods and 1-1.2 t. of green beans/ha.

Application of fertilizers in Tamilnadu

Apply 25 of FYM and 50 kg P and 25 kg K/ha as basal dose. 25 kg N and 25 kg of K/ha are applied between 20-25 days after sowing and application of remaining 25 kg of N is done between 40-45 days.

Anasazi Beans(*Phaseolus vulgaris)*

Bolita Beans (*Phaseolus vulgaris)*

Purple Beans (*Phaseolus vulgaris)*

Hopi Black Pinto Beans (*Phaseolus vulgaris)*

Little White Ice Beans (*Phaseolus vulgaris)*

****

1. Origin of French bean is _____.
2. In India, the largest area under temperate leguminous vegetable is _____.

a. Peas b. French bean c. Snap bean d. Butter bean

3. For seed germination the temperature required for lima bean is _____.

4. Origin of broad bean is _____.

5. Lima bean can be grown at an elevation of _____ MSL.

TROPICAL TUBER CROPS

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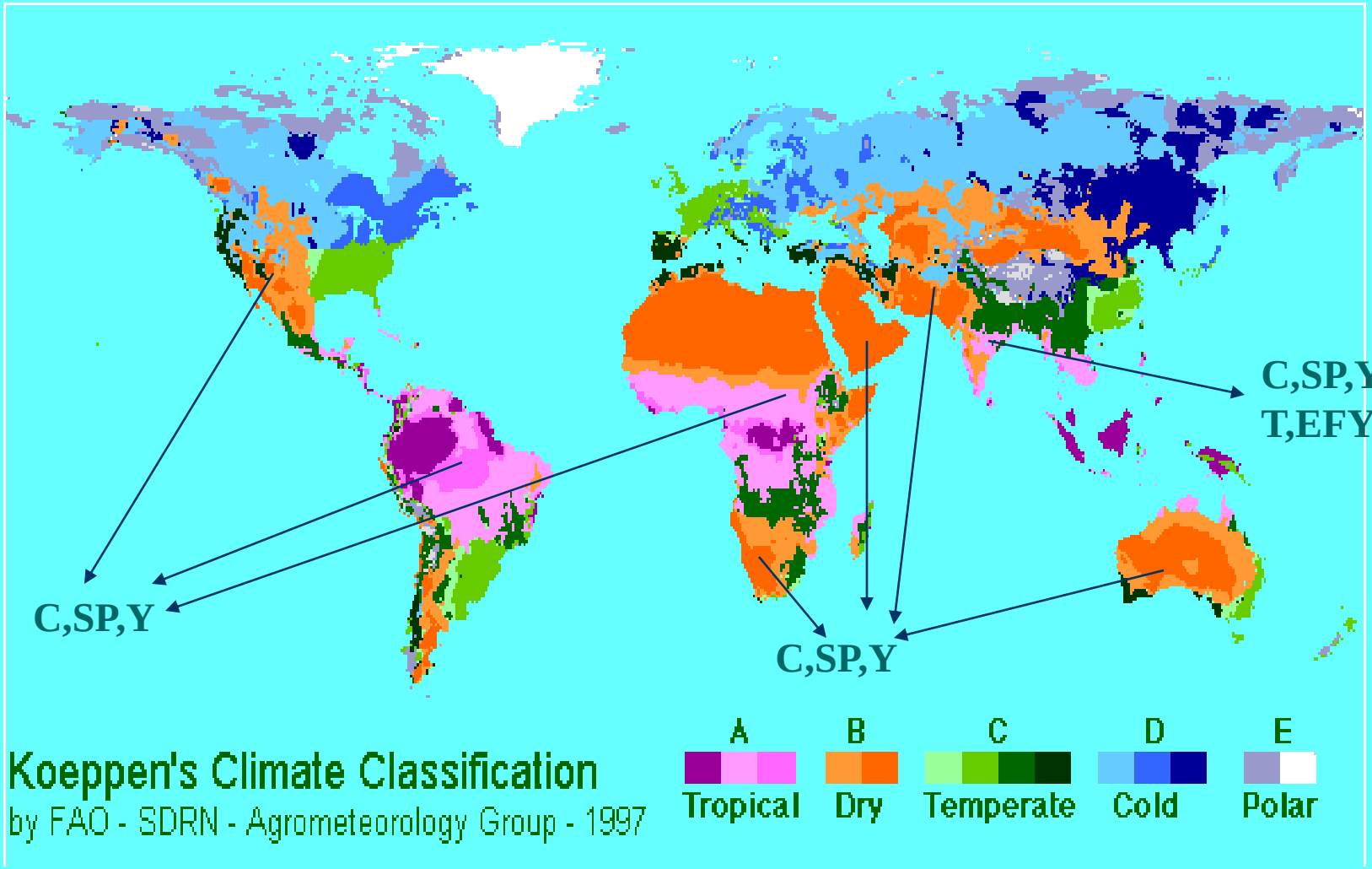
DIVERSITY OF TUBER CROPS IN HUMID TROPICS



Efficiency of food production of tuber crops

Important Food Crops

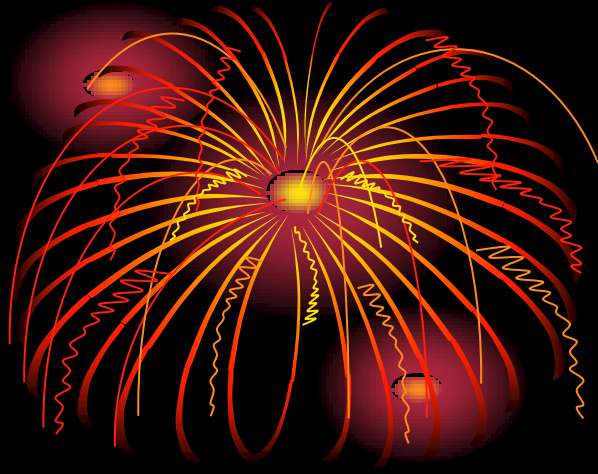
1.Wheat
2.Rice
3.Maize
4.Potato
5.Barley
6.Cassava
7.Sweet potato

(Ghosh *et. al.* 1988)

Carbohydrate production

Tuber crops - 6.7 t ha^{-1}
Rice or Wheat - 0.8 t ha^{-1}

(Mandal,1993)



Our vegetable requirement is 285-300 g/day

Balanced diet for an adult man should include 100g of root and tubers

Important tropical tuber crops

Common Name	Scientific Name	Family
Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
Sweet potato	*Ipomoea batatas*(L.)Lam	Convolvulaceae
Greater yam	*Dioscorea alata* L.	Dioscoreaceae
White yam	*Diosccorea rotundata* (Poir)	Dioscoreaceae
Lesser yam	*Dioscorea esculenta* (Lour).Burk	Dioscoreaceae
Potato yam	*D.bulbifera* var.*sativa*	Dioscoreaceae

Taro	***Colocasia esculenta*(L.) Schott**	**Araceae**
Tannia	***Xanthosoma sagittifolium***	**Araceae**
Elephant foot yam	***Amorphophallus paeoniifolius***	**Araceae**
Chinese potato **Yam bean** **Winged bean**	***Solenostemon rotundifolius*** ***Pachyrrhizus erosus(L)*Urban** ***Psophocarpus tetragonolobus* DC.**	**Labiatae** **Leguminosae** **Leguminosae**

West Indian arrow root	***Maranta arundinacea***	**Marantaceae**	**koova**
Queensland Arrow root or Purple arrowroot	***Canna edulis* Ker-Gawier**	**Cannaceae**	
Alocasia	***Alocasia macrorhiza***	**Araceae**	

Importance

- Grown in a wide range of soil and climate
- Flexibility in planting and harvesting time
- Propagation is much easier than other crops
- Can be grown in less care and management practices
- Less susceptible to insect-pests and diseases
- Give more yield with less time per unit area.
- Can be fitted well in multiple cropping systems
- Immense industrial value
- Nutritional/Therapeutic value

Negative consumption relationship with increase in per capita income- Poor man's crop

Nutritional Importance

- Major source of starch
- Excellent source of dietary fibre
- Rich in Vitamin A & C
- Rich in minerals

Cassava--50% more of wheat

Colocasia leaves - 80% more minerals than cabbage

Proximate principles and calories of tuber crops

Crop	Grams per 100g on dry-weight basis					
	Proteins	Fat	Minerals	Fibre	Other carbohydrates	Calories
Potato	7.3	0.4	2.4	1.6	89.0	382
Sweet potato	3.8	0.9	3.1	2.5	88.5	377
Cassava	1.7	4.9	2.5	1.5	84.9	386
Yam	4.7	0.3	5.3	3.3	86.6	370
Colocasia	11.6	0.4	6.3	3.7	78.5	361
Elephant foot yam	5.6	0.5	3.8	3.8	86.3	371
Colocasia leaves (Black variety)	31.9	9.4	11.8	8.5	38.0	362
Colocasia leaves (Green variety)	22.6	8.7	12.8	16.8	39.4	325
Sweet potato leaves	21.8	4.2	11.4	12.5	50.4	328

Source: Gopalan *et al* 1971

Energy Yield

Crop	Cal. $ha^{-1}day^{-1}$
Cassava	250 $x10^3$
Sweetpotato	240 x 10^3
Rice	176 x 10^3
Wheat	110 x 10^3
Maize	200 x 10^3

Area and production

	World	India
Area	29.8 m ha	1.4 mt
Production	313.5 mt	22.1 mt

Two-third production is from developing countries

Adaptability of crops

Crop	Temp (°c)	Rainfall (cm)	ph	Light	Soil fertility
Cassava	25-29	100-150	5-6	Shade sensitive	low
Sweet potato	>24	75-100	5.6-6.6	Shade sensitive	low
Yams	25-30	115-150		Shade intolerant	High
Taro	21-27	150-250	5.5-6.5	Shade tolerant	high
Tannia	13-29	140-200	5.5-6.5	Shade loving	high

Important features of tuber crops

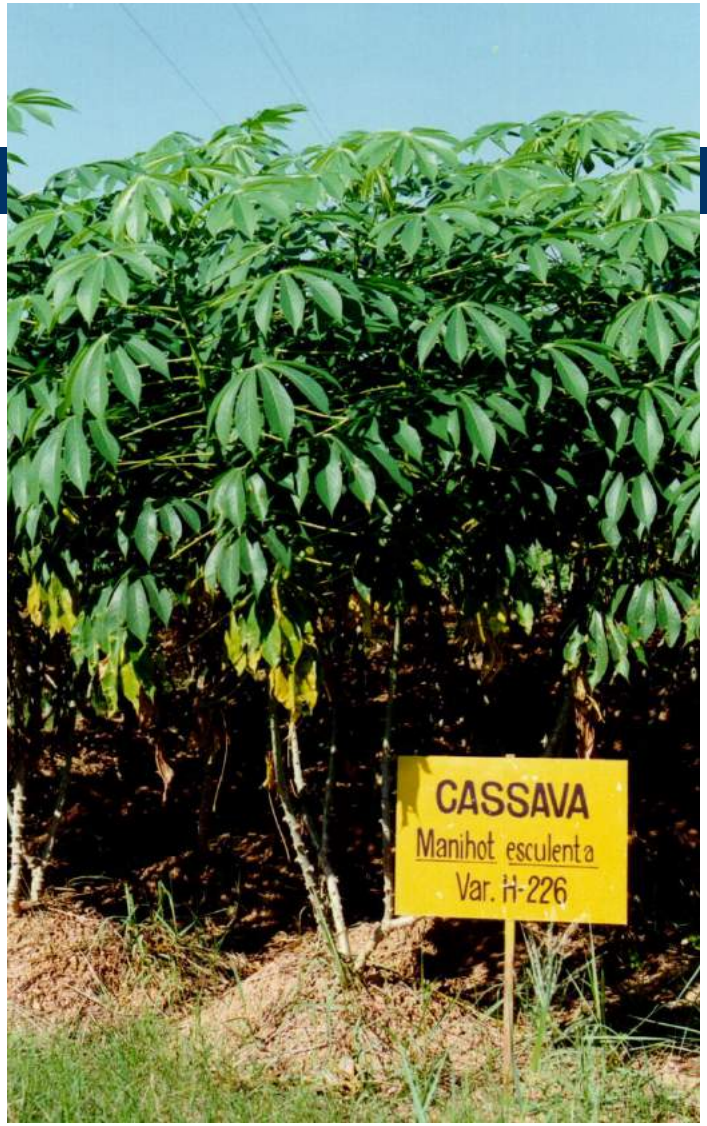
Crop	Planting time	Duration (Months)	Yield (q/b)	Income (Rs.000') /bigha
Cassava	May-June	8-9	30-40	5-6
Sweetpotato	Oct-Dec May-June	3.5-4 4-5	30-40 40-50	5-6 6-7
Yam	May-June	8-9	40-50	8-10
EFY	Feb-April May-June	5-6	90-100	15-20
Taro	Feb-April May-June	5-6	20-25	5-6
Swamp taro	Dec-Jan	7-8	35-40	7-8
Yam bean	Sep-Oct	3.5-4	85-50	7-8

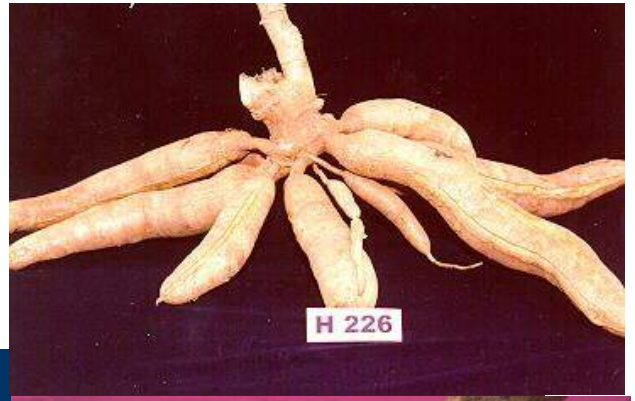
Cassava (*Manihot esculenta)*

Euphorbiaceae 2n=36

- **Native to South America (N. E. Brazil)**
- **Starchy staple in tropics (Africa, S. America, Asia)**
- **Also called *manioc, yuca and tapioca***
- **Introduced to India - Portuguese**

CASSAVA





BRAZIL

Cassava







Area and production (cassava)

	Area (m.ha)	Production (mt)	Productivity (t ha^{-1})
World	16.37	164.75	10.2
India	0.24	6.06	24.5

- Africa - > 50% of world area & production of cassava
- Nigeria – Ranks first in the world in area (16.5 %) & production (18.5%)
- India – Ranks 12th in area , 7th in production But 1st in productivity in the world
- In India, Kerala leads in area & production of cassava.

Cassava varieties

- fleshy roots contain poisonous compounds (cyanogenic glycosides - compounds that liberate cyanide) that must be removed before eating

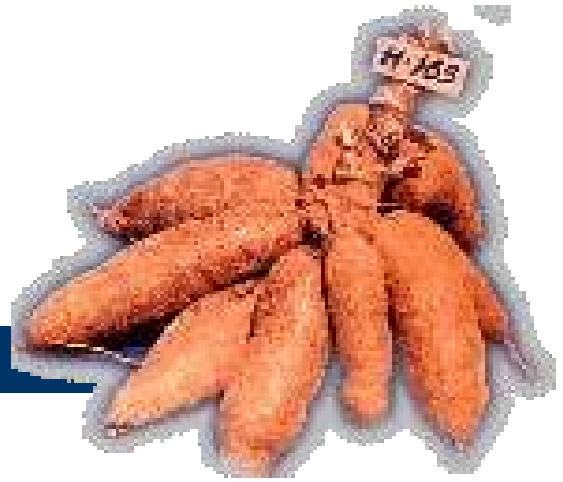
- In sweet types this will be concentrated on the rind

- The usual method of cooking, chipping, drying, parboiling and drying reduce the glucocide content significantly

H-97

- It is a high yielding variety of tapioca. Hybrid.
- Medium tall plants(1.5-2 m).
- Tubers with 27 - 29 percent starch;
- Yield of 25-35 T/Ha.
- Duration 10 months.
- Field tolerant to drought conditions as well as to Cassava Mosaic Disease (CMD) .

H -165



- It is a high yielding variety of tapioca.
- Hybrid.
- Medium tall (1.5 - 2 m).
- Starch content 23 - 25%.
- It is easily harvestable with good tuber shape.
- Duration 8-9 months.
- Yield 33- 38 T / Ha.
- Field tolerant to CMD.

Sree Visakham

- It is a high yielding variety of tapioca.
- Hybrid.
- Non branching tall (2- 2.5 m).
- Carotene content 466 IU.
- Starch content in fresh tubers 25-27 %.

Duration 10 months.

- Yield 35-38 T/ Ha.

Sree Sahya (H2304).

- It is a high yielding variety of tapioca.
- Multiple cross hybrid.
- Tall (2-2.5 m).
- Erect-branching.
- Occasional branching of tubers.
- Hardy and highly resistant to drought.
- Starch content 29-31 %.
- Yield 35-40 T/ Ha.
- Duration 10-11 months.

Sree Prakash

- It is a high yielding variety of tapioca.
- Selection from indigenous germplasm.
- Suitable for lowland cultivation.
- Short (1-1.5m) and non-branching.
- Duration 7 months.
- Yield 35-40 T / Ha.
- Starch content 29-31 % in fresh tubers.

Sree Harsha(H-2-14)

- It is a high yielding variety of tapioca.
- Triploid Variety.
- High yield and dry matter.
- Suitable for industrial purposes.
- Erect non-branching.
- Recorded an yield of 35-40t/ha.
- Starch content 38-41%.

H - 226

- It is a high yielding variety of tapioca.
- Hybrid.
- Medium tall (2-2.5 m).
- Starch content 28 - 30 %.
- Most popular variety in industrial areas.
- Duration 10 months.
- Yield 30-35 T / Ha.

Short duration varieties

Kalpaka

Non branching
Duration 6 months
Suitable for intercropping in coconut in reclaimed alluvial soils

Sree Vijaya

Duration 6 months.
Yield -25-28t/ha.
Starch content 27-30%.
The tuber flesh colour is light yellow after cooking.

Sree Jaya(CI-649)

High yielding variety of tapioca.
Duration 6 months.
Tuber yield:26-30t/ha
24-27% starch.

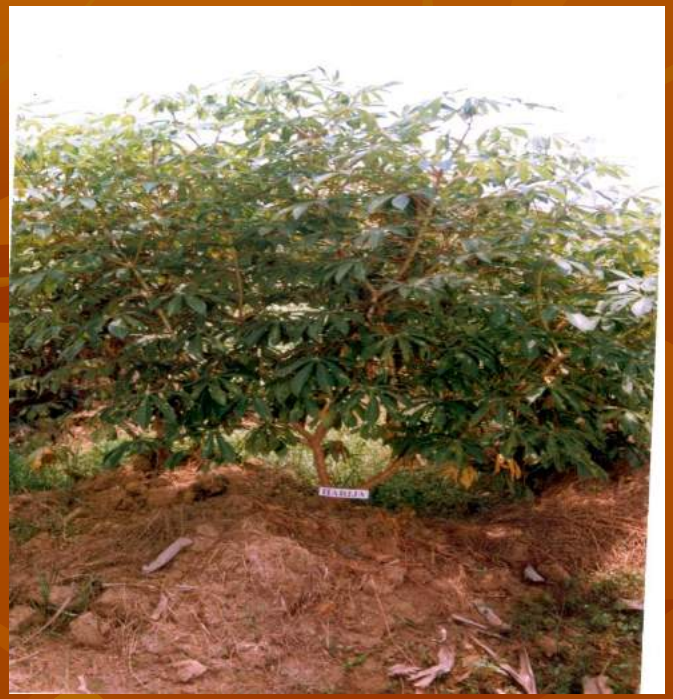
Vellayani Hraswa

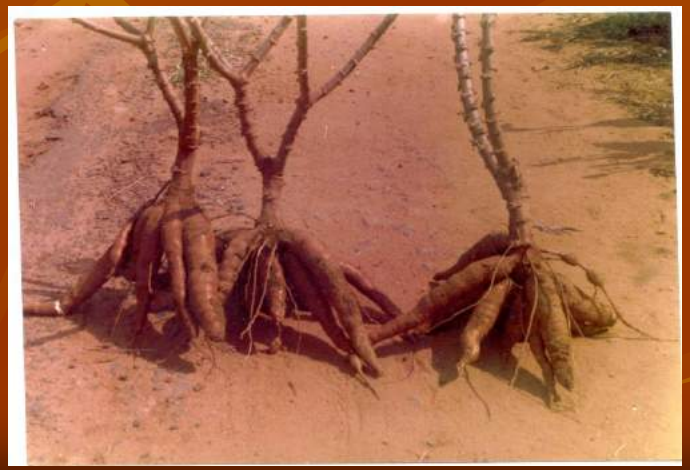
High yielding
Duration 5-6months
Very good cooking quality
Starch 27.8%
Cannot tolerate drought

Nidhi

High yielding
Duration 5.5-6 months
Tolerant to mosaic and moisture stress
Starch content 26.8%

Vellayani Hraswa





Ambakadan

Adaptability

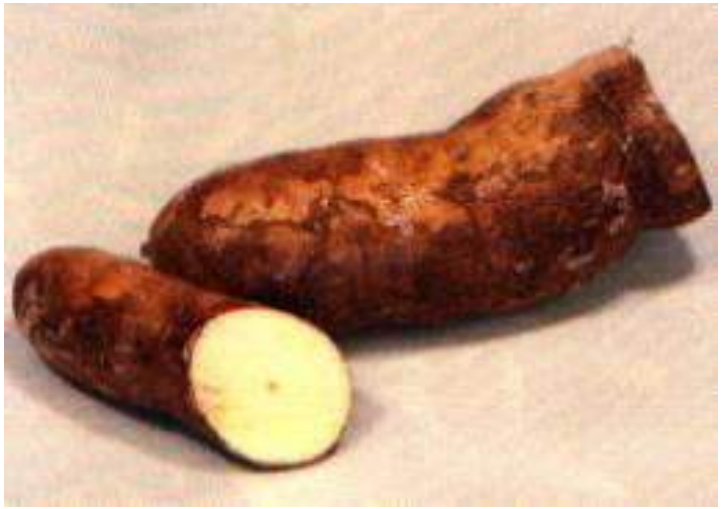
- Cassava is cultivated from latitudes 30^0 N to S.
- Crop of lowland tropics.
- Up to an elevation of 2000m.
- Optimum temp is 25-29°c.
- Tolerate very hot climate.
- Growth reduced if temperature falls below 18-20°c.
- Cassava classified as sun loving crop.

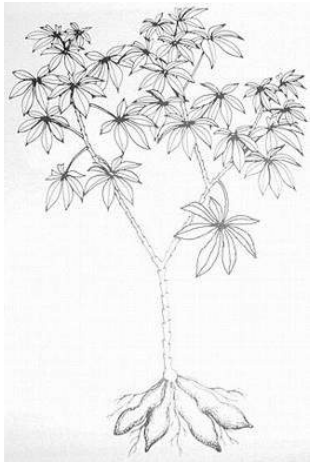
  *With shading there is drastic reduction in yield.

  * The crop can withstand drought situations
- Tolerates acidity

Varied Uses

- Best substitute for cereals in animal feed
- Raw material for the production of starch, sago etc.
- Leaves, tuber rind and ‘thippe’ (waste from starch factory) used as animal feed
- 30% starch, 1-3% protein





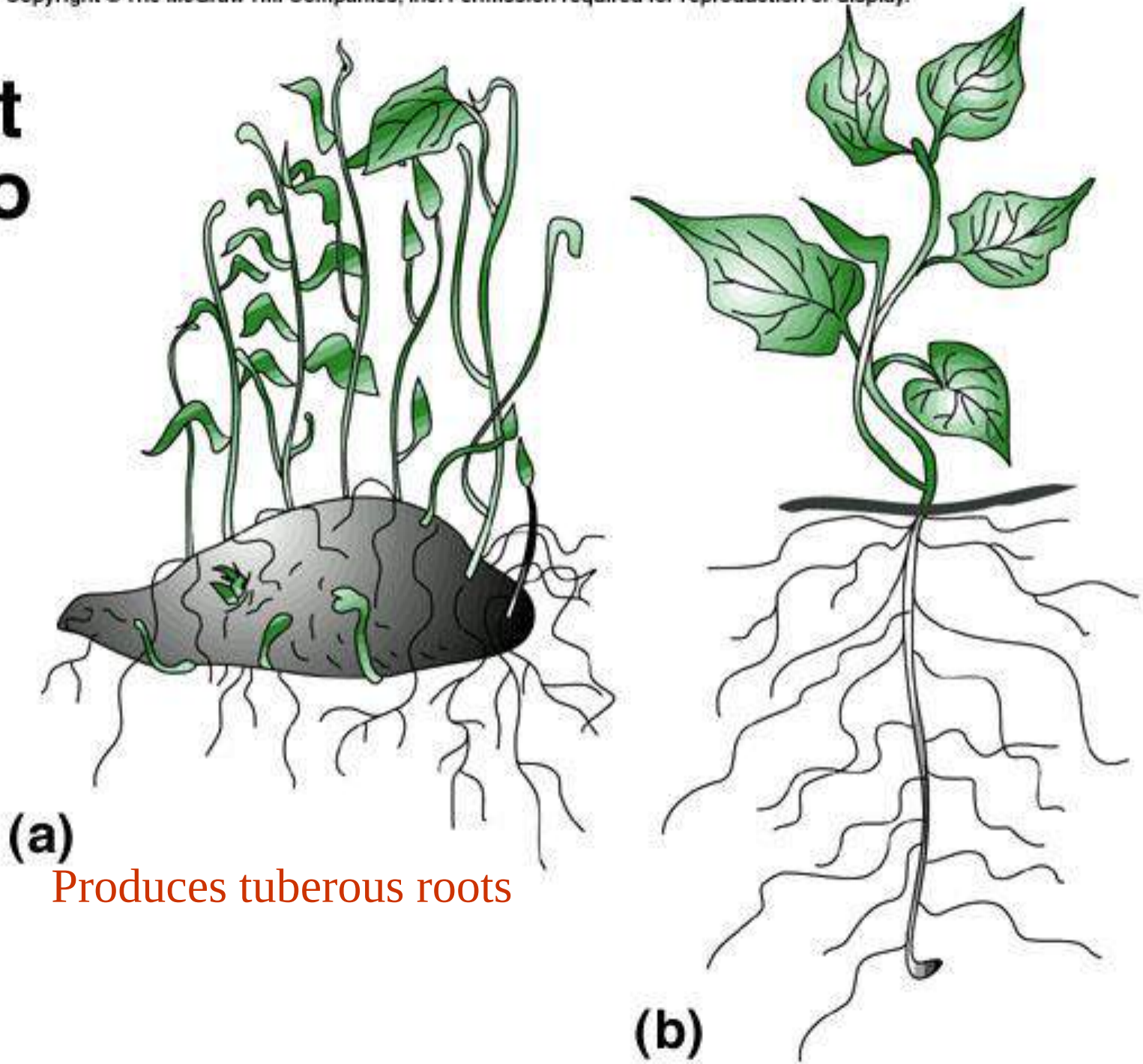
- 58% of cassava is used as food
- 28% as feed or feed ingredients
- 4% in alcohol and starch industries
- 10% is wasted

Value added products of cassava

- Starch- **Textile, Adhesive, liquid glucose, confectionery, laundry, pharmaceuticals**
- Sago - **Human consumption, Textiles**
- Wafers - **Human consumption**
- Chips - **Human consumption**
- Flour - **Animal feed, sizing clothes, gum manufacturers**
- Pappad - **Human consumption**


Sweet potato
(*Ipomoea batatas*)

Sweet Potato



Produces tuberous roots

Sweet potato (*Ipomoea batatas* (L) Lam.)

Family: Convolvulaceae

- Warm-season crop
- Tropical perennial (from S. America)
- Grown by natives of South America as well as Malaysia and Polynesia.
- Used as evidence of pre-Columbian contact between Pacific Islanders and South Americans.
- Introduced to Europe (Spain) by Columbus

Important features

- Sweet taste
- Rich in CHO
- Rich in vitamin A **(ß-carotene 0.5-40 mg/100g)** and C **(15-29 mg/100g)**
- 3-6% of carbohydrate is sugar
- Natural coloring agent
- Anti carcinogenic property

Adaptability

- Grows best at temperature above 24^0c.
- Temperature below 10^0c, crop damaged by frost.
- Shade sensitive crop. It can tolerate 25 % shade.
- Requires 500mm rain fall.
- Tuber yield affected if drought occurs in the first 6WAP.
- Grows best on sandy loam soils. Clay soil not suited, produces pencil tubers.
- Soil pH of 5.6-6.6.
- Sensitive to alkaline and saline soils.

- Sweet potatoes grown year-round in the tropics.
- Shortest growing cycle of the root crops
- The crop is normally harvested in about 4 MAP

Area and production

	Area (m.ha)	Prod. (mt.)	yield (t ha-1)
World	9.50	140.9	13.0
India	0.14	1.7	8.8

- 80 per cent of world production in China,
- U.S. accounts for 1 per cent of production

Sweet potato

Two types

- Cream-to-light yellow colored flesh
- Yellow or deep orange colored flesh


VARIABILITY IN FLESH COLOUR


VARIABILITY IN SKIN COLOUR

Sree Nandini

It is a high yielding variety of sweet potato developed through Open pollinated seed progeny
Semi spreading variety
Early maturing (100-105 days).
Suitable for paddy fallows as a catch crop
Yield 20-25 t / ha.
Good starch content (18%)

Sree Vardhini

- It is a high yielding variety of sweet potato.
- Open pollinated seed progeny.
- Semi spreading variety.
- Early maturing (100-105 days)
- Dual purpose variety.
- Carotene content 1200 IU/100g.
- Yield 20-25 t / ha.

Other important varieties

Sree Bhadra , Samrat , Gouri , Shankar,

H-85/16, OP-21,Kamala Sundari, Bidhan Jagannath , Kalmegh, R.S.-5, Pusa Safed,

Sree Arun, Sree Varun

Varied Uses

- Used as a staple food
- As a vegetable – fleshy roots, tender leaves
- Snack food
- Animal feed
- Raw material for various industries
- Yields important starch
  - **used as a food starch in noodles etc.**
  - **Technically for sizing textiles and papers**
  - **For the manufacture of adhesives and in laundries.**

- The leafy top of the plant (vines) are used as green vegetables (as salads) in Asia, Africa and Hawaii.

- Sweet potato vines, peels, trim wastes and pulp residues after starch recovery can be used for making silage.

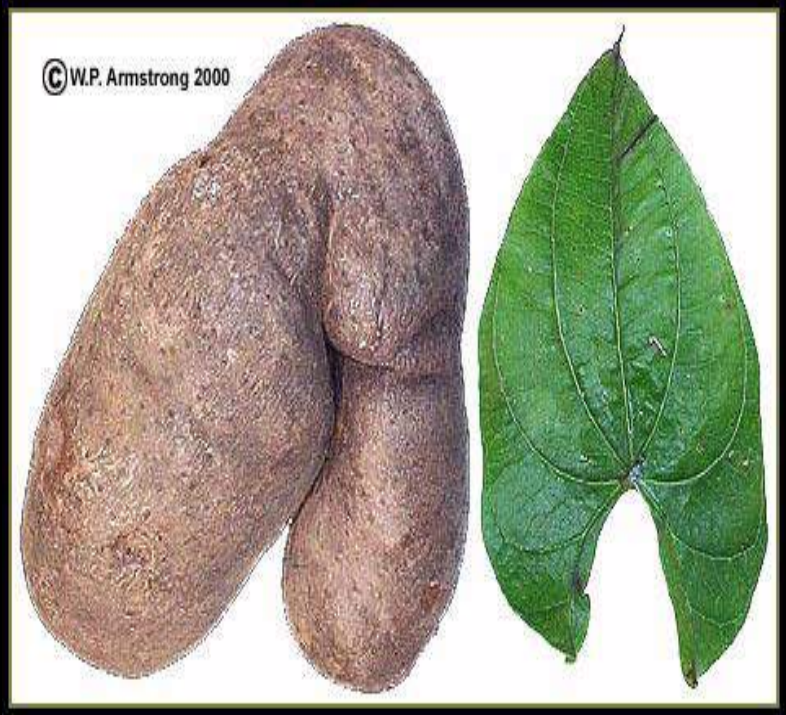
Yams *(Dioscorea sp.)*

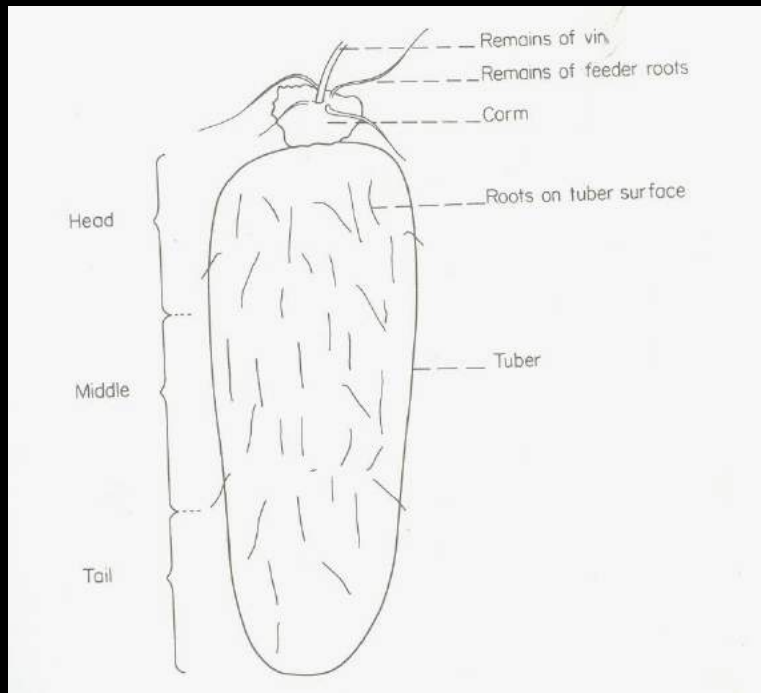
- Family Dioscoreaceae
- Origin W. Africa
- Tubers large and hard to harvest
- Contains 20% starch
- Low in protein, vitamins (low in carotene too), & minerals
- Tubers contain *saponins*, type of steroid
  Once used to make human sex hormones and cortisone

The genus *Dioscorea* contains a wide range of species (more than 500).Out of which 50 species are found in India.

The edible yams comprise mainly three species

- **African yam**
- **Greater yam**
- **Lesser yam**

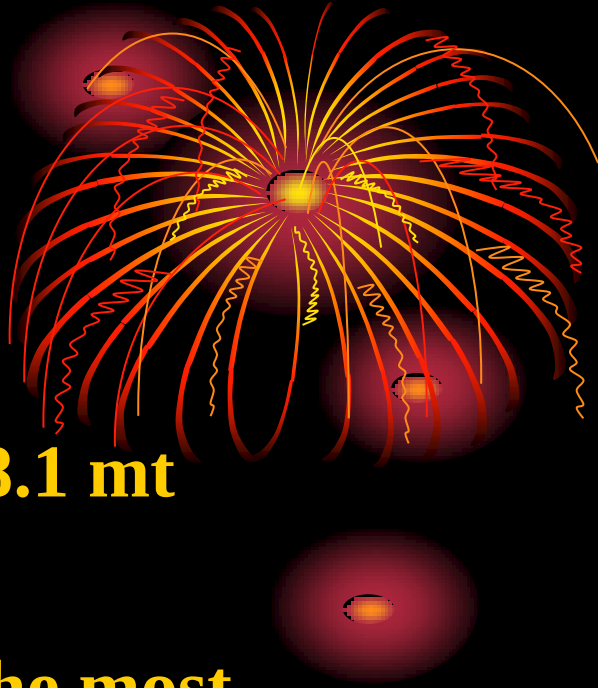




YAMS

GREATER YAM	***Dioscorea alata (L.)***	***Dioscoreaceae***
AFRICAN YAM	***Dioscorea rotundata (Poir.)***	***Dioscoreaceae***
LESSER YAM	***Dioscorea esculenta (Lour.)Burk.***	***Dioscoreaceae***

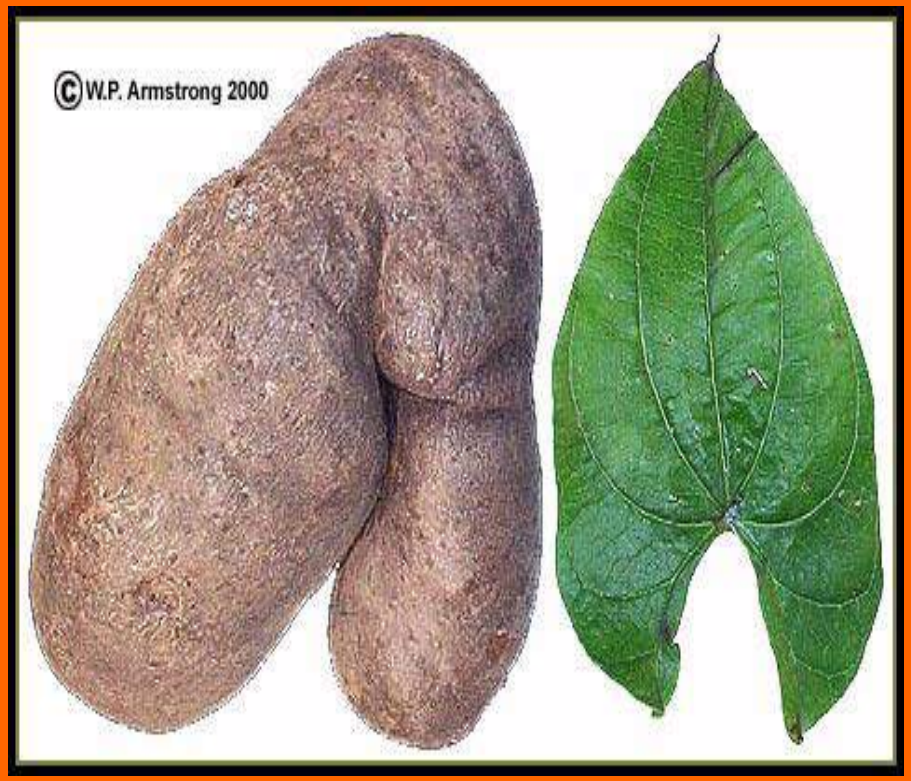
Yams



- The world production of yam -- 28.1 mt
- 96% came from West Africa
- In West Africa, yams are one of the most highly regarded food products
- They are closely integrated into the social, cultural, economic and religious aspects of life. Traditional ceremonies still accompany yam production, indicating the high status given to the plant.

Greater yam (*Dioscorea alata* L.)

- Originates from South East Asia
- The species most widely spread throughout the world
- Tuber shape is generally cylindrical, but can be extremely variable.
- Tuber flesh is white and "watery" in texture.



Varieties of Greater Yam

Sree Keerthi

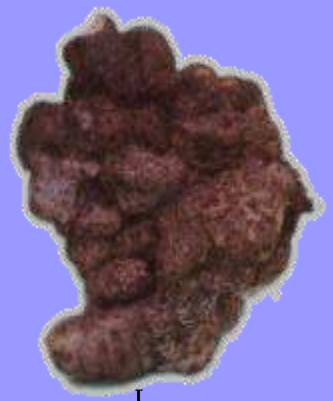
Climb to a height of 4-5m

Starch content 20-22 %

Good cooking quality

Excellent taste.

Duration 9-10 months.
Yield 25-30 T / Ha.



Sree Roopa

Climb to a height of 4-5 m

Tubers are smooth

Excellent cooking quality.

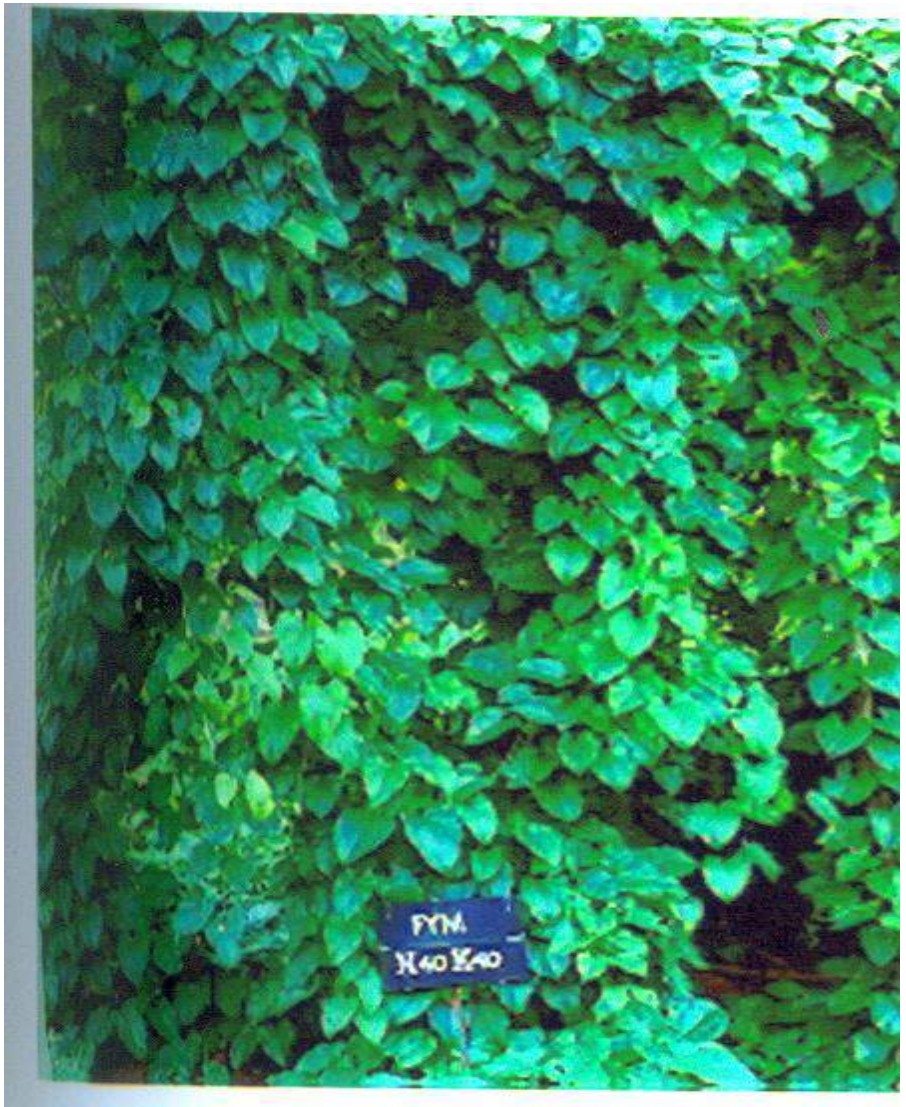
Starch content 17-19 %

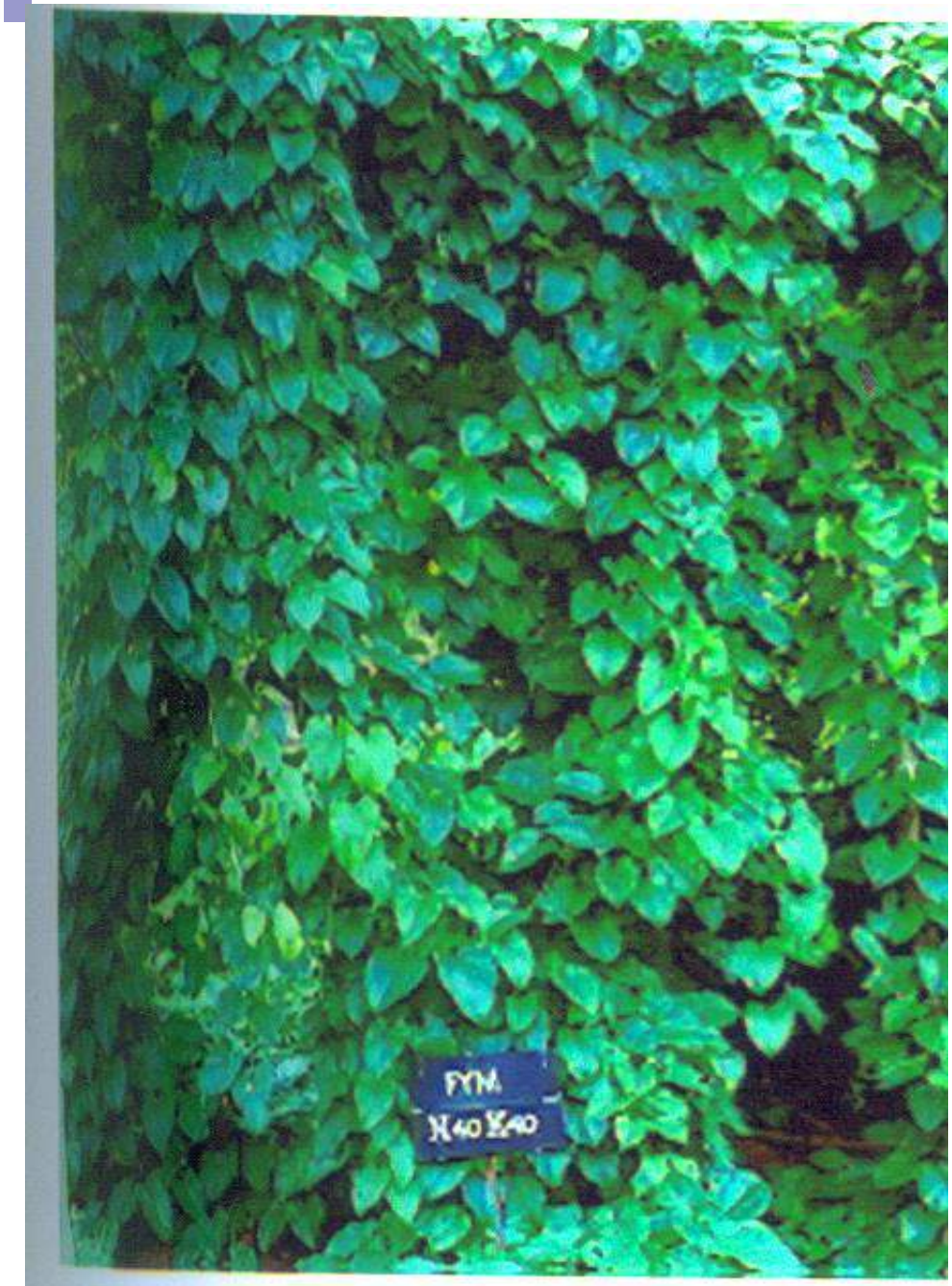
Protein 1-2 %.

Duration 9-10 months.
Yield 25-30 T / Ha.

White or African yam (*Dioscorea rotundata* Poir)

- Originated in Africa
- The most widely grown and preferred yam species
- The tuber is roughly cylindrical in shape, the skin is smooth
- The flesh usually white and firm





White yam

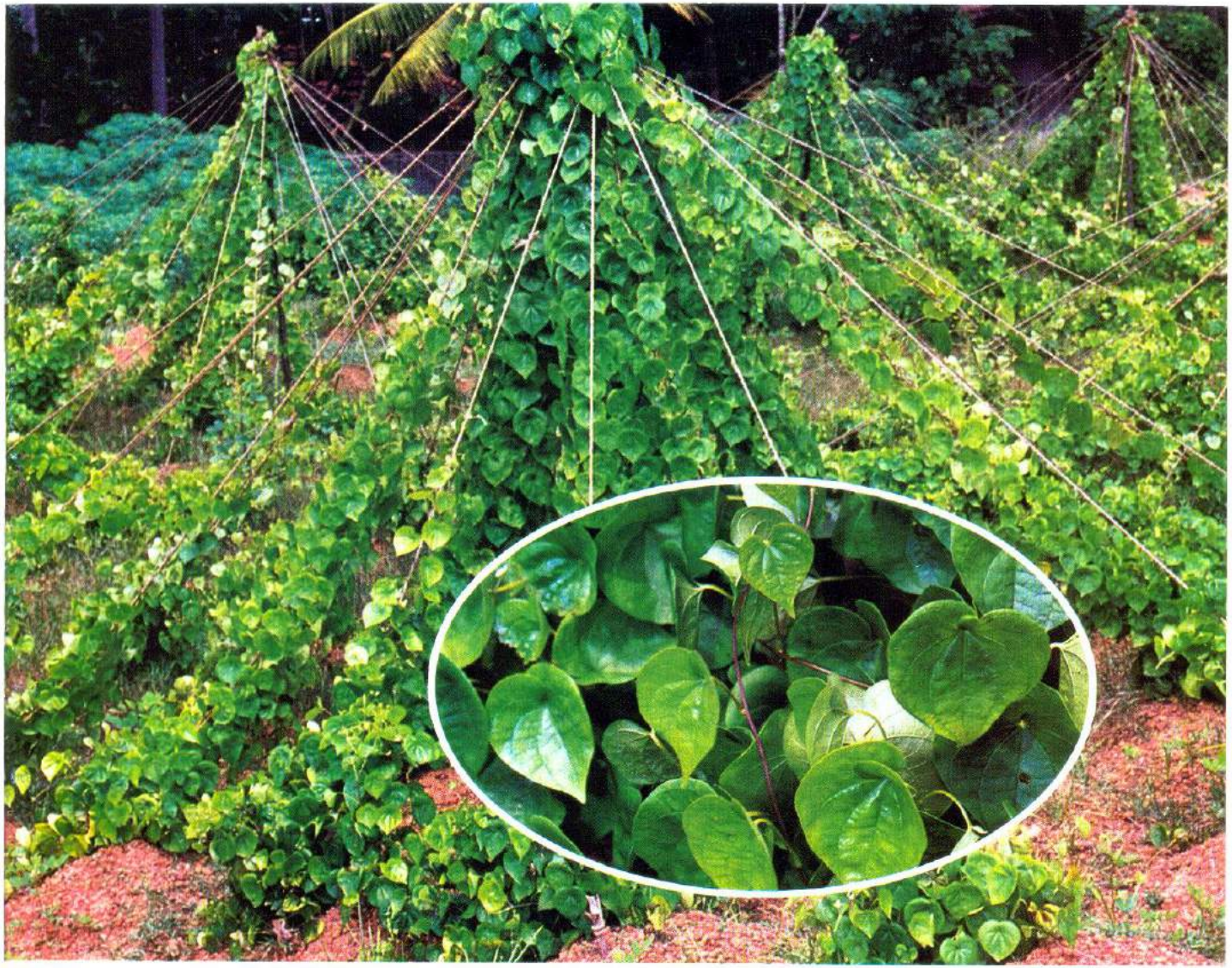
As intercrop in coconut

Varieties

Sree Priya,

Sree Subhra

LESSER YAM



LESSER YAM VARIETIES

Sree Latha

Duration 7.5- 8 months.

Yield 25 t/ ha.

Starch content 24.4 %

Sree Kala

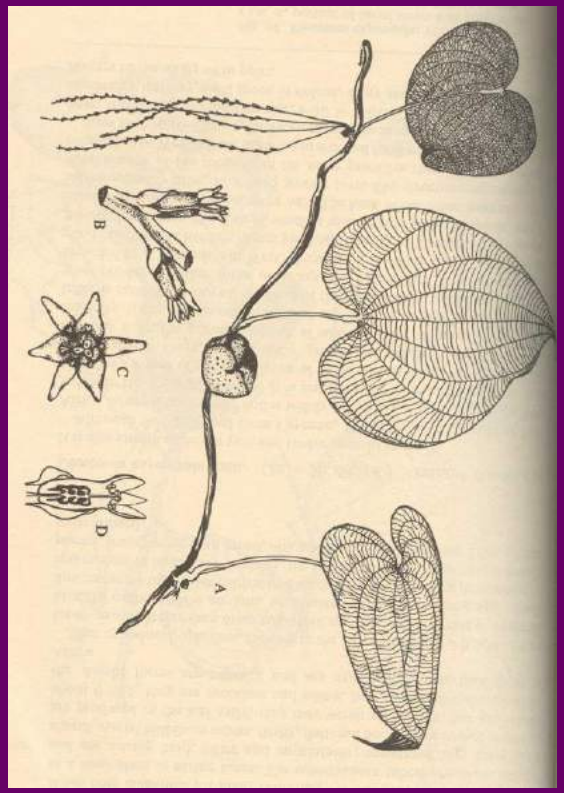
Tubers oval in shape

Excellent cooking quality

Yield 20-25 t/ha

Tuber surface very smooth and hairs absent

D. bulbifera



- **Major Alkaloid is Diosgenin-used as contraceptic pills**
- ***D. floribanda, D. prazeri*** **are the two important species, Diosgenin is commercially extracted.**

AROIDS

TARO	***Colocasia esculenta* (L.) Schott**	**Araceae**
TANNIA	***Xanthosoma sagittifolium***	**Araceae**
ELEPHANT FOOT YAM	***Amorphophallus paeoniifolius* (Dennst.) Nicolson**	**Araceae**

Classification of taro

cocoyam

- *Colocasia esculenta* (taro) → old cocoyam
- *Xanthosoma* sp. (tannia) → new cocoyam

cocoyam

- “potato of the humid tropics”
- *Poi*, traditional dish of native Hawaiians
- Corms are steamed, crushed, made into a dough, and fermented
- Cooked similar to potatoes
- Processed into flour, chips, breakfast foods

Old cocoyam

New cocoyam

Upland taro

Colocasia esculenta var *esculenta*(dasheen type)

Colocasia esculenta var. antiquorum (eddoe type)

Varieties of eddoe taro

Bidhan Chaitanya

Bidhan Joydeb

Sree Reshmi

Sree Pallavi

These two varieties are early maturing (5-6 months), tolerant to *Phytophthora* blight and give yield to the tune of 15-20 t/ha.

Dasheen type mother corm

Lowland taro

Swamp taro (*C.esculenta var. stolonifera)*

Giant swamp taro

(Cyrtosperma chamissonis)

TANNIA

Giant taro


GIANT TARO
ALOCASIA MICORRHIZA
GIANT TARO
ALOCASIA MICORRHIZA

ELEPHANT FOOT YAM
(*Amorphophallus paeoniifolius*)

- Two distinct forms
  - Forma sylvestris scabrous petiole more acrid
  - Forma hortensis smooth petiole acridity less

uses

- As vegetable
- Boiled and baked product
- Source of starch
- Medicinal property
- Flour has got varied uses

Varieties: Bidhan Kusum, Gajendra, Sree Padma

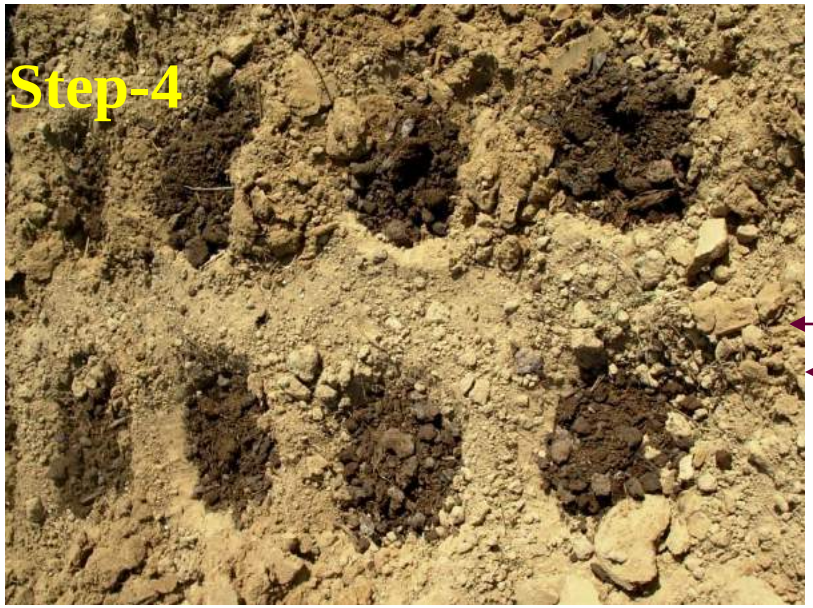
Vegetable production

- ❖Corm weighing about 500g is economically beneficial for planting.
- ❖Generally planted at a spacing of 75 cm in both ways during February to March.
- ❖Fertilized with 150 kg N, 120 kg P2O5 & 150 kg K2O along with 20-25 t FYM/ha.
- ❖Harvested within 5-6 months after planting.
- ❖Yield: 80-100 t/ha.

Seed production

- ❖100-150 g mini corm sett is ideal.
- ❖Planted at a spacing of 50 cm in both ways.
- ❖Fertilized with 100: 75: 100 Kg NPK/ha.
- ❖Harvested within 8-9 months after planting.

Seed production through mini corm setts



Minor Tuber Crops

- **Chinese potato** ***Solenostemon rotundifolius***
- **Yam bean** ***Pachyrhizus erosus***
- **Winged bean** ***Psophocarpus tetragonolobus***
- **West Indian arrow root** ***Maranta arundinacea***
- **Queensland arrow root/ Purple arrow root** ***Canna edulis***

Yam bean

It is a leguminous sexually propagated tuber crop

Raw tuber is used as juicy fruit

Seed contains rotenone which acts as botanical insecticide

Released variety- RM-1

West Indian Arrow root

- **Arrowroot introduced to Europe by European settlers of the New World from the Arawak / Caribbean Islands & regions north of Brazil.**

- **The Arawak named it *aru-aru*, meaning "meal of meals".**

- **The Arawak used arrowroot tubers to draw poison from wounds inflicted by poisoned arrows, hence the name "arrowroot".**

Arrow root

- Shade loving crop
- Arrowroot starch easily digestible
- Base for tablets
- Food for infants and invalids
- Health drink
- Possess demulcent properties

COLEUS

Chinese potato (Coleus) grown in most of the homestead gardens.

The plant is a small herbaceous bushy annual with succulent stems and aromatic leaves.

The crop duration is 5 months.

The plant bears a cluster of dark brownish tubers

Queensland arrow root

- Grown throughout the country for edible rhizomes.
- The fleshy rhizomes flavour and taste with less fibre.

- Young rhizomes used as vegetable. It contains 20-25% starch.
- The starch is easily digestible

- The bakery products from canna starch are much lighter, spongier and crisper than those from wheat products.

Tuber

Intercropping System

Cassava + groundnut

Cassava + cowpea

Homesteads

- Tuber crops are major component of most of the homesteads

Tuber crops and trade

- Enhance market appeal through value addition
- Broadening the spectrum of utilization

Tuber utilization

As food

- Boiled/baked
- Fried
- Fermented
- Sago
- Bread
- Rave

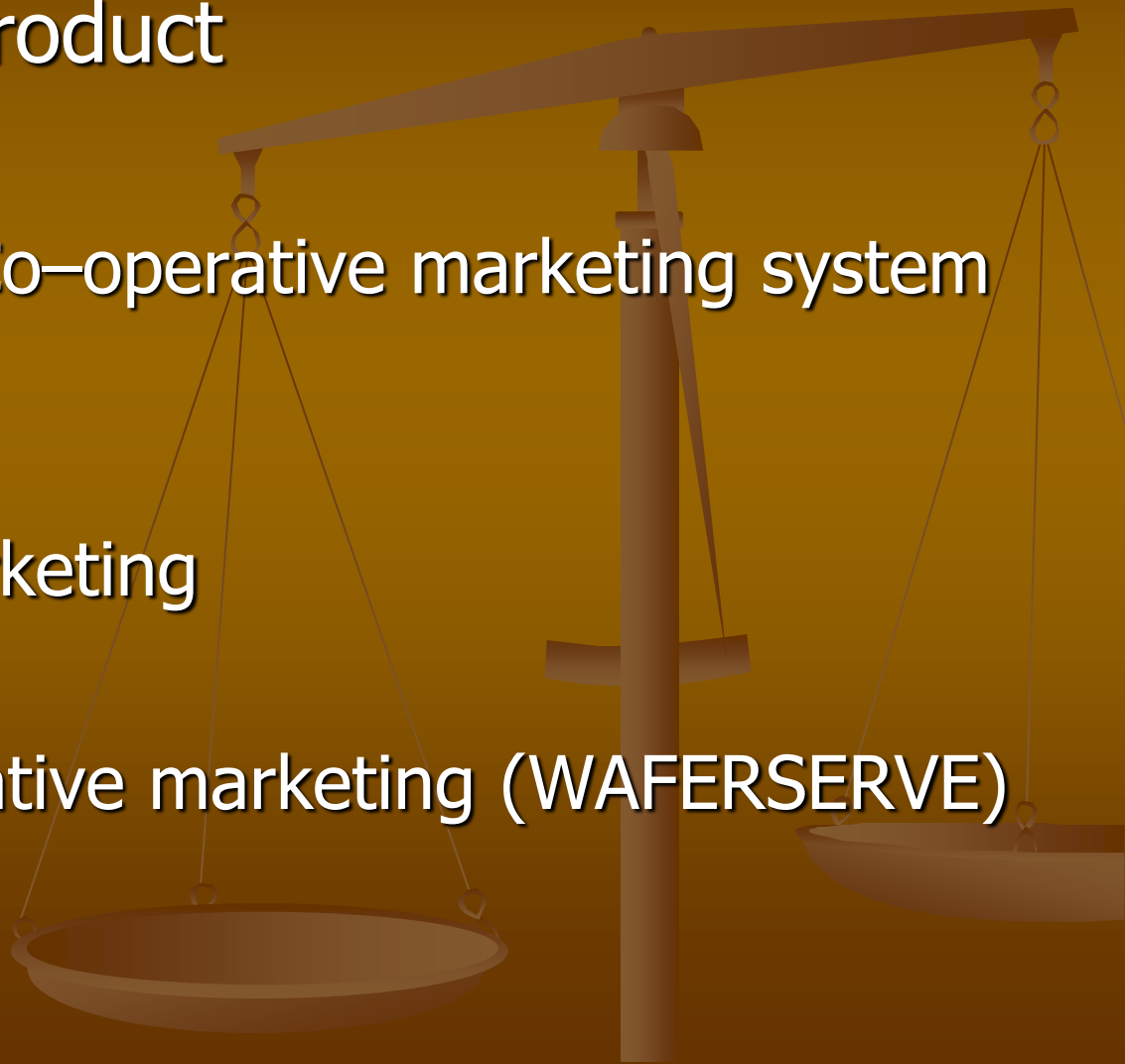
candies
pickles
jam
sauce
cutlet
puffs
gulabjamuns etc.

Cassava is marketed in three ways

- As raw materials to industries
- As value added products (starch,sago,chips)
- As by product of starch/sugar industries (Thippi & peel)

As Value added Product

- Starch & Sago – Co–operative marketing system (SAGOSERVE)
- Flour – Direct marketing
- Wafers – co-operative marketing (WAFERSERVE)



Starch

Vast potential in food and industry

- Easily digestible food
- Biodegradable plastic
- Sweeteners
- Alcohol
- Textile and paper industry
- Starch derived products **dextrins, glucose syrup, fructose syrup, sago**

Value added products

Different types of cassava products, cassava bread and cassava starch

Value added products eddoe chips and sweet potato chips

Cassava chips

Sweet potato French fries

Sweet potato Golab Jamun

Sweetpotato Jam

Sweetpotato Pickles

Sweetpotato squash

Amorphophallus Payasam

Anti-nutritional factors

Potentially toxic / reduce the bioavailability of other nutrients

(i) Cyanide in Cassava

(ii) Flatulence and Trypsin inhibitors in Sweet potato

(iii) Acridity of Aroids

Cyanide toxicity in humans

- Cyanide –normal constituent of blood
- Blood concentration of cyanide is <12 μmol / l.
- Lethal action of cyanide → blocking the reduction of O_2 in respiratory pathway.

Cyanide concentration

10-1000mg per kg of fresh tuber

Concentration, mg kg^{-1}	**Toxicity**
<50	- harmless
50-80	- slightly poisonous
80-100	- toxic
>100	- fatal

Acridity of aroids

- Forceful ejection of raphides or needle like crystals (insoluble calcium oxalate) from the idioblast causes irritation.

- Proteolytic enzymes –role in irritating reactions and proteinases occur in corms

Removal of acridity

- Selection/breeding acrid free varieties
- Treatment with acids like hydrochloric acid, tartaric acid and citric acid.
- Cooking tubers in water or steam cooking

Conclusion

Higher biological efficiency and higher rate of dry matter production per day per unit area make tuber crops inevitable and important components in our food security systems.

THANK YOU

Lecture 14. Introduction on leafy vegetables. Origin, area, production, economic importance, description of varieties and hybrids, climate, soil requirement, seed rate and preparation of field, sowing, spacing, irrigation, nutrition , inter cultivation, harvest and post harvest handling of amaranthus

- Introduction on leafy vegetables
- Cultivated indigenous leafy vegetables
- Non cultivated naturally growing leafy vegetables
- Perennial greens
- Introduced leafy vegetables
- Amaranthus
- Importance and utility
- Varieties released from TNAU, Coimbatore
- IARI Varieties
- IIHR Varieties
- Climate
- Soil
- Season
- Seed rate and fertilizer recommendation
- Land preparation and sowing
- Irrigation and inter cultivation
- Harvesting
- Yield

Introduction on leafy vegetables

Among all vegetables, the leafy vegetables have a very high protective food value. They are rich in calcium, iron and other minerals and in vitamin A & C. Besides, they are soft fibrous matter provides the necessary roughage in the diet.

In India, leafy vegetables are generally considered inferior than other vegetables like peas, cauliflower and tomato which are more palatable and appetizing but fact remains that

leafy vegetables when properly prepared are equally palatable considering their extra nutritive value, the leafy vegetables deserve greater recognition.

There are varieties of leafy vegetables under cultivation in India. Certain plants which grow wildsuch as alternanthera,celosia portulaca etc. are also used as leafy vegetables. Among the several leafy vegetables Amaranthus is one of the most important warm season leafy vegetable.

The cultivation of leafy vegetables is well known in the state since time immemorial. The state has its credit on number of local edible leafy vegetables which are both cultivated and uncultivated.

Leafy vegetables could be grouped into:

1. Cultivated indigenous vegetables
2. Uncultivated naturally occurring leafy vegetables
3. Introduced leaf vegetables
4. Cultivated perennial leafy vegetables

1. Cultivated indigenous leafy vegetables

A. *Amaranthus tricolor* B. *Amaranthus viridis*

C. *Amaranthus dubius* D. *Atriples hortensis*

E. *Anethem rowa* F. *Alterneathera sessiles*

G. *Hibiscus carbis* H. *Coriandrum sativan*

I.*Portulaca grandiflora* J. *Trigonella foenum gracum*

2. Non cultivated naturally growing leafy vegetables

A. *Alternanthera echinate* B. *Amaranthus sessiles*

C. Amaranthus caudetus D. *Amaranthus gangeticus*

E. *Amaranthus polygamus* F. *Amaranthus spinosus*

G.*Centella asiatica* H.*Celosia argentia*

I. *Coleus amboinicus* J. *Jatropa prostrate*

K. *Oxalis carniculate*

3. Perennial greens

A. Subania grandiflora B. *Moringa olerifera*

C. *Sauropus androgynus* D. *Tamarindus indica*

4. Introduced leafy vegetables

- Spinach, Celery, Lettuce. Parsely, Basella, Ceylon (Talinium triangulare) etc,.

Amaranthus

Scientific name : *Amaranthus* Sp.

Family : *Amaranthaceae*

Chromosome number : 2n=32 or 34

Origin : India

Leaf type

Amaranthus tricolor/ganetious

Amaranthus tristis

Amaranthus lividus

Amaranthus blitum

Amaranthus durbius

Amaranthus viridis

Grain Amarath species

Amaranthus caudatus

Amaranthus cruentus

Amaranthus hypochondriacus.

Amaranthus edulis.

Importance and utility

Amaranthus is the most common leafy vegetable grown during summer and kharif season in India. It fits well in crops rotation because of its very short duration and large yield of edible matter per unit area. The estimation of the extent of its cultivation is not available. Green or leafy types are usually grown in kitchen and market garden. The grain amaranthus species are popular in the high lands of tropical and sub-tropical America. It is gaining importance in the Indian plains also, particularly in Gujarat and Maharashtra. Grain types are usually grown as mixed crops along with cereals, pulses and vegetables.

The leaves and tender stems of Amaranthus are rich in protein, minerals, vitamin A and C.100g of edible portion of Amranthus consists of Protein 4.0 g, Calcium 397 mg, Iron 25.5 mg, Magnesium 247 mg, Phosphorus 83 mg, Potassium 341 mg, Sulphur 6 mg, Vit C 99 mg and Vit A 9200 IU. Besides, the soft fibrous matter provides necessary roughage in the diet.

The fresh tender leaves and stem of amaranthus are delicious when cooked and consumed like other leafy vegetables. The tiny seeds of grain. Amaranthus are parched and milled for flour.Amaranthus flour compares favourably with other cereals in taste, nutritional value and yield.

The grain amaranthus is a rich source of protein and essential aminoacids like lysine, leucine and isoleucine which are required for growth of children.

Varieties released from TNAU, Coimbatore

Co.1 (*Amaranthus dubius*)

- Developed at TNAU
- Selected for tender leaves and mature stem
- Suited for early harvest
- Not suited for clipping of leaves
- 7-8 t/ha in 30 days
- Suited for late harvesting

Co.2 (*Amaranths tricolor*)

- Developed at TNAU
- Suited for early harvest
- Not suited for clipping of leaves
- 10-11 t/ha in 25 days

Co.3 (*Amaranthus tristis*)

- Developed at TNAU
- Suited for clipping tenders greens at weekly cultivars
- First clipping 20 days after spring green
- Ten clippings can be taken continuously
- Grain yields 10-12t/ha

Co.4 (*Amaranthus hypochondriacus*)

- Green cum grain type.
- Plants are dwarf

-Make rapid vegetative growth in 20-25 days.

-7-8 tonnes of green matter per hectare

-Grain yields 2 to 2.5 tons per hectare in 80 to 120 days

IARI Varieties:

Chhoti chaulai (*Amaranthus blitum*)

- Plant erect, dwarf, small green leaves
- Respond well to clippings/cuttings
- Suited for sowing in early summer

Badi Chaulai (*Amaranthus tricolor*)

- Plants have thick stem and longer leaves
- Well to clipping/cutting
- Suited for sowing at warm summer

Pusa Chaulai (*Amaranthus tricolour*)

- Stem medium thick, tender and leaves medium to large in size.

- Suited for sowing at early summer
- Yields 45 t/ha

Pusa Kiran

- Suited for growing in rainy season
- It gives yield of 35 t/ha

Pusa Keerthi

- Suited for growing in summer season
- It gives yield of 50 t/ha

IIHR Varieties

Arka Suguna

A pure line selection from an exotic collection from Taiwan (IIHR 13560) Light green, succulent stem and broad leaves.First harvest in 25-30 days after sowing and 5-6 cuts in 90 days. Moderately resistant to white rust under field conditions.Yield 25-30 t/ha.

Arka Samraksha

Arka Suguna

Arka Samraksha: It is a high yielding amaranth variety, with high antioxidant activity of 499mg (AEAC units) and minimum nitrate content of 27.3 mg and 1.34g of oxalates per 100g fresh weight of leaves. It is a pulling type amaranth variety with green leaves and stem, yields 10.9t/ha in 30-35 days duration.

Arka Varna

Arka Varna: It is a high yielding amaranth variety, with high antioxidant activity of 417mg (AEAC units), nitrate content of 37.6mg and 1.42g of oxalates per 100g fresh weight of leaves. It is a pulling type amaranth variety with green leaves and pink stem, yields 10.6 t/ha in 30-35 days duration.

Climate

Amaranthus species are widely distributed in temperate and tropical regions of the world. Different species differ in their day length (Photo period) requirements and respond differently to changes in photo and thermoperiodism. *A. caudatus, Amaranthus edulis* and *A.cruents* are short day (plants) species while *A. hypochondriacus* is reported to be day neutral. However it does well under warm situations temperature ranging from 22 to 30^0C. Grain Amaranthus is highly resistant to drought.

Soil

Amaranthus can be grown in a wide range of soil, however well drained loamy soils are best suited for this crop. Heavy soils with poor drainage and sandy soils with poor water holding capacity are unsuited for its cultivation. It can be grown in a pH range of 5.5.-7.5. However slightly acidic in nature are preferred.

Season: It can be grown throughout the year. However March to September are the best months to start the crop.

Seed rate & fertilizer recomendation

One hectare area requires around 2.5 kg seeds with recommended NPK is 100-50-50 kg inaddition to well decomposed 15-20 tons of FYM.

Land preparation and sowing

Prepare the land thoroughly by ploughing, harrowing and bring the soil to fine tilth. Incorporate entire quality of organic manure into the soil. Prepare the beds of convenient size. 3mx2m or 2mx1.5m with irrigation channels running between every two rows of beds. After the beds are ready apply entire dose of P and K along with 50% N and mix them well in the soil.

Sow the seeds thinly. On account of smallness of seed ,it should be sown shallow to a depth of 0.5-1cm .Since the seeds of Amaranthus are small in size, to achieve even distribution, mix the seed with fine sand or red soil before sowing. For line sowing spacing between rows is 20cm.

In grain amaranthus (*Amaranthus hypochondriacus*), the plants are thinned that have a spacing of 30cm x 30 cm on 25th day and they are allowed for flowering. The crop will be ready for harvest in 80-120 days depending on the variety and season. The dried spikes are threshed to separate grain which is used to prepare popped grain, green cakes, infant foods and the preparation like amaranthus malt.

Irrigation & inter cultivation

Provide light irrigation after sowing. Three days once or weekly irrigation is necessary, depending on soil and weather conditions. Top dress the crop with remaining 50% of N 20-25 days after sowing. Keep the land free from weeds.

Harvesting

Young seedlings are pulled out with roots, washed, tied into bundles and sent for marketing.

Crop will be reading for first clipping or cutting 25-30 days after sowing. The subsequent cuttings can be made at an interval of 6-10 days. It gives about 6-10 cuttings.

Yield

It is highly perishable hence leaves should be used same day of harvest. Average yield is 25 tonnes per hectare in leaf types whereas grain types yield is around 2 to 2.5 tonnes per hectare.

Questionnaire

A. Encircle the most appropriate answers:

1.---------- is basically known as amaranths tricolour.

a. Amaranths, b. Spinach beet, c. Spinach, d. None of the above.

2. Amaranths hypochondrias species of amaranths is of having.

a. Long day, b. Short day, c. Day natural, d. Both 'a' and 'b'

3. Amaranths is rich in

a. Vit. K, b. Vit-D, c. Vit- A, d. Vit-B.

4. Amaranths originated from

a. Brazil, b. India, c. Europe, d. None of the above.

5. Basic chromosome number in amaranths is

a. 20, b. 34, c. 17, d. 16.

6. Amaranths belongs to family.

a. Amarly Diaceae, b. Amaranthaceous, c. Lilaceae, d. Araceae.

7. Amaranths is a ---------- crop.

a. Self pollinated, b. Cross pollinated, c. Often cross pollinated, d. Heraphordate.

8. ---------- is a most serioud disease of amaranths

a. Black spot, b. While rust, c. Sun Scarching, d. Leaf curl.

9. Green yield of amaranths is about---------- q/ha

a. 40-60, b. 30-40, c. 60-80, d. None of the above

10. ---------- a grain type amaranths is widely grown in Gujarat and Maharashtra.

a. Jobner Green, b. Rajgarh, c. Pusa Harit, d. Pant Haritima.

11. Seeds of amaranths are deride up to---------- percent moisture and stored in moisture proof polyethylene bags.

a. 3-4, b.5-6, c.1-3, d.8-10.

B. Say true or false.

1.The grain amaranths species are popular in African countries.

Ans: False

2. Grain Amaranths is popular in north -indian states.

Ans: False

3 Lencine & Lencine essential amino acids are present in grain amaranths.

Ans: True

4. *A.edulis, and A.cruents*.species of amaranthus are short day plants.

Ans: True

5.Grain amaranths is highly resistant to frost.

Ans: False

6 Arka Suguna and Arka Arunima varieties of amaranths developed by IIHR, Bangalore.

Ans:.True

7. Chofi chaulai is a variety of *A- blitum*.species.

Ans: True

8. Quality of amaranths seeds required for one hectare areca is around 1.5 kg.

Ans: False

9.Grain amaranths is planted at a spacing of 15 x15.

Ans: False

10. Average yield of grain amaranths is 5 t/ha

Ans: False.

MORINGA

(*Moringa oleifera* Lam)

Family: Moringaceae

Origin: India

Pods

Products

Moringa leaves at edible stage

Flowers

Nutrient Compostion of Moringa: A complete Mineral Package

Nutrient	Leaves	Pods
Iron content (mg/100g)	7.0	5.3
Calcium (mg/100g)	440.0	30.0
Magnesium (mg/100g)	147.0	45.0
Potassium (mg/100g)	337.0	461.0
Phosphorous (mg/100g)	112.0	50.0
Sodium (mg/100g)	9.0	42.0
Vitamin A (g/100g)	19690.0	110.0
Vitamin C (mg/100g)	220.0	120.0

- In India cultivated mainly in the south (Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh)

- Generally raised as a backyard tree for daily use.

- Fast growing, drought tolerant and easily adapted to varied climatic conditions

- Pods are consumed as a popular vegetables in South Indian cuisines and valued for their distinct flavour.

- Grown for its tender pods, leaves and flowers.

CULTIVARS

Perennial:

- Jaffna (Yazhpanam)
- Chavakacheri murungai producing fruits 90-120 cm long.
- Chemmurungai (red tipped fruits), flower throughout year and heavy yielding.
- Palmurungai and
- Puna Murungai

ANNUAL MORINGA VARIETIES

- KM-1
- PKM-1
- PKM-2
- GKVK-1
- GKVK-2
- GKVK-3
- Dhanaraj
- Konkan

Climate

- Grown from sea level to 1800 a.m.s.l.
- Dry, warm and semi-arid conditions are congenial.
- Performs best at 25-35^{0}C.
- Highly susceptible to frost and high temperature exceeding 40^{0}C.

Soil

- Sandy loam soils
- Most suitable pH around 6.5
- Good drainage
- Water logging and heavy clay soils are not suitable.

Propagation/Sowing

- Perennial Moringa - stem cuttings (limb cutting)(100-150cm with 14-16cm dia)
- Annual Moringa - seed.
- Seed rate: 500g/ha is sown in nursery.
- Seedlings of height 15-20 cm are ready for planting in 6-8 weeks of sowing.

Planting season

- **Perennial : 5m x 5m (400trees/ha)**
- **Annual: 2m x 2m (2500plants/ha)**
- **High density planting:6666 plants/ha@1.5 x 1.0m**

Manures and fertilizers

- **Moringa trees are generally grown successfully without fertilizers.**
- **FYM 12-15t/ha (10-15 kg/plant)**
- **135:23:45g g NPK/ pit at the time of sowing. After pinching 45:15:30g/ha NPK/plant + 25kg FYM or compost is applied within a week after cutting back every year.**

Pinching

Annual: 60th day after sowing or 75cm height
Perennial: medium pruning at 70cm from the tip.

After care

Annual Moringa

- Pinching terminal bud on central leader stem at 75cm height (2 months after sowing).
- Promote growth of many lateral branches and reduce tree height.
- Pinching reduces the damage due to heavy wind and makes harvesting much easier.

Perennial Moringa

- Pollarding or cutting down plant to a height of 1m from the ground level can be practised after one year to allow ratooning of crop.
- Pollarding or pinching following harvesting is recommended to promote branching, increase pod production and facilitate harvesting.
- It is done during winter (Nov-Dec) when no fruit production is seen.
- Crop can be retained for 3-4 years with regular pruning once in a year.

Irrigation

- Hardy and drought tolerant crop
- Require irrigation only in hot summers once in a week.
- Annual moringa responds well to irrigation and yield can be doubled.

First harvesting: 180 Days After Sowing

Harvesting Period:

- ✓ Annual: six months from sowing. Peak flowering & fruiting. Jan-May; June-Sep
- ✓ Perennial: March-June and Sep-Oct

Yield:

- ✓ **Perennial: 500-600pods/tree/year(4-5 years after planting)**
- ✓ **Annual: 250-400 pods/tree/year**
- ✓ **Fruit available for harvest in 7-8 months.**

Ratooning: Trees are cut back 90cm from ground level

Ratoon crop duration: 3 years

Industrial byproducts: Moringa leaf powder, seed oil and cake

Ivy Gourd (*Coccinia grandis*)

Origin- India

- Tropical vine grown for its small edible fruits
- Herbaceous perennial climber

Uses:

- Young leaves and long slender stem tops are cooked and eaten as a pot herb or added to soups.
- Young and tender green fruits are used as raw in salad or cooked.
- Juice of roots and leaves , and Red ripe fruit are useful treatment for diabetes.
- Particularly of significance when “Hidden Hunger” is of concern- a rich source of carotene, folic acid, iron and Protein.

Climate and soil

- Needs warm and humid climate with an ideal temperature of 20-30° C
- Produces fruits through out the year in South India but plant remain dormant during winter in Northern India.
- Grown in light, medium (loam) and heavy soils and require well drained soils


Flowers of India


Office of Karaikal District, India

- Important varieties are Indira Kundru 5, Indira Kundru 35, Arka Neelachal Kunkhi, Arka Neelachal Kirti, Arka Neelachal Sabuja, kasha Suphal
- Propagated by stem cutting.
- Stem cutting with 12-15 cm long, pencil thickness having 5-6 leaves are taken.
- Planted in basins of 60 cm diameter dug 3 m apart and put 5 kg FYM.
- Planting in June-July or February-March
- Plant population should have at least 10% male plants.
- Vines are often trained on Bower or Bamboo structures.
- 60:40:40 kg NPK/ha. Half N + Full P and K at planting time and rest of N in 4 equal splits.
- Requires good quantity of water, but cannot tolerate stagnation
- Pruning of vines is most important.
- Repeated pruning of vines must be done when look a bit weak and leaves turn yellow i.e. every 3 to 4 months to maximize yield (newly developing vines produce more flowers & yield).
- Flowering start after 50-60 days of planting and average yield is 10-15 t/ha.

Pruned stump

Newly developing vines, 2 to 3 weeks after pruning


padvalagriculture.blogspot.com

Curry Plant/Leaf

Botanical Name: ***Murraya koenigii* (L.)**

Family: **Rutaceae**

Habitat: **India**


MKG
MyKitchengarden.info

- **Although found in the wild, also widely cultivated for its aromatic leaves and as an ornamental.**
- **Used for culinary and medicinal properties.**
- **An important ingredient in South Indian and Sri Lankan cuisine**
- **Spicy leaves of plants are used extensively for seasoning and flavouring dishes.**
- **Leaves are rich source of Ca but its nutritional availability is affected due to presence of oxalic acid in high concentration.**
- **Important varieties are Sen Kaampu, DWD-1 and DWD-2**
- **Red sandy loam with good drainage is the ideal soil though can be grown in wide range of soils.**
- **Tolerate maximum temperature 26-37° C**
- **Propagation through small suckers from base of tree or by root cutting or by seed.**

- **Seed should be pulped with in 3-4 days of fruit collection and is sown in nursery.**
- **FYM 20t/ha.**
- **Planting at 1.2-1.5m in 30cm^3 pit while for low fertile soil spacing is 90 cm X 90 cm.**
- **Planting is done in May-June.**
- **Terminal bud is allowed to grow up to 1m height and later cut off to encourage basal branching to maintain plant in a bushy state (Topping) and to encourage maximum leaf production.**
- **Pruning or topping is also a part of harvesting of leaves.**
- **Leaf quality decreased if the plant is allowed to flower and fruit.**
- **First harvest starts 10-12 months after planting and yield is 250-400 kg leaves/ha**
- **After 5years, yield is 5000 kg/ha once in 3 months.**