PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURAL UNIVERSITY

DA-111

Basic Principles of Plant Breeding, Seed production Testing and Certification

Dr. K. Sumalini, Vice Principal
(Lecture No. 1-35)
&
Dr. K. Lakshmi Prasanna, Asst. Professor (Seed Tech.)
(Lecture No. 36-48)

Agricultural Polytechnic, Kampasagar,
Nalgonda Dist- 508 207

Lecture No.1:

PLANT BREEDING-INTRODUCTION-HISTORY AND ACHIEVEMENTS

Plant breeding can be defined as an art, a science, and technology of improving the genetic make up of plants in relation to their economic use for the man kind.

Introduction: Human population mainly depends on plants for food and other basic needs like cloths, fuel, construction material and medicines etc. Since civilization, man started cultivation of plants through selection.The process of bringing a wild species under human management is referred to as **domestication.** Domestication may be the most basic method of plant breeding. Domestication continuous today and is likely to continue for some time in future. Eg : In case of timber trees medicinal plants, microbes.

Likewise, man started selection of plants to meet his requirements and needs has risen as human population rises.

During the long period of historic cultivation natural selection has definitely acted on the domesticated species. Movement of man from one place to another brought about the movement of his cultivated plant species. In 1900, mendel laws of inheritance were rediscovered and laid foundation for the development of plant breeding.

For plant breeding, an applied science, a thorough knowledge on other branches of botany like genetics, cytology, plant physiology, plant taxonomy, cytogenetics, plant pathology, biometrics and agronomy is compulsory. Through application of genetics, plant breeder may achieve results in a short span of time.

History

Sir T.S. Venkatraman	An eminent sugarcane breeder, he transferred thick stem and high sugar contents from tropical noble cane to North Indian Canes. This process is known as noblization of sugarcane.
Panchanan Maheshwari	Invented invitro fertilization of angiosperms. This invention has allowed the creation of new hybrid plants that could not previously be crossbred naturally.
M.S. Swaminathan	Responsible for green revolution in India, developed high yielding varieties of Wheat, Rice, Potato and Jute. Establishment of M.S.Swaminathan Research Foundation.
Theophrastus (300BC)	Father of Botany
Parasharudu (1300 BC)	Krishi Parashara-A text on ancient Indian agriculture. Described ayurveda, types of forests, plant taxonomy, medicinal plants.
Gregor John Mendel (1850)	Done research on pea. Invented laws of inheritance and popularized as father of genetics.
Charles Darwin	Proposed theory of natural evolution. Enormous development in

	the branches of botany was achieved in 20th century.
Hugo de Vries (1991)	Invented mutations in plants.
Sutton-Boveri (1902)	Proposed Chromosome theory, a fundamental unifying theory of genetics which identifies chromosomes as the carriers of genetic material.
Watson-crick (1953)	Proposed the double helix structure of the DNA molecule.
Fraenkel-Conrat (1956)	Proposed the genetic material of RNA
Nirenberg, Har Gobind Khorana,Holley	Order of nucleotides in nucleic acids which carry genetic code of the cell and control the cell's synthesis of proteins.
Har Gobind Khorana	Artificial synthesis of gene
Knoll and Ruska (1932)	Build the first transmission electron microscope. Cell and cell organs study was became easier through electron microscope.
Prof.S.V.S.Ramdas	Eminent plant physiologist
Vode House, P.K.K.Nair, Vishnu mitre,Tharil, CGK Ramanujam, Sunil Malchnada	Developed Palynology
Sipra Guha Mukherjee and Satish Chandra Maheshwari	Developed tissue culture technique for producing homozygous pure lines of haploid plants.
Darwin	Theory of natural selection
W.L. Johannsen (1903)	Proposed the pureline theory that provided the genetic basis for individual plant selection.
G.H.Shull (1914)	Coined term heterosis. In maize, loss of vigor occur due to self pollination and hybrid vigor is more due to cross pollination.
Hugo de Vries (1900)	Used first time the term mutation
H.J.Muller (1927), L.J.Stadler (1928)	Laid foundation for mutation breeding
Karl Ereky	Coined term Biotechnology.

Plant breeding- Significant achievements

The achievements made in few crops through plant breeding is mentioned below.

1.Paddy:

- Establishment of CRRI in 1946.
- Taichung (native 1) of Taiwan was procured from IRRI, Philippines and developed dwarf varieties in 1965.
- AICRP on Rice was started at Hyderabad in 1965.
- In Japonica x Indica hybridization programme, developed ADT 27 variety and introduced Malinja and Mahsuri varieties from Malaysia.
- Released varieties in Andhra Pradesh: Tella Hamsa, Surekha, Phalguna.

2. Maize:

Established Co-ordinated research programme in 1957 at IARI, New Delhi. In collaboration with Rockfeller foundation, released first hybrid Ganga-1 in 1961.Amber Pop corn was proposed from Andhra Pradesh.

3.Wheat:

Established Co-ordinated research programme on wheat in 1964 at IARI, New Delhi. After invention of Norin 10-dwarfing gene, development of semi dwarf varieties was started. Through AICRP, released Kalyan sona and Sonalika varieties.

4. Bajra:

Tift 23A- male sterile parent

Newly developed male sterile lines:MS 5071A, MS 521, Pb 111A, MS 5054, MS 5141

Developed hybrids:PHB 10, PHB 14, CJ 104, BO 111, MBH 110

5.Jowar:

In 1960, development of sorghum hybrids was fastened. In 1964-65, released two hybrids CSH 1, CSH-2. Co-ordinated Research Project was started in 1969 at Hyderabad. Later released CSH-9.

6. Sugarcane:

Sugarcane Breeding Institute was established in 1912 at Coimbattore.Due to uniform flowering at Coimbattore, crossing work on sugar cane was started. CO word is used before the varieties ready for release. Eg: COS 410. Like that BO word is used before the varieties ready for release from Bihar. Eg: BO 91, BO 99.

7. Potato:

Central Breeding Station was established in 1935 at Simla. Later, it was changed as Central Potato Research Institute. Crossing work is carried only at Simla and Darjiling centres. Kufri name is used before the varieties ready for release from these centres.

8.Cotton:

1906: Due to introduction of Combodia cotton, cotton crop was popularized in south india as Combodia cotton is tolerant to jassids.

1917: Indian Cotton Committee was established to develop long staple cotton.

1921: Indian Central Cotton Committee was established – Notable researches on breeding and cultivation of cotton. Eg : 70 improved varieties of cotton

1965: Central Cotton Research Institute was established at Nagpur.

1967: ACIRP on cotton was started.

Hybrid Cotton H4 (Surat): In world, first hybrid released for commercial cultivation. Later, Varalaxmi hybrid was released from Dharwar.

High spinning cottons (Sujatha and Suvin) were of greatest achievements in Cotton Research. Suvin with 120 counts is as equivalent to Egyptian cotton.

9. Tea:

In tea, Assamese type is widely commercialized not only in India but also in entire world. In Tea, major breeding work is being carried out by private organizations. Tea breeding work was started at Tockle Experimental Station, Jorhat. TV word is used before the varieties ready for release through cloning. Eg: TV1,TV2,TV17,TV22,TV24.

For seed varieties 'St' word is used before the varieties ready for release. Eg: St 203 (Gourisankar), St 378 (Nandadevi), St 397.

Lecture no. 2:

DEFINITION, AIM, OBJECTIVES OF PLANT BREEDING

Definition :

Plant breeding can be defined as an art, a science, and technology of improving the genetic make up of plants in relation to their economic use for the man kind.

or

Plant breeding is the art and science of improving the heredity of plants for the benefit of mankind.

or

Plant breeding deals with the genetic improvement of crop plants also known as science of crop improvement.

or

Science of changing and improving the heredity of plants

Aim :

Plant breeding aims to improve the characteristics of plants so that they become moredesirable agronomically and economically. The specific objectives may vary greatly depending on the crop under consideration.

Objectives of Plant Breeding :

1. Higher yield : The ultimate aim of plant breeding is to improve the yield of economic produce. It may be grain yield, fodder yield, fibre yield, tuber yield, cane yield or oil yield depending upon the crop species. Improvement in yield can be achieved either by evolving high yielding varieties or hybrids.

2. Improved quality: Quality of produce is another important objective in plant breeding. The quality characters vary from crop to crop. Eg. grain size, colour, milling and backing quality in wheat. Cooking quality in rice, malting quality in barley, size, colour and size of fruits, nutritive and

keeping quality in vegetables, protein content in pulses, oil content in oilseeds, fibre length, strength and fineness in cotton.

3. Abiotic resistance : Crop plants also suffer from abiotic factors such as drought, soil salinity, extreme temperatures, heat, wind, cold and frost, breeder has to develop resistant varieties for such environmental conditions.

4. Biotic resistance : Crop plants are attacked by various diseases and insects, resulting in considerable yield losses. Genetic resistance is the cheapest and the best method of minimizing such losses. Resistant varieties are developed through the use of resistant donor parents available in the gene pool.

5. Change in maturity Duration / Earliness : Earliness is the most desirable character which has several advantages. It requires less crop management period, less insecticidal sprays, permits new crop rotations and often extends the crop area.

Development of wheat varieties suitable for late planting has permitted rice-wheat rotation. Thus breeding for early maturing crop varieties, or varieties suitable for different dates of planting may be an important objective. Maturity has been reduced from 270 days to 170 days in cotton, from 270 days to 120 days in pigeonpea, from 360 days to 270 days in sugarcane.

6. Determinate Growth : Development of varieties with determinate growth is desirable in crops like Mung, Pigeon Pea (*Cajanus cajan*), Cotton (*Gossypium sp.*),etc.

7. Dormancy : In some crops, seeds germinate even before harvesting in the standing crop if there are rains at the time of maturity, e.g., Greengram, Blackgram, Barley and Pea, etc. A period of dormancy has to be introduced in these crops to check loss due to germinatio n. In some other cases, however, it may be desirable to remove dormancy.

8. Desirable Agronomic Characteristics: It includes plant height, branching, tillering capacity, growth habit, erect or trailing habit etc., is often desirable. For example, dwarf ness in cereals is generally associated with lodging resistance and better fertilizer response. Tallness, high tillering and profuse branching are desirable characters in fodder crops.

9. Elimination of Toxic Substances : It is essential to develop varieties free from toxic compounds in some crops to make them safe for human consumption. For example, removal of neurotoxin in Khesari (*Lathyruys sativus*) which leads to paralysis of lower limbs, erucic acid from *Brassica* which is harmful for human health, and gossypol from the seed of cotton is necessary to make them fit for human consumption. Removal of such toxic substances would increase the nutritional value of these crops.

10.Non-shattering characteristics: The shattering of pods is serious problem in green gram. Hence resistance to shattering is an important objective in green gram.

11.Synchronous Maturity : It refers to maturity of a crop species at one time. The character is highly desirable in crops like Greengram, Cowpea, and Cotton where several pickings are required for crop harvest.

12.Photo and Thermo insensitivity: Development of varieties insensitive to light and temperature helps in crossing the cultivation boundaries of crop plants. Photo and thermo-insensitive varieties of wheat and rice has permitted their cultivation in new areas. Rice is now cultivated in Punjab, while wheat is a major *rabi* crop in West Bengal.

13.Wider adaptability : Adaptability refers to suitability of a variety for general cultivation over a wide range of environmental conditions. Adaptability is an important objective in plant breeding because it helps in stabilizing the crop production over regions and seasons.

14.Varieties for New Seasons : Traditionally Maize is a *kharif* crop. But scientists are now able to grow Maize as *rabi* and *zaid* crops. Similarly, mung is grown as a summer crop in addition to the main *kharif* crop.

Lecture No.3:

FLOWER AND ITS PARTS

Flower

Sexual reproduction involves fusion of male and female gametes to form a zygote, which develops in to an embryo. In crop plants, male and female gametes are produced in specialized structures known as flowers and it developed from modified vegetative shoot. A flower with a stalk is called pedunculate or pedicellate; without a stalk, it is sessile. Thalamus or receptacle is a swollen or flat or dome-shaped or concave structure present at the tip of the pedicel. The floral parts of a flower are arranged on the thalamus in a ring like fashion called whorls. A flower is basically made up of four concentric rings of structures. The outermost whorl of the flower has green, leafy structures known as sepals. The sepals, collectively called the calyx, help to protect the unopened bud. The second whorl is comprised of petals—usually, brightly colored—collectively called the corolla. The number of sepals and petals varies depending on whether the plant is a monocot or dicot. In monocots, petals usually number three or multiples of three; in dicots, the number of petals is four or five, or multiples of four and five. Together, the calyx and corolla are known as the perianth. The third whorl contains the male reproductive structures and is known as the androecium. The androecium has stamens with anthers that contain the microsporangia. The innermost group of structures in the flower is the gynoecium, or the female reproductive component(s). The carpel is the individual unit of the gynoecium and has a stigma, style, and ovary, which contains one or more ovules. The ovary is at the base of the flower.A flower may have one or multiple carpels. From the ovary, extends a tubular structure called the style and on the top of the style is a surface receptive to pollen called the stigma. Placentation is the attachment of ovules inside the ovary. The ovules inside a flower's ovary (which later become the seeds inside a fruit) are attached via funiculi, the plant part equivalent to an umbilical cord. The part of the ovary where the funiculus attaches is referred to as the placenta and it provides nutrients to the developing embryo.

The stigma can take many different forms, most of them designed to help trap pollen. The male parts of a flower consist of one or more stamens. Each stamen is made up of paired anthers (sacs containing pollen) on a filament or stalk.From the ovary, extends a tubular structure called the style and on the top of the style is a surface receptive to pollen called the stigma.The stigma can take many different forms, most of them designed to help trap pollen. The male parts of a

flower consist of one or more stamens. Each stamen is made up of paired anthers (sacs containing pollen) on a filament or stalk.

If all four whorls (the calyx, corolla, androecium, and gynoecium) are present, the flower is described as complete. If any of the four parts is missing, the flower is known as incomplete. Flowers that contain both an androecium and a gynoecium are called perfect, androgynous or hermaphrodites. There are two types of incomplete flowers: staminate flowers contain only an androecium, and carpellate flowers have only a gynoecium.

If both male and female flowers are borne on the same plant, the species is called monoecious (meaning “one home”): examples are corn, pea, colocasia, castor (Ricinus communis), coconut etc. Species with male and female flowers borne on separate plants are termed dioecious, or “two homes,” examples of which are *C. papaya, Cannabis,* date palm (Phoenix dactylifera), pistachio (Pistacia vera), etc. In "crop plants, meiotic division of specific cells in stamen and pistil yields microspores and megaspores, respectively. This is followed by mitotic division of the spore nuclei to produce gametes; the male and female gametes are produced in microspores and megaspores, respectively.The ovary, which may contain one or multiple ovules, may be placed above other flower parts, which is referred to as superior; or, it may be placed below the other flower parts, referred to as inferior.

Sporogenesis

Production of microspores and megaspores is known as sporogenesis. In anthers, microspores are formed through microsporogensis and in ovules, the megaspores are formed through megasporogenesis.

Microsporogenesis

The sporophytic cells in the pollen sacs of anther which undergo meiotic division to form haploid i.e., microspores are called microspore (MMC) or pollen mother cell (PMC) and the process is called microsporogenesis. Pollen Mother Cells are in diploid (2n) condition and each PMC produce four microspores and each microspore after thickening of the wall transforms into pollen grain.

Megasporogenesis

Ovule is considered to be an integumented megasporangium. The ovule consists of the stalk and the body. The stalk is called *funicle.* One end of the funicle is attached to placenta and the other end to the body of the ovule. The point of attachment of funicle with the body is

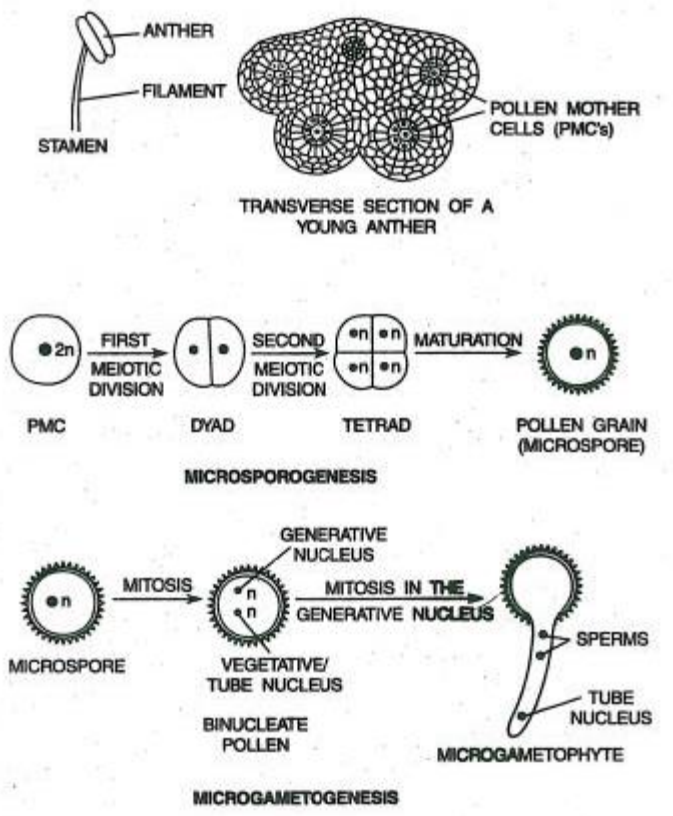
called *hilum*. Sometimes funicle gets fused with the body of the ovule one side and forms a ridge known as *raphe*. The body of the ovule shows two ends: the basal end, often called the *chalazal* end and the upper end is called *micropylar* end. The main body of the ovule is covered with one or two envelopes called *integuments*. These leave an opening at the top of the ovule called micropyle. The integuments enclose a large parenchymatous tissue known as *nucellus*. The residual part of nucellus in the mature seed is called *perisperm*. In the centre of the nucellus is situated a female gametophyte known as *embryo sac*. A single sporophytic cell inside the ovule, which undergo meiotic division to form haploid megaspore, is called megaspore mother cell (MMC) and the process is called megasporogenesis. Each MMC produces four megaspores out of which three degenerate resulting in a single functional megaspore.

Gametogenesis

The production of male and female gametes in the microspores and megaspores is known as gametogenesis.

Microgametogenesis

This is nothing but the production of male gametes or sperm and have single set (n) of chromosomes.. On maturation of the pollen, the microspore nucleus divides mitotically to produce a generative and a vegetative or tube nucleus. The pollen is generally released in this binucleate stage. The reach of pollen over the stigma is called pollination. After the pollination, the pollen germinates. The pollen tube enters the stigma and travels down the style. The generative nucleus at this phase undergoes another mitotic division to produce two male gametes or sperm nuclei. The pollen along with the pollen tube possessing a pair of sperm nuclei is called microgametophyte. The pollen tube enters the embryo sac through micropyle and discharges the two sperm nuclei. Study of Pollen grains is called Palynology.



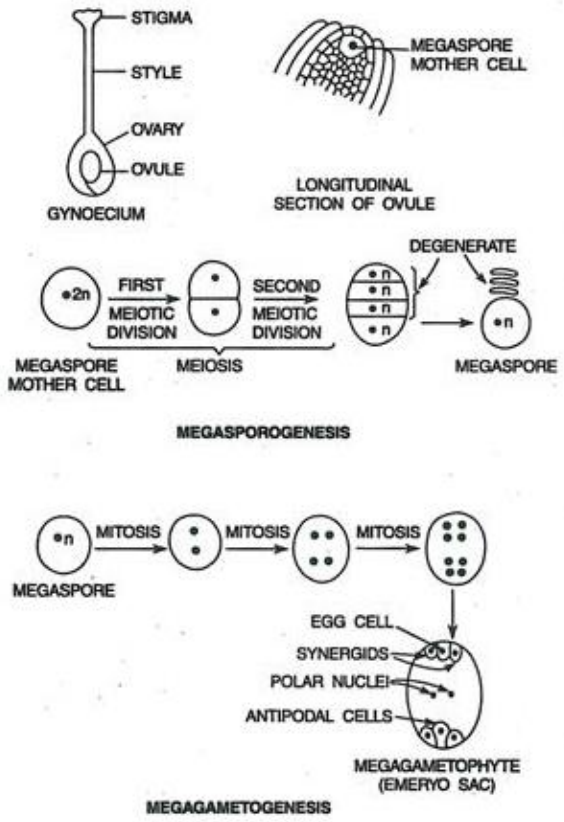
Megagametogenesis

While the details may vary between species, the overall development of the female gametophyte has two distinct phases. First, in the process of **megasporogenesis**, a single cell in the diploid **megasporangium i.e. megaspore mother cell**—an area of tissue in the ovules—undergoes meiosis to produce four megaspores, only one of which survives. During the second phase, **megagametogenesis**, the surviving haploid megaspore undergoes mitosis to produce an eight-nucleate, seven-cell female gametophyte, also known as the megagametophyte or embryo sac. Two of the nuclei—the **polar nuclei**—move to the equator and fuse, forming a single, diploid central cell. This central cell later fuses with a sperm to form the triploid endosperm. Three nuclei position themselves on the end of the embryo sac opposite the micropyle and develop into the **antipodal** cells, which later degenerate. The nucleus closest to the micropyle becomes the female gamete, or egg cell, and the two adjacent nuclei develop into **synergid** cells. The synergids help guide the pollen tube for successful fertilization, after which they disintegrate. Finger like protruded structures are present on synergids are called as filiform apparatus. . Once fertilization is complete, the resulting diploid zygote develops into the embryo, and the fertilized ovule forms the other tissues of the seed.

Fertilization

The fusion of one of the two sperms with the egg cell producing a diploid zygote is known as fertilization. The process is called syngamy or generative fertilization.The fusion of the remaining sperm with two polar nuclei or the secondary nucleus leading to the formation of a triploid primary endosperm nucleus is termed as **triple fusion** or *vegetative fertilization*. The primary endosperm nucleus after several mitotic divisions develops into mature **endosperm**, which nourishes the developing embryo. These two acts of fertilizations constitute the process of double fertilization and double fertilization occurs in angiosperms only.

A double-layered integument protects the megasporangium and, later, the embryo sac. The integument will develop into the seed coat after fertilization and protect the entire seed. The ovule wall will become part of the fruit. The integuments, while protecting the megasporangium, do not enclose it completely, but leave an opening called the **micropyle**. The micropyle allows the pollen tube to enter the female gametophyte for fertilization. When pollen from one flower fertilizes the ovule of another flower, it is called **cross pollination**. If an ovule is fertilized by pollen from the same flower, it is called self fertilization.



Microsporogenesis and microgametogenesis (a generalized scheme)

The fertilised ovules develop into seeds. A seed contains seed coat upon the embryo. The embryo is made up of a radicle, an embryonal axis and one (wheat, maize) or two cotyledons (gram and pea). The outermost covering of a seed is seed coat. It has two layers, i.e. the outer testa and the inner tegmen. The hilum is a scar on the seed coat. Above the hilum is a small pore the micropyle.

Seeds are of two types

Endospermic seeds: Paddy, Maize, Castor

Non-endospermic seeds: Pea, Beans, Chick Pea. Endosperm is not present in mature seeds and utilized in the formation of seed itself.

Embryo: Zygote developed into embryo. P**lant embryo** is part of a seed, consisting of precursor tissues for the leaves, stem (hypocotyl), and root (radicle), as well as one or more cotyledons. Once the **embryo** begins to germinate i.e. grow out from the seed is called a seedling.

Formation of fruit and Seed: The **seeds** and **fruits** are the results of fertilization or sexual reproduction in plants. The ovary in angiosperms develops into the **fruit** whereas the ovules become the **seeds** enclosed within the **fruit**. **Seeds** are found both in gymnosperms and angiosperms. The **seed coat**, or testa, is **derived** from the one or two protective integuments of the ovule. Calyx (sepals) many a time stays. (ideal example Brinjal or tomato).Corolla (petals), androecium (stamens), style and stigma mostly dries or falls. In some cases (such as monocot herbaceous plants) calyx & corolla (periyanth) persists and helps in seed dispersal.

Lecture No.4:

MODES OF REPRODUCTION – SEXUAL AND ASEXUAL REPRODUCTION

Knowledge of the mode of reproduction and pollination is essential for a plant breeder, because these aspects help in deciding the breeding procedures to be used for the genetic improvement of a crop species. Choice of breeding procedure depends on the mode of reproduction and pollination of a crop species.

Reproduction refers to the process by which living organisms give rise to the offspring of similar kind (species). In this process, characters are transmitted from parents of one generation to offspring in next generation through genetic material exchange present on chromosomes. In few methods, offspring look alike parents and in other methods characters of offspring are derived from two parents. All these changes are resultant of chromosomal exchange during reproduction.

Significance of Reproduction

For permanent existence of a species

Under favourable conditions to increase population exponentially

Differences between asexual and sexual reproduction

S.No.	Sexual Reproduction	Asexual Reproduction
1	Involves mating of two or more living organisms	Involves single living organism.
2	Formation of male and female gametes.	Involves reproduction through any part of the body. Male and female gametes are absent.
3	Involves fusion of male and female gametes	Doesn't involve fusion of male and female gametes.
4	Cell division involves reduction division and equational division	Involves equational division
5	The fusion of male and female gametes forms zygote from which develops a new individual. This process is known as 'fertilisation'.	It is a simple process of cell division and the off springs are similar to parents.
6	Mixing of genetic material takes place. Hence it shows great extent of variation.	No mixing of genetic material. Hence less variation is observed. Spontaneous mutation cause genetic variations.
7	It is a slower process.	It is a rapid process during favourable conditions.
8	Through natural selection plays a major role in evolution.	Doesn't play a major role in evolution.
	Ex: reproduction in multi-cellular organisms.	Ex: Binary fission in amoeba, budding in hydra

In crop plants, the mode of reproduction is of two types: viz. 1) sexual reproduction and 2) asexual reproduction.

Plants majorly reproduce either through asexual reproduction or vegetative propagation. In this, off springs look alike as that of parents. Even if a single plant is susceptible to pests and diseases, remaining plants also show susceptibility reaction. Pest and disease incidence completely destroy the population. To perpetuate a species, plants reproduce by sexual means.In this method, genetic changes occur in off springs. Natural or artificial selection result in selection of promising off springs.

In general, plants produce both male and female gametes in a single flower. Fusion of male and female gametes of the same plant result in genetic changes to some extent in off springs. It involves single parent only. But in plants several mechanisms prevent fusion of male and female gametes of the same plant and promote cross pollination. Fusion of male and female gametes from various parents result in genetic variation and through diversity there is a possibility selection of new varieties suitable to different environments and resistant to pests and diseases.

I. Sexual reproduction

Multiplication of plants through embryos which have developed by fusion of male and female gametes is known as sexual reproduction. All the seed propagating species belong to this group.

Significance of Sexual Reproduction

Sexual reproduction makes it possible to combine genes from two parents into a single hybrid plant. Recombination of these genes produces a large number of genotypes. This is an essential step in creating variation through hybridization. Almost the entire plant breeding is based on sexual reproduction. Even in asexually reproducing species, sexual reproduction, if it occurs, is used to advantage, e.g., in sugarcane, potato, sweet potato etc.

Lecture No: 5

SEXUAL REPRODUCTION IN PLANTS-POLLINATION, SELF POLLINATION, CROSS POLLINATION-MECHANISMS PROMOTING SELF POLLINATION

Pollination: The process by which pollen grains are transferred from anthers to stigma is referred as pollination. Pollination is of two types: viz. 1) Autogamy or self pollination and 2) Allogamy or cross pollination.

I. Autogamy: Transfer of pollen grains from the anther to the stigma of same flower is known as autogamy or self pollination.

II. Allogamy: When pollen from flowers of one plant are transmitted to the stigmas of flowers of another plant, it is known as cross-pollination or allogamy. It is of two types.

a. Geitonogamy: when pollen from a flower of one plant falls on the stigmas of other flowers of the same plant, e.g., in Maize.
b. Xenogamy: is the fertilization of a flower by the pollen of a flower from a genetically different plant.

In plants cross pollination is more useful than self pollination and in angiosperms, majority of the bisexual plants prevent self pollination and promote cross pollination.

Mechanisms promoting self-pollination: The various mechanisms that promote selfpollination are generally more efficient than those promoting cross -pollination. These mechanisms are listed below.

1. **Homogamy:** Maturation of anthers and stigma of a flower at the same time is called homogamy. As a rule, homogamy is essential for self-pollination.eg: Caltha.
2. **Safety mechanism:** In a few species, stigmas become receptive and elongate through staminal columns. This ensures predominant self -pollination. eg: Asteraceae family-Helianthus (Sunflower)
3. **Cleistogamy:** In this case, flowers do not open at all. This ensures complete selfpollination since foreign pollen cannot reach the stigma of a closed flower.Cleistogamy occurs in some varieties of wheat, oats, barley and in a number of other grasses, Commelina benghalensis, Streptocapus . In Commelina, cleistogamous flowers develop on underground branches, while chasmogamous flowers develop on aerial branches. In Streptocarpus princeps, both cleistogamous and chasmogamous flowers develop on aerial branches.

4. **Chasmogamy:** Opening of flowers only after the completion of pollination is known as chasmogamy.This also promotes self pollination and is found in crops like wheat, barley, rice and oats. Since the flower does open, some cross-pollination may occur.

5. **Position of Anthers:** In crops like tomato and brinjal, the stigmas are closely surrounded by anthers.Pollination generally occurs after the flowers open. But the position of anthers in relation to stigmas ensures self-pollination.

In some species, flowers open but the stamens and the sigma are hidden by other floral organs. In several legumes, e.g., pea, mung, urd, Soybean and gram the stamens and the stigma are enclosed by the two petals forming a keel.

Lecture No: 6

MECHANISMS PROMOTING CROSS POLLINATION AND EXTERNAL AGENTS FOR CROSS POLLINATION

Eventhough cross pollination results in profitable yields in plants, the following mechanisms promote cross pollination.

1. Dicliny: It refers to unisexual flowers. This is of two types: viz. i) monoecy and ii) dioecy. When male and female flowers are separate but present in the same plants, it is known as **monoecy**. In some crops, the male and female flowers are present in the same inflorescence such as in mango, castor and banana. In some cases, they are on separate inflorescence as in maize. Other examples are cucurbits, grapes, strawberry, cassava and rubber. When staminate and pistillate flowers are present on different plants, it is called **dioecy**. It includes papaya, date palm, spinach, hemp and asparagus, vallisnaria gigantea.

2. Dichogamy: It refers to maturation of anthers and stigma of the same flowers at different times. Dichogamy promotes cross pollination even in the hermaphrodite species. Dichogamy is of two types: viz. i) protogyny and ii) protandry. When pistil matures before anthers, it is called **protogyny** such as in pearl millet, solanum. When anthers mature before pistil, it is known as **protandry**. It is found in maize, sugarbeet, Helianthus, Gossypium and several other species.

3. Herkogamy: The spatial separation of sexual organs stigma and anthers within flowers. Self pollination is prevented even if anthers and pistil matures at the same time.

In few species, the presence of the stigma above the level of the anthers.

eg: Hibiscus

In few species, stigmas bend in opposite direction to that of anthers.

eg: Gloriosa superba.

4. Heterostyly: The condition of flowering plants in which flowers of the same species have styles of different lengths so that the stigma is positioned below the anthers in some flowers and above them in others. It is of two types.

There are 2 or 3 types of flowers with different heights of styles (and stamens),

(a) **Diheterostyly** (Dimorphic Heterostyly). There are two types of flowers, pin eyed (long style and short stamens) and thrum eyed (short style and long stamens), e.g., Primula (Primrose),Oldenlandia, Jasmine

(b) **Triheterostyly** (Trimorphic Heterostyly or tristyly).There are three types of flowers with different heights of styles (long, medium and short) and stamens (medium and short, long and short, and long and medium), e.g., Lythrum, few Oxalis spp.

Pollination occurs between anthers and stigmas of the same height present in different flowers.

5.Self incompatibilityi/Self sterility: The inability of fertile pollens to fertilize the same flower is referred to as self incompatibility. It prevents self-pollination and promotes cross pollination. Self incompatibility is found in several crop species like *Brassica, Radish, Nicotiana,* and many grass species, Abutilon, Passiflora.

In few species, self pollination cause drying of flowers. Anthers become poisonous and result in drying of flowers. eg. Orchids.

6. Pollen Prepotency: In some plants when the stigma recieves pollen from the same flower as well as from the other flower simultaneously, the foreign pollen germinates vigorously and fertilize the ovule, e.g., bean and many members of fabaceae.

7. Sensitive Stigmas: A sensitive bilobed stigma is thought to assure reproduction, avoid selfing and promote out crossing. In addition, it may also play a role in pollinator selection since only pollinators with the appropriate body size can trigger this mechanism. Sensitive stigmas close during anther dehiscence in the same flower and open later. Then the inner part of sensitive stigmas expose and receive pollen grains resulting in cross pollination.eg. Martynia, Mimulus.

8. Male sterility: In some species, the pollen grains are non functional. Such condition is known as male sterility. It prevents self-pollination and promotes cross pollination. It is of three types: viz.genetic, cytoplasmic and cytoplasmic genetic. It is a useful tool in hybrid seed production.

Cross Pollination External Agents

In this type of pollination, the pollen is transferred from the anthers of one flower to the stigma of another flower. In this case, the two flowers are genetically different from each other. Cross-pollination is always dependant on another agent to cause the transfer of pollen. The agents of pollination include abiotic agents like wind and water and biotic agents like birds, bats, insects and snails etc. Based on the agent of pollination, cross-pollination can be of different types. The pollination process is an interaction between flower and pollen vector.

Pollinating agent	Plants eg	Name
Abiotic agents		
Wind	Paddy	Anemophily
Water	Vallisnaria	Epihydrophily
	Zostera	Hypo hydrophily
Biotic agents		
Birds	Bignonia	Ornithophily
Bats	Kigelia Pinnata	Chiropterophily
Insects	Cestrum nocturnum	Entomophily
Snail	Aroids	Malacophily

II. Asexual reproduction

Multiplication of plants without the fusion of male and female gametes is known as asexual reproduction. Asexual reproduction can occur either by vegetative plant parts or by vegetative embryos which develop without sexual fusion (apomixis). Thus asexual reproduction is of two types: viz. a) vegetative reproduction and b) apomixis.

Apomixis

Apomixis refers to the development of seed without sexual fusion (fertilization). In apomixis embryo develops without fertilization. Thus apomixis is an asexual means of reproduction. Apomixis is found in many crop species. Reproduction in some species occurs only by apomixis. This apomixis is termed as **obligate apomixis**. But in some species sexual reproduction also occurs in addition to apomixis. Such apomixis is known as **facultative apomixis**.

There are four types of apomixis: viz.

1) parthenogenesis, 2) apogamy, 3) apospory and 4) adventive embryony.

Diplospory

Embryo sac is produced from the megaspore, which may be haploid or, more generally, diploid. Generally the meiosis is so modified that the megaspore remains diploid.

Diplospory leads to parthenogenesis or apogamy.

Parthenogenesis

The embryo develops from embryo sac without pollination. It is of two types

Gonial parthenogenesis – embryos develop from egg cell

Somatic parthenogenesis – embryos develop from any cell of the embryo sac other than the egg cell.

2. Apogamy. The origin of embryo from either synergids or antipodal cells of the embryosac is called as apogamy. Like

parthenogenesis, apogamy may be haploid or diploid depending upon the haploid or diploid state of the embryo sac. Diploid apogamy occurs in Antennaria, Alchemilla, Allium and many other plant species.

3. Apospory. In apospory, first diploid cell of ovule lying outside the embryosac develops into another embryosac without reduction. The embryo then develops directly from the diploid egg cell without fertilization. Apospory occurs in some species of H*ieraceum, Malus, Crepis, Ranunculus,* etc.

4. Adventive embryony. The development of embryo directly from the diploid cells of ovule lying outside the embryosac belonging to either nucellus or integuments is referred to as adventive embryony. Development of embryo does not involve production of embryo sac. Adventive embryony occurs in mango, citrus, etc.

Advantages of apomixis in plant breeding

The two sexual processes, self-and crossfertilization, followed by segregation, tend to alter the genetic composition of plants reproduced through amphimixis. Inbreeding and uncontrolled out breeding also tend to break heterozygote superiority in such plants. On the contrary, apmicts tend to conserve the genetic structure of their carriers. They are also capable of maintaining heterozygote advantages generation after generation. Therefore, such a mechanism might offer a great advantage in plant breeding where genetic uniformity maintained over generation for both homozygosity (in varieties of seIfers), and heterozygosity (in hybrids of both seIfers and outbreeders) is the choicest goal. Additionally, apomixis may also affect an efficient exploitation of maternal influence, if any, reflecting in the resultant progenies, early or delayed because it causes the perpetuation of only maternal individuals and maternal properties due to prohibition of fertilization. Maternal effects are most common in horticultural crops, particularly fruit trees and ornamental plants.

Thus, in short the benefits of apomixis, insofar as their utility in plant breeding is concerned, are:

1. Rapid multiplication of genetically uniform individuals can be achieved without risk of segregation.

2. Heterosis or hybrid vigour can permanently be fixed in crop plants, thus no problem for recurring seed production of F_1 hybrids.

3. Efficient exploitation of maternal effect, if present, is possible from generation to generation.

4. Homozygous inbred lines, as in corn, can be rapidly developed as they produce sectors of diploid tissues and occasional fertile gametes and seeds.

Lecture No.7

MALE STERILITY- TYPES AND USES

Male sterility is characterized by nonfunctional pollen grains, while female gametes function normally. It occurs in nature sporadically.

Morphological features of male sterility

The male sterility may be due to mutation, chromosomal aberrations, cytoplasmic factors or interaction of cytoplasmic and genetic factors. Because of any of the above reasons the following morphological changes may occur in male sterile plants.

- Viable pollen grains are not formed. The sterile pollen grains will be transparent and rarely takes up stain faintly.
- Non-dehiscence of anthers, even though viable pollens are enclosed within. This may be due to hard outer layer, which restrict the release of pollen grains.
- Androecium may abort before the pollen grains are formed.
- Androecium may be malformed, thus there is no possibility of pollen grain formation.

Kinds of male sterility, maintenance and uses

There are three basic kinds of male sterility based on the origin of the abnormality:

True male sterility – This is due to unisexual flowers that lack male sex organs (dioecy and monoecy), or bisexual flowers with abnormal or non-functional microspores (leading to pollen abortion).

Functional male sterility – The anthers fail to release their contents even though the pollen is fertile.

Induced male sterility – Plant breeders may use chemicals to induce sterility.

True male sterility

True male sterility may be conditioned due to cytoplasmic or genetic factors or due to interaction of both. Environment also induces male sterility. Depending on these factors male sterility can be classified in to

1.Cytoplasmic male sterility (CMS)

2.Cytoplasmic-genetic male sterility (CGMS)

3.Genetic male sterility (GMS)

In this there are two categories.

- Environment insensitive genic male sterility- commonly referred as Genetic male sterility.
- Environment sensitive genic male sterility or Environmental induced sterility which is again sub divided in to
- TGMS (Thermosensitive)
- PGMS (Photo sensitive)
- Photo thermo sensitive

Genetic Male Sterility: eg: Tomato, Barley, Brinjal, Paddy, Soybean. Due to problems in maintenance of GMS this was not utilized widely in crop improvement.

Cytoplasmic Male Sterility: Cytoplasmic male sterility may be utilized for producing hybrid seed in certain ornamental species, or in species where a vegetative part is of economic value. But in those crop plants where seed is the economic part, it is of no use because the hybrid progeny would be male sterile. EG: Onion

Cytoplasmic-genetic male Sterility: eg: Bajra, Carrot, Chillies, Maize, Wheat, Paddy, Jowar and Sunflower.

Self-incompatibility and sterility are the two mechanisms, which encourage crosspollination.

More than 300 species belonging to 20 families of angiosperms show self incompatibility.In self incompatibility plants, the flowers will produce functional or viable pollen grains which fail to fertilize the same flower or any other flower of the same plant.

1.Self incompatible pollen grain may fail to germinate on the stigmatic surface.

2.Some may germinate but fails to penetrate the stigmatic surface.

3.Some pollen grains may produce pollen tube, which enters through stigmatic surface, but its growth will be too slow. By the time the pollen tube enters the ovule the flower will drop.

4.Some time fertilzation is effected but embryo degenerates early.

In self incompatibility pollen grains, ovules are functional while in sterility pollen grains or ovules are non functional. Self incompatibility is the most effective method to promote cross pollination by preventing self pollination in bisexual flowers. In dioecy or monoecy, huge amount of pollen is produced and in some ovules, self fertilization is effected and in such cases self incompatibility prevents self pollination and it was reported in nearly about 3000 genera of plants like leguminaceae, rosaceae, solanaceae, compositae, cruciferaceae and graminae.

Self incompatibility is of two types

1. Homomorphic 2. Heteromorphic

   Homomorphic:

   a) Gametophytic –eg: Tomato, Mango, Tobacco, Pear, Peaches, Lucerns, Rye etc.

   b) Sporophytic- eg: Brassica oleracea, Brassica campestris, Cosmos etc.

   Heteromorpic:

   a) Distyly –eg: Primula

   b) Tristyly- eg: Lythrum, Linum.

Uses of Incompatibility in plant breeding

1. Existence of male sterility or self-incompatibility through which hand emasculation can be avoided.
2. Double cross hybrid production

Lecture No.8

METHODS OF VEGETATIVE PROPAGATION- NATURAL & ARTIFICIAL METHODS-USEFUL PLANT PARTS FOR VEGETATIVE PROPAGATION

In sexual reproduction, multiplication occurs through formation of specialized structures. Vegetative reproduction refers to multiplication of plants by means of various vegetative plant parts. In this fusion of male and female gametes is absent and only one parent is involved and hence it is equal to asexual propagation. Multiplication of certain plants occurs by underground stems, sub aerial stems, roots, leaves and bulbils. Progeny resemble as that of parents and this method is called as vegetative reproduction or vegetative propagation. This method is highly used in multiplication of ornamental and horticultural crops. Vegetative reproduction is again of two types: viz. i) natural vegetative reproduction and ii) artificial vegetative reproduction.

Vegetative propagation normally occur through underground stems, sub aerial stems, roots, bulbils and cuttings.

eg: Guava, Grapes, Pomegranate, Lime, Lemon, Potato, Sweet potato and

Progeny of new plants arise by using scientific knowledge resemble the parental plant types through vegetative propagation.

Significance of Vegetative Reproduction

1. Vegetatively reproducing species offer unique possibilities in breeding. A desirable plant may be used as a variety directly regardless of whether it is homozygous or heterozygous. Further, mutant buds, branches or seedlings, if desirable, can be multiplied and directly used as varieties.
2. Huge production of plants in a short span of time
3. For budding and grafting, the plants developed by asexual reproduction are used as root stocks and these root stocks are selected from disease resistant plants.

   For production of new varieties on the root stocks, the flowers of scions must be of high quality.
4. For multiplication of rarely flowered species.
5. Easy and economical method
6. For non seed plants, this is the only method of propagation.

   eg: seed less crops- Banana, Jasmine, Rose

Stem grows on soil and give rise to buds, leaves, flowers and fruits. It helps in transportation of water from roots to other parts and nutrients from leaves to other parts. Node is the portion of stem where leaf arise and distance between two nodes is termed as internode. Stem end as terminal bud and its tip portion is called terminal tip bud. Apart from terminal bud, buds arise in leaf axils and are called as auxillary buds. Buds help in plant growth are termed as vegetative buds. Bulbs may arise on roots and leaves also in few species.

Examples of Natural vegetative reproduction

1. Bulb:

A bulb is a specialized underground organ that consists predominantly of fleshy leaf scales growing on a stem tissue (basal plate).The scales wrap around a growing point or primordium to form a tight ball. Lateral bulblets, or miniature bulbs, originate in the axils of some of these scales and when developed (offsets) may be separated from the mother bulb to be planted independently as new plants.

There are two types of bulbs-***Tunicate*** and ***non-tunicate bulbs***.

Tunicate-These bulbs have outer bulb scales that are dry and membranous. This covering called tunic, provide protection from drying and mechanical injury to the bulb. The fleshy scales are in continuous, concentric layers, called lamina, so that the structure is more or less solid. eg. Onion, daffodil, tulip etc.

Non-tunicate (scaly) bulbs: These bulbs don‘t possess the enveloping dry covering. The scales are separate and attached to the basal plate. The scales are not tight but loose and can be removed individually from the bulb. In general, the non-tunicate bulbs are easily damaged and must be handled more carefully than tunicate bulbs. The daughter bulbs or bulb lets develop at the base of the of the scales of the mother bulb. eg.Galdiolus, Lily etc.

2. Corm:

The bulb consists predominantly of modified leaves; the corm is a modified stem. Food is stored in this compact stem, which has nodes and very short internodes and is wrapped up in dry, scaly leaves. When a corm sprouts into a new shoot, the old corm becomes exhausted of its stored food and is destroyed as a new corm forms above it. Several small corms, or cormels, arise at the base of the new corm. The cormels may be separated from the mother corm at maturity (die back) and used to propagate new plants. eg. Amorphophallus, Colocasia, Gladiolus etc.

3. Rhizome:

A rhizome is a specialized stem structure in which the main axis of the plant grows horizontally just below or on the surface of the ground. The stem appears segmented because it composed of nodes and internodes. The rhizome appears as a many branched clump made up of short individual sections. The rhizome tends to be oriented horizontally with roots arising from the lower side. In propagating plants by rhizome by cutting the rhizome into different sections being sure that each section has at least one lateral bud or eye. It is essentially a stem cutting.

eg. Bamboo, Banana, Iris etc.

4. **Stolon**:

It is a term used to describe various types of horizontally growing stems that produce adventious roots when come in contact with the soil. These may be prostate or sprawling stems growing above ground.

Stolon In propagating plants by stolon, the stolon can be treated as a naturally occurring rooted layer and can be cut from the parent plant and planted separately. eg. Mint, Bermuda grass *etc*.

5. **Runner**:

It is a specialized stem which develops from the axis of a leaf at the crown of a plant and grows horizontally along the ground and forms a new plant at one of the nodes. In propagating plants by runners, the rooted daughter plants are dug when they have become well rooted and transplanted to the desired locations.

eg: Lawn grass Cyanodon (Doob grass); Strawberry, Oxalis, Blue berry etc

6. **Stem tuber**:

A tuber is specialized swollen underground stem which possesses eyes in regular order over the surface. The eyes represent the nodes of the tuber. The arrangement of the nodes is spiral, beginning with the terminal bud on the stolon to produce a new plant, the tuber is divided into sections so that each section has a good amount of stored food and a bud or eye. Propagation by tubers can be done either by planting the tubers whole or by cutting them into section, each containing a bud or eye. eg.Potato.

7. Tuberous roots:

These are thickened tuberous growth that functions as storage organs. These differ from the true stem tuber, in that they lack nodes and internodes. Buds are present only at the crown or

stem end. Fibrous roots are commonly produced towards the opposite end. Most plants with fleshy roots must be propagated by dividing the crown so that each section bears a shoot bud.
eg. Dahlia, Begonia, Sweet potato

8. Offset:

It is a short thickened horizontal branch growing out of the crown ending at the apex with a tuft of leaves and a cluster of leaves below. These are special type of branches or lateral shoots which are produced from the base of main stem of parent plant. The offset often breaks away from the mother plant and the daughter starts a new independent life. eg. Pistia, Agave, Water hyacinth, Cycas, Dracaena etc.

9. **Suckers**:

It is a lateral branch developing from the underground parts of the stem or roots. The suckers arise from below the surface of the soil. There are two types of suckers.

a) ***Shoot suckers:*** These will arise from the base of the stem. The suckers may grow obliquely upwards and directly give raise a leaf shoot. Often it grows horizontally outwards only to certain extent but soon turn up. It strikes roots when it is still attached to the parent plant or when separated and planted.

Propagation by shoot suckers can be done by separating the suckers and planting.
eg.Chrysanthemum, Banana, Pineapple, Yucca.

b) ***Root suckers:*** The root suckers will arise from the adventitious buds on the roots.

Propagation by shoot suckers can be done by separating the suckers and planting. eg.Guava, Millingtonia, Curry leaf,Quis quails etc.

10. Crown:

The term crown designates that part of a plant at the surface of the ground from which new shoots are produced. This kind of crown is observed in herbaceous perennials like strawberry, pyrethrum, Gerbera or African violet wherein the stem is a short and thickened structure from which the leaves are produced in a rosette like arrangement.

11. Leaves:

Some plants produce adventitious buds on their leaves e.g., Bryophyllum, Begonia, Streptocarpus, Kalanchoe and Saintpaulia. In Bryophyllum notched margins of succulent leaves bear adventitious buds.

Certain plants do have one or more of the above mentioned specialized structures useful for propagation. But particular structure is preferred for commercial propagation for obvious reasons. Strawberry can be propagated both by runners and splits from crown.

Artificial vegetative reproduction

Multiplication of plants by vegetative parts through artificial method is known as artificial vegetative reproduction. Such reproduction occurs by cuttings of stem and roots, and by layering and grafting. Examples of such reproduction are given below:

Cuttings are vegetative plant portions such as stems, leaves and roots taken from plants to produce new independent plant which, in most cases, will be identical with the parent plant. This is one of the least expensive and easiest methods of vegetative propagation.

Cuttings are taken from 1) stem 2) leaf 3) leaf bud and 4) root

Stem cuttings: Sugarcane (*Saccharum* sp.) grapes (*Vitis vinifera*), roses, etc.

This method is widely used in propagation.

Hard wood cutting: (Deciduous)

The cuttings are fully matured with more reserve food and anatomically, the maximum of sclerenchyma can be seen. eg: Hibiscus, Rose.

Semi-hard wood cuttings

Stem cuttings of trees and shrubs that are taken from current season shoots, which are partly matured are known as semihard wood. eg: Tecoma, Clerodendron

Soft wood cutting

Cuttings are taken from soft, succulent and new growth may be called as soft wood cuttings. eg: Dahlia, Geranium

Cuttings should be taken from healthy plant grown in full sunlight. The basal cut is usually made just below a node in slanting position. Auxins like Indole-3-Acetic Acid (IAA), Indole Butyric Acid (IBA), Naphthalene Acetic Acid (NAA) are used extensively for propagation of cuttings.

Root cuttings: Root piece of 2-4” length are planted horizontally at 1” to 2” depth on sandy soils develop roots.

eg: Carrot

Layering:

Whenever propagation through cuttings is difficult, layering method is followed as an alternative to cuttings. It is a propagation method by which adventitious roots are caused to form on a stem while it is still attached to the parent plant. The rooted stems are then detached and established in a medium to become a new plant growing on its own roots. In this method, the lower portion of the stem is girdled *i.e.* removal of a strip of bark from around the entire circumference of either a branch or trunk of a plant as ring with a knife.

Lecture No.9

LAYERING METHODS IN ORCHARDS

Air layering

Air layering is carried out as follows

- Pencil size shoot of the current year growth is to be selected
- On the selected shoot, preferably on the basal portion, a ring of bark is removed and the exposed wood is scraped.
- The exposed portion is further wrapped with moist inert rooting medium like Sphagnum moss, moist coir etc.
- And covered with a polythene sheet making it air tight

This branch is left undisturbed on the mother plant for about 2-8 weeks depending on the species.

During the course several adventitious roots emerge from the base of the exposed bark, which is covered. The rooted branch will be later cut below the covered portion and planted as a separate seedling.

eg: Pome granate, Gauava, Lemon

Ground layering

It is another technique of layering and carried out as follows:

1. A healthy shoot of pencil thickness from a lower branch near the ground level has to be selected.
2. The common practice is to injure the portion to be covered, by notching, girdling, cutting or twisting. This practice destroys the phloem tissue partially or completely and retards the downward movement of food material as well as hormones manufactured by leaves. Injury is given 6-12” back from the tip
3. The bent part of shoot is inserted into the soil
4. The usual time for layering depends on species eg.for temperate species, it is done in early spring and for this, dormant, one year old shoots are used.
5. The rooted layers may be removed from the parent plant and kept under cool humid conditions for curing.

   eg: Jasmine, Rose, Grapes, Ipomea.

Principles of grafting and budding

Grafting is a propagation technique usually employed to improve the quality of the nursery stock or to produce seedlings that carry the plus qualities of a mother plant.It is the process of operation of inserting a part of one plant into another or placing it upon another in such a way that an union will be formed and the combination will continue to grow as one plant. The part of graft combination which is to become the upper portion if termed as the 'scion' (ion) and the part which is to become the lower portion or root is termed as 'root stock' or 'understock' or the 'stock' Rootstocks are commonly grown from seeds, cuttings or layers. All methods of joining plants are popularly termed as 'grafting' but when the scion part is only a small piece of bark (and sometimes wood) containing a single bud, the operation is termed as 'budding'.

eg: On a single mango plant, so many varieties can be grafted.

Advantages:

1. When other methods of asexual propagation is not successful in perpetuating a clone, eg.mango and sapota can be successfully propagated on commercial scale by grafting only.
2. Plants propagated on their own roots may be weak, susceptible to pests and diseases, or to any adverse environmental conditions may not adaptable to a particular soil or climate. For many plant species, rootstocks are available which tolerate all the above cases and hence they may be exploited as a rootstock through grafting or budding.
3. For converting poor trees into more desirable one by top-working
4. For overcoming pollination problems, self-fertile varieties may be grafted over self-sterile trees
5. For fancy purposes, different types of scion may be grafted in the same plant
6. To modify the growth of the plant as dearf one by employing suitable dwarfting rootstocks
7. Occasionally the roots, truck or large limbs of trees are severely damaged by winter injury, cultivation implements, certain diseases or rodent. But use of bridge grafting or in arching such damage can be repaired and the tree saved.

Grafting- Methods

Different techniques of grafting are seen in use for propagating different plants. The commonly followed techniques are the following.

1.Simple inarching / Approach grafting: The distinguishing feature of this method of grafting is that two independent plants on their own roots (self sustaining) are grafted together. This method provides a means of establishing a successful union between certain plants which are difficult to graft by any other method as the two plants will be on their own roots till the formation of successful graft. Cuts are made on branches of root stock and scion and tied together and in few days both branches are merged. Then above portion of stock and below portion of scion are removed.

eg: Guava, mango, Sapota.

2.Cleft grafting: Cleft grafting is the most popular and commonly used method for top working especially when thick branches are selected. Erect stem of root stock is cut or split in 'V' shape and desired 2-3 budded scion is inserted in the splitted root stock. Both scion and stock are tied tightly with grafting wax, sealing all the exposed cut surfaces.

eg: camellia, plums

3.Tongue grafting: Tongue grafting is the most popular and commonly used method for top working especially when younger and thinner branches are used. Cut off the stock using a diagonal cut. The cut should be four to five times longer than the diameter of the stock to be grafted. Make the same kind of cut at the base of the scion.Place the blade of the knife across the cut end of the stock, halfway between the bark and pith (on the upper part of the cut surface). Use a single knife stroke to draw the blade down at an angle through the wood and pith. Stop at the base of the initial diagonal cut. Prepare the scion in the same way. Fit the scion into the rootstock so that they interlock whip and tongue. Be certain that the cambia are aligned. Wrap the junction with a grafting strip or twine, and seal it with grafting wax or grafting paint. Never allow the binding material to girdle the stem.

eg: Persian walnut, apple

4. Budding: T-budding must be one when the bark will "slip." Slipping means that, when cut, the bark easily lifts or peels in one uniform layer from the underlying wood without tearing. First 'T' shaped cut is made on the root stock and the bark on both sides of the cut is loosened. The bud to

be inserted is often just a shield of bark with a bud attached or a very thin layer of wood with both the bark shield and bud attached. Cut should be deep enough to remove the bud, its shield of bark, and a thin sliver of wood. Insert the bud shield into the T flaps of the stock and slide it down to ensure that it makes intimate contact with the rootstock and tied with tape. For growth of bud, nutrients and water obtained from root stock and buds on stock must be removed to avoid competition with scion bud.

eg: Apple, Citrus, Rose and Ornamental plants.

5. Bulbil: In this case the flowers in an inflorescence are replaced by bulbils or vegetative buds, which often sprout into new plants while they are still on the mother plant.

eg: Agave.

Tissue culture, artificial/synthetic media

In 1902, Gottlieb Haberlandt, a German plant physiologist, attempted to cultivate plant tissue culture cell *in vitro*. He is regarded as the father of plant tissue culture.

Totipotency: The ability inherent property of a cell (or) tissue to give rise to whole plant irrespective of their ploidy level and the form of specialization

Culture:- Growing of cells tissues plant organs (or) whole plants in nutrient medium under aseptic conditions.

Explant:-A piece of tissue used to initiate tissue culture or removing shoots from callus separating individual shoots from proliferating mass of shoots.

Plant tissue culture is the aseptic method of growing cells and organs such as meristems, leaves, roots etc either in solid or liquid medium under controlled condition. In this method, from a single cell thousands of plants can be produced. This method is majorly used for propagation of agricultural, horticultural and forestry trees. If explants were taken in diploid state, the plants produced through tissue culture also had diploid state. Similarly, haploid explants give rise to haploid plants in tissue culture and haploid cells are used to get haploid plants. For this pollen grains in haploid state are selected.

Applications of Tissue culture in Crop Improvement

1. Micro propagation helps in mass multiplication of plants which are difficult to propagate through conventional methods.

2. Some perennial crop plants like ornamental and fruit crops can not be propagated through seeds. The vegetative propagation like grafting, budding are tedious and time consuming. In such crops micro propagation helps in rapid multiplication.

3. Rapid multiplication of rare and elite genotypes such as Aromatic and Medicinal plants. Isolation of *in vitro* mutants for a large number of desirable character Eg:- Isolation of biochemical mutants and mutants resistant to biotic (pest and disease) abiotic (salt and drought, cold, herbicide etc) stresses through the use of somaclonal variation

4. Screening of large number of cells in small space.

5. Cross pollinated crops like cordamum, Eucalyptus, coconut, oil palm do not give true to type plants, when multiplied through seed. Development of genetically uniform plants in cross pollinated crops is possible through tissue culture

6. In case of certain horticultural crops orchids etc seed will not germinate under natural conditions, such seed can be made to germinate *in vitro* by providing suitable environment.

7. Induction of flowering in some trees that do not flower or delay in flowering.

Eg:- Bamboo flowers only once in its life time of 50 years

8. Virus free plants can be produced through meristem culture

9. Large amount of germplasm can be stored within a small space and lesser cost for prolonged periods under *in vitro* condition at low temperature. The preservation of cells tissues, organs in liquid Nitrogen at – 196oC is called cryopreservation

10. Production of secondary metabolites. eg:- Caffine from *coffea arabica,* Nicotine from *Nicotiana rustica.*

11. Plant tissue culture can also be used for studying the biochemical pathways and gene regulation.

12. Anther and pollen culture can be used for production of halploids and by doubling the chromosome number of haploids using cholchicine homogygous diploids can be
produced. They are called dihaploids.

13. In case of certain fruit crops and vegetative propagated plants where seed is not of much economic impor tant, triploids can be produced through endosperm culture.

14. Inter specific and inter generic hybrids can be produced through embryo rescue technique which is not possible through conventional method. In such crosses *in vitro* fertilization helps to overcome pre-fertilization barrier while the embryo rescue technique helps to overcome post fertilization barrier.

15. Somatic hybrids and cybrids can be produced through protoplast fusion (or) somatic hybridization

16. Ovary culture is helpful to know the physiology of fruit development.

17. Development of transgenic plants.

Lecture No. 10

CROP IMPROVEMENT-METHODS OF PLANT BREEDING-INTRODUCTION-ADVANTAGES

The choice of breeding methods mainly depends on the mode of pollination, mode of reproduction, gene action and breeding objective of crop species.

In Plants the main methods of breeding are as follows

1. Introduction
2. Selection
3. Hybridization
4. Mutation breeding
5. Ploidy breeding

1. Introduction:

Taking a genotype or a group of genotypes in to a new place or environment where they were not grown previously is termed as Introduction. Thus introduction may involve new varieties of a crop already grown in that area, a wild relative of the crop species or totally a new crop species for that area. Plant introduction is applicable to all three groups of crop plants, *viz.*, self pollinated, cross pollinated and asexually propagated species. Introduction may be possible between districts in a state, between states in a country, between countries in a continent, between continents in world. Most of the introductions occurred very early in the history. In earlier days the agencies were invaders travelers, traders, explorers, pilgrims and naturalists etc.

Eg: From Mexico- Sonara 63, Sonara 64 wheat varieties

From Philippines IR8 Paddy variety were introduced in to India.

Advantages

1It is easy, simple, rapid and doesn't require any scientific knowledge. Require skill.

2.Used directly as a variety in agriculture and horticulture crops

3.Used as a variety after selection or as a parent in the hybridization for development of variety or hybrid. eg: Seed, Pollen

Lecture No.11

SELECTION-MASS SELECTION, PURE LINE SELECTION, CLONAL SELECTION-ADVANTAGES

It is an oldest method of crop improvement. Isolation of desirable plant types from the population is known as selection. It is one of the two fundamental steps of any breeding programme *viz.*, 1. creation of variation and 2. Selection.

The process where organisms better adapted to their environment tend to survive and produce more offspring. This theory of Natural Selection was first explained by Charles Darwin. **Artificial selection** is the identification by humans of desirable traits **in plants** and animals, and the steps taken to enhance and perpetuate those traits in future generations. **Artificial selection** works the same way as natural **selection**, except that with natural **selection** it is nature, not human interference.

Selection is basic to any crop improvement. Majority of the varieties were developed through selection. Success of selection mainly depends on the amount of genetic variability.

Types of Selection

1. Mass selection
2. Pure line selection
3. Clonal selection

Mass Selection: In selection, it is the oldest method. Mass selection is common in cross pollinated species and rare in self pollinated and asexually propagates species. Here a large number of plants having similar phenotype are selected and their seeds are mixed together to constitute a new variety. Thus the population obtained-from selected plants will be more uniform than the original population. However they are genotypically different. Results will be quickly seen if plants in a crop are heterozygous. Development of a variety may take 8 years in this method. eg: Cotton: Commercial Cotton varieties, Dharwar American, Doddahatti local, Combodias etc.

Bajra: Pusa moti

Advantages:

1. Easy method. Time taken for release of a variety is less. Scientific knowledge is not required. It is an art and skill is required.

2. Varieties developed will be having more adaptability since each plant is genotypically not similar. They have buffering action against abnormal environment.

3. The genetic variability present in the original population is maintained

Pureline selection:

A pureline is a progeny of a single homozygous plant of a self-pollinated species. All the plants of a pureline have the same genotype. A large number of plants are selected from a self pollinated crop. The selected plants are harvested individually. The selected individual plants are grown in individual rows and evaluatedand best progeny is selected, yield tested and released as a variety.

The concept of pureline was proposed by Johannsen in 1903 on the basis of his studies with princess variety of beans (*Phaseolus vulgaris*) and it is applicable to self pollinated crops. From the base population select best looking plants of 50-100 having the desirable characters. Harvest them on single plant basis and are grown in progeny rows and estimate the performance. Reject unwanted progenies.Repeat the process and variety development may take ten years in this method.

Eg: Groundnut: TMV3, RSB-17

Paddy: CO 4,6,10,14

Advantages:

1. To improve the local adapted varieties and self pollinated crops, this is the only method.
2. All plants within a pure line have the same genotype and extremely uniform in appearance.

Clonal Selection:

A clone is group of plants produced from a single through asexual reproduction. Thus asexually propagated crops consist of large number of clones, and they are often known as clonal crops.

Clonal selection is the selection and propagation of the desirable variations between the clones as well as within a clone. Clonal selection generally may be practiced with non-flowering or those species which produce seeds poorly or only under special conditions.

Characters of Clone

1. All the individuals of a clone are genotypically and phenotypically identical.
2. Genetically, all the members of a clone are homogeneous and heterozygous.
3. Clones are as stable as pure lines
4. A clone is also multiplied vegetatively in future generation.

5. Mutations is the only means of creating variability.

Plant parts used in vegetative propagation

Sugarcane: Canes

Rose: Cuttings

Potato: Tubers

Banana: Suckers

Onion: Bulbs

From a mixed population of a vegetatively propagated crop, few to several hundred superior plants are selected on the basis of yield, maturity, plant height, disease resistance, days to flowering etc. Clones from the selected plants are grown separately and based on morphological characters, superior clones are selected. Selected clones are grown along with a standard check and preliminary yield trial is done. Few outstanding clones are selected on the basis of these trials and put in multilocation yield trials and superior clones are identified and released as a new variety. Variety development may take place in nine years through this method.

Eg: Potato- Kufri red, Kufri safed

Mango: Mundapa Pedda Neelam

Advantages:

1. Varieties are stable and easy to maintain
2. Clonal selection, combined with hybridization generates necessary variability for several selections.

Lecture No.12

HYBRIDIZATION-HYBRIDIZATION METHOD, SELECTION OF PARENTS, EMASCULATION, BAGGING, ARTIFICIAL CROSS POLLINATION, HYBRID VIGOUR

The chief objective of hybridization is to create genetic variation. The mating or crossing of two plants or lines of dissimilar genotype to develop new plants is known as hybridization..

In each variety, both desirable and undesirable characters may exist. Plant breeder tries to transfer one or more desirable characters into a single variety from other varieties.

For eg: One variety of paddy has bold grain and resistant to fungal diseases while another variety has fine grain and susceptibility to fungal diseases. If hybridization done between these two varieties, possibility of getting varieties with fine grain and resistant to fungal diseases. Even if high yielding and early maturity etc desirable characters are transferred in to this variety, it is highly profitable to farmers. In majority of the plants, through natural cross pollination, hybridization occur continuously.

In hybridizarion, new recombinants are produced, hence genetic variability is created resulting in development of plant breeding.

Hybridization Method

1. **Selection of parents:** Self pollinated species are homozygous, hence we can start hybridization directly. Cross pollinated species, on the other hand, are highly heterozygous. Hence we can not start hybridization directly. First we have to bring to homozygous condition by developing inbred lines through continuous selfing or inbreeding and then only hybridization can be taken up.
2. **Emasculation:** Majority of the crops have bisexual flowers i.e. both male and female reproductive organs in the same flower. In self pollinated crops, emasculation procedure is compulsory. Emasculation is the process of removal of male parts (stamens) from a bisexual flower which is selected as female parent without damaging the other parts. It is normally done one day before the anthers are expected to dehisce or mature and the stigma is likely to become fully receptive. It effectively controls self pollination.

Emasculation can be done easily when buds are in big size. Select the bud that will open next day and emasculate with clean forceps by removing the calyx, corolla and the monodelphous stamens without causing injury to the style and stigma.In Jowar and Bajra spikelets occur in pairs on the lateral branches of the panicle and due to compact panicles, emasculation by forceps is

highly difficult and special techniques are needed. In this type of situation, hot water treatment of entire panicle at 40-50 ^{o}C for 1-10 minutes kills the anthers and ovary is tolerant to this temperature.

In few crops male sterility may exist. In these types of plants even if anthers are present in bisexual flowers, pollen grains are non functional or infertile while female gametes function normally. Such plants can be used directly as female parents without attending emasculation.

3. Bagging: Emasculated flowers should be covered immediately with red colored paper cover to protect against contamination from foreign pollen and also for easy identification of emasculated bud during dusting.

4. Artificial pollination: Remove the red paper cover of the emasculated bud and dust the pollen gently over the stigmatic surface using cotton or camel brush, etc and is usually done in morning hours. After dusting, the emasculated flowers are again covered with white or other coloured paper cover for two to three days. Plants are tied with labels showing information of parents and date of cross pollination.

Cover the flowers of male parents with paper covers to avoid contamination of pollen with pollen from other plants. The seeds as well as the progeny resulting from the hybridization are known as hybrid or F1. The progeny of F1, obtained by selfing or intermating of F1 plants, and the subsequent generations are termed as segregating generations. The term cross is often used to denote the products of hybridization, i.e. the F1 as well as the segregating generations. From F2 onwards the generations are known as segregating generations and they may be handled either by pedigree method of Bulk method or backcross method for evolving new varieties.

Hybrid vigour or Heterosis

The term heterosis was first used by Shull in 1914. Heterosis may be defined as the superiority of an F1, hybrid over both its parents in terms of yield or some other character. Generally, heterosis is manifested as an increase in vigour, size, growth rate, yield or some other characteristic.

Hybrid vigour has been used as a synonym of heterosis. It is generally agreed that hybrid vigour describes only the superiority of hybrids over their parents, while heterosis describes other situations as well. But a vast majority of the cases of heterosis are cases of superiority of hybrids over their parents. The few cases where F1 hybrids are inferior to their parents may also be regarded as cases of hybrid vigour in the negative directions. For example, many F1 hybrids in

tomato are earlier than their parents. Earliness in many crops is agriculturally desirable. It may be argued that the earliness of F1 hybrids exhibits a faster development in them so that their vegetative phase is replaced by the reproductive phase more quickly than in their parents. Therefore, the use of heterosis and hybrid vigour as synonyms seems to be reasonably justified.

In our country, farmers are getting high yields by cultivating hybrids. Plant breeders are exploiting the hybrid vigor in the development of high yielding hybrids.

In 1760-1766 - Joseph koelreuter, a German, made extensive crosses in tobacco and identified hybrid vigor but unable to explain the reasons responsible for hybrid vigor.

In 1914, G.H.Shull, an American scientist coined term heterosis. In maize, loss of vigor occur due to self pollination and hybrid vigor is more due to cross pollination. Hybrid vigor is the resultant of expression of more dominant genes in hybrids than their parents or heterozygosity of hybrids.

Lecture No.13

MUTATION BREEDING: SPONTANEOUS AND INDUCED MUTATIONS, ACHIEVEMENTS

Mutation is the sudden heritable change other than the Mendelian segregation and gene recombination in an organism. The term mutation was coined by Hugo Devries in 1900 for the first time while working on Oenothera Lamarkiana (Evening Prime Rose) to describe new varieties. and the word is derived from the latin word 'MUTARE' means to change.

Creation of desirable mutations in plants and using them for development of improved new varieties is called as Mutation breeding.In plant breeding methods, it is an efficient method. Experiments of Muller (1927) and Stadler (1928) laid foundation for Mutation breeding.

Based on origin, the mutations are classified as spontaneous and induced mutations.

1. **Spontaneous mutations :** Mutations occur in natural populations at a low rate (10^{-6}).Natural agents like electrical ways, atomic rays, temperature etc are responsible for spontaneous mutations. For conventional plant breeding, this is the base material.

   Eg: Prime Rose large sized plants (Oenothera zygas)

   Short Plants (Oenothera nanella)

2. **Induced mutation :** Mutations may be artificially induced by treatment with certain physical or chemical agents. By using X-rays mutations were induced first time by H.J.Muller in Drosophila and C.J.Stadler in Barley. Induced mutation produce high genetic variations in short span necessary for crop improvement.

Substances that accelerate the rate of mutations are called Mutagens. These are of two types.

1. Physical mutagens
2. Chemical mutagens

Physical mutagens: Ionising radiations-X-Rays, β-Rays, ϒ-Rays

Non ionizing radiations- Ultra violet rays.

The plant material like Seeds, Seedlings, Flowers, Cuttings may be treated with rays to induce mutations in plants.

Chemical mutagens: Colchicine, Formaldehyde, Ethane Methane Sulphonate, Malic Hydrazide. These will create more genetic vatiations. In majority of the crops, to create variations mutation breeding is the fastest method.

Achievements:-

1. Paddy-IR-8 was high yielding ,short statured and susceptible to leaf spot, leaf blight and leaf blast diseases. Disease resistance was incorporated in this variety through mutation breeding.
2. Barley- In Sweedish barley variety, hardiness was incorporated
3. Castor- Aruna (NPH1) – Fast neutrons induced mutant from HC 6

Lecture No.14

POLYPLOIDY BREEDING, PRODUCTION OF ARTIFICIAL POLYPLOIDS

In crop improvement, polyploidy breeding also plays an important role along with introduction, selection and hybridization. The somatic chromosome number of any species, whether diploid or polyploidy, is designated as 2n, and the chromosome number of gametes is denoted as n. An individual carrying the gametic chromosome number, n, is known as haploid. A monoploid, on the other hand, has the basic chromosome number, x. In a diploid species, n=x; one x constitutes a genome or chromosome complement. The different chromosomes of a single genome are distinct from each other in morphology and or gene content and homology; members of a single genome do not show a tendency of pairing with each other. Thus a diploid species has two, a triploid has 3 (3x) and a tetraploid has 4 (4x), pentaploids has 5 (5x), heaxaploids has 6 (6x), octaploids has 8 (8x) genomes and so on. Use of polyploids in crop improvement is called as Polyploidy breeding.

Hexaploids:

Commercial bread wheat- Triticum aestivum is an example of hexaploid.

Production of doubled chromosome numbers

1. During cell division cold treatment of zygote formed after fertilization
2. Chemical treatment of flower and vegetative buds with Acenaphthene, Colchicine, Coumarine
3. X-ray irradiation of flower and vegetative buds.

Of all these, Colchicine treatment is the most effective and the most widely used treatment for chromosome doubling.It belonged to Liliaceae family. It is an alkaloid derived from the seeds of plant Colchicum autumnale. In anaphase of meiosis division, colchicines inhibits formation of spindle fibres, but doesnot inhibit chromosome replication. This property of colchicines is being used to have polyploidy.

Lecture No.15

PROCEDURE OF HYBRIDIZATION

The mating or crossing of two plants or lines of dissimilar genotype are known as hybridization. In plants, crossing is done by placing pollen grains from one genotype, the male parent, on to the stigma of flowers of the other genotype, the female parent. It is essential to prevent self-pollination as well as chance cross-pollination in the flowers of the female parent. At the same time, it must be ensured that the pollen from desired male parent reaches the stigma of female flowers for successful fertilization. The seeds as well as the progeny resulting from the hybridization are known as hybrid or F1. The progeny of F1, obtained by selfing or intermating of F1 plants, and the subsequent generations are termed as segregating generations. The term cross is often used to denote the products of hybridization, i.e. the F1 as well as the segregating generations.

Hybridization result in

1. Creation of genetic variability and selection. When two genotypically different plants are crossed, the genes from both the parents are brought together in F1. segregation and recombination produce many new gene combinations in F2 and the later generations, i.e. the segregating generations. The degree of variation produced in the segregating generations would, therefore, depend on the number of heterozygous genes in the F1. This sill, in turn, depend upon the number of the genes for which the two parents differ. If the two parents are closely related, they are likely to differ for a few genes only. But if they are not related, or are distantly related, they may differ for several, even a few hundred, genes. However, it is not likely that the two parents will ever differ for all their genes. Therefore, when it is said that the F1 is 100 per cent heterozygous, it has reference only to those genes for which the two parents differ.
2. The transfer of one or more characters into a single variety from other varieties- Combination breeding. The intensity of the character in the new variety is either comparable to or, more generally, lower that in the parent variety from which it was transferred. In this approach, increase in the yield of a variety is obtained by correcting the weaknesses in the yield contributing traits, e.g., tiller number, grains per spike, test weight is that for disease resistance. The backcross method of breeding was designed for combination breeding, and often pedigree method also fulfils the same purpose. In combination breeding, the genetic

divergence between parents is not the major consideration. What is important is that one of the parents must have in a sufficient intensity the character(s) under transfer, while the other parent is generally a popular variety.

3. Direct use of hybrids by utilizing hybrid vigour- In most self-pollinated crops, F1 is more vigorous and higher yielding than the parents. Wherever it is commercially feasible, F1 may be used directly as a variety. In such cases, it is important that the two parents should produce an outstanding F1.

Steps of Hybridization

1. Choice of Parents

Intervarietal Hybridization : The parents involved in hybridization belong to the same species ; they may be two strains, varieties or races of the same spicies. It is also known as intraspecific hyrbidization. In crop improvement programmes, intervarietal hybridization is the most commonly used. In fact, it is so common that it may often appear to be the only form of hybridization used in crop improvement. an example would be crossing of two varieties of wheat, rice or some other crop.

Inter specific/ intra generic hybridization: When two species of the same genus are crossed, it is known as interspecific hybridization; Generally, the objective of such crosses is to transfer one or few simply inherited characters like disease resistance, drought tolerance to a crop species. Sometimes, interspecific hybridization may be used for developing a new variety, e.g., Clinton oat variety was developed from a cross between Avena sativa x A. byzantina (both hexaploid oat species), and CO 31 rice variety was developed from the cross Oryza sativa var. indica x O. perennis. Almost al the present-day sugarcance varieties have been developed from complex crosses between Saccharum officinarum (noble canes), S. barberi (Indian canes) and other Saccharum species, e.g., S. spontaneum (Kans.). The improvement in fiber length of Indian Cotton (Gossypium arboreum) has been brought about by crossing it with American cultivated Cotton ; many improved varieties have resulted from such crosses.

Inter generic hybridization: Crossing between two different genera is termed as inter generic hybridiztion. Inter generic hybridization may also be used to develop a new crop species, e.g., Triticale from a cross between Triticum sp. and Secale cereale (rye).

2. Mating Systems:

Single cross: Product of hybridization between two parents

A x B- Single cross

B x A- Reciprocal cross

Double cross: Product of hybridization between two single corsses

(A x B) X (C x D)

Three-way cross: Product of hybridization among three parents

A x B- F1 x C

Back Cross: Crossing of F1 with either of the parent

A x B- F1 F1 x A- Bc1……Bcn

F1 x B- Bc1……Bcn

Synthetic Cross: is produced by crossing in all combinations a 4-10 number of lines that combine well with each other. Once synthesized, a synthetic is maintained by open pollination in isolation. Some breeders use the terms synthetic variety in a restricted sense: a synthetic variety is regularly reconstructed from the parental lines and is not maintained by open-pollination.

Multiple cross: In self pollinated crops, nearly 32 pure lines are involved in different combinations so that all pure lines are used in crossing.

3. Systems of pollen control:

a. **Monoecious plants**

Staminate and pistillate flowers occur on the same plant either in the same inflorescence or in different inflorescence, the species is called monoecious (meaning "one home"): examples are corn, pea, colocasia, castor (Ricinus communis), coconut etc.

In maize, male inflorescence is called as tassel and the removal of tassel is known as detasseling.

b. **Dioecious plants**

Species with staminate and pistillate flowers occur on different plants are termed dioecious, or "two homes," examples of which are *C. papaya*, *Cannabis,* date palm (Phoenix dactylifera), pistachio (Pistacia vera), Spinach, Asparagus etc.

Removal of male plants

c. **Bisexual flowers**

Bisexual flowers contain both male and female reproductive organs in the same flower. Emasculation is the process of removal of male parts (stamens) from a bisexual flower without damaging the other parts.

4. Emasculation:

1. By hand
2. Forced or cut opening method. eg: Rice, Bengal gram, Pea, Tomato
3. Hot water treatment: At 45-53^{o}c for 1-10 minutes. eg: Rice, Maize
4. Male sterility and self sterility
5. Chemicals- a. Gametocide FW 450- Kills pollen grains in Cotton
   b. Dipping in 57% ethyl alcohol for 10 minutes kills pollen grains in Lucerne
   c. Spraying of Ethrel result in male sterility. eg: Wheat, rice, sweet potato

Emasculation is generally done in the evening, between 4 PM and 6 PM one day before the anthers are expected to dehisce or mature and the stigma is likely to become fully receptive.

5. Bagging: Emasculated flowers should be covered immediately with red coloured paper cover toprotect against contamination from foreign pollen and also for easy identification of emasculated bud during dusting.

6. Pollination: Remove the red paper cover of the emasculated bud and dust the pollen gently over the stigmatic surface using cotton or camel brush, etc and is usually done in morning hours. After dusting, the emasculated flowers are again covered with white or other coloured paper cover for two to three days.

7. The resultant seed after fertilization is the hybrid seed.

Lecture No. 16

CROP VARIETIES/HYBRIDS- EVALUATION TESTS, VARIETY NOTIFICATION.

- In any crop improvement programmes, the ultimate goal is the development of high yielding varieties with disease and pest resistance and quality over the present varieties.
- For these high yielding varieties must be developed using various plant breeding methods.
- For utilization of improved varieties on commercial basis on large scale on farmers fields, either central variety release committee or state variety release committee must release these varieties.
- The varieties ready for release are to be proved superior over the existing varieties in a systematic manner.
- New varieties are to be evaluated for yield, diseases, pests and quality traits.
- For this, new varieties are tested in various states or in various research stations in a state.
- These tests are conducted by All India Co-ordinated Improvement Project in various places for evaluation of traits.
- At the same time, the breeder who developed the variety need to confirm the good qualities of the variety.

In India, the release of new crop varieties consists of four major steps viz.

1. Development of new strains
2. Evaluation of performance
3. Identification of superior strains and
4. Release and notification

Development of new strains

The new strains are developed by ICAR crop research institutes and state agricultural universities for specific purposes. Various breeding methods are used for development of new strains in self and cross pollinated species

Evaluation of performance

Station trials

1. **Row yield trials (RYT):** In this test, for every ten rows of improved variety one row of check variety is included and it is not a replicated trial.

2. **Replicated Row Yield Trial (RRYT):** Varieties found to be superior in replicated yield trials are evaluated in replicated row yield trials along with checks and selected ones are promoted to Preliminary yield trials.
3. **Preliminary yield trials (PYT):** Varieties found superior over the checks in replicated row yield trials are tested in preliminary yield trials. These trials are conducted for two years and the selected new strains are tested under All India Coordinated Trials. At the same time, these strains are screened against biotic and abiotic stresses and selected entries are promoted to Comparative yield trials. Entries selected to All India Co-ordinated trials are sent to the Project Co-ordinator of that crop for evaluation. These entries are evaluated in Initial evaluation yield trials at various research stations.
4. **Comparative Yield Trial (CYT) or Advanced Yield Trial:** In CYT, entries are evaluated in replication with one or more checks in three seasons and the entries found superior over the checks in these three seasons are tested in Multilocation Trials.
5. **Multilocation Trials-MLTs:** Locations for testing are finalized in crop scientist meeting organized in every year. Crop breeders from various research stations propose the entries for testing. Considering the qualities of the entries, entries that should be tested in particular location are finalized for testing. This meeting is organized by Principal Scientist of that crop in state. After analyzing the crop yields and other attributes from tested locations, the promising entries are promoted to Adoptive Research Trials (ART).

   AIMS:

   - Selection of improved varieties superior over the present commercial varieties for particular environment.
   - Selection of high yielding pest and disease resistant varieties coupled with quality.
   - MLT's are tested for three years.
   - MLT's are tested in agricultural research stations, SAUs, Agricultural Colleges, training institutes, farmer's fields under supervision of evaluation agencies.
   - To develop a variety with all good traits is highly difficult and development of a variety with few good traits is useful and profitable.
6. **Adoptive Research Trial (ART)**:

In annual group meeting workshops held once in a year, all the scientists from various locations identify the improved varieties based on the data received from All India Co-ordinated trials. The

identified entries are planted in 50 cents area without replication and all recommended crop management practices are followed and yield obtained is the basis for identification of variety.

7. Minikit trials:

Minikits are conducted in identified farmers fields. High yielding varieties Crops Director, Ministry of Agriculture, Government of India conduct minikits in various locations of the country. In each zone 300-400 farmers fields are selected for testing. A paper on the size of the plot and recommended package of practices to be followed is handed over to farmer along with seed. Main objective of minikits is to make availability of seed of newly developed varieties to farmers in short span. In this way, seed of new variety ready for release is accepted by farmers in one year advance.

8. Pests/Disease Screening:

Screening against pests and diseases is carried out in green house and in fields in all the trials i.e. PYT/IET/URT/AVT for identification of resistant varieties to pests and diseases. In hot spot locations also entries are screened against pests/diseases to know the resistance or tolerance of the entries to pests/diseases.

9. **Quality tests**:

New varieties ready for release are tested for milling percentage in case of rice, shelling percentage in case of maize and ground nut and for consumer preference and values.

Identification of Entry for release

In annual group meeting workshop held once in a year, all the scientists from various locations identify the improved varieties based on the data received from All India Co-ordinated trials that are conducted across the locations of the country. Decision on identification of variety is entrusted to subcommittee.

Members of Subcommittee are as follows:

1. Deputy Director General (Crop Science), ICAR, New Delhi- Chairman
2. Project Coordinator of the concerned Crop
3. Principal Investigator of Agronomy, Pathology, Entomology, Quality, Physiology of the Project
4. Director, Seeds of the concerned crops
5. 5-6 technical members working in the project

- Breeder who developed the new variety has to prepare proposal on Identification of variety as prescribed by the concerned crop project for submission to the sub committee.

- Variety may be accepted for identification or rejected or non accepted due to non submission of relevant information.
- Breeder has to keep huge quantity of breeder seed for the identified entry.
- Decision on the supply of Breeder seed to the agencies for large scale production, adaptive and minikit trials is taken in the same meeting.
- Identified entry is tested in adaptive trials, for quality and screened against pests and diseases. The workshop recommends the new promoting varieties to replace the existing varieties.

Release and Notification

The proposal for release of new varieties is put up in a prescribed proforma to variety release committee. There are two types of variety release committees viz, state variety release committee (SVRR) and central variety release committee (CVRC). In case of state variety release committee, Director of Agriculture for field crops and Director of Horticulture for vegetable and horticulture crops is the chairman. In central variety release committee, Deputy Director General (Crop Science) of ICAR is the chairman. The release proposal of varieties recommended for All India release is put up before CVRC, while for those recommended for release in a particular state is placed before the SVRC of respective state these committees consist of scientists and representatives of seed producing organizations (NSC, SSC and SSCA) and other related govt. agencies After release, the variety is notified. Seed production can be taken up only after notification of new varieties. The notification is done by the govt. of India.

CENTRAL VARIETY RELEASE COMMITTEE

1. Deputy Director General (Crop Science) - Chairman
2. Production Commissioner, Govt. of India - Member
3. Project Director – Concerned Crop - Member
4. Principle Investigator - Member
5. Director of Agriculture of the State - Member
6. Director High Yielding Varieties - Member
7. Ministry of Agriculture - Govt. of India - Member
8. Deputy Secretary Seeds - Govt. of India – Member

STATE VARIETY RELEASING COMMITTEE

1. Director of Agriculture – Chairman
2. Director of State Seeds Development Corporation – Member
3. Director of State Seed Certification Agency - Member

4. Additional Director of Agriculture (Inputs) - Member

5. Joint Director of Agriculture - Member

6. Director of Research of State Agriculture University – Member

Lecture No. 18

SEED- IMPORTANCE- DIFFERENCE BETWEEN SEED AND GRAIN, CHARACTERS OF GOOD SEED.

Seed: Seed is matured ovule that consisting of an embryonic plant together with a store of food, all surrounded by a protective coat.

Seed quality characters: A good seed should have the following quality characters

Improved variety: It should be superior to the existing variety i.e. the yield should be higher by 20-25% than the existing variety or it should have some desirable attributes like disease resistance, drought resistance, salt tolerance etc., with good yield potential.

Higher Genetic Purity: The seed should be true to type. The seed should possess all the genetic qualities / characters, which the breeder has placed in the variety, genetic purity has direct effect on the yields. If there is any deterioration, there would be proportionate decrease in the yield or performance.

Breeder seed/Nucleus seed = 100%

Foundation seed = 99.5%

Certified seed = 99.0%

Higher Physical Purity: Physical purity of a seed lot refers to the physical composition of the seed lots. A seed lot is composed of pure seed, inert mater, broken seeds, undersized seeds, soil and dust particles weed seeds, OCS etc. Higher the content of pure seed better would be the seed quality. Pure seed together with germination gives the planting value of the seed lot.

Ladies finger, Maize = 99.0%

All crops (Most) = 98.0%

Sesame, Soybean, Jute = 97.0%

Ground nut = 96.0%

Carrot = 95.0%

Pure seed

Free from other crop seeds:

S.No.	Crop	Designated inseparable other crop seeds
1	Barley	Wheat, Oats
2	Oats	Wheat, Barley
3	Wheat	Oats, Barley

Other crop seeds are the plants of cultivated crops found in the seed field and whose seed are so similar to crop seed that is difficult to separate them economically by mechanical means. Cause physical admixture with the crop seed only when these crop mature approximately at the same time when seed crop matures.

Freedom from objectionable weeds: This is an extension of physical purity described earlier. There are certain weed species, which are very harmful to the crop and once established they are difficult to eradicate. An absolute freedom from seed of such species is highly desirable and is one of the important criteria for determining the planning quality of seeds.

Objectionable weeds

These are plants of weed species which are harmful in one or more of the following ways.

- The size and shape of their seeds are so similar to that of the crop seed that is difficult to remove their seed economically by mechanical means.
- Their growth habit is detrimental to the growing seed crop due to competing effect.
- Their plant parts are poisonous or injurious to human and animal beings.
- They serve as alternate hosts for crop pests and diseases.

Objectionable Weeds of Seed Crop Plants

S.No.	Crop	Objectionable weeds
1	Berseem	Chicory(*Chicorum intybus*)
2	Cucurbits	Wild Cucurbita sp.
3	Kasuri methi	Melilous sp.
4	Lettuce	Wild lettuce(*Lactuca sativa*)
5	Bhendi	Wild Abelmoschus sp
6	Rape &Mustard	*Argemone mexicona*
7	Wheat	*Convolvulus arvensis* (Hiran kuri)
8	Paddy	Wild paddy (*Oryza sativa* var. Fatua)

Free from designated diseases

It refers to the diseases specified for the certification of seeds and for which certification standards are to be met with. These diseases would cause contamination, when they are present in the seed field or with in the specified isolation distance (eg. loose smut of wheat).For this the the certification distance has been prescribed as 180 meters.

S.No.	Crop	Designated disease	Causal organism
1	Wheat	Loose smut	*Ustilago tritici*
2	Sorghum	Grain smut, Kernel smut	*Sphacelotheca sorghii*
3	Mustard	Alternaria blight	*Alternaria sp*
4	Pearl millet	Grain smut Green ear Ergot	*Tolyposporium penicillariae* *Sclerospora graminicola* *Claviceps microcephala*
5	Sesame	Leaf spot	*Alternaria* sp
6	Brinjal	Little leaf	Datura virus 2
7	Chilies	Anthracnose leaf blight Leaf blight	*Gloesporium piperatum* *Alternaria solani*
8	Cucurbits	Mosaic	*Cucumis virus*
9	Cowpea	Anthracnose	*Colletotricum* sp
10	Bhendi	Yellow vein mosaic	Hibiscus virus 1
11	Potato	Brown rot Root knot nematode	*Pseudomonas solanacearum* *Meloidogyne incognita*
12	Tomato	Early blight Leaf spot	*Alternaria solani* *Xanthomonas vesicatoria*

Apart from the above, seeds also should have the following qualities.

- Possession of good shape, size, colour, etc., according to specifications of variety
- Higher physical soundness and weight
- Higher germination (90 to 35 % depending on the crop)
- Higher physiological vigour and stamina
- Higher storage capacity
- It should have Optimum moisture content for storage

  Long term Storage: 6-8%

  Short term Storage: 10-13%
- It should have high market value

Importance of seed

Seed is the vital input in crop production because through seed only the investment made on other inputs like pesticide, fertilizer, irrigation and crop maintenance can be realized. The seed required for raising the crop is quite small and its cost is also less compare to other inputs, but the greater income farmer gets depends upon the quality of the small quantity of seed he uses. In addition to above seed is the basic for the following event of agriculture.

Role of good quality seed

At most care must be given upon the use of quality seed and thus certification guarantees quality and ensures high and assured yield under environmental stress conditions. This emphasizes the need for increasing the area under quality seed production. So one has to take efforts to produce quality seed and boost the yield by seed to seed seedling concept.

Significance of quality seed

- Ensures genetic and physical purity of the crops.
- Gives desired plant population.
- Capacity to withstand the adverse conditions.
- Seedlings produced will be more vigourous, fast growing and can resist pest and disease incidence to certain extent.
- Ensures uniform growth and maturity.
- Development of root system will be more efficient that aids absorption of nutrients efficiently and result in higher yield.
- It will respond well to added fertilizer and other inputs
- Good quality seeds of improved varieties ensures higher yield atleast 10 – 12 %

The distinction between seed and grain is vital, being of seminal importance to agriculture. A seed, strictly speaking, is an "embryo" a living organism embedded in the supporting or the food storage tissue. The seed pertains to material (seed, fruit or vegetative propagating material) meant for saving for planting purposes, the essential function being the reproduction. The seed when scientifically produced (such as under seed certification) is distinctly superior in terms of seed quality, namely, the improved variety, varietal purity, freedom from admixtures of weeds and other crop seeds, seed health, high germination and vigour, seed treatment and safe moisture content etc. A grain on the other hand, includes cereals and pulses meant for human consumption.

Differences between seed and grain

S. No.	Seed	Grain
1	It should be a viable one	Need not be a viable one
2	It should have maximum genetic & physical purity	Not so
3	Should satisfy minimum seed certification standards	No such requirements
4	It should be completely treated with pesticide/fungicide to protect seed against storage pests and fungi	It should never be treated with any chemicals, since used for consumption
5	Respiration rate and other physiological and biological processes should be kept at low level during storage	No such specifications
6	Should be compulsorily certified / truthful labelled	No such condition in grain production
7	Should never be converted into grain unless warranted	Can be converted as seed provided the situation warrants
8	It should satisfy all the quality norms	Not considered
9	Produced in small quantities under good management	Produced in high quantities on commercial basis.

Lecture No. 19

CLASSES OF SEED- NUCLEUS SEED, BREEDER SEED, FOUNDATION SEED, CERTIFIED SEED, TRUTHFUL LABELED SEED- SEED CLASSES AND ITS PRODUCTION

Objective: Multiplication of quality seed under vigilant supervision of breeder of seed certification agency to distribute quality seed of notified varieties for sowing purpose.Seed of notified varieties are multiplied in four tier system by the involvement of ICAR Institutes / State Agricultural Universities, State / National Seed Corporation and Seed Certification Agencies.

Mainly five classed of seed are present.

1. Nucleus seed
2. Breeder seed
3. Foundation seed
4. Certified seed
5. Truthful labeled seed

1. Nucleus seed: Nucleus seed: This is cent per cent genetic pure seed with physical purity produced under the direct supervision of the concerned plant breeder. It is the handful of original seed obtained from selected individual plants of a particular variety for maintenance and purification by the originating breeder. It is further multiplied and maintained under the supervision of qualified plant breeder to provide breeder seed. This forms the basis for all further seed production. It has the highest genetic purity and physical purity.

2. Breeder's seed: This is the progeny of the nucleus seed multiplied in large area under the supervision of plant breeder and monitored by a committee. It provides cent per cent physical and genetic pure seed for production of foundation class. Golden yellow coloured certificate is issued for this category by the producting agency.

3. Foundation seed: Progeny of breeder's seed is handled by recognized seed producing agencies in public and private sector under the supervision of Seed Certification Agency in such a way that its quality is maintained according to the prescribed standard. It should have minimum genetic purity of 99.5%.Seed Certification agency issues a white colour certification for foundation class seed. Foundation seed is purchased by Seed Corporation from seed growers. Foundation seed can again be multiplied by Seed Corporation in the events of it s shortage with similar seed certification standard.

4. Certified seed: Progeny of foundation seed produced by registered seed growers under the supervision of Seed Certification Agency by maintaining the seed quality as per minimum seed certification standards. Seed Certification Agency issues a blue colour (Shade ISI No. 104, azure blue) certificate. It should have the minimum genetical purity of 99%. Certified seed may be the progeny of certified seed, provided this reproduction does not exceed two generations beyond foundation seed and provided that if certification agency determines the genetic and physical purity, if not be significantly altered. In case of highly self pollinated crops certification of one further generation may be permitted. Certified seed produced from certified seed shall be eligible for further seed increase under certification, except in case of highly self-pollinated crops, where certification of one further generation may be permitted. Certification tags issued once for certified seed not eligible for further seed increase under certification.

5. Truthfully labeled seed: Truthfully labeled seed is one which is being produced and marketed by the producing company by maintaining the labeling standards and producing agency is totally responsible for seed sale. The farmer or the user of the seed does not know the pedigree of the truthfully labeled seed and he has to relay on the seed producing company.

To the various classes of seed, respective seed color tags are attached to the bags/containers and supplied. Breeder must sign on the breeder seed tags.

Requirement for sale of seed: The seed which is sold should be compulsorily labeled. The colour of the label shall be blue for certified seed and greenish buff colour for truthfully labeled seed. The seed container shall be labeled with following details.

1. Kind
2. Variety
3. Lot number
4. Date of test
5. Inert matter percentage
6. Pure seed percentage
7. Other crop seed percentage
8. Weed seeds percentage
9. Germination percentage
10. Net content
11. Seller’s name and address

12. If treated, then either of the following two statements should appear on the label.

“Do not use for food, feed or oil purposes”

Or

POISON

If the contents of the container is 250 gms, or less, items 5 to 9 may be replaced by the following statements:

“The seed in this container conforms to the minimum limits of germination and purity prescribed under the Act”.

The labeled seed, offered for sale must be packed in containers; must be of notified varieties; and must meet the prescribed minimum limits of purity and germination.

Seed Tags

Class of seed	**Colour of seed tag**	**Size of tag**
Breeder seed	Golden yellow	12cm x 6cm
Foundation seed	White	15cm x 7.5cm
Certified seed	Blue	15cm x 7.5cm
Truthfully labeled seed	Opel green	15cm x 10cm

Differences

S.No.	**Breeder seed**	**Foundation seed**	**Certified seed**
1	Source for breeder seed is nucleus seed	Source for foundation seed is breeder seed	Source for certified seed is either foundation seed/certified seed
2	Multiplied under the supervision of breeder/selected breeder	Multiplied under supervision of National seed corporations.	Multiplied under supervision of State seed corporations.
3	Seed is multiplied in research stations/Agricultural universities	Multiplied in government organizations.	Multiplied by registered seed growers.
4	Genetic purity- 100%	99.5%	99.0%
5	Physical Purity-100%	98.0%	98.0%
6	Breeder seed is exempted from Certification. Breeder seed is produced by the plant breeder which is inspected by a monitoring team consisting of the breeder, representative of seed	Requires seed certification and done by State Seed Certification Agency	Requires seed certification and done by State Seed Certification Agency

	certification agency (DDA), representative of NSC (Deputy Manager) & nominee of crop co-ordinator (s – 11). The crops shall be inspected at appropriate stage.		
7	Source for producing foundation seed	Source for producing certified seed	Distributed to farmers for commercial cultivation.

Differences between Certified seed and truthful labeled seed

S.No.	Certified seed	Truthful labeled seed
1	Certification is voluntary.	Truthful labeling is compulsory for notified kind of varieties.
2	Applicable to notified kinds only.	Applicable to both notified and released varieties.
3	It should satisfy both minimum field and seed standards.	Tested for physical purity and germination.
4	Seed certification officer,seed inspectors can take samples for inspection.	Seed inspectors alone can take samples for checking the seed quality.

Lecture No. 20

PRINCIPLES OF SEED PRODUCTION-GENETIC AND AGRONOMIC PRINCIPLES-REASONS FOR DETERIORATION OF GENETIC PURITY.

Deterioration of Genetic Purity

The genetic purity of a variety or trueness to its type deteriorates due to several factors during the production cycles. Kadam (1942) listed the following important factors responsible for deterioration of varieties.

1. Developmental Variations

When seed crops are grown under environments with differing soil fertility, climate, photoperiods, or at different elevations for several consecutive generation's developmental variations may set in as differential growth responses. It is therefore, preferred to grow the varieties of crops in the areas of their natural adaptation to minimize developmental shifts.

2. Mechanical Mixtures

Mechanical mixtures, the most important reason for varietal deterioration, often take place at the time of sowing if more than one variety is sown with the same seed drill, through volunteer plants of the same crop in the seed field, or through different varieties grown in adjacent fields. Two varieties growing next to each other field is usually mixed during harvesting and threshing operations. The threshing equipment is often contaminated with seeds of other varieties. Similarly, the gunny bags, seed bins and elevators are also often contaminate, adding to the mechanical mixtures of varieties. Rouging the seed fields critically and using utmost care during seed production and processing are necessary to avoid such mechanical contamination.

3. Mutations

Mutations do not seriously deteriorate varieties. It is often difficult to identify or detect minor mutations occurring naturally. Mutants such as, 'fatuoids' in oats or 'rabbit ear' in peas may be removed by rouging from seed plots to purify the seeds.

4. Natural Crossing

Natural crossing can be an important source of varietal deterioration in sexually propagated crops. The extent of contamination depends upon the magnitude of natural cross-fertilization. The deterioration sets in due to natural crossing with undesirable types, diseased plants or off types. In self-fertilized crops, natural crossing is not a serious source of contamination unless variety is male sterile and is grown in close proximity with other varieties.

The natural crossing, however, can be major source of contamination due to natural crossing are the breeding system of the species, isolation distance, varietal mass and pollinating agent. The direction of prevailing winds, the numbers of insects present and their activity and mass of varieties are also important considerations in contamination by natural crossing. The isolation of seed crops is the most important factor in avoiding contamination of the cross fertilized crops.

5. Minor Genetic Variations

Minor genetic variations can occur even in varieties appearing phenotypically uniform and homogenous when released. The variations may lost during later production cycles owing to selective elimination by the nature. The yield trials of lines propagated from plants of breeder's seed to maintain the purity of self-pollinated crop varieties can overcome these minor variations. Due care during the maintenance of nucleus and breeder's seed of cross fertilized varieties of crop is necessary.

6. Selected Influence of Pest and Diseases

New crop varieties often are susceptible to newer races of pests and diseases caused by obligate parasites and thus selectively influence deterioration. The vegetatively propagated stock also can deteriorate quickly if infected by virus, fungi or bacteria. Seed production under strict disease free conditions is therefore essential.

7. The Techniques of the Plant Breeder:

Serious instabilities may occur in varieties owing to cytogenetic irregularities in the form of improper assessments in the release of new varieties. Premature release of varieties, still segregating for resistance and susceptibility to diseases or other factors can cause significant deterioration of varieties. This failure can be attributed to the variety testing programme. In addition to these factors, other heritable variations due to recombination's and polyploidisation may also take place in varieties during seed production, which can be avoided by periodical selection during maintenance of the seed stock.

Lecture No. 21

AGRONOMIC PRINCIPLES OF SEED PRODUCTION

1. Selection of agro climatic region and location

- A crop variety to be grown for seed production in an area must be adapted to the local environment.
- A crop variety to be grown for seed production in an area must be adapted to the photoperiod and temperature conditions prevailing in that area.
- Optimum rain fall, temperature and relative humidity are favourable to crop growth.
- For majority of the crops at flowering and fertilization stages, dry weather and normal temperatures are required.
- At the time of pollination heavy rain fall and frost result in poor seed set.
- High temperatures at flowering result in drying of pollen grains and there by poor seed set.
- High intensity of temperature and dry weather have detrimental effects on flowering of vegetables, pulses and fruit crops. For these crops low humidity, cool climate are necessary for flowering and fertilization.
- Even though oil seeds tolerate high temperatures at flowering time, premature flowering due to high temperatures result in production of low quality seeds.
- Cold temperatures at different stages of crop growth are not favourable for seed production.
- In heavy downpour areas, heavy incidence of pests and diseases, difficulties in harvesting, threshing, pre germination on the crop itself normally occur, hence not suitable for growing seed crops.

Apart from above

- Light soils with good drainage facilities are favourable.

- plot selected for seed crop must be free from volunteer plants, weed plants and have good soil texture and fertility.
- The soil of the seed plot should be comparatively free from soil borne diseases and insects pests.
- Same crop/variety should not be grown on the same plot in previous season for seed production.
- Seed plot must be plain and the seed crop must be isolated from other nearby fields of the same crops and the other contaminating crops as per requirement of the certification standards.

2. Isolation distance of seed crops

- It refers to the separation of the field from field of the same crop species by a minimum distance which vary from one crop to other.
- Proper isolation distance should be provided to avoid natural cross pollination and spread of diseases. The isolation distance depends on nature of contamination and direction of the prevailing wind. Generally more isolation is required at this stage than the later stages.
- In Maize, time isolation can be practiced to avoid contamination if isolation distance is not possible.
  Self pollinated crop: *low isolation distance (3 meter generally).*
  Often cross pollinated crop: *moderate isolation distance.*
  Cross pollinated crop: *high isolation distance.*
- To produce nucleus and breeder seed in small quantities, flower buds that will open on next day must be covered with paper bags till completion of emasculation and artificial pollination.
- Provide isolation after crop harvest avoid mechanical mixtures.
- The equipment and bags used for harvesting, threshing and cleaning should be clean to avoid mechanical mixtures and to maintain purity.

Isolation distances are of three types

1. Isolation distance
2. Time isolation
3. Mechanical barriers- cloth, plastic or sesbania

3. Selection of Variety

- Good land preparation helps in improved germination, good stand establishment and destruction of potential weeds. It also aids in water management and good uniform irrigation.
- The variety of seed production must be carefully selected, should possess disease resistance, earliness, grain quality, a higher yielder, and adapted to the agro climatic conditions of the region and procured from authorized seed companies.
- Depending upon the requirement the following seed treatment may be given.

a. Chemical seed treatment.
b. Bacterial inoculation for the legumes.
c. Seed treatment for breaking dormancy

- For hard seed coats, soak the seed overnight which enable early germination.
- The seed crops should invariably be sown at their normal planting time. Depending upon the incidence of diseases and pests, some adjustments, could be made, if necessary.
- Lower seed rates than usual for raising commercial crop are desirable because they facilitate rouging operations and inspection of seed crops.

4. Method of sowing

The most efficient and ideal method of sowing is by mechanical drilling. This enable the required quantity of seed at appropriate depth.

- The equipment used for sowing should be clean to avoid mechanical mixtures.
- Row sowing makes operations like plant protection, rouging and field inspections easy.
- Maintain appropriate row-to-row and plant-to-plant spacing.
- In hybrid seed production plots, maintain female: male row ratios and proper care must be taken to avoid mixing of seed.

- Depth of sowing is extremely important in ensuring good plant stand. Small seeds should usually be planted shallow, but large seeds could be planted a little deeper.
- In light sandy soils, germination percentage is more than in clay soils.

5. Rouging

- Adequate and timely rouging is extremely important in seed production. Removal of off type (phenotypically different) plant from the field of an improved variety is known as rouging. Rouging in most of the field crops may be done at many of the following stages as per needs of the seed crop.

a. Vegetative / preflowering stage
b. Flowering stage
c. Maturity stage

- Rouging of seed fields prior to the stage (pre flowering stage) at which they could contaminate the seed crop is necessary to avoid off types particularly in cross pollinated crops. Major rouging should be done before flowering.
- The offtypes should be identified based on morphological characters such as plant type, plant height, leaf color, leaf size, leaf shape, leaf orientation and other characters like malformed, pest and disease infested plants and are totally removed.
- In few crops rouging operation at early vegetative stage helps in removal of pest and disease infested plants.
- Some plants would be identified at flowering stage rather than at vegetative stage are completely removed along with roots.
- In hybrid seed production if male sterility is used, remove pollen shedders in female rows.
- Proper care must be taken to avoid contamination of seed borne fungi to healthy plants.
- At crop maturity remove the offtypes that are difficult to identify in previous crop growth stages and the plants that reduce physical purity.
- After crop harvest observe panicles closely and remove ones with change in kernel colour, disease infested, shrunken seed coat, off textured seed coat etc. In case of tuber and vegetable crops, at the time of harvest remove offtype tubers and fruits to maintain crop quality.

6. **Supplementary Pollination**

- **Bee Hives:** Provision of honey bees in hives in close proximity to the seed fields of crops largely cross pollinated by the insects, ensure good seed set thereby greatly increase seed yields.
- **Hand pollination**: In Sunflower, rub the palm with muslin cloth on the male parental line and then on female parent so as to transfer the pollen from male to female parent during peak flowering time. This is to be repeated daily during the flowering period in the morning hours.
- **Rope pulling**: In Rice, shaking the R line panicles by rope pulling at panicle level or rod driving during anthesis can make their anthers dehisce and spread the pollen widely and evenly thus the out crossing rate could be increased. It is more effective especially on calm or breezy days. Generally, supplementary pollination is carried out at 30 minutes interval for 5 times daily both morning and evening during peak anthesis (10-12 am and 2-4 p.m.) until no pollen remains on the R line. It is not needed when the wind is greater than moderate breeze.

7. **Weed control:**

- Good weed control is the basic requirement in producing good quality seed.
- Weeds may cause contamination of the seed crop in addition to reduction in yield.
- Weeds act as alternate hosts for pests and diseases.
- Effective weed management practices are to be carried so that flowering and seed formation are affected in weeds.
- Any one of the methods like crop rotation, inter cultivation, chemical control and hand weeding etc are followed for weed control.

8. **Irrigation Management:**

- Irrigation can be important at planting for seed crops on dry soils to ensure good uniform germination and adequate crop stands. Excess moisture or prolonged drought adversely affects germination and frequently results in poor crop stands.
- Irrigation at critical stages of crop growth result in disease free quality seed and higher yields.
- Importance of irrigation mainly depends upon crop and soil texture.

- To get maximum benefit from irrigation, nutrients are supplied to the crop in organic form and inorganic form (Nitrogen and phosphorous).
- For uniform germination and optimum plant stand, optimum moisture must be available. In critical stages of crop growth i.e. vegetative stage, flowering and maturity stages, the crop should not be affected with severe drought.
- Excessive moisture and severe drought have drastic affect on crop growth and development.
- Surface irrigation either through sprinkler or drip or sub surface irrigation under soil profile is desirable.
- Withheld of irrigation prior to 2-3 weeks of crop harvest create suitable environment for harvesting.

9. Plant Nutrition

- In the nutrition of seed crops, nitrogen, phosphorus, potassium, and several other elements play an important role for proper development of plants and seed. It is, therefore, advisable to know and identify the nutritional requirements of seed crops and apply adequate fertilizers.
- Split application of nitrogen restricts excess crop growth and prevents lodging.
- Application of nitrogen at the time of flowering increase yield and quality in majority of the crops.
- Top dressing of nitrogen to early maturing varieties makes them to late maturity.
- Grass sps and pea respond to early nitrogen application. Lettuce responds to nitrogen application at the time of flowering.
- Phosphorous and potassium are responsible for root growth, strength, seed growth and hastens maturity. Increase disease resistance.
- In oil seed crops Potassium enhances the efficiency of photosynthesis thereby increasing protein and lipid metabolism.
- Essential and micro nutrient requirements of the crop can be obtained from soil testing.

10. Plant Protection

- Successful disease and insect control is another important factor in raising healthy seed crops. Apart from reduction of yield, the quality of seeds from diseased and insect damaged plants is invariably poor.

- Seed treatment controls the soil borne diseases.
- Timely application of plant protection chemicals in correct dosage effectively controls the pests and diseases.
- Plant protection measures should be taken to control the spread of pests and diseases.

11. Harvesting

- It is of great importance to harvest a seed crop at the time that will allow both the maximum yield and the best quality seed.
- Practicing all agronomic practices in growing seed crop and after meeting seed certification standards, the crop is ready for harvest.
- Full maturity of the crop results in easy threshing and reduces harvesting losses. Early harvesting result in heavy losses in threshing and processing. Late harvesting result in lodging of the crop, shattering of grains, germination, pests and disease attack, coinciding with unfavorable environment like cyclones, heavy wind etc.
- Seed moisture is the best indicator for correct time of harvesting and it varies from crop to crop. If machines are used for harvesting, the seed moisture content should not be more than 15%.

Crop	Moisture %
Soybean	13%
Wheat	15-17%
Maize	< 20%

- In general mechanical damage to the seed is low when the seed moisture is < 20%.
- Proper care should be taken for machine based harvesting and threshing to avoid seed injury and to mechanical mixtures. Proper care should be taken while handling the harvested produce.

12. Drying of seeds

- In order to preserve seed viability and vigour it is necessary to dry seeds to safe moisture content levels. For getting good quality of seed, the threshing floors should be either cement lined floors or tarpaulins. Seed should be dried by spreading in thin layer on the drying floor. Drying decrease moisture content and increase grain quality and storage. Proper care should be taken while drying to avoid mechanical mixtures.

13. Seed storage:

- The best method of sowing seed for short periods is in sacks or bags in ordinary buildings or godowns.
- Labeling should be done to the bags and piled over wooden tables/plastic pallets. Store godown should be clean and either malathion spray or fumigation should be done to control stored grain pests in godown.
- Seed bags should not be piled over three tiers.

14. Isolation distance

- In seed production isolation refers to the separation of the field from field of the same crop species by a minimum distance which vary from one crop to other. Proper isolation distance should be provided to avoid natural cross pollination from neighbouring crop fields. The isolation distance depends on nature of contamination and direction of the prevailing wind. Seed crops should be planted in an area such that it should be away from pollination by wind, water and birds, free from volunteer plants. Isolation distance helps in maintenance of genetic purity and protection against seed borne diseases.

eg: Wheat, Barley (loose smut), dwarf bunt of wheat.

Lecture No.22

ISOLATION DISTANCE- TYPES

Seed crop field should be separated from the field of the same crop such that at the time of flowering the pollen grains dehisce from the anthers didn't reach the seed crop field. It is possible in the following ways.

- To meet the seed certification standards, seed crop field should be separated from the field of the same crop by a minimum distance.
- Maintain proper isolation distance between seed crop and fields of the same or contaminated crops.
- In Maize, time isolation should be practiced to avoid contamination if isolation distance is not possible.
- To produce nucleus and breeder seed in small quantities, flower buds that will open on next day must be covered with paper bags till completion of emasculation and artificial pollination. This will surpass the necessity of isolation distance.
- Provide isolation after crop harvest to avoid mechanical mixtures.
- The equipment and bags used for harvesting, threshing and cleaning should be clean to avoid mechanical mixtures and to maintain purity.
- The distance travelled by pollen from one plant by various means and fertilize the flowers of other plants located in different field is used to decide the isolation distance of the crop. Distance travelled by pollen that is used to separate seed crop from field of the same crop is termed as isolation distance.

  Isolation distances are of three types

  1. **Isolation distance**: It refers to the separation of the field from field of the same crop species by a minimum distance which vary from one crop to other. Isolation distance is low in self pollinated crops and high in cross pollinated crops. Isolation distance varies according to the class of seed.
  2. **Time isolation**: In few crops time isolation is followed.
- If space isolation is not permitted, time isolation can be practiced to avoid contamination.
- Not permitted in tillering crops.
- Flowering of early planting and present planting crops should not be coincided.

- In Maize, Seed crop should be planted ahead of 21 days than other maize crops.

3. **Mechanical/barrier isolation**:

- Bagging of flowers-Hybrid seed production.
- Erection of barriers around the field with plastic or barrier crops like sesbania, sugar cane, maize up to 2-3 feet height.
- In self pollinated crops, crops in which pollen can't travel to longer distances and with heavy pollen this method is usually practiced.

eg: Mechanical barriers- cloth, plastic or sesbania

Examples of isolation distance in crops

1) **Paddy:**

Space isolation:

Paddy is highly self-pollinated crop, however, some cross pollination does occur. The extent of natural cross-pollination varies from 0-6.8%. For pure seed production the seed fields must be isolated by at least 3m for both foundation and certified seed production from other varieties and same varieties not confirming to varietal purity.

Maintenance of A-line or Hybrid seed Production

The hybrid paddy fields should be isolated from the other paddy fields, including commercial hybrids and same hybrid not confirming to varietal purity requirements for certification by at least 200 meters for seed classes A, B & R-line production and by 100 meters for hybrid seed production (AxR). For hybrid seed production (A x R), if space isolation is a problem we can go for time isolation or barrier isolation. In the space isolation other than same varieties or pollen parent should not be present.

For time isolation the difference between the flowering of seed plot and the contaminating plot should be at least 4 weeks. When both space and time isolation is not possible we can go barrier isolation.

In barrier isolation a barrier crop which is of 6-8 feet height should be grown around the seed plot for 10 to 10 meters. The commonly used barrier crops are daincha, sugarcane, sorghum etc.

Time isolation: If space isolation is not possible, time isolation should be followed. Male and female parents of hybrids should be sown 21days either earlier or later compared to other varieties. After 21 days, the other varieties should flower to avoid contamination.

Barrier crops: Some fields are encircled with hills, rivers and forests and act as natural barriers for foreign pollen and avoid contamination. Barrier crops like maize, sugarcane, diancha should

be planted in 3m distance around the crop for varieties and 30 m distance around the crop for hybrids or 30m wood lot or 2m plastic sheet around hybrid crops.

Maize:

Open Pollinated varieties (Synthetic's and Composites):

Maize is a highly cross pollinated crop, therefore for pure seed production the fields of maize should be isolated from other varieties of maize and same varieties not confirming to varietal purity by 400 m and 200 m foundation and certified seed production respectively.

Hybrid seed production

In maize we are having single cross, double cross and three-way cross hybrids. Maintenance of parental lines/inbred lines and single cross seed production is considered as foundation seed class and commercial hybrid seed production or double cross seed production or three-way cross seed production as certified seed production.

Maintenance of Parental lines/ Inbred lines

400 m of isolation is required from other maize varieties and hybrids with same kernel colour and texture as that of the seed parent and 600 m from other maize varieties and hybrids with different kernel colour and texture. In case where space isolation is a problem we can go for time isolation. Time isolation is provided 5% or more plants in the seed field should not be with receptive silks when more than 0.1% of plants in the contaminating field are shedding pollen.

Double cross hybrid seed production / Commercial hybrid seed production

- 200 m from any maize with same kernel color and texture of seed parent
- 300 m from maize with different kernel color or texture of that of seed parent
- 5 m from other hybrid seed production plot having same male parent.
- Differential blooming dates are permitted for modifying isolation distance provided
- 5% or more plants of the seed parent should not have receptive silks when more than
- 0.5% of plants in the contaminating field shed pollen. Or
- Distance less than 200 m may be modified by planting additional border rows of male parent if the kernel color and texture of the contaminating maize are same as that of seed parent.
- For area upto 4 hectares and with decrease in isolation distance by 12.5 m an additional border row of male parent should be planted.

Isolation distance (m)	No.of male rows
200.0	1
187.5	2
175.0	3
167.5	4
150.0	5
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50.0	13

1. Border rows must be planted in continuation to the seed field at the same time and with same seed rate and spacing.
2. Seed fields having diagonal exposure to the contaminating field should be planted with border rows in both the directions of exposure.
3. Natural barriers like thick trees and buildings cannot be substitute the border rows.
4. When two seed fields with different pollinators are within the isolation distance both are to be provided with border rows.
5. Modification of isolation distance with boarder rows is not permitted if the contaminating field parent is of different kernel color or texture if it is popcorn or sweet corn.

Jowar

Open pollinated varieties

Sorghum is a self-pollinated crop but cross-pollination up to 8-10 % may occur. In some of the varieties with loose or lax panicle types the extent of natural cross-pollination may go up to 50 %. Hence the seed fields must be isolated from other varieties of grain and dual-purpose sorghum and same variety not confirming to varietal purity by 200m for foundation seed class and 100 m for certified seed class. An isolation of 400 m is required from Johnson grass (Sorghum halepense) and other forage sorghums with high tillering and grassy panicles. Differential blooming for modifying isolation distance are not permitted (i.e. time isolation is not permitted).

Isolation distance of A, B, R lines or Hybrid seed Production (AxR)

The isolation distance for maintenance of A-line (AxB) is 300 m from fields of other varieties of grain and dual purpose sorghum and same variety not confirming to varietal purity and 400 m from Johnson grass, Sudan grass and other forage types. The isolation distance required for B and R lines are similar to that of maintenance of A-line. For commercial hybrid seed production (AxR) the isolation distance required is 200 m from fields of other varieties of grain and dual purpose

sorghum, and same hybrid not confirming to varietal purity requirements of certification, 5 m from other hybrid seed production plot having the same male parent and 400 m from Johnson grass, Sudan grass and other forage types. Differential blooming dates for modification of isolation distance are not permitted.

Bajra:

Bajra is predominantly a cross pollinated crop with 80% cross pollination due to protogynous condition. The pollinating agent is wind.The spike emerges about 10 weeks after sowing, The styles begin to protrude 2-3 days later first at the top of the inflorescence and proceeds. They take two days to complete the entire spike. Exerted stigma remains receptive for 12-24 hours. Anthers usually emerge after the styles are dry. The anther emergence starts from middle of the spike and proceeds upwards and downwards. Anthesis occurs throughout the day and night with the peak between 8.00 p.m. to 2.00 a.m.

Synthetics & Composites

For pure seed production the seed field should be isolated by 400 and 200 m for foundation and certified seed respectively from other varieties of bajra and from same variety not confirming to varietal purity requirements.

Hybrids

Isolation required is 1000 m from other bajra fields for foundation seed and 200 m for certified seed production.

Time isolation is not permitted in bajra.

Red gram:

Red gram is partially self and cross pollinated. Although anthers burst before flowers open, there is considerable cross-fertilization by bees and other insects. Natural crossing to the extent of sixty five percent has also been recorded.

Open Pollinated Varieties

For maintaining variety purity an isolation of 200 mts. for breeder seed and foundation seed class and 100 mts. for certified seed class is necessary from fields of other varieties and of the same variety not confirming to varietal purity requirements of certification.

Hybrids

It is possible to produce several hybrids in one isolation block using a common male parent and several male sterile, if their flowering can be synchronized. Hence, appropriate

isolation distance of 200 m between two seed blocks should be maintained to avoid contamination.

Green gram, Black gram and Bengal gram

Green gram and Black gram are highly self-pollinated. Natural cross pollination to the extent of 0 to 5% has been recorded. Therefore, for maintaining variety purity an isolation of 10 m. for foundation seed class and 5 m. for certified seed class is necessary from fields of other varieties and of the same variety not confirming to varietal purity requirements of certification.

Ground nut

Ground nut is highly self pollinated crop as per flower arrangement. For pure seed production the seed fields must be isolated by at least 3m for both foundation and certified seed production from other varieties and same varieties not confirming to varietal purity.

Sunflower

Sunflower is partially self and cross pollinated crop. The extent of natural cross pollination varies from 17-62% according to insect activity.

Open Pollinated Varieties

The fields must be isolated by atleast 400 meters for foundation seed class and 200 meters for certified seed class from fields of other varieties, same varieties not confirming to varietal requirement and wild sunflower.

Hybrids

The seed fields must be isolated from other sunflower fields, increase of same line seed fields not confirming to varietal purity requirements of certification and from wild sunflower species by 600-1000 meters for maintenance of Aline and 400 meters for hybrid seed production or A x R.

Castor

Castor is a cross pollinated crop, protogynous and wind pollinated. Inflorescences are borne terminally on the main and lateral branches. The racemes of castor are monoecious with the pistillate flowers on the upper 30-50% and staminate flowers on the lower part of the inflorescence. Cross-pollination by wind varies from 5-36% according to the prevailing climatic conditions.

Open Pollinated Varieties

For pure seed production the seed crop must be isolated from other variety fields and same variety not confirming to varietal purity by atleast 300m and 150 m for foundation and certified seed classes respectively.

Hybrids

The isolation required is 600m for foundation seed and 300m for certified seed from other varieties and hybrids of castor.

Soybean

Soybean is self pollinated crop and the extent of natural cross pollination is <1%. For pure seed production the seed fields must be isolated by at least 3m for both foundation and certified seed production from other varieties and same varieties not confirming to varietal purity.

Sesame:

Sesame is self pollinated crop and the extent of natural cross pollination is ranges from 4-5%.Due to favourable environmental conditions i.e. heavy wind and insect activity cross pollination may occur around 0-50%. For pure seed production the seed crop must be isolated from other variety fields and same variety not confirming to varietal purity by atleast 100m and 50 m for foundation and certified seed classes respectively. Five border rows should be planted around the seed crop.

Cotton:

Open Pollinated Varieties

Cotton is self-pollinated crop but natural cross-pollination may occur from 10-50% in *Gossypium hirsutum*, 1-2 % in *G. arboreum* and 5-10% in *G. barbadense*. Self pollination occurs as pollen grains are heavy, gelatinous and stigma doesn't emerge from flower. Insects facilitate cross pollination. It is desirable to produce only one variety at a time. For pure seed production the isolation distance required is 50 m and 30 m for foundation and certified seed respectively from other varieties of the same species and same varieties not confirming to varietal requirements and 5m from the fields of other species for foundation and certified seed production.

Hybrids

Isolation distance required is 50 m and 30 m for foundation and certified seed respectively and 5 m between the parental lines.

Jute

Vegetable gogu (*Hibiscus cannabinus*) and fibre gogu (*Hibiscus sabdariffa*)

It is highly self pollinated crop as anthers and stigma remain closely in flower. As stigma expose out from the flower, cross pollination also occur. Insect pollination is 10-16% in vegetable. For pure seed production the isolation distance required is 50 m and 30 m for foundation and certified seed respectively from other varieties of the same species and same varieties not confirming to varietal requirements and 5m from the fields of other species for foundation and certified seed production.

Lecture No. 23:

ROUGING

Rouging

The existence of off type plants is another source of genetic contamination. Off type plants differing in their characteristics from that of the seed crop are called as off types. Removal of off types is referred to as rouging. Rouging is compulsory to maintain the genetic purity of the crop in cross pollinated crops.

Removal of off types:

- All plants not typical of the variety should be pulled and removed before flowering.
- The offtypes should be identified based on morphological characters such as plant type, plant height, leaf color, leaf size, leaf shape, leaf orientation and other characters like malformed, pest and disease infested plants and are totally removed.
- Remove virus attacked plants
- In hybrid seed production if male sterility is used, remove pollen shedders in female rows.
- To control seed borne diseases, the plants bearing disease attacked panicles should be removed.
- At crop maturity remove the off types that are difficult to identify in previous crop growth stages and the plants that reduce physical purity.
- Rouging should be carried out as per seed certification standards

Synchronization

The success in hybrid seed production depends on synchronization of flowering between male and female parent. Simultaneous flowering of male and female parent in seed production is known as synchronization. Synchronization in flowering between the parental lines assumes greater importance as the seed set on female parent depends on the amount of pollen supplied from the male parent during flowering period.

Following methods should be followed for synchronization of flowering.

1. **Staggered sowing**

As the seed set on CMS line depends on cross pollination it is most important to synchronize the heading date of the male and female parents, especially for the hybrid combinations having

parents with quite different growth duration. Sowing of male parent and female parents are adjusted in such a way that both parents come to flowering at the same time is termed as staggered sowing.

- In order to extend the pollen supply time, early male parent is usually seeded twice or thrice at an interval of 4-5 days so that both male and female flowering should synchronize.
- Late flowering parent should be sown first
- In general to obtain high seed yields, for continuous supply of pollen, male parent is usually seeded twice or thrice at short intervals.
- In hybrid seed production of red gram, male parent (ICPL 87109) should be sown one week a head than female parent (MS 121). Sunflower as border crop around the field increase the seed yields.

2. Use of nutrients/chemicals

- Proper synchronization of flowering between Aline and R-line is a common problem. In-spite of taking the precautions like adjusting the sowing dates sometimes synchronization may be a problem. If the difference between the male and female parent is less than a week it can be manipulated by cultural practices. The parent which is lagging should be sprayed with 1 per cent urea solution 2-3 times at an interval of 2-3 days to the Lagging parent.
- In Rice 8 kg urea should be sprayed 2-3 times in 70 days.
- In Jowar spraying growth retardent MH 500 ppm at 45 DAS, delays flowering in advancing parent. MH wont dissolve in water and hence dissolve it in NaOH and then mix with water. Urea spraying 1% to the lagging parent. Spraying CCC 300 ppm will delay flowering.

3. Seed treatment to parental lines

Hardening treatment should be given to late germination parent for early germination and pelleting treatment should be given to early germination parent for late germination.

4. Irrigation

In Paddy, removal of irrigation in parental rows delays flowering 2-3 days.

In Jowar, the parent which is lagging should be given an additional irrigation to the Lagging parent so that it flowers early.

5. **Supplementary pollination**

Supplementary pollination increase the pollen supply and seed set and further high seed yields will be obtained. It is carried in following methods.

- **Rope pulling**: In Rice, shaking the R line panicles by rope pulling at panicle level or rod driving during anthesis can make their anthers dehisce and spread the pollen widely and evenly thus the out crossing rate could be increased. It is more effective especially on calm or breezy days. Generally, supplementary pollination is carried out at 30 minutes interval for 5 times daily both morning and evening during peak anthesis (10-12 am and 2-4 p.m.) until no pollen remains on the R line. It is not needed when the wind is greater than moderate breeze.
- **Bee Hives:** Provision of honey bees in hives in close proximity to the seed fields of crops largely cross pollinated by the insects, ensure good seed set thereby greatly increase seed yields.
- **Hand pollination:** In Sunflower due to lack of honey bees, seed setting will be poor. Hence critical or additional pollination is given to the crop for effective seed setting by rubbing the heads of two neighbouring plants with each other. It is done during mid flowering stage (i.e 58-60 days of planting for long duration varieties and 45-48 days for short duration varieties) at alternate days between 7-11 a.m for 2 weeks. The heads are rubbed with palm or muslin cloth so that pollination can be enhanced. In hybrids, the palm is first gently rubbed on the male parent flowers and then on the female line to transfer the pollen.
- Application of neera attract insects resulting in more cross pollination. (Neera=Sucrose 21%, minerals 5% etc.)
- Pollen collection and pollination by hand.

6. **Maintenance of genetic purity:**

Horne (1953) had suggested the following methods for maintenance of genetic purity;

1. Use of approved seed in seed multiplication
2. Inspection of seed fields prior to planting
3. Field inspection and approval of the Crop at critical stages for verification of genetic purity, detection of mixtures, weeds and seed borne diseases.
4. Sampling and sealing of cleaned lots

5. Growing of samples with authentic stocks or Grow -out test

Various steps suggested by Hartman and Kestar (1968) for maintaining genetic purity are as follows;

1. Providing isolation to prevent cross fertilization or mechanical mixtures
2. Rouging of seed fields prior to planting
3. Periodic testing of varieties for genetic purity
4. Grow in adapted areas only to avoid genetic shifts in the variety
5. Certification of seed crops to maintain genetic purity and quality
6. Adopting generation system

Lecture No.24

RICE- SEED PRODUCTION OF VARIETIES/HYBRIDS-TECHNIQUES

Phrenology:

Botanical Name*: Oryza sativa*

Chromosome number [2n]: 24

Family: Poaceae

Inflorescence: Panicle

Pollination: Self-Pollination

Panicle Emergence: 4 –5 days after boot leaf emergence

Flower Opening Pattern: Tip of primary & secondary branches and proceeds downward

Duration of Flowering: 6-8 days

Time of Anthesis: 7.00 –10.00 A.M

Speciality with flowering: Flower remain open for 10 minutes and afterwards it closes.

Anther dehiscence: Either before or after flower opening [independent of spikelet opening

Temperature favorable for flowering: 24 -280C

Favourable RH for flowering: 70-80%

Difference between day and Night temperature: 8-10^{0}C

Stigma receptivity: 3 days

Pollen viability : 10 minutes

Seed multiplication ratio

Varieties: 1:80

Hybrids: 1:100

Seed production of rice:

Varieties:

For seed production it is desirable to grow paddy under transplanting system so as to avoid the weed problem. Seed production should be taken up in various stages under open pollination by maintaining isolation distance. Nucleus seed is preserved by following ear-row method.

Hybrids:

Hybrid rice is produced by utilizing cytoplasmic genetic male sterile system. In this method there are three different lines i.e. A-line or male sterile line, B-line or maintainer line and restorer line

or R-line. For maintaining A-line it has to be crossed with B-line and for producing hybrid seed A-line has to be crossed with R-line. A and B lines are iso-genic lines except for fertility i.e. A line is male sterile and B line is male fertile.

Stages of seed production for certification : Breeder seed – foundation seed- certified

Seed Multiplication work at different Stages

Breeder Seed stage: A (AxB), B, R lines are raised separately under isolation.

Foundation Seed stage: A (AxB) and R lines raised separately under isolation.

Certified seed stage: A and R line are crossed under isolation to get hybrid.

1. Season:

Kharif (May- June sowing)

Rabi (December- January sowing)

Rabi is more suitable than kharif.

Favourable climatic conditions during flowering for higher seed set.

- Daily mean temperature 24 - 30^{o}C
- Relative Humidity 70 - 80 %
- The difference between day and night temperature should be 8-10^{o}C.
- Sufficient sunshine and moderate wind velocity of 2-3 m / second.
- Free from continuous rain for above 10 days during peak flowering season.

2. Land requirement:

The land should be free of volunteer plants (crop of previous season occur in this season) and the same crop or the other varieties of the same crop should not have been grown for the previous season, if it is the same crop it (previous) should be the same variety that has been certified. This selection is highly important for maintenance of genetic purity. They should have adequate irrigation and drainage facilities and the problem soils are not suitable for seed production.

3. Isolation distance:

Varieties

Foundation seed: 3m

Certified seed: 3m

Hybrids

A x B: Foundation seed – 200m

A x R: Certified seed – 100m

For hybrid seed production (A x R), if space isolation is a problem we can go for time isolation or barrier isolation. For time isolation the difference between the flowering of seed plot and the contaminating plot should be atleast 4 weeks. When both space and time isolation is not possible we can go for barrier isolation. In barrier isolation a barrier crop which is of 6-8 feet height should be grown around the seed plot for 3 to 10 meters. The commonly used barrier crops are daincha, sugarcane, sorghum etc. 2m plastic sheet around hybrid crops should also be used.

Selection of seed

Seed should be from an authenticated source (SAU, NSC, State Department).For production of certified seed, foundation seed (FS) should be used as source seed which should be purchased with bill and tag (white for FS seed).

Seed Rate (Per acre)

Varieties: 24 kg

Hybrid production

A line: 8 kg

B line: 4 kg

R line: 4 kg

Seed Upgradation Technique (Egg Floatation Technique)

Either before processing or after storage or due to improper processing Paddy seed may have less vigorous seed such as immature, ill filled and insect damaged seed which may adversely affect the planting value of the seed. Removal of this seed will favour better establishment and higher production potential. These seed may be removed by adaptation of a simple water floatation technique based on specific gravity using salt water as a dissecting solution for separation of good quality seed from low quality seed, and egg is used as an indicator for specification of specific gravity measurement of 1.03 (120g of salt in 1000ml of water)

Methodology

A bucket of potable water has to be taken and in that water one fresh egg which sinks to the bottom has to be taken. To the potable water with egg outside slowly the common salt was added to a level at which the egg floats at top exposing 2.5 cm of its shell outside (check the egg floatation now and then on addition of salt to the solution). The egg is removed and the paddy seed are dropped into the solution which separates as sinker and floater. The sinkers are good

seeds while the floaters are less vigorous and dead seeds. The floaters are removed and used as feed and sinkers are used for further multiplication.

Caution

- Egg is only for measurement of specific gravity and has no work to do with separation.
- If the density of water is more, more portion of egg will float if less egg will be inside the solution.
- If the density of water is more loss of quality seed may occur, lesser density the separation will not be perfect

Seed hardening treatment

Seeds can be hardened for 2 purposes I) Drought tolerance ii) Cold tolerance

The treatments are imposed to the seeds mainly to tolerate initial drought and cold. Cold tolerance treatment is given to germinated seeds, such treatments are given only to temperate crop and tree seeds.

The most important factors to be considered while seed hardening are

1. Seed: solution ratio (1:1)
2. The duration of soaking
3. Method of drying.

The effectiveness of the treatment depends upon the conduct of seed hardening process. The solution amount never be higher than the amount of the seeds. All solution added should be imbibed by the seeds. There should not be any leftover solution as it causes leaching effect. Once the seeds imbibe water, the germination process takes place. At the end of soaking period the seeds should be dried back to its original moisture content. These seeds when sown the germination will be completed earlier whereas in non hardened seeds the process germination takes a longer period.

Chemicals used: In Rice seed should be soaked in 1% KCl solution(KCl 1: Water 1) for ten hours and dried upto 11-12% moisture. Later seed treatment should be done with Captan/Thiram @ 2g/kg.

Sprouting of seeds (pre germination)

Paddy seeds are sown at nursery in pre germinated condition for better establishment for supply of oxygen at waterlogged condition. Seeds are soaked in big tough for 24 h in gunny bags tied loosely for easy transmission of water and for ensuring soaking of each and every seed. Seeds

are then tied tightly and incubated in dark for 12h (overnight). White protrusion of radices by the seed exposed to outside expresses the pre germination of seeds and these seeds are sown in nursery by broadcasting.

Dormancy

Paddy exhibits dormancy which varies for duration of 0-30/45days depending on the variety. This could be broken by either soaking in KNO3 0.5 % for 16 hr or soaking in 0.1N HNO3 for 16 hrs. However the duration and concentration vary with varieties Practically the intervening duration between the harvesting, and threshing, and further drying will remove the dormancy.

Nursery management

The area should be prepared by floating the area one or two days before ploughing and allowed the water to soak in. The soil should be kept at shallow sub emergence. Before ploughing the water should be allowed to a depth of 2.5cm .Then the land is ploughed and brought to a puddling condition. The optimum size of the nursery bed will be 2.5 meters broad and with channels of 30cm width in between. In paddy, on raising more varieties in a same place separate irrigation channels are to be prepared for each variety to avoid the admixture of seeds and to maintain genetic purity.

Five cents of nursery is sufficient for raising one acre of paddy and for 1 cent area 1kg seed is sufficient and apply DAP @2 kg per cent to get vigorous seedlings. For hybrid seed production, nurseries of A, B and R lines should be raised separately.

In general to obtain high seed yields, for continuous supply of pollen, pollen shedding B and R lines should be seeded twice or thrice at 4-5 days interval.

- Basal application of phosphorus to the nursery enables the seedling to store phosphorus and utilize it even in later stages of growth.
- Based on Soil testing results, application 30% of phosphorous in the main field give higher crop yields.
- Application of Phosphorous (DAP) to the nursery is highly economical.

Pulling of seedlings:

- Pull out the seedling at appropriate time.
- Do not remove the adhering soil with a hard surface.
- Tie the seedling in convenient size for easy handling.

- Do not allow the seedling to dry.

Duration of varieties	Age of transplanting
Short duration varieties	18-22days
Medium duration varieties	25-30days
Long duration varieties	35-40days

- Root dipping in chemical solution prior to transplanting in the main field gives protection against pests. Dip the roots in 100 ml Chloropyriphos 20EC+2.5 kg in 50 litres of water for 20 minutes prior to transplanting in main field.

Main field preparation:

To facilitate out crossing, the rows of male and female in the seed production plot should be perpendicular to the prevailing wind direction expected at flowering time of the parents. Practically a row ratio of 8:2 (A x R) is currently adopted for hybrid seed production. First plant male lines (B/R) and later female lines (A). Transplant 2-3 seedlings per hill in male rows and one seedling per hill in female rows. Proper care should be taken to avoid mixing of male and female plants in rows.

Organic and Chemical fertilizers:

FYM: Basal application 5 tonnes/acre

Varieties: 60:20:20 N2:P2O5:K2O/acre

Hybrids : 60:24:24 N2:P2O5:K2O/acre

N & K applied in 3 splits

(1) during basal (2) active tillering (3) Panicle initiation.

Over dosage of Nitrogen results in late flowering. Application of phosphorous and potassium result in early flowering.

If biofertilizers are applied to the field, 75% of recommended dose of nitrogen should be applied.

ZnSO4 @ 10 kg per acre should be applied uniformly over the field. If green manures @ 2.5 tonnes/acre are applied, 5 kg ZnSO4 per acre is sufficient.

Nutrient deficiencies

Nitrogen:

- Due to high mobility of N in plants, its deficiency symptoms first appear on the older leaves in the form of light green to pale yellow coloration due to proteolysis.

- The lower leaves usually fire or turn brown beginning at the leaf tip, and progressing along midrib in the form of inverted ‘V’ shape.
- Stunted growth is the manifestation.

Potassium:

- Chlorosis along the margins followed by scorching and browning of tips of older leaves which gradually progresses inwards giving burning appearance.
- Slow and stunted growth of the plant and crop lodging.
- Reduced crop yields and decrease in resistance to diseases.

Magnesium:

- Interveinal chlorosis of the leaves in which only the veins remain green and the interveinal areas turn yellow with streaky or patchy appearance. In more advanced stages the leaf tissue becomes uniformly pale yellow then brown and necrotic.
- Affected leaves turn small in final stage and curve upwards at the margins.

Iron:

- Interveinal chlorosis appearing first on the younger leaves with leaf margins and veins remaining green.
- In later stage burning of the chlorotic leaves start from the tips and margin, spread inwards.Alternate strips with green veins and yellow interveinal tissues.
- The chlorotic leaves may become white and the leaf tissues devoid of chlorophyll die.
- Under conditions of severe deficiency growth cessation occurs with the whole plant turning necrotic.

Iron toxicity:

- Toxic situations occur primarily on acid soils (<Ph 5.0) and where excess soluble iron salts have been applied as foliar sprays or soil amendments. Injury due to high soil iron concentration is not common under neutral or high Ph soil but under conditions that are saturated, poorly draining, compacted or poorly aerated. Iron toxicity also occurs where zinc levels are low.
- Lower leaves turn brown and it start from tips and margins, spread inwards.

Zinc:

Khaira disease: The first symptom of zinc deficiency appear in 3-4 week old seedlings when the young leaves develop reddish brown pigmentation. The pigmentation appears first in the middle

of the leaves, then intensifies and spread over the entire lamina. The affected tissue become papery and necrotic (rusty spots) and under conditions of severe deficiency, the entire mass of leaves collapses and further growth of the plant is arrested.

Corrective measures

- Soil application of zinc sulphate @ 50 kg ha^{-1} once for three crops or years is effective and economic to overcome its deficiency.
- Zinc sulphate can be broadcasted after final puddling before transplanting.
- When deficiency appears on standing crop, spraying of 0.2% ZnSo4 twice (2 g/litre of water).
- In acid soils, application of Lime @ 1 tonne / acre at last ploughing for every five crops.
- In heavy soils, basal application of Gypsum @ 200 kg /acre.

Hybrid Seed Production

Hybrid rice can be produced by three different methods.

1. Single line breeding
2. Two line breeding
3. Three line breeding

Single line breeding: Based on apomixes and tissue culture techniques, this method was developed.

Two line breeding: In this method hybrid seed production can be done in three ways.

a) Emasculation and dusting method.

b) Environmentally induced genetic male sterility.

It is most commonly used method. This method of hybrid rice seed production involves the use of PGMS (photosensitive genetic male sterility- based on photo period) or TGMS (Thermosensitive male sterility system-based on temperature). In this method any normal line can be used as restorer line.

c) By Using chemical emasculants: The chemicals which kills or sterilize the male gamete with little no effect on the normal functioning of the female gamete can be used to emasculate female parental line in hybrid seed production. In China chemical emasculants are commonly used in hybrid seed of rice. In India they are not used commercially for hybrid seed production, but they are used in academic studies. The chemicals which can be used as potent gametocides are etheral,

maleic hydrazide, etc. Its effectiveness depends upon the dose, uniform coverage and time of application.

Three line breeding: Based on this system, in India four hybrids namely APHR-1,2 (AP), CORH1 (TN), KRH1 (Karnataka) were released for commercial cultivation. These hybrids were developed using A, B and R lines.

In this method hybrid rice is produced by utilizing cytoplasmic genetic male sterile system. The source of male sterile cytoplasm used is wild abortive. In this method there are three different lines i.e. A-line or male sterile lines, B-line or maintainer line and restorer line or R-line. For maintaining A-line it has to be crossed with B-line and for producing hybrid seed A-line has to be crossed with R-line.

GA-3 application:

Application of GA3 increases the internode length and the panicles will be fully exerted from the flag leaves. It increases the duration of floret opening and stigma receptivity. It helps in adjusting the plant height of both the parents. It also increases the growth rate of secondary and tertiary tillers so that they bear productive panicles.

Spraying of GA3 should be done twice first when 15-20% of the plants started heading with 40% of the chemical and second at 50% flowering with 60% of the chemical. The dosage required is 50 grams with knapsack sprayer and 25 grams with ultra low volume sprayer. For first spray use 20 g GA3 in 500 litres of water and for second spray use 30 g in 500 litres of water. Morning 8-10 am or evening 5-6 pm is effective for GA3 application.

Note: GA3 will not dissolve in water and hence it should be dissolved in 75-90% alcohol (1g in 20-25 ml of alcohol) and make the required solution. Spraying should be done at 8 to 10 a.m. and 4-6p.m.

Rope pulling:

In Rice, shaking the R line panicles by rope pulling at panicle level or rod driving during anthesis can make their anthers dehisce and spread the pollen widely and evenly thus the out crossing rate could be increased. It is more effective especially on calm or breezy days. Generally, supplementary pollination is carried out at 30 minutes interval for 5 times daily both morning and evening during peak anthesis (10-12 am and 2-4 p.m.) until no pollen remains on the R line. It is not needed when the wind is greater than moderate breeze.

Rouging:

Carry out roughing both in male and female parental lines. Remove all the off type and volunteer plants from both male and female parental line. During flowering period rouging should be done daily to remove the pollen shedders from female parental line. The male sterile plants have shriveled anthers and they do not shed pollen while the pollen shedders have yellow colored plumpy anthers, which shed large amount of residual pollen. The off type plants should be identified based on morphological characters like plant height, plant type, flag leaf shape, flag leaf angle and other characters. Remove all the plants, which are infected with stem borer, and diseased plants like paddy bunt. Rouging should be done from the sowing up to harvest and remove the as and when it come across.

Weed control:

Apply any one of the pre emergence herbicides viz. butachlor 2l per ha,thiobencarb@2l/ha, pendimithalin @ 2.5 l/ha on 8th day after sowing to control weeds in the low land nursery. Keep a thin film of water and allow it to disappear. Avoid drainage of water. This will control germinating weeds.

Number of Field Inspections:

A minimum of four field inspections should be conducted. The first field inspection should be conducted before flowering stage, second and third during flowering stag and fourth before harvesting. During the first field inspection verification should be done for volunteer plants, isolation requirement, errors in planting and the actual acreage sown. During the second and third field inspection verification should be done for isolation requirement, off types, diseased plants, pollen shedders and objectionable weed plants. Actual counts should be taken during second or third field inspection. Fourth or final field inspection should be done to verify for all the above factors and the off types can be identified based on panicle or seed characters.

Characters	Maximum limit	
	Foundation seed	Certified Seed
Varieties		
Off types	0.05	0.20
Objectionable weed plants	0.01	0.02
Wild rice	0.01	0.02

Hybrids		
Off types in female rows	0.05	0.20
Off types in male rows	0.05	0.20
Pollen shedders	0.05	0.10
Objectionable weed plants	0.01	0.02

Pest and disease management:

Physiological maturity:

Seeds attain maturity with the visual symptom of turning of ear heads to golden yellow color and when the ear heads exhibit drooping symptomsi.e 28 days after 50% flowering in short and 31 days in medium and 35 in long duration. When 90% of the plants are exhibiting the symptom the crop is ready for harvest.The moisture content of the seed will be 17-20%.

Harvesting:

The crop should be harvested when the grains are hard and yellow with a moisture percentage of 23-24 %. For combine harvesting the moisture percentage should be in the range of 16-18%.

- Lodged plants should not be selected for seed purpose.
- Withhold irrigation one week before harvest.
- Delayed harvest may lead to heavy shattering.
- First harvest male rows (B/R) from field and later do harvesting of female rows (A) and care should be taken to avoid admixtures.
- Bundled plants should be stacked as ear heads facing outside to avoid heat damage.
- Threshed produce should be clean and free of admixture in cracks and crevices.
- Birds scaring are also practiced in places of requirement.

Threshing

Thresh the seed by beating the plants on a hard surface ,but take care that the seeds are not mechanically damaged. In tractor and machine threshing avoid mechanical damage by proper adjustment of speed/machine setting.Thresh at proper moisture content to avoid crushing / cracking (16-17 per cent).Clean the floor, equipment, containers to avoid genetic and physical mixture.

Winnowing and Drying

Threshed produce are cleaned and winnowed to remove the dirt and other unwanted physical material. Winnowing should be done in a cleaned surface. The seeds are dried in a threshing floor with adequate stirring which is known as tempering. The seeds are dried to 13 % moisture for better storage .On drying in a threshing avoid drying between 12 noon to 2pm to avoid the ill effects of ultra violet rays of noon sun. Through not for bulk for prolonged storage this practice should be adopted. Seeds are also can be dried in mechanical driers in places of high humidity like areas of sea shore.

Grading

The bulk seeds are normally processed through seed cleaner cum grader and the seeds of middle sieve are selected for seed purpose. Desirable sieve size is 1/13-16 x 3/4 " or (1.3-1.8mm x 19 mm)

Size of seed	Sieve Size
Long slender	1/16 x 3/4 " (1.3mm x 19 mm)
Slender	1/15 x 3/4" (1.3mm x 19 mm)
Medium Slender	1/14 x 3/4" (1.5 mm x 19 mm)
Short Bold	1/13 x 3/4" (1.8 mm x 19 mm)

Seed treatment:

Normally paddy seeds are not treated with chemicals owing to their economic utility. But for long term storage, treat it with captan or thiram or bavistin @ 2-4g / kg of seed. As a prophylactic measure seed can be fumigated with celphos @ 3-6g/m3. But the moisture content of the seed should not be above 10-12% which may interfere with the seed quality in terms of germination.

Seed Standards (Varieties/hybrids)

S.No.	Factor	Standard for each class	
		Foundation Seed	Certified Seed
1	Pure seed (maximum)	98.0%	98.0%
2	Inert matter (maximum)	2.0%	2.0%
3	Huskless seed (maximum)	2.0%	2.0%
4	Other crop seed (maximum)	10/kg	10/kg

5	Other distinguishable varieties (maximum)	10/kg	10/kg
6	Total weed seed (maximum)	10/kg	10/kg
7	Objectionable weed seed (maximum)	2/kg	2/kg
8	Germination (Minimum)	80%	80%
9	Moisture (maximum)	13%	13%
10	For vapour proof containers (maximum)	8%	8%

Seed storage:

It is a good storer. Generally paddy seeds store well up to 12-36 months depending on the genotypes but heavy infestation of storage pests reduce the storability of seed even to a month or two. For prolonged storage HDPE and polylined gunny bags are used, while for normal storage jute canvas bags are used. However the bags should not be stirred for more than 8 bags height to avoid pressure on seeds of lost bag which may cause damage to the seed. Polythene bags of 700 gauge is not highly preferable for paddy as the sharp edge may pierce the bag and convert moisture vapor proof container as moisture pervious container. Dry the seeds to 8% moisture content to store for 3 or more years.

When compared with varieties, the hybrids and parental lines A & B lines are poor in storability. The order of the storage potential is R > F1 > B > A.

Lecture No. 25 & 26

MAIZE

Floral biology

Botanical name*: Zea mays*

Chromosome number: 2n=20

Botanical Family: Poaceae

Inflorescence: Panicle cob, as the crop is monoceious in nature

Type of flowers: Female: Cob (axillary inflorescence in the middle portion of plants)

Male: Tassel (terminal inflorescence)

Husk: Enlarged leaf sheaths from each node, forming a protective covering around the inflorescence.

Pollination: Cross pollination

Special character: Protandry

Flowering pattern: Top to bottom (Tassel) Bottom to top (Cob)

Anthesis: Pollen shedding begins 1 to 3 days before the silk emerge from the cob.

Fertilization: Within 12 to 18 hrs after silk emergence

The entire silk is receptive. Silk will be pinkish and sticky at the beginning (receptive) after fertilization it will be chocolate/brown colour.

No. of pollen in tassel: 2,50,00,000

Pollen viability: 12-18h

Silk receptivity: 8-10 days

Male flower anthesis: 6.00 am to 8.00 a.m

Duration of flowering: 2-14 days

Types and Methods of seed production in maize

In maize, open pollinated varieties, synthetics, composites and hybrids are available.

a. Open pollinated varieties

Raise the varieties under isolation of 400 m in foundation seed stage and 200 m in certified seed stage and allow the plants to openly pollinate among themselves and set seed.

b.Synthetics

In cross pollinated species, a variety obtained by in mating in all possible combinations, a number of lines (>5) that combine well with each other.

c. Composite varieties

These are produced by open pollination among a number of outstanding strains usually not selected for combining ability with each other

d.Hybrids

Inbreds are used for production of hybrids. Inbred is relatively true breeding strain resulting from repeated selfing (5 times.)

Varietal seed production technique

Open pollination under isolation is the common method of varietal seed production.

Practices followed for hybrid production

Crossing technique: Manual emasculation by detasseling

Detasseling: Removal of male inflorescence from the monoecious crop and it is manual creation of male sterility.

Time for detasseling: The time taken for shedding of pollen from the tassel in 1-2 days after emergence. Hence the tassel should be removed before the shedding of pollen.

Detasseling is the removal of tassel from female parent. Detasseling is done when the tassel emerged out of the boot leaf, but before anthesis and tassel don't shed pollen. Anthers take 2-4 days to dehisce after complete emergence. Only in few cases, the anthers start dehisce before its complete emergence. In such case detasseling should be done earlier. Detasseling is done every day from the emergence of tassel upto 14 days.

Method

- Hold the stem below the boot leaf in left hand and the base of the basal in right hand and pull it out in a single pull.
- Grasp entire tassel so that all the pollen parts are fully removed.
- Do not break or remove leaves as removal will reduce yields and will result in lower quality of seed.

Precautions to be adopted during detasseling

- No part should be left on the plant as it causes contamination.
- It should be uniform process done daily in the morning in a particular direction.
- Donot break the top leaves as the field may be reduced due to the earning of source material to accumulate in sink [seed] as removal of 1 leaf course 1.5% loss 2 leaves 5.9% loss and 3 leaves 14% loss in yield.

- Detassel only after the entire tassel has come out and immature detasseling may lead to reduced yield and contamination.
- Mark the male rows with marker to avoid mistake in detasseling.
- Look out for shedders [shedding tassel] in female rows as the may cause contamination.
- After pulling out the tassel drop it there itself and bury in soil. Otherwise late emerging pollen from detasseled tassel may cause contamination.
- Do not carry the tassel through the field as any fall of pollen may lead to contamination.
- Donot practice, improper, immature and incomplete detasseling.
- **Improper detasseling**: A portion of the tassel is remaining in the plant while detasseling.
- **Immature detasseling:** Carrying out detasseling work when the tassel is within the leaves.
- **Incomplete detasseling**: The tassel is remaining in lower or unseen or unaccounted in within the whole of leaves.
- There should not be any shedding tassel.
- **Shedding tassel**: Either full or part of tassel remain in female line after detasseling and shedding pollen which may contaminate the genetic purity of the crop.

Types of hybrids

In maize, hybrids are mainly of three types.

Single cross hybrid

It is a cross between 2 inbreds. A x B. A genotype will be detasseled and crossed with B Genotype. A is female parent and B is male parent

Double cross

- It is a cross between two single crosses.
- It is a cross between 2 hybrids (A x B) x (C x D). (A x B) single cross hybrid will be produced by detasseling A and by crossing with B. (C x D) hybrid will be produced by detasseling C and crossing with D.
- Then (A x B) will be detasseled and crossed with (C x D) hybrid. For production of double cross, four inbreds (A,B,C & D) are used.

Example

Deccan hybrid: (CM 104 x CM 105) x (CM 200 x CM 201)

Ganga 2 : (CM 109 x CM 110) x (CM 202 x CM 111)

Ganga 101 : (CM 103 x CM 104) x (CM 201 x CM 206)

Three way cross

- It is a cross between a single cross and an inbred to give hybrid population.
- It is first generation resulting from the crossing of on approved inbred line and a certified single cross (A x B)
- (A x B) will be detasseled and allowed for crossing in the variety.

Eg: Ganga 5 (CM 202 x CM 111) x (CM 500)

Season

The best season for production is June - July, November- December and January – February and the flowering should not coincide either with rain or high RH and the maturation should coincide with dry weather. The temperature of 37°C is favourable for better seed setting.

Land requirement

The land required for open pollinated variety, composites and synthetics should be fertile and problem soils will lead to low pollen fertility and will adversely affect the quality and the seed set will be poor. The previous crop should not be the same crop to avoid the occurrence of volunteer plants and if to be the same crop it has to be the same variety and should be certified and has to be accepted for certification. The field should not have any volunteer plants.

Isolation distance

Seed production	Foundation seed	Certified seed
Varieties, Inbreds, Synthetics, Composites, Single cross hybrids	400 m	200 m
Single cross parents	400 m	-
Double, three –way cross hybrids	-	300 m

Selection of Seed

For production of foundation seed, breeder seed is used as the base material, while for certified seed, foundation seed should be used as the base material. The seed used should be from authenticated source with tag and bill. The required seed rate will be 20kg /ha or 8kg/acre.

Seed treatment

Thiram/Captan @ 4 g/kg of seed

Sowing

The seed are sown at a spacing of 75 x 20 cm or 60 x 25 cm at a depth of 2-4 cm based on the specific features of the variety. Nursery production will not be suited to this crop. In the main field seeds are sown either in ridges and furrows or under beds and channels. The seedlings are thinned and gap filled should be done 7-8 days after sowing.

Row ratio/border rows ratio

Female: Male: Border

Single cross hybrid: 4:2:4

Double cross hybrid: 6:2:3

Three way cross hybrid: 6:2:4

For A line seed production 4.8 kg of A line and 1.6 kg of B line should be planted in 4:2 ratio.

Fertilizer Management:

At last ploughing apply 5 tonnes of compost, N:P:K 16:30:16 kg/acre- Basal application.

1st top 20 DAS 20:0 :0 kg/acre

2nd top 40 DAS 4:0:14 kg/acre

2% DAP is sprayed at 50% flowering stage to enhance uniform flowering and increased seed set.

Rouging:

It is specific to seed crop and is done from seedling stage to harvesting stage based on the phenotypic characters. Off types can be identified through stem colour, plant structure, number of leaves, auricles, nodal colour, tassel colour, sheath colour ,grain colour etc. Remove pest and disease attacked plants.

Shedding tassel:

Shedding tassels are to be removed in roguing. It refers to the tassels in female parental rows, shedding pollen or that has shed pollen in hybrid maize plots. During field inspection a tassel whose main spike or any side branch or both have shed pollen or shedding pollen in more than 5 cm of branch length is counted as a shedding tassel during inspection the shedding tassels are taken into count for acceptance or rejection of production plot.

Weed control:

Application of atrazine @ 200g per acre in 360 litres of water as pre-emergence herbicide within 24-48 hours of sowing when sufficient field moisture is present should control the growth of weeds upto 20-25 days. (If pulses are used as intercrops don't use atrazine). One hand weeding at 17-18 days after sowing keep the field free of weeds if weedicides are not used. Weeding after boot leaf stage is not economical and shade will also minimize the weed flora. On organic production, 2 hand weeding at seedling stage and other at boot leaf formation (45 days) will keep the field weed free.

Correct Micronutrient deficiencies

Field Certification Standards

Factor (Maximum limit)	Foundation seed	Certified seed
Offtypes	0.01%	0.05%
Shedding tassel	0.50%	0.50%
Disease plants	0.05%	0.10%

Like commercial crop, pest and disease management should be taken up to control pests and diseases.

Irrigation Management

The crop should be irrigated once in 10-15days for enhanced seed set and formation of bolder grains. The critical stages of irrigation are primordial initiation stage, vegetative stage, flowering, milky and maturation stage. If the irrigation is withheld in these stages seed set will be poor and seed size will be reduced.

Primordial initiation stage: 1-14 days

Vegetative stage: 15-39 days

Silking stage: 40-65 days

Milky stage: 66-95 days

Harvesting

- In hybrid seed production first harvests the cobs of male plant and dried separately. Later harvest the cobs of female parent and dried separately. The crop attains physiological maturity 45 days after 50% flowering and the seed moisture at this stage will be around 25-30%.

- The crop is harvested as cob harvesting when the sheath of cob dries and attains straw yellow color.
- The crop is harvested as once over harvest for seed purpose.
- Dehusking:After harvest manually the sheath are removed, which is known as dehusking.
- **Cob sorting:** Based on the kernel arrangements on the shank as irregular discoloured, diseased and illfilling the Cobs are sorted out and cobs with characteristic kernel colour and shank colour andregular row arrangements are selected for seed purpose. The kernel discolouration should not 10% for certification.
- **Zenia and metazenia:** The discolouration in cobs may be due to disease infection or genetic contamination. The effect of foreign pollen on kernel colour is known as Zenia, metazenia effect which causes genetic contamination in the seed lot. Zenia is the effect of foreign pollen of same generation and metazenia is the effect of foreign pollen in next generation.
- **Shelling:** The cobs are dried under sun and threshed with fliable stick for extraction of seeds the moisture content of seed at the time of threshing will be 15-18%.On large scale production cob shellers are used, but care should be given to avoid mechanical damage, which in turn will reduce the seed quality and storability.
- **Drying:** The seeds are dried to 8 to10 % moisture content either under sun or adopting mechanical driers for long term storage as the seeds is orthodox in nature.
- **Processing:** Mechanical grading can be done with cleaner cum grader, which will remove the undersized immature and chaffy seeds. The middle screen size should be 18/64" round perforated sieves. The size can vary depending on the variety from 14/64 to 20/64 inch round perforated sieves.
- **Storage:** The treated seed with thiram @ 4 g/kg of seed can be stored up to 12 months provided the seeds are not infected with storage pests. Seed can be stored up to 3 years if the seeds are packed in moisture free containers and are stored at low temperature .The godown should be kept clean as the possibility of secondary infestation with Trifolium (red flour weevil) is much in these crop. The major problem in storage is incidence of grain weevil which will powder the seed material in a short period.

Seed standards:

S.No.	Factor	Standard for each class		
		Foundation seed		Certified seed
		Inbred	Hybrid	Inbred/Hybrid
1	Pure seed (maximum)	98.0%	98.0%	98.0%
2	Inertmatter(maximum)	2.0%	2.0%	2.0%
3	Other crop seed (maximum)	10/kg	5/kg	10/kg
4	Other distinguishable varieties based on kernel colour and texture (max)	10/kg	10/kg	10/kg
5	Weed seed (max)	--	--	--
6	Germination (Minimum)	80.0%	80.0%	80.0%
7	Moisture (maximum)	12.0%	12.0%	12.0%
8	For vapour proof container (maximum)	8.0%	8.0%	8.0%

Lecture No.27:

JOWAR

Sorghum is common millet of India with wider utility. It is used a feed, food and raw material for agri based industry. Botanically it is known as *Sorghum bicolor* L. and belongs to the family poaceae. It is an often cross pollinated crop, insects and wind are the pollinating agents.

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.

Methods of seed production

Varieties: Open pollination under isolation and selfing by bagging are the common methods of varietal seed production.

Hybrids: Using Cytoplasmic genetic male sterility seed production is taken up and A,B and R lines are utilized in seed production.

Stages of seed multiplication

Varieties: In sorghum seed is multiplied adopting three generation system, as breeder seed, foundation seed and certified seed as the crop is often cross pollinated crop where the chances for genetic contamination is high.

Hybrids: 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
CSH 13 R	296 A x RS 29
CSH 14	AKMS 14A x AKR 150
CSH 16	27 A x C 43
CSH 15 (R)	104 A x R 585
CSH 17	AKMS 14A x RS 673

Sowing season:

The best season for production is November- December and the flowering should not coincide either with rain or high RH as it will wash out the pollen and the maturation should coincide with dry weather. The temperature of 37^{o}C is favourable for better seed setting.

Land requirement

The land should be fertile and problem soils will lead to low pollen fertility and will adversely affect the quality and the seed set will be poor. The previous crop should not be the same crop to avoid the occurrence of volunteer plants and if to be the same crop it has to be the same variety and should be certified and has to be accepted for certification. The field should not have any volunteer plants.

Field Standards for isolation

Sorghum field should be isolated from contaminants as follows

Contaminants	**Minimum distance(m)**	
	Foundation seed	Certified seed
Normal	200	100
Hybrids	300	200
On presence of Johnson grass	400	400
On presence of forage sorghum	400	200

Spacing

Varieties	45 x 15 cm
A lines	45 x 30 cm
R lines	45 x solid rows
Hybrids	45 x 30 cm

Fertilizer management:

Apart from regular fertilizer application, foliar spray with 2% DAP once at primordial initiation stage and twice thereafter at 10 days interval enhances the seed set.

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.

Synchronization technique

As the seed set on CMS line depends on cross pollination it is most important to synchronize the heading date of the male and female parents i.e. nicking especially for the hybrid combinations having parents with quite different growth duration.

1. Seed treatment

To the lately germinated parent: hardening treatment should be done by soaking the seed in 2% KH_2PO_4 for 10 hours followed by drying which enhance early germination.

To the early germinated parent: by pelleting treatment, germination will be delayed.

2.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. In addition, in order to extend the pollen supply time, the male parent is usually seeded twice or thrice at an interval of 4-5 days.

3.Nutrient management

Urea spraying 1% to the lagging parent at 35-40 days of the crop.

4.Irrigation management

Withhold one irrigation to the delay flowering parent so that it flowers early

5. Spraying of hormones

Spraying growth retardent MH 500 ppm at 45 DAS, delays flowering in advancing parent. MH wont dissolve in water and hence dissolve it in NaOH and then mix with water. Spraying CCC 300 ppm will delay flowering.

Spraying before harvest

Spraying with Carbendazim helps in maintaining the seed quality even if panicles soak in rain and controls smut.

Rouging

It is specific to seed crop and is done from seedling stage to harvesting stage based on the phenotypic characters. Off types can be identified through stem colour, plant structure, number of leaves, auricles, nodal colour, grain colour etc.

In female line remove: off types, wild types, pollen shedders, rogues, partials, volunteer plants, diseased plants, R line, mosaic plants, late Early flowering plant

In male line remove: Rogues, A line, Diseased plants, Late /early flowering plants, Wild types

Types of contamination

Presence of B line in A line called as pollen shedders

Presence of A line in Bline called as off type

Presence of R line in B line called as rogue

Presence of B line in B line called as rogue

Presence of B line in Rline called as rogue

Pollen shedders and off type cause physical contamination, whereas, rogue cause physical and genetical contamination.

Partials

In certain A line plants, a part of the ear head-shed pollen due to the removal of sterility due to parental impurity (or) developmental variation or temperature.

Weed control

Nutrient deficiencies

Irrigation management

Field standards

Factor	Foundation seed	Certified seed
Off types (max)	0.01	0.05
Pollen shedders (max)	0.05	0.10
Designated diseased plants (max) (Ergot and smut)	0.05	0.10

Pest and disease management

Harvesting

- The crop attains physiological maturity 40-45 days after 50% flowering and the seed moisture at this stage will be around 25-30%.
- This stage can be easily be identified by the formation of dunken layer at the place of attachment to the ear head.
- The earheads are harvested commercially when 80 % of the earheads are physiologically matured, where the moisture content will be around 20 %.
- The crop is harvested as once over harvest as uniformity will be maintained with earheads on maturity.
- 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. If harvesting is delayed, quality of grain reduces due to ergot.

Threshing

The earheads are dried under sun and threshed with friable stick for extraction of seeds. The moisture content of seed at the time of threshing will be 15-18%.On large scale production

LCT threshers are used, but care should be given to avoid mechanical damage, which in turn will reduce the seed quality and storability.

Drying

The seeds are dried to 8-10 % moisture content either under sun or adopting mechanical driers for long term storage as the seeds is orthodox in nature.

Processing

- Mechanical grading can be done with cleaner cum grader, which will remove the undersized immature and chaffy seeds.
- The middle screen size should be 9/64" round perforated sieves. The size can vary depending on the type of seed
- For fodder sorghum 8/64"sieve is used

Seed standards

The processed seed should have the following seed quality characters both for certification and labeling.

S.No.	Factor	Standards for each class	
		Foundation seed	Certified seed
1	Pure seed (maximum)	98.0%	98.0%
2	Inertmatter(maximum)	2.0%	2.0%
3	Other crop seed (maximum) (by number)	5/kg	10/kg
4	Total weed seed (maximum) (by number)	10/kg	20/kg
5	Other distinguishable varieties (maximum)	10/kg	20/kg
6	Ergot, sclerotia, seed entirely or partially modified as sclerotia, broken or ergotted seed (maximum)	0.02%	0.04%
7	Moisture (maximum)	13.0%	13.0%
8	For vapour proof container (maximum)	8.0%	8.0%
9	Germination (Minimum)	75.0%	75.0%

Seed storage

The seeds are infested with several storage pests, to protect against these pests the seeds are given protective treatment with Thiram @2g/kg of seed. The treated seed can be stored up to 12-18 months provided the seeds are not infected with storage pests.

Mid storage correction

The seeds loose their quality during storage due to deterioration and pest infestation, when the germination falls below 5-10 % of the required standard the seeds are imposed with mid storage correction, where the seeds are soaked in double the volume of 10.4 M solution of disodium hydrogen phosphate (3.6mg/lit of water) for 6 hours and the seeds are dried back to original moisture content (8-9%).

Lecture no.27

BAJRA

Bajra is common minor millet of India with wider industrial and household utility. It is used a feed, food and raw material in soft drink industry. Botanically it is known as *Pennisetum typhoides* L. and belongs to the family poaceae.

Floral biology

It is a highly cross-pollinated crop. The pollinating agent is wind. The flowers are protogynous. The spike emerges about 10 weeks after sowing, The styles begin to protrude 2-3 days later first at the top of the inflorescence and proceeds. They take two days to complete the entire spike. Exerted stigma remains receptive for 12-24 hours. Anthers usually emerge after the styles are dry. The anther emergence starts from middle of the spike and proceeds upwards and downwards. Anthesis occurs throughout the day and night with the peak between 8.00 p.m. to 2.00 a.m.

Methods of seed production

Varieties: Open pollination under isolation

Hybrids: Using Cytoplasmic genetic male sterility seed production is taken up and A,B and R lines are utilized in seed production.

Stages of seed multiplication

Varieties: In pearl millet seed is multiplied adopting three generation system, as breeder seed, foundation seed and certified seed as the crop is highly cross pollinated crop where the chances for genetic contamination is high.

Hybrids: Seeds produced in different stages

Nucleus seed stage: Maintenance of basic source by ear 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

Sowing season:

The best season for production is October- December and the flowering should not coincide either with rain or high RH as it will wash out the pollen and the maturation should coincide with dry weather. The temperature of 37^{o}C is favourable for better seed setting.

Land requirement

Crop shouldn't be grown on problematic soils. Seed field offered for certification should not have been grown with bajra in the previous season. However if it was grown, the field should be irrigated 3 weeks before sowing to destroy the germinating seeds and should be certified and has to be accepted for certification.

Field Standards for isolation

Bajra field should be isolated from contaminants as follows.

Contaminants	Minimum distance (m)	
	Foundation stage	Certified stage
Varieties	400	200
Hybrids	1000	200

Selection of Seed

For production of foundation seed, breeder seed is used as the base material while for certified seed, foundation seed should be used as the base material. The seed used should be from authenticated source with tag and bill.

Seed rate

Varieties: 3.2 kg/acre

Hybrids: A line: 2.4 kg/acre

B/R line: 0.8 kg/acre

Spacing

Varieties: 45 x 20 cm

Hybrids: A line: 45 x 20 cm

B/R line: 45 cm x solid rows

Pre sowing seed treatment:

Seeds are soaked in brine solution (1 kg common salt in 10 litres of water), then ergot and downy mildew affected seeds float on the surface. Remove the seed and remaining seed should be washed in water 2-3 times and dried in shade.

Nursery preparation:

In some places seeds are also raised in nursery and transplanted to the main field at an age of 15 -20 days. Seeds are also treated with 5% carbofuran 3G to protect the seed from shoofly infection. Seed treatment with chlorpyriphos @4 ml /kg is also recommended against the attack by shoofly.

Planting ratio:

Foundation seed stage: 4:2 (A: B)

Certified seed stage: 6:2 (A:R) (16:2 ratio also gave good seed set).

Border rows:

Foundation seed: 4 rows of male (B) around the field to supply adequate pollen.

Certified seed: 8 rows of male (R) around the field to supply adequate pollen.

Main field preparation

In the main field seeds are sown either in ridges and furrows or under beds and channels. To control shoot fly, Monocrotophos spray should be carried out after one week as a precautionary measure.

Fertilizer Management

The seed crop is also sprayed with 2% DAP at primordial initiation stage and twice thereafter at 10 days interval to enhance uniform flowering and increased seed set.

Synchronization of flowering

Steps for synchronization of flowering

1. Withholding irrigation
2. Application DAP 1%
3. Staggered sowing
4. Jerking

Jerking

It is done 20-25 days after transplanting or 30-40 days after direct sowing. The early formed ear heads of the first tillers are pulled out or removed which will result in uniform flowering of all the tillers. It will also helpful in delaying flowering of the early parents.

Specialty with bajra in synchronization

The synchronization problem is less in bajra due to

1. Tillering habit
2. Supply of continuous pollen
3. Lesser pollen weight
4. Flight capacity of pollen
5. Pollen viability & stigma receptivity are longer.

Rouging:

It is specific to seed crop and is done in three stages i.e., seedling stage, tillering stage and formation stage based on the phenotypic characters. Off types can be identified through variation in leaf colour, leaf waviness, grain colour earhead, shape, size, etc. Rouging helps in maintaining the genetic purity.

Field standards

Standards	Maximum permitted (%)	
	Foundation seed	Certified seed
Offtypes	0.05	0.10
Pollen shedders	0.05	0.10
Downy mildew diseased plants	0.05	0.10
Earheads affected by ergot	0.02	0.04

Irrigation management

- The crop should be irrigated once in a week for enhanced seed set and formation of bolder grains.
- The critical stages of irrigation are primordial initiation stage, vegetative stage, milky and maturation stage. If the irrigation is withheld in these stages seed set will be poor and seed size will be reduced.

Pest and disease management

Harvesting:

The crop attains physiological maturity 30-35 days after 50% flowering and the seed moisture at this stage will be around 25-30%. This stage can be easily be identified by the formation of dunken layer at the place of attachment to the ear head. The ear heads are harvested when 80 % of the ear heads are physiologically matured, where the moisture content will be around 20 %.The crop is commercially harvested as once over harvest but harvesting of ear heads as 2or 3 picking will preserve the seed quality as matured seeds are not over exposed to the changes in environmental conditions.

Threshing

The ear heads are dried under sun and threshed with fliable stick for extraction of seeds. The moisture content of seed at the time of threshing will be 15-18%.

Drying

The seeds are dried to 8 to10 % moisture content either under sun or adopting mechanical driers for long term storage as the seeds is orthodox in nature.

Processing

Mechanical grading can be done with cleaner cum grader, which will remove the undersized immature and chaffy seeds .The middle screen size should be 4/64" round perforated sieves. The size can vary depending on the variety.

Seed treatment

The seeds are infested with several storage pests, to protect against these pests the seeds are given protective treatment with thiram @4g/kg of seed.

Seed packing

Seeds are packed in gunny bag for short term storage (12 months) while in HDPE and polylined gunny bags for long term storage (24 months).

Mid storage correction

The seeds lose their quality during storage due to deterioration and pest infestation, when the germination falls below 5-10 % of the required standard the seeds are imposed with mid storage correction, where the seeds are soaked in double the volume of 10-4 M solution of potassium di-hydrogen phosphate (3.6mg/lit of water) for 4 hours and the seeds are dried back to

original moisture content (8-9%). Then seed treatment with thiram/captan @ 2g/kg of seed doesn't reduce the germination percentage for 10 months in storage.

Seed standards:

S.No.	Standards	Permitted (%)	
		Foundation seed	**Certified seed**
1	Physical purity (Maximum)	98%	98%
2	Inert matter (Maximum)	2%	2%
3	Other crop seed (Maximum)	20/kg	40/kg
4	Weed seed (Maximum)	10/kg	20/kg
5	Ergot effected seeds (Maximum) by number	0.02%	0.04%
6	Germination (Minimum)	80	80
7	Moisture content - Moisture pervious (Maximum)	12	12
8	Moisture content - Moisture impervious (Maximum)	5	5

Lecture No. 28

SUNFLOWER

Sunflower is a common oilseed of India with wider utility. It is used as a source of edible oil, and as raw material for agri -based industry. Botanically it is known as*Helianthus annus* and belongs to the family asteraceae. It is a cross pollinated crop, insects (honey bees) are the pollinating agents. The crop has got two types of flowers viz. ray and disc florets. Seeds set in disc florets which are bisexual but exhibit self incompatibility due to protoandrous nature of the flower.

Inflorescence is a head, consisting of pistillate or sterile ray florets at the periphery and central hermaphrodite, disc florets. The involucre is bract. The pappus is calyx or calyx is modified into two papus scales. The five petals are united to form corolla tube. Stamens are free and attached to the base of corolla. Five anthers unite to farm anther tube and style is inside the anther tube and stigma bilobed.

Anthesis and pollination

The disc florets are protandrous. Flower opening starts from outer whorl and proceeds towards centre of head. The head bloom within 5-10 days. The pollen grains are viable for 12 hours. Anthesis take place at 5-8 a.m. Self incompatibility operates leading to cross pollination.

Causes for ill filled seed

a) Pollination

It is a cross pollinated crop, normally the insect activity is less. For increasing the insect activity bee hives should be kept in the seed production plot in adequate quantities. The insect activity depends on the pollution and insecticides application. If insect activity is less that leads to poor seed setting and formation of ill filled seeds.

b) Development of axillary flowers

Normally the axillary flowering takes place during the summer because of the high intensity of light. So these type of axillary buds receive the nutrients and assimilate whereas the main head does not get the required quantity of assimilates for seed set there by ill fillings occurs.

c) Micronutrient deficiencies: Zn:IAA-Pollen production, Fe,Boron-Pollen sterility and pollen germination

d) Self incompatibility

Presence of self incompatibility in sunflower also leads to poor seed set and ill filled seeds.

Technology for increased seed set

- **Pollination behavior**: Sunflower is a cross-pollinated crop. Two types of flowers are available. They are ray and disc flowers. Ray flowers are unisexual while disc flowers are bisexual.
- **Pollinating agent** : Honey bees

Varietal seed production technique

Open pollination under isolation is the common method of varietal seed production.

Varieties

CO 1, CO 2, Morden, K1, K 2, EC 68414, EC 68415

Varietal renovation method (Pustovit model)

- In open pollinated variety, selection of superior plants are made based on the quality characters viz., plant yield, 100 seed weight and oil content.
- The selected plants are harvested separately
- Then they are raised in rows individually
- Seeds from promising plants are collected and this form the super-elite seeds

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.

Eg: APSH-11,KBSH-1,BSH-1

Stages of seed multiplication

In sunflower seed is multiplied adopting three generation system, as breeder seed ,foundation seed and certified seed as the crop is often cross pollinated crop where the chances for genetic contamination is high.

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

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

Certified seed ---> A x R

Land requirement

The land should be fertile and problem soils will lead to low pollen fertility and will adversely affect the quality and the seed set will be poor. The previous crop should not be the same crop to avoid the occurrence of volunteer plants and if to be the same crop it has to be the same variety and should be certified and has to be accepted for certification. The field should not have any volunteer plants.

Field Standards (Isolation)

Sunflower field should be isolated from contaminants as follows

Contaminants	**Minimum distance (meters)**	
	Foundation stage	**Foundation stage**
Fields of other varieties and the same variety not confirming to varietal purity requirements for certification and wild sunflower	400	200
Hybrid	600	400

Time of sowing

Seed and sowing:

- For production of foundation seed, breeder seed is used as the base material, while for certified seed, foundation seed should be used as the base material
- The seed used should be from authenticated source with tag and bill.
- Fresh seeds of sunflower exhibit physiological dormancy of about 45-60 days. To obtain good germination 2-3 months prior harvested seed should be used. Physiological dormancy which could be broken by soaking the seeds in 300ppm ethrel for 8h or 0.5% KNO3 for 16h and are dried back to their original moisture content of 8-9% and used for sowing.

Hybrids: Seed rate-Male sterile (A line): 4.8 kg/acre ; spacing: 60 x 30 cm

Male parent (B/R line): 1.6 kg/acre; spacing: 45 x 20 cm

Row ratio: A:B/R- 8:1/4:1

Varieties: Seed rate-6 kg/acre; spacing- 45 x 20 cm

Fertilizer Management:

Supplementary pollination

- Due to lack of honey bees, seed setting will be poor. Hence critical or additional pollination is given to the crop for effective seed setting by Rubbing the heads of two neighbouring plants with each other. It is done during mid flowering stage (i.e 58-60 days of planting for long duration varieties and 45-48 days for short duration varieties) at alternate days between 7-11 a.m for 2 weeks.
- Hand pollination: The heads are rubbed with palm or muslin cloth so that pollination can be enahnced.
- In hybrids, the palm is first gently rubbed on the male parent flowers and then on the female line to transfer the pollen.

Rouging:

Plants rouged from their vegetative phase to harvesting, based on plant, height, head size, branching habit, number of heads and colour of seeds.

Weed management:

Nipping:

Normally branching types in male parent supply more pollen by enhancing the cross pollination and improved seed set in certified seed production. But in foundation seed production, pinching or nipping i.e. removal of side branches in male parent is necessary so that main head receives required quantity of nutrients and assimilates for high seed yield.

Field standards:

Factor	**Maximum permitted (%)**	
	Foundation seed	**Certified seed**
Off types at and after flowering	0.10	0.20
Objectionable weed	None	None
Plants affected by downy mildew	0.050	0.50
Plants infested with orabanche	None	None

Harvesting

Change of thalamus colour from green to yellow is the visual symptom of physiological Maturation and it reaches 40-45 days after completion of flowering. Heads are harvested as once

over harvest. 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. To obtain early maturity, MgCl2 @ 8 kg/acre should be applied.

Threshing:

The earheads are dried under sun and threshed with fliable stick for extraction of seeds. The moisture content of seed at the time of threshing will be 15-18%.On large scale production sunflower threshers are used, but care should be given to avoid mechanical damage, which in turn will reduce the seed quality and storability.

Drying

The seeds are dried to 8-10 % moisture content either under sun or adopting mechanical driers for long term storage as the seeds is orthodox in nature.

Processing:

Mechanical grading can be done with cleaner cum grader, which will remove the undersized immature and chaffy seeds .The middle screen size should be 9/64" round perforated sieves. The size can vary depending on the type of seed. In sunflower the graded seeds also can be upgraded through specific gravity separator for improvement in seed quality characters.

Seed storage

The treated seed can be stored up to 10 months provided the seeds are not infected with storage pests in gunny bags. Seed can be stored up to 2 years if the seeds are packed in moisture free containers and are stored at low temperature while stored in HDPE and polylined gunny bag for long term storage.

Mid storage correction

The seeds loose their quality during storage due to deterioration and pest infestation, when the germination falls below 5-10 % of the required standard the seeds are imposed with midstorage correction, where the seeds are soaked in double the volume of 10-4 M solution of potassium dihydrogen phosphate (3.6mg/lit of water) for 6 hours and the seeds are dried back to original moisture content (8-9%).It is more useful in storage of CMS parental lines.

Seed standards

S.No.	Factor	Standards for each class	
		Foundation	**Certified**
1	Physical purity (min.) %	98	98
2	Inert matter (max.) %	2	2
3	Other crop seed (max.) %	None	None
4	Germination (min.) %	70	70
5	Huskless seed (max.) (By number)	2.0	2.0
6	Total weed seeds (max.)	5/kg	10/kg
7	Objectionable weed seed	None	None
8	Seed infested with Orabanche (max.)	None	None
9	Moisture content (%)		
	a. Pervious container (max.)	9.0	9.0
	b. Vapour proof container (max.)	7.0	7.0

Lecture No 29

CASTOR

In world, India occupies first place in production of castor followed by China, Ethiopia, Thailand, Paraguay, Vietnam, Philippines and Angola.

Country	Production (lakh ha)
India	8.30
China	2.10
Brazil	0.92
World	12.1

- Castor is a cross pollinated crop, protogynous and wind pollinated. Inflorescences are borne terminally on the main and lateral branches.
- The main stem ends in raceme, which is the first or primary raceme. After the first raceme appears, 2 or 3 branches arise at the nodes immediately below it.
- Each of these branches terminates in racemes after 4 or more nodes have formed which are known as secondary racemes.
- Branches arise from the nodes just beneath secondary racemes, ultimately terminating in tertiary racemes. This sequence of development (indeterminate growth habit) continues.
- The racemes of castor are monoecious with the pistillate flowers on the upper 30-50% and staminate flowers on the lower part of the inflorescence.
- The proportion of pistillate and staminate flowers among the racemes varies a great deal both within and among genotypes. It is influenced by the environment of the plant, genotypes and nutrition.
- Female tendency is the highest in winter, while male tendency predominates in summer and rainy seasons.
- Also, the femaleness in young plants with high levels of nutrition is stronger than in old plants with low levels of nutrition.
- Anthesis takes place inbetween 8-12 am and the pistillate:staminate flower ratio decides the hybrid seed production.

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. Availability of irrigation is necessary for total crop period. Requirement of irrigation is more during initiation of flowering and formation of side branches.

Isolation distance

For varieties/hybrids

Foundation seed: 300 m

Certified seed: 150 m

Season

- Rabi / Winter is suitable for 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.

- The racemes of castor are monoecious with the pistillate flowers on the upper and staminate flowers in various orders.
- In general when the daily mean temperature is above 32oC favors production of male flowers and temperature below 32^{o}C favors production of female flowers.

Bloom:

Presence of white waxy coating which protects from chilling/drought and jassid attack.

4 types of bloom:

- No bloom
- Single bloom - Bloom only on stem
- Double bloom- On stem, petioles, and lower sides of leaves
- Triple bloom - On all parts.

To observe bloom, young tender parts of the plant should be observed.

Nodes-Internodes

To identify varieties, count all the nodes from ground to the primary raceme. Average number of nodes vary from variety to variety. In Aruna: 12(9-15), Bhagya: 11(8-15), Sowbhagya: 19(17-22), RC-8: 17(12-20) and in TMV-5: 13(10-18) average number of nodes upto primary raceme were observed.

Fertilizer Management:

For a location, recommended dose of fertilizers should be applied. Entire dose of Phosphorous, Potash and half dose of Nitrogen should be applied at basal and remaining half should be applied in two splits i.e., one at 40-50 DAS (second rouging) and another after 1st picking should be applied.

Inter cultivation:

Crop should be weed free upto 45 days after sowing. After that at 20-25 days and at 35-45 days, weeding and formation of deep ridges should be taken up.

Seed rate:

Varieties: 4 kg/acre

Hybrids: Female parent- 2.4 kg/acre

Male parent-1.6 kg/acre

For production of foundation seed, breeder seed is used as the base material while for certified seed, foundation seed should be used as the base material. The seed used should be from authenticated source with tag and bill.

Spacing: 60-90 cm x 45-60 cm

Planting ratio

3:1 or 4 - 6:1

Rouging and stages of filed inspection

A minimum of four inspections shall be made as follows;

S.No.	Stage of inspection	Objective of inspection
1	7-10 days prior to flowering	determine isolation, volunteer plants, outcrosses, planting ratio, errors in planting, stem color, types of leaves, internode length, bloom and other relevant factors.
2	During flowering	check isolation,No. of nodes upto primary raceme, sex expressivity,

		branching pattern.
3	Before 1st picking	nature of raceme, capsules and characters, reversion to monoecious in second order raceme.
4	After 1st picking	Reversion to monoecious or flower initiation in third order raceme.

Field standards

	Foundation seed	Certified seed
Offtypes (Varieties)	0.1%	0.2%
Hybrids (Varieties)	0.5%	1.0%

Irrigation

Irrigation should be given based on season, variety and type of soil.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.Irrigation shall be given 4-6 times in kharif and in rabi 15-20 times with an interval of 7-10 days.

Disease and pest management:

Beyond ETL, for semilooper, boll worms, hairy caterpillars and for leaf blight and leaf spot diseases plant protection measures shall be taken up.

Harvesting:

- Castor produces 4 or 5 sequential order spikes, which can be harvested in 3-4 pickings.
- It starts from 90-120 days after sowing depending on varieties and at 25-30 days interval pickings shall be taken up.
- Spikes should be ready for harvest when few capsules turn into brown.
- Matured spikes should be harvested without damaging to other immature spikes
- Harvested spikes should be spread uniformly on a threshing floor without heap.
- Kernels are separated from capsules by beating with sticks or by using castor sheller.
- 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".

Seed standards:

S.No.	Parameter	Foundation seed	Certified seed
1	Physical purity (min) %	98	98
2	Inert matter (max) %	2	2
3	Other crop seed &Weed Seed (max)	-	-
4	Other distinguishable variety seeds	5/kg	10/kg
5	Germination (min)%	70	70
6	Moisture content (max)%		
	a. Pervious container (max.)	8.0	8.0
	b. Vapour proof container (max.)	5.0	5.0

Seed storage

Seed treatment with Thiram @ 2 g / kg

Storability in Pervious container - 1 year

Storability in Moisture vapour proof container – 2 years

Lecture No.30

COTTON

Cotton botanically as *Gossypium sp.* is a fibre yielding crop. It is known as the queen of fiber crops. It serves as a cash crop to the farmer as the lint serves as the raw material for the textile industry .The seed is used both for multiplication and as animal feed. The success of commercial crop depends on the quality of the basic seed.

Introduction

Cotton is self -pollinated crop but natural cross-pollination may occur from 10-50% in Gossypium hirsutum, 1-2 % in *G. arboreum* and 5-10% in *G. barbadense*.

There is much variation in case of flower opening. Asiatic cotton opens between 8 and 10 a.m. American cotton opens much earlier. Temperature affects the flower opening. After flower opening the cream yellow colour of corolla turns pink within a day and later changes to red. The receptivity of the stigma is 8 to 10 a.m.

Method of Seed Production

Varieties: Under isolation, by open pollination, the varieties are multiplied.

Hybrids: In cotton both inter and intraspecific hybrids are available.

Interspecific Hybrid :

Varalakshmi : Lakshmi x SB298 E (*G. hirsutum x G. barbadense*)

DCH 32 / Jayalakshmi : DS 28 x SB 425 (*G. hirsutum x G. barbadense*)

Intraspecific hybrid : Suguna, Savitha (T7 x M12)

Land requirement

- The field should be fertile and formed into ridges and furrows.
- Black cotton soils are highly preferable than other soils.
- Land should be free from volunteer plants and designated diseases especially the wilt disease.
- Soil should be deep, fertile, moisture retentive with good drainage. Bottom layers of the soil shouldn’t have hard pans.
- One seed production farm is utilized for seed production of single variety.
- Hybridization technique in cotton:The hybrid seed production in cotton is achieved through emasculation and dusting technique, which is the physical removal of male organ (staminal column) from the female parent.

- Time of sowing: For obtaining good results, crop should be sown one week before onset of monsoons.
- Seeds should be obtained from an authenticated source with tag and bill.
- Seed treatment (before sowing): Fuzzy seeds will clog with one another. So for easy handling the seeds are delinted. Delinting is the removal of seed coat hairs and short fibers that remain after ginning.
- Mercury based chemicals should be used in seed treatment.
- Delinting can be done by machine, acid or flame delinting.

Acid delinting: For acid delinting the seeds are treated with concentrated sulfuric acid and then washed with water 3 or 4 times. Acid delinting is the most frequent used method for delinting of Cotton seed.

Fuzzy seeds will clog with one another. So for easy handling the seeds are delinted using H2SO4 @ 100 ml/kg of seed for 2-3 minutes.

Materials:

Fuzz seed

Sulphuric acid

Plastic bucket

Lime

Glass rod/stick

Water

1% lime water

Procedure

- 1 kg Weighed quantity of fuzzy seeds is taken in a plastic container and add 100 ml concentrated sulphuric acid. Stir well with wooden rod and after 3 minutes, a shiny black colour appears (Tar like).
- After acid treatment, the seed should be washed thoroughly for 3 to 4 times with fresh Water to remove acidity.
- Immerse seeds in 1% lime water to reach to neutrality before last washing in water. Seed germination is affected if properly not washed in water.
- Again wash the seed @1kg/10 litres of water so that the floaters, mature seeds without any visible damage can be picked and heavy seeds sink to the bottom.

- Floated seeds are removed.
- Heavy seeds are shade dried to reduce the moisture content to 12% before further handling.

Uses

- Removes seed hardiness
- Removes seed inhibitors so that increase in germination percentage is obtained.
- Reduces seed rate
- Mechanical sowing is possible
- Seed borne diseases shall be controlled

Seed rate

Varieties	
Delinted seed	3 kg/acre
Fuzzy seed	6 kg/acre
Hybrids	
Jayalakshmi	1.5 kg/acre
Male parent	0.8 kg/acre - 1 row
Female parent	1.6 kg/acre – 4-5 rows

In cotton hybrid seed is produced by manual hybridization i.e. emasculation and pollination. Individual flower buds are emasculated in the evening and pollinated next day morning. The male and female are planted in a ratio of 1:4 or 1:5. The first $4/5^{th}$of area are sown with female line and the remaining $1/5^{th}$ by male line. For example if there are 50 lines then 40 lines are sown with female parent and 10 lines with male parent. Male parent is sown 2-3 times at an interval of 8-10 days while the female is sown only once, so that sufficient number of male flowers should be available when the female flowers are receptive.

Spacing:

Long duration varieties	90 x 30 cm
Short duration varieties	60 x 30 cm
Long duration hybrids	120 x 60 cm
Short duration hybrids	90 x 60 cm
Female parents	150 x 100 cm
Male parents	150 x 50 cm

Sowing:

Per hill 2-3 seeds should be sown and immediately irrigate the field. After 4 days, second irrigation should be given and gap filling should be carriedout.For gapfilling, single seed should be raised in each polythene bag on the same day of sowing. These plants should be used for gapfilling. After 20-23 days of sowing, keep single plant per hill and remove extra plants.

Hybrids - Planting ratio

8:2. But here it is block system where flowers of 2 parts of male is sufficient to dust 8 parts of female parent. Isolation distance of 5m is kept between two blocks to control physical and genetic impurities.

Isolation distance:

Cotton is an often cross-pollinated crop where the extend of cross-pollination is > 60% depending on the species.

	Foundation seed	Certified seed
Varieties	50 m	30 m
Hybrids	50 m	30 m

Fertilizer Management

- Apply recommended dose of fertilizers to seed production plots.
- Application of FYM @3-4 tonnes/acre.
- Basal dose: 20N+20P+20K kg/acre.
- Top dressing: Nitrogen @10kg/acre at 60 DAS
  Nitrogen @10kg/acre at 90DAS.
- Foliar spray: Spray DAP 2% (for female parents, spray on 60,70,80 and 90th days after sowing. (Soak 5 kg of DAP in 25 liters of water over night and supernatant liquid should be taken and mixed with 475 liters of water for spraying 1 hectare).
- NAA application:Spray 40 ppm of NAA (40 mg of NAA dissolved in 1 liter of water) at 40 / 45th day using high volume spray liquid in 1125 liter /ha. Repeat the same dose after 15 days of first spray.

Topping and nipping

Topping arrests terminal growth by nipping the terminal 10-12th node for controlling excessive vegetative growth.

Rouging

- The crop should be rouged for off types, selfed plants, from vegetative phase to harvest phase depending on plant stature, leaf size, leaf colour, hairiness, stem colour, flower colour, petal spot, pollen colour, number of sympodia, boll size, boll shape, pittedness etc. to maintain genetic purity.
- Disease infested plants should be rouged off in the initial stages.
- At boll formation stage of the crop care should be taken such that there shouldn't be any disease infested plants in the field.

Field standards

Factor	Maximum permitted (%)			
	Foundation seed		Certified seed	
	Varieties	Hybrids	Varieties	Hybrids
Offtypes	0.10	0.10	0.20	0.50
Pollen shedders		0.05		0.10

Pest and disease management: Integrated pest and disease management should be practiced to control pests and diseases.

Weed management: Intercultivation 4-5 times and need based weedicide application should be done to control weeds.

Irrigation management:

- Based on climate and soil properties, once in 15-20 days irrigation should be given to the fields.
- Critical periods are boll formation to boll maturation stages.
- Furrow method of irrigation is advantageous.
- Specific problems: Boll shedding will occur either due to extreme dry climate or lesser frequency of irrigation or physiological disorder.
- By spraying 40 ppm of NAA and cycocel at 20ppm, this can be minimized.

Harvesting

- The seed attains physiological maturation 45 days after anthesis.
- The initiations of hair line cracks on the dried bolls are the physical symptoms of physiological maturation.

- At that time, the moisture content will be 30-35%.
- The bolls are harvested as pickings in cotton. Due to continuous flowering habit once over harvest is not practiced.
- As and when the bolls burst with hairline cracks the bolls are collected and dried.
- Normally five to seven pickings can be practiced in a crop.
- But early 4-5 pickings are recommended for seed purpose.
- Harvest in the morning hours upto 10 to 11 a.m. only when there is moisture so that dry leaves and bracts do not stick to the kapas and lower the market value.
- Pick kapas from well burst bolls only.Remove only the kapas from the bolls and leave the bracts on the plants. As kapas is picked, sort out good puffy ones and keep separately.
- Keep stained, discoloured and insect attacked kapas separately and don't mix with kapas kept for seed purpose.

Kapas sorting

Kapas is sorted manually to pick good quality seeds. Hard locks are to be removed (Kapas without proper bursting and lint is light yellow in colour), since these kapas mostly result in poor quality seeds, due to boll worm or other insect attack.Skewed bolls or ill filled or nonviable seeds are formed if stigmatic lobes are not pollinated.

Ginning and certification

- Kapas should be dried upto 6-8.5% moisture for ginning.
- Gin the crossed kapas in separate gins erected in authorized seed processing units or farm gins under the close supervision of the authorities concerned to ensure purity and avoid seed damage.
- Sieve the seed in two types of mesh to remove small, shrivelled seeds, broken seeds and clean perfectly from any dirt or dust.
- After ginning, the seeds should be dried well and cleaned by hand picking. After cleaning, certification agency will take sample for testing germination and genetic purity test. Minimum germination 65% and genetic purity 90% should be maintained.
- Certified seeds would be bagged in one kg bag, sealed and details regarding its origin, germination, physical purity per cent and genetical purity percent, besides season of production are passed on to sale agencies or respective producers for commercial sale.

- Uncertified seeds would be procured by the concerned Department or Agency at the market rate for the ordinary cotton seeds for further multiplication. This step is essential to avoid unauthorised sale of substandard uncertified seed.
- The seed can also be graded by specific gravity method by using floatation technique using water.
- The seeds will separate into floaters and sinkers. The sinkers are good seeds. From floaters, reddish (immature) and damaged (seed with insect hole) are removed. The brownish seeds which are good seeds are handpicked, dried upto 10% moisture and used for sowing.

Processing

The free flowing delinted seeds can be graded using 10/64" round perforated metal sieve,which is recommended as standard sieve in OSAW cleaner cum grader for cotton.

Seed storage

The seeds can be stored upto 8-9 months in moisture pervious container and upto 12-15 months in moisture vapour proof containers.

The seed treatment with thiram @ 2.5 kg-1 will protect the seed from storage fungi and preserve the storability.

Seed yield: 3-6 quintal/ha.

Seed standards

Factor	**Varieties**		**Hybrids**
	Foundation seed	**Certified seed**	**Certified seed**
Physical purity % (min)	98	98	98
Inert Matter % (max)	2.0	2.0	2.0
Other crop seeds (max)	5/kg	10/kg	10/kg
Weed seeds (max)	5/kg	10/kg	10/kg
Genetic purity (%)	100	100	90
Germination (min) % (variety)	65	65	75
Moisture content (max) %			
a. Moisture pervious	10	6	6
b. Moisture vapour proof	6	6	6

Tool employed for hybrid

The hybrid seed production in cotton is achieved through emasculation and dusting technique, which is the physical removal of male organ (staminal column) from the female parent.

Emasculation and dusting

- At the time of flower initiation in female line, the flowers that are going to open next day are selected and the petals are removed between 3-6 pm.
- With the help of nail or needle, the total staminal (pollen + anther + anther tube) column are removed. Then the flowers are covered with a definite colour cover for easy identification of the emasculated flowers.
- In the morning between 9 am -12 noon, which is the anthesis time, the flowers of selected male parent are plugged and dusted on the stigma of the emasculated flower on opening the cover.
- It is again covered with different coloured cover to avoid pollination with other pollen and to identify the emasculated and dusted flower from the rest.
- The pollen from a single flower is enough to dust 4-5 female flowers. The pollen receptivity of the stigma is for 46 hours.
- For easy identification of selfed boll from emasculated and dusted boll the bract can be removed while emasculating owing to the little contribution of bract to seed set and seed yield.

Lecture no.31

GROUNDNUT

Flower:

Anthesis takes place inbetween 4-6am. The release of pollen from the anthers two hours before the flowers open excluded the entry of pollen from other plants. Stigmas are receptive at 4-8 am. Kernels are formed due to self pollination and possibility of cross pollination is up to 0-5%.

Seed production method:

Varieties: The crop should be raised in isolation and seeds should be produced by self pollination.

Hybrids: By emasculation and dusting procedure, hybrids are produced at research stations.

Stages of seed production:

Due to self pollination and low seed multiplication rate(1:5-8), seed certification agencies gave permission to produce groundnut seed in five development stages.

Breeder stage-Foundation stage I,II,III,IV,V-Certified stage.

Land requirement:

Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop.It can be the same variety if it is certified as per the procedures of certification agency. The soil should be fertile and porous with good drainage facility.

Time of sowing: Crop maturity, harvesting shouldn't coincide with rains. If rains occur during harvesting, groundnut kernels germinate under the ground itself (in situ germination).

Varieties: K6,ICGV91114,Narayani etc.

Isolation distance:

	Foundation seed	Certified seed
Varieties	3m	3m

Seed selection and sowing: Certified seeds should be obtained from an authorized source. Healthy kernals free from disease and pest infection should be used for sowing. Remove the decoated, tip broken, coloured kernals and use uniformly graded seeds. Seed treatment with Thiram @4g/kg or Carbendazim @2g/kg of seed protect the seed from fungal infections during germination.

Pre-sowing seed hardening

- Harden the graded seeds by soaking in 0.5% CaCl2 (50% seed volume) for 6 h.

- After 6 h soaking, incubate the seeds in between moist gunny bags for 24 h.
- Observe the sprouting of radicle periodically at 2 h interval after 12 h of incubation.
- Separate the seeds with sprouted radicle (just visible expression of radicle) for sowing or dry under shade upto 10-12% moisture and can be stored up to 7-10 days.
- For seed dormancy, seed should be treated with Ethylene @ 200 PPM.

Seed rate: Seed rate per acre changes with varieties and seed size.

Spacing: 30 x 10 cm

Fertilizer management:

- Application of Gypsum @200kg/acre at 40-45DAS or at flowering.
- Response of the crop to Gypsum is highly observed when sufficient moisture is present in the soil.
- At flowering, DAP spray @0.5% results in good kernel set.

Nutrient deficiencies:

- **Calcium:** The calcium deficiency is reflected in poor pod formation. So, there will be less number, and small ill-developed pods per plant. The calcium deficiency also leads to restricted kernel development resulting in poor pod filling. Such pods are called as “pops”. Air fills the pods in the absence of proper kernel development. When such pods are pressed between fingers, air comes out making some sound like "pop”. Darkened plumule or "black heart" result due to calcium deficiency and pods are predisposed to fungus infections. This reduces yield, quality and crop value.
- **Boron deficiency**: Single gist kernels are formed due to boron deficiency. The inner faces of the boron deficient groundnut cotyledons are depressed and discolored. This is classified as a form of internal damage and has been termed hollow heart. These seeds have poor quality.

Apply Borax 4 kg + Gypsum 200 kg/acre at 45th day after sowing.

Weed management:

Field standards:

Factor	**Maximum permissible limit**	
	Foundation seed	Certified seed
Off-types (Last field inspection)	0.10	0.20

Rouging:

Roguing should be done from vegetative phase up to harvest. Off-types are removed based on the colour, growth pattern, flowering etc.

Irrigation management

Irrigation: Depending on soil texture, the frequency of irrigation varies. However, irrigation should be given during the critical stages of growth like flowering, peg formation and pod development / seed filling. The crop should be irrigated once in 10 – 15 days. Irrigation before harvesting will make the operation easier.

Pest and disease management

Harvesting:

When the crop matures, the older leaves will dry and fall off, top leaves will start yellowing and the inner side of the pod will turn black and the seeds inside will move freely. Soil moisture level is very critical during harvesting. Groundnut should be harvested in bright sunshine and moisture in pods at harvesting should be 35-40%.

Stripping:

After harvesting the groundnut pods are removed from the plants. This is called stripping. Stripping can be done either manually or by using machines.

Pod verification:

Practice pod verification based on varietal characteristics i.e. pod shape, size, venation and reticulation on pods etc before grading to remove genetically impure seed.

Drying:

Stake the plants as the pods are exposed outside for easy drying of pods.Dry the pods to 10 – 12% moisture content under sun.

Processing:

Store the pods till sowing and decortication i.e. the operation of breaking pods and freeing kernels from pods should be done just 7-10 days before sowing. Mechanical grading can be done with cleaner cum grader, which will remove the undersized pods and kernels.

The middle screen size should be 20-24/64” round perforated sieves for pods and 18-20/64” round perforated sieves for kernels.

Decortication:

Dry the pods to 16 per cent moisture content and decorticate manually by using hand operated or machine operated decorticator with proper adjustment.

Drying and storage:

After grading, dry the seeds to 7 to 8 per cent moisture and treat with thiram @ 2 g kg-1. Under normal conditions, seeds can be stored viable up to 6months and pods can be stored viable up to 18 months.

- Store the pods in closed plastic container or gunny bags with Calcium chloride @ 250g/30 kg of pods.
- Store the seeds in gunny or cloth bags for short term storage (8-9 months) with seed moisture content of 8 - 9%.
- Store the seeds in polylined gunny bag for medium term storage (12- 15 months) with seed moisture content of 6-8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than15 months) with seed moisture content less than 5%.

Seed standards

S.No.	Factor	Foundation seed	Certified seed
1	Physical purity (min)	96%	96%
2	Innert matter (max)	4%	4%
3	Other crop seed	-	-
4	Weed seeds	-	-
5	Germination (min)	70%	70%
6	Moisture (max)		
	a. Moisture pervious	9%	9%
	b. Moisture vapour proof	5%	5%

Lecture No.32:

SESAME

Flowers:

Flowers may vary in colour, with some being white, blue, or light pink or purple. Sesame flowers either one or 2-3 flowers at each node. Anthesis starts at 5.00 AM and closes by afternoon. Stigma is receptive upto 8.00 AM. For selfing the flowers are tied with thread before opening of the petals. Cross pollination is reported upto 60% through insects.

Seed production:

Gingelly is a cross pollinated crop and seeds are allowed to set by open pollination by maintaining isolation distance and then multiplied.

Seed production stages

Breeder seed - Foundation seed – Certified seed

Land requirement:

The land selected should not be cultivated with the same crop in the previous season. The land should be fertile with proper drainage facility.

Isolation distance:

Isolation distance maintained between varieties is 50 metres for certified and 100 meters for foundation seed production.

Land preparation:

Time of sowing:

Seed production can be done in all the three seasons - rabi (October - November), kharif (June - July) and summer (February - March).For good germination, the temperature should be 25-27^{o}C.

Seed rate: 1.2 – 1.6 kg/acre

Spacing: 60 x 30 cm (11 plants/m^2)

Sowing:

Good quality certified seeds should be sourced from an authorised dealer with seed tags and receipts. Selected seeds should be treated with bio-control agents like *Trichoderma viride* @ 4 g/kg of seeds. Fungicidal treatment shouldn't be carried after treatment with trichoderma viride seed treatment should be done with thiram 2g/kg of seed.

Fertilizer management:

Sesame require 34N+17P+34K kg/ha. FYM or compost @ 4 tonnes/acre (10 tonnes/ha) is thoroughly incorporated into the soil before the last plough. This will improve the texture as well as the nutrient content of the soil. Basal dose of NPK 20:10:10 kg/acre should be applied.MnSo4 @ 2kg/acre as basal. Spray DAP @1% at time of first flowering and again 10 days after first spray.

Rouging:

Roguing should be done from vegetative phase to harvesting phase. Off-types are removed based on the branching type, capsule size and colour of the seeds.

Irrigation Management:

Depending on the availability of soil moisture, irrigation should be given after sowing, one week after sowing, before flowering (25 days), flowering and pod formation stages.Irrigation is critical during flowering and pot filling stages.

Weed management:

Sesame is very sensitive to weed competition during the first 25 days after sowing. The first weeding is done 20 days after sowing followed by the second one in 15 days interval. Another weeding may be done in 15 days gap. Apart from hand weeding, implements such as hand hoe, bullock drawn blade harrow, rotary or finger weeders are used for weeding. Alachlor a.i.0.5 kg/acre at 20 DAS followed by irrigation effectively control the weeds.

Nutrient deficiencies:

Manganese deficiency: Leaves develop interveinal chlorosis, chlorotic tissue, later develop light brown or husk coloured necrotic lesions.

Zinc deficiency: Middle leaves develop chlorosis in the interveinal areas and necrosis along the apical leaf margins. Mix 5 kg/ha of Zinc sulphate with 45 kg of soil and broadcast evenly in the beds after sowing.

Pest and disease management:

Gingelly is commonly affected by pests like shoot webber, leaf and pod caterpillar and gall fly etc.To control these pests apply 10 kg Endosuplhon dust or Monocrotophos 250 ml or Endosulphon 400 ml/acre.

Root rot:

Proper aeration and drainage, soil application of *Pseudomonas fluorescens* (@ 1 kg/ acre or 2.5 kg/ha mixed with 20 kg / 50 kg of farmyard manure) on 30 days after sowing or soil application of neem cake @ 60 kg/acre (150 kg/ha) combined with seed treatment with *Trichoderma viride* @ 1.6 kg/acre (4 kg/ha) effectively control root rot.

Field standards

	Foundation seed	**Certified Seed**
Isolation distance	100 m	50 m
Off-types	0.10%	0.20%
Plants affected by seed borne diseases	0.50%	1.0%

Harvesting:

Harvesting should be done when 75 – 80% of the pods become brown in colour and few at the bottom have dehisced (burst open). At this stage the moisture content of the pods and seeds will be 50 – 60% and 25 – 30%, respectively. For black seeded variety, check the colour of the seeds in the 10th capsule from the bottom of the crop. If the seeds are black in colour then harvest should be done. Delaying harvest may result in yield loss.

Stacking and drying:

The harvested plants are stacked upright in the threshing yard for a period of three days. This will help the immature pods in the terminal edge to mature and also help in drying of the pods. The moisture content of the pods will reduce to 9%.

Threshing and processing

Threshing is carried out manually by beating the capsules with pliable bamboo sticks. The seeds removed from the pods are graded using round perforated metal sieves of 5/64" size.

Seed storage

Seeds are dried under the sun for 3-4 days to reduce the moisture content to 5.0% before storage. After proper drying, the seeds should be mixed with activated clay @ 1 kg/100 kg of seeds. Seeds are then stored in gunny bags or bins. Seed are treated with thiram @ 2g/kg of seed at 7-8% moisture. Seeds can be stored up to one year under open storage conditions and upto two years under moisture proof gunny bags.

Seed standards

S.No.	Factor	Foundation seed	Certified seed
1	Physical purity (min)	97%	97%
2	Innert matter (max)	3%	3%
3	Other crop seed	1%	1%
4	Weed seeds	1%	1%
5	Germination (min)	80%	80%
6	Moisture (max)		
	a. Moisture pervious	10%	10%
	b. Moisture vapour proof	8%	8%

Lecture No. 33

GREEN GRAM, BLACK GRAM

Flower:

Cleitogamous flower. Pollen dispersal takes place before opening of the flower. Both are self pollinated crops. Cross pollination is 0.5-3%.

Land requirement:

- Land should be free of volunteer plants.
- The previous crop should not be the same variety or other varieties of the same crop.
- It can be the same variety if it is certified as per the procedures of certification agency

Isolation distance

- Green gram and Black gram are highly self-pollinated. Natural cross pollination to the extent of 0 to 5% has been recorded.
- For foundation seed production leave a distance of 10m and for certified / quality seed production leave a distance of 5 m all around the field from the same and other varieties of the crop.

Management Practices

Land preparation:

The soil should be fertile with neutral pH and proper drainage facility. It should be prepared to fine tilth. If the previous crop was of different, irrigate and sow the pulse crop.

Time of sowing:

Kharif: June-July; Rabi: October-November; After paddy harvesting-December; Summer- March-April

Seed rate: Green gram: 5 kg/acre, After paddy harvesting: 12-15 kg/acre

Black gram: 6 kg/acre, After paddy harvesting: 15-18 kg/acre

Seed procurement:

Good quality certified seeds should be obtained from an authorised dealer. Seeds should be healthy with a good germination percentage. Only graded seeds should be used. Remove the off colour and out sized seeds. Seed rate is 8 kg/acre (20 kg/ha).

Method of sowing: Sow in rows

Spacing: Kharif: 30-45 cm x 10 cm; Rabi: 30 cm x 10 cm

Fertilizers:

In the last two years, if the previous crop was not of green gram/black gram, seed treatment with Rhizobium culture should be done. During land preparation, farmyard manure @ 3-5 tonnes/acre (25 truck loads/ha) should be added and incorporated into the soil by ploughing. NPK @ 8:16:0 kg/acre is recommended.

Irrigation Management:

Kharif crop don't require irrigation. Water stagnation should be avoided at all growth stages. Irrigation during flowering and pod formation stages are very critical. In rabi, 1-2 light irrigations should be given to the crop.

Inter cultivation:

Field should be free of weeds. Need based weedicides should be applied to control weeds.

Plant protection:

- Yellow mosaic virus affected plants should be removed from the field.
- To control sucking pests that spread YMV, spray systematic insecticides.
- Seed treatment with tricoderma viridae @4g/kg or pseudomonas fluoroscences @10g/kg should be done before sowing or wet the soil with carbendazim @ 1g/litre.

Rouging:

Roguing should be done from vegetative phase to reproductive phase. Off types are removed based on the leaf colour, plant stature, leaf shape, pod colour, flower colour and seed colour. Remove virus infected plants immediately.

Field standards (%)

Factor	Foundation seed	Certified seed
Off types	0.10	0.20
Plants infected with seed borne diseases	0.10	0.20

Harvesting:

Harvest is done soon after the maturation of the seeds. Seeds attain physiological maturity 30 days after 50% flowering. The mature pods of blackgram turn black and greengram pods turns brown. At this stage the moisture content of the pods will be 17 – 18%.

Seed standards

S.No.	Factor	Foundation seed	Certified seed
1	Physical purity (min)	98%	98%
2	Innert matter (max)	2%	2%
3	Other crop seed	5/kg	5/kg
4	Weed seeds	5/kg	10/kg
5	Germination (min)	75%	75%
6	Moisture (max)		
	a. Moisture pervious	9%	9%
	b. Moisture vapour proof	8%	8%

Threshing and processing

Harvested pods along with plants are dried to a moisture content of 12 – 13% and then threshed using sticks. Threshed grains are cleaned and dried to attain a moisture content of 8 – 9%. The seeds are graded using BSS 7 x 7 wire mesh sieve.

Drying and storage

Processed and graded grains are further dried to attain 9% of moisture content. Then seeds should be mixed with 3% neem seed kernel power to preserve the seeds from storage pests especially infestations of the bruchid beetle.

Lecture No 34.

BENGAL GRAM

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Chickpea is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe). India is the largest chickpea producing country accounting for 64% of the global chickpea Production. The other major chickpea producing countries include Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. In India, chickpea area was about 7.29 lakh ha with a production of 5.77 lakh tons and average yield of nearly 791 kg ha-1. It is cultivated in Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka.

Varieties: ICCV-10 (Bharati), Pusa 372, Pusa 362, Pusa 267 (Kabuli), KPG-59 (Udaya), Pusa 408, Gaurav.

Climatic requirement and important measures

Chickpea is a cool season food legume and grown as a winter crop in the tropics and as a summer or spring crop in the temperate environments. It likes cool, dry and bright weather.

- Temperature, day length and availability of moisture are the three major abiotic factors affecting flowering.
- In general, flowering is delayed under low temperatures and also under short-days.
- Chickpea is sensitive to high (maximum daily temperature >35°C) as well as low (mean of maximum and minimum daily temperatures <15°C) temperatures at the reproductive stage.
- Both extremes of temperatures lead to flower drop and reduced pod set.
- A crop grown for seed production requires extra efforts and investments than a crop grown for grain.
- While taking up seed production, high priority should be given to maintenance of genetic and physical purity of the seed.

Crop season and sowing time:

- Chickpea is grown in *rabi* (post rainy season) following a *kharif* (rainy season) crop or *kharif* fallow. The sowing is done in the month of October or November.

- Late sowing (December-January) should be avoided as the late-sown crop may experience moisture stress and high temperatures at the critical stage of pod-fi lling, leading to reduced yield and seed quality.

Isolation distance:

- Isolation of a seed crop is done by maintaining a distance from other nearby fields of the same crop and other contaminating crops. Chickpea being a self-fertilized crop has a very low out crossing percentage (0-1%).
- An isolation distance of 10 m for foundation seed and 5 m for certified seed is required.

Suitable soil type:

- Chickpea can be successfully grown in a variety of soil types including coarse-textured sandy to fine-textured deep black soils (vertisols).
- The best suited soils are deep loams or silty clay loams with a pH ranging from 6.0 to 8.0.
- Saline soil and fields with a high water table are not suitable for chickpea.

Field preparation:

- Chickpea plants are highly sensitive to poor aeration in the soil.
- Seedling emergence and plant growth are hindered if field surface is compact. Therefore, the field should have loose tilth and good drainage.
- The stubble and debris from the previous crop should be removed as these can harbor the pathogens that cause root diseases, such as collar rot.

Sowing:

- Sowing is usually done on conserved soil moisture. A pre-sowing irrigation may be needed, if the available soil moisture is not adequate for germination.
- Kabuli chickpea should never be irrigated immediately after sowing, particularly in deep black soils. This is because the kabuli chickpea seeds have thin seed coat and deteriorate faster and are also more susceptible to seed rot and seedling damping off.
- This problem can be overcome in desi chickpea as it have thick seed coat.

Sowing depth:

- Seed should be sown deeply enough to make contact with moist soil. A depth of 5-8 cm seems to be ideal for the emergence of chickpea.

Spacing:

- Line sowing is a must in the crop grown for seed production as it facilitates interculture operations, rouging and field inspection. Row-to-row spacing of 30 cm and plant-to-plant spacing of 10 cm are generally used, which give a plant population of about 33 plants per m2 (330,000 plants ha-1).
- Wider row spacing (45–60 cm) can be used in large seeded kabuli chickpea and irrigated crops (both desi and kabuli types), which are expected to have greater plant width.

Seed rate:

- It differs from variety to variety, depending on seed size.
- For initial seed multiplication of a new variety, the multiplication rate (yield per plant) is more important than yield per unit area.
- The following guidelines may be used for seed rate. Normally, the seed rate is 22-40 kg/acre and it varies depending on the size of the seed.

Seed size	100 seed weight	Variety	Seed rate kg/acre
Small	<20	JG 315	20-24
Medium	20-30	JG 11, JG 130, JAKI 9218	24-36
Large	30-40	KAK 2, Vihar, LBeG 7	36-48
Extra large	>40	JGK 3	48-60

Seed treatment:

- The seeds should be treated with fungicides (2 g thiram + 1 g carbendazim kg-1 seed) before sowing for reducing seed and soil borne fungal diseases.
- Phosphorus solubilizing bacteria (PSB) have been identified, which improve availability of phosphorus to plants. Thus, seed treatment with PSB is recommended.
- If chickpea is being grown for the first time, the seeds should be inoculated with *Rhizobium* culture.
- The seeds should be treated first with fungicides and then with PSB and *Rhizobium,* following the procedure recommended by suppliers.
- The culture-treated seeds should be dried in the shade and sown as soon as possible thereafter.

- If the seed is to be treated with pesticides, always apply insecticides first, followed by fungicides, and fi nally *Rhizobium* culture/phosphate solubilizing bacteria or follow instructions on the packets.

Fertilizer application:

- Fertilizer requirements depend on the nutrient status of the field, and thus, vary from field to field. Therefore, the doses of fertilizers should be determined based on the results of soil test.The generally recommended doses for chickpea include 8–12 kg nitrogen (N) and 16–24 kg phosphorus (P) per acre. If soils are low in potassium (K), an application of 6.8 to 10 kg K ha-1 is recommended. There will be no response to application of K in soils with high levels of available K. Total quantities of N, P and K should be given as a basal dose. Foliar spray of 2% urea at flowering has been found beneficial in rainfed crops.

Nutrient deficiencies.

- Intensive cropping without application of micronutrients, limited or no application of organic fertilizers and leaching losses lead to deficiency of one or more micronutrients in the soil.
- The important micronutrients for chickpea include sulphur (S), zinc (Zn), iron (Fe), boron (B) and molybdenum (Mo). The requirements of these micronutrients vary from field to fi eld and should be determined based on the results of soil analysis.
- **Sulphur** (S): Soil application of 20 kg S ha-1 through single super phosphate (SSP), gypsum or pyrite has given encouraging results in sulphur-deficient soils.
- **Zinc** (Zn): Zinc deficiency generally occurs in soils with a high pH and in areas under rice - chickpea cropping system. Zinc application enhances root growth, nodulation and nitrogen content of nodules. The symptoms of zinc deficiency are yellowing and then bronzing and necrosis of middle and lower leaves. Basal application of Zinc Sulfate (ZnSO4) at 10-25 kg ha-1 has been found to give positive response. Foliar application of 0.5% Zinc Sulfate mixed with 0.25% lime was also effective in correcting zinc deficiency.
- **Iron** (Fe): Iron deficiency is a complex physiological disorder of plants growing on calcareous soils with high pH. Typical symptoms of Fe deficiency are yellowing of young, newly formed leaves that dry and fall off prematurely in case of acute deficiency. Soil application of Fe is usually uneconomical due to reversion to unavailable forms. Foliar

spray of 0.5% (w/v) ferrous sulphate has been found effective in correcting iron defi ciency.

- **Boron** (B): Strongly weathered, coarse textured and shallow soils are generally deficient in boron. The critical concentration of boron in soils is 0.5 ppm. The symptoms of boron deficiency include severe chlorosis and bleaching of leaves followed by tissue necrosis. The leaflets become curled and fi nally dry up. There is reduction in the number of fl owers, which also lack pigmentation. Soil application of 1.0-2.5 kg Borax ha-1 or foliar application of 0.25 kg Borax ha-1 helps in correcting Boron deficiency.
- **Molybdenum** (Mo): The availability of molybdenum is often low in high clay soils and laterites, but it is high in saline and alkaline soils. Thus, both deficiency and toxicity of molybdenum are encountered. Toxicity symptoms appear at an earlier stage (32 DAS) than deficiency symptoms (45 DAS). Molybdenum deficiency causes reduction in the number and size of flowers and many of them fail to mature leading to lower seed yield.
- Seed treatment with 3.5 g sodium molybdate has been found to have beneficial effect in chickpea. The response to molybdenum was greater when applied along with PSB and *Rhizobium* inoculation.

Irrigation:

- Chickpea is generally grown as a rainfed crop.
- But two irrigations, one each at branching and pod filling stages, are recommended for higher yield.
- Higher number of irrigations may lead to excessive vegetative growth in heavy soils.

Weed management:

Chickpea is a poor competitor with weeds at all stages of growth. Pre-emergence herbicides, such as Fluchloralin @ 1 kg a.i. ha^{-1} or Pendimethalin @ 1.0 to 1.5 kg a.i. ha^{-1} were found effective in controlling early flush of weeds. Mechanical and/or manual weeding can be done where wide row spacing is used.

Plant protection:

Chickpea being a rich source of protein, is prone to damage by insect-pests and diseases.

Wilt: The fungus is seed and soil borne and can survive in the soil in the absence of the host. Use resistant varieties (eg, JG 11, JAKI 9218, JG 130, KAK 2, JGK 1, JGK 2). Deep ploughing during summer and removal of host debris from the field can reduce the level of inoculum. Exclude

chickpea from the crop rotations in infested fields for at least 3 years. Seed treatment with *Trichoderma viride* @ 4 g kg-1 seed has been found effective in reducing incidence of wilt.

Collar rot: High soil moisture, the presence of under decomposed organic matter on the soil surface, low soil pH and high temperature (25 to 30°C) favor the disease. The collar region of the chickpea plant is constricted and begins to rot. The affected seedlings turn yellow and wilt. Treat seeds with fungicides as suggested above, follow long term crop rotations with cereals such as wheat, sorghum and millets, and remove un decomposed debris from the field before sowing.

Dry root rot: It is a serious disease under moisture stress conditions and when the crop is exposed to temperature above 30°C.The disease generally appears around flowering and podding stage. The whole plant dries up and turns straw-colored. Roots become black and brittle and have only a few lateral roots or none at all. Follow crop rotation. Seed treatment with fungicides can reduce initial development of the disease. Timely sowing should be done to avoid post-flowering drought and heat stresses, which aggravate the disease.

Management of Insect pests

- **Pod borer**: It is an important pest. Crop damage is 20-30%. Varieties with high levels of resistance to pod borer are not available, but released varieties such as ICCV 10 and Vijay suffer low damage. Though pod borer can be effectively controlled through application of insecticides, an integrated pest management (IPM) strategy is recommended as it is eco-friendly, does not eliminate natural enemies of pod borer, reduces pesticide residues, and the risk of development of resistance to insecticides.
- **Termites**: Termites may be a problem in some fields, as these can infest chickpea plants at all stages of the crop growth. The initial damage to the seedlings can cause substantial seedling mortality. The roots and stems are tunneled and one can see termites inside. *Odontotermes* spp. cover themselves with earthen galleries under which they feed. Chemical control in rainfed crop at later stages is difficult and expensive. However, some cultural practices such as destroying the termite mounds in the vicinity of the field, removal of plant residues and debris from field and timely harvest can help to minimize the damage. The termite nests can be destroyed by drenching with chlorpyriphos (10 ml in one liter of water) after disturbing the mounds.

Rouging:

It refers to systematic examination of seed production fields and removal of undesirable plants that may contaminate the seed crop. Roguing not only maintains varietal purity but also protects the seed crop from seed-borne diseases. The off-type plants, other crop species (with similar seed size), weed plants, parasitic weeds such as *Cuscuta* spp. and plants infected with seed-borne fungal diseases and viruses should be removed from the seed fields from time to time. Roguing should be done once before flowering and once after flowering based upon varietal morphological characters.

Harvesting and threshing

The time of harvesting is crucial in maintaining the quality of seeds. The crop should be harvested when leaves start to senesce and start shedding, pods turn yellow, plants are dry, and seed feels hard and rattles within the pod. After harvest, the plants can be dried in the sun for a few days to ensure that seeds get dried well. Threshing can be done using commercially available power threshers.

Seed processing

- The dried seeds are cleaned to remove the undesirable contaminants such as plant parts, soil particles, stones, weed seed, other crop seed, and shriveled, broken, or damaged seed.
- Cleaning and upgrading is based on physical differences between good seed, poor seed and undesirable contaminants.
- The cleaning and grading of seeds is first achieved by winnowing and then through a set of mechanical sieves. In addition to air cleaners and aspirators, indented separators, disc separators, gravity separators, spiral separators and drum separators are frequently used.

Seed storage:

- The seed must be properly dried before storage. The ideal seed moisture level is 10-12% for short-term storage (up to 8 months).
- After drying, the seed should be either stored in polythene-lined gunny bags or in safe storage structures (metal bins or earthen containers).
- The bags should be kept in a rodent free room and placed on wooden planks (not more than five in a stack) and away from walls to avoid dampness to the seeds.
- The traditional methods of protecting the seed from bruchid damage by mixing with ash, dried neem leaves, or chickpea or wheat straw are useful for small quantities of seed.

- In case of large scale storage, the seed store or the seed bins should be fumigated periodically with commercially available fumigants (ethylene dibromide or phosphine) to protect seed from storage pests.
- The main advantage of fumigation is that all stages of the insect, including eggs, larvae and pupae, are controlled and also affect other storage pests and rodents.

Lecture No. 35

RED GRAM

- Pigeonpea is a short-day plant and flowering in this species is induced by long periods of darkness.
- The photo-period sensitive reaction in pigeon pea germplasm is positively linked to their maturity duration and biomass production. The recently developed early maturing genotypes are relatively less sensitive to photo-period and the long-duration types are most sensitive. If a photo-sensitivegenotype is planted during the long days of mid-June, then the plants will produce greater biomass, more branching, more pods, and therefore, a population of about 26,640 plants $acre^{-1}$ will be sufficient for realizing optimum yield levels.
- On the contrary, in the late (September–October) sowings the plants of the same variety will be short in height, flower quickly, and produce only a few branches and pods. Therefore, to establish an optimum biomass canopy per unit area and to record high yields, over 132,000 plants $acre^{-1}$ would be necessary.
- For consistency in the expression of any trait of a given variety, it is essential that its genetic purity be maintained. In most pulses, the genetic contamination of varieties through natural out-crossing is not an issue as their flowers are cleistogamous with high levels of self-pollination, and the genetic drifts due to natural out-crossing are minimum. In contrast, pigeonpea is grossly different in its pollination behavior and a considerable level (25–30%) of natural out-crossing is observed.
- Since pigeonpea is a perennial plant, its flowering continues until an optimum pod load on an individual plant under specific environmental conditions is achieved. This characteristic behavior of pigeonpea exposes its flowers for a longer period to insect visits. The large yellow flowers of pigeonpea attract various insect species, particularly bees. The frequent visits of pollen-carrying insects across various genotypes lead to natural crosspollination, resulting in sharp deterioration of genetic purity of cultivars and genetic stocks.

Crop production Technology

Seed: The first and foremost pre-requisite for a good crop production is timely procurement of quality seeds of the given variety or hybrid parents for sowing. The reliability of the seed source

should be of the highest order and should be obtained from an authenticated source with tag and bill. Also, it is essential that the contract growers identified for seed production should be willing to cooperate with the seed producing agency. In pigeonpea there exists a large variation for maturity and plant type, leading to the development of markedly different phenologies. Therefore, a uniform agronomic package cannot be adopted or recommended for optimizing the grain productivity of all types of genetic materials and for different pigeonpea growing areas.

Field preparation

- To select a field for large-scale seed production of pigeonpea, it is essential to ensure the availability of recommended isolation distance and irrigation.
- Also, the field should have a known history of good soil fertility.
- Since pigeonpea cannot withstand water-logging, low-lying fields should never be selected for seed production.
- In Vertisols, where the probability of water-logging is always high, the sowings on raised beds or ridges with appropriate slopes offer greater probability of raising a healthy crop.

Fertilizer management

The recommended basal doze of 40 kg $acre^{-1}$ of di-ammonium phosphate and other recommended soil amendments for the known soil deficiencies is also advisable.

Sowing

Sowing should be undertaken at the onset of the rainy season. This will ensure good plant growth and canopy development. Seed rate varies depend upon crop duration and spacing. The seeds are placed about 5 cm deep and covered firmly with soil to ensure a good contact between seed and soil particles and ultimately germination.

Crop duration	Spacing	Seed rate
Early duration	30-45 x 10-20 cm	10-12 kg/acre
Medium/Long duration	75-90 x 20-30 cm	4-6 kg/acre

Isolation distance:

- Red gram is partially self and cross pollinated.
- Although anthers burst before flowers open, the large yellow flowers of pigeonpea for long duration attract various insect species there is considerable cross-fertilization by bees

and other insects. Natural crossing to the extent of sixty five percent has also been recorded.

- Therefore, for maintaining variety purity an isolation of 200 mts. for foundation seed class and 100 mts. for certified seed class is necessary from fields of other varieties and of the same variety not confirming to varietal purity requirements of certification.

Weed control

- The slow initial seedling growth of pigeonpea makes it prone to weed competition particularly during the first six weeks of growth.
- In general, three hand weedings, the first at 25–30 d, the second about 50–60 d, and the third at 80–90 d after sowing are sufficient to get rid of most weeds.
- Alternatively, spraying of a mixture of pre-emergence herbicide such as *Basalin* or *Prometryn*, each @1.5 L acre-1, followed by two-hand weedings has also been found effective in controlling weeds.

Irrigation Management

- Irrigation is generally not recommended if the crop is grown for domestic consumption on deep Vertisols.
- However, if the crop is grown for seed purposes, either on light Vertisols or Alfisols, an irrigation during the early growth stage and another at the early podding stage is considered beneficial.

Insect Management

Pod borers (*Helicoverpa armigera* and *Maruca vitrata)*, pod fly (*Melanagromyza obtusa*) and blister beetle (*Mylabris pustulata*) are major pigeonpea insects. These may cause severe reduction in yields and grain quality. Also, sometimes a total crop loss is also observed.The first insecticide spray is recommended at flower initiation, and the second and third sprays should be done at 10–15 d intervals. If pest incidence persists, then one or two additional sprays can also be done.If Knapsack sprayers are used, then 500 L of spray liquid is recommended to cover one hectare of a pigeonpea field.

Integrated Pest Management (IPM):

- In redgram following IPM practices increase the grain yield and improved quality.
- Monitoring the pests with pheromone trap.

- Growing of trap crops such as marigold (*Chrysanthemum* spp.) on the borders of the field and in between rows as an inter-crop also helps in reducing pod borer damage.
- Planting of tall sorghum on the borders of the pigeonpea field acts as perches for birds that eat pod-borer larvae. The border also harbors natural enemies of pigeonpea pests.
- Use of neem seed kernel extract (5%) against pod borers is quite effective.
- On noticing the eggs and fi rst instar larvae of *H. armigera*, spraying of HNPV (hydro nuclear polyhedrosis virus that infects *H. armigera*) is recommended @ 250 LE (larval equivalent) ha^{-1}.
- Manual shaking of plants helps in dislodging the grown Helicoverpa pod borer larvae from the plants. These larvae are collected on the ground on a plastic sheet and are physically destroyed.
- Since the blister beetles are large in size and slow moving insect, they can be controlled manually by hand picking or by using small insect catching nets and later crushing them. Use of hand gloves in catching insects is always advisable for these operations. This will protect the skin from blisters caused by this insect.

Disease Management

- Fusarium wilt and sterility mosaic are major pigeonpea diseases.
- Wilt is caused by a soil-borne fungus *Fusarium udum*. The pathogen can survive in the field for three years or more.
- Therefore, to control the losses caused by wilt, we recommend the following:

(i) Use wilt resistant varieties.

(ii) Use disease free fields with no previous record of wilt.

(iii) Do not grow pigeonpea after pigeonpea in the same field; follow appropriate crop rotations.

- Sterility mosaic disease is caused by a virus, which is transmitted through the eriophide mite (*Aceria cajani)*. The virus-carrying insects survive on a number of alternative hosts, pigeonpea plants and stubble left in the field after harvesting the main crop.

The simple disease management options are:

(i) Grow sterility mosaic resistant cultivars.

(ii) Select a field well away from perennial or ratooned pigeonpea.

(iii) Uproot infected plants at an early stage of disease development and destroy them.

(iv) Spray acaricides such as Kelthane, Morestan or Metasystox @ 0.1% to control the mite vectors in the early stages of plant growth.

Crop Harvesting and threshing

- The crop can be harvested by picking pods, cutting the pod-bearing branches, or by cutting the whole plant at ground level when about 75–80% pods are mature.
- The harvested materials should be left in the field for a few days to dry in the sun. Threshing can be done as per the local practices.
- If suitable harvesters are available, then the top half of the plants may be harvested mechanically.

Emasculation and Pollination

- The first step in hybridization is to identify appropriate parental lines and purify them by removing obvious off-types and mixtures.
- It is always better to acquire genetically pure seed for hybridization.
- To avoid difficulties in handling the seeds, it is advisable to allocate an identification number to each cross with male and female parents properly identified.
- The land for the crossing block should always be selected near an irrigation source and be protected from stray animals.
- The parental lines should be planted at row-to-row spacing of 75–100 cm. This will allow a person to sit comfortably between the two rows while making crosses. The plant-to-plant spacing is kept at 30–50 cm.Each parental row should be labeled properly and purified by removing off-type plants, if any.
- Within each row of female parents each plant should be given an identification number. This will help in keeping an effective crossing record. This should be followed by the selection and identification of individual plants to be used as a male and a female parent in each combination. If a large number of crossed seed is required then more than one plant can be used as parents for crossing. The pollinating buds harvested from the male parent should be kept in a labeled petri plate with moist filter paper in the base.
- Emasculation of male fertile buds in the female rows is carried out with a fine sharply-pointed forceps. For emasculation, tightly closed buds, approximately two thirds the size of mature buds, are selected. Such buds have a bright yellow corolla without any greenish hue.

- The anther filaments are carefully held with forceps without touching the stigma and they are removed from the stamen column. It is essential to ensure that no anther is retained inside the dissected bud and tied with a colored thread. This emasculated bud is now ready for pollination.
- The selected pollinator bud should be fully grown but still closed.
- For pollination, the entire stamen column is removed with the pair of forceps and the pollen-bearing anthers are brushed on the stigma of the emasculated bud to effect fertilization.
- Tying a piece of colored thread around the pedicle of the pollinated bud will help in distinguishing the hand-pollinated bud on the female plant.
- If the female plants are limited in number and more crosses need to be made, then more than one cross can be made on a single plant. In such a situation, different colored threads can be used to identify different crosses.

Rouging

•Pigeonpea, being a partially out-crossing crop, requires extra precautions to maintain variety purity. Some of the important steps that would help maintain variety purity and minimize the contamination of farmers' seed are listed below:

• Always purchase good quality seed from a reliable source. Plants that were not of true to type, plants affected with wilt, leaf spot, canker, sterility mosaic virus etc should be rouged and burned.

• Avoid delayed sowing for seed production as it may produce low yield and poor quality seed.

• Select a field in which pigeonpea was not sown in the previous season. This will avoid emergence of dormant seeds of the previous season.

• Certified Seed production plots should be isolated from other pigeon pea cultivars by at least 100 m.

• The farmers should be advised to refrain from selling their seed if its quality is visibly inferior.

• Remove all off-type and late flowering/maturing plants as soon as they are spotted in the field.

• Prevent mechanical mixing and physical injury to the seeds.

• Soon after threshing and cleaning remove off-colored and small and over sized seeds.

• Sundry the seed for a few days to bring the seed moisture level to 9.0%.

• Treat the seed with fungicides and pack it in small polythene bags for storage and distribution.

Male-sterility systems in red gram

Genetic male sterility system

Sterile line: msms x Fertile: Msms

Msms : Msms

50% sterile 1: 1 50% fertile

Cytoplasmic genetic male sterility

Cytoplasmic nuclear male-sterility is the most widely accepted means of producing commercial hybrids in the field crops. The three-line system is geared for multiplying ‘A’ line with the help of ‘B’ line and for producing hybrid seed the ‘A’ line is crossed with ‘R’ line.

Foundation seed: A x B: 4 ‘A’ rows: 1 ‘B’ row gives ‘A’ seed.

Certified seed: A x R: 4 ‘A’ rows: 1 ‘R’ row gives ‘hybrid (F1)’ seed.

Lecture No. 36

SEED CERTIFICATION

Seed certification is a legally sanctioned system for the quality control of seed during seed multiplication and production. As per Indian Seed Act seed certification is voluntary and it is not compulsory.

Objective of Seed Certification

The main objective of the Seed Certification is to ensure the acceptable standards of seed viability, vigour, purity and seed health. A well organized seed certification should help in accomplishing the following three primary objectives.

- The systematic increase of superior varieties;
- The identification of new varieties and their rapid increase under appropriate and generally accepted names.
- Provision for continuous supply of comparable material by careful maintenance.

Functions of Seed Certification Agency

(a) Certify seeds of any notified kinds or varieties

(b) Outline the procedure for submission of applications and for growing, harvesting, processing, storage and labelling of seeds intended for certification till the end to ensure that seed lots finally approved for certification are true to variety and meet prescribed standards for certification.

(c) Maintain a list of recognised breeders of seeds;

(d) Verify, upon receipt of an application for certification that the variety is eligible for certification, that the seed source used for planting was authenticated and the record of purchase is in accordance with these rules and the fees have been paid;

(e) Take sample and inspect seed lots produced under the procedure laid down by the certification agency and have such samples tested to ensure that the seed conforms to the prescribed standards of certification;

(f) Inspect seed processing plants to see that the admixtures of other kinds and varieties are not introduced;

(g) Ensure that action at all stages, e.g. field inspection, seed processing plant inspection, analysis of samples taken and issue of certificates (including tags, marks, labels and seals) is taken expeditiously;

(h) Carry out educational programmes designed to promote the use of certified seed including a publication listing certified seed growers and sources of certified seed;

(i) Grant certificates (including tags labels, seals etc.) in accordance with the provisions of the Act and these rules;

(j) Maintain such records as may be necessary to verify that seed plants for the production of certified seed were eligible for such planting under these rules.

(k) Inspect fields to ensure that the minimum standards for isolation, roguing (where applicable) use of male sterility (where applicable) and similar factors are maintained at all times, as well as ensure that seed borne diseases are not present in the field to a greater extent than those provided in the standards for certification.

Board of Director (From Agril. university & Dept. of Agriculture)

Director

Technical	**Other Staff**
Chief Seed Certification Officer	Accounts Officer
Regional Seed Certification Officer	Accountant
Seed Certificate Officer	Clerks
Seed Certificate Inspector	Lower Staff

Seed certification standards

The minimum seed certification standards can be broadly grouped into two groups.

A. General Seed Certification Standards

B. Specific Crop Standards

General Seed Certification Standards: The general seed certification standard aims at outlining the general requirements for the production of genetically pure good quality seed. These standards prescribed the procedure for certified seed production so that maximum genetic purity and good quality of the seed is ensured.

Specific Crop Standards: Specific crop standard consists of Field Standards and Seed Standards Field standards consist of: -

1. The minimum preceding crop requirement have been specified to minimize genetic contamination from the disease, volunteer plants.

2. The minimum isolation requirement has been specified to minimize seed born disease contamination.
3. The number of feed inflection and specified stage of crop have been described to ensure verification of genetic purity and other quality factors.

Seed Standard consists of:

1. The minimum percentage of pure seeds and maximum permissible limits for inert matter, other crop seeds have been prescribed.
2. The maximum permissible limits for objectionable weeds, seeds infected by seed borne diseases have been prescribed to ensure goods seed health.
3. The maximum permissible limits for moisture content have been prescribed for the safe storage of seeds.

Phases of Seed Certification

Certification shall be completed in six broad phases listed as under:

(a) Receipt and scrutiny of application;

(b) Verification of seed source, class and other requirements of the seed used for raising the seed crop;

(c) Field inspections to verify conformity to the prescribed field standards;

(d) Supervision at post-harvest stages including processing and packing;

(e) Seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verity conformity to the prescribed standards

(f) Grant of certificate and certification tags, tagging and sealing.

Procedure for seed certification

1. Receipt and scrutiny of the application: All those persons who are interested in seed certification should submit an application in Form No 1 to the concerned seed certification officer with the prescribed fees of Rs 25/-. The fee is for one season for a single variety and for an area up to 25 acres (10 ha.) If the area is more than 25 acres or if more than one variety is planted separate applications should be made for each variety. If the area is less than 25 acres under one variety but if the fields are scattered and separated by more than 50 meters separate applications

should be made. On receiving the applications the seed certification agency verifies for the following conditions:

1. Eligibility of the variety: Only those varieties that are notified by the central govt. are eligible for certification.

2. Establishing the seed source: The seed producer should submit the tag, invoice, and a copy of Form No2.)

3. There should not be any difficulty in reaching the field for carrying out timely field inspection.

4. Whether the required isolation and land requirement is followed or not.

5. Whether the processing plant facility is available to the applicant.

6. Whether the applicant has paid the requisite registration fee or not.

If all the six conditions are fulfilled then the seed producer has to pay the field inspection fees

2. Verification of seed source, class and other requirements : The seed should be from authentic source and from appropriate class and should be in accordance with Indian Minimum Seed Certification Standards.

3. Inspection of Seed Fields : The certified seed producers should grow and harvest the crop as per the guidelines issued by the seed certification agency. They must carefully and faithfully carry out the roguing and other operations as per the directive of the certification agency. The certification staff conducts field inspections at appropriate stages of crop growth to ensure that minimum standards of isolation, preceding crop requirement, roguing and other special operations are maintained at all times. The inspection of seed crop is done at different stages of crop growth such as at the time of sowing (when new crop is introduced), vegetative stage or preflowering stage, flowering stage, post flowering or preharvest stages and at the time of harvest. The contaminants to be observed during field inspections are offtypes, pollen shedders, shedding tassels, inseperable other crop plants, objectionable weed plants and diseased plants. The field inspections are designated to ensure that the crop is up to the prescribed field standards. All the seed fields, which do not meet the required field standards, are eventually rejected. The procedure for taking filed counts differs for different crops.

4. Rejection of seed fields: All the seed fields, which do not confirm to the required standards for any of the factors should be rejected. The rejection letter should be immediately communicated to the seed grower stating the reasons for the rejection. As far as possible the seed growers should be convinced for rejecting the seed fields by showing the contaminants.

5. Post Harvest Inspection: The personnel from the seed certification agency should inspect the fields during harvesting or post harvesting, so that there are no mechanical mixtures and the seed is not handled badly during threshing or afterwards. Then the seed is sent to seed processing plant with a threshing certificate. The personnel from the seed certification agency will be inspecting the seed processing plant to avoid mechanical mixtures and damage caused to the seed during processing.

6. Seed Sampling and Testing: The representative from seed certification agency draws a representative sample from the seed lot at the time of processing or after processing and sends the sample to official seed testing laboratory for evaluation. In the seed testing laboratory the samples will be evaluated for seed standards such as pure seed, inert matter, other crop seed, weed seeds, germination percentage and moisture percentage etc.

7. Grant of certificate, tagging and sealing: After receiving a satisfactory report from the seed testing laboratory, tagging and sealing of bags will be done under the supervision of seed certification agency. Under special circumstances, advance tags will also be issued to the extent of 75 per cent of the see d lot. Tags and seals should be in accordance with general seed certification requirements. Affixing of tags and seals on the containers completes the process of certification of seeds.

8. Validity period: The seed is initially valid for a period of nine months from the date of testing the samples. If the seed is not sold within the stipulated period, it can be revalidated for a period of six months if the seed lot meets the required seed standards. The seed can be revalidated as long as it meets the prescribed seed standards and for each revalidation the validity period will be extended for six months.

9. Revocation of certificate: If the certification agency is satisfied that the certificate granted by it has been obtained by misrepresentation of essential facts, or the holder of the certificate has failed to comply with the conditions subject to which the certificate has been issued, can revoke the certificate. The certificate can be revoked only after giving a show cause notice to the holder of the certificate.

10. Appeal against seed certification agency: If any certified seed grower is not satisfied by the decision taken by the seed certification agency (in rejecting the seed plot), he can make an appeal to the appellate authority specified by the state government. The appeal should be made within 30

days from receiving the rejection letter. The decision of the appellate authority will be final and it is binding on the seed certification agency and the seed grower.

Lecture No. 37

SEED DRYING

The process of elimination of moisture from the seed is called drying. Seed drying should reduce the seed moisture content to safe moisture limits to maintain its viability and vigour during storage, which may otherwise deteriorate quickly owing to mould growth, heating and enhanced microbial activity.

Drying of seeds is done by following methods:

1. Sun drying(Natural Drying)
2. Forced air drying (Mechanical drying)
3. Use of desiccants (Chemical) for drying

Sundrying / Natural drying

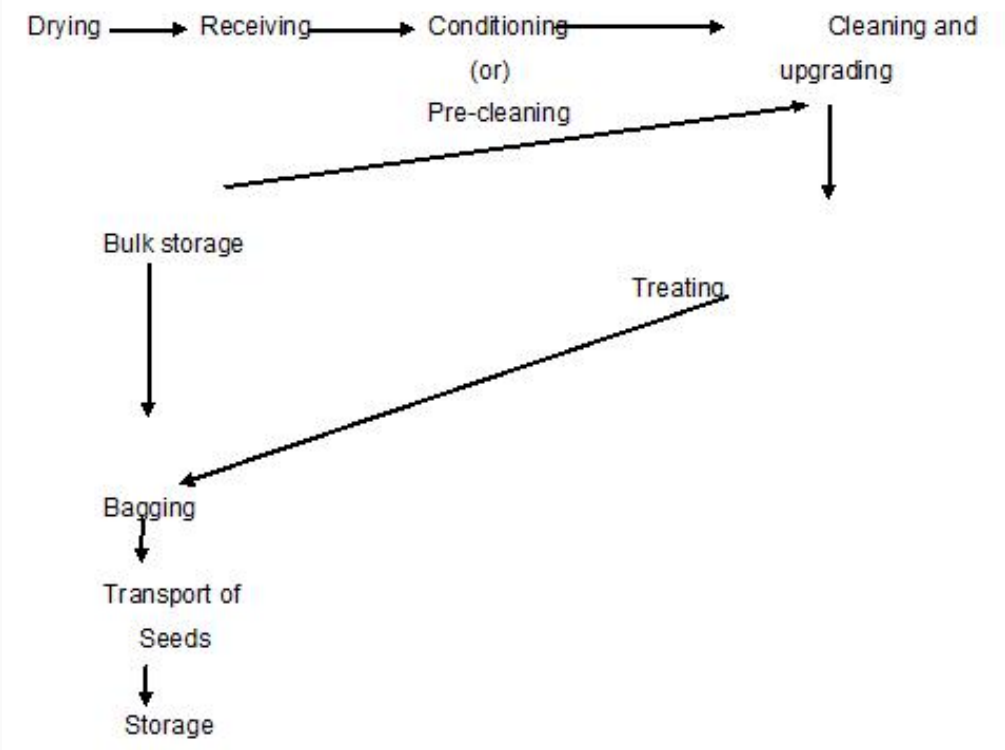
- Here the seeds are uniformly spread over clean dried yard and allowed for drying to the required moisture level.
- The seeds should not be dried under hot sun during 12.00 noon to 2.00 pm as it causes damage to seeds by UV rays.
- This method depends on weather conditions, which are unpredictable one.

Advantages

- Easy process
- Cheap method
- Requires no additional equipment
- Does not require any expenditure on electricity or fuel

Disadvantages

- More chance for mechanical admixture
- Seed loss is more while drying due to insects, birds and animals.
- Takes long time for drying.
- Uneven drying.
- High weather risk and damage due to sudden rain or heavy wind.



Equilibrium moisture content: A seed is in equilibrium with the environment when the rate of moisture loss from the seed to the surrounding atmosphere is equal to the rate of moisture gained by the seed from the atmosphere.

Drying temperature

- Greater the seed moisture content lesser should be the drying temperature and vice versa.

• 10% MC and below= 110^{o}F (43.3^{o}C)

• 10-18 % MC =100^{o}F (42.2^{o}C)

• 18-30 % MC= 90^{o}F (32.2^{o}F)

Continuous flow dryer In this type of drier, the seed moves horizontally or vertically through a stream of hot air and then into a cooling chamber. These driers are however difficult to clean when there is a change of cultivar. These driers can use air temperature higher than those of batch dries, because the seed is heated for a much shorter time. There are further two types of continuous flow dryers

i) L.S.U. dryers (Louisiana State University dryers)

ii) Non mixing column dryer:

i) L.S.U. dryers (Louisiana State University dryers)

Continuous column heated air drier largely used for paddy. The paddy seeds are fed from the top with the help of gravity force in zig zag manner and heated air is blown from the bottom usually at right angles to the direction of seed motion. The falling seeds get dried up by the heated air and this process is repeated till to get a reduction of moisture content to the expected level.

ii) Non mixing column dryer

Consist of a tall vertical column through which paddy flows by gravity. No provision is made for agitating the seed as it flows and hence there is no attempt to drive the seed from a straight path. Seed descends gradually between two parallel screens and heated air is forced through the screens.

Advantages of mechanical drying

1. Quick method, timely and uniform drying is possible
2. Makes early harvest possible
3. It reduces the chances of losses due to over ripening and shattering of seed
4. Losses due to rodents and birds are prevented.
5. Less damage during processing operation.
6. Permits long time storage by preventing sun checks and other damages.

Disadvantages

1. Initial cost of drying the equipment is high
2. Fuel is expensive
3. It produces possible fire hazards
4. Considerable supervision is necessary.

Use of seed desiccants (Chemical drying)

In this method silica gel or fused calcium chloride ($CaCl_2$) is used to absorb the moisture from the seed and its surrounding environment.

Silica gel is of two types, as

i) Indicator type

ii) Non-indicator type

Active ingredient in Silica gel is Lithium chloride, which is responsible for drying process. Silica gel can absorb moisture upto 15 per cent of its weight. So to get very low moisture content we can use this, which is not possible in mechanical driers.

Indicator type will be blue in colour and on absorbing moisture, this turns to pink colour. So we can remove this and reuse after dehydration.

Non – indicator type will be white in colour and remains same (white) even after absorption of moisture content. So there is no indication in this type. But this can also be reused after dehydration.

Calcium chloride is used for most of the vegetable and flower seeds of breeding material. Here the quantity needed is more. It can absorb 10 per cent of its weight. This method is suitable for drying small quantities of seeds only. It is a sophisticated and costlier method.

Lecture No. 38

SEED PROCESSING, CLEANING AND GRADING

The process of removal of dockage in a seed lot and preparation of seed for marketing is called seed processing. The price and quality of seed is inversely related to dockage, which should not exceed a maximum level permitted for different crops for seed certification.

Purposes of seed processing:

- To lower the cost of further processes likes storage including transport. This is achieved by reducing the bulk of the seed lot by cleaning debris and by removing empty or fractured seed (pre- cleaning)
- To increase the longevity of seeds; by drying seeds to safe moisture content and treating with protective chemicals
- To reduce the variability in vigour by invigorating the seeds and removing the low vigour seeds
- To improve the uniformity in seed shape or size by grading or by pelleting.

Types of materials removed during seed processing

1. Inert materials
2. Common weed seeds
3. Noxious weed seeds
4. Deteriorated seeds
5. Damaged seeds
6. Other crop seeds
7. Other variety seeds
8. Off-size seeds

Sequence of operations in seed processing:

- Sequences of operations are based on characteristics of seed such as shape, size, weight, length, surface structure, colour and moisture content. Because each crop seed possesses individually seed structure.
- Therefore, sequence of operation will be applied using proper equipments.
- However, sequences of operation in seed processing are drying, receiving, pre-cleaning, conditioning, cleaning, separating or upgrading, treating (Drying), weighting, bagging and storage or shipping.

Physical characteristics used to separate seeds are

1. **Size grader:** Based on size it can be separated with air screen cleaner
2. **Length:** Disc or indented cylinder separator
3. **Weight:** Specific gravity separator
4. **Shape:** Spiral separator or draper separator for round and flat seeds
5. **Surface texture:** Rough from smooth surface seed- dodder mill Receiving Conditioning & precleaning Cleaning Separating and Treating and bagging Storage Bulk storage
6. **Colour :** Electronic colour separator
7. **Electrical conductivity**: Seed differing in their ability to conduct electrical charge can be separated with electronic separator.
8. **Affinity to liquid**: The seed coat of seed will absorb water, oils etc., which provides a means of separating seed on the magnetic separator.

Seed processing equipments:

I. Air screen cleaner : This is the most important machine of every cleaning plant. It uses screens and aspiration (air blow) for two separations. A coarse upper screen removes larger material, a lower fine screen stops the seeds and lets through fine matter and then the seed fraction passes through a transverse or nearly vertical air stream which can separate light impurities such as empty or partly filled seeds, husks and glumes from the seed. In most cases a number of sieves with different sized perforations are used and the cleaning is a process of gradually shifting out smaller particles.

II. Cleaner cum grader :

III. Disc separator: It consists of a series of discs, which revolve together on a horizontal shaft inside the cylindrical body. Each disc contains many under cut pockets. The seed enter the intake end of the separator and move through the open centers of the discs towards the discharge end of machine. As the discs revolve through the seed mass the pockets lift out short seed but rejects longer seed. Longer seeds are conveyed by flights on the disc spokes towards the discharge end of the machine where they go out through the tailings gate.

IV. Indented cylinder separatr : Indent lines are there inside the surface of the cylinder. The indented cylinder revolves, turning the seed mass to give each seed a chance to fit into indent. Short seeds are lifted out of the seed mass and are dropped into the lifting and long seeds remain in the cylinder and are discharged out via. a separate spout at the end of the cylinder.

V. Specific gravity separator:

If seeds which differ in specific gravity (relative weight / unit of volume) are placed on substrate of intermediate density, seeds of higher specific gravity will fall down through the substrata, while seeds of lower specific gravity will be buoyed up the substrata. Here air is used as separation substrata.

VI. Roll mill or dodder mill or velvet roll mill

The mixture of smooth and rough seeds is fed into the place, where the rollers touch each other, at the high end of the machine. As the rollers turn up and out, seeds that are rough or have sharp or broken edges are caught by the nap of the fabric covering the rollers. These seeds are thrown up against the curved shield. They strike the shield at an angle, bounce back down to the roller and are again thrown up against the shield. Smooth seeds bounce down the inclined position forward between the rollers, and discharge at the lower end of the machine.

VII. Magnetic separator: The separation is mainly based on the affinity for liquids which is used for separation. Since seeds contains no free iron and are not attracted by a magnet they must be selectively pretreated with a magnetic material such as finely ground iron powder. Rough seed coats, cracked or broken seed coats, dirt lumps, chaff or seed with a sticky residue on the surface will hold the liquid and become sticky, so that iron powder will adhere to them. Smooth coated seeds will not absorb liquid. So no iron powder will adhere to them. The seed are then discharged from mixing chamber and brought into contact with a powerful magnet, which removes the iron coated seeds.

VIII. Colour separator: Many large crop seeds such as peas and beans differ in colour between varieties. colour variation may also occur due to immaturity or disease. Electronic colour sorting machines can separate such seeds by difference in colour and also remove mud balls and discolored seeds in the same operation.

IX. Spiral separator:

The separator, which classifies seed according to its shape and rolling ability, consists of sheet metal strips fitted around a central axis in the form of a spiral. The unit resembles an open screw conveyor standing in a vertical position. The seed is introduced at the top of the inner spiral. Round seeds roll faster down the incline than flat or irregularly shaped seeds, which tend to slide or tumble.

Seed Treatment:

Processed seeds are treated with fungicides and insecticides to protect the seed against storage pests.

Benefits or advantages of seed treatment

a) Protects the seed from seed rot and seedling blights

- *Pythium* and *Rhizoctonia* will rot the seed even before it emerges.
- Mechanical injury can be protected using fungicide coating.

b) Improves germination

- Controlling seed borne fungi.

c) Provides protection from storage pest

- 20% loss due to storage pest.

d) Controlling soil insects

- Nematodes, maggots, roots grub.

e) Addition of nutrition

- Addition of nutrients to the seeds by seed pelleting.

f) Facilitate easy sowing

- Increasing the size of seed signluation of fuzzy seeds.

g) Inoculation of bio-fertilizers / or bio-control agents

- To increase nitrogen fixation. *Trichoderma viridae* to control wilt disease in pulses.

h) To remove dormancy factors

- Removal of hard seed coat – acid heat treatments.

Types of seed treatments:

Seed disinfection

- To eliminate pathogens which have penetrated into the living cells of the seed infected it and become established, the fungicidal treatment must actually penetrate the seed.

Seed disinfestations

- Seeds are commonly contaminated on the surface by spores or other forms of pathogenic organisms without being penetrated or infected by the organisms (*i.e.*,) destruction of surface borne organism.

Seed protectants

- To protect the seed and young seedlings against the pathogenic organisms either under storage or in the soil.

Precautions in Seed Treatment

- Most products used in the treatment of seeds are harmful to humans, but they can also be harmful to seeds.
- Extreme care is required to ensure that treated seed is never used as human or animal food.
- To minimise this possibility, treated seed should be clearly labelled as being dangerous, if consumed. The temptation to use unsold treated seed for human or animal feed can be avoided if care is taken to treat only the quantity for which sales are assured.
- Care must also be taken to treat seed at the correct dosage rate; applying too much or too little material can be as damaging as never treating at all.
- Seed with very high moisture content is very susceptible to injury when treated with some of the concentrated liquid products.
- If the seeds are to be treated with bacterial cultures also, the order in which seed treatments should be done shall be as follows

1. Chemical treatments
2. Insecticide and fungicide treatments
3. Special treatments

Seed storage:

Harrington thumb rule on seed storage

The following thumb rules by Harrington are useful measures for assessing the effect of moisture and temperature on seed storage.

Factors affecting seed longevity in storage

1. Kind (or) variety of seed
2. Initial seed quality
3. Moisture content
4. Relative humidity and temperature during storage
5. Provenance
6. The activity of organisms associated with seeds in storage.

1. Kind or variety of seed

Seed storability is considerably influenced by the kind or variety of seeds. Some seeds are short lived. E.g.: Onion, Soybean and Groundnut. As a general rule starchy seeds can be stored considerably for a longer period compared to proteinaceous or oily seeds because of their hygroscopic nature.

2. Initial seed quality

Seed lots having plumpy, vigorous undamaged seeds store longer than that of deteriorated. Even seed lots having good germination at the beginning of storage period, may deteriorate at a faster rate depending upon the severity of weathering damage, mechanical injury or otherwise in the field. The low quality seeds should invariably be rejected. Even at best storage conditions, the initial quality of the seed cannot be improved (except for the dormant seed) but can only be maintained.

3. Moisture content

The most important factor influencing seed viability during storage is the moisture content and the rate of deterioration increases, as the seed moisture content increases. The drier the seed the higher will be the storage life.

Seed moisture content (%)	**Storage life**
11-13	½ year
10-12	1 year
9-11	2 years
8-10	4 years

The importance of seed moisture content in extending the shelf life of seeds under ideal storage conditions can be well known and understood from the Harrington's thumb rule

- For every decrease of 1% seed moisture content, the life of the seed doubles. This rule is applicable when moisture content between 5 and 14%.
- For every decrease of 5°C (10°F) in storage temperature the life of the seed doubles. This rule applies between 0°C to 50°C.
- Good seed storage is achieved when the % of relative humidity in storage environment and the storage temperature in degrees Fahrenheit add up to hundred but the contribution from temperature should not exceed 50°F.

4. Relative humidity and temperature during storage

Seeds are hygroscopic. They attain rather specific and characteristic moisture content when subjected to given level of atmospheric humidity at a particular temperature (equilibrium moisture content). The general prescription for seed storage is a dry and cool environment. Most kinds of seed will maintain quality for 2-3 years when stored at 600F and 50-55% relative humidity or better. For storage longer than 3 years, conditions should be 500 F and 50% relative humidity or better.

5. Provenance

The seeds harvested in different climates (or) at different times show differences in viability. Because they would have been subjected to different pre harvest conditions which will have caused different amounts of deterioration by the time, the seeds are harvested.

6. The activity of organisms associated with seeds in storage

The bacteria, fungi, mites, insects, rodents and birds may do harm to seeds in storage. The general limits of temperature and relative humidity for the multiplication of the various biological agencies infesting stored seeds are,

Organism	Temperature		Relative humidity
	Range for multiplication	Optimum range	
Insects	21-42^{o}C	27-37^{o}C	30-95%
Mites	8-31^{o}C	19-31^{o}C	60-100%
Fungi	8-80^{o}C	20-40^{o}C	60-100%
Microbes	8-80^{o}C	26-28^{o}C	91-100%

It is also interesting to note that the favourable limits of temperature and RH for germination are 16-42^{o}C and 95-100 per cent respectively.

Lecture No. 39

SEED TESTING

Seed testing is required to assess the seed quality attributes of the seed-lots which have to be offered for sale. These quality attributes are seed moisture content, germination and vigour, physical and genetic purity, freedom from seed-borne diseases and insect infestation. In India, during seed testing, moisture, germination and physical purity of seeds are generally determined.

The science of seed testing, that is, the science of evaluating the planting value of seed has been developed to achieve the following objectives for minimizing the risks of planting low quality seeds:

Objectives of Seed Testing

1. To determine their quality, that is, their suitability for planting
2. To identify seed quality problem and their probable cause
3. To determine the need for drying and processing and specific procedures that should be used.
4. To determine if seed meets established quality standards or labeling specifications.
5. To establish quality and provide a basis for price and consumer discrimination among lots in the market.

Seed Testing Laboratories

- International Seed Testing Association (ISTA), 1924, Norway
- Central seed testing Laboratory, NSRTC, Varanasi
- State seed testing Laboratory

In a seed testing laboratory, germination test, purity test, test for other seeds and moisture test are known as routine test. For all such crops where the analysis for diseased seeds or other variety seeds is also desired on the routine basis (as in the case of certified seed samples for the issuance of seed certification tags) these tests should also be included in the routine tests. These tests must be done as per rules, that is, rules mentioned in the 'Seed Testing Manual'.

Physical purity test :

Physical purity of a seed lot refers to the physical composition of the seed lots. A seed lot is composed of pure seed, inert mater, broken seeds, undersized seeds, soil and dust particles weed seeds, OCS etc. Higher the content of pure seed better would be the seed quality.

Genetic purity: Grow out test, biochemical tests and gel electrophoresis are used to identify the genetic purity of the varieties.

Moisture test: The amount of moisture in the seeds is the most important factor influencing seed viability during storage. Generally if the seed moisture content increases storage life decreases. Estimation of moisture content in the seed helps to determine the drying requirements and packing material to be used for the seed.

Seed viability and vigor : Seed viability estimates the ability of the seed in a seed lot to produce normal seedlings when sown in the field. The storability and ability of the seed to produce normal seedlings in unfavourable environmental conditions can be found out by estimating seed vigour.

Seed health testing: It gives the information about the presence or absence of disease organisms or insect pests on the seed which helps to produce healthy stand in the field by seed treatment.

Seed lot : A designated quantity of seed that is uniquely identified by a lot number.

Seed Sampling

Sampling intensity

Seed Size	**Maximum quantity per lot**
Larger than wheat and paddy	20,000 kg
Smaller than wheat and paddy	10,000 kg
Maize	40,000 kg

Sampling intensity

The intensity of sampling should be maintained in accordance to the rules described by ISTA. When seeds are stored in bags or other containers of similar capacity that are uniform in size.

a. For seed lots in bags (or container of similar capacity that are uniform in size)

up to 5 containers	**Sample each container but never < 5 Primary Sample (PS)**
6-30 containers	Sample atleast one in every 3 containers but never> than 5 Primary Sample
31-400 containers	Sample atleast one in every 5 containers but never < 10 Primary Sample Sample
401 or more	Sample atleast one in every 7 containers but never < 80 Primary Sample

When the seed is in small containers such as tins, cartons or packets a 100 kg weight is taken as the basic unit and small containers are combined to form sampling units not exceeding this weight e.g. 20 containers of 5 kg each. For sampling purpose each unit is regarded as one container.

b. For seeds in bulk

Up to - 500 kg	Atleast 5 Primary samples
501 - 3000 Kg	One primary sample for each 300 kg but not less than 5 primary samples
3001-20,000 Kg	One primary sample for each 500 kg but not less than 10 primary samples
20,001 and above	One primary sample for each 700 kg but not less than 40 primary samples

Sampling principle: Sampling is done to get a uniform and representative sample from a seed lot. Care must be taken to ensure that the sample represents the lot of the seed to be tested.

Methods of sampling

a. Hand sampling

- This is followed for sampling the non free flowing seeds or chaffy and fuzzy seeds such as cotton, tomato, grass seeds etc.,
- In this method it is very difficult to take samples from the deeper layers or bag.
- To over come this, bags are emptied completely or partly and then seed samples are taken.
- While removing the samples from the containers, care should be taken to close the fingers tightly so that no seeds escape.

b. Sampling with triers

By using appropriate triers, samples can be taken from bags or from bulk.

1. Bin samplers

Used for drawing samples from the lots stored in the bins.

2. Nobbe trier

The name was given after Fredrick Nobbe father of seed testing.

- This trier is made in different dimensions to suit various kinds of seeds.
- It has a pointed tube long enough to reach the centre of the bag with an oval slot near the pointed end.
- The length is very small.
- This is suitable for sampling seeds in bag not in bulk.

3. Sleeve type triers or stick triers

It is the most commonly used trier for sampling: There are two types viz.,

1. With compartments 2. Without compartments.

- It consists of a hollow brass tube inside with a closely fitting outer sleeve or jacket which has a solid pointed end. Both the inner tube as well as the outer tube has been provided with openings or slots on their walls. When the inner tube is turned, the slots in the tube and the sleeve are in line. The inner tube may or may not have partitions.
- This trier may be used horizontally or vertically. This is diagonally inserted at an angle of 30^0 in the closed position till it reaches the centre of the bag. Then the slots are opened by giving a half turn in clockwise direction and gently agitated with inward push and jerk, so that the seeds will fill each compartment through the openings from different layers of the bag, then it is again closed and withdrawn and emptied in a plastic bucket. This trier is used for drawing seed samples from the seed lots packed in bags or in containers.

Types of Samples:

1. Primary sample

- Each probe or handful of sample taken either in bag or in bulk is called primary sample.

2. Composite sample

- All the primary samples drawn are combined together in suitable container to form a composite sample.

3. Submitted sample

- When the composite sample is properly reduced to the required size that to be submitted to the seed testing lab, it is called submitted sample.
- Submitted sample of requisite weight or more is obtained by repeated halving or by abstracting and subsequently combining small random portions.

4. Working sample

- It is the reduced sample required weight obtained from the submitted sample on which the quantity tests are conducted in seed testing lab.

Types of sample used in Seed Testing Laboratory (STL)

- **Service sample:** Sample received from other than seed certification agencies and seed inspectors
- **Certified sample:** Sample received from certification agencies or officers.
- **Official sample:** Sample received from the seed inspectors.

Mixing and dividing of seeds

- The main objective of mixing and dividing of seeds is to obtain the representative homogenous seed sample for analysis by reducing the submitted sample to the desired size of working sample.

Method of mixing and dividing

1. Mechanical dividing
2. Random cups method
3. Modified halving method
4. Spoon method
5. Hand halving method

1. Mechanical method

The reduction of sample size is carried out by the mechanical dividers suitable for all seeds except for chaffy and fuzzy seeds.

Objective of mechanical dividing

- To mix the seed sample and make homogenous as far as possible
- To reduce the seed sample to the required size without any bias

Types of mechanical dividers

a. Boerner divider

It consists of a hopper, a cone and series of baffles directing the seeds into 2 spouts. The baffles are of equal size and equally spaced and every alternate one leading to one spout. They are arranged in circle and are directed inward. A valve at the base of the hopper retains the seeds in the hopper. When the valve is opened the seeds fall by gravity over the cone where it is

equally distributed and approximately equal quantity of seeds will be collected in each spout. A disadvantage of this divider is that it is difficult to check for cleanliness.

b. Soil divider

It is a sample divider built on the same principles as the Boerner divider. Here the channels are arranged in a straight row. It consists of a hopper with attached channels, a frame work to hold the hopper, two receiving pans and a pouring pan. It is suitable for large seeds and chaffy seeds.

c. Centrifugal or Gamet Divider

The principle involved is the centrifugal force which is used for mixing and dividing the seeds. The seeds fall on a shallow rubber spinner which on rotation by an electric motor, throw out the seeds by centrifugal force. The circle or the area where the seeds fall is equally divided into two parts.

2. Random cup method

This is the method suitable for seeds requiring working sample upto 10 grams provided that they are not extremely chaffy and do not bounce or roll (e.g.) Brassica spp.

Six to eight small cups are placed at random on a tray. After a preliminary mixing the seed is poured uniformly over the tray. The seeds that fall into the cup is taken as the working sample.

3. Modified halving method

The apparatus consists of a tray into which is fitted a grid of equal sized cubical cups open at the top and every alternate are having no bottom. After preliminary mixing the seed is pouted evenly over the grid. When the grid is lifted approximately half the sample remains on the tray. The submitted sample is successively halved in this method until a working sample size is obtained.

4. Spoon method

This is suitable for samples of single small seeded species. A tray, spatula and a spoon with a straight edge are required. After preliminary mixing the seed is poured evenly over the tray. The tray should not be shacked there after. With the spoon in one hand, the spatula in the

other and using both small portions of seed from not less than 5 random places on the tray should be removed. Sufficient portions of seed are taken to estimate a working sample of approximately but not less than the required size.

5. Hand halving method

This method is restricted to the chaffy seeds. The seed is poured evenly on to a smooth clean surface and thoroughly mixed into a mound. The mound is then divided into 1/2 and each half is mound again and halved to 4 portions. Each of the 4 portions is halved again giving 8 portions. The halved portions are arranged in rows and alternate portions are combined and retained. The process is repeated until the sample of required weight is obtained.

Genetic purity testing

Different Morphological Methods

1. Seed morphology
2. Examination of seedlings
3. Examination in green houses
4. Grow out test

Morphological test in laboratory examine features of seeds such as length, width, thickness, shape, weight, colour, seed coat colour etc. and comparing them with those of authentic sample. These are examined with naked eye / with magnified hand lens / with the help of scanning electron microscope.

Physiological test: the seedlings which are germinated are observed for deviation in seedling characteristics.

Fluorescence tests: Fluorescence tests Under UV & near UV light, seeds, parts of seedlings or secretion from seedling reflect particular colour light, in others this phenomenon doesn't occur.

eg: Oat yellow oat absorbs UV light but seeds of white seeded var fluoresce clearly in UV light.

Seedling pigmentation: Seed samples grown for evaluation of anthocyanin or purple pigment development in hypocotyls, coleoptiles or shoots should be grown in inert sand. eg. Sunflower and maize.

Grow out test

Standard and recommended agronomic / cultural practices such as field preparation, size of the plot, row length, distance between the rows, distance between the plants, irrigation and fertilization, etc., in respect of the specific crop shall be followed both for the sample in question and its control (standard sample).Grow-out test plots must be examined throughout the growing season with emphasis on the period from the flowering to ripening. All plants must be examined keeping in view the distinguishing characters described for the cultivars both in the test crop as well as the control.

While taking the observation, the plants showing deviations in characters against the control should be tagged and examined carefully at a later stage to confirm whether they are off-types or not. The number of the total plants and the off-type plants found should be recorded.

Chemical tests for varietal identification

a. Phenol test

The Standardized phenol test is widely used for varietal purity testing in crops like paddy and wheat. Seed should be soaked in water for 16 h under ambient condition and then 50 seeds are placed in 15 cm petridishes with two layers of filter soaked in 1% phenol solution. The petridishes should be immediately covered and make the observation after 6 h.

b. Sodium Hydroxide (NaOH) test

This test is commonly used for identification of red and white rice varieties. Seed is soaked in 5 % NaOH for one hour. Both red and white rice varieties turn to bright yellow colour first then after 15 minutes red rice cultivars turn to orange colour and the intensity of colour increases with time. Yellow colour of the white rice varieties gradually disappears with time.

c. Peroxidase test :

Seed coats of some soybean var contain a high or low activity peroxidase enzyme. This difference in enzyme activity is used to distinguish between varieties. Remove seed coats and place in separate test tubes Add 0.5-1.0 ml of 0.5% guaiacol & wait 10 min. Then add 0.1 ml of 0.1% H_2O_2 solution to each tube. If solution turns dark reddish brown then it indicates positive reaction & If solution remains clear indicates negative reaction.

d. Electrophoresis:

It is the latest method of cultivar identification based on protein banding and isoenzyme activity. Here single seeds are defatted and extracted for protein and esterases. The extracted proteins or esterases are separated by polyacrylamide gel electrophoresis.

Seed viability/ Germ ability: A viable seed is one which is capable of germination under suitable conditions. The definition includes dormant but viable seeds, in which case the dormancy must be broken before viability can be measured by germination.

Seed have traditionally been grouped into two main groups according to their physiological storage potentials viz recalcitrant and orthodox seed.

Orthodox seed: Seeds which can be dry to low (2-5%) mc successfully stored at low or sub freezing temperature for a long period. Viability is prolonged in a predictable manner by such moisture reduction and reduction in storage temperature.

Recalcitrant seed: This include a number of large seed that cannot with stand appreciable drying without injuring, they maintain high mc at maturity (often >30-50%) and are sensitive to desiccation below 12-30%, depending on species. They have a short storage potentials and rapidly lose viability under any kind of storage conditions.

Based on storability the crops are divided into following groups

Good crops	Paddy
Medium Crops	Cotton, Wheat, Jowar
Poor Crops	Soybean, Groundnut

Viability of the seed can be tested by two major methods i.e., Germination test and tetrazolium test.

Germination test: The main aim of a laboratory germination test is to estimate the maximum number of seeds which can germinate in optimum conditions. The use of standardized ideal conditions in the laboratory such as those prescribed by ISTA ensures that results obtained from a given seed lot in one laboratory should be identical with those obtained from any other laboratory in the same or in other countries. On the other hand, it is clear that results obtained under ideal controlled conditions in the laboratory are not directly applicable in the field nursery, where only limited control over environmental conditions is possible.

Tetrazolium (Tz) test: Tetrazolium is a rapid test to estimate seed viability and vigour based on color alterations of seed's living tissues in contact with a solution of 2,3,5 triphenyl tetrazolium chloride, thus, reflecting the degree of activity of the dehydrogenase enzyme system closely related to seed respiration and viability.

Membrane permeability test, lipid peroxidation test, Automatic seed analysis and alpha tocopherol test can also be used to assess the seed quality in storage.

Lecture No. 40

SEED VIGOUR TESTING

Seed vigour is the sum total of all those properties that determine the activity and performance of seed lots having acceptable germination in a wide range of environments' (ISTA). When the growing conditions are optimal, every viable seed could germinate except the hard or dormant one, but if the conditions are stressed and some seeds could still perform better than the rest, we need to address the concept of seed vigour.

Vigor testing does not only measure the percentage of viable seed in a sample, it also reflects the ability of those seeds to produce normal seedlings under less than optimum or adverse growing conditions similar to those which may occur in the field.

Types of seed vigour tests

1. Physical tests
2. Growth tests
3. Stress tests
4. Biochemical tests

1. Physical tests

These tests are inexpensive, quick, can be applied to large number of samples, and are positively correlated with seed vigour.

a) Seed Size and Mass:

Physical tests determine seed characteristics such as size and mass. The main feature of seed development is accumulation of nutritive materials, which is also in direct correlation with vigour, *i.e.*, with size and mass of seed.

b) Physical Soundness: Seed colour and appearance also indicates the vigour of seed

c) X- Ray test

X-radiography is a quick test to differentiate empty, under-developed, insect or physically damaged seeds from morphologically intact and healthy seeds by the aid of X-rays.

2. Growth tests:

The basic principle behind these tests is that seeds with high vigour grow at a faster rate as compared to seeds having poor vigour potential. This difference in growth can be easily observed even under favourable conditions.

a) First count: The test is done along with the regular standard germination test. Number of normal seedlings emerged on the first count day are counted. The number of normal seedlings gives an idea of the seed vigour potential in the seed lots. Higher the number of normal seedlings, greater is the seed vigour.

b) Speed of germination: Number of seedlings emerging daily are counted from day of planting the seeds in the medium till the time germination is complete. Thereafter a germination index (G.I.) is computed by using the following formula:

$$\mathbf{G.\ I = n/d}$$

where, n =number of seedlings emerging on day 'd' d = day after planting. The seed lot having greater germination index is considered to be more vigorous.

c) Seedling length and dry weight: The seedlings are grown either in laboratory, green house or field. In laboratory, 'between paper' method should be followed. After a specified period of time (according to reference crop), length of emerged seedlings is measured and mean seedling length is calculated. Seed lots producing the longer seedlings are considered more vigorous. For dry weight determination, the seedlings are taken and dried in an air oven at 100°C temperature for 24 hours.

d) Seedling vigour indices: These indices are given by Abdul-Baki and Anderson in 1973. These are derived from standard germination and seedling growth parameters i.e. length and dry weight as per the following formulae: i) Vigour Index-I = Standard germination (%) × Average seedling length (cm) ii) Vigour Index-II = Standard germination (%) × Average seedling dry weight (mg or g)

3. Stress Tests

a) Cold Test (CT):

The cold test simulates early spring field conditions by germinating the seeds in wet soils (»70% water holding capacity) and incubating them at 5-10°C/41-51°F for a specified period. At the end of the cold period, the test is transferred to a favorable temperature for germination (e.g., 25°C/77°F in case of sweet corn). The percentage of normal seedlings is considered as an indication of seed vigor. Vigorous seeds germinate better under cold environments.

b) Accelerated Aging Test (AAT) :

The principle of this test is to stress seeds with high temperatures of (40-45°C/130-139°F) and near 100% relative humidity (RH) for varying lengths of time, depending on the kind of

seeds, after which a germination test is made. High vigor seeds are expected to tolerate high temperatures and humidity and retain their capability to produce normal seedlings in the germination test.

c) Hiltner test (Brick gravel test):

The sand is sieved, moistured and filled in the germination box leaving about 3 cm empty at the top. One hundred seeds are 'placed in each box in the impressions made by a sand marker. After this 2-2.5 cm of porous brick gravel is spread over the seeds. The box is kept in the germinator at appropriate temperature. After the period required for germination, the box is removed and the seedlings which have emerged through the brick gravel layer are counted. The percentage of emerged seedlings are used to compare seed vigour of different lots.

d) Paper piercing test :

The principle of paper piercing test is similar to that of brick gravel test. High vigour seed lots are expected to produce strong seedlings which can pierce a particular type of paper while seedlings of poor vigour lots may not be able to pierce the paper.

4. Biochemical Tests

a) Tetrazolium (Tz) test:

Tetrazolium is a rapid test to estimate seed viability and vigour based on color alterations of seed's living tissues in contact with a solution of 2,3,5 triphenyl tetrazolium chloride, thus, reflecting the degree of activity of the dehydrogenase enzyme system closely related to seed respiration and viability. Usually, this test is considered as a viability test but its results can also be interpreted to estimate the vigour of the seed. Vigorous seeds show dark stains as compared to seeds having poor vigour.

b. GADA (Glutamic acid decarboxylase activity):

Seed proteins are hydrolyzed into amino acids during germination. Glutamic acid comprises a high percentage of the total amino acids in seeds. Amino acid decarloxylases catalyze the removal of CO_2. As seeds age in storage, a decrease in GADA can be detected before germination is affected.

c. ATP test:

ATP is the energy for biochemical reactions in living cells. ATP production is measured using a photometer or a liquid scintillation counter. Requires specialized equipment and personnel.

d. Electrical Conductivity test:

Weakening of cell membrane in low vigour seeds causes the leakage of water soluble solutes like sugars, amino acids, electrolytes etc. when immersed in distilled water. EC is negatively correlated with the quality of seeds. The reading is expressed as desi Siemens or micro Siemens/cm/g of seed. Lower the value of EC, greater is the seed vigour.

e. Respiration Quotient:

The ratio of the volume of carbon dioxide evolved to that of oxygen consumed by a seed in a given time is called as RQ. Positive correlation between rate of oxygen uptake and seedling growth

Lecture No. 41

SEED DORMANCY

Dormancy refers to lack of growth due to any external or internal cause. Seed dormancy refers to failure of a viable seed to germinate even when given favourable environmental conditions.

Types of dormancy: Different types of dormancy include

1. Exogenous Dormancy: This type of dormancy is imposed by factors outside the embryo. In exogenous dormancy, the tissues enclosing the embryo can affect germination by inhibiting water uptake, providing mechanical resistance to embryo expansion and radicle emergence, modifying gaseous exchange (limit oxygen to embryo), preventing leaching of inhibitor from the embryo and supplying inhibitor to the embryo.

It is of three types:

a) Physical dormancy (seed coat dormancy): Seed coat or seed covering may become hard, fibrous or mucilaginous (adhesives gum) during dehydration and ripening as a result they become impermeable to water and gases, which prevents the physiological processes initiating germination In various plant families, such as, Leguminosae, the outer seed coat gets hardened and becomes suberized and impervious to water.

b) Mechanical dormancy: In some fruits seed covering restricts radicle growth, resulting in dormancy of seeds. Some seed covering structures, such as shells of walnut, pits of stone fruits and stones of olive are too strong to allow the dormant embryo to expand during germination. Germination in such seeds does not occur until and unless the seed coats are softened either by creating moist and warm conditions during storage or by microbial activity.

c) Chemical dormancy: In seeds of some fruits chemicals that accumulate in fruit and seed covering tissues during development and remain with the seed after harvest. Some of the substances associated with inhibition are various phenols, coumarin and abscisic acid. These substances can strongly inhibit seed germination.

2. Endogenous dormancy: This type of dormancy is imposed by rudimentary or undeveloped embryo at the time of ripening or maturity. This can be of different types such as morphological, physiological, double dormancy and secondary dormancy.

a. Morphological dormancy (Rudimentary and linear embryo): Dormancy occurs in some seeds in which the embryo is not fully developed at the time of seed dissemination. Such seeds do

not germinate, if planted immediately after harvesting. Formation of rudimentary embryo is common in various plant families such as Ranunculaceae (Ranunculus), Papavaraceae (poppy).

b. Physiological dormancy

i) Non-deep physiological dormancy: After ripening time is required for seeds in dry storage to lose dormancy. This type of dormancy is often transitory and disappears during dry storage. Temperate fruits such as apple, pear, cherry, peach, plum and apricot, cultivated cereals, vegetables and flower crops, have this type of physiological dormancy which may last for one to six months and disappears with dry storage.

ii) Photo dormancy: Seeds that either require light or dark condition to germinate are termed as photo-dormant seeds. It is due to photo-chemically reactive pigment called phytochrome widely present in some plants.

iii) Thermo dormancy: Some seeds have specific temperature requirement for their germination, otherwise they remain dormant. Such seeds are called as thermo dormant .For example seeds of lettuce, celery and pansy do not germinate if the temperature is below 25^{o}C.

C. Double dormancy: In some species, seeds have dormancy due to hard seed coats and dormant embryos. For instance, some tree legumes seed coats are impervious and at the same time their embryo are also dormant. Such seeds require two years for breaking of dormancy in nature. In the first spring, the microorganisms act upon the seed making it weak and soft and then embryo dormancy is broken by chilling temperature in the winter next year. Combination of two or more types of dormancy is known as „double dormancy". It can be morpho-physiological i.e. combination of under developed embryo and physiological dormancy or exo-endodormancy i.e. combination of exogenous and endogenous dormancy conditions i.e. hard seed coat (physical plus intermediate physiological dormancy).

D. Secondary dormancy it is due to germination conditions. It is a further adaptation to prevent germination of an imbibed seed if other environmental conditions are not favorable. These conditions can include unfavorably high or low temperature, prolonged darkness and water stress. It is of two types:

I) Thermo dormancy: High temperature induced dormancy.

II) Conditional dormancy: Change in ability to germinate related to time of the year.

Advantages

1. Permitting germination only when environmental conditions favour seedling survival as in fruit plants of temperate region.
2. Helpful in creation of a "seed bank"
3. Dormancy can also synchronize germination to a particular time of the year.
4. Seed disposal can be facilitated by specialized dormancy conditions. For example modification of seed covering through digestive tract of a bird or other animals.

Methods of breaking seed dormancy

1. Softening seed coat and other seed coverings: This helps in better absorption of water and gases, which ultimately leads to better germination of the seeds. This can be achieved by scarification.

a) Scarification: Scarification is the process of breaking, scratching, mechanically altering or softening the seed covering to make it permeable to water and gases. Three types of treatments are commonly used as scarification treatments. These include mechanical, chemical and hot water treatments.

i) Mechanical scarification : It is simple and effective if suitable equipment is available. Chipping hard seed coat by rubbing with sand paper, cutting with a file or cracking with a hammer are simple methods useful for small amount of relatively large seeds. For large scale, mechanical scarifiers are used. Seeds can be tumbled in drums lined with sand paper or in concrete mixers containing coarse sand or gravel. The sand gravel should be of a different size than the seed to facilitate subsequent separation. Scarification should not proceed to the point at which the seeds are injured and inner parts of seed are exposed.

ii) Acid scarification: Dry seeds are placed in containers and covered with concentrated Sulphuric acid (H_2SO_4) or HCl in the ratio of one part of seed to two parts of acid. The mixture should be stirred cautiously at intervals during the treatment to produce uniform results. The time may vary from 10 minutes to 6 hours depending upon the species.

Large seeds of most legume species, brinjal and tomatoes are reported to respond simple sulphuric acid treatment.

iii) Hot water scarification Drop the seeds into 4-5 times their volume of hot water with temperature ranging from 77 to 100^{o}C. The seed should be sown immediately after hot water treatment.

iv) Warm moist scarification: The seeds are placed in moist warm medium for many months to soften the seed coat and other seed coverings through microbial activity. This treatment is highly beneficial in seeds having double seed dormancy.

b. Stratification:

Stratification is a method of handling dormant seed in which the imbibed seeds are subjected to a period of chilling to after ripen the embryo in alternate layers of sand or soil for a specific period. It is also known as moist chilling.

c. Leaching of inhibitors: Soaking of seeds in the running water for 12-24 hours or placing them in water for few hours help in leaching off the inhibitors and phenolic compounds, which help in easy seed germination.

d. Pre-drying: This is also a useful practice in some seeds to overcome seed dormancy. In this treatment, the dry seeds are subjected to a temperature of 37-40^{0}C for 5-7 days prior to sowing. After this, seed can be sown in the field.

e. Treatment with chemicals: Some compounds other than hormones are also used to break dormancy but their role is not clear. Thiourea is one example known to stimulate germination in some kinds of dormant seeds. The seeds are soaked in 0.5 – 3 per cent solution of thiourea for 3-5 minutes. Similarly, potassium nitrate and sodium hypochlorite also stimulate seed germination in many plant species.

f. Hormonal treatment: Among various hormones, GA3 is commercially used for breaking seed. Dormancy in different types of seeds. The concentration of GA3 depends upon the kind of seed but generally a concentration of 200-500 ppm is most widely used. Cytokinin is another group of hormones used for breaking physiological dormancy and stimulating germination in seeds of many species. Kinetin and BA (6-benzyle aminopurine) are commercial preparations of cytokinin used for breaking seed dormancy. Soaking seeds in 100 ppm solution of kinetin for 3-5 minutes is highly effective concentration for overcoming seed dormancy of many species.

Lecture No. 42

SEED HEALTH

Health of seed refers primarily to the presence or absence of disease causing organisms, such as fungi, bacteria and viruses and animal pests, including nematodes and insects, but physiological conditions such as trace element deficiency may be involved.

The object of seed pathology testing is to determine the health of the seed lot for use in planting. Plant diseases are known to greatly reduce yield. Not all plant diseases are contained in or on seed but it is important to know if you have one or more that is. Seed may contain plant pathogens or agents that cause disease in plants. These diseases may affect storage, vigour, germination, market availability, harvest yield, seed appearance, or contain toxins.

Factors that affect seed health are

1. Management of crop
2. Harvesting, threshing and processing
3. Unfavorable conditions for seed storage

(i) Dry Seed Examination:

Inspection of dry seed can be applied to detect seed- borne pathogen which when present in the seed may cause discoloration of seed coat or changes in the seed size and shape. The seed sample is first examined by naked eyes, then under stereoscopic binocular microscope to record observation on the mixture of seeds, weed seeds, plant parts, inert matter, discoloration, malformations, sclerotia, galls, bunt balls, bacterial ooze, fungal bodies like, acervuli, Pycnidia, Perithecia, hyphae, spore masses etc. Mechanical damage of seed is also recorded as they act suitable site for the entry of pathogen.

All parts of a seed sample are examined carefully by naked eye or with the help of hand lens. During the examination, emphasis is laid on galls, sclerotia and smut balls; the technique is simple and gives quick information about the health status of the seed lot.

ii) Washing Test:

The washing test is a seed health testing method which is used solely to test seeds for externally seed borne pathogens, the inoculum of which is present loosely on the seed surface.

The washing test is a qualitative test for which no standard working sample has been approved so far by the ISTA. The washing test as mentioned here is generally used to detect presence or absence of fungal prop gules.

2. Incubation Method:

In this method the seeds are examined after incubating them on some suitable media or substrata.

(i) Standard Blotter Method:

The blotter method was developed by Doyer in 1938 which was later included in the International seed Testing Association (ISTA) rules of 1966.

The blotter method is widely used for detecting fungi which are able to produce mycelial growth and fruiting structures under the incubation conditions available in the test. All kinds of seeds, cereals, vegetables, legumes, ornamentals and forest seeds are test by this method.

It is the most widely practiced seed health testing method. Many laboratories use it as the first screening test for seed health testing method. Obligate parasites can't be observed by this method.

(ii) Rolled Paper Towel Method:

The seeds are placed on moist paper towel and covered with another moist paper towel and rolled carefully. The rolled paper towels containing seeds are incubated in dark at suitable temperature for a fixed period of time. The seeds are examined after incubation for the presence of micro-organisms and germination. (This method is used for the detection of Fusarium spp. in cereals and Ascochyta diseases in pea).

(iii) 2, 4-D Method:

The use of 2, 4-D in the blotter test was first introduced by Neergaard (1973) while testing cabbage seeds for Phoma lingam, although Hagborg (1950) first used it in agar medium for the detection of colletotrichum lindemuthianum on bean seeds. However, it gives a lower count as compared to standard blotter.

(iv) Deep Freeze Method:

This method is used for seed health investigation. The seeds are plated as in blotter method and incubated for 24 hours under usual conditions. Seeds are placed on blotters moistened with a solution containing 0.1% (100 pg/ml) streptomycin sulfate or terramycin, incubated for three days at 10±1°C then frozen at -20°C over night and further incubated for 5-7 days at the required temperature (20-25°C). This allows better growth of certain fungi as the imbibed seeds

on moist blotters are killed by deep freezing and the enclosed nutrients in seeds are utilized by fungi. Deep freezing does not affect the fungi associated with the seed.

(v) Agar Plate Method:

This method is used for identification and detection of microorganisms associated with seed based on the growth and colony characteristics on a nutrient agar. In Northern Ireland Muskett and Malone (1941) first time used this method for seed health testing of flax seeds. Most commonly used media are Potato dextrose agar and Czeapak's dox agar.

(vi) Seedling Symptoms Test:

The seeds are sown in autoclaved soil, sand, gravel or similar material under standard conditions of temperature and moisture. The infected seeds rot and seedlings exhibit symptoms as in field. This procedure helps to see the field performance of the seed lot in relation to seed borne seedling diseases.

Lecture No. 43

SEED PACKAGING

Seed packaging is the process of filling, weighing and sewing of bags with seed. An ideal storage facility should satisfy the following requirements

1. It should provide maximum possible protection from ground moisture, rain, insect pests, moulds, rodents, birds, fore etc.,
2. It should provide the necessary facility for inspection, disinfection, loading, unloading, cleaning and reconditioning.
3. It should protect grain from excessive moisture and temperature favourable to both insect and mould development,
4. It should be economical and suitable for a particular situation

The factors to be considered while selecting the packaging materials are,

1. Kind of seeds to be packed.
2. Quantity of seed
3. Value of seed
4. Cost of packaging material
5. Storage environment in which the packed materials will be held
6. Period of storage
7. Transport of seed

Classification of packaging materials or containers used for bag storage

1. Moisture and vapour pervious containers

- These containers allow entry of water in the form of vapour and liquid.
- These are suited for short term storage.
- The seeds in these containers will attain seed equilibrium moisture with the surrounding atmosphere eg., cloth bags, gunny bags etc.

2. Moisture impervious but vapour pervious containers

- These allow entry of water in the form of vapour and not in liquid.
- The seeds in these containers can’t be carried over for long period in hot humid conditions.

- eg., polythene bags of < 300 gauge thickness and urea bags.

3. Moisture and vapour proof containers

- These containers will not allow entry of moisture in the form of liquid or vapour.
- These are used for long term storage even in hot humid conditions if the seeds are sealed at optimum moisture content eg., polythene bags of > 700 gauge thickness, aluminium foil pouches, rigid plastics etc.

Equipment used for packaging

1. Bagging

Bagger- Weigher: Seed weighing is used for accurate and fast weighing of all kind of seeds. Manual, semi automatic and automatic kinds of machines are available in the market.

Bag sewing Machine

These sewing systems are used for closing bags after filling them with seeds. Mainly used for bags with a larger quantity of seeds (5-25 kg.)

2. Handling: Conveyers are used for conveying the seed from one place to another place in the processing unit.

Lecture No. 44

SEED ACT, 1966

Inorder to ensure the availability of quality seeds, Government of India have enacted Seeds act, 1966 and Seed rules, 1968. The seed (Control) order, 1983 was promulgated under essential commodities act, 1955 in order to ensure the production, marketing and equal distribution of the seeds.

Seeds Act, 1966

The object of Seed Act is to regulate the quality of certain notified kind /varieties of seeds for sale and for matters connected therewith. The seed act passed by the Indian Parliament in 1966 was designed to create a 'Climate' in which the seeds man could operate effectively and to make good quality seed available to cultivators. Seeds rule under the act were notified in September 1968 and the act was implemented entirely in October, 1969. Seed legislation could broadly be divided into two groups

1. Sanctioning legislation

Sanctioning legislation authorizes formation of Advisory bodies, Seed Certification Agencies, Seed Testing laboratories, Foundation and Certified Seed Programmes, Recognition of Seed certification Agencies of Foreign countries Appellate authorities etc.

2. Regulatory legislation

Regulatory Legislation controls the quality of seeds sold in the market including suitable agencies for regulating the seed quality.

Statutory Bodies and Agencies Established in India Under the seeds Act, 1966

1. **Central Seed Committee:** The Central Seed Committee set up under the Act is the main source of advice to the Central Government on the administration of the Act, and any other matter related to seeds.
2. **Central Seed Certification Board:** Deal with all problems related to seed certification and to co-ordinate the work of State Seed Certification Agencies.
3. **State Seed Certification Agencies:** The Act provides for the establishment of State Seed Certification Agencies by notification in the official Gazette of State Government /Central Government in consultation with the State Government. On recommendation of the Central Seed Committee these agencies have been established in the form of societies having a governing body and an executive wing.

4. **Central Seed Testing Laboratory:** The Seed Testing Laboratory at the Indian Agricultural Research Institute, New Delhi, has been notified as the Central Seed Testing Laboratory. Act as referee laboratory in testing seed samples for achieving uniformity in seed testing. The State Seed Testing Laboratories are required to send five percent samples to the Central Seed Testing Laboratory along with their analysis results.
5. **State Seed Testing Laboratories:** The function of the State Seed Testing Laboratory is to carry out the seed analysis work of the State in a prescribed manner.
6. **Appellate Authority:** The Act envisages appointment of an appellate authority /authorities through an official notification in the Gazette by the State Governments to look into the grievances of certified seed producers against a seed certification agency; and that of seed traders against seed law enforcement officials.
7. **Recognition of seed certification agencies of foreign countries:** The Central Government, on the recommendation of the Central Seed Committee and by notification in the official Gazette, may recognize any seed certification agency established in any foreign country, for the purpose of the Indian Seeds Act, 1966.

GATT (General Agreement on Trade and Tariffs)

The setting up of International body-the World Trade Organization (WTO) in January 1995 – was to restructure international institutions in the areas of finance, trade and economic stability. India was one of the 136 member countries and signatories to the Agreement which altered the whole framework of international trade which has existed under the earlier General Agreement on Trade and Tariffs (GATT). Three-fourths of the member countries are developing countries, and together, they account for over 90% of world trade.

Lecture No. 45

PROTECTION OF PLANT VARIETIES AND FARMERS' RIGHTS (PPV&FR) ACT, 2001

In order to provide for the establishment of an effective system for the protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants it has been considered necessary to recognize and to protect the rights of the farmers in respect of their contributions made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties. The Govt. of India enacted "The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001" adopting sui generis system. Indian legislation is not only in conformity with International Union for the Protection of New Varieties of Plants (UPOV), 1978, but also have sufficient provisions to protect the interests of public sector breeding institutions and the farmers. The legislation recognizes the contributions of both commercial plant breeders and farmers in plant breeding activity and also provides to implement TRIPs in a way that supports the specific socio-economic interests of all the stakeholders including private, public sectors and research institutions, as well as resource-constrained farmers.

Objectives of the PPV & FR Act, 2001

1. To establish an effective system for the protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants.
2. To recognize and protect the rights of farmers in respect of their contributions made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties.
3. To accelerate agricultural development in the country, protect plant breeders' rights; stimulate investment for research and development both in public & private sector for the development new of plant varieties.
4. Facilitate the growth of seed industry in the country which will ensure the availability of high quality seeds and planting material to the farmers.

Rights under the Act

1. **Breeders' Rights:** Breeders will have exclusive rights to produce, sell, market, distribute, import or export the protected variety. Breeder can appoint agent/ licensee and may exercise for civil remedy in case of infringement of rights.

2. **Researchers' Rights:** Researcher can use any of the registered variety under the Act for conducting experiment or research. This includes the use of a variety as an initial source of variety for the purpose of developing another variety but repeated use needs prior permission of the registered breeder.
3. **Farmers' Rights**
    - A farmer who has evolved or developed a new variety is entitled for registration and protection in like manner as a breeder of a variety;
    - Farmers variety can also be registered as an extant variety;
    - A farmer can save, use, sow, re-sow, exchange, share or sell his farm produce including seed of a variety protected under the PPV&FR Act, 2001 in the same manner as he was entitled before the coming into force of this Act provided farmer shall not be entitled to sell branded seed of a variety protected under the PPV&FR Act, 2001;
    - Farmers are eligible for recognition and rewards for the conservation of Plant Genetic Resources of land races and wild relatives of economic plants;
    - There is also a provision for compensation to the farmers for non-performance of variety under Section 39 (2) of the Act, 2001 and
    - Farmer shall not be liable to pay any fee in any proceeding before the Authority or Registrar or the Tribunal or the High Court under the Act.

Implementation of the Act

To implement the provisions of the Act the Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare established the Protection of Plant Varieties and Farmers' Rights Authority on 11" November, 2005. The Chairperson is the Chief Executive of the Authority. Besides the Chairperson, the Authority has 15 members, as notified by the Government of India (GOI). Eight of them are ex-officio members representing various Departments/ Ministries, three from SAUs and the State Governments, one representative each for farmers, tribal organization, seed industry and women organization associated with agricultural activities are nominated by the Central Government. The Registrar General is the ex-officio Member Secretary of the Authority.

General Functions of the Authority

1. Registration of new plant varieties, essentially derived varieties (EDV), extant varieties;
2. Developing DUS (Distinctiveness, Uniformity and Stability) test guidelines for new plant species;
3. Developing characterization and documentation of varieties registered;
4. Compulsory cataloging facilities for all variety of plants;
5. Documentation, indexing and cataloguing of farmers' varieties;
6. Recognizing and rewarding farmers, community of farmers, particularly tribal and rural community engaged in conservation and improvement;
7. Preservation of plant genetic resources of economic plants and their wild relatives;
8. Maintenance of the National Register of Plant Varieties and
9. Maintenance of National Gene Bank.

Registration of varieties

A variety is eligible for registration under the Act if it essentially fulfills the criteria of Distinctiveness, Uniformity and Stability (DUS). The Central Government issues notification in official Gazettes specifying the genera and species for the purpose of registration of varieties. So far, the Central Government has notified 157 crop species for the purpose of registration.

Distinctiveness: A newly bred variety should differ from existing varieties within the same species

Uniformity: The characteristics used to establish Distinctness are expressed uniformly

Stability: These characteristics do not change over subsequent generations

Certificate of Registration

The certificate of registration issued will be valid for nine years in case of trees and vines and six years in case of other crops. It may be reviewed and renewed for the remaining period on payment of renewal fees subject to the condition that total period of validity shall not exceed eighteen years in case of trees and vines from the date of registration of the variety, fifteen years from the date of notification of variety under the Seeds Act, 1966 and in other cases fifteen years from the date of registration of the variety.

Benefit Sharing

The benefit sharing is one of the most important ingredients of the farmers' rights. Section 26 provides benefits sharing and the claims can be submitted by the citizens of India or firms or non-governmental organization (NGOs) formed or established in India. Depending upon the extent and nature of the use of genetic material of the claimant in the development of the variety along with commercial utility and demand in the market of the variety breeder will deposit the amount in the Gene Fund. The amount deposited will be paid to the claimant from National Gene Fund. The Authority also publishes the contents of the certificate in the PVJI for the purpose of inviting claims for benefits sharing.

Rights of Community

1. It is compensation to village or local communities for their significant contribution in the evolution of variety which has been registered under the Act.
2. Any person/group of persons/governmental or non- governmental organization, on behalf of any village/local community in India, can file in any notified centre, claim for contribution in the evolution of any variety.

Convention countries

Convention country means a country which has acceded to an international convention for the protection of plant varieties to which India has also acceded or a country which has law of protection of plant varieties on the basis of which India has entered into an agreements for granting plant breeders' rights to the citizen of both the countries.

Plant Varieties Protection Appellate Tribunal

Plant Varieties Protection Appellate Tribunal (PVPAT) has been established by appointing Technical Member. All orders or decisions of the Registrar of Authority relating to registration of variety and orders or decisions of the Registrar relating to registration as agent or licensee can be appealed in the Tribunal. Further, all orders or decisions of Authority relating to benefit sharing, revocation of compulsory license and payment of compensation can also be appealed in the Tribunal. The decisions of the PVPAT can be challenged in High Court. The Tribunal shall dispose of the appeal within one year.

Lecture No. 46

SEED PELLETING

Seed pelleting is the process of adding inert materials to seeds increasing their weight, size and shape. This improves plantability allowing for precise metering, spacing and depth of seed in the field. Pelleting turns a long thin seed into a larger, round-shaped seed, so seeds can be mechanically singulated much more readily and so placed accurately in the field. This helps place seeds precisely, which is a great advantage.

Advantages of seed pelleting

- It reduces seed rate required for planting
- It increase in size of the seed
- It makes sowing and planting precision
- It maintains the seed moist by making moisture available from soil
- It efficiently supply available growth regulators and nutrients
- It stimulates the seed germination
- It influences the micro environment required for better germination and seedling emergence
- It makes crop and seedling establishment uniformity

Materials used for seed pelleting

Adhesive materials: These are: gum arabic (45% W/ V), Methyl cellulose (3% W/V), nitric coat (4.3% W/ V), gelatin (5% W/V), plastic rexins, dextran etc.

Properties of adhesive materials: –

- Must have the affinity for both seed coat and selected filler material. –
- Should have the required degree of water solubility for easy emergence. –
- Should have required strength and plasticity to prevent dusting and breakage. –
- Should have the appropriate viscosity for each application.

Filler materials : These are used as a protectant for a seed eg. Rhizobia including lime, gypsum, dolomite, and rock phosphate, clay minerals, dried blood, poultry manure, moss etc.

Properties of filler materials : –

- Must be porous
- Easily weaken or break down
- Low cost
- Fine size of particles (150-300 mesh sieve).

Coating material – Plant leaf powders (neem , Arappu, pungam, prosopis and nochi leaf powders) are widely used for pelleting now a days as they have growth promoters like saponin

Lecture No. 47

BIOTECHNOLOGY

The literal meaning of Biotechnology as implied from this word is the study of tools from living things Bios – life: Teuchos – tool: Logos - Study of or essence.

- ✓ **Spinks** (1980) **defined biotechnology** as, "the application of biological organisms, systems or processes to manufacturing and service industries".
- ✓ The **European Federation of Biotechnology** defines **Biotechnology** as 'the integration of natural science and organisms, cells, parts thereof, and molecular analogues for products and services'
- ✓ **Bull** et al., 1982 defined biotechnology as the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services.

Uses of biotechnology

- ➢ Biotechnology is not a new concept; traditional products like bread, beer, cheese, wine, and yoghurt are produced through fermentation of yeast and bacteria.
- ➢ **Production** of vaccines and antibiotics (pencillin)
- ➢ In a symbiotic relationship with the soil bacteria known as '*rhizobia*', *legumes* fix nitrogen.
- ➢ Genetic engineering can be used to introduce genes into a plant, which do not exist in any member of the same plant family.
- ➢ Production of Transgenic Plants.

Areas of Biotechnology along with their products

S. No.	Areas	Products
1.	Recombinant DNA techniques (Genetic engineering)	Fine chemicals, Enzymes, Vaccines, Hormones, Antibodies, Antibiotics
2.	Plant cell culture/Animal Cell Culture Techniques	Fine chemicals (alkaloids, steroids, essential oils, dyes), somatic embryos, Monoclonal antibodies, Diagnostic and Therapeutic kits
3.	Process Engineering	Harvesting, Pretreatment, Filtration, Effluent treatment, Water recycling, Product extraction, Novel reactors
4.	Waste product treatment and utilization	Herbicide/Insecticide detoxification, sewage treatment and utilization, byproduct utilization
5.	Traditional Fermentation	Alcohol, Organic acids, Amino acids, Polysaccharides, antibiotics

6.	Biofuels	Methane (biogas from wastes), Hydrogen, Alcohol (from waste)
7.	Enzymes and Biocatalysts	Food processing, Fine chemicals, Diagnostic kits, Chemothrapy, Biosensors
8.	Nitrogen Fixation	Microbial or Algal biofertilizer

Branches of biotechnology

Blue Biotechnology: This branch of biotechnology helps to control the marine organisms and water-borne organisms. Blue biotechnology is used to protect the marine organisms from harmful diseases underwater.

Bioinformatics: Bioinformatics is the combination of computer and biotechnology. It helps in finding the analysis of data related to Biotechnology.

Green Biotechnology: It is the term used for the agricultural sector. With the help of the process called the Micropropagation (a practice of producing larger number of plants through the existing stock of plants) which helps in selecting the right quality of plants and crops. Also with the help of Transgenic plants (plants whose DNA is modified); this design of transgenic plants helps to grow in a specified environment with the help of certain chemicals.

Red biotechnology: It is referred to as Medical Biotechnology. It is used for the production of drugs and antibiotic medicines. It also helps to create or design organisms. Through the process of genetic manipulation it helps to cure genetic issues in organisms.

White Biotechnology: It is also called as Industry Biotechnology. The various uses of this Biotechnology include; biopolymers (Plastics) Substitutes, the new invention of vehicle parts and fuels for the vehicles, an invention of fibers for the clothing industry, it is also involved in developing new chemicals and the production process.

History of Plant biotechnology

Year	Scientist
1927	Muller concluded that the x-ray exposure caused the lethal mutations in the offspring of the x-ray treated flies.
1941	The *term genetic engineering* was coined
1944	Streptomycin was discovered by Selman Waksman
1953	Double helix structure of DNA revealed (Watson and Crick)
1954	Tissue culture methods
1961	Nirenberg and Heinrich J. Matthaei were the first to reveal the nature of a codon
1973	Stanley Cohen and Herbert Boyer develop DNA cloning and recombinant DNA
1981	Chinese scientists successfully clone a fish, a golden carp
1983	First plant gene to be inserted in a plant of different a different species
1992	China was the first country to commercialize transgenic plants, introducing a virus-resistant tobacco
1994	Flavr Savr, a genetically modified tomato, the first transgenic food product
1997	Cloned a sheep named Dolly
2001	Tests were carried out on Golden Rice (Vitamin A enriched rice) for its future usage
2002	Rice Genome sequenced

Role of biotechnology in agriculture

a) Biofertilizers

Nitrogen fixing biofertilizers: Nostoc, Anabaena, Plectonema, Rhizobium spp., Azotobacter

Phosphate solubilizing biofertilizers: Pseudomonas, Aspergillus, Bacillus,

Phosphate mobilizing biofertilizers: VAM (vesicular-arbuscular mycorrhizae)

Plant Growth Promoting biofertilizers: Bacillus, Pseudomonas, Enterobacter, Erwinia

b) Biopesticides

The most widely used microbial pesticides are subspecies and strains of Bacillus thuringiensis, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae.

eg: *Bacillus thuringiensis, Hirsutella thompsonii,* Nuclear Polyhedrosis Virus (NPV),

c) Tissue culture :

1. Some plants, which do not multiply by seeds, can be propagated through plant tissue culture technique.
2. By the help of tissue through protoplast fusion, cell fusion, genetic engineering and hybridization technique, new improved varieties of crops can be produced within a short time period.
3. The plant produced by the application of tissue culture retain the power of disease resistance.
4. Large no. of plants can be produced in a short time.
5. Chemicals which are used in the tissue culture increase the capacity of produced plants to resist with biocidal chemicals, environment stress and competitive to survive over weed.
6. By tissue culture technique, mutation can be introduced in the cultures and resistant mutants can be selected to produce resistant varieties.

d) Production of Plants with desirable traits

Insect-pest resistance plants: Using gene transfer technique the Bt. gene (Cry I protein from Bacillus thuringiensis) has been transferred to many crop plants like rice, cotton, tomato, potato, etc. and insect resistant plants (Bt. crops) have been developed.

Herbicide resistant plants: Using biotechnological approaches many herbicide resistant crop plants have been obtained as in Brassica, tomato, corn, cotton, soya-bean, etc. which are resistant against glyphosate (Roundup), L-phosphinothricin (Basta), etc.

Virus resistant plants: Viral coat protein genes can be introduced to get the virus resistant plants as has been done in tomato, potato, squash, papaya, etc.

Resistance against bacterial and fungal pathogens: Several examples are available where the transgenic plants against bacterial and fungal pathogens have been developed. The chitinase gene have been introduced in tobacco to get the resistance against brown spot; acetyl transferase gene has been introduced in tobacco to get the resistance against wild fire disease

Improvement in nutritional quality: Nutritional quality can be improved by introducing the genes for production of cyclodextrins, vitamins, amino acids, etc. Transgenic potato has been obtained to produce cyclodextrin molecule; the transgenic rice named as ‘Golden rice’ has been obtained to produce pro vitamin-A which has opened the way for improving the nutritional standards; Ama-I gene has been introduced in potato. Starch content has been increased in transgenic potato.

Quality of seed-protein and seed-oil: Recombinant DNA technology has been used successfully for improvement of protein quality in seed as has been done in pea plant which is rich in sulphur containing amino acids; lysine rich cereals have also been produced.

Oilseed rape has been made transgenic which has the modified seed oil quality, i.e., low erucic acid. Reduced linolenic acid containing flax and high stearic acid containing soya-bean and safflower also have been produced.

Improvement of quality for food- processing: 'Flavr-Savr' variety of tomato has been raised which shows bruise resistance as well as delayed ripening.

Male sterility and fertility restoration in transgenic plants: Barnase – Barstar system.

Production of stress tolerant: Several projects are going on for transgene application to develop the tolerance against different abiotic stresses, e.g., cold (tobacco), drought (mustard), salt (rice).

Transgenic plants:

Transgenic plants are plants that have been genetically engineered, a breeding approach that uses recombinant DNA techniques to create plants with new characteristics.

Lecture No. 48

INTELLECTUAL PROPERTY RIGHTS AND PLANT BREEDER'S RIGHT

Intellectual Property:

Intellectual property is an idea, a design, an invention etc which can ultimately give rise to a useful product / application. For the development of such intellectual property, requires intellectual inputs, innovativeness, considerable monetary and other resources. Therefore, the inventor would like to ensure a fair reward for his invention. But the major problem with intellectual property is that they can be copied, imitated or reproduced, this minimizes the returns to the original inventor.

The right on an invention to derive economic benefits for his invention (*i.e.* intellectual property) is called as intellectual property rights (IPR). The IPR however is recognized by the govt. only so long as it is not detriment to the society. **Protection of Intellectual Property Rights** – The protection of IPR may take several forms depending on the type of intellectual property and the type of protection sought. Each form of protection has its own advantages & disadvantages. The main forms of IPR protection are as follows.

1. Trade secrets
2. Patents
3. Plant Breeder Rights (PBR)
4. Copyright

1. Trade secret: When the individual / organization owning an intellectual property does not disclose the property to any one and keeps it as a closely guarded secret to promote his business interests, it is called trade secrets. Trade secret may relate to formulae, processes or parented lines in hybrids, in biotechnology trade secret include cell lines, microorganism strains etc.

Advantages:

1. They are for unlimited duration
2. It is not necessary to satisfy the stringent procedures for patents
3. The cost of facing, contesting & enforcing patents is saved
4. The risk of some one improving upon the product etc is reduced

Limitations:

1. Maintaining a trade secret itself is a costly affair
2. It is not protected from independent innovation / invention
3. Non-disclosure of the invention does not give others as chance to improve upon the original inventions. This prevents or delays the progress in that particular field.

4. It cannot be applied to many inventions eg. Equipments designs, plant varieties, books etc.

2. Patents: A Patent is the right granted by a government to an inventor to exclude others from imitating, manufacturing, using or selling the invention in question for commercial use during the specified period.

Patent Requirement: For granting a patent the main requirements are as follows

1) Novelty
2) Inventiveness
3) Industrial application & usefulness
4) Patentability
5) Disclosure

Novelty: The invention must be new and should not be already known to public.

Inventiveness: The invention should represent an innovation

Industrial Application & Usefulness: The patent must have an industrial application should be useful to the society/nation.

Patentability: It must be patentable under the existing law and its current interpretation. The criteria at present varies from country to country and with time within the same country. The Indian Patent Act 1970 does not allow product patents in pharmaceuticals, food and agriculture. The key element is that substances used as food/medicine/drug and the entire class of materials formed by any chemical reaction do not qualify as patentable subject matter i.e. product patents are not allowed in India. As a result, an antibiotic is not patentable in India, while the process of its production is in contrast; both the product & the processes are patentable in Europe & USA.

Disclosure: The inventor has to describe his invention in sufficient detail so that a person of normal skill is able to reproduce it. In case of biological entities already known, organisms may be simply named. But if they have been genetically modified, the nature and the method of modification has to be described fully.

A patent may be viewed as a contract between the society and the inventor where in the inventor discloses his intention in return for the protection granted to him by the society to control the commercial aspects of his invention to the extent that is not determined to the society. The disclose of an invention gives an opportunity to other inventors to improve upon the various features of the invention, so that it became more efficient & /or more useful. This in-turn, results in scientific and economic progress of the society/nation.

Limits of a patent: A patent is limited both in time and space

a) **Limitation of Time** – A patent is valid for a specified period of time from the date of award in most countries this period is 15-20 years. The Indian patent act (1970) grants protects for 7 or 14 years. However, there is a strong argument for larger protection as it may take upto 10 years from the time or patent is awarded to the time the product reaches market.

b. **Limitation of Space** – A patent is valid only in the country of its Award and not in other countries. A group of nations may agree to honour the patents awarded by any member country eg. European Economic community. WTO has a similar provision that a patent awarded by WTO will be valid in all member countries.

3. **Copyright**: Certain intellectual properties are not patentable. They are protected by Copy right eg: Books, Audio, Video cassettes & Computer software. The copyright is limited both in time and extent.

Plant Breeder Rights: The rights granted by the Govt. to plant breeder, or owner of a variety to exclude others from producing commercially the propagating material or that variety for a period of 15-20 years.

To qualify for PBR protection a variety has to be novel, distinct from existing varieties and uniform and stable in its essential characteristics. A person holding PBR title to a variety can authorize other organizations to produce and sell the propagating material of that variety.

PBR in India – India had evolve a *sui generis* system of PBR. Which means a system of their own. The essential features of UPOV - 1978 act are being considered for adoption. Some important features of the Indian *sui generis* system are

1. Farmers rights
2. Researchers right to use the material for research
3. Protection period of 15 years for annuals and 18 years for fruit trees
4. Compulsory deposit of the material in national gene bank
5. Establishment of National Authority for the protection of Breeders, farmers and researchers use rights.

Benefits of PBR –

1. Profits obtained by breeders through PBR will act as an incentive in promoting Plant Breeder research.
2. It encourages private companies to invest in Plant Breeding Research.
3. It will enable access to varieties developed in other countries & protected by IPR laws
4. Increased competitiveness among various organizations engaged in Plant Breeding is likely to benefit both farmers and the nation

Disadvantages of PBR –

1. PBR will encourage monopolicy in genetic material for specific use
2. It suppress free exchange of genetic material and encourage unhealthy practices
3. The PBR holder may produce less seed and increase the price for achieving more profit.
4. Farmers privilege to re sow the seed produced by him may be gradually diluted
5. PBR may result in increased cost of seed and may be burden for poor farmers