SSJP'S COLLEGE OF AGRICULTURE
KHANDALA
TQ – VAIJAPUR DIST - AURANGABAD

COURSE NO. – **GPB 366**

COURSE TITLE –

Crop Improvement- II *(Rabi crops)*

CREDIT – **2 (1+1)**

NAME -……

REG. NO. -……

BY
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Course No. GPB 366	**Credit** - 2(1+1)
Course Title - Crop Improvement- II *(Rabi crops)*	

Lecture no.	Topic	Weightage (%)
1	Cereals –Wheat, oat and barley - Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	10
2	Pulses –Chickpea- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
3	Oilseeds –Sunflower and Safflower- Centers of origin, Distribution of species, Wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	10
4	Oilseeds –Linseed, Rapeseed and Mustard- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
5	Fodders –Napier, Bajra, Sorghum, Maize and Berseem- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
6	Cash -Sugarcane - Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	6
7	Vegetable-Potato- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic	5

	stress tolerance and quality (physical, chemical, nutritional)	
8	Vegetable-Field pea- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
9	Horticultural crops-Mango, Aonla and Guava- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
10 - 11	Plant genetic resources, its utilization and conservation	8
12	Adaptability and stability	5
13 - 14	Hybrid seed production technology in Rabi crops -Sunflower, Safflower, Castor, Rabi Sorghum	12
15 - 16	Ideotype concept and climate resilient crop varieties for future- Wheat, Rice, Maize, Sorghum and Cotton	10
	Total	**100**

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LECTURE NO. 1
CEREALS
1. WHEAT

B. NAME- *Triticum aestivum*
FAMILY - Poaceae
CHROMOSOME NO. – 2n=42
ORIGIN - South Asia
DISTRIBUTION OF SPECIES -
Wheat is widely cultivated cereal, spread from 57ºN to 47ºS latitude. Hence, **wheat** is cultivated and harvested throughout the year in one country or other. China, India, Russian federation, USA, France, Canada, Germany, Pakistan, Australia and Turkey are most important **wheat** growing countries
Wild Relatives *T. aethiopicum T. araraticum T. compactum*
FLORAL BIOLOGY
1. Inflorescence of wheat is called Ear or Head. In botanical it is called as spike.
2. The unit is called spikelet.
3. Each floret consist of lemma, palea, androecium and gynoecium.
4. Flowers are bisexual and zygomorphic.
5. Each floret has three stamens with large anthers and a pistil bearing bifid feathery stigma.
6. Wheat stamens are small and produce about 1000-4000 pollen grains per anther.

MAJOR BREEDING OBJECTIVES
1. Breeding for high grain yield.
2. Breeding for good quality with high spikletes.
3. Disease and insect resistance and tolerance to abiotic stresses.
4. Mineral, moisture and heat tolerance.

BREEDING PROCEDURES:
1. Introduction :
Semi dwarf wheat from Mexico, Sonara 63, Sonara 64, Mayo 64, Lerma Roja 64
2. Pure line selection :
Earlier varieties like P_4, P_6, P_{12} evolved at Pusa institute are result of pure line selection from local population.
3. Hybridisation and selection
a) Inter varietal:
A number of successful derivatives were developed at IARI New Delhi and Punjab. NP 809 - New pusa multiple cross derivative.
However all these varieties were lodging and poor yielder when compared to other countries. Hence the wheat hybridization programme was changed by
b) Inter specific crosses
To get Hessian fly resistance. So also for rust resistance.
c) Back cross method of breeding
Rust resistance in Chinese spring from Thatcher.
4. Hybrid wheat :
At Kansas Agri. Expt. Station USA male sterile lines were identified by crossing

T.timophevi x *T. aestivum* Bison variety By repeated back crossing a male sterile line resembling
Bison was evolved. At present USA and Canada are doing work on this.

5. Mutation breeding

Dr. M. S. Swamina than did extensive work on this with gamma rays.
Sharbati Sonara with increased protein content was evolved.

6. Development of multilines

Borlaug developed multilines against rust. MLKS 15 was developed at IARI.
Multiline is a mixture of pure lines which are phenotypically similar but genotypically dissimilar.
Each line is produced by separate back cross method of breeding. Each line having resistance against a particular race of a disease.

BREEDING CENTERS:

- International Maize and Wheat improvement Centre (CIMMYT) Mexico.
- Directorate of Wheat Research (DWR), Karnal.
- All India Coordinated Wheat Improvement Project (AICWIP) – Karnal (earlier New. Delhi)

PRACTICAL ACHIEVEMENT:

The semi dwarf varieties of wheat have been developed through the use of Japanese line Norin 10 as a source of dwarfing gene which led to "green revolution" in wheat production. The
productivity of Semi dwarf varieties is about two and half times more than old tall growing varieties. More over these varieties are highly resistant to lodging and are highly responsive to
fertilizer doses.

2. OAT

B. NAME - *Avena sativa*
FAMILY - Poaceae
CHROMOSOME NO. – 2n=42
CENTERS OF ORIGIN - South Asia
DISTRIBUTION OF SPECIES -
Wheat is widely cultivated cereal, spread from 57ºN to 47ºS latitude. Hence, **wheat** is cultivated and harvested throughout the year in one country or other. China, India, Russian federation, USA, France, Canada, Germany, Pakistan, Australia and Turkey are most important **wheat** growing countries
WILD RELATIVES - *T. aethiopicum T. araraticum T. compactum*
FLORAL BIOLOGY

7. Inflorescence of wheat is called Ear or Head. In botanical it is called as spike.
8. The unit is called spikelet.
9. Each floret consist of lemma, palea, androecium and gynoecium.
10. Flowers are bisexual and zygomorphic.
11. Each floret has three stamens with large anthers and a pistil bearing bifid feathery stigma.
12. Wheat stamens are small and produce about 1000-4000 pollen grains per anther.

MAJOR BREEDING OBJECTIVES

5. Breeding for high grain yield.
6. Breeding for good quality with high spikletes.
7. Disease and insect resistance and tolerance to abiotic stresses.
8. Mineral, moisture and heat tolerance.

3. BARLEY

B. NAME - *Hordeum vulgare*
FAMILY - Graminacae / Poaceae
CHROMOSOME NO. - 2n = 14
Fertility of the lateral spikelets forms the basis of barley classification and the cultivated barley may be classified into three main groups viz.,
i) Six rowed barley (*H. vulgare* L. emend, Lam)
ii) Two rowed barley (*H. distichum*, L. emend, Lam)
iii) Irregular barley (*H. irregular*, E. Aberg and Wiebe)

CLASSIFICATION
In traditional classifications of barley, these morphological differences have led to different forms of barley being classified as different species. Under these classifications, two-row barley with shattering spikes (wild barley) is classified as *Hordeum spontaneum* K. Koch. Two-row barley with nonshattering spikes is classified as *H. distichum* L., six-row barley with nonshattering spikes as *H. vulgare* L. (or *H. hexastichum* L.), and six-row with shattering spikes as *H. agriocrithon* Åberg.
Because these differences were driven by single-gene mutations, coupled with cytological and molecular evidence, most recent classifications treat these forms as a single species, *H. vulgare* L.

WILD RELATIVES
Wild *Hordeum* species are distributed through Europe, Asia, Africa and the Americas. Secondary centers of diversity of cultivated barley are found in Ethiopia and Morocco and parts of Asia. *H. spontaneum*

FLORAL BIOLOGY
1. Inflorescence of barley is called Ear or Head. In botanical it is called as spike.
2. The unit is called spikelet.
3. Each floret consist of lemma, palea, androecium and gynoecium.
4. Flowers are bisexual and zygomorphic.
5. Each floret has three stamens with large anthers and a pistil bearing bifid feathery stigma.
6. Barley stamens are small and produce about 1000-4000 pollen grains per anther.

BREEDING OBJECTIVES
i) Yield improvement.
ii) Increased adaptability.
iii) Resistance to yellow rust, aphid and nematode.
iv) Improvement in nutritional quality.
v) Improvement in attributes related to malt industry.

ACHIEVEMENTS OF BARLEY :

Sr.	Name	Parentage	Release	Specific area of

No.			year	adaptation
1.	K603	K257/C135	2000	NEPZ
2.	BH393	California/ mariout	2001	Haryana
3.	NBBNOB(020)	Ratna K-425/Jyoti	2001	UP
4.	RD3592	RD2503/UBL9	2003	Rajastan
5.	K713	RD2540/BH407	2004	NEPZ

IMPROVED VARIETIES / HYBRIDS :

Sr. No.	Varieties	Features
1	Ratna, Jyoti, Kailas	Hulled varieties
2	Karan-750, Amber, Himadri	Huskless varieties
3	C-138, RS-6, RD-57, RD-137, Clipper	Malting varieties
4	Karan 16, Karan 18, 19, Jyoti karan-3,4 Amber, Azad	Salt tolerant varieties
5	Kailash, Himani, Dolma, NP-100, NP-13, 21, 103	Suitable for hilly areas
6	Rajkiran	Nematode resistant variety
7	Nilam and Karan 19	Better chappati making quality for barley varieties

LECTURE NO. 2
PULSES
1. CHICKPEA

B. NAME - *Cicer arietnum*
FAMILY – Leguminoceae
CHROMOSOME NO. – 2n=16
ORIGIN -
The chickpea is most probably originated in an area of present day south-eastern Turkey and adjoining Syria.

RELATED SPECIES - *C. reticulatum, C. pinnatifidum, C. songaricum*
Two main categories of Chickpea are recognized which are distinguished mainly by their seed characteristics. They are
1) Desi types, which are relatively smaller, angular seeds with rough yellow to brown coloured testas.
2) Kabuli types, with large, more rounded and cream coloured seeds.

WILD SPECIES
The wild species of *Cicer* closely related to chickpea are :
i) *C. bijugum*
ii) *C. echinospermum*
iii) *C. ecticulatum*

FLORAL BIOLOGY
1. The flowers are papilionaceous.
2. They are solitary in axillary racemes.
3. Double flowers are rare, but are very much sought after by the breeders as possible sources of yield increase.
4. The calyx has five deep lancelolate teeth. Peduncle and calyx are hairy.
5. Generally, corolla is white.
6. The vexillum is obovate, 8-11 mm long and 7-10 mm wide.
7. Wings are obovate, 8-9 mm long. The keel is 6-8 mm long.
8. Number of pods/plant is highly variable, generally between 30 and 150 depending on the year, location, sowing time and other factors.

BREEDING OBJECTIVES
(i) Increased seed yield.
(ii) Increased biomass, tall, erect and compact cultivars
(iii) Resistance to diseases
(a) Ascochyta blight.
(b) Fusarium wilt.
(c) Root rot.
(d) Botrytis grey mould
(iv) Resistance to insect pests:
(a) Pod borer.
(v) Tolerance to stress environments:
(a) Cold

(b) Heat
(c) Drought
(d) Saline and alkaline soils.
(vi) Mechanical Harvesting

BREEDING PROCEDURES

1. **Pedigree method:** for resistance breeding (disease, insect, nematode, orobanche spp)
2. **Modified bulk method:** for stress situations (drought, cold, heat, iron deficiency)
3. **Back cross method:** for interspecific hybridization. Limited backcross (one or two) for desi x kabuli introgression and also for resistance breeding. Resistance to fusarion wild can be easily transferred from desi to kabuli type
4. **Somaclonal variation:** through plant tissue culture appears to be a potential tool for generation and exploitation of useful variability.

IMPROVED VARIETIES / HYBRIDS :

Sr. No.	Varieties	Features
1	BDN-9-3	Early, wilt resistant, drought tolerant
2	BDNG-797	Early, wilt resistant and high yielding
3	Phule Vikrant	Yellowish brown, medium size seeds, wilt resistant
4	Phule Vikram	Tall growth habit, suitable for mechanical harvesting, medium size, yellowish brown seeds.
5	Himali	Extra bold seeded kabuli variety, wilt resistant
6	Kripa	Extra large seeded kabuli variety, milky white seed colour
7	Digvijay	High yield potential, bold seeds, wilt resistant
8	Rajas	Yellowish brown bold seeds, wilt resistant
9	Vihar	Extra bold seeded kabuli variety, wilt resistant
10	Virat	Extra bold seeded kabuli variety, wilt resistant
11	Vishal	Attractive yellowish brown bold seeds, wilt resistant
12	Vijay	High yield potential, wilt resistant, drought tolerant
13	BDNG-798	Kabuli, medium bold
14	Jaki-9218	Deshi, high yielding, wilt tolerant
15	ICCV 2	Early, kabuli type
16	Hirwa Chaffa (AKGS-1)	Green seeded, for rainfed and irrigated areas
17	PKV Harita	Wilt and drought tolerant, recommended for rainfed cultivation, green seeded.
18	PKV Kanchan	Wilt tolerant, recommended for irrigated condition for Vidharbha region
19	Gulak 1	Bold seeded, wilt tolerant, pink seeded, suitable for roasted purpose
20	PKV Kabuli- 4	Extra large seeded, kabuli, wilt tolerant, suitable for export purpose.

LECTURE NO. 3
OILSEED CROPS
1. SUNFLOWER

B. NAME – *Helianthus annus*
FAMILY – Composite
CHROMOSOME NO. – 2n=34
ORIGIN – America
DISTRUBUTUION –
USSR, Romania, Canada, UAS, in India this crop is introdeced in 1969 From USSR.
In India it is cultivated in Tamil Nadu, Karnataka, Maharastra and Andhra pradesh, Punjab and Hariyana.
WILD SPECIES -
Helianthus hirsutus, Helianthus rigidus
The genus Helianthus comprises of 67 species. Two species H. annus and H. tuberosus are cultivated as food plants genus has basic chromosome number of 17 and diploid, tetraploid and hexaploid species are found.

FLORAL BIOLOGY
- ✓ The inflorescence is a capitulum or head, characteristic of composite family.
- ✓ The number of flowers in oilseed cultivars may vary from 700 to 3000.
- ✓ The flower of the outer whorl of the head are called as ray florets.
- ✓ They have five elongated petals which are united to form straplike structures.
- ✓ They have vestigeal styles and stigmas and no anthers.
- ✓ The other flowers arranged in concentric rings over the remainder of the head are called as disc flowers.
- ✓ Five anthers are united to form a tube with separate filament attached to the base of the corolla tube.
- ✓ Inside the anther tube, there is the style, terminating in a stigma which is divided.
- ✓ The receptive surfaces of stigma remain in close contact in bud stage.
- ✓ The achene or the fruit of the sunflower consists of a seed often called the kernel.
- ✓ The adhering pericarp is usually called the hull.
- ✓ The seed consists of seed coat, endosperm and embryo.
- ✓ Major part of embryo is in the form of cotyledons.

BREEDING OBJECTIVES
i) High seed yield
ii) Early maturity
iii) Lodging resistant dwarf plant type
iv) Uniformity of plant type
v) High oil percentage
vi) Tolerance to stress conditions
vii) Resistance to bird damage
viii) Resistance to diseases

BREEDING METHODS
1. **Introduction** : Morden from Canada.

2. **Mass selection**:
Ec 68414 from Russia. Co1 mass selection from Morden. Useful for characters which are highly heritable. E.g. Plant height, disease resistance.
3. **Hybridization and selection**
a) **Intervarietal**
b) **Interspecific** :
Wild species of North American origin and best Soviet varieties were crossed and number of varieties were evolved.
They are resistant to *Verticillium* wilt also
4. **Mutation**
Co_3 (Mutant from Co_2 thro' gamma rays)
5. **Head to row and remnant seed method**
Developed by **Pustovoit** in Russia. By this method oil content is increased. In this method the following are the steps:
a) From open pollinated type a large no (10,000 to 12,000) plants are selected based on Head size.
b) The selected lines are analysed for oil content and high oil content lines are isolated (1000 plants).
c) Part of the seed reserved and the part is sown in progeny rows along with check to estimate yield.
d) Second season testing is also done. The best lines are identified.
a. The remnant seed of elite plants which give high yield were raised in isolation and multiplied for crossing *interse* next season.
b. The multiplied lines also tested for oil content and high yielding high oil content lines were raised in isolation and crossed *interse*.
6. **Population improvement**
By mass selection, recurrent selection and use of male sterile lines population can be improved and utilised for breeding.
7. **Heterosis breeding** :
Development of inbred lines and crossing them to harness heterosis was first done as early as 1920 in Russia. During 1970 cytoplasmic geneic male sterility was identified in wild types and obsolete cultivars. Now this system is being extensively used for production of hybrids.
First hybrid
BSH 1, APSH – 11
A number of CGMS lines were bred by Government as well as private seed growers and are utilised now.
Male sterility can also be inducted by GA 100 ppm.
Steps
1. Development of inbreds.
2. Evaluation of inbreds for combining ability.
3. Conversion of inbreds into CGMS lines and R lines.
4. Production of hybrids.

BREEDING CENTRE
Directorate of oil seed Research (DOR) **Hyderabad.**

All India coordinated sunflower improvement project (**Bangalore**)

PRACTICAL ACHIEVEMENTS

Varieties EC 68414, EC 68415, Mordern, Co-1, surya

Hybrids BSH-1, KBSH-1, LSH-1, APSH-1 LDMRSH-1, 3

IMPROVED VARIETIES / HYBRIDS :

Sr. No.	Varieties	Features
1	LSH-1	Downy mildew resistant, rainfed
2	LSH-2	Downy mildew resistant, rainfed
3.	LS-11	High yielding having high oil content
4.	SS-56	Suitable for rainfed conditions, oil content 32-35 %
5.	Bhanu	Tolerant to drought, oil content 35-36 %
6	Phule Raviraj (Hybrid)	Oil content 34 %, big head size with central filling head, tolerant to bud necrosis and alternaria
7	Bhaskar	Early maturing, high yield, oil content 37-38 %, dark black shiny seeds.
8	PKVSH952	92-95 days duration, Black seeded, 38-40 % oil (seeds), with 15-18 q/ha yield potential.

2. SAFFLOWER

B. NAME - *Carthamum tinctorius*

FAMILY – Compositae

CHROMOSOME NO. – 2n=24

ORIGIN -

Safflower has been grown for many centuries from **Egypt in north Africa eastward to India.** Safflower is believed to have two centers of origin, **Ethiopia & Afghanistan**.

DISTRIBUTION

Afghanistan, India, Pakistan, USA, Egypt middle east in India, Maharashtra, Andhra Pradesh, Karnataka together accounts for more than 90 per cent of country's area

RELATED SPECIES

- ✓ The wild species *Carthamus oxycanthus* is found in many parts of Punjab.
- ✓ It is a dwarf bushy plant, very spiny, forming small achenes.
- ✓ The oil content is 15 to 16 percent.

CULTIVATED SPECIES - *Carthamum tinctorius* L (2n = 2X = 24)

WILD SPECIES

C. palaestinus, C. oxycantha, C. lanatus, C. flavenscens

FLORAL BIOLOGY

- ✓ It is often cross-pollinated crop.
- ✓ Marginal florets open first followed by florets in central (centripetal order).
- ✓ It is completed within 1 to 5 days.
- ✓ The opening of florets takes place in the morning hours between 9 to 10 a.m.
- ✓ The style elongates and stigma emerges from corolla tube.
- ✓ At the same time, corolla opens and anthesis takes place.
- ✓ However, hairy portion of style is still within tube.

BREEDING OBJECTIVES

1) High seed yield of oil contents
2) Wide adaptability
3) Development of early and non-spiny varieties
4) Tolerance / Resistance to Diseases & Pest
5) Tolerance to abiotic stresses:
6) Development of appraisal type genotypes (to accommodate more plant population)
7) Development of stable GMS lines
8) Improvement in oil quality

(Breeding Methods same as a Sunflower)

ACHIEVEMENTS

1) Pure line selection: N7, N 62-8, Bhima (81), Manjira
2) Pedigree selection after hybridization: Tarea Annegiri 1, Girna
3) Development of Commercial hybrids by using GMS: DSH 129

IMPROVED VARIETIES / HYBRIDS :

Sr. No.	Variety	Features
1	Bhima	Moderately tolerant to aphid and fusarium wilt, oil content 29-30 %, tolerant to moisture stress.
2	Girna	Moderately tolerant to aphid and Fusarium wilt, oil content 28-30 %.
3	Phule Kusuma	Moderately tolerant to aphid, oil content 30 %
4	Phule Chandrabhaga	Moderately tolerant to aphid, oil content 29 %
5	SSF-658 (Non spiny)	Moderately tolerant to aphid and Fusarium wilt, oil content 28 %
6	Sharda (PBN-12)	High yielding, tolerant to drought Fusarium wilt and aphids.

LECTURE NO. 4
OILSEED CROPS
1. LINSEED (Flax)

B. NAME- *Linum Usitatissimum*
FAMILY - Linaceae
CHROMOSOME NO. – 2n=30
ORIGIN – South Western Asia
DISTRIBUTION –

- ✓ *Linum usitatissimum* is now grown widely in many parts of the world, including the tropics.
- ✓ Fibre flax is cultivated in cool and humid temperate climates, whereas linseed is grown in warmer climates.
- ✓ Socio-economics also affect the distribution; Eastern Europe and the Russian Federation produce mainly fibre flax, Canada and the northern United States mainly linseed.

WILD RELATIVES - *Linum bienne, Linum floccosum, Linum mysorense, Linum hirsutum, linum nervosum,*

VARIETIES –
Surbhi (KI-1), Nagarkot (KL-31), Jeevan (DPL-21), Janaki (KL-43), Himalini,

FLORAL BIOLOGY -

- ✓ **Inflorescence -** Racemose or cymose, scorpioid (Flax), rarely solitary.
- ✓ **Flower -** Showy, actinomorphic, hermaphrodite, pentamerous, hypogynous.
- ✓ **Calyx -** Sepals 5, polysepalous, or more or less connate, usually persistent, very rarely caduous, imbricate, quincunical, rarely valvate.
- ✓ **Corolla -** Petals 5, variously coloured, often more or less clawed, polypetalous, Fugucious, caducous, sometimes with ligule like appendages, usually with pocket like slits above the bases, imbricate or twisted.
- ✓ **Androecium -** Stamens 10 usually, outer whorl being reduced to staminodes and inner one united at the base to form a ring, on the inner side of which is a disc or nector secreting glands, staminodes lie opposite to the petals; anthers elliptic, introrse, bithecal, connective often apically acute.
- ✓ Disc absent or interstaminal, free of adnate to staminal tube or extrastaminal forming a ring being united with the staminal tube.
- ✓ **Gynoecium -** Carpels 2-5, syncarpous, ovary superior, 2-5, syncarpous, ovary superior, 2-5 locular each locule further divided by false septum, so ovary cells or locules increased in number.
- ✓ Styles as many as ovary chambers or fewer or more free, axile placentation, ovules are 2 in each chamber; stigma terminal.
- ✓ **Pollination -** Entomophilous, insects are attracted by coloured and honey glands.

BREEDING OBJECTIVES –

1. **High** yielding varieties with high oil content for rainfed conditions.

2. **Devlopment of short duration varieties (105 days).**
3. **Li**nseed varieties resistance to pest and Diseases.
4. Screening of Germplasm under abiotic stress.
5. Maintenane, evaluation and utilization of germplasm.

2. RAPESEED

B. NAME – *Brsassica napus*
FAMILY – Brassicacea
CHROMOSOME NO. – 2n=38
ORIGIN - Europe region
WILD SPECIES - *B.oleracea, B.rapa*
DISTRIBUTION - Canada, India, China, France, Australia, U.K, etc...
FLORAL BIOLOGY –

1. ConsistsTap rootsystem with succulent, straightand cylindrical stem.
2. The inflorescence is racemose And the flowering is inderterminate with beginning at the lowest bud of the main raceme.
3. The syncarpous ovary develops into pod with two carpels separated by a false septum.

BREEDING OBJECTIVES –

1. High yield.
2. Early maturity.
3. High oil content.
4. Resistance to diseases.
5. Resistance to pests.
6. Low erucic acid and glucosinolates.

3. MUSTARD

B. Name – Brassica spp
Family - Brassicaceae
Chromosome No. – 2n=36
Origim – India
Distribution:
China, Canada, India, Europe, Pakistan, collectively contribute 90 per cent of the global production. In India Uttar Pradesh, Rajasthan, Punjab, Assam, Bihar and West Bengal.
Floral Biology –

1. Their presence or absence may be a good taxonomic character.
2. A simple and well known example may be that of *B. oleracea, B. nigra* and *B. campestris* where the first is completed glabrous and the two others hairy.
3. The amphidiploids where one of the parents is *B. oleracea* (i.e. *B. carinata* and *B. napus*) are only very slightly hairy (Gomez Campo, 1980).
4. The flower has typical cruciferae formula (K2 + 2, C4, A2 + 4, G (2)).
5. The inflorescence is racemose and flowering is indeterminate beginning at the lowest bud on the main raceme.

6. The syncarpous ovary develops into a pod (silique) with two carpels separated by a false septum.

Breeding objectives

1. High yield
2. Early maturity
3. High oil
4. Low erucic acid and glucosinolates
5. Resistance to diseases
6. Resistance to insects pest

Breeding methods

1. Introduction - Regina from Sweeden

2. Simple selection

3. Hybridization and selection

Intervarietal

a) Bulk method
b) Pedigree method
c) single seed descent

Inter specific

4. Back cross method

5. Population improvement

Recurrent Selection, mass selection

6. **Heterosis breeding** CMS lines
7. **Mutation breeding**

8. Tissue culture technique for production of homozygous diploids

Saline resistance screening. Induction of mutation in haploids.

9. Embryo rescue technique for inter specific crosses.

BREEDING CENTRES:

National Research Centre for Mustard (NRCM) – Bharatpur (Rajasthan)

Coordinated project at **Bharathpur**.

PRACTICAL ACHIEVEMENTS

Varieties Kranti, RLM 198, Krishna, Varun, Pusa Kalyani etc.

LECTURE NO. 5
FODDER CROPS
1. NAPIER

B. NAME - *Pennisetum purpureum*

FAMILY - Poaceae

CHROMOSOME NO. - 2n =27,28,56

ORIGIN - Cross land of Africa (Tropical Africa)

WILD RELETIVES - P. polystachion (mission grass)
P. macrourum (sueamp grass)
P. pedicellatum (deenanth grass)
P. benthamii

DISTRIBUSTION :- China,India,USA,Srilanka,Bangladesh

FLOWER BIOLOGY

1. The inflorescence is a stiff terminal bristly spike, up to 15-20 cm in length, yellow-brown to purplish in colour.
2. Spikelets are arranged around a hairy axis, and fall at maturity.
3. Spikelets are 4-6 mm long and surrounded by 2 cm long plumose bristles.
4. There is little or no seed formation.
5. When seeds are present they are very small (3 million seeds/kg) *P. purpureum* relies on wind to achieve cross-pollination, due to asynchrony of male and female flower parts.
6. However, this is also an apomictic species which can produce seed by this asexual method of reproduction (Brown and Emery, 1958; Stevens, 2012).
7. The species is an inconsistent seed producer and in some habitats it rarely develops seeds, possibly due to low pollen viability (Tropical Forages, 2013).
8. When seeds are produced they are dispersed by wind (Francis, 1992), but are often off.

BREEDING OBJECTIVE

1. High yeild
2. High protein contain
3. Disease resistance
4. Pest resistance
5. Drawfness
6. High vigrous
7. Abiotic and biotic stress resistance
8. Early maturity

CONVENTIONAL BREEDING

- ✓ Napier grass is a cross-pollinating allotetraploid species with a chromosome number of 2n = 4x = 28 (genome A'A'BB).
- ✓ Although there is no clear information on the genetic origin of allotetraploidy in Napier grass, the A'A' genome has been reported to be homologous to the AA genome of pearl millet (Pennisetum glaucum (L.)) and the A' chromosomes are larger than the B chromosomes, which contribute genes controlling the perennial growth habit .

- ✓ To date, Napier grass 'improvement' has mainly been based on the evaluation and selection of existing accessions for traits of interest.
- ✓ For example, accessions were screened for resistance to diseases, and Napier grass head smut- and stunt-resistant lines were identified from the existing collections.
- ✓ Plant breeding and selection in Napier grass has primarily been aimed at improving different agronomic traits such as disease resistance, yield, nutritional quality, growth habit (dwarfing), palatability and abiotic stress tolerance.
- ✓ Napier grass is cross-compatible with the closely related species pearl millet (Pennisetum glaucum) (2n = 2x = 14, genome AA) the resultant hybrids are triploid and sterile and can only be propagated by vegetative means which, although labour intensive, ensure a true-to-type variety.
- ✓ A number of agronomically important traits, nutritional quality and palatability for example, have been introgressed into the genome of Napier grass from pearl millet through conventional plant breeding and hybrids have become a crucial part of the forage crop value chain in Africa, Asia and South America.

2. BAJRA

B. NAME - *Pennisetum glaucum*
FAMILY – Poaceae/Graminea
CHROMOSOME NUMBER – 2n=14
ORIGIN - Originated in India or Africa, W. Africa

NEW VARIETIES

NBH-149, VBH-4 developed for Andhra Pradesh, Madhya Pradesh, Gujrat, Maharashtra are capable of producing 14% higher yield.
ICM4-155 gave higher yield than the standard check and adopted for all growing tracts of India. Also MH-306, NH-338 and hybrid like MP-204, MP205 have been identified.

DISTRIBUTION:

- ✓ Bajra is widely grown in Africa and Asia since pre historic times.
- ✓ The important pearl millet growing countries are India, China, Nigeria, Pakistan, Sudan, Egypt and Arabia India is the largest producer of pearl millet in the world.
- ✓ Principal pearl millet growing states are Rajasthan, Maharashtra, Gujarat, Western Uttar Pradesh, Haryana and Karnataka which accounts for 90 % of the total area and 86% of production
- ✓ In Karnataka, bajra is extensively cultivated as a rainfed crop in red, black and sandy soils during kharif season.

FLORAL BIOLOGY

1. Inflorescence is a spike, terminal, drooping.
2. The spikelets are oval or eliptical in shape with two to three bristles.
3. The spikelets contain two flowers partially protected by two membranous glumes.
4. Lower floret with L1 and P1, sterile; upper floret with L2, P2, stamens three, styles two, fruit a caryopsis.

BREEDING OBJECTIVES :

1. Breeding for high grain yield To get high yields the following plant characters are necessary

a) more number of tillers

b) well filled, compact, long panicle.

c) heavy grains.

d) Uniformity of ripening. 41 Under irrigated conditions photo insensitivity and early maturity are essential for multiple and relay cropping.

2. Breeding for improved grain quality. .

3. Breeding for drought tolerance.

4. Breeding for disease resistance.

5. Breeding for alternate source of cytoplasm in male sterile lines.

6. Breeding for sweet cumbu to have high forage value.

BREEDING PROCEDURES

1. **Introduction** : Hybrid bajra from Punjab.

Tift 23 A from USA

2. **Selection** : Pure line selection : Co 2, Co 3,

3. Hybridisation and selection

Interspecific hybridisation.

Pennisetum glaucum x *P.purpureum*

Cumbu napier hybrids.

4. **Heterosis breeding** : **Hybrid bajra**

In earlier days before the identification of male sterile lines utilising the protogynous nature hybrids were released. The hybrids were produced by sowing both parents in the ratio of 1:1. After the discovery of cytoplasmic genic male sterile line Tift 23A by Burton in Tifton, Georgia led to development of hybrids. Earlier hybrids of India *viz.,* HB1, HB2 to HB5 were produced utilising Tift 23 A. But due to susceptibility to downy mildew they went out of cultivation. Even before the discovery of CGMS lines by Burton it was discovered by Madhava Menon and his coworkers at Coimbatore. Unfortunately due to failure of publishing it was not recognised.

To over come the problem of downy mildew male sterile lines L 111A and 732 A were isolated and at present used in breeding programme.

There are number of CMS lines developed by private agencies like Nath seeds, Mahyco, Mahendra.

5. Population improvement :

ICRISAT entry WCC 75 is an example for population improvement. This was developed from world composite by recurrent selection method. It was developed from derivatives of numerous crosses between diverse sources of germplasm and Nigerian early maturing land races known as ‘Gero’ millets. Another example is ICMV 155 of ICRISAT.

6. Synthetic varieties :

Synthetics are produced by crossing in isolation a number of lines tested for their GCA. E.g. ICMS 7703.

It is a result of crossing between 7 inbred lines of India x African crosses.

7. Mutation breeding

At IARI Tift 23 A was gamma irradiated and 5071 A resistant to downy mildew was evolved. With this the hybrid NHB 3 was evolved (5071 A x J 104)

BREEDING CENTERS:

1. International Crops Research Institute for Semi Arid Tropics (**ICRISAT**,) **Hyderabad**

2. All Indian Pearl Millet improvement project (**AIPIP**) **Jodhpur (Rajasthan**)

PRACTICAL ACHIEVEMENTS

Varieties: PS B – 8, PSB 15, mukta

Hybrids : HHB 45, HHB 50 from Hissan GHB 30, GHB – 27 from Gujarat

3. SORGHUM

B. NAME – *Sorghum bicolor* L.

FAMILY – Poaceae/Gramneae

CHROMOSOME NUMBER – 2n=20

ORIGIN – Northeastern Africa or at the Egyptian

RELATED VARIETIES

In Tamil Nadu , CO 25 CO26, CO 27 ,K5, K7, CO 19, CO 21, K9, BSR 1, CO 26, K4, K8, CO 25, APK 1, K 10, Paiyur 1 and 2 are the popular varieties for grain purpose ,while CO 20 and CO 28 is a fodder sorghum

FLORAL BIOLOGY

- ✓ Sorghum is an often cross-pollinated crop.
- ✓ The extent of out crossing is 6-45% and depends on nature of earhead.
- ✓ In loose panicles the cross-pollination is more and less in compact panicle.
- ✓ Spikelets occur in pairs on the lateral branches of the panicle.
- ✓ One is sessile while the other spikelet is pedicelled.
- ✓ Sessile is bisexual and pedicelled spikelet is male or sterile.
- ✓ Sessile spikelet is comparatively larger than staminate spikelet and each spikelet has two florets.
- ✓ Flower opening starts after 2 to 4 days of emergence of panicle from the boot leaf.
- ✓ Flowering starts from the tip of the panicle and proceeds downwards (basipetal).
- ✓ Flowering completes in 7 days.
- ✓ The pollen is viable for 10 to 20 minutes under field conditions.
- ✓ Fertile pollen will be lemon yellow in colour.
- ✓ Older pollen grains will normally turn to orange.
- ✓ Receptivity of stigma starts two days before opening and remains for several days (5 days).
- ✓ Flower opening and anthesis will be from 2.00 am to 8.00 am.

BREEDING OBJECTIVES

1. Breeding for high grain yield To get high yields the following plant characters are necessary

a) more number of tillers

b) well filled, compact, long panicle.

c) heavy grains.

d) Uniformity of ripening. 41 Under irrigated conditions photo insensitivity and early maturity are essential for multiple and relay cropping.
2. Breeding for improved grain quality. .
3. Breeding for drought tolerance.
4. Breeding for disease resistance.
5. Breeding for alternate source of cytoplasm in male sterile lines.
6. Breeding for sweet cumbu to have high forage value.

BREEDING PROCEDURE

Sorghum is often cross pollinated crop. So to maintain varietal purity isolation distance of 400 meters is necessary. Compared to other often pollinated crop like red gram, maintenance of inbreds is easy in sorghum. By putting brown paper and selfing the genetic purity can be maintained.

1. Introduction : Varieties of milo and kafir sorghum introduced from USA are used in conversion programme to convert the local long duration photo sensitive varieties to short duration, non-photo sensitive lines.

2. Selection : Old varieties like Co1, Co2, Co4 are all selection made from local land races.

3.Hybridization and selection

a) Inter varietal

(IS 4283 x Co 21) x CS 3541, Three way cross derivative Co 25 (MS 8271 x IS 3691) - Single cross derivative Co26

b) Inter specific

Co 27 Sorghum. (Co11 x *S.halapense*)

4. Heterosis breeding :

Use of CMS lines.

CSH 5 2077 A x CS 3541

5. Mutation breeding :

X ray mutant from CSV 5 (148) Co 19 is a natural mutant from Co 2

6. Back cross method :

By following backcross method of breeding sorghum conversion programme was initiated. The long duration photosensitive germplasm was converted in to photo insensitive short duration sorghums. This was done at USA Similar programme was done at ICRISAT also.

7. Population improvement :

With the use of cytoplasmic genetic male sterility as well as genic male sterility we can go for population improvement. The local land races can be used as pollinators and by half sib family selection, we can isolate lines. We can follow recurrent selection idea to develop superior inbreds.

8. Use of Apomictic lines :

Some apomictic lines have been identified which can be utilised in breeding programme and by vegetative propagation we can fix up heterosis. E.g. R473 from Hydrabad.

BREEDER CENTERS:

International sorghum improvement work is carried out by ICRISAT (International Crop Research Institute for Semi Arid Tropics)

In India at Directorate of Sorghum Research (**DSR**), **Hyderabad**

PRACTICAL ACHIEVEMENTS:

Hybrids are developed by using cytoplasmic genetic smale sterility combined kafir 60
Varieties: CSV1 CSV-2, CSV-4, M35-1, CSV-13
Hybrids: CSH-1, CSH-2, 3 etc for *kharif* and CSH 7, 12, 13 for *Rabi*

4. MAIZE

B. NAME - *zea mays*
FAMILY- Poaceae
CHROMOSOME NUMBER: 2n=20
CENTRE OF ORIGIN: Central America,mexico
DISTRIBUTION OF SPECIES: USA,india,china,france**.**
WILD RELATIVES
- ✓ It has two close relatives,
- ✓ Gama grass tripsacum ;(2n=36;72)
- ✓ Teosinte (2n=20)
- ✓ Teosinte is the closest relatives of maize and crosses readily with it

FLORAL BIOLOGY
Maize is tall determinate annual plant producing large ,narrow ,opposite leaves borne alternately along the length of a solid stem.
- ✓ **Maize is a monoceous plant.**
- ✓ **Maize is protoandrous plant.**
- ✓ **Male flower is called as tassel.**
- ✓ **Female flower is called cob.**

MAIZE VARIETIES
1. African tall
2. APFM-8
3. J-1006
4. Pratap makka chari 6

BREEDING OBJECTIVES –
1. Reduce internodal Length.
2. Branching habit.
3. Increasing nutrient content in leaves.
4. Resiatance to disease and pest.
5. Fertilize response activity.
6. Non logging.

BREEDING METHODS:
1. Introduction :
Initially the varieties were all introduced one.
Sikkim primitive 1
Sikkim primitive 2.
Mexican line were first introduced during 16th century by Portugeese
2. Mass Selection : Prior to 1945 mass selection was the only method used for maize improvement.
KT 1 - **U. P.**
RAS 1 - **Rajasthan.**
By adopting mass selection technique it is possible to get yield increase by 19% per cycle.

3. Ear to Row Selection :

First proposed by **Hopkins** for improving oil and protein content of maize. This method involves selection of a number of phenotypically desirable ears out of a population grown in isolation. The selecte d cobs are harvested on single plant basis and keeping part of the seeds and remaining sown in rows. Based on the best performing rows during next season the reserve seeds are sown.

This method is suitable for characters having high heritability like oil content and protein content. But it was not helpful to get increased yield.

4.Modified Ear to Row method :

Proposed by **Lonquist.**

I. Best ear heads from population selected (100 No.) and harvested on single plant basis. And threshed individually.

II. The single heads harvested are raised in progeny rows in more than one location representing different environment with local checks.

III. In the main station the progeny rows are used as crossing block. Pollen from best plants are collected, mixed and used for crossing the rows.

Select best five plants from each rows and harvest them separately record the yield. On the basis of performance of over all locations only top 20% progenies are selected.

These 20% will include the five plants selected.

IV. The seeds from 5 plants selected are sown in progeny rows and cycle is repeated.

5. Hybridization and Selection

Not popular since isolation of superior recombinants was not made.

6. Heterosis breeding :

- ✓ Instead of using CGMS lines, detasseling the female inbred line is followed in India.
- ✓ Since use of CGMS line is costlier compared to detasseling it is not followed.
- ✓ Crossing the inbreds of indigenous x exotic origin resulted in release of best hybrids.
- ✓ Indian x Indian - 24 to 43% yield increase.
- ✓ Indian x U.S. dent – 58 % yield increase.
- ✓ Indian dent x Caribbean Flint – 47 to 54 % yield increase.

1. Single cross hybrid
2. Three way cross hybrids - Ganga -5, Trishulatha.
3. Double cross hybrids - COH 3
4. Double top cross hybrid - White kernel hybrids - Ganga safed 2, Histarch, Ganga 4.

7. Population Improvement:

Recurrent selection technique was initiated by Dhawan in 1963. The initial synthesis of composites were done from high yielding inter varietal crosses which exhibited minimum inbreeding depression.

Kisan, Jawahar, Vikram, Sona, Vijay, Amber.

5. BERSEEM

BOTANICAL NAME - *Trifolium alexandrium*

FAMILY - Leguminosae

CHROMOSOME NO. - 2n = 16

ORIGIN - Asia minor and from there it was introduced to Egypt

CULTIVATED SPECIES - Trifolium which consists of nearly 290 species as most important forage legumes.

Berseem doesn't have original wild forms.

Shaftal (*T. resupinatum*)
White clover (*T. repens*)
Red clover (*T. pratense*)
Crimson clover (*T. incarnatum*)
Alsike clover (*T. hybridum*)
Subterraneum clover (*T. subterraneum*)

FLORAL BIOLOGY -

- ✓ Berseem known as king of fodder crops.
- ✓ It is popular among livestock farmers of the world.
- ✓ It is a fast growing annual crop with 30-60 cm plant height.
- ✓ The stem is hollow and succulent.
- ✓ Roots do not extend beyond two feet in general and contains nodules.
- ✓ Inflorescence is head and each inflorescence contains around 100 papilionaceous flowers, white in colour with around 1cm length.
- ✓ Seed is egg shaped, yellowish in colour and is of around 2mm in length.
- ✓ In berseem white coloured flowers are produced in cluster which are hermaphrodite in nature with five fused sepals and five free petals.
- ✓ The stamens are always ten in number and their filaments are fused in a group of 9+1.
- ✓ Berseem is a cross pollinated plant and is entomophilous in nature.

BREEDING OBJECTIVE

- ✓ High yield.
- ✓ High protein contain.
- ✓ Disease resistance.
- ✓ Pest resistance.
- ✓ Drawfness .
- ✓ High vigorous.
- ✓ Abiotic and biotic stress resistance.
- ✓ Early maturity.
- ✓ Regeneration capacity allowing 2-3 cuts.

ACHIEVEMENTS

Variety	**Features**
Mescavi	Varieties under this group develop short side branches at the base of the stem in advanced stage of its growth. **Varieties: Wardan, JB-1, JB-2, JB-3, UPB-103.**
Fahl	Develop small side branches in the upper portion of the stem very freely. They give only one cut.
Saidi	They develop shoots for a short time. Develops branches at upper portion

	less freely then in fahl. **Varieties: Khandwari, pusa giant, ICFRI-99-1, IGFRI-54, Jawahar.**

VARIETIES

Diploid varieties like Meskavi, Fahali, Sauidi, Zaidi, BL-1, BL-2, BL-10, BL-22, BL-30, BL-92, JB-3, JB-4, IGFRI-S-99-1, UPB-101, UPB-103, UPB-104, UPB-1905, and Khadrabi are very popular but newly evolved high yielding tetraploid varieties like Pusa Giant, T-526, T-724, T-780, T-529, T-560, T-561, T-674, T-678, T-730 etc. are very promising and give about 50 per cent higher fodder yield.

LECTURE NO. 6
CASH CROP - SUGARCANE

B. NAME - *Saccharum officinarum*
FAMILY: Gramineae
CHROMOSOME NUMBER – 2n=80
ORIGIN – India
DISTRIBUTION : India, Brazil, Cuba, China, USA, Mexico, France, Germany and Australia. In India, Uttar Pradesh, Maharashtra, Haryana, Andhra Pradesh, Tamilnadu, Karnataka, Bihar and Punjab. India stands first in sugar and sugarcane production in world.
CULTIVATED SPECIES :
There are three cultivated and two wild species of sugarcane. Their brief description is a follows (Rao *et. al.* 1983; Purseglove, 1988).
1. *Saccharum officinarum (2n = 8x = 80)*
2. *Saccharum barberi (2 n =90,92)*
3. *Saccharum sinense (2n = 116, 118).*

WILD SPECIES :
1. *Saccharum spontaneum* (*2n = 40 to 128).*
2. *Saccharum robustum* (2n = 60 to 194).

FLORAL BIOLOGY :
- ✓ The inflorescence of sugarcane is an open, branched panicle and is called as an arrow due to its shape which is like an arrow.
- ✓ Flowering is seasonal and takes place when the day length decreases.
- ✓ In the northern hemisphere the flowering coincides with the onset of winter (Oct.-Nov.) and in the southern-hemisphere in May-June.
- ✓ The spikelets open about sunrise, beginning at the top of the panicle and proceeding downwards and from the tips of the branches inwards, over a period of 5 – 15 days.
- ✓ Approximately1/6 to 1/10th of the panicle opens each day.
- ✓ The swelling of the lodicules by water uptake causes the glumes to be pushed apart and the stigmas come out.
- ✓ The anthers dehisce about three hours after the elongation of the filaments.
- ✓ High humidity delays an thesis.
- ✓ Natural pollination is by wind.

BREEDING OBJECTIVES
1. High cane yield.
2. Moderate high sucrose content
3. Early to full season maturity
4. Resistance to diseases.
5. Resistance / tolerance to insect pests
6. Tolerance to Aboitic stresses
7. Wider adaptability

BREEDING PROCEDURES
1. Hybridization: 3 basic types of crosses are made
i) Biparental crosses:- These are the crosses resulting from 2 known parental clones.

This is easily achieved by bringing together the two parents in an isolated area or under lanterns

ii) Area crosses: In this system several male sterile female clones are pollinated by one male parent in an isolated area.

iii) Melting pot crosses: Melting pot crosses or polycrosses are made by bringing together arrows of large number of superior / potential parental cultivars in an isolated area.

Natural cross pollination is allowed. This procedure allows the evaluation of breeding behaviour of a large number of clones at a minimum expense.

2. Breeding for resistance to diseases:-

1. Red rot:- It is a major problem in sub-tropical countries. The major sugarcane varieties which are found to be resistant to this disease are Co 1148, 1336, 6304, Co 5659, CoS 698 etc.

Smut: Serious disease in many sugarcane growing countries resistant commercial varieties in India are Co 449, 527, 853, 1148, 1336.

3. Mutation Breeding:

According to Heinz x-ray - Irradiation to induce mutations in sugarcane were carried out in 1927. Many mutation breeding programmed with x – rays and gamma – rays were started during early sixties in India.

- Mutation breeding in sugarcane aims at creating economic mutants for higher cane yield, non – flowering and resistance to various diseases such as redrot, smut, downy mildew and to various insect borers.
- Gamma-rays as well as chemical mutagens such as EMS are applied mostly on buds.

4. Abiotic stress tolerance / reistance:-

- Common abiotic stresses for sugarcane as in other crops are drought, flooding, salinity, high temperature freezing temperature
- According to Zobel, they are following 3 basis steps for breeding stress resistance cultivars.

(i) Identifying and characterizing crop traits that are needed for resistance against a particular stress

(ii) Identifying and characterizing the genotypes that are capable of filling the needs are determined under step I above.

(iii) Manipulating genes to pr oduce an adapted variety that has the required characteristics and fills other specific needs.

5. Biotechnology:

- Regeneration of sugarcane plant from callus has been possible.

Breeding centres:-

1. Sugarcane breeding institute, Coimbatore
2. Indian Institute of Sugarcane Research, Lucknow
3. State sugarcane research stations, such as shahjahanpur (UP), Seorali, (Deoria) (UP), Pusa (Bihar), Padegaon (Maharashtra) and Anakapalli (AP).

Drought : Co 285, Co 740, Co 997, Co 1148
Frost : Co 1148, N Co 310
Salinity : Co 453, Co 62125
Lodging : Co 6304, Co 7117, CoS 7918
Water logging : Co 1157, Co 975, Co 785, Bo 91, Bo 104, Bo 106, Bo 109
Top borer : Co J 67, Co 1158

Inter nodal borer : Co C 671, Co 975
Red rot : Co 7627, Co J 64, CoR 8001.

Achievement :

1. Sugarcane breeding institute has been the source of germplasm and genetic variability for selection of varieties suited to different agro-climatic zones of the country. The spread of Co canes to foreign countries began when Co 285 was taken to Cuba and USA (Florida) for cultivation. Varieties bred at Coimbatore are / were being used in 28 other countries either for commercial cultivation or as parents. Co 419 released in 1933 became the most popular variety in tropical India and was rightly hailed as the wonder cane the world over.
2. Two outstanding varieties viz., Co 658 for Tamil Nadu and Co 740 for Maharashtra were released in 1940s. Co 740 continues to be cultivated in Maharashtra even now.
3. Co 997 and Co 1148, released during 1950s, became ruling varieties in Andhara Pradesh and North India respectively. Co 1148 remained the most predominate variety in sub-tropical region for over four decades.
4. Co 6304, a high yielder, became the most important variety in Tamil Nadu replacing Co 419.
5. Varietal evaluation for juice quality conduced across seasons helped in the indemnification of high sucrose varieties viz. Co 7204, Co 7704, CoA 7601, CoC 671, Co 8336, Co 8338 etc.
6. Co 86249, an elite variety with resistance to red rot and high reasonability has been evolved by the Institute and notified for release in the East Coast zone, It is also serving as a source of resistance to red rot in the breeding programmes.
7. Co 86032 Combining high yield and quality evolved by the institute and identified by the AICRP (S) has been notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agricultural Crops and is occupying a major area in Tamil Nadu (90%), Karnataka, Maharashtra and Gujarat.

IMPROVED VARIETIES / HYBRIDS

Sr. No.	Variety	Features
1	Co-94012	14-16 duration months with 150 t/ha yield, Drought tolerant, non breaking of internode when lodge, high sugar 14.24 percentage, moderately resistant to smut and red rot.
2	Phule 265	14-16 months duration, 15-20 % higher sugar than Co86023, profuse tillering, easy for detrashing, suitable for saline soil, good ratoonability, moderately resistant smut, red rot and wilt.
3	Co-92005	Suitable for suru planting, 12-14 month duration, 128 t/ha yield capacity quality jaggery for high recovery with more market price, recommended for Western Maharashtra.
4	Phule 10001	Suitable for preseason and suru cultivation, yielding 150 t/ha (preseason), suru 133 t/ha, tolerant salinity, no pith formation, drought tolerant, excellent ratooability early maturity, moderately resistant red rot, wilt and smut.
5	COM 09057	Non lodging, suitable for mechanical harvesting, 125-130 t/ha with best jaggery quality.

6	VSI 08005	Early, good ratoonability, 15-16 % sugar, 135-145 t/ha productivity, good jaggery quality

LECTURE NO. 7
VEGETABLE CROP
POTATO

BOTANICAL NAME *: Solanum tuberosum L.*
FAMILY : Solanaceae
CHROMOSOME NO. : 2n= 48
ORIGIN : Tropical South America

Distribution

- ✓ The potato is a native of tropical south American region.
- ✓ It is believed that the cultivated potato originated from its wild ancestors near the lake Tritica basin in Peru Bolivian region in high mountains.
- ✓ The potato was introduced in India from Europe in early 17th century .

Floral Biology

- ✓ The inflorescence of potato is cymose.
- ✓ The flowers are actinomorphic and hypogynous.
- ✓ Calyx has 5 lobes & Corolla tube consists of 5 petals.
- ✓ The calyx colour may be green or partially or totally pigmented.
- ✓ The **corolla** consists of **five petals** which are joined at the base by a short corolla tube each lobe ands in a triangular point.
- ✓ Cool wet weather makes flowering more while hot weather depresses flowering
- ✓ Pollen production is abundant from early morning to 10am
- ✓ *Bombus impatiens* is very effective in pollinating potatoes in the field
- ✓ Stigma receptivity and anther dehiscence are also at the same time
- ✓ Wind or gravity has no significance in the pollination
- ✓ Diploid species have abundant pollen

Breeding Objective

1. High tuber yield
2. Earliness
3. Photoperiod insensitivity
4. Responsiveness to fertilizer
5. Better keeping quality (resistance/tolerance against shrinkage, rottage etc)
6. Better quality tubers
7. Resistance to

i. Late blight
ii. Early blight
iii. Charcoal rot
iv. Common scab
v. Bacterial wilt

Potato breeding development in India

- ✓ In India, potato breeding programme was initiated in 1935 at the Potato Breeding Station, Shimla.
- ✓ Regular breeding programme was started in 1949 with the establishment of the Central Potato Research Institute (CPRI) at Patna, Bihar.
- ✓ Headquarter of the CPRI was later on shifted to Shimla (1956) in order to facilitate hybridization and maintenance of seed health.
- ✓ All varieties released by the **CPRI** carry the prefix '**KUFRI'** as a memento to the place of hybridization.

BREEDING METHODS

1. Introduction

The introduced European varieties were long-day adapted

The multiplication of these varieties in Indian conditions was accompanied by progressive accumulation of degenerative viral diseases

✶ **Earlier varieties**

Criags defence

Magnum bonum

Up-to-date

✶ **Secondary introductions** –

Hybrid DN-45- Katahdin × President

Kufri kisan is a multiple cross involving Ekishrozn from Japan

✶ **Clonal Selection**

- **Kufri red** from Darjeeling red round
- **Kufri safed** is selction from phulwa

2. Hybridization technique

- ✓ Potato naturally flowers under cool climate and long-day condition of more than 15hrs light.
- ✓ Such conditions are available during long-summer days when potatoes are grown in hills.
- ✓ Hills are therefore, ideal for hybridization work.
- ✓ Potato flowers are hermaphrodite (bisexual) and therefore emasculation is done in selected female parents mostly in the evening.
- ✓ Flowers from selected fertile male parents are collected a day in advance, shade dried and pollens extracted next day in the morning in petri- dish or container
- ✓ **Pollination** : In the morning
- ✓ **Bagging** : 2-3 days
- ✓ **Berry setting** : 5-7 days
- ✓ **Seed extraction** : From ripened berries by macerating in water and separating the seeds from pulp by repeated washing

3. Hybridization and selection

- ✓ In hybridization, crosses are made between selected parents.
- ✓ Hybridization can be between varieties(intervarietal) or between species(interspecific).
- ✓ Since yield and most of the desirable characters are polygenic in nature, the parents for hybridization are generally selected on the basis of their combining ability.
- ✓ Being vegetatively propagated, breeders take advantage of selecting and multiplying genetically identical individuals in the succeeding generations.

- **KUFRI KUNDAN**-selection from Ekishrozan×katahding
- **KUFRI JYOTHI** –Selection from A-3069×A-2814

4. Back cross method

✓ Cultivated potato does not posses resistance to most of the diseases and pests.
✓ Resistance genes are mostly found scattered in wild and semi-cultivated species available in centre of origin and diversity in South America.
✓ In this method the hybridization is done between cultivated and wild or semi cultivated species with the aim of transferring specific characters like resistance to diseases and pests.
✓ It is followed by repeated back crossing keeping cultivated type as recurrent parent.
✓ Selection is practiced in successive back cross generation for the character to be retained from the wild species.
✓ However, transfer of the resistant genes from wild species into cultivated potato is a difficult task.

5. HETEROSIS

✓ Heterosis is observed for earliness, tuber size and tuber weight
✓ Pollen sterility is common
✓ Inbreeding depression is more
✓ Seed set is poor
✓ Not exploited

6. BIOTECHNOLOGY

✓ The application of biotechnology in potato breeding has been found useful in many ways
✓ Tissue culture technique is used for propagation of virus free plant material
✓ It can generate somaclonal variation useful for selection
✓ Protoplast fusion by somatic fusion of leaf mesophyll protoplasts has provided opportunity to transfer useful genes especially for disease and insect resistance from wild species and other diverse sources to cultivated potatoes.
✓ Genetic transformation through *Agrobacterium tuminifaciens* in genetic engineering, incorporation of bt gene for insect control and insertion of genes for herbicide resistance, and high amino acid contents are other applications of biotechnology in potato
✓ The CPRI has successfully developed protocol for genetic transformation using the agrobacterium vector
✓ Transgenics through transformation are being devoloped to have potato lines resistant to tuber moth,virus,late blight and also for nutritive quality and processing quality
✓ The first GM potato appeared in the market in 1995 was named “NewLeaf” by Monsanto®, which was genetically engineered using a toxin *Bt* gene to generate resistance against Colorado beetle (*Leptinotarsa decemlineata*) (Kilman, 2001).
✓ Another engineered potato variety appeared in March 2010; a GM potato “Amflora,” developed by BASF Plant Science and aimed at improved amylopectin content (waxy tuberous starch) for the processing industry, was approved by the European Commission (Lucht, 2015; Zaheer and Akhtar, 2016).

➢ **FUTURE PROSPECTS**

✓ The potato embodies a unique combination of features; it is tetraploid and heterozygous, it can be asexually propagated, is amenable to tissue and cell culture methods, possesses

an extremely large gene pool, and can be transformed by *Agrobacterium tumefaciens* or other methods.

- ✓ Hence holds great promise for the future.
- ✓ To extend potato cultivation in non-traditional areas there is need to develop heat tolerant genotypes.
- ✓ Varieties rich in protein & vitamin A need to be developed.
- ✓ Varieties for improved processing attributes.
- ✓ Varieties resistant to late blight- early blight charcoal rot & mosaic.

COMMERCIAL VARIETIES AND HYBRID

Maturity	Varieties	Resistant
Earlymaturing	Kufri chandramukhi Kufri lauvkar, Kufri kuber	Moderately Resistant to late & early blight warmer climate variety
Mediummaturing	Kufri badshah Kufri pukhraj Kufri jyoti, Kufri kundan, Kufri sheetman Kufri dewa Kufri jawahar Kufri Bahar Kufri chipsona-2	Late and early blights Early blight and moderately late blight. Late and early blights & tolerant to viruses. Late blight Resistant to frost Resistant to frost Late blight and ideal for intercropping - Late blight & excellent for chip making
Latematuring	Kufri kumar, Kufri chamatkar, Kufri sindhuri,	Late blight Early blight -

TRUE POTATO SEED (TPS)

- ✓ Non-availability of quality seed tubers, high seed cost, virus infiltration in seed tubers causing degeneration of seed stocks and problems of long distance transport of seed from seed-producing areas have led to the development of true potato seed (TPS) technology of crop production.
- ✓ It can be easily stored over long periods of time. About 100-120 g TPS is enough to raise a seedling crop for one hectare or if the commercial crop is to be produced using seedling tubers, the produce of 40-45 g TPS is enough to plant one hectare crop next year.
- ✓ They also provide better disease resistance because of high heterogeneity in the population.

LECTURE NO. 8
VEGETABLE CROP
FIELD PEA

B. Name - *Pisum sativum L.*
Family - Fabaceae
Chromosome No. - 2n= 14
Origin - Mediterranean region, western and central Asia and Ethiopia
Distribution –
The first cultivation of peas appears to have been in western Asia, from where it spread to Europe, China and India.
In classical times, Greek and Roman authors mentioned its cultivation as a pulse and fodder crop.

FLORAL BIOLOGY

- ✓ Flowering usually begins 40 to 50 days after planting.
- ✓ Flowering is normally two to four weeks, depending on the flowering habit and weather during flowering.
- ✓ The flowers are arranged in the form of an axillary raceme.
- ✓ The flowers may be reddish, purple or white.
- ✓ They are self-pollinated and develop into 5 cm to 9 cm long, inflated or cylindrical pods containing five to 11 seeds inside them.
- ✓ **Calyx:** Calyx is the lowermost green tubular part of the flower.
- ✓ It consists of five slightly unequal lobes called sepals.
- ✓ It protects the other whorls in the bud stage from possible external injuries.
- ✓ **Corolla:** It consist of five petals of different shapes and sizes.
- ✓ The outermost petal is the largest and spreading and is known as standard or vexillum which covers the other petals in the bud stage.
- ✓ The next two lateral petals look like wings. Hence they are called wings or alae.
- ✓ The two innermost ones unit loosely along their ventral margins to form a boat-like structure and are known as keel or carina.
- ✓ The attractive color and sweet scent of the corolla attract insects for pollination.

BREEDING OBJECTIVE

1. Early maturity
2. Pod characteristics
3. Seed size
4. Shelling percentage
5. Pod yields
6. Suitability for processing
7. Resistance to disease
8. Resistance to insect
9. Resistance to abiotic stress

BREEDING METHODS

1. Breeding for abiotic stress

Breeding peas for cold resistance or cold hardiness by recurrent selection and resistance to waterlogging has been undertaken abroad.

2. Breeding for high protein and sugar content

The wrinkled seeded content 26 -33 per cent protein content and in smooth seed it is 23-31 per cent.

The inheritance of protein content is polygenically controlled and mainly by recessive factor for high protein content.

The varieties GS 195 and the local cultivar, kinnauri have high soluble protein content due to the presence of a very high number of dominant alleles.

3. Integration of Biotechnology in Conventional Pea Breeding:

- ✓ Transformation and regeneration protocols are now available in peas.
- ✓ The most common method involves *Agrobacterium tumefacience* mediated transformation.
- ✓ The major difficulty lies in the fact that this transformation is genotype specific and only a small portion of cultivars have responded to this technique.
- ✓ Somaclonal variation arising from the regeneration of plants from callus, led to the use of cotyledonary meristem from freshly imbibed seed as a source of tissue for successful transformation.
- ✓ The use of this technology in the pea breeding is limited to proof of concept.
- ✓ Partial resistance to alfalfa mosaic virus (AMV) has been reported as a consequence of transformation with chimeric virus coat protein gene, a-amylase inhibitor (α-A 1) and the promoter phytohemagglutin, both found in French-bean when transferred to pea, have shown constitutive expression and resistance to pea weevil.
- ✓ The expression of inhibitor (α-amylase) served to block the development of the larvae at an early stage and this resulted in less seed damage and better seed quality.
- ✓ This transgenic pea product could not reach to large scale field testing due to legal issues.
- ✓ Transfer of herbicide resistance both as a reportable marker and a trait have also been reported, but not carried through to commercial release.
- ✓ While GM crops are on increase in many parts of world with global acreage of 134 million hectares in 2009, the adverse reaction to GM crops in Europe and low rates of transfer have all contributed to the pea breeding industry not engaging in the development and release of GM peas till date.

LECTURE NO. 9
HORTICULTURAL CROPS
1. MANGO

B. NAME - *Mangifera indica* L.
FAMILY – Anacardaceae
CHROMOSOME No. - (2n=4x=40)
ORIGIN - Indo-Burma Region.
WILD RELATIVES –
M. laurina, M. gedebe, M. grifith, M. pentandra, M.minor, M.odorata, M.foetida, M.zeylanica, M.pajang
DISTRIBUTION:
It is extensively cultivated in India, Indo-China warm parts of Australia, Philippines, Pacific Islands, Himalayas. In India Andhra Pradesh, Uttar Pradesh, Bihar, Karnataka, Maharashtra, West Bengal and Gujarat.
BREEDING OBJECTIVES:
- ✓ Dwarfness
- ✓ Precocity
- ✓ Profuse and regular bearing
- ✓ Attractive, good sized and quality fruit
- ✓ Absence of physiological disorders
- ✓ Disease and pest resistance and improved shelf life
- ✓ High Productivity

BREEDING METHODS
1. Introduction:

Name of the variety	**Country from where introduced**
Sweet	Thailand
Sensation	USA
Tomy Atkins	Brazil
Early Gold	USA

2. Selection:
a. Chance seedlings:
Mango was previously propagated through seeds and hence the old orchards in India were mostly of seedling origin. Some seedling progenies gave rise to varieties such as 'Chinnaswarnarekha' and 'Mundappa'. The popular, salt tolerant rootstock (13-1) was identified in Israel by this technique.
b. Clonal selection:
Extensive survey of Dashehari orchards around Maliabad in Uttar Pradesh has resulted in the isolation of best clone *viz* Dashehari -51 with higher yield and regular bearer.
3. Hybridization:
- ✓ Since a large number of male and perfect flowers are borne on a mango panicle, it requires a special crossing technique.
- ✓ The panicle should be bagged with a muslin bag (60 cm x 30cm) fully stretched and field with two rings and a rod made of spliced bamboo.

- ✓ A piece of thick in wire can also be made into a good frame for stretching the muslin bag Staminate flowers of the selected panicle to be used as female parent should be removed daily before dehiscence.
- ✓ Panicles of the variety selected as male parent should also be bagged before their flowers begin to open.
- ✓ Freshly dehisced male flowers should be carried in a small petridish lined trth a filter paper and covered with another petridish to protect the flower to avoid contamination with foreign pollen carried by insects.
- ✓ The conventional method of pollination is time consuming, cost intensive and inefficient because of tallness and difficult to handle trees poor fruit set.
- ✓ 'Caging technique' for crossing, developed at IARI following the discovery of self incompatibility in Dashehari, Langra, Chausa and Bombay Green, involves planting of grafted plants of the self incompatible varieties along with those of male parents enclosed in an insect proof cage and allowing pollination by freshly reared house flies and thus ting away with the tedious hand pollination.
- ✓ In hybridization on mango, work taken up in post independence period laid emphasis on regular and precocious bearing, dwarfness, high percentage of pulp, fibreless flesh, large fruits with red blush, good keeping quality and freedom from spongy tissue.
- ✓ Few of these such as Mallika and Ratna have received commercial recognition.
- ✓ The cultivar 'Sindhu' evolved through intensive back crossing between Ratna and Alphonso develops fruits parthenocarpically under natural temperature conditions.
- ✓ The average size Sindhu fruits has been reported to be 215 g.
- ✓ It may be observed that the parents used in hybridization programme were of the best commercial varieties, superior in most of the traits but lacking in few qualities, which may be available in the other parents.
- ✓ Though in some cases (e.g. the hybrids at Sangareddy), the parents were the same the hybrids were differently named, due to the heterozygous nature of parents resulting in heterogeneous hybrid population.

The constraints encountered in mango hybridization are:

1. High fruit drop: In early stages, many young fruits drop after pollination and fertilization.
2. Only one seedling can be obtained from one fruit (since the varieties are monoembryonic).
3. The heterozygous nature and cross fertilization makes it difficult to predict the qualities of the hybrids.
4. Complex nature of panicle and flower and excessive fruit drop.
5. Large area of land is required for hybrid seedlings.
6. Polyembryony - Difficulty in accurately identifying the zygotic seedling: polyembryonic varieties in Israel show that weight of zygotic seedling is higher than the nucellar seedling. Use of polymorphic enzyme systems (isozyme) has been used to identify zygotic seedling since the nucellar seedlings have the same isozyme alleles as in the maternal parent.

4. Mutation Breeding:

No variety has been developed so far by mutation breeding. Some attempts at IAR!, New Delhi using physical mutagens showed that the LD so for Neelum, Dashehari and Amrapali was between 2 and 4 Kr of gamma rays. LD so values has been found to be around 2 to 3 Kr for Neelum and Alphonso at Coimbatore.

2. AONLA

B. NAME – *Phyllanthus emblica*
FAMILY – Euphorbiaceae
CHROMOSOME NO. – 2n=28
ORIGIN - Indo – china
VARIETIES
The most popular cultivable varieties of amla are Banarasi, NA 7, Krishna, Kanchan, Chakaiya, BSR 1.
It is also called 'Indian Gooseberry', 'Amla', 'Nalli', 'Amali', 'Ambala'.
DISTRIBUTION
- ✓ Grown in various agroedaphic situation.
- ✓ Indigenous to tropical South –Eastern Asia particularly Central and Southern India.
- ✓ Wild and cultivated species available in the region extending from the base of Himalayan to sri lanka and from Malasia to South China.
- ✓ In India, it is widely grown in UP, Gujarat, Rajasthan, MP and TN.

FLORAL BIOLOGY
- ✓ Flowers, unisexual, pale green, 4 to 5 mm in length, borne in leaf-axils in clusters of 6 to 10.
- ✓ Staminate flowers, tubular at the base, having a very small stalk, gamosepalous, having 6 lobes at the top; stamens 1 to 3, polyandrous, filaments 2 mm long.
- ✓ Pistillate flowers, fewer, having a gamopetalous corolla and two-branched style.
- ✓ Female flowers take about 72 hours to open fully. Pedicel is very short.
- ✓ Disc is a lanceolate cup with 3 carpels.
- ✓ Style is short, connate, twice bifid and distally dilated.
- ✓ The new shoot emerge out during first week of April.
- ✓ The flowering period varied in different varieties from 17-26 days.
- ✓ Flowering period twice in a year February- March and June-July.

BREEDING OBJECTIVES
- ✓ To breed var. having wider geographic adaptability.
- ✓ To develop var. suitable for export.
- ✓ To evolve colored var. based on market demand.
- ✓ To breed var. resistant to frost.
- ✓ To breed var. resistant to biotic and abiotic stresses.
- ✓ Exploitation of available hybrid vigour (heterosis) for yield and quality.
- ✓ To breed var. having high yield with good quality fruits.
- ✓ Varieties with less fibre content.
- ✓ Good pollinating var.
- ✓ Var. with hight sex ratio with more number of female flowers.

BREEDING METHODS
1. Introduction
- ✓ It is one of the oldest method for improvement of fruit crops. It is bringing or exchange of germplasm / genetic material from one place where it is not known previously.
- ✓ Presently, germplasm exchange is being done in different crop through NBPGR, new delhi.

- ✓ This method may be an important tool to bring exotic materials from foreign country for further evaluation and incorporation of specific gene lacking in indigenous aonla.

2. Selection

- ✓ While selecting new ideotypes, plant height, vigour, growth habit, precocity, fruiting intensity, fruit size etc are kept in mind.
- ✓ There are sufficient variation in fruit size and number of fruit / determinate shoots, which directly affect the fruit yield and provide ample scope for selecting superior type.
- ✓ **Major work done at NDUAT, Faridabad (NA-4, 5, 6 ,7 10) GAU (Anand-1, 2 and 3) RBS, college, Agra (Balwant)**
- ✓ Recently some coloured and cluster bearing genotypes have been identified through exploitation in Rajasthan, which will be further evaluated at national repository of aonla at CIAH, Bikaner.

3. Polypoidy

- ✓ Exact ploidy level is not known in aonla but it is realized by the scientists that aonla is characterized by polyploidy behavior in composition of chromosome.
- ✓ The structural and numerical changes in chromosome can be made through application of colchicines, which is found to be useful for getting small seeded fruit or seedlessness.
- ✓ Keeping in view the usefulness of polypoidy breeding, these principles may be applied in aonla to obtain desirable economic attributes.

4. Mutation

- ✓ Mutation is sudden heritable change in a character of plant.
- ✓ In India, research work related to application of mutation in aonla is almost negligible but there is greater prospects to develop coloured varieties through induced mutation and selection from bud sport.

5. Biotechnological Tools

- ✓ Incorporation of desirable gene in aonla is possible only with the application biotechnological approach.
- ✓ In fact, there is absolute dearth of information on biotechnological approaches.
- ✓ Tissue culture, cell culture and genetic manipulation through molecular technique may
- ✓ be useful to get early result in varietal improvement programme.
- ✓ This technique can also be helpful to modify particular traits and in turn provide new avenue for improving both the colour and quality of the fruit available for industrial and domestic uses.

6. Hybridization

- ✓ Hybridization is crossing of two parents which are genetically dissimilar.
- ✓ Not a single variety has been bred so far through this method.
- ✓ Occurance of xenia effect between Chakaiya x Krishna, Banarasi x NA-9, Francis x NA-7, kanchan x NA-6 and NA-6 x NA-9 for fruit size and weight were reported from crosses.

BREEDING PROBLEMS

- ✓ Since, aonla is highly heterozygous plant, therefore, large size of population is required for selection.
- ✓ It has long generation cycle i.e. 2-8 years, depending upon sp. and var.
- ✓ Lack of recombination.
- ✓ Long juvenile phase prohibiting early assessment of strain.

- ✓ Precedence of self incompatibility.
- ✓ Frost susceptibility.
- ✓ Lack of knowledge on inheritance pattern.

3. GUAVA

B. NAME - *Psidium guajava*
FAMILY - Myrtaceae
CHROMOSOME NO. - 2n=22
ORIGIN - Tropical America / West Indies
DISTRIBUTION
America, Canada, Australia, India, Burma, Indonesia, Bangladesh etc. In India Uttar Pradesh, Andhra Pradesh, Maharashtra, Karnataka etc.
BREEDING OBJECTIVES
1. Development of seedless variety
2. Less pectin content for edible purpose
3. More pectin content for processing
4. Uniform ripening
5. High keeping quality
6. Resistance to tea mosquito bug and wilt.

FLORAL BIOLOGY
- ✓ Guava bears flower solitary or in cyme of two to three flowers, on the current season growth in the axil of the leaves.
- ✓ About one month is required from flower bud differentiation to complete development upto calyx cracking stage.
- ✓ Peak time of Anthesis is between 5.00-6.30 AM in most of the varieties of guava.
- ✓ The dehiscence of anthers starts 15- 30 minutes after Anthesis and continues for two hours.
- ✓ The pollen fertility is high in almost all the cultivars.
- ✓ The pollen fertility is 78% and 91% in Allahabad Round and Lucknow Safed, respectively.

BREEDING METHODS

1. Clonal Selection
- ✓ Improvement work in guava was started for the first time in the country in 1907 at Ganesh khand fruit Research Station, Pune primarily with the collection of seeds of varieties, grown in different places to isolate superior strains.
- ✓ At Horticultural Research Station, Saharanpur, evaluation of seedling types resulted in a superior selection, S-1, having good fruit shape, few seeds, sweet taste and high yield.
- ✓ At IIHR, Bangalore, from 200 open pollinated seedlings of variety Allahabad Safeda collected from Uttar Pradesh, one seedling selection, selection-8, was found to be promising

2. Hybridization
- ✓ At IIHR, Bangalore, as a result of hybridization among Allahabad Safeda, Red Flesh Chittidar, Apple color, Lucknow-49 and Bananas, 600 F1 hybrids were raised.

- ✓ One hybrid Arka Amulya has been released recently.
- ✓ It is a progeny from the cross Allahabad Safeda x Triploid.
- ✓ Hybrid 16-1 (Apple color x Allahabad safeda) has been developed.
- ✓ At Fruit Research Station, Sangareddy (Telangana), inter-varietal hybridization resulted in the isolation of two superior hybrids.
- ✓ ***Safed Jam***: This is a hybrid between Allahabad Safeda and Kohir (a local collection from Hyderabad – Karnataka region).
- ✓ It is similar to Allahabad Safeda in growth habit and fruit quality.
- ✓ The fruits are bigger in size with good quality and few soft seeds.
- ✓ ***Kohir Safeda*:** It is a hybrid between Kohir x Allahabad Safeda, Tree is vigorous, fruits are larger with few soft seeds and white flesh.
- ✓ CISH, Lucknow isolated two hybrids H-136 for red pulp and Soft seeler with high TSS.
- ✓ Haryana Agricultural University, Hisar has released two hybrid varieties.
- ✓ ***Hisar Safeda***: It is a cross between "Allahabad Safeda" x 'Seedless', which has upright growth with a compact crown.
- ✓ Its fruits are round, weighing about 92g each, pulp is creamy – white with less seeds, which are soft, TSS is 13.4% and ascorbic acid 185 mg/100g.
- ✓ ***Hisar Surkha****:* It is a cross between 'Apple Color' x 'Banarasi Surkha'. Tree is medium in height with broad to compact crown, fruit is round weighing 86g each.
- ✓ Pulp is pink having 13.6% TSS.0.48% acidity and 169 mg/100g ascorbic acid. Yield is 94 kg/tree/year.

3. Polyploidy Breeding

- ✓ Producing triploids will be futile since the fruit shape in triploid is highly irregular and misshapen because of differential seed size.
- ✓ However, in order to evolve varieties with less seeds and increased productivity, crosses were made at IARI, New Delhi, between seedless triploid and seeded diploid variety Allahabad Safeda.
- ✓ Of the 73 F1 hybrids raised 26 were diploids, 9 trisomics 5 double trisomics and 13 tetrasomics.
- ✓ Distinct variation in tree growth habit and leaf and fruit characters was observed.
- ✓ Three trisomic plants had dwarf growth habit and normal shape and size of fruits with few seeds.
- ✓ The imbalance in chromosome numbers in aneuploids imparted sterility resulting in seed reduction in fruits.

VARIETIES -

Sr.No.	Varieties	Character
1	**L.49**	Developed at GFES, Pune, Seedling selection of Allahabad Safeda, Semi dwarf tree, high yielding
2	**Banarsi Surkha**	It is a selection from local red fleshed type, heavy bearer, large fruits, flesh soft and pink.
3	**CISHG-1**	Developed at CISH, Lucknow. Fruit skin color is deep red, TSS 15° Brix, soft seeds.

4	**Bangalore**	Local It is a local selection, with white flesh and soft seeds, fruit is large
5	**Arka Mridula (Sel -8)**	Developed at CISH, Lucknow, it is a selection from apple color seedling, skin and flesh color is pink with good acid sugar blend.
6	**6 Plant prabhat**	Seedling selection from GBPUAT, Pantnagar, Prolific bearer, soft seed with good quality

LECTURE NO. 10 & 11
PLANT GENETIC RESOURCES, ITS UTILIZATION AND CONSERVATION

PLANT GENETIC RESOURCES:

The sum total of genes in a crop species is referred to as genetic resources. **Or**
Gene pool refers to a whole library of different alleles of a species. **or**
Germplasm may be defined as the sum total of hereditary material i.e., all the alleles of various genes present in a crop species and its wild relatives.
It is also known as gene pool or genetic stock or germplasm or genetic resources.
Germplasm or gene pool is the basic material with which a plant breeder has to initiate his breeding programme.

Important features of plant genetic resources are -

- ✓ Gene pool represents the entire genetic variability or diversity available in a crop species.
- ✓ Germplasm consists of land races, modern cultivars, obsolete cultivars, breeding stocks, wild forms and wild species of cultivated crops.
- ✓ Germplasm includes both cultivated and wild species or relatives of crop plants.
- ✓ Germplasm is collected from the centres of diversity, gene banks, gene sanctuaries, farmers fields, markets and seed companies.
- ✓ Germplasm is the basic material for launching a crop improvement programme.
- ✓ Germplasm may be indigenous (collected with in country) or exotic (collected from foreign countries)

AIMS OF PGR: Prevent genetic erosion by
1.Collection
2. Conservation
3. Study of documentation and
4. Utilization

The **Convention on Biological Diversity (CBD)** defines genetic resources as genetic material of actual or potential value. The term 'Genetic material' means any material of plant, animal, microbial or other origin containing functional units of heredity. The value of any functional units of heredity can be captured in two dimensions: which is the genetic structure per se can be utilised; or the information encapsulated in the nucleotide sequence of the genetic material can be read. FAO (1989) used the term to mean any economic, scientific or societal value of the heritable materials contained within and among plant species.. According to IPGRI (1993),

PGR include the following categories of plants:
i) Cultivated varieties (cultivars) in current use;
ii) Newly developed varieties;
iii) Obsolete cultivars;
iv) Primitive cultivars (land races);
v) Wild and weedy relatives of cultivated varieties and
vi) Special genetic stocks (including elite and current breeders' line and mutants)

KINDS OF GERMPLASM

The germplasm consists of various plant materials of a crop such as
land races , advanced (homozygous), breeding materials, obsolete cultivars, wild forms of cultivated species , modern cultivars, wild relatives, mutants

These are briefly discussed below:

1**. Land races**

These are nothing but primitive cultivars which were selected and cultivated by the farmers for many generations without systematic plant breeding efforts. Land races were not deliberately
bred like modern cultivars. They evolved under subsistence agriculture. Land races have high level of genetic diversity which provides them high degree of resistance to biotic and abiotic stresses. Land races have broad genetic base which again provides them wider adoptability. The main drawbacks of land races are that they are less uniform and low yielders. Land races were first collected and studied by N.I. Vavilor in rice.

2. Obsolete Cultivars

These are the varieties developed by systematic breeding effort which were popular earlier and now have been replaced by new varieties. Improved varieties of recent past are known as obsolete cultivars. Obsolete varieties have several desirable characters they constitute an important part of gene pool. Example : Wheat varieties K65, K68, pb 591 were most popular traditional tall varieties before introduction of high yielding dwarf Mexican wheat varieties. Now these varieties are no more cultivated. They are good genetic resources and have been widely used in wheat breeding programmes for improvement of grain quality. Now such old varieties are found in the genepool only.

3. Modern cultivars

The currently cultivated high yielding varieties are referred to as modern cultivars. They are also known as improved cultivars or advanced cultivars. These varieties have high yield potential and uniformity as compared to obsolete varieties land races.They constitute a major part of working collections and are extensively used as parents in the breeding programmes. As these are good sources of genes for yield and quality, can be introduced in a new area and directly released. However, these have narrow genetic base and low adoptability as compared to land races

4**. Advanced breeding lines**

These are pre -released plants which have been developed by plant breeders in modern scientific breeding programmes. These are known as advanced lines, cultures and stocks.This group includes, nearly homozygous lines, lines derived from biotechnology programmes i.e. transgenic plants and mutant lines etc. These lines which are not yet ready for release to farmers. They often contain valuable gene combinations.

5. **Wild forms of cultivated species**

Wild forms of cultivated species are available in many crop plants. Such plants have generally high degree of resistance to biotic and abiotic stresses and are utilized in breeding programmes. They can easily cross with cultivated species. Wild forms of many crop species are extinct.

6. Wild Relatives

Those naturally occurring plant species which have common ancestry with crops and can cross with crop species are referred to as wild relatives or wild species. Wild relatives include all other
species, which are related to the crop species by descent during their evolution. Both these groups are sources of valuable genes for biotic and abiotic stress and for quality traits and yield.

7. Mutants

Mutation breeding is used when the desired character is not found in the genetic stocks of cultivated species and their wild relatives. Mutations do occur in nature as well as can be induced through the use of physical and chemical mutagens. The extra variability which is created through induced mutations constitutes important components of genepool. Mutant for various characters sometimes may not be released as a variety, but they are added in the genepool. The germplasm includes those carrying gene mutations, chromosomal aberrations and markers genes etc. are considered special genetic stocks. They are useful in breeding programmes.

The gene pool system of classification

The pool of a crop includes all cultivars, wild species and wild relatives containing all the genes available for breeding use.

Based on degree of relationship, the gene pool of crops can be divided into three groups (Harland and Dewet, 1971)

1. **Primary gene pool**
2. **Secondary Gene pool**
3. **Tertiary gene pool**

These are briefly discussed below:

1. **Primary gene pool (GP1)** : This is also known as gene pool one (GP1). The gene pool in which intermating is easy and leads to production of fertile hybrids is known as primary gene pool. It includes plants of the same species or of closely related species which produce completely fertile offspring on intermating. In such gene pool, genes can be exchanged between lines simply by making normal crosses. This is the material of prime breeding importance.
2. **Secondary gene pool (GP2)** : This type of gene pool is also known as gene pool two (GP2). The genetic material that leads to partial fertility on crossing with GP1 is referred to as secondary gene pool. It includes plants that belong to related species. Such material can be crossed with primary gene pool, but usually the hybrids are sterile and some of the progeny to some extent are fertile. Transfer of gene from such material to primary gene pool is possible but difficult.
3. **Tertiary gene pool (GP3) :** The genetic material which leads to production of sterile hybrids on crossing with primary gene pool is termed as tertiary gene pool or gene pool three (GP3). It includes material which can be crossed with GP1, but the hybrids are sterile. Transfer of genes from such material to primary gene pool is possible with the help of special techniques.

Types of seed collections

Based on the use and duration of conservation, seed collections are of three types

1. **Base Collection**

2. **Active Collection**
3. **Working collection**

Base collections: It is also known as principal collection. These consist of all the accessions present in the germplasm of a crop. They are stored at about -18C or -20C with 5 + 1% moisture content; they are disturbed only for regeneration. When the germination of an accession falls below, usually, 95% of its germination at the start of storage, the accession is regenerated. For reasons of safety, duplicates of base collections should be conserved in other germplasm banks as well. High quality orthodox seeds can maintain good viability upto 100 years.

Active collections : The accessions in an active collection are stored at temperatures below 15C (often near 0C), and the seed moisture is kept at 5%. The storage is for medium duration, i.e., 10-15 years. These collections are actively utilized in breeding programme. These collections are used for evaluation, multiplication and distribution of the accessions. They are usually maintained by multiplying the seeds of their own accessions. But from time to time, base collection material should be used for regeneration of these collections. Germination test is carried out after every 5-10 years to assess the reduction in seed viability.

Working collections : The accessions being actively used in crop improvement programmes constitute working collection. Their seeds are stored for 3-5 years at less than 15C and they usually contain about 10% moisture. These collections are maintained by the breeders using them.

Core collection

The concept of core collection was proposed by Franked it refers to a subset of base collection which represents the large collection. Or a limited set of accessions derived from an existing germplasm collections.

Germplasm activities

There are six important activities related to plant genetic resources

1. Exploration and collection
2. Conservation
3. Evaluation
4. Documentation
5. Multiplication and Distribution
6. Utilization

Exploration & Collection :-

Exploration refers to collection trips and collection refer to tapping of genetic diversity from various sources and assembling the same at one place. The exploration and collection is a highly scientific process. This process takes into account six important items, *viz*, (1) sources of collection, (2) priority of collection, (3) agencies of collection, (4) methods of collection, (5) methods of sampling and (6) sample size.

Merits and Demerits

There are several merits and demerits of exploration and collection of germplasm, some of which are as discussed below:

Merits:

1. Collection helps in tapping crop genetic diversity and assembling the same at one place.

2. It reduces the loss of genetic diversity due to genetic erosion.

3. Sometimes, we get material of special interest during exploration trips.

4. Collection also helps in saving certain genotypes from extinction.

Demerits:

1. Collection of germplasm especially from other countries, sometimes leads to entry of new diseases, new insects and new weeds.

2. Collection is a tedious job.

3. Collector, sometimes has encounter with wild animals like elephants, tigers etc.

4. Transportation of huge collections also poses difficulties in the exploration and collection.

2. Germplasm Conservation

Conservation refers to protection of genetic diversity of crop plants from genetic erosion. There are two important methods of germplasm conservation or preservation. or

Germplasm conservation refers to maintain the collected germplasm in such a state that there is minimum risk for its loss and that either it can be planted directly in the field or it can be prepare for planting with relative ease when ever necessary. There are two important methods of germplasm conservation or preservation *viz.,*1. In situ conservation 2. Ex situ conservation

i. ***In situ* conservation**

Conservation of germplasm under natural habitat is referred to as in situ conservation. This is achieved by protecting this area from human interference : such an area is often called as natural park, biosphere reserve or gene sanctuary. A gene sanctuary is best located within the centre of origin of crop species concerned, preferably covering the microcenter with in the centre of origin. NBPGR, New Delhi is making attempts to establish gene sanctuaries in Meghalaya for Citrus and in the North-Eastern region for *Musa, Citrus, Oryza*, *Saccharum* and *Megifera.*

This method of preservation has following main disadvantages

Each protected area will cover only ve ry small portion of total diversity of a crop species, hence several areas will have to be conserved for a single species.

The management of such areas also poses several problems.

This is a costly method of germplasm conservation

Merits : Gene sanctuaries offer the following two advantages.

A gene sanctuary not only conserves the existing genetic diversity present in the population, it also allows evolution to continue. As a result, new alleles and new gene combinations would appear with time.

The risks as sociated with ex situ conservation are not operative.

ii. ***Ex situ* conservation**

Conservation of germplasm away from its natural habitat is called ex situ germplasm conservation. This method has following three advantages.

It is possible to preserve entire genetic diversity of a crop species at one place.

Handling of germplasm is also easy

This is a cheap method of germplasm conservation

Preservation in the form of seed is the most common and easy method, relatively safe, requires minimum space and easy to maintain. Glass, tin or plastic containers are used for preservation and storage of seeds. The seed can be conserved under long term, medium term and short term storage conditions.

Roberts in 1973 classified seeds on the basis of their storability, into two major groups.*viz.,*

1. Orthodox seeds 2. Recalcitrant seeds

1. Orthodox Seeds:

Seeds of this type can be dried to low moisture content of 5% and stored at a low temperature without losing their viability are known as orthodox seeds. Most crop seeds belong to this category. Such seeds can be easily stored for long periods; their longevity increases in response to lower humidity and storage temperature. Eg. Wheat, Rice, Corn, Chickpea, Cotton, Sunflower

2. Recalcitrant Seeds:

The viability of this group of seeds drops drastically if their moisture content is reduced below 12-30%. Seeds of many forest and fruit trees, and of several tropically crops like Citrus, cocoa, coffee, rubber, oil palm, mango, jackfruit, etc. belong to this group. Such seeds present considerable difficulties in storage. They require *in situ* conservation.

3. Evaluation

Evaluation refers to screening of germplasm in respect of morphological, genetical, economic, biochemical, physiological, pathological and entomological attributes. Evaluation requires a team of specialists from the disciplines of plant breeding, physiology, biochemistry, pathology and entomology. First of all a list of descriptors (characters) for which evaluation has to be done is prepared. This task is completed by a team of experts from IPGRI, Rome, Italy. The descriptors are ready for various crops. The evaluation of germplasm is down in three different places, *viz.,* (1) in the field, (2) in green house, and (3) in the laboratory.

4. Documentation

It refers to compilation, analysis, classification storage and dissemination of information. In plant genetic resources, documentation means dissemination of information about various activities such as collection, evaluation, conservation, storage and retrieval of data. Now the term documentation is more appropriately known as information system. Documentation is one of the important activities of genetic resources. Large number of accessions are available in maize, rice, wheat, sorghum, potato and other major crops. About 7.3 million germplasm accessions are available in 200 crops species. Handling of such huge germplasm information is only possible through electronic computers.

5. Distribution

- The specific germplasm lines are supplied to the users on demand for utilization in the crop improvement programmes.
- Distribution of germplasm is the responsibility of the gene bank centres
- The germplasm is usually supplied to the workers who are engaged in research work of a particular crop species.
- Supplied free of cost to avoid cumbersome work of book keeping.
- The quantity of seed samples depends on the availability of seed material and demands

▪ Proper records are maintained about the distribution of material.

6. Utilization

It refers to use of germplasm in crop improvement programmes. The germplasm can be utilized in various ways. The uses of cultivated and wild species of germplasm are briefly discussed below:

a) Cultivated Germplasm

It can be used in three main ways: (1) as a variety, (2) as a parent in the hybridization, and (3) as a variant in the gene pool.

Wild Germplasm: it is used to transfer resistance to biotic and abiotic stresses, wider adaptability and sometimes quality such as fibre strength in cotton.

Organizations associated with germplasm

IPGRI – International Plant Genetic Resources Institute

NBPGR – National Bureau of Plant Genetic Resources

ROLES OF PLANT GENETIC SOME USES AND RESOURCES

In order to grasp the importance as well as current challenges in the conservation and utilization of PGR, there is need to outline some benefits of PGR.

1. Development of new variations through genetic modification techniques.
2. Transfer of a genetic trait, such as a gene for pesticide resistance taken out of one species and put into another.
3. Production of recombinant cell lines and transgenic plants.
4. Use of *in vitro* nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA); and direct injection of nucleic acid into cells or organelles
5. Use of fusion of cells beyond the taxonomic family.
6. Sequencing genes or genomes (e.g. identification of genes coding for useful traits; molecular systematics for understanding evolutionary relations; genotyping of plants for identification and DNA barcoding of plants for identification; environmental genomics)
7. Phenotyping of the characteristics of plants, animals and micro-organisms for ecological and other studies and purposes
8. Experimental evaluation of heritable characteristics
9. Creation of collections of reference specimens in repositories such as museums and herbaria Isolation of a compound from genetic material for the purpose of characterization and evaluation.

Cryopreservation: Cryopreservation is a technique that ensures safe, long-term conservation of genetic resources of plant species with recalcitrant seeds, of vegetatively propagated species and of biotechnology products such as somatic embryos, cell lines and genetically transformed material. The technique was implemented at the end of the 20th century and could be used today for routine cryostorage as long as some important factors were taken into consideration. Tissue culture procedures are usually required to multiply super cooled material via axillary shoots or somatic embryogenesis, and were improved for use with tree species in recent years. In addition, production of transgenic tree species and molecular breeding procedures require functional cryopreservation protocols.

LECTURE NO. 12
ADAPTABILITY AND STABILITY

Adaptability & Stability –

The success of crop improvement activities largely depend on the identification of superior varieties for mass propagation. A variety can be considered superior if it has potential for high yield under favourable environment and the same time great deal of phenotypic stability. Stability of a genotype refers to its performance with respect to changing environment factor over time within a given location.

Adaptation and Adaptability:

Adaptation:-

It refers to those changes in structure or function of an individual/population which lead to better survival in a given environment is known as adaptation.

Adaptability:

Ability to genotype to exhibit relatively stable performance in different environment or capacity of a genotype or population for genetic change in adaptation.

Types of Adaptability –

Adaptation

Genotypic Adaptation	Population Adaptation
It is associated with the individual genotype whether homozygous (inbred) or heterozygous (hybrid) in as specific environment	It is related with the heterozygous population in a specified environment
1. **Specific** genotype adaptation 2. General genotypic adaptation	1. Specific population adaptation 2. General population adaptation

1. **Specific genotype adaptation –** It is the close adaptation of genotype to a limited environment.
2. **General genotypic adaptation –** It is refers to the capacity of a genotype to produce a wide range of phenotypes compatible with a wide range of environmental conditions.
3. **Specific Population adaptation –** It refers to the capacity of heterogeneous population to adapt to specific environment.
4. **General population adaptation –** It is the capacity of heterogeneous population to adapt to the variety of environment.

FACTOR AFFECTING ADAPTABILITY-

1. **Heterogeneity –** The heterogeneous population have broad genetic base, Such population have greater capacity to stabilize production over a wide range of changing environment.
2. **Heterozygosity –** It has been observed that heterozygous individual such as F1 hybrids are more stable than their homozygous parents to environmental variation.
3. **Genetic polymorphism –** The regular occurrence of several phenotypes in a genetic population is known as genetic polymorphism.

4. **Mode of Pollination –** The cross pollination species have better buffering capacity that self pollination species because of more heterozygosity.

STABILITY ANALYSIS

It refers to the suitability of variety for general cultivation over wide range of environments.

- ✓ Stability refers to the performance with respective changing environmental factors overtime within given location.
- ✓ Selection for stability is not possible until a biometrical model with suitable parameters is available to provide criteria necessary to rank varieties / breeds for stability.
- ✓ Low magnitude of G.E interaction involves the consistent performance of a population over variable environments.
- ✓ It consists of following steps: Location / environment wise analysis ofθ variance. pooled analysis of variance for all the locations/ environments.
- ✓ If G.E interaction is found significantθ ,stability analysis can be carried out using one of the four methods:

1.Finlay and Wilkinson model (1963)
2.Eberhat and Russell model(1966)
3.Perkins and Jinks model(1968)
4.Freeman and Perkins model (1971)

1. Finlay and Wilkinson model (1963)

- ✓ **Used two parameters**

1)Mean performance over environments.
2)Regression performance in different environments.
The following inferences can be drawn:
1)The regression coefficient of unity indicates average stability.
2)If the regression coefficient is >1,it means below average stability.
3) If the regression coefficient is <1, it means above average stability
4) Regression coefficient of 0 would express absolute stability.

MERITS

- ✓ Analysis of this model is simple.
- ✓ 2 parameters- mean yield over locations and regression coefficient are used to asses the phenotypic stability.

DEMERITS

- ✓ The deviations from the regression line are not estimated which are important for the stability analysis.
- ✓ Greater emphasis is given on mean performance over environments than regression coefficients.

2. Eberhat and Russell model(1966)

- ✓ It is the most popular and useful model.
- ✓ In 1966 both made further improvement in stability} analysis by partitioning the G.E interaction of each variety into 2 parts. one is slope of the regression line , second is deviation from regression line.
- ✓ In this model total variance is first divided into 2 components: -genotypes -environment plus interaction (E+G*E)
- ✓ The second component is further divided in to 3 components.

I. Environment linear
II. G.E linear
III. Pooled deviations

- ✓ Sum of squares due to pooled deviations are further divided into sum of squares due to individual genotype.

MAIN FEATURES OF THIS MODEL

- ✓ This model consists of three parameters
  a) mean yield over locations
  b)regression coefficient =bi
  C)Deviation from regression =s^2di
- ✓ Analysis of stability parameters is simple asϖ compared to other models of stability analysis.
- ✓ The degree of freedom for environment is 1.
- ✓ It requires less area hence less expensive when compared to other models.
- ✓ It does not provide independent estimation forϖ mean performance and environmental index

ANOVA TABLE

Source of variation	Degrees of freedom
Genotypes	g-1
E+ G*E interaction	g(e-1)
environment (linear)	1
G.E linear	g-1
pooled deviations	g(e-2)
genotype-1	e-2
genotype-2	e-2
Pooled error	ge(r-1)

Merits:

It measures three parameters of stability
A=mean yield over environments
B=regression coefficient
C=deviation from regression line

- ✓ It provides more reliable information on stability than Finlay and Wilkinson model.
- ✓ Analysis is simple.

Demerits:

- ✓ Estimation of mean performance and environment index is not independent.
- ✓ There is a combined estimation of sum of squares of environment and interactions which is not proper.
- ✓ Eberhart and Russell (1956) defined stable variety as one with a regression coefficient of unity(b=1) and a minimum deviation from the regression lines(s^2d=0).

3. Perkins and Jinks model(1968)

- ✓ In this model total variance is first divided into 3 components.

1)genotypes
2)environments

3)genotypes x environment
G-E variance is sub divided into
a) heterogeneity due to regression
b) sum of square due to remainder

- ✓ This model is less expensive than Freeman and Perkins.
- ✓ It requires less area for experimentation.
- ✓ The degree of freedom for environment is e-2
- ✓ Analysis is more difficult than Eberhart and Russell model.
- ✓ It does not provide independent estimation of mean} performance and environmental index.

ANOVA TABLE

Source of variation	Degrees of freedom
Genotypes	g-1
Environment	e-1
Genotype x environment	(g-1)(e-1)
Heterogeneity among regressions	g-1
Remainder	(g-1)(e-2)
Error	ge(r-1)

4. Freeman and Perkins model (1971)

- ✓ In this model total variance is first divided into 3 components.

1)Genotypes
2)environment
3) G*E

- ✓ The environmental s.s is sub divided into 2 components

a) combined regression
b) residual 1 The interaction variance is also subdivided into two parts
a)homogeneity of regression b) residual 2

- ✓ This model also includes 3 parameters like Eberhart and Russell model and provides independent estimation of mean performance and environmental index.
- ✓ The degree of freedom for environment is e-2 like perkins and jinks model.
- ✓ Analysis of this model is more difficult and expensive} as compared to earlier two models. Source of variation D

ANOVA TABLE

Source of variation	Degrees of freedom
Genotypes	g-1
Environment	e-1
Combined regression	1
residual (1)	e-2
Interaction(GxE)	(g-1)(e-2)
Heterogeneity of regressions	g-1
residual (2)	(g-1)(e-2)
error	ge(r-1)

Applications of Stability Analysis –

1. Stability analysis is helps in understand the adaptability of crop varieties over wide range of environment conditions and in the identification of adaptable genotype.
2. The use of adaptable genotype for general cultivation over wide range of environmental conditions helps in achieving stabilization in crop production over locations and year.
3. Use the stable genotypes in the hybridization programme will lead to development of phenotypically stable high potential cultivars of crop species
4. Stability analysis is an important tool for plant breeders in predicting response of various genotypes over changing environments.

LECTURE NO. 13 & 14
Hybrid seed production technology in Rabi crops -Sunflower, Safflower, Castor, Rabi Sorghum

1. HYBRID SEED PRODUCTION IN SUNFLOWER

- ✓ Hybrids are produced by employing cytoplasmic genetic male sterility.
- ✓ The male sterile female and male parents are raised in BSH 3, 1:6, KBSH 1,⌉ 1:4 ratio under 400 m isolation.
- ✓ Seeds are produced by transferring the pollen of male parent to the female parent with the help of honeybees reared at 5 hives / ha.

HYBRIDS

BSH -1 = CMS 234 A x RHA 274
KBSH 1 = " x 6 DI
MSFH 1 = MHS 71 x MHR 48
MSFH 8 MSFH -17
TCSH 1 = CMS 234 A x RHA 272
Season: June - July, October - November
Isolation distance: **Foundation** seed **Certified** seed Hybrids **600 m 400 m**

SEEDS AND SOWING

Seeds are sown in ridges and furrows
Seed rate: Female 12 kg /ha and Male 4 kg/ha.
Spacing 60 x 30 cm (hybrids)
Planting ratio : 8:1 or 4:1
Border row : two

Manures and fertilizers

Compost : 12.5 t/ha
NPK : 60:45:45 kg /ha

Supplementary pollination

1. As in varieties In hybrids, the palm is first gently rubbed on the male parent flowers and then on the female line to transfer the pollen.
2. Keeping of bee hives 5 ha-1 .

ROGUING

Plants are rogued based on plant height, head size and colour of seeds during pre-flowering stage upto harvest.

Field standards

	Foundation seeds	**Certified seeds**
Off types	0.1 %	0.2%

Harvesting

The change of head colour from green to **lemon yellow** is the indication of **physiological maturity.**
The heads are harvested separately **first** in **male** and **then** in **female**.

Drying, processing and others – as in varieties

Seed standards

The graded seed should possess the following characters for certification and sale as certified/ truthfully labelled seeds

Parameter	FS	CS
Physical purity (min) %	98	98
Inert matter (max) %	2	2
Germination (min)%	60	60
Moisture content (max)%		
(a) Open storage	8	8
(b) Moisture vapour proof Storage	5	5

2. HYBRID SEED PRODUCTION IN SAFFLOWER

Varieties – Manjira, Sgaramuthyalu (APRR – 3), Parbhani Kusum, Phule Kusum, A-1 (National Check)

Hybrids - DSH – 129, NH – 1 (Firdt non-spiny hybrid in the world), NARI – 15, NARI – 38, Bhima, Girna, Sharda and Sweta.

LAND PREPARATION:

- ✓ Safflower requires fairly pulverized seed bed free from clods. Being a deep rooted crop it requires deep ploughing.
- ✓ Crop raised for dye purpose require more and fine tilth than oil crop.
- ✓ One deep ploughing with M.B. plough is sufficient followed by 2-3 harrowings with planking.

Isolation Distance-

Foundation seed **Certified** seed Hybrids **600 m 400 m**

SEED AND SOWING:

Season – *rabi*

Time of Sowing –

II. FN September to I. FN of October.

If the crop is delayed, Aphid damage is more common.

Seed Rate – 8-10 kg/ha pure crop.

4-6 kg/ha- Mixed crop/ Border crop.

Spacing - 45×20 cm.

Method of sowing – Broadcasting, behind the plough (pora method) and seed drill.

Depth of sowing – 4-5 cm (Normal). 7.5-10 cm (dry Land).

Thinning – 10-15 DAS.

Very high density of plant population significantly reduces the branching ability.

MANURES AND FERTILIZERS:

NPK- 60 - 65kgN, 30 kgP 2O5 and 40 – 45 kg K2O ha

FYM @ 5-10 t/ha

HARVESTING:

- ✓ The crop comes to maturity within 110-120 days.
- ✓ As soon as the leaves and most of the bracteoles except a few of last formed become brown and seeds are dried and easily separated from the head.
- ✓ The crop is harvested either by uprooting the plant or cutting at the bottom.

- ✓ Plants are thorny and harvesting is taken up at the early hours of the day and to be completed before 10.00 am when the spines will be soft.
- ✓ As the day advanced, spine becomes stiff causing inconvenience to harvesting.
- ✓ The harvested plants are heaped for a day or two in the field and threshed by beating with stick, cleaned, dried and stored at 8% moisture content.
- ✓ Combined harvesters used in wheat could also be used for harvesting and threshing.
- ✓ The heads are harvested separately **first** in **male** and **then** in **female**.

Drying, processing and others – as in varieties

Seed standards

- ✓ The graded seed should possess the following characters for certification and sale as certified/ truthfully labelled seeds

3. HYBRID SEED PRODUCTION OF CASTOR

Land requirement

- ✓ Well drained fertile soil should be selected.
- ✓ The crop cannot tolerate alkalinity and salinity.
- ✓ It performs well with medium to deep sandy loam and heavy loam soils are highly suited for seed production.

Isolation distance

	Foundation seed	**Certified seed**
Varieties and Hybrids	600 m	300 m

Season

Rabi / Winter – Hybrid seed production.

Summer and kharif provide ideal male promoting environment for undertaking seed production of the variety, male and female parents of hybrids.

Kharif and summer encourages good expression of less productive plant which could be easily eliminated through timely roguing.

Female parents when raised in male promoting environment produce environmentally sensitive staminate flowers, which are very essential for self production of the female parents.

Seed and sowing

Seed rate : **10 kg** / ha (varieties)

2 kg / ha male and 5 kg/ ha female for hybrids.

Spacing

Varieties : 90 x 20 to 90 x 60 cm

Hybrids : 90 x 40 to 90 x 60 cm

Planting ratio 3:1 or 4 - 6:1

Fertilizer : Basal 40:60: 40 NPK / ha Top: 1st 20 kg N/ha (40-50 DAS) , 20 kg N/ha. (After 1st picking)

Bloom: Presence of white waxy coating which protects from chilling and jassid attack.

4 types of bloom:

1. No bloom
2. Single bloom - Bloom only on stem
3. Double bloom- On stem, petioles, and lower sides of leaves

4. Triple bloom - On all parts

Stages of inspection

- ✓ 10 days prior to flowering -Stem colour, inter-node length.
- ✓ During flowering - No. of nodes upto primary raceme
- ✓ Before 1st picking (Spike and capsule character, reversion to monoecious in second order raceme)
- ✓ After 1st picking - Reversion to monoecious or flower initiation in third order raceme.

Irrigation

- ✓ Critical stages are primordial initiation and flowering stage in differential segmental order branches.
- ✓ Moisture stress in sensitive crop growth stages may lead to production of more male flowers in monoecious varieties.

Harvesting

- ✓ Castor produces 4 or 5 sequential order spikes, which can be harvested in 3- 4 pickings starting from 90-120 days at 25-30 days interval.
- ✓ Premature harvesting leads to reduced seed weight, oil content and germination.
- ✓ If shattering is not a problem in a variety, harvesting can be delayed until all capsules are fully dried.

Grading

The seeds are size graded using round perforated metal sieve of 8/64".

Field standards

	Foundation seeds	Certified seeds
Off types (Varieties)	0.1	0.2%
Off types (Hybrids)	0.5	1.0%

Seed storage

- ✓ Seed treatment with Thiram @ 2 g / kg
- ✓ Storability in Pervious container - 1 year
- ✓ Storability in Moisture vapour proof container - 2

Seed standards

The graded seed should possess the following characters for certification and sale as certified/ truthfully labelled seeds

Parameter	Foundation seed	Certified seed
Physical purity (min) %	98	98
Inert matter (max) %	2	2
Other crop seed &Weed Seed (max)	-	-
Other distinguishable variety seeds	5 / kg	10/kg
Germination (min)%	70	70
Moisture content (max)%		
(a) Open storage	8	8
(b) Moisture vapour proof storage	5	5

Varieties - SA 1, SA 2, TMV 4, 5, 6, CO 1, Aruna, Bhagya and Sowbaghya.

5. HYBRID SEED PRODUCTION OF RABI SORGHUM

Breeding technique for Commercial production

Cytoplasmic genetic male sterility (CGMS)

Seeds produced in different stages

Nucleus seed stage : Maintenance of basic source by seed to row progenies.

Breeder Stage : A (AxB), B and R line are multiplied

Foundation Stage : A (AxB) and R line are multiplied

Breeder and foundation seed stage : Multiplication of male sterile line or maintenance of A and B line

Certified seed stage : A x R – F1 hybrid produced.

Certified seed stage : Production of hybrid seed

Stages of Seed Production

Breeder seed - - -> A x B - B - R

Foundation seed - - -> A x B - B - R

Certified seed - - -> A x R

Popular hybrids of their parents:

The first hybrid (CSH 1) was released in 1964. In 1969, the Coordinated Sorghum Improvement Project was established. Now there are more than 30 hybrids.

Some popular are

CSH1	CK 60 A x IS 84
CSH5	2077A x CS3541
CSH9	MS 296 A x CS 3541
COH2	2219A x IS3541(Kovilpatti Tall)
COH3	2077A x CO21
COH4	296A x TNS30
CSH13 R	296 A x RS 29
CSH14	AKMS 14A x AKR 150
CSH16	27 A x C 43
CSH15 (R)	104 A x R 585
CSH17	AKMS 14A x RS 673

Stages of seed multiplication : Breeder seed – foundation seed – certified seed.

Foundation seed production : A and B line are raised in 4:2 ratio with 4 rows of B line as border row and allowed for cross pollination. The seeds from A line will be collected as A line seeds (multiplied).

Certified seed production : Hybrid seed production

Commercial in Hybrid seed production techniques

	Isolation distance	
	FS	**CS**
Normal	200	100
On presence of Johnson Grass	400	400
On Presence of forage Sorghum	400	200
Hybrids	300	200

SEEDS AND SOWING

Seed rate : A line : 8 kg ha-1 R line : 4 kg ha-1

Spacing : A line : 45 x 30cm R line : 45 x solid row spacing.
Planting ratio : Foundation seed stage: 4:2 (A: B)
Certified seed stage : 5.2 (A:R)
Border rows : 4 rows of male (either B or R line) to, supply adequate pollen.
Live markers : • Live plants used for identification of male line live markers are used.
• It should have distinguishable morphological characters.
• Live markers can be sunflower, daincha etc.

MANURES AND FERTILIZERS
Compost : 12.5 t / ha
NPK : 100:50:50 kg ha-1
Basal : 50:50:5 kg ha-1
Top dressing : 25kg N after last ploughing
25kg N after boot leaf stage (45 days)
Synchronization technique
1. Staggered sowing: Sowing of male parent and female parents are adjusted in such a way that both parents come to flowering at the same time.
✓ CSH-5, MS 2077 A must be sown 10-15 days earlier to the male
✓ CS 3541,CSH 6, the female parent MS 2219 A can be sown simultaneously with CS 3541
✓ CSH 9, the female parent MS 296 A must be sown 7-10 days earlier than male
✓ CS 3541 in November- December season.
2. Spraying growth retardent MH 500 ppm at 45 DAS, delays flowering in advancing parent.
3. MH wont dissolve in water and hence dissolve it in NaOH and then mix with water.
4. Urea spraying 1% to the lagging parent.
5. Withhold one irrigation to the advancing parent.
6. Spraying CCC 300 ppm will delay flowering.

FIELD STANDARDS

	Isolation Distance	
	FS	**CS**
Offtypes (max) Varieties	0.05	0.10
Hybrids	0.05	0.10
Pollen shedders (max)	0.05	0.10
Designated diseased plants (max) (Ergot and smut)	0.05	0.10

Designated disease
1. Kernel smut
2. Head smut
3. Sugary disease of sorghum
✓ It is specific to hybrid

- ✓ Occur due to low seed set
- ✓ Spray rogor 0.03% (or)
- ✓ Endosulfan 0.07%

METHOD OF HARVESTING

- ✓ Male and female lines should be harvested separately.
- ✓ The male rows are harvested first and transported to separate threshing floor.
- ✓ Like that female rows are harvested and threshed separately.

Threshing

- ✓ At the time of threshing the seed moisture content should be reduced around 15-18%.
- ✓ Threshing can be done by beating the earheads with bamboo sticks.
- ✓ While using the mechanical threshers, care should be taken to avoid mechanical damage.

Drying

Seed should be dried to 12% for short term storage and 8% for long term storage.

Processing

The sorghum seeds can be processed in OSAW cleaner cum grader using 9/64" round perforated metal sieve.

SEED TREATMENT AND STORAGE

- ✓ The seeds are treated with captan or thiram @ 2 g/kg of seed and pack it in cloth bag at 12% moisture content for short term storage and 8% moisture content in 700 gauge poly ethylene bag for long term storage (or) The seeds can also be treated with halogen mixture @ 3 g/kg of seeds.
- ✓ Thehalogen mixture is prepared by mixing CaOCl2 and CaCO3 +Albizzia amara at the rate of 5:4:1 and this mixture is kept in an air tight plastic container for 1 week.
- ✓ After one week the mixture is used for seed treatment.
- ✓ The treated seeds can be stored upto 12 months under open storage and upto 18 months in moisture vapour proof containers, provided it is not infested by the storage insects.

Seed yield : 3000 kg ha-1

SEED STANDARDS

	Foundation seed	**Certified seed**
Physical purity (%)	98	98
Inert matter (%)	2	2
Other crop seed	5 kg^{-1}	10 kg^{-1}
Weed seed	10 kg-1	20 kg-1
Other distinguishable variety	10 kg-1	20 kg-1
Ergot disease by number	0.020%	0.040%
Moisture content		
Moisture pervious container	12	12
Moisture vapour proof container	8	8

LECTURE 15 & 16
Ideotype concept and climate resilient crop varieties for future- Wheat, Rice, Maize, Sorghum and Cotton

IDEOTYPE CONCEPT

Crop Ideotype :-

Crop **ideotype** refers to model plants or ideal plant type for a specific environment.

"In broad sense an **ideotype is a biological model which is expected to perform or behave in a predictable manner within a defined environment"**.

- ✓ More specifically, crop ideotype is a plant model which is expected to yield **greater quantity of grains, fibre, oil or other** useful product when developed as a cultivar.
- ✓ The term ideotype was first proposed by **Donald in 1968 working on wheat.**

Ideotype Breeding :-

Ideotype breeding can be defined **as a method of crop improvement which is use to enhance genetic yield potential through genetic manipulation of individual plant character.**

Main features of ideotype breeding are:-

1. Emphasis on individual trait
2. Includes yield enhancing traits
3. Exploits physiological variation
4. Slow progress
5. Selection
6. Designing of model
7. Interdisciplinary approach
8. A continuous process

Differences between traditional and ideotype breeding

Sr. No.	Traditional	Ideotype
1	The main objective is defined before initiating the breeding work.	The conceptual theoretical model is prepared before initiation of breeding work
2	Selection is focused on yield and some other characters	Selection is focused on individual plant characters.
3	It usually includes various morphological and economic characters.	It includes various morphological, physiological and biochemical plant characters
4	Value of each character is not fixed in advance	Value of each trait is defined in advance.
5	This is a simple and rapid method of cultivar development	This is a difficult and slow method of cultivar development
6	The phenotypic of a new variety is not specified in advance	Phenotype of new variety to be developed is specified in advance

Features of crop ideotypes

- ✓ The crop ideotype consists of several morphological and physiological traits which contribute for enhanced yield or higher yield than currently prevalent crop cultivars.
- ✓ The morphological and physiological features of crop ideotype differ from crop to crop and sometimes within the crop also depending upon whether the ideotype is required for irrigated cultivation or rainfed cultivation.
- ✓ Ideal plant types or model plants have been discussed in several crops like wheat, rice, maize, barley, cotton and beans.

The important features of ideotype from some crops are

WHEAT

The term ideotype was coined by **Donald in 1968** working on wheat. He proposed ideotype of wheat with following main features:

- ✓ **A short strong stem.** It imparts lodging resistance and reduces the losses due to lodging.
- ✓ **Erect leaves.** Such leaves provide better arrangement for proper light distribution resulting in high photosynthesis or CO2 fixation.
- ✓ **Few small leaves.** Leaves are the important sites of photosynthesis, respiration and transpiration. Few and small leaves reduce water loss due to transpiration.
- ✓ **Larger ear.** It will produce more grains per ear.
- ✓ **An erect ear.** It will get light from all sides resulting in proper grain development.
- ✓ **Presence of awns.** Awns contribute towards photosynthesis.
- ✓ A single culm.

RICE

The concept of plant type was introduced in rice breeding by **Jennings in 1964**, through the term ideotype was coined by Donald in 1968. He suggested that in rice an ideal or model plant type consists of

- ✓ Semi dwarf stature
- ✓ High tillering capacity and
- ✓ Short, erect, thick and highly angled leaves
- ✓ More panicles /m2,
- ✓ High (55% ore more) harvest index.
- ✓ Now emphasis is also given on physiological traits in the development of rice ideotype.

MAIZE

IN **1975, Mock and Pearce** proposed ideal plant type of maize.

- ✓ Stiff-vertically-oriented leaves above the ear.
- ✓ Maximum photosynthetic efficiency.
- ✓ Efficient translocation of photysynthate into grain.
- ✓ Short interval between pollen shed and silk emergence.
- ✓ Small tassel size.
- ✓ Photoperiod insensitivity

- ✓ Cold tolerance
- ✓ Long Grain -filling period

SORGHUM

IN **Dr. Swaminathan 1972** proposed ideal plant type of Sorghum.

- ✓ High grain yield.
- ✓ Harvest index greater than 30.
- ✓ High ear head exertion.
- ✓ Panical DM of total Dm: >50%
- ✓ Higher relative water content.

COTTON

Ideotype for irrigated cultivation

- ✓ Short stature (90-120 cm).
- ✓ Compact and sympodial plant habit making pyramidal shape.
- ✓ Determinate in fruiting habit with unimodal distribution of bolling.
- ✓ Short duration (150-165 days).
- ✓ Responsive to high fertilizer dose.
- ✓ High degree of inter plant competitive ability.
- ✓ High degree of resistance to insect pests and diseases, and
- ✓ High physiological efficiency.

Rainfed conditions (Singh and Narayanan 1993)

- ✓ Earliness (150-165 days).
- ✓ Fewer small and thick leaves.
- ✓ Compact and short stature, indeterminate habit.
- ✓ Sparse hairiness,.
- ✓ Medium to big boll size.
- ✓ Synchronous bolling.
- ✓ High response to nutrients.
- ✓ Resistance to insects and diseases.

Classification of crop plants based on mode of pollination and mode of reproduction

Mode of pollination and reproduction	Examples of crop plants
Self Pollinated Crops	Rice, Wheat, Barley, Oats, Chickpea, Pea, Cowpea, Lentil, Green gram, Black gram, Soybean, Common bean, Moth bean, Linseed, Sesame, Khesari, Sunhemp, Chillies, Brinjal, Tomato, Okra, Peanut, Potato, *etc.*
Cross Pollinated Crops	Corn, Pearlmillet, Rye, Alfalfa, Radish, Cabbage, Sunflower, Sugarbeet, Castor, Red clover, White clover, Safflower, Spinach, Onion, Garlic, Turnip, Squash, Muskmelon, Watermelon, Cucumber, Pumpkin, Kenaf, Oilpalm, Carrot, Coconut, Papaya, Sugarcane, Coffee, Cocoa, Tea, Apple, Pears, Peaches, Cherries, grapes, Almond Strawberries, Pine apple, Banana, Cashew, Irish, Cassava, Taro, Rubber, *etc.*
Often Cross Pollinated Crops	Sorghum, Cotton, Triticale, Pigeonpea, Tobacco.

TABLE

Common Name	Botanical Name	Family	Chromosome No.	Origin
CERELS				
Wheat	*Triticum aestivum*	Poaceae	2n=42	South Asia
Oat	*Avena sativa*	Poaceae	2n=42	South Asia
Barley	*Hordeum vulgare*	Graminacae	2n = 14	Egypt
PULSES				
Chickpea	*Cicer arietnum*	Leguminoceae	2n=16	south-eastern Turkey and adjoining Syria.
OILSEED				
Sunflower	*Helianthus annus*	Composite	2n=34	America
Safflower	*Carthamum tinctorius*	Compositae	2n=24	Ethiopia & Afghanistan
Linseed	*Linum Usitatissimum*	Linaceae	2n=30	South Western Asia

Rapeseed	*Brsassica napus*	Brassicacea	2n=38	Europe region
Mustard	*Brassica nigra*	Brassicaceae	2n=36	India
FODDER				
Napir	*Pennisetum purpureum*	Poaceae	2n =27,28,56	Africa (Tropical Africa)
Bajra	*Pennisetum glaucum*	Poaceae/Graminea	2n=14	W. Africa
Sorghum	*Sorghum bicolor* L.	Poaceae/Gramneae	2n=20	Northeastern Africa or at the Egyptian
Maize	*zea mays*	Poaceae	Central America,mexico	2n=20
Barseem	*Trifolium alexandrium*	Leguminosae	2n = 16	Asia minor and from there it was introduced to Egypt
CASH CROP				
Sugarcane	*Saccharum officinarum*	Gramineae	2n=80	India
VEGETABLE CROPS				
Potato	*Solanum tuberosum L.*	Solanaceae	2n= 48	Tropical South America
Field Pea	*Pisum sativum L*	Fabaceae	2n= 14	Asia and Ethiopia
HORTICULTURAL CROPS				
Mango	*Mangifera indica* L.	Anacardaceae	2n=40	Indo-Burma Region
Aonla	*Phyllanthus emblica*	Euphorbiaceae	**2n=28**	Indo – china
Guava	*Psidium guajava*	Myrtaceae	2n=22	Tropical America / West Indies

……BEST LUCK……