MODEL ANSWER

MAHARASHTRA AGRICULTURAL UNIVERSITIES EXAMINATION BOARD, PUNE
SEMESTER END EXAMINATION
B. Sc. (Hons) Hort.

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|---|---|
| Semester: II (New) | Academic Year: 2018-19 |
| Course No. : H-BOT123 | Title: Principles of Plant Breeding |
| Credits: 2+1=3 | Total Marks: 80 |
| Day & Date: | Time: |

Note: 1) Solve any eight questions from 'SECTION - A'
2) All questions from 'SECTION B' are compulsory.
3) All questions carry equal marks.
4) Draw neat diagrams wherever necessary.

## SECTION 'A'

**Q.1 Enlist the different methods used in self pollinated crops and describe procedure of pure line selection.**

Ans **Breeding methods used in self-pollinated crops** (3)

1) Introduction and Acclimatization

2) Selection

a) Pure line selection
b) Mass selection

3) Hybridization and selection

i. Pedigree method
ii. Bulk method
iii. Back cross method
iv. Single seed descent method

4) Other methods

v. Multiline varieties
vi. Shuttle breeding
vii. Hybrid breeding

5) Mutation breeding

6) Polyploidy breeding

7) Distant hybridization

8) Transgenic breeding

9) Biotechnology

**Procedure of pure line selection:** (5)

**First year-** A large number of plants are selected from a desi or local variety or some other genetically variable but homozygous population and their seeds are harvested separately.

**Second year-** Progenies from individual plants are grown separately with proper spacing. The top 15-20 progenies are selected and seed of all plants in each progeny is bulked. The progenies are evaluated visually; poor weak and defective progenies are rejected.

**Third year-** If the seeds of individual plant progenies are not enough to conduct replicated trial they are grown in an unreplicated trial. The best variety is used as a check and should be planted at regular intervals. However, if enough seed is available a preliminary yield trial should be conducted.

**Fourth year-** Replicated yield are conducted by the breeder using the best available variety as a check. Each progeny is equivalent to a strain as it is a pure line.

**Fifth to seven year-** The promising strains are evaluated at several locations. The best released varieties are used as checks.

**Eight year-** The best progeny or strain is released as a new variety and its seed multiplication is initiated for distribution.

**(Flow chart)**

**Q.2 a) Define heterosis. Describe main features of heterosis.**

**Ans** **Heterosis-** The superiority of $F_1$ hybrid over both its parents in terms of yield and some other characters. (2)

**Main features of heterosis:** (6)

1) Superiority over parents – Heterosis leads to superiority in adaptation, yield, quality disease resistance, maturity and general vigour over its parents. Generally positive heterosis is also desirable eg. negative heterosis for higher maturity duration and toxic substances is desirable in some cases.
2) Confined to $F_1$ – Heterosis is confined only to the $F_1$ generation of a cross due to segregation and recombination.
3) Genetic control – The expression of heterosis is governed by nuclear genes. In some cases heterosis results due to interaction between nuclear genes and cytoplasm.
4) Reproducible – Heterosis once identified can be easily reproduced in a define environment.
5) Association with SCA – Heterosis has positive association with specific combining ability (SCA) variance.
6) Effect of heterozygosity – The magnitude of heterosis is associated with heterozygosity because the dominance variance is associated with heterozygosity.
7) Conceals recessive genes- In case of heterosis deleterious recessive genes are covered by the favourable effect of dominant genes.
8) Low frequency- The frequency of desirable heterotic combination is very low.

Q.3 **a) Define mutation and give its characteristics.**

Ans **Mutation**- Refers to sudden heritable change in the phenotype of an individual. (1)

**Characteristics of mutations** (3)

i) Mutations are generally recessive but dominant mutations also occur.
ii) Mutations are generally harmful to the organisms.
iii) Mutations are random, they may occur in any gene.
iv) Mutation is recurrent.
v) Induced mutation show pleiotropy.
vi) Mutations are reversible.
vii) Mutations are spontaneous or can be induced artificially.

**b) Define polyploidy and describe autopolyploidy.**

Ans **Definition**- An organism or individual having more than two sets of (1)
chromosomes is called polyploid and such condition is known as polyploidy.

**Autopolyploidy**- (3)
Also called simple polyploidy or single species polyploid.

i) Autotriploid - Three copies of the same genome. (3Z). eg. banana, apples, sugarbeet, watermelon etc.
ii) Autotetraploid - Four copies of the genome of same species. (4Z) eg. rye, grapes, alfalfa, potato, groundnut, coffee, maize, grasses, ornamentals etc.
iii) Autopentaploid - Five copies of the genome from similar species. (5Z).
iv) Autohexaploid - Six copies of the genome from similar species. (6Z) eg. Sweet potato.

Q.4 **Define plant breeding. Describe achievements of plant breeding.**

Ans **Define**- It is an applied branch of botany which deals with genetic improvement of crop plants. (2)

**Achievements of Plant Breedings:** (6)

1) **Semi dwarf and dwarf varieties in wheat and rice:**
Many dwarf and semi dwarf varieties are developed in crop like wheat and rice Dr. Borlaug used a apense variety NORIN -10 as a source dwarfing gene, in wheat at CIMMYT (Mexico). In 1963 ICAR has introduced semi dwarf selection from CIMMYT. Variety Kalyansona and Sonalika were selected from these materials.

2) **Developed hybrids:**
The development of hybrid varieties of maize, jowar and bajra deserves a special mention. Several hybrid varieties have been released. e.g. ganga sated 2 and and deccan are a few examples. Similarly, several hybrids have been released in jowar e.g. CSH 1, CSH 2, CSH 3 etc. and in bajra e.g. HB1, HB 2, HB 3, PHH 10, PHH 14 etc.

3) **Noblisation of sugarcane:**
The Indian canes were of *Saccharum barberi*, largely grown in North India. They were hardy but poor in yield and sugar content, while tropical cane of *Saccharum oficinarum* had thicker stem and higher sugar content but it performed badly in North India due to low winter temperature. C.A Barber and T.S Venkatraman at Sugarcane Breeding Institute, Coimbtore transferred thick stem higher sugar content and other desirable characters from the noble cane to Indian cane is commonly referred as nobilization on of Indian canes.

4) **Developed synthetic and composite varieties:** Partially exploitation of heterosis or hybrid vigour.
a) Maize: African Tall, Manjari, kissan, shakti etc.
b) Bajara: WCC-75, PHB-10, ICTP-8203, ICMS 7703 and 4.
c) Sugarbeet: Synthetic 3

5) **Developed hybrid in cotton:**
The first hybrid variety of cotton was H4, since then several other hybrid varieties have been developed e.g. varlaxmi, savitri, jayalaxmihave been released for commercial cultivation.

6) **Bt Cotton:** Strains of the bacterium *Bacillus thuringiensis* produce over 200 different Bt toxins, each harmful to different insects. Most notably, Bt toxins are insecticidal to the larvae of moths and butterflies, beetles, cotton bollworms and ghtu flies but are harmless to other forms of life. The gene coding for Bt toxin has been inserted into cotton as a transgene, causing it to produce this natural insecticide in its tissues.

**Q.5 Define male sterility. Enlist its types and describe cytoplasmic genetic male sterility.**

Ans Male sterility- Pollen either absent or non functional (2)

**Types of male sterility** (2)

1) Genetic male sterility
2) Cytoplasmic male sterility
3) Cytoplasmic genetic male sterility
4) Chemical induced male sterility
5) Transgenic male sterility

Describe cytoplasmic male sterility

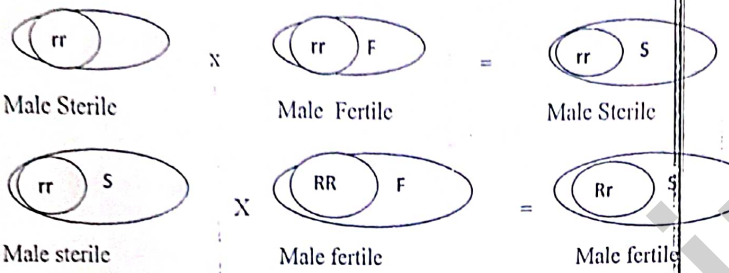
**Cytoplasmic- genetic male sterility:** (4)

This male sterility is also called as three line breeding system. This male sterility is due to interaction between nuclear genes and cytoplasmic gene. It involves A, B and R lines. It is commonly used in sorghum, pearl millet, rice, sunflower etc.

**Advantages:**
1. It is used in both the crops sexually and asexually propagated crops.
2. It is stable.

**Disadvantages:**
1. More area required for maintenance of lines.
2. More expensive.

**Diagrammatic representation.**




Use of cytoplamsmic genetic male sterility has certain limitations due to

1. Cytoplasm may bring certain undesirable effect.
2. Problems in fertility restoration.
3. Unsatisfactory pollination.
4. Effect of modifying genes.
5. Breakdown of sterility particular environmental conditions of cytoplasm.
6. Difficulty in developing suitable restorer due to polyploidy nature of crop or undesirable linkage e.g. wheat.

**Q.6 Explain in brief**

**1) Types of heritability**

**Ans There are two types of heritability**

**1. Broad Sense Heritability** (2)

Broad sense heritability is the percentage ratio of genotypic variance to the phenotypic variance,

The broad sense heritability, from different materials, is estimated in different ways. From replicated data of several genotypes, heritability is calculated as follows:

**Main features of broad sense heritability**

1. It is more useful in animal breeding
2. It is estimated from genotypic variance
3. Selection of elite type of genotypes from homozygous population.
4. It is estimated by using formula

$$\text{Heritability (bs)} = \frac{V_G}{V_p} \times 100$$

Where, $V_G$ = genotypic variance, $V_p$ = Phenotypic variance

**2. Narrow Sense Heritability** (2)

Narrow sense heritability is the ratio of additive variance to the phenotypic variance.

**Main features of narrow sense heritability**

1. It is useful in plant and animal breeding.
2. It is estimated from additive variance.
3. Selection of elite type of genotypes from segregating population.
4. Crosses are made in definite fashion.
5. It is estimated by using formula

$$\text{Heritability (ns)} = \frac{V_A}{V_P} \times 100 \quad \text{OR}$$

$$\text{Heritability (ns)} = \frac{\frac{1}{2} D}{VP} \times 100$$

**2) Modes of Pollination** (4)

Pollination refers to the transfer of pollen grains from anthers to stigmas. Modes of pollinations three types

**Self pollination**: Pollen from an anther may fall on to the stigma of the same flower leading to self pollination or autogamy.

Many cultivated plant species reproduce by self pollination. Self pollinated species are believed to have originated from cross pollinated ancestors in response to the environmental conditions to which such species are typically subjected.

**Cross pollination**: When pollen grains from flowers of one plant are transmitted to the stigmas of flower of another plant, it is known as cross pollination or allogamy.

In cross pollinating species, the transfer of pollen from a flower to the stigmas of the others may be brought about by wind, water or insects. Many of the crop plants are naturally cross pollinated. In many species a small amount of selfing may also occur.

**Often Cross pollinated species**: In many crop plants cross pollination often exceeds 5 percent and may reach 30 percent. Such species are generally known as often cross pollination species. eg. jowar, cotton, arhar, safflower etc. The genetic architecture of such crops is intermediate between those of self pollinated and cross pollinated species. Consequently in such species breeding methods suitable for both of them may be profitably applied. But often hybrid varieties are superior to others.

**Q.7 Define self incompatibility. Give classification of self incompatibility and describe utilization of self incompatibility.**

**Ans Self incompatibility:-** It refers to the failure of pollen to fertilize the same flower or other of the same plant (2)

**Classification-**

1) Floral morphology a) heteromorphic i) distyly ii) Tristyly (3)
   b) homomorphic i) sprorophytic ii) gametophytic
2) On the basis of gene involved a) monoallelic ii) diallelic iii) polyallelic

3) Site of expression i) stigmatic ii) stylar iii) ovrian
4) Poly cytology a) binucleate b) trinucleate

**Utilization of self incompatibility:**

**Utilization of self incompatibility** (3)

Self incompatibility is of great significance to plant breeders. It is an important pollination control device which prevents autogamy and promotes allogamy.

1. **Production of hybrids** – Self incompatibility provides a way to genetic or cytoplasmic male sterility. Self incompatibility has been utilized for production of commercial hybrids in brassica and sunflower. Two self incompatibility lines (strains) are planted in the alternate row for hybrid seed production. The harvest from both the lines would be hybrid seed.
2. **Combining desirable genes:** Self incompatibility system permits combining of desirable genes in a single genotype from two or more different sources through natural cross pollination which is not possible in self compatible species. Moreover knowledge of self incompatibility specially in fruit crops, helps fruit growers to increase the yield of fruits by providing suitable pollinators.

Q.8 **What is sporogenesis? Describe process of microsporogenesis and microgametogenesis.**

Ans **Sporogenesis:** (2)

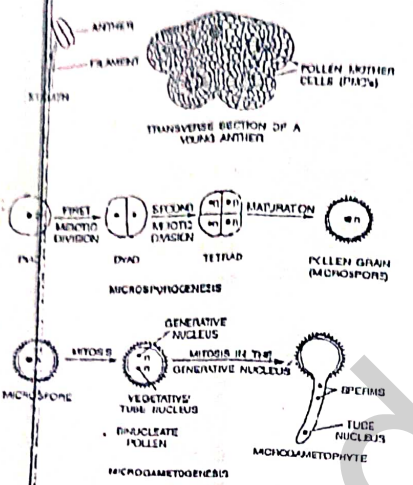
Production of microspores and megaspores is known as sporogenesis. Microspores are produced in anthers (microsporogenesis), while megaspores are produced in ovules (megasporogenesis)

**Microsporogenesis:** (3)

Each anther has four pollen sacs, which contain numerous pollen mother cells (PMC). Each PMC undergoes meiosis to produce four haploid cells or microspores. This process is known as microsporogenesis. The microspores mature into pollen grains mainly by a thickening of their walls.

**Microgametogenesis:** (3)

This refers to the production of male gamete or sperm. During the maturation of 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, when the pollen lands onto the stigma of a flower, it is known as **pollination.** Shortly after pollination, the pollen germinates. The pollen tube enters the stigma and grows through the style. The generative nucleus now undergoes into mitotic division to produce two **male gametes or sperms.** The pollen, along with the pollen tube is known as **microgametophyte.**




Microsporogensis and microgametgenesis

**Q.9** Write short notes on (*Any two*)

**1) Combining ability**

**Ans** Combining ability refers to the capacity or ability of genotype to transmit superior performance to its crosses. (4)

**General combining ability:**

The average performance of a strain or genotype in a series of hybrid combination is termed as general combining ability: It is estimated from half sib families. Half sib families – progeny having one parent in common. In other words the crosses which have one parent in common are used for the calculation of gca is due to additive genetic variance and additive x additive epistasis. It helps in selection of suitable parents for hybridization. It has relationship with narrow sense heritability.

**Specific combining Ability:**

The performance of a parent in a specific cross is known as specific combining general combining ability. Thus sca refers to the deviation of a particular cross from the general combining ability. The sca is estimated from the full sib families. Sca is due to dominance genetic variance and all the three types of epistasis. It helps in the identification of superior cross combinations. It has relationship with heterosis.

**advantages and disadvantages**

**Advantages of combining Ability**

1. Combining ability analysis is useful for evaluation of strains or genotyoes in terms of their genetic value. It helps in the selection of suitable parents for incorporation in the hybridization programme.

2. It helps in the identification of superior hybrid combinations which may be utilized for commercial exploitation of heterosis

3. Combining ability analysis is useful in the development of synthetic varieties

4. The combining ability estimates are free from genetic assumption and are based on empirical results

5. The estimates of gca and sca effects are based in first order statistics mean values and hence are statically robust.

6. The combining ability analysis provides information about the gene action involved in the expression of various quantitative characters and thus helps in deciding breeding procedure for genetic improvement of such traits.

**Dis-advantages**

1. The estimates of combining ability are specific to the material under evaluation.

2. Combining ability analysis requires atleast two crop seasons. In the first season the crosses are affected and the second season the crosses are evaluated.

3.The analysis of data is some what difficult.

4. In order to obtain accurance results the crosses have to be evaluated over multi locations for two or three years.

**2) Vertical and horizontal resistance**

**Vertical Resistance:** **(2)**

Specific resistance of a host to the particular race of pathogen is known as vertical resistance. This is governed by one or few genes and therefore referred to as oligogenic resistance or major gene resistance since vertical resistance controls only one race of a pathogen, it is also termed as specific resistance. Because of its simple inheritance it is also known as qualitative.

**Main feature of vertical resistance are**

1. Vertical resistance displays discontinuous variation among genotypes and classification of genotypes into resistant and susceptible classes is possible.

2. Transfer of oligogenic resistance from one host genotype to another is simple.

3. Oligogenic resistance is usually short lived or less durable. The resistance can easily break down when new race of a pathogen is formed.

4. It provides protection only from one race of pathogen.

5. It has heritability and can be easily identified in the breeding programme.

6. It applies to host pathogen gene for gene relationship.

**Horizontal Resistance** **(2)**

The resistance of a host to all the race of pathogen is called horizontal resistance. The host plan provides protection from all the prevailing races of a pathogen (general resistance). The resistance is controlled by a numbers of genes (polygenic heritance)

Each gene involved in the resistance has small effect which is not visible (minor gene resistance). The host resistance is not for a specific race of pathogen (non specific resistance)

**Main features of horizontal resistance are**

a) Horizontal resistance exhibits continuous variation among genotypes and therefore classification of genotypes into different distinct classes is not possible.

b) It has low heritability; therefore identification of resistance types is difficult

c) It provides protection from several races of a pest.

d) The resistance cannot be easily overcome by new races of a pathogen due to polygenic control.

e) It is difficult to transfer polygene resistance from one host genotype to another because individual allele in a parent cannot be identified.

f) General resistance is not applicable to gene for gene relationship.

**3) Inbreeding depression** (4)

Inbreeding is mating between individual related by descent or ancestry. When the individuals are closely related eg. in brother , sister mating or sibmating, the degree of inbreeding is high. The highest degree of inbreeding is achieved by selfing. The chief effect of inbreeding is an increase in homozygosity in the progeny.

Inbreeding depression may be defined as the reduction or loss in vigour and fertility as result of inbreeding. Effect of inbreeding- is generally accompanied with a reduction in vigour and reproductive capacity that is fertility. There is general reduction in the size of various plant parts and the yield.

Estimation of inbreeding = $\frac{F_1 - F_2}{F_1} \times 100$

**Categories of degree of inbreeding depression**- High, medium (moderate), low inbreeding depression, and lack of inbreeding depression.

**Effects of inbreeding depression**

**Q.10 What is hybridization? Describe its types and objectives of hybridization.**

Ans **Hybridization**

The mating or crossing of two plants of dissimilar genotypes is known as hybridization. (2)

**Types of Hybridization**

**1) Intervarietal Hybridization** – The parents involved in intervarietal hybridization belong to the same species they may be two strains, varieties or races of the same species. It is also known as intraspecific Hybridization. In crop improvement programmes, intervarietal hybridization is the most common used. The intervarietal crosses may be simple or complex depending upon the number of parents involved. (3)

2) **Interspecific hybridization:** Crossing between two different species of same genus. It is also called as intrageneric hybridization.

3) **Intergenetic hybridization:** Crossing between two different genera of same family.

**Objectives of hybridization** **(3)**

1) **Combination breeding** – The main aim of combination breeding is the transfer of one or more characters into a single variety from another variety or other varieties. These characters may be governed by oligogenes or polygenes. A familiar example of combination breeding is that for disease resistance.

2) **Transgressive breeding** – Transgressive breeding aims at improving yield or its contributing characters through transgressive segregation. Transgressive segregation refers to the appearance of such plants in an $F_2$ generation that are superior to both the parents for one or more characters.

3) **Development of hybrids** – In most self pollinated crops $F_1$ is more vigorous and higher yielding than the parents. Wherever it is commercially feasible. $F_1$ may be used directly as a variety such a variety is called hybrid variety.

4) **Development of varieties**

5) **Creation of genetic variability**

## SECTION 'B'

**Q.11 Define** **(8)**

1) **Domestication** - The process of bringing wild species under human management is known as domestication.

2) **Mutation** - Sudden heritable change in the phenotype of an individual.

3) **Dichogamy** - Stamens and pistils of hermaphrodite flowers may mature at different times thereby facilitation cross pollination.

4) **Pure line** – The progeny obtained from single self fertilized plant is called pure line.

5) **Protogyny** - Pistils mature before stamens.

6) **Back cross** - $F_1$ is crossed with either of its parent.

7) **Pollination** - Transfer of pollen grains from anthers to the stigmas.

8) **Cleistogamy** - Pollination and fertilization takes place in unopened flower.

**Q.12 Fill in the blanks** **(8)**

1) An individual with one pair of chromosome less than the normal somatic chromosome number is known as **nullisomic.**

2) The parent one time used in back cross is called **non recurrent parent/ donor parent.**

3) Removal of male reproductive organ from bisexual flower is called **emasculation.**

4) The union of male and female gametes is called **fertilization.**

5) Average heterosis is also called as **relative heterosis/ mid parent heterosis.**

6) **Genetic male sterility** type of male sterility is unstable.

7) The term mutation was first coined by **Hugo de vries.**

8) Matuation of male and female reproductive organs mature at the same time is **homogamy.**

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