VSC 611 BREEDING OF VEGETABLE CROPS (2+1)

Course Content Prepared by

Dr. T.Uma Maheswari
Assistnat Professor
Department of Horticulture
Faculty of Agriculture
Annamalai University
&
Dr. K.Haripriya
Professor
Department of Horticulture
Faculty of Agriculture
Annamalai University

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Objectives

To impart knowledge on principles and practices of breeding of vegetable crops.

Theory

Origin- botany- taxonomy- cytogenetics- genetics- breeding objectives- breeding methods (introduction- selection- hybridization- mutation)- varieties and varietal characterization- resistance breeding for biotic and abiotic stress- quality improvement- molecular markers- genomics- marker assisted breeding and QTLs- biotechnology and their use in breeding in vegetable crops- issue of patenting- PPVFR act of the following crops:.

Unit I Breeding of solanaceous vegetables

Tomato, brinjal, chilli and sweet pepper.

Unit II Breeding of cucurbitaceous vegetables

Cucurbitaceous vegetables.

Unit III Cool season vegetables

Cabbage, cauliflower, carrot, beet root and radish.

Unit IV Bulb and tuber crops

Onion, garlic, potato, tapioca and sweet potato.

Unit V Greens and beans

Okra, moringa, peas, beans and amaranthus.

Practical

Modes of pollination and reproduction- pollen morphology and viability- palanological studies- selfing and crossing techniques in vegetable crops- assessment of variability- estimation of genetic distance- techniques of hybridization in vegetable crops- emasculation

and hybridization- techniques of handling segregating progenies- D^2 analysis- heterosis and combining ability- diallel and line x tester analysis- assessment of character association- path analysis- study of superior varieties and hybrids in vegetable crops- visit to vegetable crops breeding centers and research institutes.

Lecture schedule

Origin- botany and taxonomy- genetics- cytogenetics- plant genetic resources- anthesis- pollination- fertilization mechanism- sterility and incompatability- constraints- breeding objectives- methods and achievements of the following crops:

1. - 2. Tomato.
3. - 4. Brinjal.
5. - 6. Chilli.
7. Sweet pepper.
8. Bitter gourd.
9. Ridge gourd.
10. Pumpkin.
11. Ash gourd.
12. Watermelon.
13. Muskmelon.
14. Cabbage.
15. Cauliflower.
16. Carrot.
17. Mid -semester examination
18. Beet root.
19. Radish .
20. - `21. Onion.
22. Garlic .
23. - 24. Potato.
25. Tapioca.
26. Sweetpotato.
27. - 28. Okra.
29. Moringa.
30. Peas.
31. Beans.
32. Amaranthus.
33. Issue of patenting, PPVFR act.
34. Marker assisted breeding and QTL.

Practical schedule

1. Study of pollination mechanisms, pollen morphology and viability in solanaceous vegetable crops.
2. Study of pollination mechanisms, pollen morphology and viability in cucurbits.
3. Study of pollination mechanisms, pollen morphology and viability in crucifers.
4. Assessment of variability for vegetable improvement.
5. Estimation of genetic distance – D^2 analysis
6. Estimation of heterosis and combining ability
7. Study of diallel and line x tester analysis
8. Study of correlation and path analysis
9. Floral biology and techniques of hybridization in solanaceous vegetables.
10. Floral biology and techniques of hybridization in leguminous vegetables.
11. Floral biology and techniques of hybridization in cucurbitaceous vegetables.
12. Practices in breeding methods of cruciferous vegetable crops.
13. Practices in breeding methods of potato, tapioca and sweet potato.
14. Practices in breeding methods of root vegetables.
15. Practices in breeding methods of onion and garlic.
16. Practices in breeding methods of moringa and amaranthus.
17. Practices in breeding methods of okra.

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Tomato

L-1&2

Solanum lycopersicum

Solanaceae
2n= 2x =24

Tomato is the most widely grown fruit vegetable. It is marketed in fresh as well as in processed form. It is a rich source of Vitamin A, Vitamin B, Vitamin C, Vitamin K and minerals like Ca, P, K and Fe. They are the potential source of anti-oxidants like lycopene, B-Carotene, Chlorogenic acid and the flavanoid naringenin present in fruit skin. The meager amount of carbohydrate present is in the form of fibre. India ranks second in the world production next to China with a productivity average of 21 t / ha. The demand for this vegetable is constantly on increase as in recent times; focus on tomato based products of food industry is catching up in Mediterranean and Arabian countries. Therefore the crop is profitably cultivated throughout the year under protected conditions also.

Origin

The wild relatives of cultivated tomato are native of Western South America along the Coast and High Andes from Central Equador, through Peru and Bolivia. Therefore, South America is recognized as primary centre of origin. Domestication occurred in Mexico of North America. One of the most dramatic changes through domestication is fruit size. Wild tomato has tiny berries while modern tomato cultivars are large and succulent. Mutations in about six Quantitative Trait Loci (QTLS) appear to be responsible for this remarkable transformation in size. The gene loci " fw 2-2" accounts for about 30 % of the changes in fruit weight.

Related Genera

Capsicum
Cyphomandra

Related Species

It has been established through biosystematic studies that Lycopersicon is represented as a 'Section' under the subgenus, Leptostemonum. Further clarity on gene substitutions has lead to the fixation of recent changes in nomenclature as given below:

Solanum pimpinellifolium
S. lycopersicoides
S.pennellii
S.sitiens
S.habrochaites(L.hirsutum)
S. chmielewskii
S.peruvianum
S.cheesmaniae
S.neorichii (L. parviflorum), S.rickii, S. juglandifolium, S. ochranthum

Solanum Chilense

Solanum peruvianum

S.Pennelli

Solanum pimpinellifolium

S.cheesmaniae

S.habrochaites

All these species of Solanum and a few others have either through introgression or by gene transfer mechanisms has lead to modifications in present day cultivated tomatoes (i.e) Improvement in

1) Resistance to pest
2) Resistance to Pathogens
3) Tolerance to humidity
4) Tolerance to drought
5) Tolerance to chilling temperature
6) Tolerance to high temperature
7) Tolerance to salinity
8) High Brix content
9) More of anti-oxidants
10) Thick pericarp

BOTANICAL VARIETIES

Solanum lycopersicum var commune	Common tomato
Solanum lycopersicum var pyriforme	Pear shaped tomato
Solanum lycopersicum var validum	Upright tomato
Solanum lycopersicum var cerasiforme	Cherry tomato
Solanum lycopersicum var Grandifolium	Large leaved tomato plants

Common Tomato Cherry Tomato

Habit

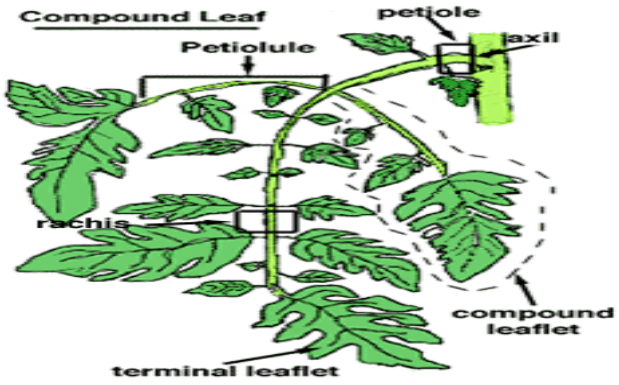
The crop is a short- lived perennial in its native habit, but grown as an annual for production. A tomato breeder needs to be aware of the growth habit of the crop to distinguish the variants. Besides, the objective determined for yield characteristics fluctuates within certain limits based on the growth habit.

Growth Habit

The primary shoot of a young tomato plant produces 5- 10 leaves, after which it produces a flower cluster. In indeterminate cultivars, the growth of this primary shoot ends with the formation of first flower cluster. From the axils of last leaf before the first flower cluster, a side shoot develops that grows upward. This new shoot produces 3 more leaves before it ends in a flower cluster. This process of new shoot development from the axils of last leaf initiated before every flower cluster continues indefinitely, giving the appearance of a main stem with a flower cluster between every three leaves.

In determinate cultivars, the process differs in that the upward growth above the first flower cluster produces 0-2 leaves and a flower cluster but no further vegetative shoots. But many side shoots arise from the main stem, giving the plant a bushy appearance. Each of these secondary shoots eventually terminates in a flower cluster.

Shoots of semi-determinate or intermediate plants produce several flower clusters to the side of an apparent main stem, like indeterminates, but eventually the shoot terminates in a flower cluster as in determinate plants.

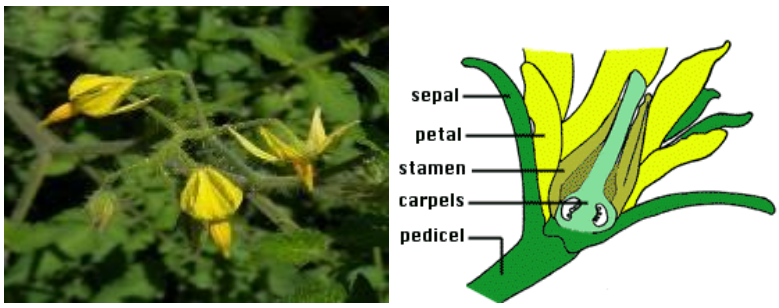


Floral Morphology

Flowers are borne in three fashions (i.e) singles, in simple cyme and in dichotomous cymes. Each flower cluster is called a 'truss'. Five to twelve flowers are present in a truss. Individual flowers (each flower is borne on short pedicel which is constricted at the middle point marking the position of abscission layer) pendent, perfect and hypogynous, calyx or sepals are green, mostly six in number that alternate with petals. They are persistent. Corolla or petals are rotate with a short tube of six lobes and look yellow or pale yellow in colour. Stamens are also six, each with two elongated comportments. Base is attached with corolla tube and filaments are bright yellow joint at top forming a cone. There are six carpels that are united and the basal ovary is typically six celled with a central fleshy placenta. The style is first short and later elongates. Petioles, peduncles, stem, flower buds are throughout covered with hairs.

Floral biology

The bottom most flower in a truss is the oldest and this will open first. Anthesis is between 6 to 11 am. On the same day or the next day, anthers dehisce longitudinally releasing pollen. This pollen easily get deposited over the stigma placed in most varieties inside the anther cone. This structure of the flower by nature favours self-pollination. Hence under green house condition mild shaking of the truss is done artificially to improve the fruit set. The optimum temperature for pollination is around 21^{o}C.



Breeding objectives

The average productivity in India is 21t/ ha whereas the world productivity is > 30 t / ha. We do have developed hybrids that yield around 100 t/ha. Any crop improvement strategy adopted does not have choice of compromise on yield, which is prioritized as main objective. Coupled with this trait is 'earliness'. Flowering generally occurs within one month of transplanting. Further, 'uniformity' in flowering with genes for jointless pedicel is advantageous to facilitate harvesting

with less energy spent on labour or mechanical means. 'Adaptation' to a particular soil or climatic condition warranting tolerance to abnormal abiotic situations like high or low temperature, humidity, drought, extended rainy days is advantageous. (ie) varieties or hybrids with high 'stability index' is preferred. Potential yield of preferred cultivars are drastically brought down due to attack of pests including nematodes and pathogens. Therefore development of high yielding varieties exhibiting multiple disease resistance as well as tolerance to attack of common pests including nematodes is popular among farmers.

Tomatoes are compulsorily subjected to either short or long distance transportation. Hence, tough skinned types' possessing ripening inhibitors or non-ripening genes is meritorious. Eye appeal by consumers rests with deep and uniformly coloured, medium sized fruits having smooth surface. Those grown for local consumption are preferred with good flavor and richness of vitamin C. Large, thick fleshed, crispy textured fruits are procured by restaurants where salads, display or food decorations are made with such types. Tomato plants meant for processing sector are developed with good sugar: acid ratio, less seeds, more flesh and good colour. Of late, purple skinned tomatoes have also been developed holding nutraceutical value. Therefore a group of breeders or scientists work together in the development of a variety.

Important tomato genes

CHARACTERS	GENES
Anthocyanin pigments	Af
Potato leaved	C
Elongated Fruit	El
Exerted stigma	Ex
Fascicated	F
No fruit formation	a,f,hl, ms-31
High pigment	Hp
Jointless pedicel	J
Light green foliage	Lg
Macro calyx	Mc

Yellow flesh	R
Compound inflorescence	S
Tangerine	T
Non ripening	Nor
Aubergine	Abg
Locules	L

Breeding Methods

Breeding Methods

Conventional Breeding Methods

- Introduction
- Selection
- Hybridization
- Pedigree method
- Bulk method
- Back cross method
- Heterosis
- Mutation

Non Conventional Breeding Methods

- Tissue culture
- Genetic engineering (Recombinant DNA technology)

1) INTRODUCTION:

- Seeds of improved varieties from one ecological area are introduced into another and evaluated.
- Several introductions like **Sioux, Roma, Marglobe, Best of All and La Bonita** became popular with farmers for large scale cultivation

2) SELECTION:

- Mainly Individual Plant Selection is adopted where chance variants, superior types from a mixed

homozygous population is selected.

- ❖ Effectively done to make maximum use of germplasm.

Source	Selections
Meeruti	Improved Meeruti
Local Cultivars	Punjab Kesar , Angur Lata
Tip Top	Arka Vikas
V-685	Arka Saurabh
Exotic Line	HS 110
Ottawa-60	Arka Ahuti
UC 83 B	Arka Aashish
Pearl Harbour (BWR 1)	CO-1
AC 238	Pant Bahar
VC 8-1-2-1, CL 114-5-1-0	Arka Alok (BWR 5)

3) HYBRIDIZATION(Heterosis breeding)

- ❖ First tomato hybrid cultivar was "Karnataka" introduced by Indo- American Hybrid Seed Company (IAHS) in 1973.

Examples

- Arka Vishal (IHR-837 X IHR-932)
- Arka Vardan: IHR-550-3 X IHR-932
- Arka Shreshta: 15-SBSB X IHR-1614
- Arka Abhijit: 15-SBSB ×IHR-133
- COTH1: IIHR 709 x LE. 812
- COTH2: LCR 2x CLN 2123A
- TNAU Tomato Hybrid CO3: HN2x CLN 2123A

Varieties	Parentage
Pusa Ruby	Sioux X Improved Meeruti
Pusa Early Dwarf	Improved Meeruti X Red Cloud
HS -101	Selection 2-3 X Exotic Cultivar
HS-102	S 12 X Pusa Early Dwarf
Punjab Chhuhara	Punjab Tropic X EC 55055
Marglobe	Marvel X Globe
Sel.1	Pusa Early Dwarf X HS 101

Sel.2	(HS 101 X Punjab Tropic) X (H-14 X Punjab Tropic)
Improved Cultivars developed by Interspecific Hybridization	
Hisar Anmol	*S. esculentum* X *S. hirsutum f. Glabratum*
Pusa Red Plum	*S. esculentum X S. pimpinellifolium*

4) BACK CROSS METHOD

- Successfully used in breeding varieties resistant to diseases such as Fusarium, Verticilium, Stemphylium and Root Knot Nematode.

5) HYBRIDIZATION FOLLOWED BY PEDIGREE SELECTION

- Most common breeding method in tomato.
- Single plant selection is initiated in F2 and continued through successive generations till pure lines are obtained (generally till F6).
- Selection pressure is on heritable characters.
- EX : Pusa Ruby - Sioux X Improved Meeruti

6) HYBRIDIZATION FOLLOWED BY SINGLE SEED DESCENT METHOD:

- SSD is a modification of bulk method.
- SSD is a system to rapidly develop pure lines followed by selection among those pure lines.
- This is classic procedure of having a single seed in each plant, bulking the individual seeds, and planting out the next generation.
- One or two seeds bulk are collected from each F2 plant and then F3 generation is grown.
- Now encouraged to be used by tomato breeder as generation can be advanced in the off-season.
- Allows the maintenance of broad genetic base in advanced generation Hybridization

7) MUTATION BREEDING

- PKM 1 -This is induced mutant from a local variety called Annanji.
- CO3(Marutham)- It is an induced mutant from Co 1.
- Pusa lal Meeruti – Mutant from Improved Meeruti.

BREEDING FOR BIOTIC STRESSES

- Include disease and pest resistance.
- Existing old/new variety, land races and closely related species provide genes for resistance.
- Genetics of resistance should be known before using a particular breeding method.
- Emphasis should be given for development of complete resistance by major genes.
- In tomato, the wild related species of Solanum are the primary source of genes for resistance.
- Successful transfer of genes for resistance from related species to the cultivated species is done by back crossing and of late by genetic engineering.

Many wild species widely used as donors of genes for disease resistance

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, Solan Vajar, Kalyanpur No.1
Late Blight	*S. pimpinellifolium* *S. esculentum* var. *cerasifolrme*	Ottawa 30, Ottawa 31, Red Cherry, Early Market

BREEDING FOR ABIOTIC STRESSES

Include environmental conditions such as;

- ❖ Low and high temperature
- ❖ Drought conditions
- ❖ Flooding
- ❖ Moisture stress
- ❖ Soil salinity
- ❖ Water logging conditions

A few species tolerant to abiotic stresses are

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
S. lycopersicoides	Cold tolerance

Abiotic stress resistant varieties

VARIETY	FEATURES
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

Varietal Achievement

VARIETY	ORGANIZATIO N	PARENTAGE	FEATURES

Pusa Ruby	IARI, New Delhi	Sioux X Improved Meeruti	Indeterminate, early, firm, medium size, uniform ripening
Pusa Early Dwarf	IARI , New Delhi	Improved Meeruti X Red Cloud,	determinate Plants dwarf, early maturing, medium size
HS 101	HAU , Hisar	Sel. 2-3 X An exotic culture	A very promising variety, determinate, dwarf, fruit medium size juicy, wide stability
HS102	HAU ,Hisar	S 12 X Pusa Early Dwarf	Extremely early, Fruits medium to small, round juicy, thin pericarp
HS110	HAU , Hisar	Selection from an exotic line	Determinate, late, potato leaf type, fruit large, highly suitable for table purpose.
Hisar Arun	HAU , Hisar	Pusa Early Dwarf X K1	Extremely early and high yielding,plant dwarf, fruimedium to large
Hisar Lalima	HAU , Hisar	Pusa Early Dwarf X HS 101	Early, determinate, fruits round, large, high Yielding
Hisar Lalit	HAU , Hisar	HS 101 X Resistant Bangalore	Semi- determinate, early, fruit round, medium to large, resistant to root knot nematode
Hisar Anmol	HAU , Hisar	Hisar Arun X *L. Hirsutum f. glabratum*	Field resistance to tomato leaf curl virus, plant determinate, fruit medium size
PKM 1	TNAU, Coimbatore	Mutant of Annanji	Long distance Transportation
CO 3	TNAU, Coimbatore	A mutant of CO 1	Determinate, fruit red round, medium size

COTH1	TNAU, Coimbatore	IIHR 709 x LE. 812	Fruit are acidic (0.61%) High yielding
COTH2	TNAU, Coimbatore	LCR 2x CLN 2123A	Resistance to leaf curl virus disease.
TNAU Tomato Hybrid CO 3	TNAU, Coimbatore	HN2x CLN 2123A	Suitable for high density planting. Resistant to leaf curl virus diseases.
KS 2	Kalyanpur		Determinate, round, high yielding
Punjab chhuhara	PAU , Ludhiana	EC 55OO5 X Punjab Tropic	Determinate, dwarf, high yield, pear shaped fruit, suitable for long transportation .
Sel .120	IARI , NewDelhi		Semi- determinate, late, fruit large, root knot nematode
Pant T3	GBPUA&T, Pantnagar	Pure Line Selection	Plant semi-determinate, fruit medium round, Smooth
Arka Vikas	IIHR , Bangalore	A selection from a variable population American variety Tip Top	Plant indeterminate, fruit medium large, suitable for fresh market
Arka Saurabh	IIHR , Bangalore	Selection from a line V-685, introduced from Canada	Semi determinate, suitable for both processing and fresh Market
Arka Rakashak	IIHR , Bangalore		Triple disease resistance to ToLCV, Bacterial Wilt and early blight.
Arka Samrat	IIHR ,Bangalore		Triple disease resistance to TLCV, Bacterial Wilt and early blight
Pusa Gaurav	IARI , NewDelhi		Fruit yellowish red, good for processing and

			long distance transportation
Pant Bahar	GBPUA&T.Patnagar		Bushy branched, flattish round, n Fruit
Pusa Hybrid1	IARI , Newdelhi		F1 hybrid Determinate plant, prolific bearing, round fruits
Pusa Hybrid 2	IARI, New delhi		F1 hybrid Semi – determinate, dwarf plant, medium sized fruits

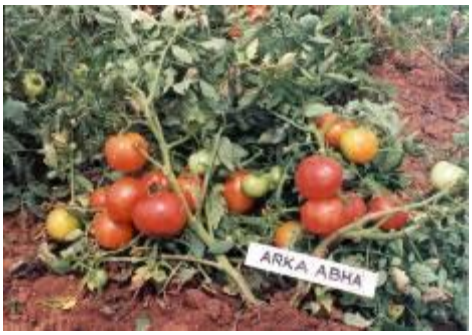
IMPORTANT HYBRIDS AVAILABLE IN PRIVATE SECTOR

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

VARIETIES OF TOMATO

COTH1

COTH2



Arka Abha

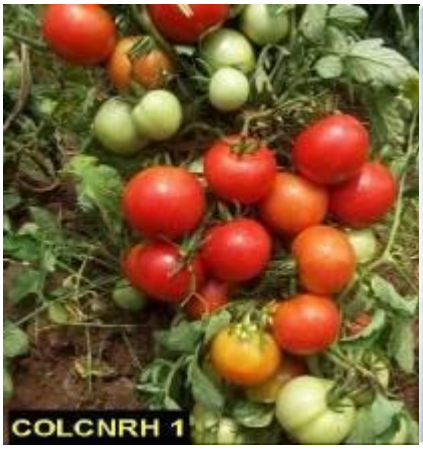
Arka Abhijit

Arka Raskshak

Arka Samrat

Arka Saurab **Arka Vikas**

Vaishali **Naveen**



TNAU Tomato Hybrid CO3 **PKM 1**

Technology of production of hybrid seed

Hand emasculation and hand pollination is to be practiced. Two parents having good combining ability are selected. Varieties maintained by selfing can be taken as parents. In a few cases 2-3 years selfing is done to maintain the purity. A large number of such parents crossed in different combination and resultant hybrids evaluated at one or more location. In a

few cases sca is studied to select a potential hybrid. Practically, superiority is judged by *per se* performance.

Hybrid seeds largely produced by hand emasculation and hand pollination. Seed plants and pollen parents are grown under healthy condition in 12:1 ratio. Emasculation of seed parent is taken 12-15 hr before anthesis, by forceps, needle or fingernail. Generally emasculation is done in the afternoon and pollination is done in the following morning. Pollen collected from anthers by needle, forceps or electric vibrator. Generally fresh pollen is used. Pollen can be stored for 2-3 days under normal condition. Soon after pollination, 2-3 sepals of the pollinated flowers are removed for easy identification. (No need to put bag or cotton). 4-5 days - ovary start swelling. More than 90% fruit set after hybridization.

Questions

1. Name botanical varieties of tomato
2. What are the breeding objectives in tomato breeding?
3. What is the chromosome number of tomato?
4. Name multiple resistant varieties in tomato
5. List out tomato varieties released from IARI.

References

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L- 3&4

Brinjal

Solanum melongena

Solanaceae

2n=2x=24

Brinjal is proved to have originated in India with many diversified forms and China is the secondary centre of diversity. In the south East Asian Countries the crop finds a place in native medicine besides its versatility in consumption as vegetable as it is simple and delicious. In addition to bringing in a unique texture and mild flavour to recipes brinjal brings a load of health benefits. It is a nutrient dense food as it contains considerable amount of Vit.C, Vit. K folate, Manganese and Potassium. It is high in fibre and polyphenols, solasodine which helps in fighting against a type of cancer. Rich anthocyanin content also contributes to this quality. It is reported that 'Nasunin' is a type of antioxidant predominantly found in fruits. Owing to such merits, the crop is widely cultivated in all tropical and subtropical parts of the world. Moreover native cultivars respond to ratooning and give satisfactory yield.

Breeding objectives

Preference for fruit colour, shape and size determines market potential in any particular region. Therefore development of high yielding varieties with preferred fruit characteristics is given importance. Since drastic yield reduction occurs due to the major pest, shoot and fruit borer, disease, little leaf; resistance breeding for incorporation of interested specific genes in otherwise good cultivars are progressing. Further, development of tolerant genotype for drought, salinity is advancing. Related rootstocks are also utilized in breeding strategies. Since technique of grafting is successful in brinjal.

Related genera

Capsicum

Cyphomandra

Related species

Solanum sisimbrifolium- ancestral form, leaves are variegated.

S. aethiopicum

S. macrocarpum- leaves are edible

S. indicum

S. trilobatum

S. viarum

S. nigrum

S. xanthocarpum – all are used in native medicine

Botanical varieties:

S. melongena variety esculentum – bears round fruits

S. melongena variety serpentium- bear long fruits

S .melongena variety depressum – dwarf plant stature.

Solanum melongena var esculentum

S .melongena var serpentinum

S. melongena var depressum

The crop is cultivated as annual and grows to a height of 1 to 2 m. Flowers are in cluster Individual flowers are perfect. Corolla is purple mostly and white is also seen rarely. Anthers are dark yellow arising from base of petals. They are lengthier than filaments. Ovary is superior and length of style in individual flower varies rendering the chances of fruit set per cent to vary accordingly. This phenomenon is called heterostyly where stigma either coincides the tip of anthers or stays just below it or slightly protrudes making it visible outside. The other two forms namely pseudo short and true short style flowers do not set fruits whose style length is just the half or quarter of anther length. As the dehiscence of anthers takes place in their tips(apical dehiscence) and they are arranged together in the top portion, the dispersed pollen doesn't get deposited over the stigmatic lobes, which results in no fruit set. Genetic as well as physiological factors are reasoned for distribution of varied style length in a particular variety grown under specific climatic condition.

Long styled Medium styled Short styled

Floral biology

Corolla or petals are showy in purple colour. Calyx or sepals are 5 and united at the base. They are persistent. Anthers are bilobed, dark yellow attached to base of petals by short filaments.

Flowers open in morning hours from 6 am to 8 am under tropical climate. Anthers dehisce through apical pores on the same day after an hour of anthesis. Stigma is receptive a day before flower opening and on the day of anthesis. Stigmatic fluid dries up after bright sun shine on the next day of flower opening.

Breeding methods

- **Pure line selection**

  IIHR

- Arka Shirish-Pureline from IIHR-194.
- Arka Kusumakar-from IIHR- 193.

  TNAU

- Co-1
- Co-2(from Varikathirikaai)
- MDU-1(From kallampatti local)
- VRM-1(From Elavambadi village of vellore)
- KKM-1(From Kulathur local)
- **Pedigree method**

  Arka Nidhi

- Bulk method
- Modified pedigree (single seed descent)
- **SINGLE LINE SELECTION**

  PPI(B)-From Karungal local type.

  PLR-2 - From Sevanthampatti local).
- Combination of bulk and pedigree methods
- Backcrossing
- Heterosis breeding
- **Mutation breeding**

  PKM-1(From Puzhudhikathiri).
- Heterosis is commercially exploited
- Hand emasculation and pollination is practiced.

Methods of crossing

- Extent of cross pollination is about 29 %.
- Hence , called as often cross pollinated or facultative cross pollinator.
- Out crossing by means of insects like bumble bees,wild bees & domestic bees(entomophilous).
- Use of male sterility – 'Blackey' – male sterile
- Inducing male sterility through growth regulators and gametocides is achieved.

Interspecific hybridization

- Related species of *S. melongena* for disease resistance
- Among 22 Indian species, 5 are closely related
- *S. melongena*,
- *S. incanum (S. coagulans)*
- *S. xanthocarpum*,
- *S. indicum*
- *S. maccani*

- *S. melongena* – readily crossable with *S. melongena* var. incanum
- Hybrid between *S. melongena* and *S. sisymbrifolium* – failed to produce viable seeds

- **Sources of resistance**

Species	**Resistance**
S. melongena var. incanum	Bacterial wilt (*Pseudomonas solanacearum*)
S.xanthocarpum, *S. sisymbrifolium, S.nigrum*	Fruit rot(*Phomopsis vexanas*)
S. sisymbrifolium	Root knot nematode
S. indicum	Wilt (*Verticillium alboatrum*)
S. torvum, S.mammosum, S.khasianum	Spotted beetle*(Epilachna vigintioctapunctata*)

- **Intergeneric grafts**
  - *Solanum, Capsicum and Lycopersicon* are intergraftable
  - Side grafting and patch budding – successful
  - Problematic areas – one genus thrives well

Varieties and hybrids

Arka Anand

It is a high yielding F1 hybrid with **resistance to bacterial wilt.** Average fruit weight is 50-55 g. Yields 60-65 t/ha in 140-150 days.

Arka Anand

Arka Neelkanth

Violet blue glossy fruit skin with green purple calyx. Resistant to bacterial wilt. Duration 150 days. Yield 43 t/ha

Arka Neelkanth

ARKA NIDHI (BWR)

Resistant to bacterial wilt. Duration 150 days. Yield 48.5 t/ha.

Arka Nidhi

Arka Shirish

Tall plants with white flowers. Fruits green, extra long. Solitary bearing habit.

Arka Shirish

Some popular brinjal varieties and hybrids

Name	Methods	Organization	Attributes
Arka Sheel	PLS from Kodagu local	IIHR, Bangalore	Plants well branched and erect, Fruits medium long, tender, deep purple. Less seeds, yields 39t/ ha in 110-120 days.

Arka Kusumakar	PLS from Karnataka local selection	IIHR, Bangalore	Dwarf plants, fruits small, Finger shaped, light green in colour and borne in clusters of 5 to7. Yield 45 t/ ha in 110-120 days
Pusa Purple Long	Selection from Batia , Punjab	IARI, New Delhi	Semi erect, dwarf plants, 20-25 cm long purple fruits, suitable for autumn and summer planting, susceptible to bacterial wilt.
Pusa Purple Cluster	Selection from local material	IARI, New Delhi	Medium early, erect, purple pigmentation on stem, leaves purple and non spiny, fruits in clusters, deep purple , moderately resistant to bacterial wilt.
Pusa Kranti	(PPLxHyderpur)x Wynad Giant (Hybridization followed by Pedigree selection)	IARI, New Delhi	Plants medium tall, purple pigmentation on young leaves, non spiny, fruits oblong, thick, less seeded,
Pusa Bhairav	Complex	IARI, New Delhi	Fruits dark purple, non spiny, glossy, resistant to phomopsis fruit rot
MDU1	PLS from local Kallampatti	ACRI, Madhurai	Fruits round, bright purple, less seeded, yields 30 t /ha
CO2	PLS from local variety, Varikathiri	TNAU, Coimbatore	Fruits oblong, with dark purple streaks under pale green background, without spines on the calyx surface. Yields 35t/ ha in 150 days.

PKM1	Induced mutant from Puzhuthi Kathiri	HCRI, Periyakulam	Fruits small, oblong ovate with green stripes, suitable for rainfed cultivation.
PLR1	Selection from Nagpur ecotype	VRS, Palur(TNAU)	Egg shaped fruits, bright glossy purple colour, yields 25 t/ ha.
Pant Samrat	Selection from local cultivar	Pantnagar ,Agricultural University	Medium long fruits in clusters,resistant to bacterial wilt, tolerant to shoot and fruit borer.
KKM1	Selection from local type of Kulathur	Agricultural College, Killikulam(TNAU)	White colured egg shaped fruits, cluster bearing (2-4) with green calyx. Yields 36t/ ha.
PPI1	Single line selection from Karungal local type		Long plae green fruits, less seeded, bitter less,yields about 50 tonnes/ ha in a crop duration of 185 days.
F1 hybrids			
Pusa Anmol	PPLx Hyderpur	IARI, New Delhi	Gives 80 % more yield than PPL.
Azad Hybrid	Azad b1x Kalyanpur 3	C.S.Azad Agri University, Kaliyanpur, (UP)	Early fruiting, bright purple coloured fruits, less prone to fruit and shoot borer infestation, yields 45 t/ha.
Arka Navneet	IIHR 221x Supreme	IIHR, Bangalore	Fruits round to oval, big sized, black purple, yields 65-75t/ ha.
NDBH1	PBR 91-1xK202-14		Plant semi erect, non spiny, round purple fruit, soft textured, less seeded.

Co 1

CO 2

PKM 1

MDU 1

COBH 1

PLR 1

PPI (B) 1

KKM 1

Questions

1. _____ is the origin of brinjal.
2. What is heterstyly?
3. What are the botanical varieties of brinjal ?
4. Name some brinjal varieties released from IIHR
5. Name some brinjal varieties resistant to bacterial wilt.

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2. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.

L- 5&6

Chilli

***Capsicum annuum* L.**
Solanaceae
2n=24

It is an important vegetable cum condiment. The pungent or hot types are grouped under Red pepper or hot pepper (*Capsicum annuum* L.), whereas the less pungent types are grouped under sweet pepper (*Capsicum annuum* var.annuum) locally called as 'Kudai Milagai', which are used as vegetable.Pungency of the chilli is due to the presence of Capsaicin C18 H27 NO3 and the coouring principle is due to the presence of Capsanthin.

ORIGIN & DISTRIBUTION

The domestication of *Capsicum annuum* L. first occurred in Central America, most likely in Mexico where archaeological remains from almost 7000 B.C. indicate that pepper were used by man even before the advent of Agriculture. Chillies were introduced by Portuguese into South India probably in 16th century as evidenced by the fact that there were three races of chillies being cultivated in India by 1542. By the end of 19th century, its cultivation spread throughout India. Chilli is mainly cultivated in Brazil, Mexico, Spain, South and Central America, China and India. In India, Andhra Pradesh, Maharashtra, Karnataka, Tamilnadu and Himachal Pradesh grow the crop extensively.

CULTIVATED SPECIES ARE:-

- *C. annuum* - Mexico
- *C. frutescens* - Amazonia
- *C. chinense* - Amazonia
- *C. pendulum* - Peru and Bolivia
- *C. pubescens* - Peru and Bolivia (Extinct)
- *C. pendulum - C. baccatum var. pendulum ,*
- *C. microcarpum - C. baccatum var. baccatum*

Capsicum pubescens

Capsicum baccatum- Bishop's crown

***Capsicum frutescens* -Upright fruits**

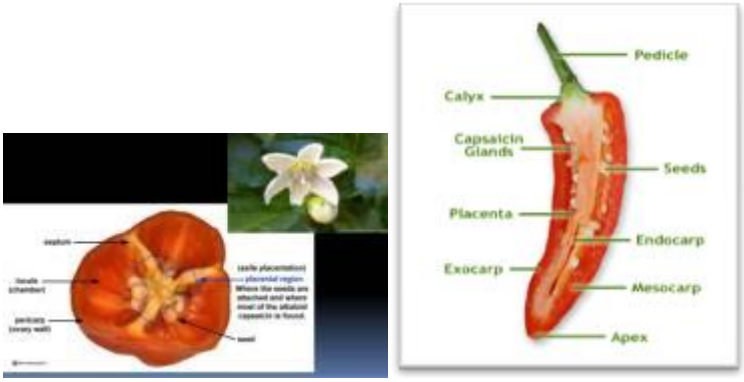
Capsicum chinense

Horticultural classification of Pepper

Groups	Size (inch)	Pungency of Common cultivars	Uses
Bell	3 to 5 X 2 to 4	California and Yolo wonder (non & few)	Fresh market, salad, and canning
Pimiento	2.5 to 5 X 2 to 3	Pimiento and pimsan (non)	Fresh market, salad, and canning
Squash	1 to 2 X 2 to 4	Yellow cheese, (non)	Processing, canning, pickling
Ancho	4 to 6 X 2 to 3	Ancho, Mexican chilli(mild)	Powder, dried chilli
cayenne	5 to 10 X 0.5 to 1	Cayenne long red(high)	Dried, powder, sauce, salads
Jalapeno	1.5 to 3 X .75 to 1	Jalapeno (high)	Green,
Anahelm	5 to 8 X 0.75 to1.75	Paprika (non pungent)	Color, canning
Cuban	3 to 6 X 0.5 to 2	Cuban, golden greek (mild)	Salads, pickled
Small hot	1. 5 to 3 X0 .25 to 1	Fresno chilli, Serrano (high)	Seasoning and Sauce
Cherry	0.5 to 2	Pungent	Pickling
Short wax	2 to 3 X 1 to 2	Cascabella, floral gem	Processing, pickling

Morphology of fruit

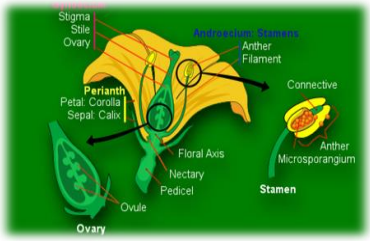
- Fruit type is berry
- Capsaicin glands – between placenta and endocarp - produce capsaicin
- Calyx – Persistent calyx
- Seeds – rich in lecithin, capsaicin absent, hotness due to absorbance
- Placenta – metabolic exchange fruit to seed
- Chilli hotness measured by SHU (Scoville Heat Unit)
- Bhut jolokia – 1,001,304 SHU
- Naga morich – 1,598,227 SHU



Fruit structure

Flowers

- Flower - Actinomorphic, Bisexual, Pedicellate, Hypogynous
- Gynoecium - Superior ovary,
- Androecium - Stamens 5-6, Epipetalous



Flower structure

Floral Biology

- Both self and cross pollination occur, the latter being about 16% by bees, ants and thrips. Flowering begins 1-2 months after planting and it takes another month for fruiting.
- Flowers open in the morning between 5.00 a.m. to 6.00 a.m. Anthers normally dehisce between 8.00 a.m. to 11.00 a.m..
- Flower opening and anther dehiscence depend on the weather conditions to a large extent.
- During cool as well as cloudy days, the flower opening is delayed.
- Pollen is fertile on the day of anthesis and stigma is receptive for about 24 hours after flower opening.

BREEDING OBJECTIVES:

1. Earliness

2. Desirable fruit shape and size (obovate and round fruit in bell pepper and long fruits in chilli).
3.Superior fruit quality (pleasing flavour, high sugar/ acid ratio, high pigment content and high capsaicin).
4. Resistance is to diseases (fruit rot, cercospora leaf spot, powdery mildew, bacterial leaf spot, phytopthora root rot, root knot, common TMV).
5. Resistance to insects (thrips, mite, aphid, fruit borer)
6. Resistance or tolerance to abiotic stress (heat, water stress, salinity etc.)

BREEDING METHODS:

Pure line selection:

This method is applicable to land races or local cultivars being grown by farmers. Eg ., G1, K1, CO.1, CO. 2, Sindhu, PLR. 1

Pedigree method:

It involves selection of superior plants following hybridization between superior cultivars. Eg., Andhra jyothi(G5), pusa jawala, Punjab lal, Jawahar 218, K2, PKM.1, Pusa Sada Bahar

Back cross method:

It is used to transfer single gene or few genes from primitive cultivars or wild forms to leading cultivars.

Heterosis breeding:

F1 hybrids are popular in USA and Europe and gaining popularity in India after the initiation. A hybrid MS12x LLS has been identified for commercial production at PAU , Ludhiana.

F1 hybrids in chilli

Public sector

PAU(Ludhiana) : CH-1, CH-3

IIHR-: Arka Suphal, Arka Meghana, Arka Sweta, Arka Harita

Private Sector

Hung Nong : Delhi Hot, Hot green, Skyline

Mahyco: : Tejaswini

Sandoj : Agni

Scoul :Champion

Mutation breeding:

Found to be effective and efficient breeding tool in pepper. MDU-1 has been developed at the Agriculture College, Madurai by treating the seeds of K.1 by gamma rays @ 30 Kr. It posses compact plant type and determinate growth habit with fruits borne in clusters of 4-9 at nodes as against single fruit borne at nodes in K.1 or K.2 varieties. Duration 205-215 days with a dry pod yield of 1809 kg/ ha.

Sterility in chilli

First male sterile(ms) plant was isolated from an Indian accession.

GMS:

The ms-509 was renamed as ms-10. This ms-509 line (bell pepper type) of Dr. Pochard was introgressed in 3 chilli genotype, viz., MS-12, MS-13 and MS-41. MS-12 Line has been developed by transferring ms-10 gene into cultivar "punjab Lal" through backcrossing. Using MS-12 line 3 chilli hybrid CH-1, CH-3 and CH-27 has been released by PAU.

CGMS:

First reported in an introduction from India (PI-164835). Chilli CGMS lines (CCA-4261) introduced at the IIVR from AVRDC is utilized to produce hybrid – Kashi Surkh (CCH-2). IIHR, Bangalore has also developed CGMS based hybrids i.e. Arka Meghna (MSH-172),Arka Harita (MSH-149) and Arka Sweta (MSH-96).

Genes considered too important for breeders

Important *Capsicum* genes

Gene symbol	**Phenotype**
A	Anthocyanin- basic gene for purple colour in foliage, incompletely dominant
B	Beta carotene-high in mature fruit
T	High Beta carotene, complementary with B
Y	Yellow or orange mature fruit colour
Ys	Yellow spot on corolla of *C.pendulum*
Yt_1. Yt_2	Young expanding leaves are yellow
dw_1, dw_2	Dwarf plant

HL	Hairless
Bs_1	Bacterial Spot resistance
N	Root knot nematode resistance to *M.incognita*
O	Oblate or round fruit shape dominant over elongate
P	Pointed fruit apex incompletely dominant over blunt
ms	Male sterile

Crossing technique:

Emasculation and pollination in chilli

Crossing technique

A bud one day prior to anthesis should be selected for emasculation.

#

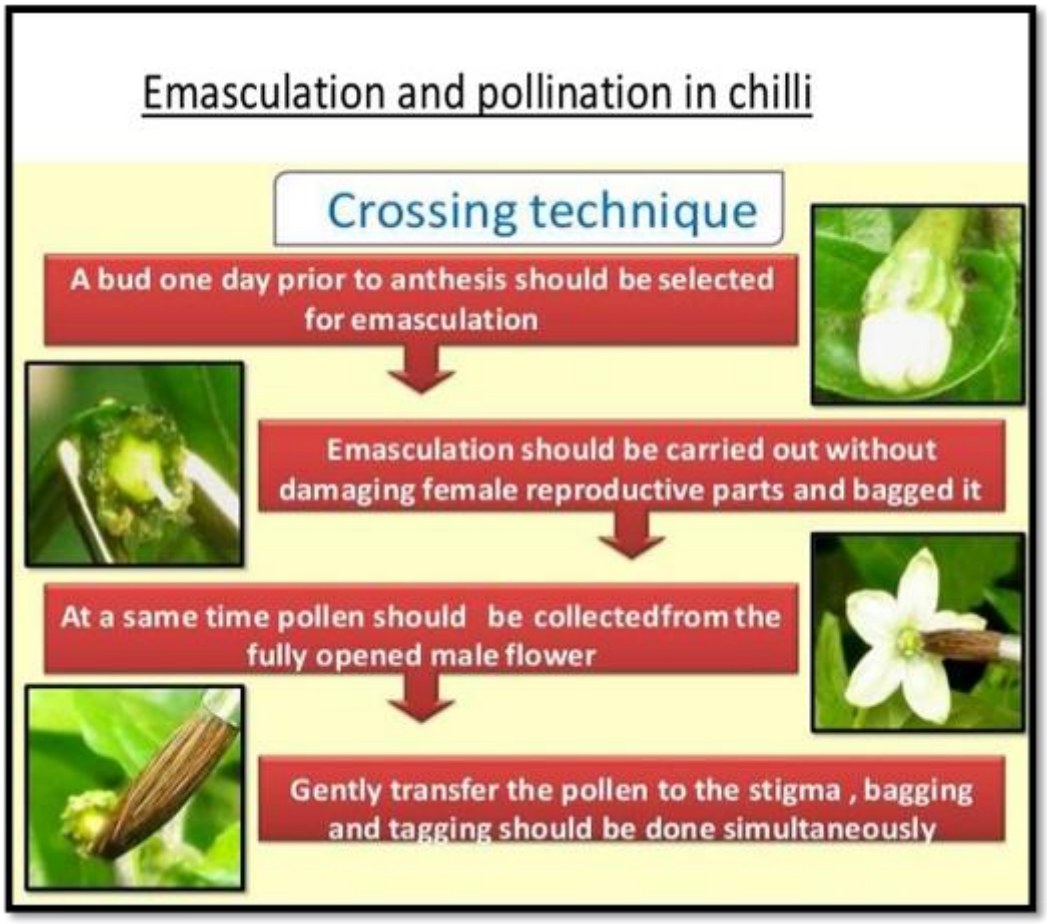
Emasculation should be carried out without damaging female reproductive parts and bagged it.

#

At a same time pollen should be collected from the fully opened male flowers.

#

Gently transfer the pollen to the stigma, bagging and tagging should be done simultaneously.



Varieties & Hybrids

Variety	Institution	Parentage	Breeding Methods	Remarks
Arka Haritha	IIHR, Bangalore	CMS	F1	Green & dry; Resistant to Powdery mildew & virus
Arka Sweta		CMS	F1	Dual purpose
Arka Meghana		CMS	F1	Dual purpose; tolerant to Powdery mildew & virus
Arka Suphal PMR 57		CMS	F1	Indeterminate, PM resist, Tolerant to virus
Arka Lohit		Ihr324local collection	PLS	Tolerant to powdery mildew

Arka Abhir		Devanur dubha	PLS	Paprika variety suitable for extraction of colour
Kashi Anmol	IIVR, Varanasi	IC-523656, Sri Lanka	Introduction	Dwarf , Umbrella type
Kashi Surkh(CCH-2)			Heterosis breeding(F1)	Tall indeterminate(110-120 cm)
Kashi Early(CCH-3)			Heterosis breeding(F2)	indeterminate(80-100 cm)
Pant C1	GP Pant Agricultural Uinversity, Pantnagar	NP46Ax Kanthari	PLS	Tolerant to virus, erect bearing
Pant C2		NP46Ax Kanthari	PLS	Pendant fruits
Pusa Jwala	IARI, New Delhi	NP46Ax Puri Red	Pedigree	Tolerant to thrips, mites, aphids
Pusa Sadabhahar		Pusa Jwalax Ic31339	Pedigree	Virus resistant
CH.1	Punjab Agricultural University, Ludhiana	MS12xLLS	GMS	Tolerant to virus and fungi
CH.3		MS12xS-2530	F1	Mild Pungent, Processing
Punjab Lal		Perennial long Red		Resistant to CMV, TMV, LCV.

K1

K2

CO1

CO2

CO3

CO4

KKM1

PKM1

PKM2

Arka Harita

Arka Lohit

Arka Meghana

Arka Suphal PMR 57

Arka Sweta

Questions

1. What is the pungency pricnciple of chilli ?
2. What is the origin of chilli?
3. What are the breeding objectives of chilli?
4. What are the related species of chilli?

5. What is the breeding system in chilli?

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Ram. 2001. Vegetable Breeding. Kalyani Publishers, Ludhiana

CAPSICUM

L-7

Scientific name **: *Capsicum annuum* var. *grossum***

Common name : Bell pepper, Sweet pepper.

Family : Solanaceae

Chromosome number : 2n=2x=24

Origin :South America

Importance of the crop:

- Bell pepper is grown as autumn- winter crop in the plains and summer crop in the hill regions of India.
- It is consumed both in green mature and ripe form, salads, cooked, mixed and stuffed vegetable.
- It is widely used in the preparations of pickles, sauces, soups and stews.

Floral biology and pollination:

Flower:

- The flowers of bell pepper are larger than chilli.
- They are bisexual located in the nodes of the stem.

Anthesis : 5:30 to 6:30 AM

Pollination : Self-pollinated crop; cross pollination occurs to an extent of 62 %. Insects are responsible for natural crossing. Therefore treated as often cross pollinated crop

Stigma receptivity : 2 hrs before and 2 hrs after anthesis

Cytogenetics:

- Chromosome number : 2n=2x=24
- Somatic chromosome number : 2n= 24

- Polyploids - 2n=36
- Aneuploid -2n=25 has been reported.

Breeding objectives:

- High yielding and earliness.
- Good quality: high vitamin C content, high oleoresin content, pigment content, pleasing flavour, shiny fruits, pungent and non-pungent.
- Desirable fruit shape and size: oblate or round.
- Resistance to diseases like fruit rot, cercospora leaf spot, powdery mildew, common TMV, etc.
- Resistance to insects like thrips, mites, aphids, fruit borer.
- Resistance to abiotic stresses like heat, water stress, salinity.

Breeding methods

Conventional breeding methods:

Introduction, Selection, Pureline selection, Pedigree method, Backcross method, Heterosis and Mutation breeding.

Non-conventional breeding methods:

Tissue culture and Genetic engineering.

Introduced varieties:

California Wonder, Yolo Wonder : Introduction from USA by IARI, New Delhi_World Beater, Chinese Giant : Introduced by IAHS, Bangalore.

Varieties developed by selection:

- **Arka Mohini** : Selection from Titan of USA by IIHR, Bangalore.
- **Arka Gaurav** : Selection from Golden California wonder_of USA by IIHR, Bangalore. Indeterminate variety tolerant to bacterial wilt.
- **Arka Basant** : Selection from Hungarian variety "Soroksari" by IIHR, Bangalore. Excellent keeping and cooking qualities.
- **Nishant 1** : A selection from Capsicum Sel-2 (SKUAS&T, Srinagar)

Arka Mohini

Arka Basant

Arka Gaurav

California wonder

Pedigree method:

Selection of superior plants in the segregating generations. Hybridization is done between superior cultivars along with maintenance of pedigree record.

Some of such cultivars are

- **Spartan Garnet**: (California Wonder × Dwarf Pimiento Selection from variety Santanka)
- **Spartan Emerald**: (Morgold × California Wonder)
- **Sonnette**: An F2 line (Morgold × California Wonder) × Keystone Resistant Giant.

Backcross method:

- In bell pepper generally 4-5 backcrosses are required to produce near-isogenic lines for the novel gene in the pure line.
- Backcrossing is used whenever disease resistance, improvement of male sterile line or any other simply inherited morphological trait is to be transferred because its application is convenient in bell pepper.
- Incorporation of resistance (powdery mildew) from *C. baccatum* var. pendulum.

Mutation breeding:

Direct mutant cultivars:

MDU 1 developed from TNAU by gamma rays induction inthe year 1976. Plants are compact, high yield and capsaicin content.

Heterosis breeding:

First hybrid variety was Bharat from IAHS.

Private sector hybrids:

- Mahabarath

- Chocolate wonder
- Mamatha
- Lakshmi
- Super gold

Public sector hybrid:

- **Pusa Deepti (Kt - 1)**: hybrid between Yolo Wonder and Reunion Yellow, released by IARI Regional Station, Katrain (HP). High yielding, tolerant to bacterial leaf spot and anthracnose.
- **Solan Hybrid - 2**: Released by YSPUHF, Solan. Resistant to fruit rot and virus.
- **Solan Hybrid - 1**: Released by YSPUHF, Solan.
- **Solan Bharpur**: Released by YSPUHF, Solan.
- **KTCPH - 3**: Yolo Wonder x HL-201, released by IARI Regional Station, Katrain (HP).
- **KTCPH - 5**: Yolo Wonder x EC- 143570, released by IARI Regional Station, Katrain (HP).
- **Punjab - 27**

Varieties / Hybrids	**Breeding methods**	**Features**
Sweet Banana	-	-
California Wonder	Introduction from USA	Plants vigorous, upright, prolific bearer, medium thick flesh, Early harvest in 70 days
Yolo Wonder	Introduction from USA	-
Arka Mohini	Introduced from USA	Determinate, medium large fruits, dark green skins
Arka Gaurav	Introduced from USA	Dark green fruits, erect, 4-5 lobed thick flesh, Tolerance to bacterial wilt
Arka Basant	Introduced from Hungary	Proloific bearing, good export potential, creamish white colour
King of North	-	-
Pusa Deepthi	Yolo Wonder x Russian Yellow	F1 Hybrid
Kt – 1	-	
Bharath	F_1 hybrid	1st F1 Hybrid (1973)by IAHS, Bangalore
Mahabharath		Tolerant to TMV
Chocolate Wonder		Dark brown colour fruit
Mamatha		Red colour fruit
Lakshmi		Red colour fruit
Super Gold		Yellow colour fruit

Indam bharath

Yolo wonder

Lakshmi

Super gold

Chocolate wonder

Mahabarath

Tissue culture:

Bulgarian cultivars

- Hebar
- Stryama

Indian cultivar

- Mathania

Important donors for resistance to disease and pests

Disease/ insect	Resistant sources
Fruit rot	*C. chinense* Accs 1555, Chinense Giant
Cercospora leaf spot	California wonder, Hungarian Wax
Root Knot	Santaka
Leaf curl	Pant C1, Puri red, Puri Orange
Thrips	Caleapon Red, Chamatkar
Mite	Kalyanpur Red, Punjab Lal
Aphid	Kalyanpur Red x 1068

Questions :

1.Name a F1 hybrid f Capsicum

2. ----------is the resistance source for fruit rot.

3. What is the Chromosome number of Capsicum?

4. What is the mode of pollination in Capsicum?

5. What is the time of anthesis in capsicum?

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Ram. 2001. Vegetable Breeding. Kalyani Publishers, Ludhiana

BITTER GOURD

L-8

Scientific name **:** *Momordica charantia* L.

Family : Cucurbitaceae

Origin : Indo-Burma region

Chromosome No : 2n=22

Importance

1. The vegetable *Momordica charantia L*. belongs to cucurbitaceae, is known variously as bitter gourd, balsam pear, bitter melon, bitter cucumber and African cucumber.
2. It occupies first rank among the cucurbits in respect of iron (1.8mg/100g), vitamin C (88mg/100g).
3. Alkaloid momordicasoides gives the bitter taste of the fruit.
4. Fruit is rich in P (55mg/100g), Ca (20mg/100g) and vitamin A (210IU/100g).
5. Fruit is wormicidal and cure stomach disorders and has beneficial effect on the persons suffering from diabetes arthritis and asthmatic complaints.
6. Powder prepared from plants is useful against ulcers.

7. Protein of bitter gourd inhibit the growth of HIV 1 viruses in human cell cultures

Taxonomy

The genus *Momordica* has 45 species domesticated in Asia and Africa. The genus *Momordica* has only six valid species in India, which can be grouped under two headings.

Monecious

M.charantia L.

M.balsamina L.

Dioecious

M.dioica

M.cochinchinensis

M. foetida

Indian bitter gourd is classified into two botanical varieties based on fruits, size, shape, colour, and surface texture:

M.charantia var.charantia has large fusiform fruits,which do not taper at both ends and posses numerous triangular tubercles giving the appearance of crocodiles back.

M.charantia var.muricata(wild) which develops small and round fruits with tubercles, more or less tapering at ends.

M.dioica

M. foetida

Momordica cochinchinensis

Momordica balsamina

M. charantia is propagated through seeds and is monoecious. *M. dioica* and *M. cochinchinensis* are propagated through underground tubers and are dioecious in nature. Both species have small fruits covered with spines. Main differences between the two species are as follows,

Kakrol or sweet gourd (*Momordica cochinchinensis* Roxb)	**Kartoli or spine gourd** (*Momordica dioica* Roxb)
Roots develop bigger tuber	Roots develop small tuber.
Leaves are bigger.	Leavers are small.
Flowers large and white to light yellow in colour.	Flowers small and yellow in colour.
There are three small circular dots at the base of petals which are deep blue.	No circular dot on the base of petals.
Anthesis during early morning (3.30-6.30 hours) and flowers take 72 hours to open.	Anthesis during evening (16.30-18.00 hours) and flowers take 7-22 minutes to open.
Fruits are large and oblong	Fruits are small and round to oval.
Individual fruit weight is around 60-80g and attains upto 500g.	Individual fruit weight is around 10-15 g and attains upto 30g.
Fruit ripening starts from periphery to inner	Fruit ripening starts from inner to periphery.
Fruit light green to light yellow in colour	Fruits dark green in colour.
Tough spines on fruit.	Smooth and false spines on fruit.
It takes 26 days to reach edible maturity from days to bud formation	It takes 20 days to reach edible maturity from days to bud formation.
Short flowering and fruiting period	Flowering and fruiting continue for long period.

CYTOGENETICS

- Chromosome number is 2n=22, x=11
- Tetreploid lines with 2n=44, were obtained by treatment by seedlings with 0.2 % colchicines for 18 hr to the shoot tips and triploids by crossing 4x with 2x plants.
- The natural triploid (2n=33) of the cultivated *M.charantia* was reported from India.

Floral Biology

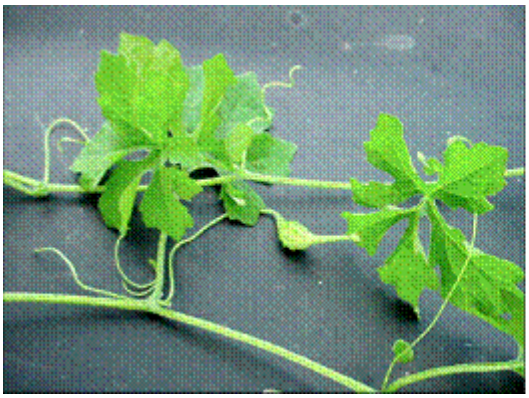
Bitter gourd is highly cross pollinated. Flowers are auxiliary with long pedicel and are yellow in colour. Stamens are 5 in number with free filaments and united anthers. Stigma is divided

Anthesis and Pollination:

The anthesis starts from 4am and extends till 9am.

Anthers dehisce from 5am to 7am.

Stigma is receptive 24hr before and extends for a day even after anthesis.



Female flower **Male flower**

BREEDING OBJECTIVES

1. Early fruiting.
2. High female to male sex ratio.
3. Whitish green to glossy green fruit colour depending upon consumer's preference.
4. Less ridged fruit surface.
5. Immature seeds for longer period during edible stage.
6. Higher yield (number of fruit weight). Fruit sizevariation as per consumer's preference (small 7.5-10cm long, medium long 10-15cm long 15-20cm and extra long 20-40cm).
7. Resistance to red pumpkin beetle, fruit fly, downy mildew and mosaic virus.

BREEDING METHOD

Bitter gourd is highly cross pollinated in nature due to pre dominantly monoecious sex form and entomophilous nature.

Selection

Single plant selection and mass selection methods were followed to develop high yielding lines of bitter gourd in India.

Pusa Mousami, Priyanka, Konkan Tara, Arka Harit and Pusa Vishesh.

Heterosis Breeding

Heterosis in bitter gourd was investigated at the Indian Agricultural Research Institute, New Delhi,

Pusa hybrid-1

RHR BGH-1

Mutation Breeding

One such bitter gourd cultivar, MDU 1, developed as a result of gamma radiation (seed treatment) of the landrace cultivar MC 103, was found to posses improved yield.

Hybridization: Major varieties developed through hybridization are

Pusa hybrid-1 : Pusa Do Mausami × Pusa Vishesh

Pusa hybrid-2 : S-63 × Pusa Do Mausami.

Urvasi : IC-85650B × IC-4435

Phule Green Gold : Green long × Delhi Local

BTH-7 : VRBT-3A × VBRT-82-1
BTH-165 : KB-1 × VRBT-36

Polyploidy Breeding:

Tetraploidy was induced by colchicines treatment. Soaked seeds(24hr) and sprouted seeds were treated separately with 0.1 and 0.3 % colchicines for 6,12 and 24 hr. Soaked seed treatment for 24 hr colchicines were effective.

Intergeneric hybrization:

M.charantia with *Trichosanthes anguina* was crossed. Over 50% of the pollinated flowers developed into fruit. Of the seeds, 50% germinated well, producing a normal crop. The floral and vegetative characters of *M.charantia* were dominated.

Resistance Varieties for biotic and Abiotic stress

Varieties	**Features**
Kalayanpur Barahmasi	Tolerant to fruit fly and mosaic virus
Phule BG4	Resistance to fruit fly
Kalyanpur Sona	Tolerant to mosaic virus and fruit fly
Phule Green Gold	Tolerant to downy mildew
BG 98 and BG 102	Resistant to red pumpkin beetle
IC 68275	BDMV Bitter gourd distortion mosaic virus resistant
Pant karela-1	Highly resistant to red pumpkin beetle
BTH-7	Field tolerant to powdery mildew
Green rough, Green smooth,White Rough and White smooth	Resistant to fruit fly
BTH-165	Tolerant to powdery and downy mildew

VARIETIES AND HYBRIDS

Consumer preferences in bitter gourd vary from region to region depending on size, colour, presence or absence of tubercles / ridges and bitterness of fruits. Accordingly a number of varieties are developed in India and details are furnished below:

Variety	Organization	Breeding method	Characteristics
Pusa Do Mousmi	IARI, New Delhi	Selection	This variety has been obtained through selection from local germplasm at IARI and released by the same organization. It is suitable for both the spring –summer and rainy season. The fruit are dark green long (18cm), medium thick, somewhat club shaped, and 7-8 continuous ribs. Fruit weight 100-120 g. Yield 12-15 t/ha.
Pusa Hybrid 1	IARI, New Delhi	Hybridization	Fruits medium thick, long and gloss green, yield 20 t/ha in 120 days
Pusa Vishesh	IARI, New Delhi	Selection from a local collection	suitable for growing during summer. Fruits glossy green medium long and thick.
Priya (VK1)*	KAU, Vellanikkara	Selection	This variety came as a result of selection at KAU,Vellanikkara in the local germplasm. It is characterized by extra-long fruits (about 50 fruits/plant) Extra long green spiny fruits with white tinge at stylar end, av. Fruit length 39

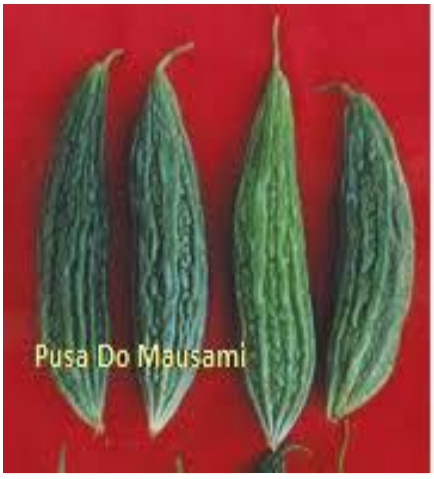
			cm. av. Fruit weight 235 g. productivity 24.5 t ha^{-1}
Preethi(MC 4)*	KAU, Vellanikkara	Selection	High yielding variety released from the KAU,Vellanikkara. Medium sized greenish white fruit, with spines, av. Fruit length 30 cm, av. Fruit girth 24 cm, av. Fruit weight 0.31 kg. Average yield is 10-35t/ha. Relatively less susceptible to fruit fly attack. Suitable for growing in Thrisur,Palakkad and Ernakulam districts.
Priyanka			Large white spindle shaped fruits with smooth spines, thick flesh and less seeds. Av. Fruit length 25 cm. av. Fruit girth 20 cm. av. Fruit weight 0.30 kg. Productivity 28.0 t/ha-1
Arka Harit	IIHR, Bangalore	Selection	The fruit are short, spindle shaped, attractive, glossy green with smooth regular ribs and thick flesh with moderate bitterness. Yield 9-12 t/ha.
Pant Karela 1	GBPUAT, Pantnagar	Selection	This is a selection from inbreds of indigenous germplasm at Pantnagar released in

			1999 by UP State variety release committee. Fruits are thick 15cm long, Yield is about 150q/ha.
Coimbatore long Green	TNAU, Coimbatore	Selection	It is a local type selected at TNAU, Coimbatore. Fruit are extra long, up to 60cm, dark green weighing 300-400g yield potential is 180q/ha
CO.1	TNAU, Coimbatore		Fruits dark green with medium length (20-25 cm) and weight (100-120 g). Yield 14 t/ha.
MDU.1	Tamil Nadu Agricultural University		Fruit weight 300-450 g. yield 15-18 t/ha. Induced mutant with long (30-40 cm) greenish white fruits, fruit length 30-40 cm, yield 30-35 t/ha.
Coimbatore Long White	TNAU, Coimbatore		Extra long fruits (60-65 cm) with white colour, yield 15 t/ha.
COBgH 1	TNAU, Coimbatore	Hybridization	F1 hybrid developed by crossing MC 84 x MDU1. Fruits are light green in colour, plumpy with more warts, each weighs 200g.-300g. Yields 44.40 t/ha in 115-120 days. It is rich in momordicin (2.99 mg per 100g).

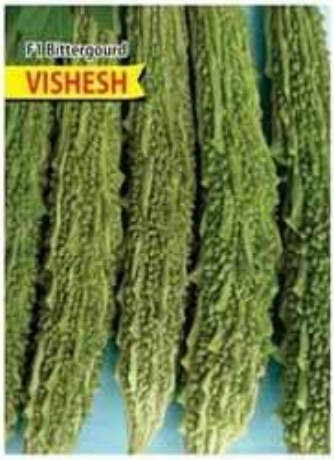
Phule Green Gold	MPKV, Rahuri	Hybridisation	It has been developed by pedigree method from a cross of Green long × Delhi Local at MPKV, Rahuri. Fruit is dark green, 25-30cm long and prickled. yield potential is about 200q/ha in 150-180 days, tolerant to downy mildew.
Phule Priyanka	MPKV, Rahuri	Hybridisation	Hybrid variety with dark coloured fruits. Fruits are 20-25cm long with tubercles.
Phule Ujwala	MPKV, Rahuri	Selection	Fruits 18-20cm long, dark green in colour with a few white tubercles, average yield 30-35t/ha.
Hirkani	MPKV, Rahuri.		Fruits dark green, 15-20 cm long, spindle shaped with warts and prickles, yield 14 t/ha in 160 days.
Konkan Tara	Konkan Krishi Vidya Peeth, Dapoli	.	Fruits green, prickly, medium long (15-16 cm) and spindle shaped. Yield 24 t/ha
Punjab 14	Punjab Agricultural University, Ludhiana		Plants bushy and bear light green fruits with average weight of 35 g. Yield 14 t/ha.
Kalyanpur Baramasi	CSAUA&T. Kanpur		Fruits long (30-35 cm), light green, thin and tapering, tolerant to fruit fly and mosaic, yield 20 t/ha in 120 days.

Arka Harit **MDU1**

Preeti



Pusa Do Mausami



Pusa Vishesh

Co1

CoBgH1

Questions:

1.What are all the dioecius species of bittergurd?

2. Name some varietes released from TNAU

3. What are the breeding objectives in bittergurd?

4. What is the mode of pollination?

5. Name some F1 hybrids of bittergourd

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RIDGE GOURD

L-9

Ridge Gourd (***Luffa acutangula*** Roxb.)) **(**Hindi : Ghia tori)
Smooth Gourd **(***Luffa cylindrica* Roem.**)** (Hindi: Kali tori)
Cucurbitaceae

CHROMOSOME NO : *2n=26*

Ridge gourd can be grown throughout the year and are used as vegetables. It is more popular vegetables in the south and east India.

ORIGIN: India

wild species

Luffa graveolens

Luffa echinata

⊡ The wild species, *Luffa graveolens* is progenetor of cultivated species

Luffa acutangula

Luffa cylindrica

Importance of the crop

- Both ridge or ribbed gourd and smooth or sponge gourd contains a gelatinous compound called luffein. It has lot of medicinal uses.
- Ridge gourd is very important for those who suffering from diabetes and hypoglycemia.
- Ridge gourd is also a good anti-inflammatory agent thus helping with cardiovascular disease, strokes, and cancer.
- The oils from the seeds are known to cure coetaneous complaints, the roots have laxative effects.
- The juice from the leaves is used to cure granular conjunctivitis of the eye, adrenal type diabetes and hemorrhoids.
- Genus name was derived from the product “Loofah” used as bathing sponges, scrubber pads, doormats, pillows, mattresses, cleaning utensils, etc.

Floral Morphology

- The sex form in ridge gourd is monoecious, gynomonoecious, andromonoecious and hermaphrodite.
- Male inflorescence in raceme of several flowers.
- Female flower solitary, borne axillary as male flowers.
- The flowers are pale yellow to yellow in color.

- Calyx – 5 lobed, united at the base .
- Corolla – 5 petals, companulate, bright yellow in colour .
- Androecium – stamens are three attached to the calyx tube, anthers free.
- Gynoecium – ovary is inferior, three carpellary with one or three called with 3 parietal placements.

Floral Biology

- ANTHESIS :
- Anthesis starts in the evening by 5.00 p.m. and continues uptop 8.00 p.m
- POLLINATION : cross pollination .
- ANTHER DEHISCENCE
- The anther dehiscence is seen immediately after anthesis.
- Pollens are fertile from the time of dehiscence till 2 to 3 days in winter and 1 to 5 days in rainy season.
- The stigma is found to be receptive even 6 hrs before anthesis and continues to be receptive till 84 hrs after anthesis.

Male flower

Female flower

Breeding objectives

- Earlyness
- High fruit yield (Arka swathi gives high yield 52t/ ha)
- Earlyness
- Uniform thick cylindrical fruits.
- Tender , non fibre fruits for longer lime.(eg for tender *:* Punjab Sadabahar*)*

- Resistance to diseases like powdery mildew *(eg.*Hisar Kalitori*)* , downey mildew , virus (eg. Gujarat Anand ridge gourd-1).
- Resistance to insects like red pumpkin beetle.
- Resistance to biotic and abiotic stress.
- FIBRE TYPE :
- *L. aegyptiaca* may be allowed to mature and use as a bath or kitchen sponge after being processed to remove everything but the network of xylem fibers.
- BITTER TYPE : eg . *Luffa amara*
- NON BITTER TYPE: Eg. Pusa Nutan and other cultivable varieties.
-

Fibre type

Bitter type

Breeding objectives

Single plant selection :, co-1, co-2

- pedigree method

Useful to improve highly heritable characters interspecific hybridization.

Luffa actutangula × *L.cylindrica*

Luffa actutangula × *L. graveolens*

Luffa echinata × *L. graveolens*

Polyploidy breeding

- Colchicine induced tetra ploids of Taiwan variety to exhibited thicker and shorter fruits lower fertility than corresponding dipliods.
- Breeding for resistance to diseases in heritance of ridge gourd resistant to downy mildew using dialleles crosses among 6 cultivars.
- **Hybridization**

Major varieties developed through hybridization are

Arka Swathi : cross between Medium fruits at IIHR-54 × long fruit at IIHR- 18

Arka Sumeeth : cross between Early fruits at IIHR-54 × long fruit at IIHR-18

Maintanence of inbred lines

- Uniform inbreds of luffa could be developed with comparable vigor of open pollinated varieties.
- They can be maintained through open pollination by growing them at proper isolation distance.
- Isolation distance of 1000 m is quite appropriate.
- Inbreds can also be maintained by hand pollination.

Genetics of sex expression		
Form	Genotype	Behavior on selfing
Monoecious	AAGG	Monoecious
Gynoecious	A-gg	Unstable and do not breed true
Androecious	aaGG	
Andromonoecious	a' a' GG	Andromonoecious
Gynomonoecious	AA g' g'	
Hermaphrodite	aagg a'a' gg aag' g' a' a' g' g'	Hemaphrodite Hermaphrodite Hermaphrodite Hermaphrodite

Varieties

Varieties	Organization	Breeding methods	Features
Pusa Nasdar	IARI, New Delhi	Selection	Midseason,flowering in 50 days,15-20 fruits/vine, fruits ridged,light green. More suited for rainy season.
Pusa Nutan	IARI, New Delhi	selection	Fruits are long (25-30cm), straight attractive green, average fruit wt.105g, flesh tender
Hisar Kalitori	HAU,Hisar, Haryana	Selection	Early long thin and straight fruited to Powdery mildew, suitable for rainfed areas.

GJRGH-1 – GAU, Gujarat

The fruits of GJRGH-1 are long in size with green colour.

Suitable for kharif season

Gujarat Anand Ridge gourd -1

AAU, ANAND, GUJARAT

This variety is medium sized and elliptical shape with green fruit skin colour. The variety has less mosaic virus and downy mildew disease reaction.

Pant Toria-1

GBUA &T, Pantnagar

The main shoot is 5m long. Fruits are 15-20 cm long and club shaped. It takes about 65 days to first harvest.

It is specifically suitable for rainy season.

CO1

TNAU, Coimbatore

Fruits are long (60-75cm) light green and weight 300 g each. Yield 14t/ha.

CO-2

Fruits are very long(1m) green & fleshy. Yield 28 t/ha.

Satputia

RAU Sobour Bihar

Vine produce bisexual flowers instead of male and female flowers separately.

Fruit borne in clusters.

Arka swathi

IIHR, Banglore

Cross between medium fruits at IIHR-54 and long fruited IIHR. Yield 50t/ha.

Arka sumeeth

- IIHR, Banglore
- It is a cross between early fruiting IIHR- 54 and long fruited IIHR.
- yield 50t/ha**.**

Punjab Sadabahar

- PAU, Ludhiana
- This varieties are medium sized with dark green leaves. The fruit is 3-5 cm long thick,smooth green ridged, tender, slightly curved and rich in protein.

Pusa Nutan

Gujarat Anand

CO -1

Satputia

GJRGH-1

Arka sumeet

Pusa Nasdar

Pant Toria-1

Swarna Sawani(satputia 2013,IVRC)

- Pureline selection
- Plant vigorous with 3-4m vine length
- Early flowering and fruiting

- Suitable for rainy seasons

Swarna Uphar (2006,Gazette No.1422)

- Pedigree method
- Early flowering and fruiting

Arka Prasanth (IIHR)

- open pollinated ridge gourd
- Release by Institute VTIC during 2016
- Early flowering & first female flowers appears at 9th node from the base of the vine.

Arka Vikram F1 hybrid

- Early flowering & first female flower appear.
-

Swarana Sawani **Swarna Uphar**

Arka Prasanth **Arka Vikram**

Varieties – Sponge gourd

Developing institution	Variety	Special features
IARI, New Delhi.	Pusa Chikni	Early variety. Fruits smooth dark green and cylindrical, 15-20 fruits / plant.
	Pusa Supriya	Fruits pale green, 15-20 cm long, straight and slightly curved at stem end, pointed distal end with long peduncle, average fruit weight 110 g at vegetable harvest stage. Yield 10-11 t/ha.
	Pusa Sneha	Suitable for long distance transport, fruits dark green, 20-25 cm long with hard skin and soft flesh. Yield 12 t/ha.
MPAU, Rahuri.	Phule Prajakta	Fruits medium green with dark green sutures, yield 15 t/ha.
BAC, RAU, Sabour, Bihar	Rajendra Nenua 1	Fruits long, greenish white, smooth and thick, resistant to fruit fly and fruit rot. Yield 25 t/ha.

Questions :

1.Ridge gourd varieties released from IIHR

2. What is the origin of Ridgegourd?

3. What is the mode of pollination ?

4. Ridgegourd variety released from TNAU

5. Name some hybrids of Ridgegourd.

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PUMPKIN

L-10

- BOTANICAL NAME *: Cucurbita moschata*
- FAMILY : Cucurbitaceae
- CHROMOSOME NO : 2n=40
- ORIGIN: : South America
- FRUIT TYPE: : Pepo

Species

- *C.moschata* - Pumpkin
- *C.pepo* – Summer Squash
- *C.maxima* – Winter Squash
- *C.ficifolia* – Fig leaf gourd
- *C.mixta*
- *C.foetidissima* – Buffalo gourd

Diversity in size shape and colour:

Importance of the crop

- Mature and immatre fruit: vegetables,
- Large seed (Pumpkin nuts or pepitas)-rich in Zn,
- Seed : De - worming treatment,
- Nutritious,
- Diuretic.

- Leaves: Pain killer.

Seeds

Botany

- Monoceous, annual Herb, viny growth, Runner.
- Hairy trichomes, spring like long, branched tendrils.
- Leaves: Five-loabed, long petiole, alternately arranged on the stem.
- Flowers: Large, showy, yellow or creamy corolla.

Plant **Flower**

- Male flower: Near the centre of plant & long slender pedicels
- Female flower: Short, slender pedicels, Calyx and corolla companulate.
- 3 Anther , thick style, stigma are three each are two loabed.
- FRUIT: Pepo

Floral biology:

- Anthesis, Stigma receptivity,
- Pollen dehiscence at early morning.

- Stigma receptivity til mid day.
- Flower open at temperature above 50^{o} F.

Breeding objectives

- High yield
- Earliness, high female to male ratio.
- Brta carotine (yellow) rich,
- Non ridged rind, Thick flesh and narrow seed cavity
- First pistilate flower at early node numbers,
- High Anti-oxidents specially carotinoids.
- Rich in vitamin – A
- High Anti-oxidents specially carotinoids
- Tolerence to low temperature & saline,
- Resistance to pest and disease

Genes responsible for various attributes

- Deep colour fruit with vitamin – A(B gene)
- Mottled light and dark green fruit colour(mldg)
- Herbicide tolerence (T)
- Silver leaf mottling (m)
- Yellow mosaic virus (zym)
- Fruit fly resistance in *C.maxima* 'Arka suryamukhi' (Fr)
- Gynoceous sex expression on sp – *foetidissima* (G)
- Green rind from 'Long Neopotitan' (Gr)
- Hard rind – in ornamental gourds(Hr)
- Powdery mildew resistance from *C.lundelliana* (Pm)
- Umbrella like leaves (uml)

Breeding Methods

- INBREEDING:
- Inbreeding along with selfing.
- No inbreeding depression in cucurbita sp
- Even after prolonged selfing.
- Inbreeding applicable for all cucurbits

Hybrid breeding

- 1.MANNUAL POLLINATION:
- Maintain several female rows alternate with one male row.
- Male flowers detected and removed from female rows before anthesis.
- Female flowers in female parent row are hand pollinated by male flower of male parent row.
- USE OF CHEMICALS:
- 2-chloroethyl phosponic acid(Ethephon)-
- Sex regulator(suppression of male flower)
- Spray at 2 and 4 leaf stage at 600 ppm is completely supprese male flower in plant.

Interspecific Hybridization

F1 hybrid between 2 sp difficult because such hybrid are sterile.

C. maxima x C. moschata found to be fertile and produce fruit.

MMMM x PPPP-------- MMPP x MM---------- MMP x MM --------- MM P

M=C. moschata

p=C. maxima

SELECTION:

Punjab Chappan Kaddu 1(Inbreeding selection)

Arka Chandan-collection from Rajasthan.

High beta-carotene content.(*C.moschata*)

Arka Suryamukhi-selection from forign introduction, Resistant to fruit fly(*C.maxima*)

Pusa Bishwas- selection of line SM-107

(*C.moschata*).

Hybrids

- Pusa alankar- EC-27050 x Sel.IPI-8
- Pusa hybrid – 1: Sel-107 x Sel -124
- transgenic varitiey:

Freedom: Resistant to Zucchini virus

Varieties

CO 1

It was evolved at Tamil Nadu Agricultural University, Coimbatore. A local selection, with late maturing fruits, medium large size with a characteristic broad proximal end. The distal end will be slightly tapering to form a tip. Immature fruits are dark green in colour. After full maturity, they become brownish orange. Each fruit weighs on an average 7-8 kg. It yields 30 t/ ha in a crop duration 150-160 days.

CO 2

Another selection from a local type with small flat fruits weighing 1.5-2.0 kg each. It yields about 23-25 tonnes/ha. in a crop duration of 135 days. Suitable for kitchen garden and family use.

Arka Chandan

It was developed at Indian Institute of Horticultural research, Hessarghatta. A selection from Rajasthan Collection. Fruits are medium in size each weighing 2.3 kg with depressed polar ends. Rind colour is light brown with creamy patches at maturity. The crop duration is 125 days.

Ambili

This variety was developed at the College of Horticulture, Kerala Agricultural University, Vellanikara. It is a pure line selection made from a local cultivar of Thrissur. It is a vigorously growing spreading variety having flat-round fruits of medium size with shallow grooves. The fruits are green in colour in the immature stage. Leaves are characterized by white spots on the upper surface of the lamina. Each fruit weighs on an average of 5-6 kg. It has got an yield potential of 34 t/ ha.

Solan Badami

It was developed at University of the Horticulture and Forestry, Solan, Himachal Pradesh. It is a small-fruited variety with a yield potential of 22.5 t/ ha.

Pusa Biswas

A local selection of the line CM 107 at IARI, New Delhi. It has vigorous growth, darkgreen leaves with white spots including veins. Fruits are light brown with thick golden yellow flesh and are spherical. Average weight is 5 kg. It matures in 120 days. The potential yield 20 t/ ha.

Pusa Vikas

It was developed at IARI, New Delhi. It is a small-fruited semi-dwarf to dwarf type. The fruits are small, round and flat weighing on an average 2.0 kg each, fruit flesh being yellow. Highly suitable for cultivation in spring-summer season in North India. Its potential yield is 30 t/ ha.

Cucurbita pepo

Early Yellow Prolific

It is a bush type with fruits medium in size and tapering towards the stem end; skin orange yellow at maturity. It was released by IARI Regional Station at Katrain. Duration 80-90 days.

Australian Green

Fruits are dark green with longitudinal white stripes; 25-30 cm long, very tender at edible stage. It was also released by IARI Regional Station, Katrain.

Patty Pan

An introduction from USA with disc shaped chalky white fruits, duration 85 days. Released by IIHR, Hessarghatta, Bangalore.

Punjab Chappan Kaddu

It is an inbred selection from segregating local material of Punjab, developed at Punjab Agricultural University, Ludhiana. Plants are bush type, foliage thick and erect. Leaves non-lobed and green without white specks. Fruits green, disc shaped. Average fruit weight 800 g and a plant bears about 10 fruits. It has a potential yield of 20-22 t/ ha.

Pusa Alankar

It is an F_1 hybrid of EC 27050 x Sel-1-PI.8 developed at IARI, Regional Station, Katrain. It is an early maturing (50 days) variety with uniform dark green skin with light coloured stripes. Fruits round with slightly tapering towards stem end.

Cucurbita pepo(Spoon gourd) ***Cucurbita pepo(* Summer squash*)***

Cucurbita maxima

Arka Suryamukhi

It is a selection made at IIHR, Hessarghatta from a foreign introduction. Fruits are small (1 kg) round with flat ends and deep orange skin and pale white stripes just like rays of sun; flesh firm, orange in colour and with pleasant flavour; Duration 100 days. This variety is resistant to fruit fly (*Daucus cucurbitae*).

Cucurbita maxima(winter squash***)***

Questions:

1.What are all the related species of Pumkin?

2. Name some varietes released from TNAU

3. What are the breeding objectives in Pumkin?

4. What is the mode of pollination?

5. Name some F1 hybrids of Pumkin

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Ash gourd

L-11

(Hairy melon, winter melon, ash pumpkin, white pumpkin, wax gourd, white gourd, petha)

Scientific Name : *Benincasa hispida*

Family : Cucurbitaceae

Chromosome No : 2n = 24

Origin:

Ash gourd probably originated from India.

Distribution:

Southeast Asia, East Asia and South Asia

Importance of the crop

- Ash gourd is cultivated for its immature as well as mature fruits which are used as a cooked vegetable and are used in confectionary and ayurvedic medicinal preparations.
- The delicacy 'Petha' made out of ash gourd is famous all over India.
- A small fruited medicinal ash gourd is also grown in Kerala.
- The famous ayurvedic preparation 'Kooshmanda rasayana' is made of ash gourd fruits.
- Ash gourd is good for people suffering from nervousness.

Botanical Description:

Habit: Robust, annual, usually monoecious, climbing herb up to several metres long.

Plant: Ash gourd is a crawling or climbing vine. The vines can be several meters long.

Leaves: Alternate, simple, reniform - rounded, 10-25 cm long and as broad, deeply cordate, upper surface scabrous, lower.

Root: Tap root

Stem: Branched, diffuse, having slender tendril.

Stem Anatomy of white gourd:

Inflorescence: Plants monoecious, male flowers solitary, pedicels 5-15 cm long, densely hispid and villous. Bracts ovate or broadly oblong, 6-15 × 5-10 mm, apex acute.

Calyx: Tubular 12 -15 mm in diameter, densely villose, lobes lanceolate, 8-12 × 3-5 mm.

Corolla: Yellow, lobes 3-6 × 2.5-3.5 cm, both surfaces pubescent.

Androecium: Stamens 3, free, inserted at the calyx tube, filament hispid, 2-3 mm long, base expanded, anthers 4 mm long, base expanded, anthers 4 mm long, sub- trilobite.

Flowers: Solitary in leaf axils, large, 8-12 cm in diameter, yellow, unisexual, pentamerous, pedicel densely hispid

Male flowers: 5-12 cm long, 5 stamens, 4 of these in connate pairs.

Female flowers: 3-4 cm long, cylindrical ovary and short style with three curved stigmas.

Fruit: Pepo, the outer layer covered with chalk white easily removable layer of wax, flesh 2-4 cm thick, white, succulent, slightly fragrant, spongy in the middle.

Seeds: Numerous, flat, ovate-elliptic, white, often with marginal rigid.

Floral biology

- Cross pollinated due to monoecious condition
- Male : Female 34:1
- Anthesis – 4.30 – 7.30 am anther dehiscence 3-5 am
- Stigma receptivity – 8 hours before anthesis to 18 hours after anthesis

- Pollen fertility – 95% at anthesis

MALE AND FEMALE FLOWER

Related Species and Genera:

Benincasa cerifera Savi

B . cylindrica Ser.

B. hispida var .chieh –qua

B.hispida var. hispita

*B. pruriens (*Parkinson)

B. vacua

Cucurbita hispida Thunb.

Gene symbol:

Sex controlled by two genes.

A-G : Monoecious

A-gg : Gynomonoecious

Aa G : Andromonoecious

Aagg : Hermaphrodite

Ar-1 : Anthracnose resistance to race 1

f : Farrowed fruit surface, recessive to smooth

Fo-1 : Dominant gene for resistance to race 1 of Fusarium oxysporum sp. Niveum.

Fwr : Resistance to fruit fly dominant gene

Pm : Powdery mildew susceptibility

Ag : Tolerant to aphids.

Breeding objective:

1) Earliness
2) High female to male sex ratio.
3) High fruit yield.
4) Resistance to drought and salt stress.
5) Resistance to common diseases like powdery mildew, downy mildew and virus and the insects like red pumpkin beetle.
6) Tough skinned fruits for long transportation
7) Development of seedless ash gourd.

Breeding Methods:

- Cross pollinated
- Mass selection
- Pedigree method
- Bulk population method

Selection:

- Ash gourd being a highly cross pollinated crop has a high degree of heterozygosity.
- Therefore selfing followed by selection improves the population and helps to develop a new variety with district feature from the original.
- Different selection methods can be applied for population improved.
- CO 1 & CO 2 developed through selection

Mass Selection:

- The selection of superior plants form the base population and missing of their seeds for raising the next generation are followed in this method.
- This selection procedure is repeated in uniform growing conditions up to the selection as a new variety / type.

- This method is effective in improving simply inherited and highly heritable qualitative characters.

Single Plant Selection:

- Single plant selection is a very common method of selection.
- The selfed individually in the next generation for evaluation and maintained by selfing.
- The advanced progenies do not show loss of vigour due to inbreeding.
- Therefore, homozygosity for the concerned, the best can be attained in the individuals of the progeny by selfing.
- After necessary evaluation, the best selection can be treated as a new type.
- Several varieties have been developed by single plant selection is ash gourd.

Inbreeding and Selection:

- Inbreeding is the mating of closely related individuals, that is either selfing or sib mating.
- Individual selection of practiced after attaining maximum uniformity and claimed as a variety.

Hybridization:

- Hybridization creates new genetic variability in the F2 and subsequent generations that helps efficient selection of desirable types.
- The hybrid progenies are advanced in the subsequent generations by selfing to selected desired types.
- Single plant selection by maintaining the pedigree of segregating generation is applied.

Backcross Breeding:

- Backcross breeding consist of crossing of F1 with one of the parents (Recurrent parent) followed by selection of genotypes for specific characters.
- One to three backcross may be made till homozygosity is attained. This method is generally applied to transfer simple inherited characters like resistant and some morphological traits to the unimproved variety.

- Two types of parents are involved in this breeding method: One as a recurrent parent (high yielding) and the other as a donor parent (Low yield but processing specific desirable traits).
- This method is commonly used for the development of resistant varieties.

Heterosis Breeding:

- The heterosis for the number of fruits and total yield were found to be 46% and 26%, respectively.
- High yield of F1 hybrid was contributed by various traits such as early maturity, longer vine, more fruits per plant, bigger fruit size and higher fruit weight.
- In most of the crosses, all the characters were under the control of duplicated epistasis indicating high promise for heterosis breeding in ash gourd.
- It is a highly cross- pollinated crop therefore it is necessary to produce inbred lines.
- If varieties / lines are maintained as pure lines by inbreeding, these lines can be used as inbred lines.
- These inbred lines will be crossed in different mating designs (diallel, line × tester) to test the specific and general combining abilities of lines.
- Once a good heterosis parental combination has been identified, the hybrid seed can be easily produced by adopting any one of the following methods.

1) Pinching of staminate flowers before anthesis and head pollination where isolation distance is not available.
2) Pinching of staminate flowers before anthesis on pistillate parent and insect pollination where isolation distance is available.
3) Chemical suppression of staminate flowers and insect pollination (at proper isolation).

Mutation Breeding:

- Generally mutations are heterozygous and recessive. Therefore, the mutant phenotypes are not expressed in the M generation.
- Several chemical mutagens (ethyl methane sulfonate, diethyl sulphate ethyl amine etc.) may be used for inducing the mutation.
- Besides, physical mutagens such as X- rays, gamma rays and neutrons also may be used for induction of mutation.
- In ash gourd the development of seedless fruits may be one of the mutation breeding.

Breeding Achievements:

Variability in ash gourd is limited except for size and shape of fruits. The improved varieties are:

TNAU Ash gourd hybrid Co 1:

- It is a F1 hybrid between PAG 3 × CO 2.
- Plants are medium viny.
- Fruits are oblong and medium sized (4-5 kg) in a duration of 120-130 days and suitable for small families.
- High yielding with an average yield of (91 -82 t/ ha).

CO1:

- Developed by TNAU, fruits are oblong oval shaped.
- This is a local selection variety of Tamilnadu, each fruit weighing 8 to 10 kg with crop duration 140 to 150 days.
- Yield about 50 to 60 kgs per acre.

CO 2:

- Selection from Coimbatore local variety.
- Fruits are oblong in shape.
- Each fruit weights about 2 to 4 kg with crop duration 120 to 130 days. Yield about 84 tons per acre.

INDU AG 1:

- Round shaped fruits with high flesh thickness, length 24 cm weighing about 4 to 5 kg each.
- This variety is tolerant to mosaic virus diseases.

Ekalavya:

- Developed by innovative farmer, Shri A.S. Joy of Thrissur, Kerala as a Hybrid.
- This is a Mosaic resistant variety.
- Fruits weigh 12 Kg. Crop duration 140 days. Yield 250 tons per acre.

KAU Local:

- Developed by Kerala Agricultural University, Thrissur, Kerala, Oval shaped fruits having high flesh thickness, length 45 to 55 cm and weight 6 to 8 kg.
- Yield about 70 tons per acre.
- This variety is tolerant to mosaic diseases.

Kashi Surbhi:

- Fruits oblong, ellipsoid, rind greenish white, flesh white, average fruit weight 10 -12 kg.
- Fruits are suitable for long distance transportation.
- It has yield potential of 600 -700 q / ha.

Pusa Ujawal:

- Developed by IARI, New Delhi.

- This is resistance to viral Disease.
- Average yield 40 ton / ha during summer and 43 ton / ha during Khariff season.

Kashi Dhawal (IVAG 502):

- Derived from a local collection, vine length 7.5 -8 m, fruit oblong, flesh white, thickness 8.5 -8.7 cm, seed arrangement linear, average weight 11-12 kg, crop duration 120 days, yield 550 -600 q / ha.

Kashi Ujawal (IVAG 90):

- Derived from local collection, vine length 7.5 -8 m, fruits round with average weight of 10 -12 kg fruit flesh white with 7 cm thickness, seed arrangement linear, crop duration 110 -120 days, yield 55-60 t /ha.


Kashi Surbhi Kashi Dhawal


Kashi Ujwal TNAU Ash gourd Hybrid CO 1

KAU Local

Some other varieties of ashgourd

Developing Institution	**Variety**	**Special features**
APAU, Hyderabad.	APAU Shakthi	Fruits long and cylindrical, yield 30-35 t/ha in 140-150 days.
UAS, Bangalore.	"Karikumbala"	Local cultivar where the fruits are covered with ashy coat.

In addition to above open pollinated varieties, a few F1 hybrids like MAH 1; MHAG 2 etc. are developed under private sector in the country.

Questions :

1.Ashgourd varieties released from IIHR

2. What is the origin of Ashgourd?

3. What is the mode of pollination ?

4. Ashgourd variety released from TNAU

5. Name some hybrids of Ashgourd.

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Fageria, M.S., P.S. Arya. & A.K. Choudhary. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani Publ.,New Delhi.

Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

WATERMELON

L-12

- Scientific name : *Citrullus lanatus*
- Family: Cucurbitaceae
- Chromosome No: 2n=2x=22
- Origin :

  Primary: Southern Africa

  Secondary: China (related species found in India)
- Grown in Middle East, the United States of America, Africa, India, Japan and Europe.

OTHER SPECIES

- *Citrullus edulis* 2n = 22, 24
- *C. naudinus n = 22*
- *C. colocynthes 2n = 22*
- *C. fistulosus*
- **Types** : seeded, seedless
- **Sizes** : ice-box, small, medium, large, giant
- **Shapes** : round, oval, blocky, elongate
- **Rind patterns**: gray, narrow stripes, medium stripes, wide stripes, light solid, dark solid.
- **Flesh colours** : white, yellow, orange, red

  Variations in flesh colour


BOTANY

- Plants are viny type, monoecious, with angular stem.
- Leaves are pinnately divided into 3-4 pairs of lobes
- COROLLA: rotate, five lobed, sulphur yellow or chrome yellow.
- cross pollinated crop
- Fruit sizes varies from 1.5kg to 50kg(10-12kg common)
- The greater part of fruit flesh is mostly derived from placentae.
- **Edible part** : mesocarp.
- **Flower** : less showy, monoecious cultivars. Pistillate or hermaphrodite flowers occur every seventh leaf axil intervening axil are staminate flowers.
- Three stamens are at the base of the corolla.
- Andromonoecious
- Controlled and open pollination

FLOWERS

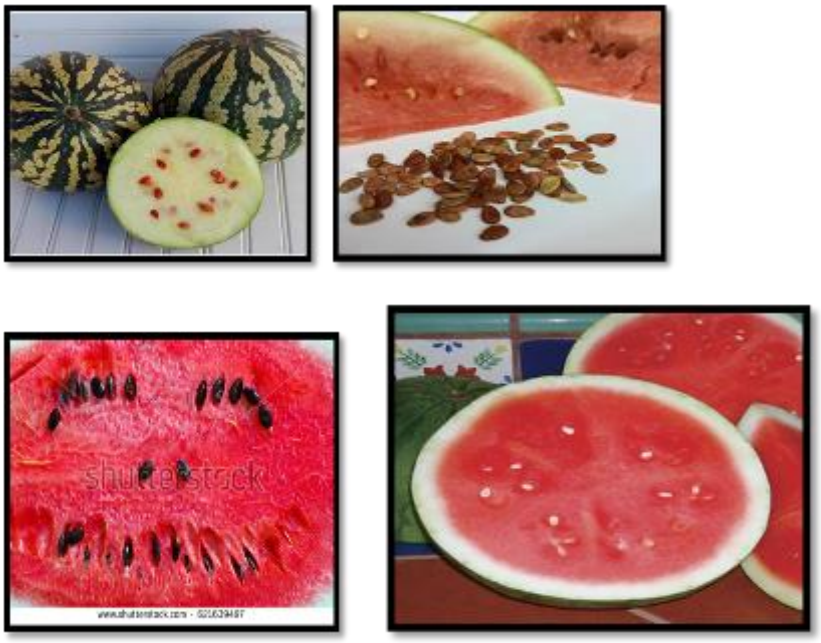
- **Anthesis** : 5.30 to 6.30 am
- **Fruit setting**: watermelon does not have flowering peaks or fruiting cycle there is an inhibitory influenced produced by fruit already set that reduces further fruit setting.

Important genes :

- a - andromonoecious, recessive to monoceious.
- Ar_1^-, Ar_2^- - Anthracnose resistance, resistance to *Giomerella cingulata* var. *orbiculare*
- *C - canery yellow flesh, dominant to pink.*
- *d* - dotted seed coat, black dotted seed when dominant for r, t and w
- dw-1 - dwarf-1, short internodes, due to fewer shorter cells than normal.
- dw-2 - dwarf-2, short internodes, due to fewer cells.
- *e - explosive rind, thin, tender rind, bursting when cut.*
- f - furrowed fruit surface, recessive to smooth
- g - light green skin, light green fruit, recessive dark green.
- g^s - striped green skin, recessive dark green but dominant to light green skin.
- g o - golden, yellow colour of older leaves and mature fruit.
- gms^* - glaborous male sterile, foliage lacking trichomes, male sterile.
- l - long seed, long recessive to medium length of seed, interact with s.
- m - mottled skin, greenish white mottling of fruit skin.
- nl - nonlobbed leaves, leaves lack lobbing, dominance incomplete.
- o - oval fruit
- p - pencilled lines on skin, inconspicuous stripes, recessive to netted fruit
- pm - powdery mildew susceptibility, susceptibility to *Sphaerotheca fuliginea*
- r - red seed coat , interacts with w and t
- s - short seed, epistatic to l.
- Scr - scarlet red flesh
- s u - suppressor of bitterness, non- bitter fruit
- t - tan seed coat, interacts with r and w
- w - white seed coat, interacts with r and t
- W f - white flesh, dominant to red

- Y^0 - orange flesh
- y - coral red flesh

Variations in seed coat colour seed coat colour



Breeding objectives

- Earliness
- Pistillate flowers at lower node number
- Tough skinned fruits for long distance transportation
- Dark red flesh
- Firm and non fibrous flesh texture
- Black seed
- Proper sugar to acid ratio
- TSS content not less than 10% (Arka Manik – 12-15%)
- Firm flesh
- Fruits with smaller and fewer seeds with attractive deep red flesh
- Intermediate fruit shape between typical long and round ones
- High yield (Arka Muthu – 55 to 60 t/ha)

- Resistance to disease ,viz., virus, fusarium wilt (race 0,1,2), anthracnose, gummy stem blight, powdery mildew
- Resistance to insect (cucumber aphids, fruitfly, cucumber beetle, red pumpkin beetle)

GENETIC RESOURCES

- USA – leader in watermelon breeding.
- The USDA watermelon collection is stored at the Regional Plant Introduction Station, Griffin, Georgia with the back up collection at the National Seed Storage Laboratory, fort Collins, Colrado.
- 1600 accessions in the collection, 300 heirloom cultivars in NSSL
- Germplasm conserved place :IIVR, Varanasi, NBPGR, New Delhi and few SAUs and IIHR, bangalore.

BREEDING METHODS

- Pedigree method – single seed descent method
- Backcross breding
- Hybrid breeding

SEEDLES WATERMELON

- It requires :

✓ production of stable tetraploid

✓ crossing of tetraploid as female with a diploid parent

✓ Evaluation and commercialization of triploid hybrids.

TETRAPLOID PRODUCTION

- Triploid hybrids produce seedless fruit.
- Seedless cultivars are produce by crossing a tetraploid(2n=4x=44) inbred line as the female parent with a diploid (2n=2x=22) inbred line as the male parent of hybrids.
- The reciprocal cross (diploid female parent) does not produce seeds.
- The resulting hybrid is a triploid (2n=3x=33).

STEPS

- ❖ Stage 1: involves choice of diploid lines to use in tetraploid production.
- ❖ Stage 2: production of tetraploid plants.
- ❖ Stage 3: tetraploid line development
- ❖ Stage 4: evaluation of tetraploids as parents of triploid hybrids.

TRIPLOID EVALUATION

- It's similar to evaluation of diploid cultivars.
- Commercial production of elite triploid hybrids is done by hand where labor is inexpensive or by bee.
- The tetraploid and diploid inbreds are planted together in alternating rows, or in alternating hills within each row.
- The pollen in triploid male flowers is not viable and female flowers in triploid plants require viable pollen to set fruit.

COMMERCIAL SEED PRODUCTION

- **Through manual pollination**

In this method tetraploid and diploid lines are planted in alternate rows or in alternating hills within each row.

Female buds are capped in evening.

Next morning , freshly opened staminate flowers are collected from diploid male parent and are used to pollinate the pistillate flowers

Pollinated flowers are again covered, tagged . Fruit can be harvested after 40-50 days.

- **Pollination through bees in isolation blocks**:

tetraploid and diploid are planted in alternate rows in isolation block.

During flowering, all staminate flowers from seed parent are removed for a period lasting several weeks. Pistillate flower on female are tagged with date.

Fruit harvesting is done after 40-50 days after anthesis.

BREEDING MEHODS

- Highly cross pollinated crop. Supported methods are mass selection, pedigree method and bulk population.
- Modified backcross breeding: Arka Manik – an advanced generation derivative of modified backcross between IIHR 21 and crimpson sweet. TSS 12-15%, average fruit weight 6kg. Triple resistant to Powdery mildew, Downey mildew and anthracnose.
- Introduction : Sugar baby, crimpson sweet and Asahi Yamato and New Hampshire Midget
- Heterosis breeding: heterosis expression for total yield, early yield, and quality parameters and exploited along with disease resistance eg., Arka Jyoti - Crimpson Sweet * IIHR 20
- Polyploid breeding: Application of colchicine (0.2-0.4%) morning and evening to the growing points of young seedlings over a period of 4 to 6 days and soaking of seeds solution of colchicine(0.4%) for 24 hour.
- Problems

  Tetraploid lines are low in fertility.

  The cost of seed is high

  Yield of seedless watermelon is low

  eg: Pusa Bedana- Tetra2xPusa Rasal
- Interspecific hybridization : *C.vulgaris* readily crossable with *Citrullus colocynthis*

VARIETIES

- Caltham gray, Summit, Shipper, White hope – resistance to Fusarium oxy f. sp.
- Fairfax – resistance to Alternaria cucumerina
- Alena is a tetraploid from diploid sugar baby

QUALITATIVE TRAITS

- Example include A for monoecious vs. andromonoecious sex expression, Ar-1 and Ar-2 for resistance to anthracnose races 1 and 2

- C for canary yellow flesh color, dw-1 and dw-2 for dwarf vines, E for non explosive rind, F for non furrowed fruit surface, Fo-1 for Fusarium wilt resistance, gs for striped green rind pattern, Go for non golden rind at maturity, M for non mottled fruit skin.
- o for oval rather than elongate fruit shape, Pm for resistance to powdery mildew, s and 1 for short seeds, Scr for scarlet red flesh, yo for orange flesh, and Y for coral red flesh.
- Crop development: Crimpson Sweet, Sugarlee, Kengarden has dwarf vines.
- 'Tri – X- 313' F1 3x is seedless.

Varieties	Breeding methods	Features
PKM-1		It was developed at Horticultural College and Research Institute, Periakulam. Fruits are bigger in size with dark green skin and pinkish red flesh. It yields 36-38 t/ ha. The duration is 120-135 days.
RAU, Rajasthan		
Durgapura Meetha	Selection from local cultivar	Developed at Agricultural Research Station, Durgapura, Rajasthan.
Durgapura Kesar	Selection from local type	Yellow fleshed variety
Durgapura Lal	Sugar baby x K-3 566	Unlobed leaf marker
IIHR varieties		
Arka Aishwarya	F1 hybrid	High yielding, good keeping and transport quality
Arka Akash	-	-
Arka Manik	IIHR – 21 x Crimpson sweet	Resistant to anthracnose & powdery mildew
F1 hybrid		
Arka Jyoti	IIHR -20 x Crimpson sweet	The fruits are round in shape. Each fruit weighs on an average 6-8 kg, bright crimson flesh with good texture, flavour and high sugar content (11-13 °B TSS) and low seed content. The rind is pale green in colour with dark green stripes. The fruits possess good keeping quality and transport quality. It is an early variety and produces about 80-85 tonnes/ha. in 90 days.
Arka Madhura	Triploid seedless	Suitable for year round production under protected condition.
Amrut	It is an F_1 hybrid developed by MAHYCO.	Fruits are oblong in shape weighing 6-8 kg. The skin is dark green with blackish shade and flesh is dark red. It has an yield potential of 100 t/ ha in 95-100 days.

VARIETIES AND HYBRIDS

- Pink fleshed – little baby flower
- Golden fleshed – yellow doll
- Red fleshed – crimson sweet, mickylee
- Super sweet – jubilee
- Yellow flesh – golden midget
- Lemon colored dots surface – moon and star
- Miniature – pixie
- Creamy fleshed –cream of saskatchewan
- Scarlet coloured – sangria (non fibrous flesh)
- Pink colour – starbrite
- Amaranth colored fruit – starlight
- Green stripes streaking across its rind – star ‘n’ stripes
- Dark green rind – sugarbaby (ice box)
- Summer flavour – Crimson sweet + all sweet
- Sweet favorite – light green patches on a blue green rind, ruby coloured fruit
- Yellow baby – similar to yellow doll.

SEEDLESS MELON

- Extazy
- Bijou – round deep red
- Captivation – red flesh, crimson sweet stripe appearance, deep green rind
- Kingman
- SVO 258 WA
- Citation
- Cut above

- Harvest moon
- Sweetpolly
- Traveler – deep red(hollow heart tolerance)
- Triple treat – red , ice box type .

VARIETIES

Watermelon- Arka Madhura

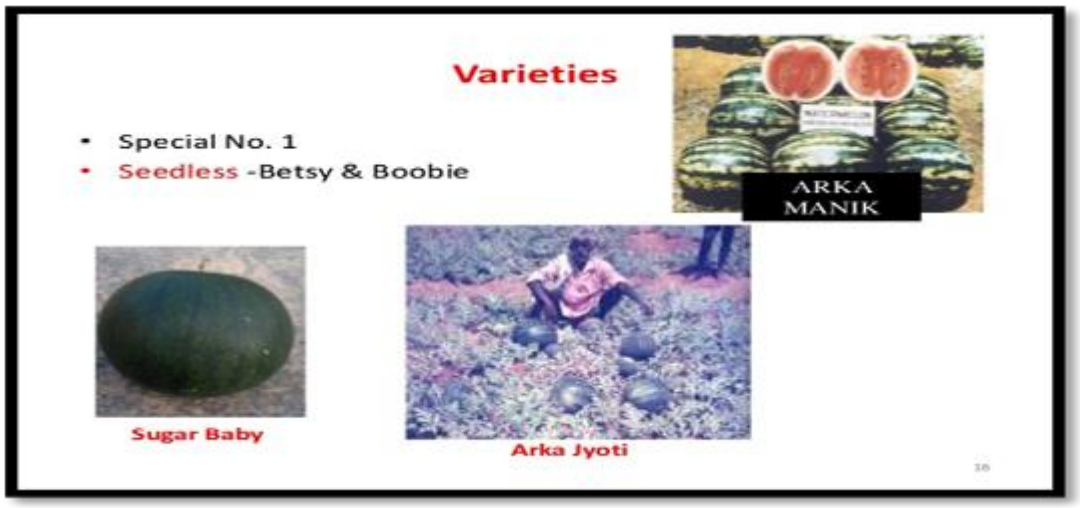
Arka Madhura

Triploid seedless watermelon hybrid between Tetra-1 X Arka Manik. Fruits round with dark green rind colour with light green broad stripes. Crimson red flesh with pleasant aroma without seeds, TSS 140 Brix. Average fruit weight 6 kg. Yield 50-60 t/ha. In 100-110 days

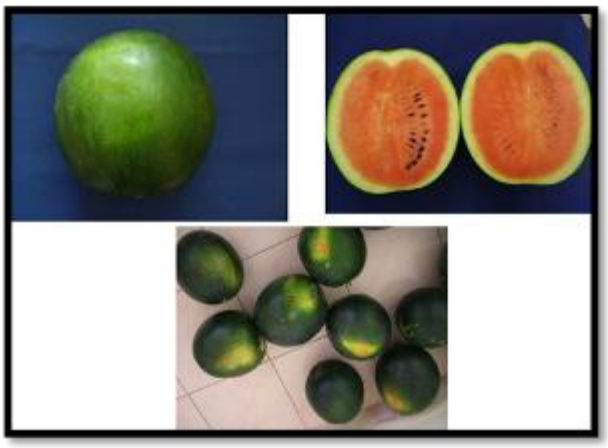
WATERMELON – Arka Aiswarya

- High yielding F1 hybrid. Green with Dark green deeply lobbed foliage, round to oval fruit, Dark green with light green broken stripes, red flesh, with TSS of 13-14% (brix), average fruit weight 7.5kg with 1-2 fruit per vine. Duration 95-100 days. Fruit yield 75 to 80 t/ha, red flesh, crispy, delicious, juicy and very good taste. Good keeping and transport qualities.

NEW HAMPSHIRE MIDGET



ARKA MUTHU



SUGAR BABY

Questions :

1.Watermelon varieties released from IIHR

2. What is the origin of watermelon?

3. What is the mode of pollination ?

4. Name some triploid seedless varieties of Watermelon

5. Name some F1 hybrids of Watermelon

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Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

L-13

MUSKMELON

Scientific name : *Cucumis melo*

Family : Cucurbitaceae

Chromosome number : 2n=2x=24

Origin : Tropical India

Related species : *Cucumis anguina, Cucumis sativus, Cucumis ficifolius.*

Importance of the crop:

- The musk melons are annuals with climbing, creeping or trailing vines.
- They contain small amounts of protein, fat, minerals, and vitamins.
- Edible portion: Endocarp.
- The desert types quench thirst and add nutrient content of main diet.
- Non desert type melons are used as vegetables.

Melon Botanical varieties:

Scientific name	Common name
Cucumis melo var. cantalupensis	Cantaloupe, muskmelon
Cucumis melo var. inodorus	Winter melon (casaba, honeydew)
Cucumis melo var. flexuous	Snake melon, Armenian cucumber
Cucumis melo var. conomon	Oriental pickling melon
Cucumi smelo var. *chito*	Mango melon
Cucumis melo var. *dudain*	Pomegranate melon
Cucumis melo var. *momordica*	Snap melon
Cucumis melo var. *agrestis*	Wild type
Cucumis melo var. *utilissimus*	Serpent melon
Cucumis melo var. *reticulatus*	Persian melon
Cucumis melo var. *chicko*	Garden melon
Cucumis melo var. *albida*	New melon
Cucumis melo var. *hime*	Orange melon
Cucumis melo var. *saccharinus*	Pineapple melon
Cucumismelo var. *acidulous*	Sour melon
Cucumismelo var. *tamago*	Egg melon

Floral biology and pollination:

Flower:

- The flowers of muskmelon are smaller and less showy
- They are located in leaf axils, most commonly singly.
- Most cultivars are monoecious (producing pistillate and staminate flowers separately), but a few older cultivars are andromonoecious (producing staminate and pistillate flowers)

Floral biology:

- The staminate flowers are clustered.
- The pistillate flowers are solitary on short stout pedicels.
- Campanulate calyx with 5 linear lobes, 5 corolla yellow in colour.
- Staminate flowers bearing 3 free stamens.
- Pistillate flowers bear staminodes, an inferior ovary topped by ashort style.
- Stigma – 3 lobed.
- Ellipsoid ovary.

Anthesis : 5:30 to 6:30 AM

Pollination : Highly cross pollinated crop due to monoecious nature.

Stigma receptivity : 2hrs before and 2 hrs after anthesis

Genetics of Muskmelon:

Gene	Character
A-G	monoecious
Aagg	Hermophrodite
Dcl	Resistant to Dacuscucurbitae
Jf	Juicy flesh

Cytogenetics:

- Chromosome number : 2n=2x=24
- Somatic chromosome number : 2n= 24
- Polyploids with 2n=48
- Cantaloupe is a polyploid with 2n=48

Breeding objectives:

- High yielding and earliness.
- Thick skin and flesh with good consistency.
- Good flavour, attractive outer colour and flesh colour texture.
- Small and negligible hollowness of fruit with high TSS not less than 10%.
- Resistance to powdery mildew and downy mildew, CMV, squash virus, cucumber green mottle.
- Exploitation of heterosis for yield and quality.
- Attractive round shape / spherical fruit shape.
- Attractive orange / green colour.
- Small seed cavity.
- Tough netted skin.

Breeding methods:

MASS SELECTION:

Arka Jeet, Arka Rajhans and MH1 were developed by single plant selection and later maintained by mass selection

PEDIGREE METHOD:

Pusa Sharbati - Kutana x American Cantaloupe

Punjab Sunehri - Hara Madhu x Edisto

HETEROSİS BREEDING:

It is observed for

1. Days to fruit harvest

2. Early yield

3. Soluble solid content, sugar content

4. Fruit weight

5. Keeping quality, transportability, fruit flavour

6. Number of nodes, vine length

7. Total yield

POLYPLOID BREEDING:

Attempts have been made to produce triploid seedless muskmeons by crossing tetraploidwith diploids.

MUTATION BREEDING:

Male sterile lines have been developed through mutation breeding. The unity of mutationbreeding is restricted to creation of variability in musk melon.

BACK CROSSING:

The back cross method was combined with selection for resistance to powdery mildew in field. A superior cultivar Powdery Mildew Resistant **Cantaloupe 45 (PMR45)** was released.

INTERSPECIFIC HYBRIDIZATION:

The botanical varieties *Cucumis melo* are intercrossible. Attempt made to cross with cucumber hasfailed. Somatic hybidization suggested.

Commonly utilized genetic mechanisms for hybrid development:

Mechanism	Remarks
Commercial method	All monoecious cucurbits
Emasculation and hand pollination	Due to andromonoecious flower structure
Use of monoecious lines	Problem due to uneven fruit shape
Use of gynoecious lines	
Use of GMS system	

Breeding Achievements:

RESISTANT VARIETIES

- Downy mildew : Georgia 47, Gulf stream
- Watermelon virus 1 : B665
- Muskmelon mosaic : Oriental pickling melon
- Aphids : p1371795
- Powdery mildew : campo,jacumba

High yieldingvarieties:

- Arkajeet important local selection from lucknow (IIHR 103).
- ArkaRajhans : PLS from local collection from rajasthan (lIHR 107)
- Hara Madfhu, PusaSharbati, PusaMadhuras, DurgapuraMadhu, Punjab Sunheri, NDMI and NDM2.

Varieties / Hybrids	Breeding methods	Features
IIHR varieties:		
ArkaJeet		High TSS
ArkaRajhans		Tolerant to powdery mildew
IARI varieties:		
PusaMadhuras		
PusaSharbati	Kutana x PMR – 6 (USA)	
IIVR varieties:		
KashiMadhu		Long storage capacity
Punjab Raseela	Phoot x Indian cultivar	Moderately resistant to downy mildew
Punjab Sunheri	HisarMadhu x Edisto	
HisarMadhur		
HisarSaras		
HisarMadhu		Do not slip stage at maturity
DurgapuraMadhu		
MHY – 5	DurgapuraMadhu x Hara Madhu	
Jobner 96-2		
F1 Hybrids:		
PusaRasraj	M – 3 x DurgapuraMadhu	Utilization of monoecious line
Punjab Hybrid	MS – 1 x Hara Madhu	1 st F1 Hybrid
MH - 10	Gynoecious line x Indian cultivar	

Questions:

1.What are all the botanical varieties of muskmelon?

2. Name some varietes released from IIHR

3. What are the breeding objectives of muskmelon?

4. What is the mode of pollination?

5. Name some F1 hybrids of muskmelon

References

Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

Rai, N. and M. Rai. 2006. Heterosis Breeding in Vegetable Crops. New India Publ. Agency, New Delhi.

L-14

CABBAGE

Brassica oleracea var. *capitata*

Cruciferace (2n = 2x = 18)

Origin:

Modern hard-head cabbage cultivars originated from wild non-heading brassicas somewhere in the easten Mediterrnean and Asia Minor region.

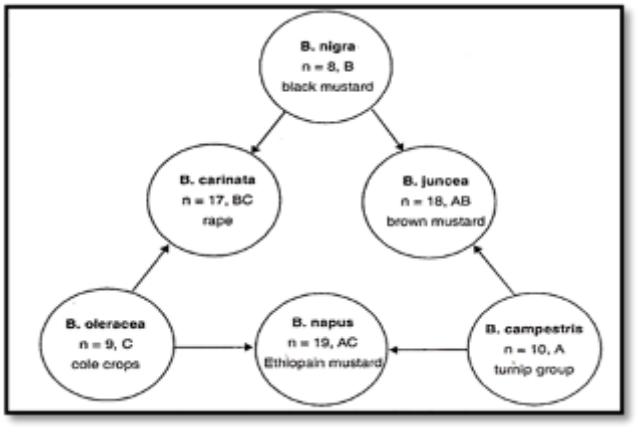
The species *Brassica oleracea* is divided into:

- *Brassica oleracea* var. *accephala* – Kale and collords
- *Brassica oleracea* var. *fimbrieata* – Curly kale
- *Brassica oleracea* var. *botrytis* – Cauliflower
- *Brassica oleracea* var. *capitata* – Cabbage
- *Brassica oleracea* var. *gemmifera* – Brussels sprouts
- *Brassica oleracea* var. *gongylodes* – Kohlrabi

- *Brassica oleracea* var. *italic* – Sprouting broccoli

All these species have the c genome the same number of chromosomes (2n = 2x =18) and readily cross with each other.

CYTOLOGY:



FLORAL BIOLOGY:

A cabbage flower has four sepals, four petals, six stamens in tetradynamous condition (two short and four long stamens) and a bicarpellary ovary which is superior and has a false septum. Ovules are attached on both the side of septum. Two active nectarines are located between the bases of short stamens and ovary. The buds open under pressure of rapidly growing petals and become fully expanded in about 12 hrs.

Flowers are slightly protogynous and cabbage is naturally cross pollinated due to sporophytic self-incompatibility. Pollination is brought about by bees and flies.

Bud pollination is effective to achieve selfing. For cross-pollination flower buds expected to open within 1-2 days are emasculated and are pollinated immediately with desired pollen using a brush/ flower stamens.

Bud pollination:

The basic seed of parental inbred lines is obtained by hand selfing at bud stage. The bud top is removed by tweezers and stripers to expose stigma which is then pollinated with pollen collected from the same plant/line. The seed production plot of parental inbred lines is covered with net to avoid contamination by bees or other insects. Pollen grains are collected afresh from the opened flowers on the same day. The mixed

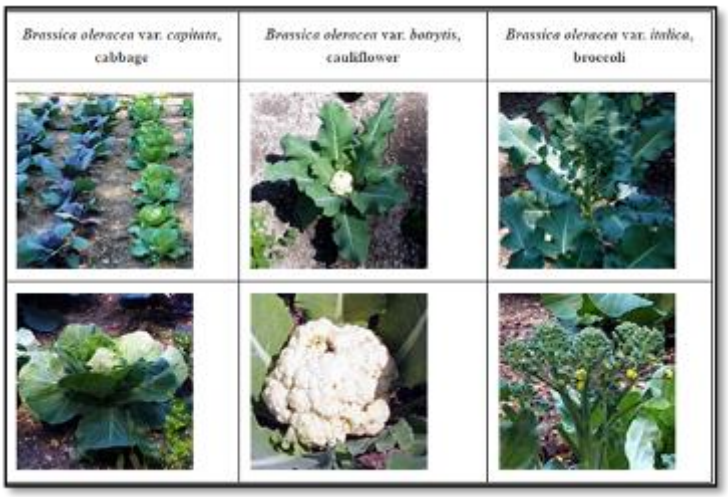
pollen grains are collected from the same line should be used for pollination to avoid viability depression from continuous selfing. If the bagging isolation is applied to multiply the basic seeds, the flowering branch is covered with paraffin bag/muslin cloth bag before the bud opens. The bud size should not be too small or big. Bud pollination done 2-4 days prior flowering gives the highest seed set.

Propagation of basic seeds of incompatible lines by bud pollination is labour intensive and costly. In consideration of this disadvantage, the electricity-aided pollination, wire brush pollination, thermal –aided pollination, CO_2 enrichment, ect., have been suggested. However, each one of these has its limitations and has not been used on commercial scale. Spraying a solution of 5% common salt has been used to overcome the self-incompatibility and increase the seed set by scientists in china. This method has been successful in the propagation of basic seeds (Zhiyuan *et al*., 1999).

Special consideration for F_1 hybrids production plots

- Isolation distance of at lest 2000 m from cauliflower, kohlrabi, broccoli, kale, Brussels sprouts, ect.,
- Provision of approximately 15 honey bee boxes/ha
- Building-up framework through appropriate staking to prevent lodging
- Control of insect and diseases
- Synchronised flowering of the parental inbreds
- Planting ratio of 1:1 for the parental inbreds
- Although harvested seeds from both parents can be mixed-up, it is better to harvest seeds from both the inbreds separately to improve seed uniformity





The shape of the cabbage head can be classified in three groups:

- ✓ **Ballhead (round head).** This is most common type. It has a round 6-7 in. (15-17 cm) in diameter. It has smooth white-veined leaves forming firm head.
- ✓ **Conical head (oxheart, sugar loaf).** This type has a smaller pointed head.
- ✓ **Drumhead.** This type has large flat head.

Breeding objectives:

- ➢ High yield
- ➢ Longer staying capacity in field after head formation/ greater field holding capacity
- ➢ Desirable heal weight (1-1.5 kg)
- ➢ Early head formation and early maturity
- ➢ Storage ability
- ➢ Head shape and colour as per preference of consumers (essentially round heads, light green- green colour)
- ➢ Less proportion of outer and wrapper leaves
- ➢ Short and narrow cone
- ➢ Firm head with short internal stem
- ➢ Ability to tolerate frost
- ➢ Resistance to diseases (Block rot, Alternaria, Black leg)
- ➢ Tolerance to insect (Diamond back moth)

BREEDING METHODS:

1. Introduction
2. Mass selection
3. Inbreeding
4. Heterosis breeding

Pusa Ageti:

Tropical type, produces seeds under sub tropical conditions, forms marketable head at a temperature range of 15-30°C but day temperature should not be above 35°C, recommended for March and August-October planting in northern plains, head weight 600-1200 g, ready for harvest in 75-90 days after transplanting. Yield 110-330 q/ha.

Pusa Drum Head:

Heads are large (3-4 kg), flat, cover leaves are light green, field resistant to black leg *(Phoma lingam*) disease, ready for harvest in 80-90 days after transplanting. Yield 300 q/ha.

Golden Acre:

Plants with short stalk and small frame, heads round, very compact cover leaves with dark green, cup shaped with prominent veins, ready in 60-75 days after transplanting. Yield 250 q/ha.

Pusa Mukta:

Plants with short stalk heads flattish round, medium in size, leaves are light green with slightly wavy margins, resistant to black rot (*Xanthomonas campestris*), ready for harvest in 70-75 days after transplanting. Yield 300 q/ha.

KGMR-1

Round, compact, green and covered head with outer leaf crimping, medium waxy, green and slightly serrated leaves, early in heading (60 days), better staying capacity in the field after maturity (20 days). Average yield(350-400 q /ha).

Questions :

1. **Name some species of *Brassica oleracea***
2. **What are all the breeding methods in cabbage?**
3. **Name cabbage classification based on types of head**

4. **Name breeding achievements in cabbage**

5. **What is bud pollination techbique in cabbage**

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Rana, M.K. 2011. Breeding and Protection of Vegetables. New India Publishing Agency. New Delhi.

Singh, P.K., S.K. Dasgupta. and S.K. Tripathi. 2004. Hybrid Vegetable Development. International Book Distributing Co., New Delhi.

L-15

Cauliflower

Brassica oleraceae var botrytis
2n=18
Cruciferae

Botany
Leaves :
Leaves are large entire with wavy margin.
Flowers:
Inflorescence is a Raceme , Flowers are complete and bisexual.
Calyx:
4 sepals
Corolla:
4 petals
Androecium:
Tetradynamous.6 stamens(4 long and 2short).
Gynoecium:
Superior ovary of two joined carpels with a single short stled. Ovules are numerous. Partial placentation but ovary is divided into two chambers b the development of false septum
Fruit:
Siliqua.The siliqua is typically long , slender and smooth with short conical beak.Seeds are grayish brown in colour.


Leaves with Wavy margin


Seeds

Breeding Objectives:
High yield
Earliness.
White and compactness.
Absence of malformation
Non bolting, erect leaf orient
Resistant to Black rot and tolerant to diverce condition.

BREEDING METHODS
Introduction

Mass selection
Pedigree method
Bulk population method

Introduction:

Improved Japanese is an introduction from Israle.

Heterosis breeding:

F1 hybrids: Inbreds are self incompatiable lines are produsedthrough bud pollination, late pollination,electrically stimulated pollination,stigma mutilators.

Inbreeding depression in cauliflower is not significantly higher,

SI lines can also be maintained through clonal propagation.

Inter specific hybridization:

Resorted to generate variability in caulliflower.

Intergeneric crosses:

Cross between cauliflower and radish was fairly successful only whencauliflower acts as male parent. Failure of resiprocal crosses was due to inabilityof the radish polle to penetrate the styles of the cauliflower.

Breeding Achievement

For different seasons:

Mid September to mid October:

Pusa Katki, Early Kunwari.

Mid October to Mid November:

Pant Shubra, Synthetic 1, Pusa Deepal

December:

Hissar 1, Pusa synthetic , Pusa Shubra.

Late maturity or snowball type:

Snow ball 16,Pusa Snowball1 and Pusa Snowball 2

Resistant to Pest:

Resistant to stiped flea beetle:

Snowball A

Other hybrids:

Self blanched variety:

Pusa Deepali.

Self blanched off season variety:

Pusa Himjyoti , Hisar -1

Tropical Cauliflower

Arka Kanti

Synthetic Variety:

Pant Gobhi-**3**

Varietal Description:

Arka Kanti:

- Selection from a local collection from Hazipur, Bihar.
- An early tropical cauliflower variety.
- White, compact curds.

Duration 60 days. Yield 22-25 t/ha.

Kashi Kunwari:

States for which Released:Punjab, U.P., Bihar and Jharkhand. Characterstics: This is an early maturity group variety. Suitable time of sowing is end of June to July under Indian plain conditions. It can tolerate high rainfall during its vegetative growth. Curds are semidome type, white compact; fine texture and weight about 300450 g; an yield of 300350 q/ha.

Kashi Agahani:

States for which Released: Recommended for Punjab, U.P., and Jharkhand, notified through Central Variety Release Committee. Characterstics: Midlate maturity group.

Pusa Deepali

Developed at IARI, New Delhi. Recommended for Northern India particularly Delhi and Punjab. Early maturing variety, curds compact, self-blanching, white, medium sized and almost free from riceyness.Curds ready for harvest in late October. Average yield is 12 t/ha.

Early Kunwari Recommended for Haryana, Punjab, and Delhi. Very early variety. Curds hemispherical with even surface, ready for harvesting from mid September to mid October. Average yield is 8 t/ha.

Punjab Giant-26:

Main season variety. Curds solid, white, medium-sized. Ready for harvesting from mid November to December. Average yield is 17 t/ha.

Punjab Giant-35

Main season variety. Curds white, compact medium sized. Ready for harvesting from mid November to December. Average yield is 17t/ha.

Pant Shubhra

Recommended for cultivation in Northern India. Early growing variety. Curds are compact, slightly conical and creamish white. Ready for harvest in November. Average yield is 20 t/ha.

Pusa Snowball-1

Late maturing variety. Curds very compact, medium in size and snow white in colour. Ready for harvesting from January to April. Average yield is 25-30 t/ha. Susceptible to black rot.

Sonwball-16

Ideal for cooler climates of North Indian states. Late maturing variety. Curds medium sized, solid, having attractive white colour. Ready for harvesting from January to March. Average yield is 25-30 t/ha.

Pusa Early Synthetic

Main season variety. Curds somewhat creamy white to white and compact. Ready for harvest from mid December to mid January. Average yield is 11 t/ha.

Pant Gobhi-2

Early maturing variety. Curds compact, composite and creamy white. Curds ready for harvesting from November to December. Average yield is 12 t/ha.

Pant Gobhi-3

Early maturing variety. Curds medium sized and solid white. Curds ready for harvest from October. Average yield is 10 t/ha.

Dania Kalimpong

Commonly grown in eastern parts of India. Late season variety. Curds are medium-large, compact, attractive and white. Less sensitive to fluctuations of environment. Ready for harvesting from January to April. Average yield is 25-30 t/ha.

Questions

1. **What are all the breeding objectives of cauliflwer?**
2. **Name some early maturing varieties of cauliflower.**
3. **What are all the breeding methods in cauliflower**
4. **What is the mode of pollination of cauliflower ?**
5. **Name some self blanched varieties of cauliflower**

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1. Rana, M.K. 2011. Breeding and Protection of Vegetables. New India Publishing Agency. New Delhi.

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L-16

CARROT

(Hindi – Gajar)

Daucus carota L.

2n = 2 x= 18

Apiaceae

- 16 species in the genus Daucus
- - 2 cultivated are *D. carota, D. sativus*
- Cultivated types are selection from interspecific cross between the above two species
- Cultivars are classified into 2 types viz., Asiatic and European

Importance of the crop

- Carrot is an ancient cool season root vegetable.
- Roots are used for making soups, stews, curries, pies, pickles and for salad purposes. Sweet preparation 'gajar halwa' prepared out of carrot is delicious and popular
- . Roots are also canned. Carrot roots are rich sources of α and β carotenes (1890 µ g/100g) and contain sucrose 10 times that of glucose or fructose.
- Carrot leaves are a good source of leaf protein. It is sued as fodder and for preparation of poultry feeds.Carrot has many medicinal properties.
- It increases quantity of urine and helps in elimination of uric acid. It has cooling effect and is beneficial for people suffering from gall stones, constipation and heat troubles.
- Purple and black carrots are used for preparation of a beverage called 'kanji which is a good appetizer.
- In France, essential oil separated from seeds is used for flavouring liquors and all kinds of food substitutes.

Origin

- Afghanistan is the primary centres of origin of carrot since a large diversity for morphological and root characters occur.

- Considerable variability for root also exists in India, indicating India also as a centre of origin.
- Root colour varies from absolutely colourless through light lemon light orange, deep orange, light purple, deep purple to almost black.

Botany

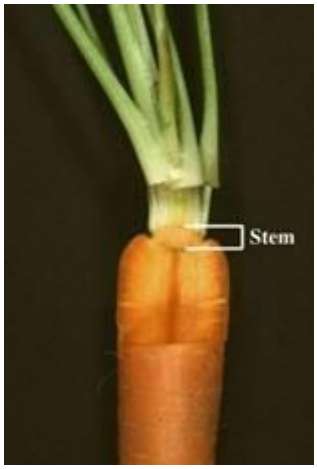
- Carrot is an annual or biennial herb with an erect or branched stem (30-120 cm high) arising from a thick fleshy root.
- Leaves are pinnate. Edible portion is the fleshy tap root composed of an outer cortex (phloem) and inner core (xylem).

Floral Biology

- Inflorescence is compound umbel and is produced during second phase.
- Anthesis in a single umbel is completed in 7-9 days.
- Individual flowers are bisexual with white or yellow petals.
- Andromonoecious – Hermaphrodite flowers – periphery & Centre
- - Male flowers – in between the two

Seeds

- They so called carrot seed is actually a fruit, an indehiscent mericarp, which consists of a single seed.
- Two mericarps pair to form a single rhizocarp, the real carrot fruit which develops from a two-loculed ovary.







Carrot Inflorescence

Carrot seeds

Carrot seed

- The so-called carrot seed is actually a fruit, an indehiscent mericarp containing a single seed.
- In fact, two mericarps pair to form the schizocarp the true carrot fruit.

Root shape and size

- Generally, the carrot root develops from a secondary thickening of the hypocotyl and tap root.
- In most cultivars, the root first grows in length and then increases faster in diameter than in length, so that it becomes thicker with age.
- The increase in diameter is most rapid at the crown and comparatively slows down towards the tip.
- Many physical and biological factors which cause defects such as **cooking, forking** and **stubbed off** roots through injury or interruption of natural tap root growth may act during this period of early growth.
- **Branching** of root is quite common and results from certain hereditary factors:

i) presence of undecomposed organic mater or plant refuse in the soil

ii) from injury to young taproot and

iii) from any impediment to its downward growth.

  - Heavy soils develop more **mis-shapen** roots than lighter soils.
  - Temperature also affects markedly the shape of roots.
  - The typical shape of the cultivar ‘Chantenay’ was evident only when grown at 18.3 °C. At 13 °C, the roots were longer and more slender and at 24 °C they were shorter and thicker.

- High temperature and irregular water supply usually causes **deep horizontal depressions** on the root surface.
- Excessive moisture following drought often results in white **corky outgrowths**, where side roots may develop.
- Under high temperature and low rainfall, the shoulders become comparatively square or sharply rounded .

Root pigmentation

- White, yellow, orange, red, purple and pink types are known.
- The visual colour being determined by level of total **carotenoids present**, the accumulation of **specific pigments**, and the distribution of pigments between phloem and xylem.
- In some **yellow and purple** cultivars, the root colour is due to **anthochlor** and **anthocyanins.**

- The red rooted carrot **'Kintoki'** contains 150-270 mg/ g total carotenoids of which about 3 per cent are **carotenoids**.

- The major pigments in this cultivar are **lycopene** and *B. carotene* is present in small amount.

- A temperature range of 15.5 - 21.1 °C is found best for colour development. In fact, carotene content in the roots is weather dependent, especially in the period preceding harvest, wet weather resulting in low carotene content.
- Similarly carotene synthesis is greater when sunshine is plentiful and rainfall is scarce.

Cultivars

Cultivars may be classified on the basis of shape of their roots or on temperature response

A. Classification based on shape:

1) Long rooted: Roots may be 25 cm or more in length, generally tapering, performs best in light soils.
2) Half-long rooted: Root length does not exceed 20 cm.

   i) Roots cylindrical with straight or sloppy shoulders (eg.) Nantes.

   ii) Roots tapering with blunt or semi blunt tip (eg.) Chantenay, Imperator

3) Short stump rooted: These are suitable for growing in heavy soils.

   i) Heart shaped (eg.) Oxheart

   ii) Oval (eg.) Early Scarlet Horn

   iii) Round (eg.) French Forcing.

B) Classification based on temperature response to flowering

1) Temperate or European or Biennial types

These require low temperature (4.8-10 °C) treatment for flowering to occur. These do not produce seeds in the plains of India (eg.) Nantes, Chantenay, Imperator etc.

2) Tropical, Asiatic or Oriental or Annual types

These do not require any low temperature treatment for flowering to occur. They seed freely in the plains of India.

Breeding objectives

High yield

High root weight

Good colour

Shape & texture of root

High sugar and carotene

Resistant to pests and diseases.

Breeding Method

- Highly cross pollinated
- Heterozygous – Andromonoecy
  - Protandry of perfect flower
  - Male sterility
  - Self incompatibility

Introduction

Imperator, Danvers, Nantes, Perfection

Mass selection

Spontaneous mutation coupled with selection – Cultivated varieties

Mass selection for root length – high yielding lines

Bulk population method

Pusa Kesar – Selection from Nantes x Local Asiatic

Mutation breeding

NEU (Nitroso ethyl urea) – 0.025 to 0.6%

NMU (Nitroso methyl urea) - 0.012%

Male sterile mutants

Polyploidy breeding

- Tetraploids (2n=36) and Octaploids (2n=72)
- Only limited utility

Heterosis breeding

Earliness, root length, root diameter, core diameter, carotene and yield

Hybrid development – Male sterility

- Self incompatibility

Male sterility

- Functional male sterility (closed anther mutants)
- Structural male sterility (stamenless mutants)
- Genetic male sterility – controlled by plasma gene 'S' and chromogenes (a and B) with duplicate gene action

The action of 'a' and 'B' genes with duplicate gene action disappears in the presence of complementary factors 'C' and 'D'.

Interspecific hybridization

- To generate variability

Varieties

Pusa Kesar

- It is an improved selection from a cross between Local Red and Nantes Half Long. Rich in carotene content (3.8 mg/ 100 g). This variety can tolerate higher temperature and is suitable to grow in early September to mid-November.

Nantes

- Roots are orange coloured, slim, well-shaped, cylindrical with stumped end forming a small thin tail. It has good qualities like thin skin, fine texture and sweet flesh. This variety is not suitable for seed production in the plains.

Chantaney

- It is a temperate variety highly suitable for canning and storage. Roots are reddish-orange with a length of 11.5 -15.0 cm and a diameter of 3-5 cm.

Zeno

- It is also a temperate variety. It was popularised in Ooty. It is high yielding and possesses good quality.

Danvers

- It is a mid-season cultivar suitable for fresh market and processing. The roots are deep orange in colour with ends either tapering or slightly rounded.

Imperator

- It is a cross between Nantes and Chantaney. This mid-season cultivar is suited for fresh market. The roots are deep orange coloured, 15.0-17.5 cm long and 2.5-4.5 cm in diameter.

American Beauty

- The roots are orange with self-coloured core, 17.5 cm long, cylindrical with blunt end.

Ooty 1

- It was developed at Horticultural Research Station, Udhagamandalam of TNAU by half sib progeny evaluation from a local type.
- The plants are robust in growth.
- The roots are 25 cm long with attractive deep orange colour.
- The yield potential is 45-50 t/ ha in a crop duration of 100-110 days.
- This variety is capable of setting seed profusely in the Nilgiris of Tamil Nadu at 2500 m MSL.

Questions

1. **Write the classification of carrot .**
2. **Name the variety released from TNAU**
3. **What are all the breeding objectives ?**

4. **What are all the breeding methods in crop improvement of carrot ?**

5. **What are all the breeding achievements in carrot ?**

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L-18

BEETROOT

Scientific name : *Beta vulgaris*
Family : Chenopodiaceae
Chromosome no : 2n=2x=18

- Origin :Table beet is originated from the Mediterranean Europe and North Africa. Later on it spread all over Europe to western India, forming a secondary diversity centre in the Near East.

Importance of crop

1. Decreases the risk of obesity, diabetes, and heart diseases.

2. Beets contain an antioxidant known as alpha-lipoic acid, which may help lower glucose levels, increase insulin sensitivity.

3. It is a rich source manganese, thiamine, riboflavin, vitamin, magnesium, phosphorus, potassium, zinc and copper.

***Beta vulgaris* classified into three sub species**,

- *Beta vulgaris* subsp. Adanensis
- *Beta vulgaris* subsp. maritima
- *Beta vulgaris* subsp. Vulgaris

Other imporatnt species are,

Beta cicla

Beta crispa

Beta esculenta

Beta sulcata

Floral morphology

INFLORESCENCE: Large spike

FLOWER: Bisexual, white, Small, Inconspicuous without corolla, but with green calyx which becomes thicker and covers the seed completely.

MULTI-GERM SEED:

- Also called beet seed
- Fruit containing usually 2 to 6 seeds.
- Small, kidney shaped and brown
- Anthesis -9.00 am -10.00 am Sepals - *4*, Polysepalous, erect.
- Petals - *4*, Polypetalous, regular, clawed.
- Gynoecium – 2 Carpels, Syncarpous & Superior ovary
- Androecium - 6 Stamens in two whorls.
- 2 outer stamens are short,4 Interior stamens are long.
- Anther dehiscence coincides with the Anthesis.
- Pollen viability – On the day of Anthesis , pollen viable for 60 days.
- The stigma is receptive at the time of Anthesis & continues for four days.

Inflorescence

Beet leaves

Seed ball

GENETICS

- Root Colour atleast two genes involved.

  Intensity of red colour is influenced by minor genes.

- R_Y_ : Red roots , hypocotyls, petioles
- RrY_ : Yellow roots, petioles and hypocotyls
- R_yy : White roots with red hypocotyls
- Rryy : White roots and yellow hypocotyls

Breeding objectives

- High root yield (Detroit dark red)
- Round to globe shaped roots
- Dark red, uniformly coloured roots
- Improved colour and sweetness
- Uniform root shape

- Absence of internal white rings in roots
- Increased betalain concentration
- Slow bolting (Avon early)
- Mono-germ seed (khavskaya)
- Resistance to downy mildew, powdery mildew, cercospora leaf spot, rhizoctonia root rot.

Breeding Methods

- Most of the garden beet cultivars cultivated today are resultant of mass selection rather than evolved by means of controlled breeding programme.
- The garden beet is a cross-pollinated crop and it is mostly self-incompatible.
- Self sterility in beet can be overcome by sib-mating.
- By using sib-mating for several generations **Ohio Canner**, a cultivar with a uniformly dark red flesh colour, has been developed.
- The garden beet cultivars are biennial, and if young plants are exposed to low temperature, they initiate flowers prematurely.
- Roots of early bolters are usually smaller in size and are more lignified than roots of normal plant.
- **Avon Early**, a selection made from a population of 70-80 Detroit cultivars, has been developed in the U.K. as a bolting resistant cultivar
- Another recent achievement in beet breeding is the development of monogerm (unilocular seed ball) seeds.
- **Khavskaya**, a monogerm cultivar, was bred at the Voronesh Experimental Vegetable Station (U.S.S.R.) using elite seed plants of the cultivar Bordeaux with monogerm and digerm fruits.

- The breeding programme included several selection cycles and inbreeding. **Khavskaya** is a mid-season cultivar with spherical or near spherical root, dark red flesh and a seed germination percentage of 85.

Classification of cultivars

Beet cultivars are usually classified on the basis of shape of roots.

i. Flat - Flat Egyptian

ii. Short top shaped - Flattened at top and bottom with rounded sides.

Eg., Crosby Egyptian, Early Wonder, Asgrow Wonder.

iii. Rounded or globular - Roots are round or globular in shape.

Eg., Detroit Dark Red, Crimson Globe

Half long - Length is shorter than long types

Eg., Half Long Blood, Winter Keeper.

iv. Long - Roots are long, may grow as much as 40 cm, quite popular in Europe

Eg., Long Dark Blood.

The cultivars recommended for cultivation in India are Detroit Dark Red and Crimson Globe.

Some of the important varieties are,

FLAT EGYPTIAN:

- Introduction from Germany by Ernst Benary Company.
- Early ,small foliage, flat roots.
- Roots are small sized and suitable for canning.

FLAT EGYPTIAN

CROSBY EGYPTIAN

- Introduction
- Rounder and smoother than flat egyptian
- It matures in 55-60 days
- It shows pronounced white zoning in warm weather
- Selection
- Roots are perfectly round with smooth, uniform, deep red skin, flesh dark blood red with light red zoning
- Maturation in 80 – 100 days

CROSBY EGYPTIAN

CRIMPSON GLOBE

- Introduction
- Roots globular to flattened, medium red with small shoulders, flesh medium, indistinct zoning

AVON EARLY : Bolting resistant variety

KHAVSKAYA : Mid season & monogerm cultivar (unilocular seed ball)

BOLDOR- Smooth, golden beet with yellow flesh and an excellent sweet taste

AVALANCHE-white coloured roots

DETROIT DARK RED

Selection

Roots are perfectly round with smooth, uniform, deep red skin, flesh dark blood red with light red zoning

Maturation in 80 – 100 days

DETROIT DARK RED

CRIMPSON GLOBE

AVON EARLY

CYLINDRICA

AVALANCHE-white coloured roots

OOTY 1

- Selection from the local type.
- It yields on an average of 31.45t/ha of roots.
- The roots are blood red in colour with thin skin and good quality.
- It can be used as a salad. It is a direct sown crop, which can be harvested in 120-130 days, whereas transplanted crop comes to harvest in 135 to 150 days.
- It grows upto 40 to 52 cm in height.
- It yields 1.5 to 2.3t of seed per hectare.
- It can be grown throughout South-Indian hills.

BOLDOR- Smooth, golden beet with yellow flesh and an excellent sweet taste

Questions

1. **Write about the beetroot classification**
2. **Name the variety suitable for south Indian Hills**

3. **What is the origin of beetroot**
4. **What are all the breeding objectives in beetroot?**
5. **What is seed ball ?**

References

1. Fageria, M.S., P.S. Arya. & A.K. Choudhary. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani Publ.,New Delhi.
2. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.

L-19

RADISH

Botanical Name : *Raphanus sativus*

Family : Brassicaceae

Origin : Europe (or) Asia

Chromosome no : 2n= 18

Importance of the crop

- Radish (Mooli) is a quick growing and short duration vegetables crop.
- It has high nutritive value.
- It is a good source of ascorbic acid and trace elements. Pink – skinned radish is generally richer in ascorbic acid than the white skinned.
- Cultivation of radish both for root and seed is very easy.
- Radish is an ancient vegetable. Inscriptions in pyramids in Egypt showed its existence about 2000 B.C.
- It is widely grown in almost all states of India. It is most suitable for raising in kitchen garden (or) home garden.

Origin

- Radish probably originated in Europe and Asia. It has been under extensive cultivations in Egypt since long.
- It was introduced in England and France in the beginning of 16^{th} century.

Cultivated radish types

R. sativus L. var. *radicula,*

R . Sativus L. var. *niger*

R. sativus L. var. *mougri*

R. sativus L. var. *oleifera*

R. sativus* L. var. *radicula, *R . Sativus* L. var. *niger*

R. sativus L. var. *mougri*

Botany

- The edible portion of radish develops from the primary root and hypocotyl the inflorescence is a typical terminal receme of cruciferae.
- The flowers are small, usually white in colour, sepals (four) are erect and petals (four) are clawed.
- Radish is cross pollinated due to sporophytic system of self- incompatibility.
- It shows considerable in breeding depression on selfing. It is entomophilous. It is pollinated mainly by wild honey bees and wild- flower flies. Stigma receptivity is maintained upto four days after anthesis.

Leaf

Attitude : erect, semi- erect (or) horizontal

Length : short, medium (or) long.

Leaf blade

Shape : Narrow- obovate, obovate (or) broad obovate, pointed (or) rounded

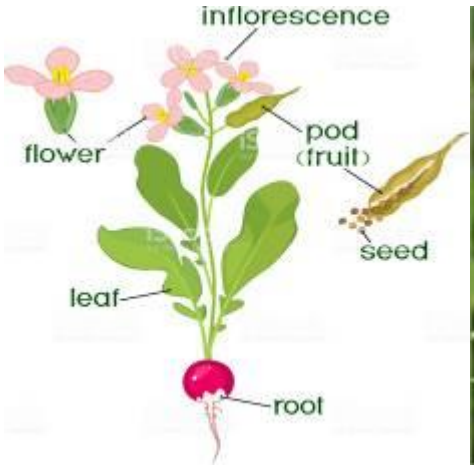
Colour : yellowish- green (or) greyish green

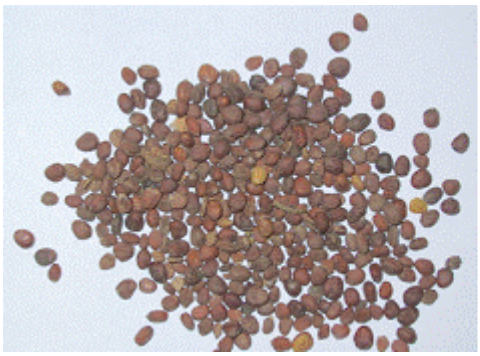
Pubescence : Slight, medium (or) strong

Petiole

Anthocyanin coloration : absent (or) present

Intensity of anthocyanin coloration : weak, medium (or) strong.






Cytogenetics

Basic and haploid chromosome numbers of radish X=n=9.

Chromosome size range 1.5- 3.5 m

Basic genome of radish has both homologus and non – homologous chromosome.

Basic cytological and phylogenetics relationship, the species of raphanus evolved from a commom ancestral form with chromosome number 2n= 6 by chromosome duplication.

Breeding objectives

- Early rooting
- High yield (Arka Nishant- 18- 20 t/ha)
- White, long/stump roots with thin tap root and non- branching habit
- Non pithy roots
- Pungency of roots as per consumers preference
- Slow bolting habit
- Heat tolerance
- Drought resistance
- Wet tolerance

- Resistance to alternaria blight, white rust, RMV
- Tolerance to aphids

Breeding Methods

Mass selection

This is practiced in cultivars collected from the farmer's fields.

Arka Nishant from IIHR.

Pedigree method

Pusa Himani : Black Radish × Japanese White

Pusa Rashami : Green Top × Desi

- **Polyploid breeding**
- Polyploids with 2n= 36 produced. No distinct advantages. Two polyploid varieties have been developed and these yield more than diploids.
- Sofia Delicious (2n=36)
- Semi long Giant (2n= 36)

Variety and varietal character

A. European (or) Temperate Types

1. White lcicle

- The roots are thin and tender and icicle shaped. The skin of roots of this variety is pure white.
- It is a flavoured variety. It is very short duration (20-25 days) and suitable for kitchen garden.

Delay in harvesting causes pithiness in roots that reduces quality of roots. It is sown in oct-nov in plains.

White lcicle

2**. Scarlet Globe**

It is an early variety takes about 25-30 days for development of harvestable roots, outer skin of roots is scarlet in colour with white tip, and flesh is pure white.

Roots are round in shape.

Scarlet Globe

3. **Scarlet Long**

It is an early variety (25-30 days). Leaves are 15-20 cm in length and light green in colour. The roots are long and tapering to a point.

B.Tropical (or) Asiatic types

1. Japanese White

It in introduction from Japan,c.v. “shiroaguri- kiyO” recommended by IARI Regional Station, Katrain (HP).

The roots are pure white, 20-30 cm (or) so long, blunt at root –end.

They are mildly pungent.

It is suitable for Oct- Dec sowing.

Japanese White

2.Pusa Desi

Roots are long (30-35cm) white, tapering with green stem-end variety is suitable for sowing in early Aug- Oct in two northern plains of India, roots become ready for harvesting in 45- 50 days

Pusa Desi

3.Pusa Chetki

It is developed by IARI, New Delhi from the seeds collected from Denmark. Roots are pure white and they are mildly pungent.

The leaves are entire, upright, dark green and slightly lobed.

Pusa Chetki

4. **Pusa Reshmi**

It was developed through recombination breeding, released by IARI, New Delhi.

The roots are white, long(30-35cm), tapering with green stem end.

The foliage is medium , light green with cut leaves.

Pusa Reshmi

5. **Punjab Safed** (White 5 × Japanese White)

The roots of this variety are white, tapering, mildly pungent and 30-40cm long.

The roots are ready for harvesting in 40-45 days.

Punjab Safed

6. **Kalyani White**

The roots are pure white having blunt ends,25-30 cm long. Top growth is short.

The roots are mildly pungent. This variety is suitable to grow all the year round except during hot summer.

Roots become ready for harvesting in 45-50 days.

Kalyani White

7. **Chinese pink**

An introduction identified by Dr. Y.S.Parmar. University of Horticulture and Forestry, Nauni, Solan (HP).

The roots are 10 -15 cm long pink with white colour towards the tip. The roots are ready for harvesting in about 50- 55 days.

Chinese pink

8. **Arka Nishant**

This variety was developed from the seed collected from Singapore; and released byIndian Institute of Horticultural Research, Banglore in 1980.

The roots are mildly pungent, marble white in colour, non –pithy roots of excellent quality.

Pre mature bolting and root forking are not commonly seen.

Resistance Breeding For Biotic Stress

Asmer Tip Top: To insect *Erioischia brassicae*

Punjab Safed : To Leaf spot

Nerina : To Mosaic Virus

Summer Wonder: Res. To Black rot

Chinese Rose White: Res. To Downy Mildew

Questions

1. **What are all the cultivated radish types?**
2. **Name some resistant varieties of radish to some biotic stresses.**
3. **Name some varieties developed from IARI?**
4. **Name a variety developed from IIHR**
5. **Name a radish variety with pink skin.**

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Rana, M.K. 2011. Breeding and Protection of Vegetables. New India Publishing Agency. New Delhi.

L-20-21

BIG ONION (or) COMMON ONION

- Scientific Name : *Allium cepa*
- Chromosome no :2n = 16
- Origin – Pakistan(According to Vavilov)
- Inflorescence: in each flower – 6 stamens, 3 carpels, 6 perianth segment

IMPORTANCE OF THE CROP

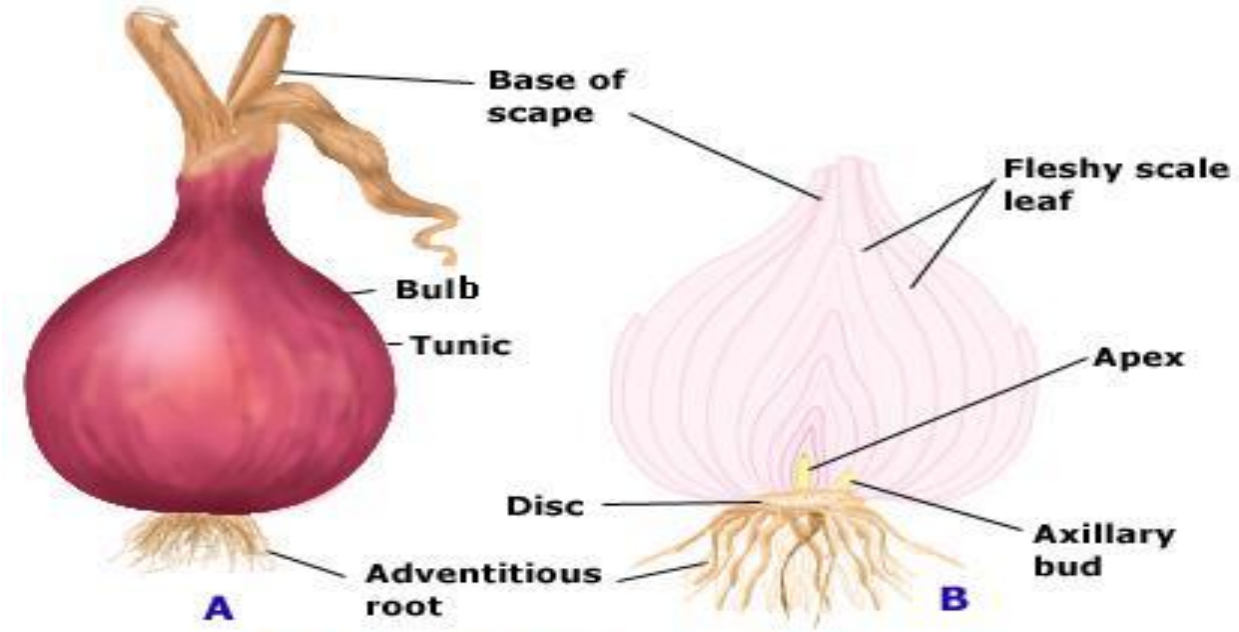
- Onion is cool season vegetable
- It is grown for its bulbs which are used as salad, cooked in various ways in all curries, fried, boiled, used in soup making in pickles and many other purpose
- In India, the most important onion growing states are MH, AP, TN, Bihar and punjab.
- It is a export oriented crop

ORIGIN AND DISTRIBUTION

- The Russian scientist Vavilov reported central Asia is the primary center of origin.
- Western Asia and area around Mediterranean Sea are its secondary centers of origin.
- Now it is distributed throughout the world.

FLORAL BIOLOGY

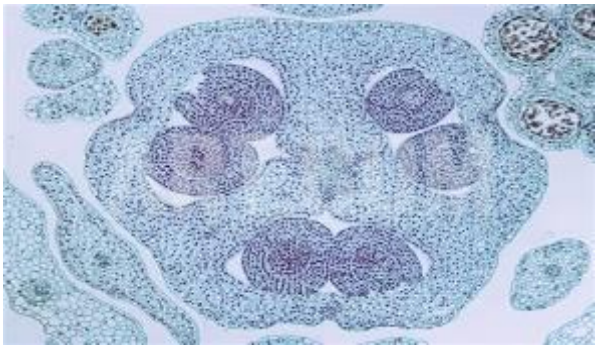
- The flowering structure of onion is called umbel.
- Umbel is an aggregate of many small inflorescences of 5 to 10 flowers.
- The inflorescence may consists of a few to more than 2000 flowers for umbel
- Anthesis occurs in early morning (6-7 hrs). Anther dehiscence is between 7.00 and 17.00 hr and on next day also with peak between 9.30 and 17.00 hr.
- Pollen fertility is highest on the days of anthesis. Stigma receptivity is also high on the day of anthesis.



A. Tunicated bulb of onion B. L.S. of bulb

Onion flowers

Floral Formula: Br ⊕ P3+3 A3+3 G(3)



Onion seed head Onion seeds

MODE OF POLLINATION

- Onion is highly cross pollinated crop and pollinators are bees and other insects
- The reason for cross pollination is heteromorphism and male sterility.

Related species


Tree onion-bulblets are produced in flowerheads-hybrid between *Allium cepa and Allium fistulosum*

***Allium canadense* (Wild onion)**


CHIVE- *Allium schoenoprasum*

***Allium porrum* (LEEK)**

SHALLOT- *Allium ascolonicum*
(2-3 individual bulbs inside)

WELSH ONION

OBJECTIVES OF BREEDING

- Varieties with improved quality(good shape, colour) and high yield suited to different agro climatic conditions and better stability
- Varieties resistant to diseases like basal rot and phythium blight etc.
- Develop to short day, high yielding F1 hybrids With longer storage life.
- Development of white onion varieties suitable for dehydration and export.

- High yield
- Longer bulb storage life
- Resistance to diseases (purple blotch, basal rot, stemphyllium blight)
- Resistance to insect pests(thrips)
- Resistance to abiotic stress
- Single centered bulbs especially for fresh market

BREEDING METHODS

MASS SELECTION:

- Arka Kalyan developed from MS from IIHR-45 (moderately resistant to purple blotch).
- Arka Niketan: developed from MS from IIHR-153(red colour excellent keeping quality)

PEDIGREE METHOD: Arka Pitambar: Yellow onion.

HETEROSIS: Arka kirthiman:(tolerant to purple blotch)

INTERSPECIFIC HYBRIDIZATION:

- *A. cepa* var. Cepa X *A. fastulosum* –welsh onion popular in china and spain

Salient breeding achievements

- IARI: Pusa Red, Pusa Madhushri, Pusa Ratnar, Pusa White Round.
- NHRDF: Agri found Dark Red, Agri found Light Red.
- TNAU: CO1 to CO4-All red
- PAU: S48,Punjab selection-Red
- MPKV:NS-4-1,Baswant 780-Red

Qualitative Genetics

- Inheritance of bulb colour in onion:
- Colour classes: White, Yellow, Red and Brown
- Dominant basic colour factor ‘C’ is necessary for either red or yellow colour(Clarke *et al* 1944).

- ❖ All the plants with 'cc' have white bulbs regardless of presence of other colour factors.
- ❖ Dominant 'R' with 'C': red bulb colour
- ❖ 'r' with 'C': Yellow bulb
- ❖ 'I' colour inhibiting factor incompletely dominant over 'i'.
- ❖ 'II' : White bulb colour regardless of presence or absence of C and R factors.-

Sources of resistance to diseases and insect pests in onion

Diseases/Insect pests (causal organization)	Level of resistance	Name of the variety/line
A. Diseases		
i) Purple blotch (Alternaria porri (Ellis) Cliff.)	Resistant Moderately resistant	'IHR 56-1' 'Red Creole', '33-2', New Selection and VL-67 Pusa Red, VL-1, N-2-4-1, Ph. Sel-3, Pusa Ratnar and Pb. Sel-5 IHR 25, IHR 471, IHR 500 and Arka Kalyan
	Tolerant	Rampur Local, Pusa Red and Patna Red
ii) Stemphylium blight (*Stemphylium vesicarium* (Wallroth))	Tolerant	40 accessions
iii) Stemphylium blight + purple blotch	Combined tolerance	IC 32176, 42900, 47954, 47972-3, 47997, 48001, 421452-2, 48710, 48724, 48954, 48903, 49012 and 49121, 48268-1, 48548, 48575
iv) Basal rot (*Fusarium oxysporum* f.sp. Cepae, Schlect.)	Resistant	Telagi Red, White large, Poona Red, Bellary Red, Udaipur 103, Patna Red and N-257-9-1 IHR 141, IHR 506 and Sel-13-1-1

B. Insect pest		
i) Thrips (*Thrips tabaci* Lind.)	Resistant	N-2-4-1, Sel-104, Pusa Ratnar, Sel-171, HR Brown & Sel-1202. No. 544, Kalyanpur Red Round, Udaipur 103, Safed Gol, No.5, White, Mathewad-1, Shirwal-2, White Creole, Kagar-2 & Peth -1
	Tolerant	Hissar-2, Panipat Local, Rajpur Red, Onion Karachi, Pusa Ratnar, Bombay White, N-53, Red & white big round
	Lowest incidence	*Allium fistulosum*, BS 956, BS 929, BS 968 and K-1-7-1, Ludhiana Selection, N-2-4-1 Hissar-2, 123-7-1, Bombay white
ii) Gram caterpillar (*Heliothis armigera*)	Least preference	Sel-102-1, Large red S-76, Verma Giant, S-207, S-243 & S-16 (seed crop)

Some important varieties in India and their characters

1.Pusa Red	IARI ,New Delhi	Red colored bulbs, good storage
2.Pusa Ratnar	IARI New Delhi	Deep red, round, yield 30 to 40t/ha
3.Arka Nikethan	IIHR, Banglore	Good for storage
4.Arka Kalyan	IIHR, Banglore	Moderately resistant to purple blotch
5.Arka Bindu	IIHR, Banglore	Suitable for export
6.Arka Lalima	IIHR, Banglore	Resistant to purple blotch
7. Pusa white flat	IARI ,New Delhi	Suitablefor dehydration
8 .Punjab 48	PAU, Ludhiana	Suitable for dehydration
9.Early Grano	IARI, New Delhi	Yellow onion Good for salad purpose
10.Agri found Dark red	NHRDF	Suitable for kharif

Agri found Dark red

Agri Found Light Red

Pusa Riddhi:

- Single bulb weight ranges from 70.0 -100.0 g.
- Pungent and rich in antioxidant (quercetin107.42 mg/100g).
- Suitable for kharif and crop,, and export.
- Average. Yield: 31.66 t/ha.

Pusa Soumya

- First bunching onion variety
- suitable for round the year green onion production.
- least affected by pests and diseases.
- Yield: 26.38 t/ha.

Arka Akshay:

It is a tri-parental synthetic variety with dark Red globe shaped bulbs. Average bulb weight is 115 g. Yield 45 t/ha in 130 days.

Arka Bheem (Syn-6) :

- It is a tri-parental synthetic variety
- Red to pinkish red, elongated globe shaped bulbs
- Average bulb weight is 120 g
- Yield 47t/ha in 130 days.

Arka Sona

Arka Sona has the yellow bulb colour, globe shape, big size of bulb diameter 6.5-7cm, bulb weight 140.0g, low TSS 10^0 B, bulb yield 45 t/ha, duration 120 days, suitable for growing in Rabi season and suitable for export.

Arka Vishwas

Arka Vishwas has the bulb colour dark red, flat globe shape, small size of bulb diameter3-4cm, bulb weight 40.0g, TSS 16^0 B, bulb yield 30t/ha, duration 115 days, suitable for growing in Rabi season and suitable for export.

Arka Swadista :

- white onion variety
- bulbs are oval globe in shape,
- TSS 18-20%,
- edible bulb 98%, weight 35-40g,
- suitable for bottle preservation.
- Yield =16-18t/ha in 105 days.

Arka Swadista :

Arka Kirthiman :

A F1 between MS-65 x Sel. 13-1-1 Medium size bulbs with globe shape and firm texture. Bulbs red in colour with bulb weight 120 -130 g. Tolerance to purple blotch, basal rot & thrips. Long storage (4-5 months) Suitable for kharif and rabi seasons. Duration 125-130 days. Yield 47 t/ha.

Arka Kirthiman

Arka Lalima

- F1 hybrid. Suitable for Kharif and Rabi Bulb yield: 50 t/ha

Arka Kalyan:

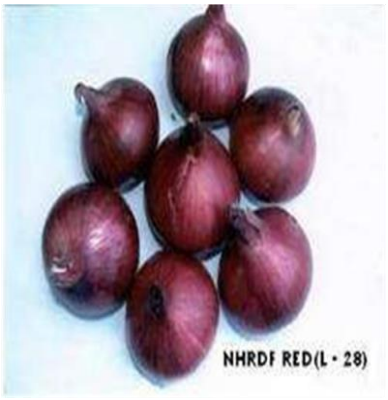
Developed through vigorous mass selection from IIHR-145 Globe shaped bulbs with medium large size. Deep red coloured outer scales and fleshy succulent internal scales. Average bulb weight 130-180g. Pungent with TSS 11-13%. Moderately resistant to purple blotch caused by Altermaria porii Seed yield 8 quintals/ha. Suitable for kharif season. Duration 140 days. Yield 47 t/ha.

Arka Pitambhar

Developed through pedigree selection from the cross U.D. 102 x IIHR-396. Bulbs uniform yellow. Medium size (5.2-6.0cm) bulbs with globe shape and thin neck. Mild pungent with TSS 11% and total sugar 9.81%. Tolerance to purple blotch, basal rot diseases and thrips. Long storage life (3 months). Suitable for export market Suitable for kharif and Rabi seasons. Duration 140 days. Yield 35 t/ha.

VARIETIES / F1 HYBRIDS FROM NHRDF, Nasik

- ☐ Agrifound Dark Red
- ☐ Agrifound Light Red
- ☐ NHRDF Red



NHRDF Red

VARIETIES / F1 HYBRIDS FROM IARI, New Delhi

- ☐ Pusa Red
- ☐ Pusa Ratnar
- ☐ Pusa Madhvi
- ☐ Pusa White Round
- ☐ Pusa White Flat

VARIETIES / F1 HYBRIDS FROM VPKAS, Almora

- ☙ VL 1
- ☙ VL 3

VARIETIES / F1 HYBRIDS FROM MPKV, Rahuri

- — Nasik 53
- — N 2-4-1
- ☙ Baswant 780
- ☙ N 257-9-1
- ☙ — Phule Suvarna

Nasik 53

VARIETIES / F1 HYBRIDS FROM TNAU, Coimbatore

- CO 1
- CO 2
- CO 3
- CO 4

VARIETIES / F1 HYBRIDS FROM RAU,Bikaner

- Udaipur 101
- Udaipur 102

Udaipur 103

Varieties /F1 hybrids from DOGR, Rajagurunagar

Bhima Raj

- Suitable for kharif and late kharif season the states of Maharashtra, Karnataka and Gujarat.

Bhima Red

This variety already recommended for *rabi* season in Maharashtra and Madhya Pradesh, is also recommended for release for *kharif* season in Delhi, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Rajasthan and Tamil Nadu. It can also be grown in late *kharif*. Maturity is 105-110 DAT during *kharif* and 110-120 DAT during late *kharif* and *rabi* seasons. The average marketable yield in *kharif* season is 19-21 t/ha, in late *kharif* season is 48-52 t/ha and it is 30-32 t/ha in *rabi* season.

It can be stored up to 3 months. in *rabi*.

Bhima Super

A red onion variety from DOGR has been identified for release for *kharif* season in Chhattisgarh, Delhi, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan and Tamil Nadu. It can also be grown in late *kharif*. It is reported to have an average yield of 20 - 22 t/ha in *kharif* and 40 - 45 t/ha in late *kharif*. Bulbs attain maturity within 100-105 days after transplanting (DAT) in *kharif* and 110 -120 DAT in late *kharif*. It produces mostly single centered bulbs.

Bhima Kiran

- ❖ good keeping quality suitable Storage for upto 5 to 6 months

Bhima Shakti

- ❖ Very less number of bolters 2.15%

Bhima Shweta :

This white onion variety already recommended for *rabi*, is also recommended for release for *kharif* in Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu. TSS is around 11-120B and it matures within 110-120 DAT. It has medium keeping quality and can be stored up to 3 months. Average marketable yield during *kharif* season is 18 - 20 t/ha and in *rabi* is 26-30 t/ha. It is tolerant to thrips

Bhima Shubra

This white onion variety has been recommended for Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu for *kharif* season. It is also recommended for late *kharif* in Maharashtra. It matures in 110-115 DAT during *kharif* and 120-130 DAT in late *kharif*. TSS is 10-120B. It is a medium storer with a capacity to tolerate environmental fluctuation. Average marketable yield during *kharif* is 18 - 20 t/ha and during late *kharif* 36-42 t/ha. It has capacity to tolerate environmental fluctuation, hence can be cultivated in all season

The acceptable Indian onion varieties for dehydration among white flesh onions are

- Bombay White
- No-36-1-3-4 ‘
- Udaipur-102’,

- ‘S-74’,
- ‘Pb-48’,
- ‘L-131’,
- ‘L-124’,
- ‘L-106’,
- ‘Pusa White Round’,
- ‘Pusa White Flat’, ‘
- N-257-9-1’ etc.

- Generally, Indian white onion varieties have low TSS (10-14%),

  which is not suitable for dehydration.
- After assessing Indian varieties and land races which do not have high TSS, Jain Food Park Industries, Jalgaon, introduced White Creole, which was further subjected to selection pressure for high TSS and they developed V-12 variety with TSS range of 15-18%.
- TSS in any variety is a function of genotype, environment and cultural practices. Long day onion grown under mild climate is high in TSS, whereas, short-day onion maturing under short winters does not develop high TSS. Internationally, long-day and intermediate short-day varieties have been developed mostly from USA, Spain, Israel, Mexico, etc.

Molecular markers for colour improvement in onion

- Bulb colour is one of the important traits in onion (*A. cepa L).* Three major colours of white, yellow, red and a variety of other bulb colours such as chartreuse and gold exist in onion germplasm.
- The bulb colour is due to flavonoid compounds and 54 kinds of flavonoids have been reported in onion.
- Critical mutations in the chalconeisomerase (CHI) gene causing gold onions were identified.
- The inactivation of dihydroflavonol 4-reductase (DFR) in the anthocyanin synthesis pathway was responsible for colour differences between yellow and red onions, and two recessive alleles of the anthocyanidin synthase (ANS) gene were responsible for a pink bulb colour .
- Based on mutations in recessive alleles of these two genes PCR based markers were developed for identification of polymorphisms between pink and red alleles of the

ANS gene. Most pink onions were homozygous recessive for the ANS gene indicating the homozygous recessive. The two pink onions, heterozygous for the ANS gene, were also heterozygous for the dihydroflavonol 4-reductase (DFR) gene indicating that the pink colour was produced by incomplete dominance of a red colour gene over that of yellow colour.

- Functional CAPS markers were developed for two inactive DFR-A alleles, DFR-APS and DFR-ADEL, for detection of inactive DFR-A alleles responsible for a failure of anthocyanin production in onions. Of these two alleles, DFR-APS predominantly occurs in yellow onion cultivars.

Breeding for yellow onion

- Indians do not prefer yellow onion but these find international market in European. Minimum requirements for export are: bigger sized (>60 mm diameter), less pungent and single-centered types.

- "NuMexStarlite",a new yellow-onion variety developed which was resistant to bolting and the short-day type was obtained by 5 recurrent selections from TexasGrano502PRR.

- Texas 'Grano 1015 Y', a mildly pungent, sweet, short-day yellow onion variety, was developed through original, single-bulb selection from Texas Early Grano 951 through 5 generations of selections.

- Similarly, "Texas Grano1030 Y" was developed from F2 selections of Texas Early Grano 502 x Ben Shemen which is a late maturing mildly pungent short- day onion variety.

- Only two varieties were developed, viz., Phule Swarna from MPKV, Rahuri and Arka Pitambar from IIHR, Bangalore and were released at the state / institute level. Yield of these varieties was comparatively less than in commercial red onion varieties. 12 varieties of onion were assessed during kharif season and found lowest bulb diameter of 4.2 cm in Arka Pitambar, along with low yields.

Questions

1. **Breeding objectives in onion**
2. **Write about Floral biology of onion**
3. **Name some varieties developed from IIHR**
4. **Name some varieties developed from IARI**
5. **What are all the methods of breeding in onion.**

References

1. Gupta, S.K. 2008. Plant Breeding : Theory and Techniques , Motilal UK Books of India (2008).

MULTIPIER (or) AGGREGATUM ONION

Allium cepa* var. *Aggregatum

Unlike the bellary onion, the propagation of aggregatum onion is through bulblets (Vegetative propagation).

Breeding objectives

- bulbs with bright red colour
- high yield
- bold bulblets

Varieties

CO 1

It is a clonal selection from CS 450, an onion type introduced from Manachanallur, suitable for cultivation in all the onion growing districts of Tamil Nadu. It has an yield potential of 9-10 t/ ha in a crop duration of 85 days. The bulbs are large and pink in colour.

CO 2

It is a selection from germplasm type CS 911. It has an yield potential of 12 t/ ha in a crop duration of 65-70 days. Bulbs are bigger in size with crimson colour.

CO 3

It is a clonal selection from the open pollinated progenies of CS 450. The crop duration is 65-70 days. It yields 15-16 t/ ha.

CO 4

It is a hybrid derivative of the cross AC 863 x CO 3. The crop duration is 65 days. It yields 10 t/ ha. Each clump weighs on an average of 90 g. Bulbs are bold in size with attractive pink colour. The bulbs store well for more than 150 days devoid of sprouting in well ventilated store rooms.

Agri Found Red

Developed by NHRDF Dindugal. Each clump weighs 65 g with 5-6 bulblets per clump. The colour is light red. TSS 15-16 °brix. It can give 18-20 t/ ha in 65 days.

Arka Ujjwal:

- A multiplier onion variety
- bright dark red bulb color, compound bulb with flat shape
- Bulb size 4-5cm,
- Number of bulblets/bulb 3-5,
- Bulb weight 40-45g,
- TSS 16-18%,
- Dry matter content 14-16% and
- Bulb yield 20-25t/ha in 85 days.

Arka Ujjwal:

COOn 5 (2001)

It is a high yielding variety developed by mass pedigree method of selection. This variety has the ability of free flowering and seed set throughout Tamil Nadu. It possess high

bulb yield 18.9 t/ha (18.8 per cent higher than CO.4) in a crop duration of 90 days. It is free flowering type with seed setting ability of 250-300 kg/ha and so it is propagated through seeds. March–July for bulb production and November– January for seed production. It possesses attractive pink coloured bold size bulbs. The total soluble solids content is 13 per cent. The pungency principal measured as pyruvic acid is 2.37 µm/g of fresh weight. It is adaptable to Coimbatore, Trichy, Pudukottai, Nagapattinam, Thanjavur, Tiruvarur, Theni, Madurai, Namakkal, Cuddalore, Tiruvannamalai, Thoothukudi, Erode and Dharmapuri districts.

Questions

1. **Breeding objectives in onion**
2. **Write about Floral biology of onion**
3. **Name some varieties developed from TNAU**
4. **Name some varieties developed from IIHR**
5. **What are all the methods of breeding in onion.**

References

Gupta, S.K. 2008. Plant Breeding : Theory and Techniques , Motilal UK Books of India (2008).

GARLIC L-22

***Allium sativum* L.** **Family: Alliaceae (2n=16)**

Garlic (*Allium sativum* L.) is the second most widely used cultivated allium after onion. It is a very hardy herbaceous perennial species, which has been recognized as a valuable spice for foods and a popular remedy for several ailments and physiological disorders.

It is a herbaceous annual for bulb production and a biennial for seed production. The edible underground stem is a composite bulb made of numerous smaller bulbs known as cloves. If very small cloves are planted or if the growing conditions are poor, single solid

clove usually called “round” is produced. “Rounds” if planted under favourable conditions give rise to usual composite bulb.

Many clones of garlic do not produce flower stalks or the inflorescence may be partially or not at all exerted, its bulbils forming a swelling somewhere within the false stem one to five centimeter above the bulb.

The typical flavour of garlic is due to the presence of the chemical allein plus diallyl disulphide. It is a cross pollinated crop. The yield potential depends on the amount of vegetative growth made before bulbing commences and as soon as the bulbing commences leaf initiation stops. Generally after 6 to 8 leaves, bulbing commences. At the base of each leaf sheath, 3-5 cloves will be formed in 4 to 5 leaves depending on the varieties. A total of 12 leaves are produced under normal conditions.

Nutritive composition of fresh by peeled garlic cloves and dehydrated garlic powder is as follows:

Nutritive Value of Garlic

Particular	**Fresh peeled garlic cloves**	**Dehydrated garlic powder**
Moisture (%)	62.80	5.20
Protein (%)	6.30	17.50
Fat (%)	0.10	0.60
Mineral matter (%)	1.00	3.20
Fibre (%)	0.80	1.90
Carbohydrates (%)	29.00	71.40
Energy K. Cal	145.00	--
Calcium (%)	0.03	0.10
Phosphorus (%)	0.30	0.42
Potassium (%)	--	0.70
Magnesium (mg/100 g)	71.00	--
Iron (%)	0.001	0.004
Niacin (%)	--	0.70
Sodium (%)	--	0.01
Copper (mg/100 g)	0.63	--
Manganese (mg/100 g)	0.86	--
Zinc (mg/100 g)	1.93	--
Chromium (mg/100 g)	0.02	--
Vitamin A (IU)	0.40	175.00
Nicotinic acid (mg/100 g)	0.40	--
Vitamin C (mg/100 g)	13.00	12.00
Vitamin B (mg/100 g)	16.00	0.68
Riboflavin B2 (mg/100 g)	0.23	0.08
Thiamin (mg/100 g)	0.06	--

Healthy garlic bulbs contain allicin, colourless, odourless and water-soluble amino acids. On crushing the garlic bulbs the enzyme allinase breaks down into allin to produce allicin of which the principal ingredient is odoriferous diallyl disulpide. Garlic contains about 0.1% volatile oil. The chief constituents of oil are diallyl disulfide (60%), diallyl trisulfide (20%), allyl propyl disulfide (6%), a small quantity of diethyl disulfide and probably diallyle polysulfide. Diallyle disulfide possesses the true garlic odour. Garlic has been cultivated for thousands of years. It is the most ancient cultivated vegetables giving pungency of the genus *Allium*. Original abode of garlic is said to be Central Asia and Southern Europe especially Mediterranean region. Some authorities consider that *Allium longicuspis* Regael, which is endemic to Central Asia, is the wild ancestor and spread in ancient times to Mediterrenean region. It is known in Egypt in Predynastic times, before 3000BC and also to ancient Greeks and Romans. It has long been grown in India and China. Garlic was carried to the Western hemisphere by the Spanish, Pourtuguese and French. Garlic was not liked by Romans due to strong odour. It was used in England as early as first half of the 16th century. The early domestication of garlic took quite different turn from that of seed propagated leek and onion. Garlic became exclusively vegetatively propagated by cloves or bulbils. Some cultivars are reported to produce flowers but there is no seed setting. Garlic cultivars differ in maturity, bulb size, clove, clove size and number, scale colour, bolting and floweringhabits

VARIETIES

Garlic varieties, Agrifound White, Yamuna Safed, Yamuna Safed 2 and Yamuna Safed 3 have been notified by the Government of India. The varieties developed by NHRDF are given below:

AgrifoundWhite :

The variety was notified by Govt. of India in 1989 vide notification no. 28(E) dated 13/4/1989. The variety was developed by mass selection from a local collection obtained from Biharsharif area in Bihar. The bulbs are compact, silvery white with creamy flesh. Bigger elongated cloves with 20-25 in numbers. Diameter 3.5 to 4.5 cm size index 12-15

cm2. The variety is susceptible to purple blotch and stemphylium blight which are common in the northern parts. TSS 41% dry matter 42.78% and good storer. The yield is 130 q/ha. It is recommended for cultivation in the areas where there is not much problem of purple blotch or stemphylium blight in rabi season.

YAMUNA SAFED (G-1)

This variety was notified by Govt. of India in the year 1991 vide notification no.527 (E) dated 16/8/1989. It was developed by mass selection from a local collection obtained from Delhi (Azadpur) market. The bulbs are compact, silvery white skin with creamy flesh. Diameter 4.0 cm to 4.5 cm. Sickle shaped cloves, 25-30 in number, size index of bulb 12-15 cm2, diameter of cloves 0.8 to 1.00 cm. The variety is tolerant to insect pests and diseases like purple blotch, stemphylium blight and onion thrips. TSS 38%, dry matter 39.5% and good storer. Yield 150-175 q/ha. It is recommended for cultivation all over the country.

YAMUNA SAFED-2 (G-50)

The variety was notified by Govt. of India in the year 1996 vide notification no.115 (E) dated 10/2/1996. It was developed by mass selection from a local collection obtained from Karnal area in Haryana. The bulbs are compact attractive white creamy flesh, bulb diameter 3.5-4.0 cm, size index 11-12 cm2,, number of cloves 35-40, diameter 0.75 - 14 cm. Clove size index 1.75-2.5 cm2,, 10 bulb weight 160-240 g, TSS 38-40%, dry matter 40-41%. Average yield 150-200 q/ha. The variety is recommended for Northern India.

YAMUNA SAFED-3 (G-282)

The variety has done very well in Northern parts and also in Central parts of India. It was developed by mass selection technique from a local collection obtained from Dindigul (TN) in 1990. The leaves are wider than other varieties. Bulbs are creamy white and bigger sized (5-6cm dia). Size index 27-29cm2, diameter of cloves 1.2-1.5 cm. 15-16 number of cloves per bulb TSS 38.42%, dry matter 39-43%, medium storer. Average yield 175-200 q/ha. The

variety is suitable for export. The variety was notified in the year 1999 vide notification no.1092 (E) dated 26/10/1999.

AGRIFOUND PARVATI

This variety was developed in 1992 by selection from an exotic collection obtained from Hongkong market. The variety is long day type and as such is suitable for cultivation in mid and high hill of Northern states. Bulbs are of bigger size (5-6.5 cm), creamy white colour with pinkish tinge. Size index 16-72 cm2, diameter of cloves 1.5 to 1.8 cm, 10-16 cloves in number tolerant to common disease. Average yield 175-225 q/ha, medium storer. Suitable for export.

YAMUNA SAFED-4 (G-323)

The variety has done very well in Zone VI. It was developed by mass selection technique from a local collection obtained from Jaunpur, Uttar Pradesh in 1988. Leaf wide, Bulb- compact, attractive creamy white colour, creamy flesh, bulb diameter 4-5 cm, size index 14-16 cm2, no. of cloves 18-23 per bulb, diameter of cloves 0.75-1.0 cm, cloves size index 1.8-2.0 cm2, Matures in 165-175 days. Yield 200-250 q/ha. Storage quality is better than Yamuna Safed-3. Suitable for exports. The variety was notified by Government of India in 2006 vide notification no. S.O. 597(E) dated April 25,2006.

MEDICINAL VALUE

Garlic is one of the important bulb crops grown and used as a spice or a condiment throughout India. According to the Unani and Ayurvedic systems as practised in India, garlic is carminative and is a gastric stimulant and thus help in digestion and absorption of food. Allicin present in aquous extract of garlic reduces cholesterol concentration in human blood. The inhalation of garlic oil or garlic juice has generally been recommended by doctors in case of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and red eyes. Garlic

possesses insecticidal action. About 1% garlic extract gives protection against mosquitoes for 8 hours. Extract of garlic along with chilli and ginger has beneficial action against soil nematodes. Beneficial use of garlic extract has been found against many fungi.

Institutions engaged in Allium Research in India

1. Division of Vegetable Crops, Indian Agricultural Research Institute (IARI), New Delhi - 110 012.
2. Indian Institute of Horticultural Research (IIHR), 225, Upper Palace Orchards, Bangalore - 560 080.
3. National Horticultural Research and Development foundation (NHRDF), 2954-E, Kanda Batata Bhavan, New Bombay, Agra Road, Nasik - 422 001, Maharashtra.
4. Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri - 413 722, Ahmednagar, Maharashtra.
5. Tamil Nadu Agricultural University (TNAU), Coimbatore - 641 004, Tamil Nadu.
6. Punjab Agricultural University (PAU), Ludhiana - 141 004, Punjab.
7. Haryana Agricultural University (HAU), Hisar - 125 004, Haryana.
8. Rajasthan Agricultural University (RAU), Durgaoura - 302 015, Jaipur, Rajasthan.
9. Dr. Y.S. Parmar University of Horticulture and Forestry (YSPUHF), Nauni, Solan - 173 230, Himachal Pradesh.
10. Division of Crop Improvement, Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS), Almore - 263 601, U.P.
11. National Bureau of Plant Genetic Resources (NBPGR), IARI, Campus, New Delhi.
12. JawaharLal Nehru Krishi Viswavidyalaya (JNKV), Jabalpur - 482 004, Madhya Pradesh.
13. Chandra Shekar Azad University of Agriculture and Technology (CSAU), Kalianpur, Kanpur - 208 002, U.P.
14. G.B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar - 263 145, District Nainital, U.P.
15. Orissa University of Agriculture and Technology (OUAT), Bhubaneswar - 751 003, Orissa.

Varietal status

Tamil Nadu - i) Mettupalayam Local, (Malai Poondu) and Ecotypes.

ii) Five Month Garlic.

iii) Singapore

iv) Ooty - 1 (HRS, Ooty, TNAU).

Preference : PINK varieties, Medium clove size, Shorter duration.

GUJARAT - Jamnagar - Large cloves

ANDHRA PRADESH - Fawari, Rajella Gaddi

VARIETIES RELEASED BY NHRDF (NASHIK): Agri found white (G41) - Recommended for Maharashtra

Yamuna Safed (G1) - Recommended for North India

Agri Found Parvati (G313) - Recommended for Hills of North India.

G282 - 16 T/ha; TSS - 41.93 - Suited for export.

HG1, HG6 - Haryana Agricultural University

Questions

1. **What is the chromsme number for garlic**
2. **Name garlic varieties Recommended for Hills of North India.**
3. **Name a variety suitable for Tamilnadu**
4. **Name garlic varieties suitable for export**
5. **Write about the breeding achievement in garlic**

References

Kalloo, G. and B.O.Bergh.1993. Genetic improvement of vegetable crops. Elsevier Ltd

Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

L-23-24

POTATO

- Botanical Name : *Solanum tuberosum*
- Family : Solanaceae
- Chromosome no : 2n= 4x= 48 (Tetraploid)
- Origin : Andean mountains of Bolivia and Peru in South America .

HISTORY :

- Potato was introduced to India by Portuguese in 17th century.
- The early history of potato in India is obscure till mid 18th century . However potato continued to be brought in to India by British settlers and grown in backyards of residences.
- In 1830 onwards potato was commercially grown in higher altitudes of hills in India (Hooker,1984 and Buck,1925) from where it spread to plains of India
- Cultivated from originated from wild diploid species *Solanum leptophytes* and the first domesticated species was *Solanum stenotomum.*

SPECIES OF POTATO

- *Solanum demissum*: 2n=72(Resistant to late blight)
- *Solanum antiporizii*: 2n=48(Resistant to late blight)
- *Solanum acaula*: 2n=48(Resistant to frost)
- *Solanum curtilobum* : 2n =24(Resistant to frost)
- *Solanum rybinii*: 2n=24(resistant to certain viruses and it is a non dormant type)
- *Solanum phureja*: 2n=24(develop tubers in comparatively hotter regions)
- *Solanum chacoense*: 2n=24(develop tubers in comparatively hotter region)

Others Species :

- *Solanum infundibuliforme* **:** Drought Resistant.
- *Solanum jamesii* : Resistant to Alternaria leaf spot and Phytophthora.
- *Solanum fendleri* : Can be hybridized with wild and cultivated potatoes

Botany

Habit :

- ❖ Potato is a much branched. The plants are erect when young and thus grow prostrate to the ground because of leaf form. The above ground shoots are called ‘haulms’.

Inflorescence :

- ❖ It is a monochasial cyme (cymose inflorescence developed in single system of branching) .
- ❖ Flowers are white. Petals are white /cream in colour

Stamens :

- ❖ Five in number (yellow to orange in colour). Anthers are erect and longer than the filaments with apical dehiscence.

Ovary :

- ❖ Ovary is superior ,bicarpillary , style is simple and erect capitates. Stigma is capitate.

Fruit :

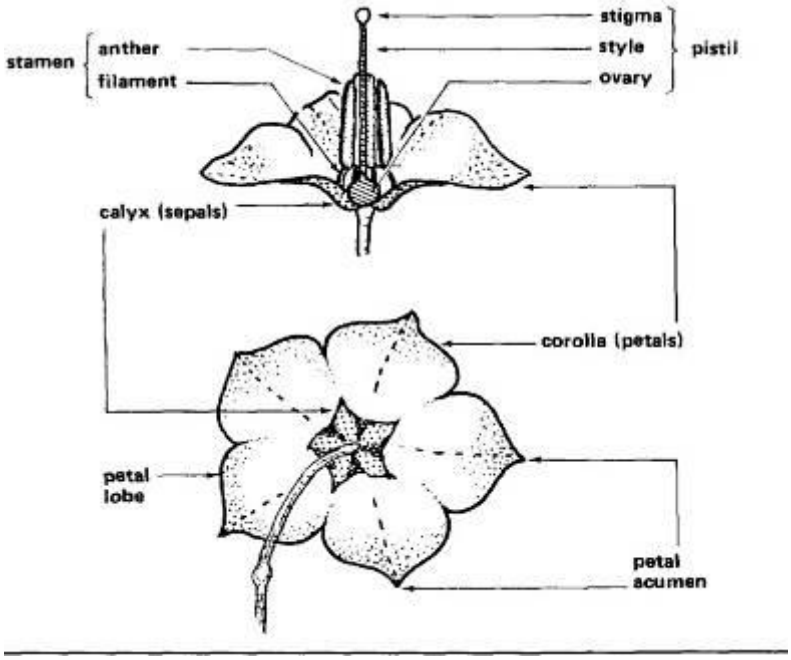
- ❖ Fruit is a berry with numerous small seeds. Potato fruit is also called as potato ball (or) Potato apple (or) Seed apple.

Floral biology

- ❖ Anthesis time and closing of flowers varies with varieties and species. Pollen production is abundant from early morning to 10am.
- ❖ Production of fertile pollen is more in diploids.
- ❖ Stigma receptivity and anther dehiscence also takes place at the same time.

POLLINATION AND FERTILIZATION:

- Self pollination occurs.
- Pollination takes place either by direct contact of the anthers with the stigma or through insect, mostly bumble bees.



Flower

Variations in flowers of different species of potato

PLANT MORPHOLOGY

ROOTS:

Potato plant may develop from seed or tubers .

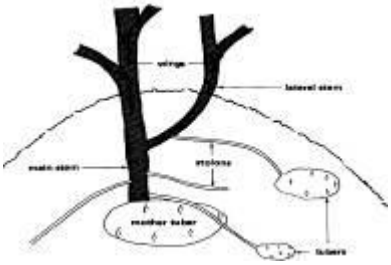
Plants grown from seed form a slender tap root with lateral branches.

Plants grown from tubers form adventitious roots at the base of each sprout and, later above the nodes of the underground part of each stem.

Occasionally, roots may also grow on stolons. In comparison with other crop, the potato root system is weak. Therefore good soil condition is necessary for potato growing

Plants grown from tubers form adventitious roots at the base of each sprout

STOLONS: Morphologically, potato stolons are lateral stems which grow horizontally below ground from buds of the underground part of stems .stolon may eventually form tubers by enlargement of their terminal end.



The potato stem system consists of stems, stolons and tubers.

TUBERS: Morphologically, tubers are modified stems and constitute the main storage organs of the potato plant. The eye of the potato tuber morphologically corresponds to the nodes of stem. Sprouts grow from the buds in the eyes of a tuber. The color of the sprout is a distinguishing varietal character.

Stem:

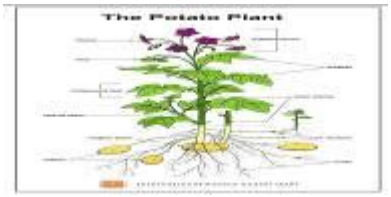
- Stem is generally solid , ribbed or smooth .

Leaves :

- Leaves are compound, pinnate, 10-20 cm long alternately arranged.Terminal leaflets are larger in most varieties and therefore the shoots lie prostrate to the ground.

PLANT MORPHOLOGY

GROWTH HABIT (herbaceous)



*****The growth habit of the potato varies within and between species

Breeding objectives :

1. **Breeding for high yield**

Yield of tubers is decided by number of tubers and tuber

2. **Breeding for varieties having better morphology of tuber**

Better morphology of tuber is determined by

a) Eye depth

b) Flesh colour

c) Growth cracks

d) Hollow heart

e) Shape

f) Skin colour

3. **Breeding for better quality:**

Depends on many factors

a) After cooking blackening

b) Dry matter.

c) Enzyme browning.

d) Glycoalkaloid level

e) Reducing sugar content

f) Storage properties

4. **Breeding for disease resistance**

Early blight, late blight, powdery scab., *verticillium* wilt, virus diseases.

Resistant source : *S.demissum, S.acaule* ssp. *andigena*

5. **Breeding for pest resistance**

Nematode is the major pest

ssp.*andigena* - tolerant.

S.verineii resistant to Aphids, Colorado beetle.

GENETIC RESOURCES:

Potato germplasm at CPRI

Ssp andigena :872-from 7 countries

Ssp tuberosum :854- from 32 countries

Wild semiculture sp :250-from 4 countries

Source of resistance

Bacterial wilt : *S.microdontum*

PVX, PVY : *S.acaule*

Potato tuber moth : CP 1824,CP 1832

Aphids :*S.berthaulti*

Group *tuberosum* germplasm has narrow genetic base because

They are descedent from a very small number of introduction of *andegena* potato
Blight epidemic of the 1840' s reduces greatly amount of variation present in potato

Group *andegena* : short adopted and ancestral form of *tuberosum* has wide variability

Resistant / tolerant –biotic and abiotic stress
High starch and protein content .good keeping quality
Responsiveness to fertility applied .

BREEDING METHODS :

1. **Introduction :**

Earliar varieties viz., Magnum Bonum, Craigs defiance and Up-to-date

Secondary introduction: Hybrid DN-45-Katahdin × president

Kufri kisan is a multicross involving Ekishrozn from japan

2. **Clonal selection:**

Kufri red from Darjeeling Red Round K-1241 is selection from phulwa.

3**. Hybridization and selection** :

Flowering problem at Kufri
Kufri Jyothi :selection from A-306× A2814
Kufri Kundan :selection from Ekishran× Katahdin

4. **Heterosis breeding:**

Heterosis is observed for earliness, tuber size, tuber weight
F1 seed production by hand emasculation and pollination after identification of good specific combination. Pollen sterility is common.
Inbreeding depression is more. Seed set is poor. Not exploited

Emasculation and Pollination in potato

5. Polyploidy breeding:

Potato is basically a polyploid
Haploids -teraploid×diploid
Different species are with different ploidy level
For, resistance breeding , ploidy breeding is must

6. **Bridging Species:**

- KufriKuber -(*S. curtilobum* x *S. tuberosum*) x *S. andigenum*) (Resistant to Potato leaf roll)
- A species used in gene transfer from one species to another sexually incompatible species, bridging species is compatible with both donor and recepients species, it may be a natural or a synthetic species.

Interspecific hybridization :

1. *S. demissum* × *S. tuberosum*

2n=72 2n=48

F1 sterial (univalents)

Bridge species: *S .demissum* × *S. ryberoum*

F 1 (fertiel) ×*S.tuberosum*

Fertile progenies

2. *S. acaule* × *S. tuberosum*

F1 sterial (univalents)

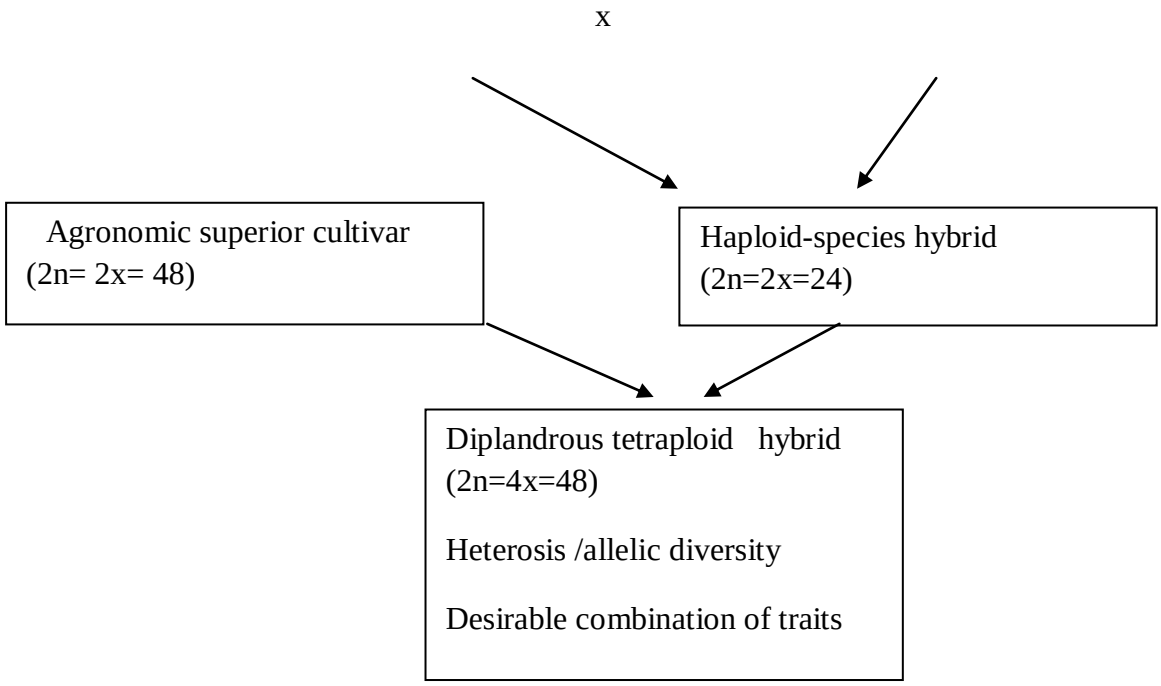
S. acaule × *S.simplicifolium*

F 1 (fertiel) ×*S.tuberosum*

Fertile progenies

Breeding strategy to obtain 4x hybrid from 4x-2 crosses.

Haploid tuberosum /andegena (2n=2x=24) female fertility	Cultivated /wild species (2n=2x=24) new



7. **Mutation breeding :**

Kufri sindhu (+LB 120 ays), Kufri Chandramukhi(95 days),

Kufri Alankur , Kufri Chamatkar, Kufri Jeevan, Kufri Naveen

Kufri Jyoti, Kufri Moti, Kufri Lauvkar, Kufri Dewa

Kufri Sheetman: (+ Frost)

Hybrid 2236 did well at short and day conditions

HB827, HB841 and HB 858 suited for high temperature

Kufri Badshah : Horizontal resistance to LB

JW 160 -Tolerant to late blight with inter adaptability

H92/621: Tolerant to heat and drought and resistant to mites and leaf hopper

Breeding achivements

- Kufri Sindhuri - Resistant to Lateblight Duration 90 days
- Kufri Swarna - Resistant to golden cyst Nematode.
- Kufri Badshah- Resistant to Potato virus X
- HB821, HB841,HB 858 – Suited to High Temperature.
- JW 160 - Tolerant to late blight
- H92 / 621 - Tolerant to heat and drought and Resistant to mites and Leaf hopper .

BIO TECHNOLOGY:

- Potato was ideal material for application of biotechnological method such as anther culture, somatic hybridization, genetic information , i*n vitro*, ,somaclonal variation selection and production of transgenic.
- The potato has many pest and pathogens that can reduce yield and overall plant vigor. The Colorado potato beetle (*Leptinotarsa decemlineata*) is high destructive pest of potato in North central and Asia.
- Defoliation by adults and larvae can reduces yield and even result in total tuber loss. Despite breeding effort, no potato cultivars with demonstrated resistance to Colorado potato beetle have been released commercially.
- The bacterium *Bacillus thuringiensis* (Bt) ssp.*tenebrionis* Berliner, produces a cry 3A protein that has toxic effects on coleopteran, including Colorado potato beetle.
- The choice of a Bt gene for engineering host plant resistance has multiple advantages. Bt protein have very specific modes of action.
- Such that a protein with specific toxicity towards coleoptera would not be toxic to humans.

Crop improvement:

Varieties	**Breeding method**	**Specific features**
New varieties		
Kufri Himalini	-	Moderate resistant to late blight
Kufri Shaillja	-	Moderate resistant to late blight
Kufri Girdhari	-	Highly resistant to late blight
Kufri Himsona	-	Highly resistant to late blight
Kufri Jyoti		Large white oval tubers with white flesh; resistant to early and late blight. It has an yield potential of 25 t/ ha in a crop duration of 90-95 days. Suitable for hills in North India.
Early varieties (80-90 days)		
Kufri Chandramukhi	Seedling 4485 x Kufri Kuber	Tubers are oval in shape with white skin. Suitable for North Indian plains and plateau. Duration is 90-100 days. It yields 25-27 t/ ha.
Kufri Jawahar	Kufri Neelamani X	Medium, round-oval, creamy white, fleet eyes and pale yellow flesh. Crop matures in 80-90

	Kufri Jyothi	days. Average yield is 40 t/ha. Moderately resistant to late blight. Suitable in intensive-cropping system
Kufri Laukar	Adina X Sarkov	Large, round, white, fleet eyes and white flesh. Able to build up yields rapidly under warmer climate. Crop matures in 75-80 days. Average yield is 30 t/ha.
Kufri Sheetman	Craigs defiance x phulwa	Resistant To Frost
Kufri Khyati	-	-
Kufri Surya	Kufri Laukar x LT-1	Heat tolerant variety, field resistant to leaf hoppers
Kufri Ashoka	EM/C-1020 x Allerfruheste Gelbe	Large, oval-long, white, fleet eyes and white flesh. Susceptible to late light. Crop matures in 70-80 days, Average yield is 40 t/ha.
Medium varieties (90-100 days)		
Kufri Bahar	Kufri Red ×Kufri Gineke	It has large sized tubers of round to oval shape. The sprouts will be red in colour. The skin as well as flesh are white. Though it has a better yield potential than Kufri Chandra Mukhi, it is susceptible to major diseases.
Kufri Sutlej	Kufri Bahr x Kufri Alankar	Moderately resistant to late blight
Kufri Anand	PJ-376 PH/f-1430	Resistant to late blight, tolerant to frost
Kufri Arun	Kufri Lalima x MS/82-797	Field resistant to late blight; tolerant to frost
Kufri Pukhraj	Craig ' defiance X JEX/B-687	Moderately resistant to late blight
Kufri Pushkar	QB/A 9-120 x Spatz	Field resistant to late blight, moderately resistant to *phoma* and early blight
Kufri Lalima	Kufri Red x AG 14 (Wis. X 37)	Moderately resistant to early blight and resistant to PVY
Kufri Kanchan	SLB/Z-405(a) x Pimpernel	Field resistant to late blight

Kufri Chamatkar		It possesses round medium sized tubers with white skin and pale yellow flesh. It is susceptible to a number of diseases. The duration is 110-115 days.
Kufri Muthu		It has large round to oval shaped tubers with white skin and flesh. It is suitable to grow in Nilgiris. The duration is about 100-110 days.
Late varieties (100-110 days)		
Kufri Sindhuri	Kufri Red x Kufri Kundan	Suitable for dehydrated flakes and canning. It has an yield potential of 35-40 t/ ha in 120 -125 days. The tubers are red in colour hence called "Sindhuri", and round in shape. It is fairly tolerant to frost.
Kufri Badshah	Kufri Jyoti x Kufri Alankar	Moderate resistant to late blight ,early blight an potato virus X
Kufri Dewa		It is tolerant to frost and tuber rotting. The tubers are brownish white with pink tinge near the eyes. The flesh is white in colour. It is commonly grown in Uttar Pradesh and Bihar.
Kufri Jeevan		The tubers are oval in shape with white skin. The flesh is pale yellow. It has an yield potential of 40 t/ ha in 125-130 days. It is commonly cultivated in Himachal Pradesh.
Processing Variety		
Kufri Frysona	MP/92-30 x MP/90-94	Suitable For Processing To French Fries
Kufri Chipsona - 3	MP/91-86 x Kufri Chipsona-2	Resistant To Late Blight, medium Maturing Variety
Kufri Chipsona - 1	MEX.750826 x MS/78-79	Chips and flakes
Kufri Chipsona - 2	F-6 x QB/B 92-4	Chips and flakes
Kufri Chipsona-4	Atlantic x MP/92-35	Early Maturing Resistance To Late Blight
Kufri Surya	Kufri Lauvkar x LT-1	Heat Tolerant Variety Field Resistance To Leaf Hoppers

Kufri Alankar **Kufri Anand** **Kufri Arun**

Kufri Ashoka **Kufri Badshah** **Kufri Bahar**

Kufri Chamtakar **Kufri Chandramukhi** **Kufri Chipsona 1**

KufriChipsona 2 **KufriChipsona 3** **KufriChipsona 4**

KufriDewa **KufriKuber** **KufriKuber**

Kufri Frysona **Kufri Kundan** **Kufri Lalima**

Kufri Laukar **Kufri Sheetman** **Kufri Surya**

Kufri Sutlej **Kufri Sindhuri** **Kufri Red**

Breeding for Biotic Stress

Late blight of Potato	*S. bulbocastanum , S. demissum , S. stoloniferum , S. sucrense, S. Verrucosum , , S. chacoense , S. pinnatisectum , S.microdontum*
Wart	*S. chacoense , S. sparsifolium , S. spegazzinii*
Charcoal rot	*S. chacoense , S. sparsifolium*
Bacterial diseases	*S.microdontum*
Insect pest(Aphids)	*S. berthaulti*
Viral diseases (Potato virus x and y)	*S. chacoense , S. acaule , S. stoloniferum , S.microdontum*
Potato cyst Nematode	*S. chacoense , S. sparsifolium*
Root Knot nematode	*S.microdontum , S. vernei , S. spegazzinii*

Questions

1. **Write down the related species of potato**
2. **Write down the resistnace sources of potato against biotic stresses**
3. **Write down the breeding objectives**
4. **Write in detail about the crop improvement in potato**
5. **Name some varieties suitable for chips making**

References

Bradeen, J.M. and C. Kole . 2011. Genetics, Genomics and breeding of potato. CRC, Press, Science Publishers, Hampshire.

L-25

CASSAVA (TAPIOCA)

(Syn: Tapioca) *Manihot esculenta* (Crantz)

(2n = 2x = 36)

(Hindi: *Mravuli)*

Family: *Euphorbiaceae*

Cassava is the most important starchy root crop grown in the tropics and is mainly cultivated in southern peninsular India. Introduced during seventeenth century by Portuguese, the crop played a significant role to overcome food shortage among the low income group of people in Kerala. Underground tuber is rich in starch and mainly consumed after cooking. Processed products like chips, sago and vermicelli made of tapioca are also popular in the country. Being easily digestible, it forms an important ingredient in poultry and cattle-feeds. It is also widely used for production of industrial alcohol, starch and glucose.

Origin and distribution

Cassava is not known in wild state. North-Eastern Brazil is the centre of origin. Portuguese distributed the crop from Brazil to countries like Indonesia, Singapore, Malaysia and India. Nigeria is the major growing country in world accounting for 50% of area and production. In India crop is cultivated in southern peninsular region, particularly Kerala, Tamil Nadu and Andhra Pradesh contributing 93% of area and 98% of production in the country. Kerala accounts for nearly 50% of total area under cassava in India and is mainly grown as rainfed crop.

Botany

Cassava belongs to family Euphorbiaceae and is diploid (2n=36). Polyploids with 2n=54 and 72 are also available. It is a perennial shrub producing 5-10 cylindrical tubers per plant. Being a member of family Euphorbiaceae, it produces latex. The stem is woody and variously branched. Two distinct types are present – one without branching at the top and the other with spreading nature. Leaves are palmately lobed with 5-9 lobes. Cassava is monoecious in nature and cross-pollinated. Female flowers are a few in numbers and are borne in the base of inflorescence and male flowers are borne above. Female flowers open about 10 days before male flower anthesis. Stigma is receptive from 6.30 a.m. and continues up to 2.30 p.m.

Plants when raised from seeds produce typical tap root system. Since crop is mainly propagated by vegetative means by stem cuttings, numerous adventitious roots develop, of which a few develop into tubers. Tubers are composed of a thin peridium, white a few develop into tubers. Tubers are composed of a thin peridium, white or purple cortex known as rind and central massive flesh rich in starch (25-40%). Bitterness often encountered in a few varieties and at certain stage is due to a bitter principle cyanogenic glucoside (HCN).

Varieties

Improved varieties developed at Central Tuber Crops Research Institute, Thiruvananthapuram are as follows:

H 97

It was developed by crossing Manjuvella and Brazilian seedling selection. It has an yield potential of 25-30 t/ ha in 9½-10 months duration. The tubers have 29 per cent starch. This variety is tolerant to cassava mosaic disease and drought.

H 226

It is a cross between Ethakka Karuppan x M4. The tubers have sweet flesh encased in light purple rind and possess good cooking quality. Tubers contain 28 per cent starch. It comes to maturity in 9½-10 months and yields 30-35 t/ ha.

Sree Visakham (H 1687)

It was developed by crossing AC No. 1501 x S 2313 (Madagascar). The plants are erect and sparsely branched. Tubers are non-bitter with 28 per cent starch content. The tubers mature in 10 months. This variety has an yield potential of 33-38 t/ ha.

Sree Sahya (H 2304)

It was developed from a multiple cross. Plants are non branching, tubers are medium in size, non-bitter; starch 28 per cent. Tubers have neck. It yields 35-40 t/ ha in a crop duration of 10-10½ months.

Sree Prakash (S 856)

It is a selection from a local accession. It yields 35-40 t in 7½ months. The tubers have good culinary qualities with 30 per cent starch. The mature stem is pinkish with purple petiole. It is resistant to *Cercospora* leaf spot and tolerant to drought.

Sree Harsha

This variety was developed at CTCRI, Thiruvananthapuram. It is an improved version of Sree Sahya (H2304) with plants having top branching. The average yield of tuber is 35 to 40 t/ ha; starch content is 38 per cent. It is an ideal variety for industrial use and poultry feed.

At Tamil Nadu Agricultural University, Coimbatore varieties with better adaptability to Tamil Nadu conditions have been developed.

CO 1 (ME 7)

It is a clonal selection from a local type collected from Tiruchi District. The Tubers have whitish brown skin with a cream rind and white flesh. It has an yield potential of 29-30 t/ ha in a crop duration of 8½ -9 months. But it is susceptible to cassava Mosaic Disease.

CO 2 (ME 167)

It is an open pollinated seedling progeny raised from the seeds collected from a Thiruvarur type of Tanjore District. It is a branching type with compactly arranged tubers having brown skin, creamy white rind and creamy white flesh. It is suitable for consumption as well as starch industry. It yields 35-37 tonnes/ha. in crop duration of 8½ months.

CO 3 (ME 120-1)

It was developed at TNAU by selection from OP seeds received from IITA, Ibadan, Nigeria. Since the plants are heavily branching, periodical removal of sprouts is necessary. In a crop duration of 8½ months it can yield 42 t/ ha. Outer skin is dark brown with yellowish

white rind and white flesh. It is resistant to Cassava Mosaic Disease. Tubers have 35.6 per cent starch.

MVD 1 (S2371)

This was developed at Tapioca Experiment Station, Mulluvadi of Salem district in Tamil Nadu. It has a yield potential of 34 t/ ha in 9 months. It is rich in starch (35.6%).

Questions

1. **Name the Tapioca varieties developed from TNAU**
2. **Name the variety released from Tapioca Experiment Station**
3. **Name some varieties released from CTCRI, Thiruvananthapuram**
4. **What is the centre of origin for Tapioca?**
5. **What is the system of breeding of tapioca?**

References

1. Kalloo, G. and B.O.Bergh.1993. Genetic improvement of vegetable crops. Elsevier Ltd

2. Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

L-26

Sweet potato

***Ipomoea batatas* L.**
(Hindi: *Shakarkand, Mitha alu*)
Convolvulaceae
2n = 90

Sweet potato is cultivated for its sweet root tubers. It is mainly used for human food after boiling or steaming, baking or frying and also as animal feed. Since roots contain 16% starch and 4% sugar, it is sued for production of industrial starch, syrup and alcohol.

Origin and distribution

Sweet potato is a native of tropical America. It is an important tuber crop in tropical and sub-tropical countries like Africa, China and India. In India, it is grown mainly in Andhra Pradesh, Assam, Bihar, Tamil Nadu and Orissa.

Botany

Sweet potato is a hexaploid species with 90 somatic chromosomes. It is a perennial herb with trailing vines and with a cluster of a few medium sized tubers. For cultivation purpose, it is treated as an annual with duration of 90 to 120 days. Though plants produce viable seeds, highly heterozygous nature of the crop results in a heterogeneous population. Hence stem cuttings are used for propagation purpose.Sweet potato has an extensive fibrous root system both at stem cuttings and at nodes touching soil. Some roots act as storage organs for storing reserve food. Storage roots may be fusiform, spindle or globular in shape and surface is smooth. Skin has white, red or light copper colour. Flesh may be white or with different combinations of orange and red.Leaves are simple, alternate and stipulate. They vary in size and shape, occasionally in same plant. Shape varies from ovate to cordate, hastate or deeply lobed and may change on ageing. Leaf shape is an important character for identifying clones.All clones do not flower and in flowering ones, duration and initiation of flowering vary. Flowers are axillary and borne solitary or in simple cymes. Flowers are bisexual. Corolla is attractive and funnel shaped formed by fusion of five petals. Anthesis starts before dawn and closes by 9-11 a.m. Pollination is entomophilies. Fruit is a capsule with false septa. Seed coat is hard and impervious to water. Hence, scarification is required for promoting germination.

Varieties

Pusa Safed

It was developed at IARI. Tubers are long white, less affected by weevil. It yields 26-30 t/ ha in 105-120 days.

Pusa Lal

Tubers are long and pinkish red. It yields 20 - 22 t/ ha in 120 days.

Kalmegh

The tubers are round, light brown. It has an yield potential of 26 - 32 t/ ha in a crop duration of 90-105 days.

CO 1 (IB 3)

It is a clonal selection developed at TNAU, Coimbatore. It is moderately vigorous and less spreading. The tubers are with light pink skin and white flesh and have a starch content of 24.2 per cent. It has an yield potential of 28 t/ ha in a crop duration of 135 days.

CO 2 (IB 81)

It is a seedling clone obtained from open pollinated seeds of IB 37 in the germplasm maintained at Faculty of Horticulture, Tamil Nadu, Agricultural University, Coimbatore. The tubers are medium sized with light pink skin and white flesh. Tubers are rich in starch (29.5 %). It has an yield potential of 32 t/ha in a crop duration of 110-115 days.

CO 3 (IB 2837)

It is a seedling clone obtained from the seeds of random mating population of IB 75. The tubers are medium sized with light red skin and orange flesh indicating high carotene content (13.28 mg/100 g). The starch content is 30.7 per cent and the sugar content is 2.9 per cent. It has an yield potential of 43.6 t/ha in a crop duration of 105 days.

Varieties which were developed at CTCRI, Thiruvananthapuram are as follows;

H 41

It was evolved by crossing Norin (Japanese types) with a local type. It is a semi spreading type with fusiform tubers having reddish purple skin and white flesh. It possesses good culinary quality. It yields 20-25 t. ha in a crop duration of 120-125 days.

H 42

It was developed from a cross Kelladumph (indigenous variety) x Triumph (American variety). Purple coloured tubers have medium thick pink rind and cream flesh. It has an yield potential of 20-25 t/ ha in 120 - 125 days.

Sree Nandini (76-OP-217)

It is a selection from the open pollinated progenies of the mother parent S 32 from CTCRI germplasm. It has a semi-spreading plant type with simple entire leaves. Emerging leaves are light green in colour, tuber skin light cream and flesh white in colour. It has a good culinary quality. The potential yield is 20-25 t/ ha in 100-105 days.

Sree Vardhini (76-OP-219)

It is an open pollinated seedling selection of the mother plant S 13. It is a semi spreading type with shallow lobed leaves; the colour of emerging leaf is light brown. Three to four tubers are produced per vine. The skin colour of the tuber is light pink while the flesh is light orange in colour indicating high carotene content (1200 IU/g). It has an yield potential of 20-25 t/ ha in 100-115 days.

Sree Bhadra

Released by CTCRI, Thiruvananthapuram through introduction and evaluation from IITA, Nigeria; vines are semi-spreading, greenish brown with broad cordate leaves. Tubers

are spherical with pink skin and creamy flesh. It yields 25-27 t/ ha. The starch content of the tubers is 20.2 per cent and carotene content is 972 IU/ g.

Sree Retna

Another variety developed at CTCRI, Thiruvananthapuram from a cross S187 x Sree Vardhini. The vines are greenish brown in colour. Tubers are spherical with purple skin and orange flesh. The starch content of the tubers is 23 per cent while the carotene content is 3578IU/ g.

Varsha

It is a high yielding variety of sweet potato. Hybrid, Semi spreading type. Drought tolerant.Released for konkan region of Maharashtra. Duration 120 days. Yield 17-22 T / Ha.

Questions

1. **Name a sweet potato variety developed from TNAU**
2. **Name some varieties develped from IARI**
3. **Name some varieties develped from CTCRI**

4. **Name a hybrid of Sweet potato**

5. **What is the mode of poliination in sweet potato**

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Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

L-27-28

Bhendi (Okra)

***Abelmoschus esculentus* (L.) Moench**
Malvaceae (2n=72)

Origin and distribution

Okra originated in tropical and subtropical Africa. Existence of a large number of related species with wide variability and dominant characters suggest possible role of India as a secondary centre of origin.

India is the largest producer of okra in the world. It is also used as a vegetable in Brazil, West Africa and many other countries. In India, major okra growing states are Uttar Pradesh, Bihar and West Bengal.

Breeding objectives

1. To develop high yielding varieties with dark green, tender, thin, medium long smooth 4-ridged pods.
2. To evolve varieties resistant to YVM, fungal diseases like fusarium wilt, cercospora leaf spot, powdery mildew, alternaria leaf spot, fruit rot and anthracnose.
3. To combine resistance to YVM virus with resistance to fruit and shoot borer, white fly, jassids and root knot nematodes.
4. Suitable ideotype; short plants with more number of nodes with short or, internodal length; easy snap of fruits from the stalk.
5. Varieties tolerant to abiotic stress especially tolerance to low temperature, excessive rains saline and alkaline soil.
6. To develop varieties suitable for export market and for processing industry.

Genetic Resources

The major collection is maintained by the NBPGR, New Delhi. IBPGR has designated NBPGR with global responsibility of base collection of okra. Okra germplasm endemic to India have been given emphasis for collection and evaluation. The prime object has been to identify sources of resistance to YVM virus.

Cytogenetics

Successful intra specific hybridization in the species *Abelmoschus esculentus* (L) Moench has helped to generate considerable variability in isolating desirable genotypes.

There are 30 species under the genus Abelmoschus in the old world and few species in the new world . *A. esculentus* is the only species known to be cultivated. Now, it has been known that *A. manihot* spp. *manihot* is also cultivated on a limited scale in the African Continent.

However, barriers in the interspecific hybrids have restricted the progress to transfer useful genes from the wild species to the cultivated ones. Cultivated okra (*A. esculentus*) is polyploid in nature (2n = 130) .

Interspecific hybrids between *A.esculentus* (n = 65) with 3 wild species viz., *A. tetraphyllus* Roxle (n = 69), *A. manihot* Medik (n = 33) and *A. manihot* L Medik sp. Manihot (n = 97) were studied . From the pollen sterility, which is one of the isolating mechanisms, *A. tetraphyllus* appears to be more closely related to *A.esculentus* as compared to two other wild species.

Taxonomy and botany

Cultivated bhendi belonging to Malvaceae was earlier placed under *Hibiscus esculentus* L. Since its calyx, corolla and staminal column are fused together and fall down at anthesis (caducous), it was renamed as *Abelmoschus esculentus* L.since in *Hibiscus*, calyx *is* persistent. Cultivated bhendi is an annual herb with duration of 90-100 days. Flowers are bisexual and often cross-pollinated. Time of anthesis is 8.00-10.00 a.m. Dehiscence of anthers occurs 15-20 minutes after anthesis and is completed in 5-10 minutes. Pollen fertility is maximum in the period between one hour before and after opening of flower. It takes 2 to 6 hours for fertilization after pollination. Stigma is receptive at opening of flower and hence, bud pollination is not effective in okra. Fruit is a capsule. Usually fibre development starts from fifth to sixth day.

Most of cultivated varieties are amphidiploids with 2n=130. *A. esculentus* is noted for its chromosome polymorphism and 2n ranges from 72 to 144. It tolerates addition or deletion of one or a few chromosomes. The chromosome number of *A .esculentus* is 2n=130 which is evolved by crossing. A. *tuberculatus* (2n=58) with *A. ficulneus (*2n=72). The F1 developed was subjected to colchicine treatment to make it an amphidiploid. *A. esculentus* (2n=130).

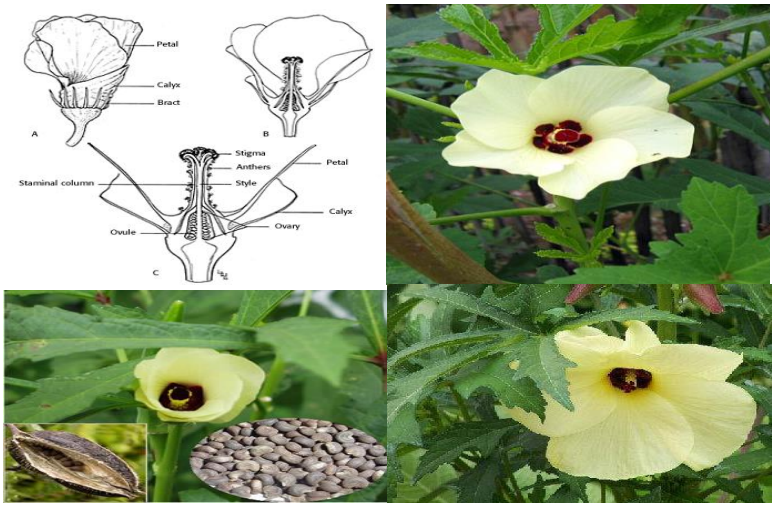
Similarly, *A. caillei*, a complex polyploid, was evolved by colchicines treatment of F1 of cross between A. manihot and A. esculentus.

Four species viz., *A. esculentus*, *A. manihot*, *A. caillei* and *A. moschatus* include both cultivated and wild forms.

Various Species of bhendi

Abelmoschus species	**Somatic Chromosome number**	**Wild(w)/Cultivated(c)**	**Distribution**
A. angulosus	56	W	India and Srilanka
A.aberculatus	58	W	India
A.moschatus	72	WC	India, Nepal and Srilanka
A.ficulneus	72	W	India and Bangaladesh
A.tetraphyllus	138	W	India, Nepal and Srilanka
A.tetraphyllus var.pungent	138	W	India, Nepal and Srilanka
A.crinitus	9	W	India and Srilanka

A.callei	196	W	India
A.manihot	66	WC	India and Srilanka
A.esculentus	130	C	worldwide



A.moschatus ***A. manihot***

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BREEDING METHODS

Pure-line Selection:

- This is applicable to landraces/cultivars collected from Farmers' field, for example, PusaMakhmali was bred from a material collected from West Bengal. Similarly, Co 1 is a single plant selection from Red Wonder.

Pedigree Method:

- This method is applicable to the segregating generations after hybridization between desirable promising donors.
- The individual plant selection starts in the F_2 generation and continues till F_5 or F_6.
- For example, Pusa Sawani was developed through this method in an inter-varietal cross. Punjab Padmini, ParbhaniKranti, P_7, Arka Anamika and Arka Abhay are examples of pedigree selection following interspecific hybridization.

Mutation breeding

- MDU 1 is an Induced Mutant from Pusa Sawani
- Punjab 8 - It is an induced mutant derived from Pusa Sawani treated with 1% EMS.

Heterosis breeding

- Heterosis in okra has been reported for various economic traits, viz. early and late flowering, plant height, number, weight and size of pods, number of ridges, marketable and total yield.
- Using hand emasculation and pollination, commercial hybrids are developed. There are promising hybrids under private sector seed companies in India. The current seed market of okra in India is approximately 4000 tons for open-pollinated cultivars and 1000 tons for hybrids.

Crop improvement

Yellow vein mosaic virus disease being a serious problem in okra cultivation, concerted effort was made to develop high yielding as well as YVMV resistant varieties in the country. With development of YVMV resistant variety, Pusa Sawani, most of the primitive low yielding local cultivars has become less significant. After break down of

resistance of Pusa Sawani, research on virus resistance was intensified at various research centres in India and it resulted in development of a number of YVMV resistant varieties.

Identified promising lines of okra for various attributes

Early flowering	IC-128062, 11479,117218, EC-325356, 329370
Long fruiting duration	IC-264697, 2647, EC-305749, 306741
Resistant to damping off, *Rhizoctonia solani*	Red Ghana, Sel-7-1, BH-27, IC12096
Resistant to powdery mildew	Nigeria, EC32598, IC8248, *A.tetraphyllus, A.angulosus*
Resistant to Cercospora blight	Sel-7-1, Round selection, EC-32598, *A.crinitus, A.moschatus A.angulosus*
Resistant to Fusarium wilt	IS-9273, Pusa Sawani, Pusa Makhmali
Resistant to leaf curl virus	*A.ficulnes, A.manihot*
Resistant to microphomina	IC-90186, U-43087, U4365
Resistant to Yellow vein mosaic virus	*A.manihot,* Parbhani Kranti, Punjab Padmini, IC-1542, ACC-49, NIC-9303A
Resistant to Jassid	IC194, Sesswal Local, IIHR21, AE30 Crimson Smooth
Resistant to fruitborer	A.tuberculatus, Red -1, Pusa Sawani, Long green
Resistant to nematode	Long green smooth
Tolerant to mite	*A.angulosus*

Varieties

Pusa Sawani

Developed at IARI - fruits - bright green, medium length, 5 ridges; It has got an yield potential of 8-10 t/ ha in a crop during of 90 - 95 days. This variety can be grown in Kharif and Rabi. Not suited for summer as it is susceptible to YVM.

Pusa Sawani

MDU 1

Developed at AC & RI Madurai by gamma irradiation of seeds of 'Pusa Sawani'. Fruits - light green with long stylar end. Plants - compact with close arrangement of nodes also susceptible to YVM. Yield: 10 - 11 t/ ha.

CO1

It is a pure line selection from Hyderabad 'Red Wonder'. Fruits - pinkish red. Yield: 12 t/ ha; susceptible to YVM; not very popular among farmers.

Punjab Padmini

Evolved from PAU - Ludhiana, fruits - dark green - 20 g each. It tolerates yellow vein mosaic to certain extent under field condition.

CO 2

F_1 hybrid (AE 180 x Pusa Sawani), developed at Department of Horticulture, TNAU. Fruits - very long - 22 - 25 cm, 7 - 8 ridges and light green. Highly susceptible to YVM and hence cannot be recommended for summer - suitable for dehydration.

Parbhani Kranti

Marathwada Agricultural University, Parbhani - Maharashtra. Field tolerant to YVM (more than 5%) recomended for growing during summer season.

Fruits: dark green in colour. Yield: 10 - 12 t/ ha in kharif and 7-8 t/ ha in summer season. Evolved by back cross method using a wild relative called *Abelmoschus manihot*.

Arka Abhay (IIHR Sel. 4)

IIHR - Inter specific hybridization using *Abelmoschus manihot* ssp tetraphyllus variety etraphyllus as a source of resistance and it exhibits a very high degree of resistant to YVM. Yield: 10 - 12 t/ ha (summer); 16 - 18 t/ ha.

Fruits - short, dark green in colour and fetch a primium price in the market in summer season. Duration: 120 - 135 days.

Arka Anamika (IIHR Sel.10)

This is yet another variety developed at IIHR by interspecific hybrid as before. It shows a high degree of resistance to YVM disease and hence suitable for growing in summer. Fruits - dark green and lengthier than Arka Abhay. Yield: 12 - 13 t/ ha (Summer); 16 - 18 t/ ha (Kharif); duration: 120 - 135 days.

CO 3 (Hybrid 8)

It is an F_1 hybrid of Parbhani Kranti and MDU 1 rlesed from TNAU and has an yield potential of 16 - 18 t/ha. It is moderately resistant to YVM. Suitable to kharif and summer season.

Pusa Makhmali:

- It was developed by Plant Introduction Division, IARI, New Delhi, as a result of selection from the local material collected from West Bengal. It is an early variety.

- ❖ Pods are smooth, straight, 5-edged, attractive, light green, slender, 15-20 cm long. The yield potential is 100 q/ha.

Pusa A 4:

- ❖ This variety has been released by IARI in 1994 as a substitute for Pusa Sawani. The plants are dark-green with sparse pigmentation (occasional) on stem and petiole, with usually single stem having short internodes (2-4 cm). The leaves are broad and medium lobed.
- ❖ The fruits are 5-ridged, attractive dark-green, 12-15 cm long having excellent shelf-life. It is resistant to YVMV and tolerant to jassids and shoot and fruit borer.
- ❖ Green fruit yield during summer season ranges 10-12 tonnes/ ha while during kharif and late kharif it could give still higher yields. It also responds to pruning to extend the summer crop for added harvests during kharif season.

Kashi Mohini (VRO 3):

- ❖ Developed by IIVR, Varanasi, 110-140 cm tall plant, flowers at 4-5th node during summer and 5-7th node during rainy season, fruits five ridged, 11 -12 cm long pods, 130-150 q/ha pod yield, tolerant to YVMV under field conditions.

Kashi Pragati (VRO 6):

- ❖ Developed by IIVR, Varanasi, 130-175 cm tall plants with average of 2 effective branches/ plant, flowering at 4th node after 36-38 days after sowing in rainy season, 8-10 cm long pods, 23-25 pods/plant, 150-180 q/ha yield, highly tolerant to YVMO.

Varsha Uphar (HRB 9-2):

- ❖ This variety has been developed by Haryana Agricultural University, Hisar from the cross, Lam Selection 1 x Parbhani Kranti following pedigree selection method. It was released in 1992 and notified in 1995 by the Central Sub-Committee on Crop Standards.
- ❖ It has resistance to YVMV and field tolerance to leaf hopper and suits to disease prone rainy as well as disease-free spring- summer season.
- ❖ Plants are medium tall (90-120 cm) with short internodes, producing 2-3 branches each. Petiole is pigmented.
- ❖ It takes 40 days to first flowering and 50 days to first picking. Fruit bearing starts from 4th node. Fruits are smooth, dark-green, attractive with long tapering tip and measure 18-20 cm on full maturity.
- ❖ Average number of seeds per fruit is 55-60. It is a prolific bearer with an average fruit yield of 10 tonnes/ha.

Hisar Unnat (HRB 55):

- ❖ Developed by Haryana Agricultural University, Hisar from the cross, Se.1 2-2 x ParbhaniKranti, has been released by the Central Variety Release Committee and notified in 1996. It is resistant to YVMV, early (first picking in 46-47 days) and high yielding (12-13 tonnes/ha green fruits) variety.
- ❖ Plants are medium tall with short internodes producing 3-4 branches each. Foliage is green, petioles occasionally pigmented.
- ❖ Petal base is pigmented on inner side only. Fruits are green, attractive, 5 ridged and measure 15-16 cm in length on full maturity.
- ❖ It is suitable for growing during summer as well as rainy season.

Questions

1. **Write down the breeding objectives for okra**
2. **Name some varieties developed from IIVR, Varanasi**
3. **Name some varieties resistant to YVMV**
4. **Name a pink fruited variety**
5. **Write in detail about the breeding methods for crop improvement in okra.**

References

1. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.

L-29

Moringa

(***Moringa oleifera*** Lam.)
(Hindi : Seeng, Sahgan)

Moringaceae

2n = 22

Moringa/Drumstick is grown for its nutrient rich tender, pods, leaves and flowers which are used for culinary preparations. Fruits are rich in vitamin C (120 mg/100g), carotene (110 mg), phosphorus (110 mg) and minerals like magnesium (28 mg), potassium (259 mg), sulphur (137 mg) and chlorine (423 mg). The crop is grown in most homesteads in India. Tender leaves and flowers are comparable to that of colocasia in vitamins and minerals and have great role for combating malnutrition of urban and rural masses. Certain morigna types principally grown for its foliage are reported from West Indies. Drumstick roots are good substitute for horse radish. Root, bark and seed have many industrial uses also.

Origin and distribution

Originated in South West India, drumstick became a popular vegetable in South Indian states. The crop is widely distributed in India, Sri Lanka, Pakistan, Singapore, Malaysia, Cuba, Jamaica and Egypt.

Botany

Drumstick is a small or medium sized perennial tree of about 10 m height with fragile and corky stem. The leaves are usually tri-pinnate with elliptic leaflets. Pods are pendulous and length ranges from 20 cm to 100 cm. Seeds are trigonous with wings on angles. Flowers are produced on current season growth on large and erect panicles or monocladial

cyme. Flowers were yellowish creamy white and sweet smelling. Individual flowers are bisexual, zygomorphic and pedicellate.

Calyx and corolla consist of five sepals and petals. Androecium also has five stamens alternating with five stamindodes. Gynoecium has a superior, one celled and three carpelled ovary containing many ovules on parietal placentation. Stigma is truncate.

Flowering in drumstick varies from place to place and is greatly influenced by rain, temperature, humidity, wind, soil temperature, soil moisture etc. Under South Indian condition, one or two distinct peak periods of flowering noticed. Peak period of flowering in central parts of Kerala is December-January while in southern part it is February-March and July-August with maximum flowering in February-March. Under Coimbatore and Bangalore conditions, flowering seasons are March-May and July-September respectively. Anthesis continues throughout the day. Two anthesis peaks i.e., 2.00 p.m and 4.00 a.m. are noticed at Thiruvannthapuram. In most parts of Tamil Nadu, flowering is from 4.30 a.m. to 6.30 p.m.

In southern part of Kerala, stigma becomes receptive one day prior to flower opening and continues with maximum receptivity on the day of opening and a sudden decline thereafter.

Two common species

- Moringa oleifera
- Moringa concanensis

M. oleifera

- Leaves usually tripinnate, leaflets 12-18 mm long,
- Petioles yellow (or) white without red streaks and the tree is medium sized.

M. concanensis

- Bipinnate leaves, leaflets 15-30 mm long, petals with red streaks (or) reddish at base and the tree is large.

Breeding objectives

- Breeding varieties with dwarf stature.
- Varieties suitable for leaf purpose
- Development of high yielding types
- Breeding varieties with more seed and oil content
- Development of types resistant to pest and diseases

Breeding Methods

- Mass selection

- Selection of types starts with open pollination.
- Select one line with the highest potential and test in various conditions and various sites.
- Then, go for control pollination.
- PKM-1 annual moringa was released through this method.
- Hybridization
- Annual moringa PKM- 2 is a hybrid derivative from the cross between MP31 and MP28.
- PKM 2exhibits 48% increase in yield over PKM1.
- Mutation breeding
- Very little work has been carried out in annual moringa through mutation breeding.

Varieties / cultivars

A number of local cultivars are known by the place of their cultivation. Details of local cultivars are given:

- **Jaffna moringa** - a perennial type which bares 60-90 cm long pods with soft flesh and good taste.

- **Chavakacheri muringa** - a perennial type producing 90-120 cm long pods.
- **Chemmuringa**- This perennial type flowers throughout year and bears red tipped fruits.
- **Yazhpanam muringa** – same as Jaffna type
- **Pal muringai** – Pods having thicker pulp and better taste

- **Puna muringa**– Thinner fruits.
- **Kodikal muringa**– produces short pods of 15-20 cm long and is sued as support for betel vine plants. Propagated by seeds.

There are only a few named varieties and the details are given below:

KM-1 (Kudumianmalai 1)– Bushy variety propagated through seeds. Plants come to bear 6 months after planting and can be rationed for 2-3 years. Productivity 400-500 fruits / year. Developed at Anna Pannai, Kudumianmalai of Pudukottai.

PKM – 1 **–** This "seed moringa", propagated through seeds is developed at Horticultural Research Station, TNAU, Periyakulam. Plants grow to a height of 4-6 m and come to flower in 90-100 days after planting. The first harvest starts 160-170 days after planting and on an average each tree bears 200-225 fruits / year. Pods are 65-70 cm long with 6.3 cm girth and 150 g weight. Fruits are green coloured and highly pulpy.

PKM 2– This "seed moringa", propagated through seeds, is also developed at Horticultural Research Station, TNAU, Periyakulam. Pods are extra long (125-130 cm), pulpy and suitable for homestreads.

Dhanraj– This is also an annual drumstick propgated through seeds and is evolved at KRC College of agriculture, UAS, Arabhavi, Karnataka.

Crop improvement programmes in the Department of Olericulture, Kerala Agricultural University, Vellanikkara resulted in the development of three promising perennial drumstick clones *viz.*, MO 70, MO 95 and MO 44 and one annual seed drumstick, AD 4.

Questions

1. **Name some moringa varieties developed from HCRI, Periyakulam**
2. **Name some seed moringa varieties**
3. **Name some local cultivars in moringa**
4. **What are all the breeding methods for moringa**
5. **Write in detail about the breeding achievements in moringa**

References

1. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.

L-30

Peas

INTRODUCTION

Scientific name : *Pisum sativum*

Common names : Matar (Hindi, Nepali) Pea; split pea, garden pea.

Family : Fabaceae

Chromosome number:2n=14

ORIGIN AND DISTRIBUTION

- The Mediterranean region, western and central Asia and Ethiopia have been indicated as centers of origin.
- Recently the Food and Agriculture Organization (FAO) designated Ethiopia and western Asia as centers of diversity, with secondary centers in southern Asia and the Mediterranean region.
- Archaeological evidence of the use of peas dating from 8000 BC has been found in the Fertile Crescent.
- The first cultivation of peas appears to have been in western Asia, from where it spread to Europe, China and India.

Species:

- ✓ **Ancestor of *Pisum sativum* –***Pisum elatius*
- ✓ **Garden peas** - *P. sativum* ssp. *hortense* Asch. & Graebn.,
- ✓ **Field peas** - *P. sativum* ssp. *arvense* (L.) Poir.,
- ✓ **Edible podded peas** - *P. sativum* ssp. *Macrocarpon*
- ✓ **Early dwarf pea** -*P. sativum* var *humile*

Types of peas

Garden peas :

- Garden peas have rounded pods that are usually slightly curved in shape with a smooth texture and vibrant green colour.
- Inside of them are green, rounded pea seeds that are sweet and starchy in taste.

Snow pea and Snap pea:

- Snow peas are flatter than garden peas and are not fully opaque. Snap peas, a cross between the garden and snow pea, have plump pods with a crisp, snappy texture.

- The pods of both snow peas and snap peas are edible, and both feature a slightly sweeter and cooler taste than the garden pea.


Snow Peas **Snap Peas**

BOTANY

Habit:

Pea is an annual herbaceous plant or leguminous crop.

Roots:

Plants have a taproot system with nodules on the surface.

Stem:

Stems are hollow, slender, succulent and ridged.

Leaves:

It bears pinnately compound leaves with three pairs of leaflets and the terminal one is modified into a branched tendril.

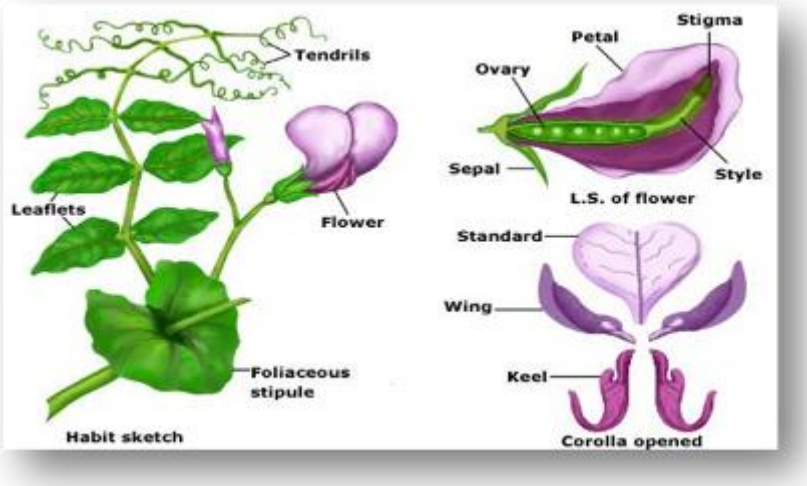
At the base of the petiole, a large pair of stipules or bracts is found, and they cover the petioles in such a way that the leaves appear to be sessile.

Seeds:

Seeds are globose or angled, smooth or wrinkled, whitish, grey, green, or brownish.

Floral Biology

- Exclusively self pollinated crop.
- Favoured by cleistogamy.
- Stigma is receptive several days prior to anthesis – protogynous in nature.
- Pollen remains viable from the time of dehiscence of anthers until several days thereafter.
- Bud pollination is effective.



Peas flower

BREEDING OBJECTIVES

- Early maturity
- Pod characteristics
- Dark green pods
- Bold seed size
- Shelling percentage
- Pod yield
- Suitability for processing
- Resistance to disease
- Resistance to insect

- Resistance to abiotic stress

BREEDING METHODS

- The breeding procedure adopted for pea improvement include,
- Introduction : Bonneville (USA)
- Individual plant selection(P. 88)
- Pedigree method
- Single seed descent method of selection
- Bulk method of selection
- Recurrent selection
- Hybridization(Jawahar Matar 1, 2, 3 and 4)
- Backcrossing
- Line breeding
- Resistance breeding: Powdery mildew: JP. 83, JP.71, JP.4, PRS 4

Improvement of pea by breeding has been undertaken at PAU(Ludhiyana), HAU(Hisar), GBPUAT(Pantnagar), JNKV(Jabalpur), CSAU(Kanpur), Dr.YSPUHF(Solan), IARI(Delhi), PDVR(Varansi), NDUAT(Faizabad) and VL(Almora).

Inheritance of qualitative characters:

Gene	Character
Plant height	
cry	Influences internode length and plant height along with *la* and *le*
la	Internode length and plant height along with *cry* and *le*
le	Internode length and plant height along with *cry* and *la*
Colour	
a	Absence of anthocyanin : dominant allele for anthocyanin production in plant, flower and seed
Ch-l	Plant light yellowish green
d	Green leaf axil : *D dependent on* A for manifestation of colour

pa	Dark green immature seed and foliage
vm	Effect to similar to *pa*
Inflorescence , Number of flowers	
fn	With fna determines number of flower on the inflorescence :greatly influenced by environment
fna	With fn determines number of flowers on the inflorescence, greatly influenced by environment
Branching	
fr	With *fru* determines number of basal branches
fru	With *fr* determines number of basal branches
ram	Increases number of branches
Leaves and stipules	
af	Leaflets converted into tendrils
lat	Double leaflet and stipule area
tac	Tendrils present on acacia leaves
tl	Leaves with extra leaflets and no tendrils
Pods	
it	Increases pod with 25 per cent
Bt	Apex of pod blunt
Com	Affects curvature of pods
n	Pod Wall thick
Dpo	Pods tough and leathery : readily dehisce at maturity
P	Reduces or eliminates sclerenchymatous membrane on inner pod walls
V	Same as p
gp	Young pod yellow
pu	With A Pur pod colour purple
pur	With A Pu pod colour purple

Varieties

Pea cultivars grown in different parts of the world exhibit wide variation in height of stem, branching, pod size, seeds per pod, shelling percentage, smoothness of seeds (smooth / wrinkled) etc. The cultivars / varieties are grouped based on various characters as given below:

Based on maturity period

- Early types – green pods will be ready for harvest by 65 days after sowing.
- Mid season types – pods will be ready for harvest by 85-90 days after sowing.
- Late main season types – pods will be ready for harvest by 110 days after sowing
- Based on height of plant
- Bush or dwarf types
- Medium tall
- Tall

Usually dwarf types are early and mid season types are medium tall. Late types are tall and require support.

Varietal Achievement

Cultivar	Parentage	Salient features	Institution
Early Group			
Arkel	Introduction from England	Early season variety introduced from England Dwarf plants bearing double pods at lower nodes and single at upper nodes. Pods 8.8 cm long and sickle shaped. Suitable for fresh market and dehydration. Susceptible to collar rot at high temperature. Yield 7.5 t/ha in 50-55 days.	IARI, New Delhi
Pusa Pragati	-	Yield 7 t/ha in 60-65 days.	IARI, New Delhi
Jawahar Matar3	T_{19} x Early badger	Early season variety developed through selection from cross between T 19 x Early Badger. First picking in 50 DAS, Pods 7 cm long, light green and round oval / ovules.	JNKVV, Jabalpur
JM4	T_{19} x Little Marvel	Yield 8 t/ha in 55-60 days.	JNKVV, Jabalpur

Pant Matar2	Early Badger x IP3	Yield 6 t/ha in 55-60 days.	GBPUAT, Pant nagar
Hisar Harit	Selection from cross between Bonneville x P 23.	Pods large sickle shaped and single or double. Yield 9 t/ha.	HAU, Hisar
Kashi Mukti	Pedigree selection from the cross No. 7 x PM-5.	powdery mildew resistant variety developed through Yield 110-120 q/ha	IIVR, Varanasi
Kashi Nandini	Pedigree selection from the cross P 1542 x VT-2-1.	Plant height is 47-51 cm, first flower 32 DAS, bears 7-8 pods per plant. Pods are 8-9 cm long, attractive, length 8-9 cm, well filled with 8-9 seeds, shelling percentage 47-48, yield 110-120 q/ha. It is tolerant to leaf mine and pod borer	IIVR, Varanasi
Matar Ageta 6	_	Early season dwarf variety. Tolerant to high temperature. Yield 6 t/ha with 44.67% shelling percentage. Seeds smooth and green.	PAU, Ludhiana
Mid season and late group			
Bonneville	Introduction from USA	Mid season variety introduced from USA. Medium tall plants bearing double pods. Pods more than 9 cm long. Yield 8.5 t/ha. Seeds green and wrinkled.	IARI, New Delhi
Lincoln	Introduction from USA	Early season variety introduced from France. Medium tall plants bearing double pods of 8-9 cm length and sickle shaped. Mature seeds wrinkled. First picking 85-90 days after sowing (DAS). Yield 68-10 t/ha.	IARI, New Delhi
Jawahar Matar 1	T_{19}x Greater Progress	Mid season dwarf variety with big, attractive green, 8-9 cm long pods containing 8-10 sweet green ovules	JNKVV, Jabalpur
Jawahar Matar 2	Russian 2 x Greater Progress	Pods dark green, big, curved with 8-10 sweet ovules, wrinkle seeded, susceptible to powdery mildew.	JNKVV, Jabalpur
Pant Uphar(IP3)	-	Medium maturity, ready for harvest by 70-80 DAS. Flowers white, Pods round. Seeds wrinkled, Susceptible to powdery mildew. Resistant to stem fly. Yield 10 t/ha.	GBPUAT, Pantnagar
Punjab 88(P	Pusa 2x	Early season variety. Pods dark green, long (8-10 cm) and slightly curved. Days to first harvest –	PAU,

88)	Morrasis 55	100. Yield 15 t/ha with 47% shelling percentage.	Ludhiana
VL Matar 3	Old Sugar x Early Wrinkled Dwarf 2-2-	Plants determinate. White flowers, straight and double podded. Length – 6.8 cm. First picking is 100 DAS. Yield 10 t/ha.	VL, Almora
Mithi Phali	-	Yield 11-12 t/ha in 90 days.	PAU, Ludhiana
JP 19	-	Yield 10-11 t/ha in 90 days.	JNKVV, Jabalpur
Ooty-1		Dwarf variety having a yield potential of 11.9 t/ha in 90 days. Resistant to white fly.	TNAU, Coimbatore

Breeding for Disease Resistance

Disease	**Resistance Source**	**Institution**
Powdery mildew (*Erysiphe polygoni*)	Jawahar Pea 83 JP4(JM 6), PRS4, FC 1	JNKVV, Jabalpur
Fusarium wilt (*Fusarium oxysporum f. sp. Pisi)*	Kalanagini JP179 PushaVipasha	Local cultivar JNKVV, Jabalpur IARI, New Delhi
Rust (*Uromyces fabae*)	JP.Batri Brown3 Jp.Batri brown4	JNKVV, Jabalpur
Aschochayta blight (*Aschochayta pisi*)	Kinnauri	Local cultivar
Bean yellow mosaic virus	Bonneville	IARI, New Delhi

Breeding for resistance to insect pests

Pest	**Resistance Variety**	**Institution**
Leaf miner (*Phaytomyza articormis)*	LMR-4,LMR-10,LMR-20	HAU, Hisar
Bruchus (*Collosobruchus*	JP 9 ,JP 179, JP JP Batri Brown 3, JP Batri	JNKVV, Jabalpur

chinensis)	Brown 4	
Multiple disease and pest resistance		
Pest/Diseases	**Resistance source**	**Institution**
Highly resistance to powdery mildew, tolerant rust ,resistance to *Fusarium* wilt, Bruchus, leaf miner	JP 179	JNKVV, Jabalpur
Resistance to powdery mildew, bruches	JP 9	JNKVV, Jabalpur
Resistance to powdery mildew, wilt, bruches	JP 501	JNKVV, Jabalpur
Resistance to rust and powdery mildew	Arka Karthik, Arka Sampoorna	IIHR, Bangalore

Rondo – High Yielding Variety

Kashi Nandhini **Kashi Mukti**

MUTATION BREEDING

Mutants:

Afila:

Leaflets are converted into tendrils.

Acacia:

- Tendrils are converted into leaflets.
- The induced mutations developed are the early flowering

  46 C and JP 829 (Flowering from 4th to 6th node),

  Fascinated mutants, R701, R710, JP 625,JP 67,251 A, 997,999 and others.

Breeding for processing qualities

- Dehydration, canning and freezing are the most common processing method of peas.
- Large sized wrinkled and dark green peas like Arkel are suitable for dehydration, for canning, both round and wrinkled seeded varieties like T19 and Bonneville can be used and for freezing wrinkled seeds.

Biotechnology:

- There are several reports on micropropogation of peas by tissue culture using apical meristems of seedling, immature and mature leaves, axillary buds primary scales and cotyledons.
- Plants could be regenerated by protoplasm through somatic embryogenesis.
- For genetic transformation *Agrobectarium tumefenciens* and micro projectile had been used.
- Production of transgenic plants in peas has also been reported.
- Recently detailed genetic maps have been assembled in eight genera of the fabaceae, including *Phaseolus, Pisum,Vicia* and *Vigna.*
- There is a common gene order across at least 40 per cent of the lentil and pea genomes and conservation with many chromosomal regions in *Vicia.*
- Studies are in progression comparative genomics and legumes.
- Detailed genetic map has been developed for pea.
- Genes of interest have been located and closely linked markers have been identified.
- Marker assisted selection procedure using RFLP, RAPD and isozymes have been established for pea venation mosaic virus, pea seed borne mosaic virus, and powdery mildew resistance.

Questions

1. **What are all the relative species of Peas?**
2. **Write about the floral biology of peas**
3. **Write in detail about the breeding objectives for peas**
4. **Write in detail about the resistant breeding in peas**
5. **Name a variety developed from TNAU**

References

1. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices.

New India Publishing Agency, Pitam Pura, NewDelhi.

L-31 **FRENCH BEANS**

Phaseolus vulgaris L.

Fabaceae

2n = 22

Common Name: Snap bean, String bean, Kidney bean, Haricot bean, Fresh bean
Hindi: *Vilaiti sem*

The French bean (syn. Kidney bean, haricot bean, snap bean, navy bean) is one of the most important leguminous vegetables. It is grown for the tender vegetable, shelled green beans and dry beans (*rajmah*) as a pulse.

Origin : South mexico and Central America

There are four cultivated species in the new world:

Phaseolus vulgaris : The common, haricot, navy, French or snap bean.

P.coccineus : The runner or scarlet runner bean.

P.lunatus :The Lima (large-seeded), sieva (small-seeded), butter or Madagascar bean.

P.acutifolius var. *latifolius* : The tepary bean

All the species are diploid with 2n = 2x = 22. *P.coccineus (Scarlet runner bean)* is generally cross-pollinated and the other three species are self-pollinating with only a small amount of cross-pollination.

Ancestor of French bean: *Phaseolus aborigineus*

•Potato bean - *Pachyrrhizus tuberosus* .Tuber is used as vegetables

- *P.aborigineus* in North West Argentina as the wild progetor of French beans

Based on growth habit it can be classified into

pole type, semi pole type and bushy type,

1.Indeterminate - 17-35 internodes

2.Indeterminate - Semi climber 14-30 internodes

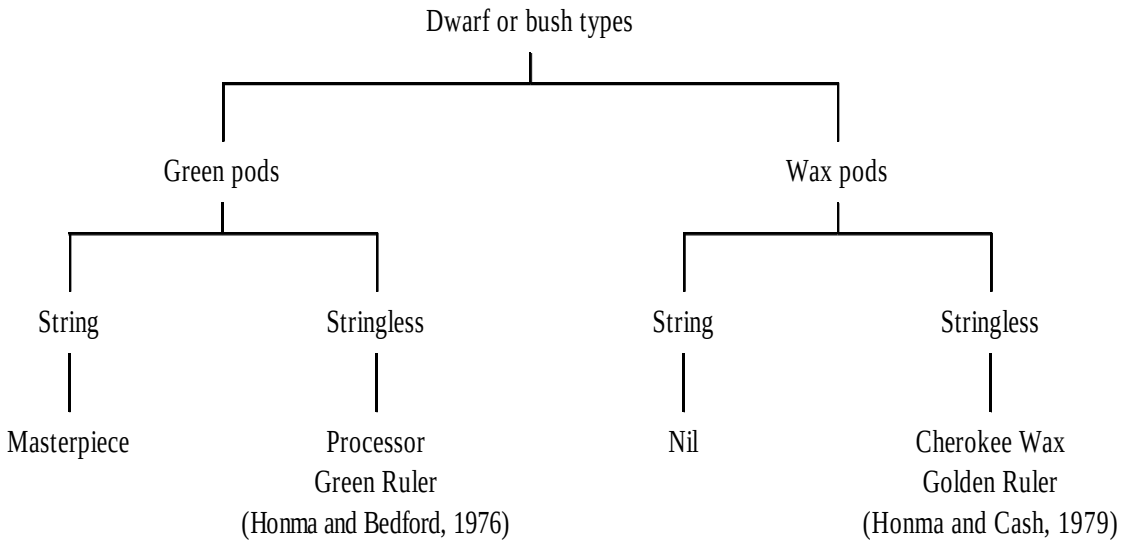
3.Indeterminate - Bush 13-12

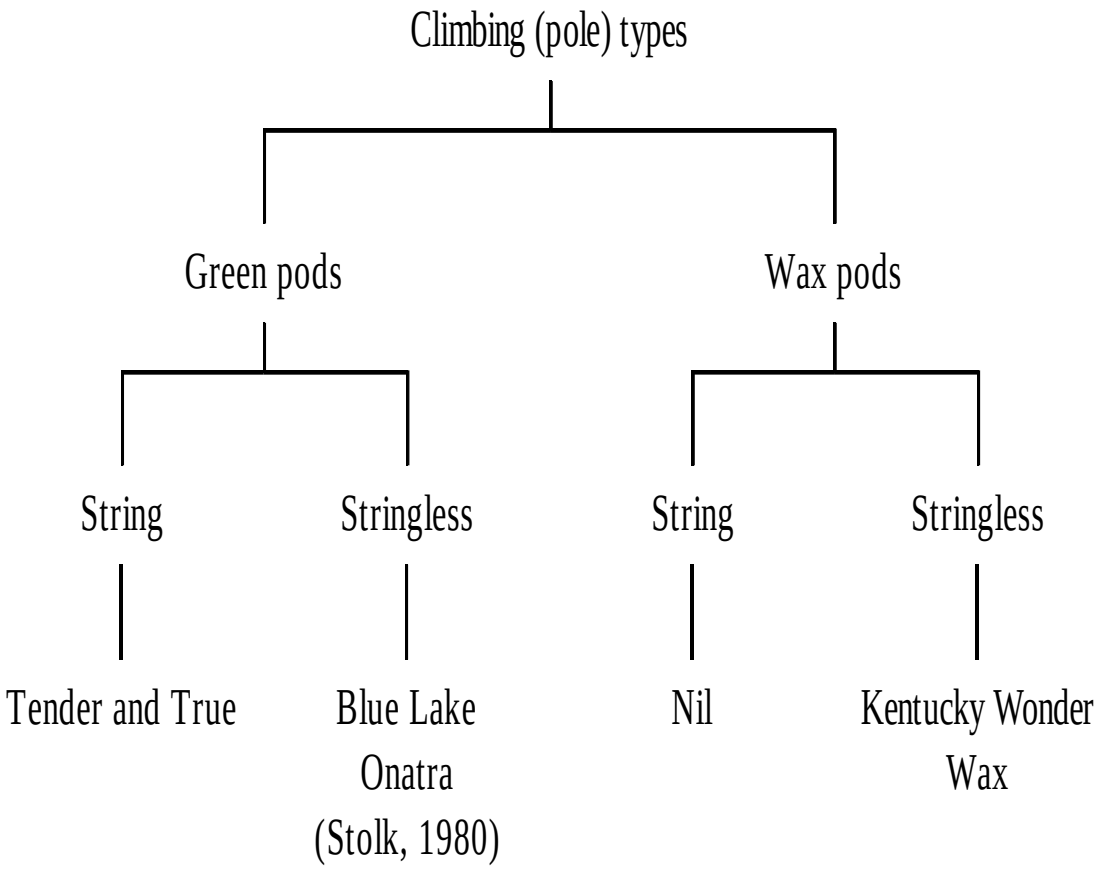
4.Determinare climber - 12-15

5.Determinate bush

Classification of cultivars

The French bean cultivars are classified as follows.





There is a large number of French bean cultivars.

1. Snap beans - for vegetable pods.
2. Green-shell beans - used in the green-shelled condition.
3. Dry-shell beans - used in the dry state (field beans).

Each group is again divided into climbing (pole) and dwarf (bush) types.

Some of the green-shell bean cultivars are Low's Champion, French Horticultural, Dwarf Horticultural, Brilliant, Flash and Green Lime Light which are bush type cultivars. Pole type cultivars are London Horticultural and Red Cranberry.

Some of the important snap beans cultivars are as follows.

There are three types of bush beans, namely, flat, oval and round types.

The flat types are Bountiful, Plentiful, Green Ruler, Golden Ruler and Romano.

The oval types include Pusa Parvati, Contender, (disease-tolerant, green and prolific bearer), Spartan Arrow, Premier, Tendergreen, King Green, etc.

The pole types include Blue Lake, Kentucky Wonder and Phenomenal Long Podded. Most of the local types native to North-Eastern Region of India are pole types.

Tender crop and Cascade are popular processing cultivars. However, the latest concept in the U.K. is to go in for cultivars with short pods so that they can be processed whole.

FLORAL BIOLOGY

- **Flower**: (Inflorescence) Racemose
- **Anthesis**: 11:30am-12pm
- **Anther dehiscence**: 88%
- **Stigma receptivity**: 10 hrs after anthesis
- Fruit is usualIy a Legume or pod

Crop improvement

The French bean improvement is being carried out in some Research Institutes and Agricultural Universities in India.

This has led to the identification/evolution of cultivars like VL Boni (Almora); UPF-191, UPF-204, etc., (Pantnagar); SVM (an interspecific cross) from Solan; Sel.2, Sel.5 and Sel.9 (Bangalore) and Pusa Parvati from Indian Agricultural Research Institute, New Delhi, India.

All the research institutes excepting Indian Council of Agricultural Research Complex, Shillong are involved in evolving bush bean lines.

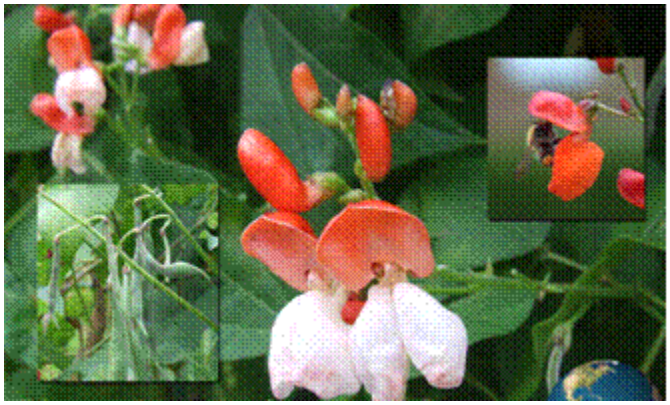
The work in North-Eastern region of India is towards evolving pole bean cultivars. Because of high rainfall, farmers prefer pole type as the fruiting height is much above the ground level thus preventing the pods from being infected with pathogens from soil.

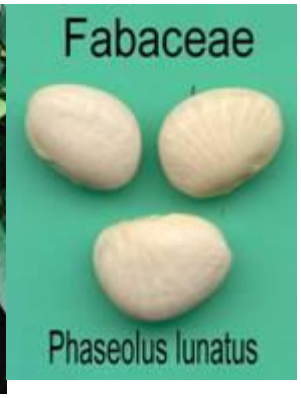
Besides, there are many local pole types being grown which can be improved for specific traits like yield and quality.

Breeding objectives

1. High yield
2. Quality for fresh market and sloughing free cultivars for canning industry
3. Short pods for whole pod processing.
4. Resistance to pests and diseases.
5. Exploitation of hybrid vigour by induction of male sterility

P.vulgaris ***Phaseolus coccineus***





White Tepary Beans

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.







METHODS OF BREEDING

1.Introduction: Contender, Kentucky wonder

2. Pure line selection : Arka komal, (sel -9), APLS from IIHR-60 collection IIHR-220,PLS from hungary collection. Arka Bold + rust and bacterial blight.

3.Pedigree method : IIHR-909 pod selection from Blue crop x Contender (Arka Suvidha)

Mutation breeding:

Pusa Parvati derived from a mutant waxy type EC1906, X-ray seeds were exposed.

- Early bushy
- Resistance to anthracnose.

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	Breeding Method	Special features
IIHR, Bangalore.	Arka Komal*	Introduced bushy variety from Afghanistan.	Bush type.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 Suvidha* (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	Plants bushy with pink flowers. Pod green, round long. Resistant to mosaic and powdery mildew.

		irradiation followed by selection from wax podded variety EC 1906.	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	Selection from the accession PV 24.	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.

Contender

Kentucky Wonder

PUSA PARVATI

DOLICHOS BEAN

INTRODUCTION

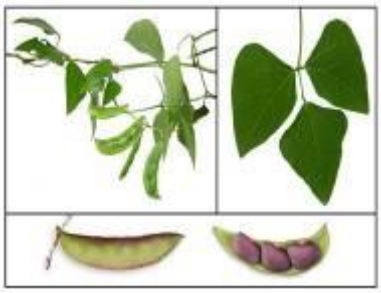
- *Dolichos lablab* (L.syn. *Lablab purpureus*)
- Family : Leguminoaceae
- Chromosome no. : 2n = 20, 22, 24
- Origin : Asian
- Spread throughout the tropical and temperate region of Asia, Africa and America.
- Ancestral species : *Dolichos purpureus.*
- It is leguminous pod vegetable.

GENETICS

- Number of pods per plant, number of seeds per pod and 00 seed weight are highly heritable and highly correlated with yield.
- Pigmentation of vegetation and flower: monogenic where purple dominant to white.
- **Pod colour** : Monogenic where green dominant to light green.

- **Pod character** : Flat pod dominant to swollen pod. Fp/Fp
- **Seed colour** : Monogenic where chocolate (dark brown) is dominant over brown.

MORPHOLOGY



FLOWER COLOUR

POD COLOUR

POLE TYPE

BUSH TYPE

SEED COLOUR AND SHAPE

BREEDING OBJECTIVES

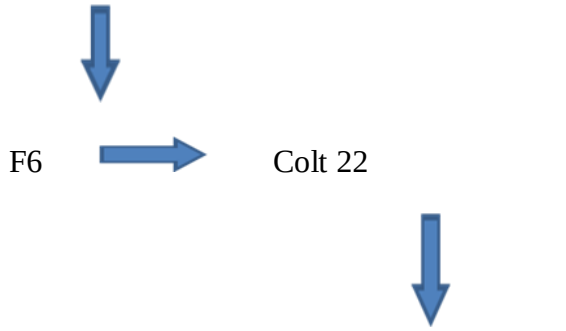
- Bushy habit
- High yielder eg Arka Prasidhi 37t/ ha @ 120 d
- Early yielder
- Photo insensitive eg. Konkon Bushan
- High sugar to polysaccharide ratio

- Less fiber (string less)
- Fleshy pod pericarp

BREEDING METHODS

- Highly self pollinated crop.
- **Pure line selection and back cross:**
- Arka Jay (sel-1): Developed from back cross and pure line selection from cross Hebbal Avare * IIHR 93. Photo insensitive and tolerant to heat and drought.
- Arka Vijay (sel-2): Developed from back cross and pure line selection from cross Hebbal Avare * IIHR93. Photo intensive and tolerant to heat and drought.
- **Bulk population method:** Bred DL 2539 and released as CO1 Mochai which is early, high yielder and drought tolerant
- **Pedigree method:**

CO 9 (bush type) * Yanaikathu (pandal type)



- **Heterosis breeding**
- Hand pollination and emasculation
- Use of protruded stigma
- Gametocides use eg. FW 450
- CO5*DL3196: High yield and better pod quality
- 6023 A * 6010 : High ascorbic acid content.

MUTATION BREEDING

- DL 244 (garden bean)* DL 3196 (field bean)

CO 6

Seeds were gamma irradiated

In M2 isolated Mutant 3 which is high yielder than CO9 and released as CO10 Avarai

ACHIEVEMENTS

- ✓ Pusa Early Prolific : IARI
- ✓ Rewa : High protein content (25.00%)
- ✓ CO 1: Selection from cross between var. *typicus* and var. *lignosus.* It is early and high protein and fat content.
- ✓ CO2 (DL 250)
- ✓ CO 3 (DL 269)
- ✓ CO 4 (DL 453)
- ✓ CO 5 (DL 692)

VARIETIES OF INDIAN BEAN

Pole types	**Bush types**
Pusa Early Prolific, Pusa Sem-2, Pusa Sem-3	Arka Jay, Hebbal Avare-3 * IHR99
Arka Sambhram	Arka Vijay, Hebbal Avare-3 * Pusa Early Prolific
Arka Soumya, Avare-3 * Web-1	Konkan Bhusan (DPLD-1): Hebbal
Arka Komal, Arka bold, Arka Amogh	CO-8: CO-5*DL-3169
Kashi Harittima	
Rajni, KDB-403,KDB-405	
Dasarawal , deepaliwal	Mutant variety
JDL-79,JDL-53	CO9- spontaneous mutant MS-98678

CO1-selection from HD18 of Hiser	CO10: X ray induced mutant of CO6
CO2-selection from Chinna avarai	CO11: CO9 x white yanai kathu
CO3-selection from yanaikathu avarai	CO12: CO9 x CO4
CO4-selection from sivappu avarai	
CO5- selection from kozhikkal avarai	

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.

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 4oC. 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 issued 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

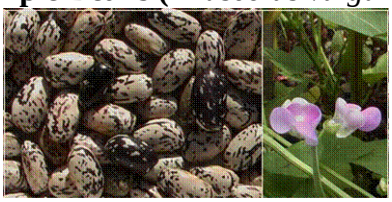
Masterpiece White Long Pod, Masterpiece Green Long Pod, Imperial White Windsor and

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'.

Anasazi Beans(*Phaseolus vulgaris)*

Bolita Beans (Phaseolus vulgaris)

Purple Beans (*Phaseolus vulgaris)*



Hopi Black Pinto Beans (Phaseolus vulgaris)

Questions

1. **Write in detail about the crop imprvement in French bean**
2. **Write in detail about the crop imprvement in Broad bean**
3. **Write in detail about the crop imprvement in Dolichos bean**
4. **Write in detail about the crop imprvement in Lima Bean**
5. **Write in detail about the classification of french bean cultivars**

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1.Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.

2.Kalloo, G. and B.O.Bergh.1993. Genetic improvement of vegetable crops. Elsevier Ltd

3. Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

L-32

Amaranthus

***Amaranthus* sp. (2n = 32, 34, 64) - (Hindi: *Chaulai*)**
Amaranthaceae

Amaranthus is the most common leaf vegetable grown in Kerala and Tamil Nadu. Leaves and succulent stem are good sources of iron (38.5 mg/100g), calcium (350-400 mg/100g), vitamin A and vitamin C. Absorption of calcium from amaranth is however poor. The iron availability is only about 15.2 – 53.6% of total iron. High oxalate content (1-2 %) and nitrate (1.8-8.8 g/ kg dry matter) levels are reported from leaves of various species. Short duration, quick response to manures and fertilizers, high yield, easiness in cultivation and availability of diverse types suited to specific agro-climatic situations make it a favourite crop of farmers to fit in any cropping systems. Both leaf and grain types play a vital role to combat malnutrition of poor people.

Origin and distribution

Centres of diversity for amaranth are Central and South America, India, South East Asia with secondary centres of diversity in West and East Africa. Leaf amaranth is a native of

India.Taxonomists recognize two sections in *Amaranthus, viz., Amaranthus and Blitopsis,* Section A*maranthus,* includes important grain types where the inflorescence is terminal. Section *Blitopsis* includes leaf types and flowers are borne in clusters in leaf axils. Majority of leaf cultivars grown in India belong to *Amaranthus tricolor.* Major species found in India are:

A. *tricolor* (Syn) A. *gangeticus,*

A. mangostanus, A. polygonoides	cultivated - leaf type
A dubius	cultivated -leaf type
A. blitum (Syn: *A. lividus*)	cultivated - leaf type
A. tristis	wild - leaf type
A. viridis	wild - leaf type
A. spinosus	cultivated - grain type
A. cruentus	cultivated - grain type
A. caudatus	cultivated - grain type

A. viridis

A. tristis

A. blitum

A. dubius

A. spinosus

A. cruentus

A. caudatus

Botany

Amaranth is an annual herb with erect growth and scarce to profuse branching habit. Stem is succulent and green or purple or mixed shades of these two. Leaf is simple, alternate, with obviate to lanceolate shape. Leaf colour is green or red or with different shades of above. Flowers are borne terminally and in axils of leaves in clusters. Basic unit of inflorescence is called as glomerule. Flowers are small, unisexual and monoecious. Most of cultivated types are monoecious. Proportion of male and female flowers varies in an inflorescence. Each glomerule consists of a staminate flower and a number of pistillate flowers. The extent of cross pollination is governed by proportion of male and female flowers in an inflorescence and position of inflorescence in plant. Percentage of male flowers in a glomerule is 0.5 in grain types and 10.25 in leaf types. According to Pal and Khoshoo (1978),leaf amaranths are predominantly self pollinated due to presence of a large number of male flowers per glomerule, terminal inflorescence and development of axillary glomerules. Grain types favour cross pollination.

Stigma of pistillate flower is receptive several days prior to opening of staminate flowers in an inflorescence. Wind help in transfer of pollen grains from male flowers of a glomerule / inflorescence / plant to another glomerule / inflorescence / plant. But grain species with colorful inflorescence are occasionally visited by bees (Khoshoo and Pal, 1970).Chromosome number varies with species in amaranth. The diploid species have 2n=32 or 34. A *tricolor* is with 2n=34 white *A. cruentus* and *A. tristis* have 2n=32. The tetraploid species, *A dubius* has 2n=64.

Breeding objectives

Breeding for low anti-nutrient factors – low oxalate and low nitrate lines

Breeding methods

Mass selection – common method

CO 2 – from local – *A. tricolor*

CO 1 – *A. dubius* - Leafy types - green

CO 3 – *A. tricolor* var. *tristis*

CO 4 – *A. hypochondriacus* – Grain type

Bulk population method
Interspecific hybridization

- To generate variability
- To transfer desirable characters to cultivated spp.

Polyploid breeding

- *A. dubius* – natural polyploid – allopolyploidy

  - 2n = 16 + 16

- *A. blitum* – Colchicine induced tetraploids – larger and numerous leaves – longer vegetative cycle
- *A. dubius* - Seeds and seedlings – treated with colchicine

  - Polyploidy – reduction of plant height, leaf size and inflorescence length.

  - Pollen and seed sterility

Hybridization and selection

Monoecious

A. spinosus – upper part of panicle – male flowers - topping for emasculation. Lower part with female flowers are bagged

A. tricolor, A. lividus, A. dubius – Emasculation tedius

- Intermixed nature of male & female flowers within same glomerule
- Emasculation incomplete – due to subsequent opening of male flowers

Anthesis – 8.30 – 9.30 am

- Pollination is repeated for 3 consecutive days – all female flowers are not receptive on the same day

Crossing – enclosing a part of ripe inflorescence of male parent in the bag with emasculated inflorescence

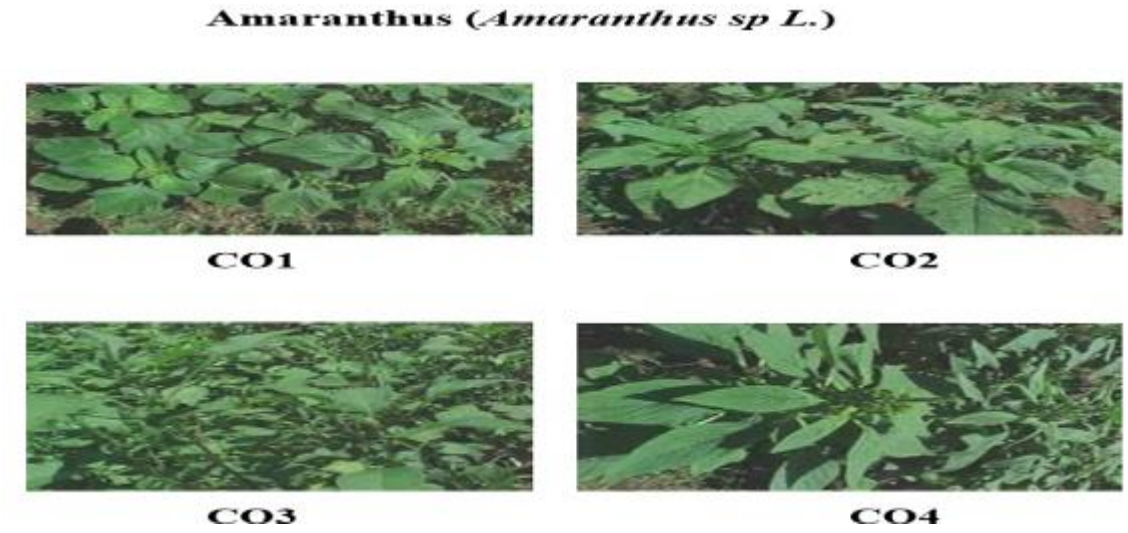
Varieties

Cultivated leaf amaranth varieties and cultivars differ in size, shape and colour of leaves and stem, position of inflorescence etc. and belong to different species. A brief description of improved varieties developed by different Research Institutes is given below:

1) Tamil Nadu Agricultural University, Coimbatore-3

CO. 1 (*A. dubius*)	This tetraploid variety was developed by selection from ("local germplasm. Stem and leaves are dark green; leaf-stem ratio is 2.0; inflorescence terminal and axillary; lacks initial vigour but makes rapid growth after 30 days; suitable for late harvest; resistant to *Rhizoctonia* leaf blight; green yield 8.0 t/ha; seed yield 1.5 t/ha.
CO.2 (*A. tricolor*)	Stem and leaves green, leaves lanceolate and slightly elongate, leaf-stem ratio 1.8; suited for early harvest; yield 10.78 t/ha.
CO.3 (*A. tristis*)	This is specifically suited for clipping of tender greens and is locally known as ‘Araikeera' in Tamil. Leaves are small and green; stem is slender and tender. First clipping is possible in 20 days after sowing. Nearly 10 clippings can be taken over a period of 90 days. Due to very high leaf-stem ratio, cooking quality and taste are excellent. Special care is required in land preparation for the variety.
CO. 4 *(A.hypochondriacus)*	This grain type makes rapid vegetative growth within a period of 20-25 days. Plants are dwarf; grain yield 2.0-2.5 t/ha in 80-90

	days.
CO.5 (*A. tricolor*)	Leaves double coloured with Green and pink and is free from fibre. It gives a rosette growth in early stages and first harvest is possible in 25 days; yield 40 t/ha in 55 days.



Sirukeerai (*A. polygonoides*) is a traditional cultivar in Tamil Nadu, suited for uprooting at 25 days after sowing; leaves are small, ovate with blunt bifurcated tip and have long petiole; collar region is dark pink and at leaf axil a miniature branch initiates.

2) IARI, New Delhi

Pusa Chotti Chaulai (*A. blitum***):** Plants dwarf with succulent, small and green leaves; responds well to cutting.

Pusa Badi Chaulai (*A. tricolor***):** Plants tall and stem thick with large green leaves; responds to cutting.

Pusa Kirti (*A. blitum***):** Green leaved variety with green and thick stem; leaf lamina broad ovate; ready for harvest in 30-35 days and extends up to 70-85 days; yield 55 t/ha; specifically suited for summer.

Pusa Kiran (*A. tricolor*): This is developed by natural crossing between *A. tricolor* and *A. tristis* and has more characteristics of *A. tricolor*. Leaves are glossy green with broad ovate lamina; leaf-stem ratio is 1.0:4.6; yield 35 t/ha in 70-75 days; suited for *kharif* season.

Pusa Lal Chaulai (*A. tricolor*): Upper surface of leaves are deep red and lower surface purplish red; yield 45-49 t/ha in 4 harvests.

3) IIHR, Bangalore

Arka Suguana (*A. tricolor*): A multicut variety with broad green leaves. First picking starts in 24 days after sowing and continue up to 90 days. Moderately resistant to white rust. Yield 17-18 t/ha.

Arka Arunima (*A. tricolor*):A multicult variety with broad dark purple leaves. First picking starts in 30 days after sowing and two subsequent cuttings at 10-12 days interval. Yield 27 t/ha.

CO5

Arka Suguna

Thandukeerai (VPM LOCAL)

Araikeerai

Questions

1. **Which is the centre of origin of Amaranthus ?**
2. **Write down the breeding objectives for amaranthus**
3. **Write down the breeding methods for amaranthus**
4. **Write down the relative species of amaranthus**
5. **Write in detail about the breeding achievements in amaranthus**

References

- Kalloo, G. and B.O.Bergh.1993. Genetic improvement of vegetable crops. Elsevier Ltd

  Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.
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Issue of patenting, PPVFR Act L-33

Patents represent a contract between an inventor and society. By granting time-limited market exclusivity, patents create the potential for inventors to generate high returns on successful innovations. In exchange, the inventor provides a complete description of the invention so that others may build on the technology to create improvements or other breakthrough discoveries. Patent protection of intellectual property is particularly important to inventors in the biotechnology field because of the relatively high fixed cost of research and the ease with which discoveries may be copied. By attracting investment capital for research, patent protection increases the pace of innovation, thus benefiting society.

The Patent Act, 1970 specifies what are not considered inventions under Section 3. Section 3(b) of the Act earlier recited: *'What are not inventions – an invention the primary or intended use of which would be contrary to law or morality or injurious to public health;*'

This definition was brief and the words tapered the scope of the section. An amendment was brought in 2002, to accommodate the TRIPS regulations. The amendment resulted in a new and more descriptive definition of the section. The section now reads –

> *'3(b) an invention the primary or intended use or commercial exploitation of which could be contrary to public order or morality or which causes serious prejudice to human, animal or plant life or health or to the environment;'* [Is not invention]

The Amendments:

TRIPS mainly aimed at excluding subject matter relating to medical methods, or those contrary to public order and morality, and subject matter covering plants and animals, and essentially biological processes from being patentable subject matter.

The amendments were hence made in 2002 to bring under the Act, the regulations of TRIPS and to extend the scope of the Act to protect plants, animals and human beings alike. Along with Section 3(b), Sections 3(h), 3(i), 3(j) and Section 3(p) were amended with a similar point of view.

According to Section 3(h), methods of agriculture or horticulture are not patented. Further, Section 3(i) prohibits patenting process used in medicine and treatments of human beings and animals, both either as part of treatment and for increasing their economic value or the economic value of their products.

Section 3(j) includes further provisions to prevent patenting of plants and animals as a whole or in part thereof. The Section further prevents patenting of '*biological processes for production or propagation of plants and animals'*. However, micro-organisms are patentable subject matter.

Section 3(p) prohibits patenting of traditional knowledge.

Coming to the point where these sections are considered eco-friendly, it is important to note that all the above mentioned sections have a direct impact on the protection of bio diversity.

The debate on Technology V. Bio diversity will always appear in the front row, and as always, a check on the use of technology is the only supportive argument.

The Seed Act 1966, the Bio-diversity Act, 2002, The Protection of Plant Variety and Farmer's Rights Act, 2001 are all laws brought forward to support the cause. For example, the Section 6 of the Biodiversity Act says- '*Application for intellectual property rights not to be made without approval of the National Biodiversity Authority*'.

The Laws:

Laws that are in contrary to public order and morality have always faced criticism. Article 19 of the Indian Constitution holds any Act violating or hindering the operation of law an offence. In other words the main aim of any law is to bring order and to protect the moral and social values in the society.

The patent laws emphasize the need for novelty, non-obviousness, utility and the presence of a human intervention, when it comes to biological matter.

Plants and Patents:

Though "Bio-Diversity" is an 'all-inclusive' word, it is more often used as a synonym for "Plants and Animals"

Inventions that drastically affect both Plants and Animals are not patentable under the Section 3(b).

This however is not accepted without arguments that for more than one reason, people would want better technology. The need is as simple as the explanation for livelihood. Man depends on plants and animals in numerous ways and inventions that help better are always welcome. Be it the chemical preparation of weedicides and insecticides or the enormous saws that bring down gigantic trees, man wants it all. For example, US7520118 and EP1583434 are patents that are granted to machines that cut down plants. Genetically modified crops are also a big hit in the market.

In R.W.Emerson's words, *a weed is a plant whose virtues have not yet been discovered.* However, the general perceptions of weeds outweigh the good points about them. Where on one side one may argue about soil stability, a farmer would argue about the reduced crop quality.

Monsanto, an agricultural company tried to claim protection to its "Method for producing a transgeneric plant (with increased stress tolerance)" the application was rejected protection by India's Patent Office, and the same was upheld by the Intellectual Property Appellate Board on the grounds that the invention lacked inventive step.

The **Protection of Plant Variety and Farmers Right Act, 2001** (**PPVFR Act**) is an Act of the Parliament of India that was enacted to provide for the establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders, and to encourage the development and cultivation of new varieties of plants. This act received the assent of the President of India on the 30 October 2001.

The PPV&FR Act, 2001 was enacted to grant intellectual property rights to plant breeders, researchers and farmers who have developed any new or extant plant varieties. The Intellectual Property Right granted under PPV&FR Act, 2001 is a dual right – one is for the variety and the other is for the denomination assigned to it by the breeder. The rights granted under this Act are heritable and assignable and only registration of a plant variety confers the right. Essentially Derived Varieties (EDV) can also be registered under this Act and it may be new or extant. Farmers are entitled to save, use, sow, re-sow, exchange or sell their farm produce including seed of a registered variety in an unbranded manner. Farmers' varieties are eligible for registration and farmers are totally exempted from payment of any fee in any proceedings under this Act. The period of protection for field crops is 15 years and for trees and vines is 18 years and for notified varieties it is 15 years from the date of notification under section 5 of Seeds Act, 1966. Annual fee has to be paid every year for maintaining the

registration and renewal fee has to be paid for the extended period of registration. Farmers can claim for compensation if the registered variety fails to provide expected performance under given conditions. The rights granted under this Act are exclusive right to produce, sell, market, distribute, import and export the variety. Civil and criminal remedies are provided for enforcement of breeders' rights and provisions relating to benefit sharing and compulsory licence in case registered variety is not made available to the public at reasonable price are provided. Compensation is also provided for village or rural communities if any registered variety has been developed using any variety in whose evolution such village or local community has contributed significantly. The procedural details and modes of implementing this Act are provided in PPV&FR Rules, 2003. In the present article, we are discussing some of the important legal provisions of this Act along with some of the case studies.

The Protection of Plant Varieties and Farmers' Rights Authority also confers **Plant Genome Savior "Farmer Reward" and "Farmer Recognition"** to the farmers engaged in the conservation of genetic resources of landraces and wild relatives of economic plants and their improvement through selection and preservation and the material so selected and preserved has been used as donors of gene in varieties registerable under the PPV&FR Act, 2001 (53 of 2001) Upto 10 rewards and 20 recognitions (consisting of a citation, memento and cash prize) are conferred in a year.

Questions

1. **What is patending?**
2. **What is the issue of patending?**
3. **What is PPVFR act?**
4. **Explain Plant Genome Savior "Farmer Reward" and "Farmer Recognition".**
5. **Expand EDV**

References

1. Elizabeth, V. 2007. Law of plant Varieties protection, Eastern Book Company.
2. National Research Council. 1993. *Global Dimensions of Intellectual Property Rights in Science and Technology*. Washington, DC: The National Academies Press. https://doi.org/10.17226/2054

Marker Assisted Breeding and QTL L-34

A molecular marker is a DNA sequence that is readily detected and whose inheritance can easily be monitored. The use of molecular markers is based on naturally occurring DNA polymorphism, which forms the basis for designing strategies to exploit for applied purposes.

Marker Assisted Breeding is a method of selecting desirable individuals in a breeding scheme based on DNA molecular marker patterns instead of, or in addition to, their trait values. A tool that can help plant breeders select more efficiently for desirable traits.

Recently, the DNA markers have become the marker of choice for the study of crop genetic diversity has changed the plant biotechnology. Techniques are being developed to more precisely, quickly and cheaply assess genetic variation. With the use of molecular markers technique, it is now possible to hasten the transfer of desirable genes among varieties and to introgress novel genes from related wild species. Polygenic characters which were previously very difficult to analyse using traditional plant breeding methods, would now be easily tagged using molecular markers. It would also be possible to establish genetic relationships between sexually incompatible crop plants.

Techniques in assisting selction of desirable charcters involves the use of molecular markers such as Random Amplified Polymorphic DNAs (RAPDs), Restriction Fragment Length Polymorphisms(RFLPs), microsatellites and PCR-based DNA markers sch as Sequence Characterized Amplified Regions(SCARs), Sequence Tagged Sites(STs) and Inter- Simple Sequence Repeat amplification(

ISSR), Amplified Fragment Length Polymorphic DNA's (AFLPs) and Amplicon Length Polymorphisms(ALPs) using F2 and back-cross populations, near –isogenic lines, doubled haploids and recombinant inbred lined.

Identification of molecular markers linked to disease resistance genes facilitates marker-assisted selection(MAS) for achieving gene combinations in breeding programs. Various molecular marker systems such as RFLP, RAPD, ISSR, AFLP and microsatellites(SSRs) have been widely used to tag resistance genes in all the crops.

Identification of markers linked to disease resistance in Tomato

CROP	PATHOGEN	GENE IDENTIFIED	TYPE OF MARKER
Tomato	*Meloidogyne incognita*	Mi	RAP
	Cladosporium fulvum	Cf9	D
	Leveillula taurica	Lv	AFL
	Phytophthora infestans	Ph	P
	Verticillium dahliae	2	RFLP,
	Yellow leaf curl virus	Ve	RAPD RFLP
		Ty1	RAP
			D
			RFL
			P

- Genetic transformation in tomato by the vector *Agrobacterium tumefaciens*, electroporation and direct gene transfer.
- Possible to produce somatic hybrids between *S. lycopersicum* and *L. peruvianum* by protoplast fusion in tissue culture.
- Molecular genetic markers like RFLP, RAPD are used.
- Genetic engineering utilization for development of transgenic tomato for disease and insect pest resistance and slow or delayed fruit ripening tomato.
- Bt genes transgenic tomato – first developed and tested by Monsanto in 1989.
- Transgenics with insecticidal properties, like delta-endotoxin of *Bacillus thuringiensis* (Bt) protienase inhibitors
- In India, gene cry AC was introduced into tomato to produce transgenic resistant to *Helicoverpa armigera.*
- In India, Parker, Bonus, VFN-8 possesses resistance against

H. armigera

- Genotype 122775 was found resistant against *H. armigera*
- Bt genes (Gui ai, G42Aa (cry AB)) are being utilized to develop transgenics with resistance to fruit borer.
- Coat protein(cp) from the viral genome TMV(Tobacco mosaic virus) and CMV(cucumber mosaic virus).
- Genetic mapping and QTL (quantitative trait loci) analysis by RFLP technology.
- (fw 2.2) - One of the major genes in tomato domestication.
- Recently genetically engineered male sterility system have been developed in tomato Cytoplasm(*L. peruvianum)* and *L. pennelii*

Genetic engineering in Capsicum

The coat protein (CP) gene of cucumber mosaic virus (CMV) was cloned from a Chinese CMV isolate, the CMV promoter and NOS terminator added and the gene construct was transformed into both sweet pepper and tomato plants to confer resistance to CMV. Safety assessments of these genetically modified (GM) plants were conducted. It was found that these two GM products showed no genotoxicity.

Molecular markers for colour improvement in onion

- Bulb colour is one of the important traits in onion (*A. cepa L).* Three major colours of white, yellow, red and a variety of other bulb colours such as chartreuse and gold exist in onion germplasm.
- The bulb colour is due to flavonoid compounds and 54 kinds of flavonoids have been reported in onion.
- Critical mutations in the chalconeisomerase (CHI) gene causing gold onions were identified.
- The inactivation of dihydroflavonol 4-reductase (DFR) in the anthocyanin synthesis pathway was responsible for colour differences between yellow and red onions, and two recessive alleles of the anthocyanidin synthase (ANS) gene were responsible for a pink bulb colour .
- Based on mutations in recessive alleles of these two genes PCR based markers were developed for identification of polymorphisms between pink and red alleles of the ANS gene. Most pink onions were homozygous recessive for the ANS gene indicating the homozygous recessive. The two pink onions, heterozygous for the ANS gene, were also heterozygous for the dihydroflavonol 4-reductase (DFR) gene indicating that the pink colour was produced by incomplete dominance of a red colour gene over that of yellow colour.

- Functional CAPS markers were developed for two inactive DFR-A alleles, DFR-APS and DFR-ADEL, for detection of inactive DFR-A alleles responsible for a failure of anthocyanin production in onions. Of these two alleles, DFR-APS predominantly occurs in yellow onion cultivars.

Questions

1. **What is QTL?**
2. **What is MAB and MAS?**
3. **Write in detail about identification of markers linked to disease resistance in Tomato.**
4. **Write in detail about molecular markers for colour improvement in onion.**
5. **Write in detail about molecular markers?**

References

1. Boopathi and N Manikanda.2013. Genetic Mapping and Marker Assisted Selection:Basics, Practice and Benefits Springer Nature Switzerland AG. Springer is part of Springer Nature.
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