Model Answer Paper

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

Semester	:	II (New)	Term	:	I	Academic Year	:	2022-23
Course No.	:	GPB-232	Title	:	Fundamentals of Plant Breeding			
Credits	:	2(1+1)						
Day & Date	:		Time (hrs.)	:	2 hrs.	Total Marks	:	40

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'

Marking scheme

Q.1 **Define Heterosis?**
Enlist different theories of heterosis.
Explain Dominance hypothesis of heterosis with objections.

Ans: **Heterosis:** 1

Heterosis may be defined as the superiority of an F_1 hybrid over both its parents in terms of yield and some other character.

Theories of heterosis:

(1) Dominance hypothesis, (2) Over dominance hypothesis and 1
(3) Epistasis.

Dominance hypothesis of heterosis with objections:

Dominance Hypothesis:

The dominance hypothesis was first proposed by **Davenport** in 1908. It was later expanded by Bruce, and by Keeble and Pellew in 1910. In simplest terms, this hypothesis suggests that at each locus the dominant allele has a favourable effect, while the recessive allele has an unfavourable effect. In heterozygous state, the deleterious effects of recessive alleles are masked by their dominant alleles. Thus heterosis results from the masking of harmful effects of recessive alleles by their dominant alleles. Inbreeding depression, on the other hand, is produced by the harmful effects of recessive alleles, which become homozygous due to inbreeding. Therefore, according to the dominance hypotheses, heterosis is not the result of heterozygosity; it is the result of prevention of expression of harmful recessives by their dominant alleles. Similarly, inbreeding depression does not result from homozygosity per se. but from the homozygosity of recessive alleles, which have harmful effects. 1

Objections:

1. **Failure in the Isolation of Inbreds as vigorous as Hybrids:**
   According to the dominance hypothesis, it should be possible to isolate inbreds with all the dominant genes. Such inbreds would be as vigorous as the F_1 hybrids. However, such inbreds have not been isolated in many studies. But in some studies, it has been possible to recombine genes so that inbred lines as good as or superior to the heterotic hybrids were isolated.
2. **Symmetrical Distribution in F_2:** 1
   In F_2, dominant and recessive characters segregate in the ratio of 3 : 1. According to the dominance hypothesis, quantitative characters, therefore, should not show a symmetrical distribution in F_2. This is because dominant and recessive phenotypes

would segregate in the proportion $(3/4 + 1/4)^n$, where n is the number of genes segregating. However, F_2's nearly always show a symmetrical distribution.

Q.2. **Define recurrent selection.**
Enlist its types.
Explain in brief procedure for reciprocal recurrent selection.

Ans: **Recurrent selection:** 1

Recurrent selection may be defined as a "Method which involves reselection generation after generation with interbreeding of selects to provide for genetic recombination". 1

Types of recurrent selection:

1. Simple recurrent selection
2. Recurrent selection for GCA
3. Recurrent selection for SCA
4. Reciprocal recurrent selection

Procedure for reciprocal recurrent selection:

Reciprocal recurrent selection was first proposed by Comstock, Robinson and Harvey in 1949. This would be useful.

1. For selecting both for SCA and GCA
2. For improving two source population simultaneously.

Procedure : 2

I year : Two source populations (A & B) are taken, several phenotypically superior plants are selected from each population. Each of the selected plant is selfed. Each of the selected plant from source A is crossed with random plants from B. Similar each of the selected plants are crossed with random plants of A. plants of a will act as tester for B. The selfed seed is harvested separately and saved for planting in III year. Top crossed seed from each plant is also harvested separately.

II year: Two replicated yield trials are conducted, progeny rows of Test cross seeds of population A in one plot and test cross seeds of population B in another plot are raised. Plants (I year) producing superior progenies (in II year) are identified.

III year: Selfed seed (saved in I year) from plants selected on the basis of evaluation of progeny rows (in the II year) is planted in plant to row progeny in two crossing plots. Seeds of selected plants from population A in one plot and that of the B in another plot. All possible intercrosses among the progeny rows in each plot are made. Equal amount of seed from all intercrosses from the crossing plot A is mixed to raise the source population of 'A' next year. Similarly equal amount of seed from inter crosses of plot B is mixed to raisesource population B next year. This completes original selection cycle.

IIIyear : Source populations of A & B are raised from composited seeds of A & B (III year).

IV year: Operations of the first year i.e. selection of plants, selfing and crossing with the plants of other population etc. are done.

V year: Operations as in second year are repeated.

VI year: Operations as in third year are repeated. This completes first selection cycle. The populations may be subjected to further selection cycles, if necessary by repeating the procedure outlined above.

Q.3. **Define Plant Breeding?**
Explain in brief general objectives of plant breeding.

Ans:

Plant Breeding: 1

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 benefitof mankind.

General Objectives of Plant Breeding: (point wise brief description & e.g. is necessary) 3
of any 6-8 objectives of following...

1. Higher yield
2. Improved quality
3. Abiotic resistance
4. Biotic resistance
5. Change in maturity Duration / Earliness
6. Determinate Growth
7. Dormancy
8. Desirable Agronomic Characteristics
9. Elimination of Toxic Substances
10. Non-shattering characteristics
11. Synchronous Maturity
12. Photo and Thermo insensitivity
13. Wider adaptability
14. Varieties for New Seasons

Q.4. **Explain in brief clonal selection.**
Write merits and demerits of clonal selection.

Ans: **Clonal selection:** 2

The various steps involved in clonal selection are briefly mentioned below.

First year : From a mixed variable population, few hundred to few thousand desirable plants are selected. Rigid selection can be done for simply inherited characters with high heritability. Plants with obvious weakness are eliminated.

Second year : Clones from the selected plants are grown separately, generally without replication. This is because of the limited supply of propagating material for each clone, and because of the large number of the clones involved. Characteristics of the clones will be more clear now than in the previous generation. Based on the observations the inferior clones are eliminated. The selection is based on visual observations and on judgement of the breeder on the value of clones. Fifty to one hundredclones are selected on the basis of clonal characteristics.

Third year : Replicated preliminary yield trial is conducted. A suitable check is included for comparison few superior performing clones with desirable characteristics are selected for multilocation trials.At this stage, selection for quality in done. If necessary, separate disease nurseriesmay be planted to evaluate disease resistance of the clone s.

Fourth to eighth years : Replicated yield trials are conducted at several locations along with suitable check. The yielding ability, quality and disease resistance etc. of the clones arerigidly evaluated. The best clones that are superior to the check in one or more characteristics are identified for release as varieties.

Ninth year : The superior clones are multiplied and released as varieties.

Merits: (Any 2) 1

1. Varieties are stable and easy to maintain
2. Avoids inbreeding depression
3. Clonal selection, combined with hybridization generates necessary variability forseveral selections.
4. Only method to improve clonal crops
5. Hybrid vigour is easily utilized selection may be used in maintaining the purity of clones.

Demerits: (Any 2) 1

1. Selection utilizes the natural variability already present in the population.
2. Sexual reproduction is necessary for creation of variability through hybridization.
3. Applicable only to the vegetatively propagative crops.

Q.5. **Enlist different breeding methods in self-pollinated crops.**
Discuss in brief advantages and limitations of pure line selection. 2

Ans: **Methods of Breeding in self-pollinated crops:** (Any 8 of....)

Plant breeding methods that are used for genetic improvement of self-pollinated or autogamous species include:

1. Plant Introduction

2. Pureline selection
3. Mass selection
4. Pedigree method
5. Bulk method
6. Single seed descent method
7. Backcross method
8. Heterosis breeding
9. Mutation breeding
10. Polyploidy breeding
11. Distant hybridization
12. Transgenic breeding.

Four breeding approaches, *viz.*, recurrent selection, disruptive selection, diallele selective mating, and biparental mating are used for population improvement.

Advantage of pureline selection: (Any 2) 1

1. The purelines are extremely uniform since all the plants in the variety willhave the same genotype.
2. Attractive and liked by the farmers and consumers.
3. Purelines are stable and long test for many years.
4. Due to its extreme uniformity the variety can be easily identified in seed certification programmes.

Limitations of pureline selection: (Any 2) 1

1. New genotypes are not created by pureline selection.
2. Improvement is limited to the isolation of the best genotype present in population.
3. No more improvement is possible after isolation of the best available genotype in the population.
4. Selection of pureline requires great skill and familiarity with the crop.
5. Difficult to detect small differences that exist between cultures
6. The breeder has to devote more time
7. Pure lines have limited adaptability hence can be recommended for cultivationin limited area only.

Q.6. **Define polyploidy.**

Discuss in brief applications of autopolyploidy in crop improvement with their limitations.

Ans: **Polyploidy:** 1

Polyploidy may be defined as a condition in which a normally diploid cell or organism acquires one or more additional sets of chromosomes.

Autopolyploidy in crop improvement: 2

Triploids are produced by hybridization between tetraploid and diploid strains. They are generally highly sterile, except in a few cases. This feature is useful in the production of seedless watermelons. In certain species, they may be more vigorous than the normal diploids, e.g., in sugarbeets. These two examples are described in some detail.

Seedless watermelons are produced by crossing tetraploid (4x, used as female) and diploid (2x, used as male) lines, since the reciprocal cross (2x x 4x) is not successful. The triploid plants do not produce true seeds; almost all the seeds are small, white rudimentary structures like cucumber (*Cucumis sativus*) seeds. But few normal size seeds may occur which are generally empty. For good seed setting pollination is essential. For this purpose diploid lines are planted in the ratio 1 diploid : 5 triploid plants. There are several problem *viz.,* genetic instability of 4x lines, irregular fruit shape, a tendency towards hollowness of fruits, production of empty seeds and the labour involved in trioploid seed production.

Triploid sugarbeet : Among root crops triploid sugar beets apparently represent the optimum level of polyploidy because 3n plants have longer roots than diploid and also yield more sugar per unit area.

Tetraploid rye: the advantage of tetraploid over its diploid counterpart are large kernel size, superior ability to emerge under adverse condition and higher protein content.tetraploid rye varieties have been released for cultivation. eg. Double steel, Tetra petkus.

Limitations of autoployploidy: (Any 2 ...) 1

1. Larger size autoployploiods generally contain more water and produce less dry matter content than diploids
2. High sterility with poor seed setting is observed
3. Due to complex segregation, progress through selection is slow
4. Monoploids and triploids cannot be maiontained except through clonal propagation
5. The varieties cannot be produced at will
6. Effects of autopolyploidy cannot be predicted.

Q.7. **How to develop a multiline variety?**
State characteristics of a good multiline.
Give its achievements in plant breeding.

Ans: **Development of multiline varieties:** 2

A multiline variety is usually created by mixing the seeds of several lines that are similar in appearance but have different genes for resistance to a given disease. There are two main steps in the development of multilines:

1. Development of component lines
2. Evaluation and grouping of the components.

1. **Development of component lines:**

The resistance genes are incorporated in an elite variety or line to produce as many near-isogenic lines as there are distinct R genes. This is done through a conventional backcross programme (5-6 backcrosses), a limited backcrossing (2-3 backcrosses, followed by pedigree selection) or by making double or multiple crosses. The lines obtained from the last two approaches are likely to differ for agronomic and other features as well; therefore, a detailed evaluation of such lines is essential.

2. **Evaluation and grouping of the components:**

The number of component lines should be large. 15-20 according to Borlaug (1959), if durability of resistance is desired. But if a reduced level of disease is the objective, a rather small number of component lines would be adequate.

Characteristics of a good multiline: 1

1. Its genetic diversity for vertical resistance genes for the concerned disease
2. The vertical resistance genes should be strong enough
3. It should have normal resistance to other diseases
4. Components of multiline should be uniform for agronomic and other features.
5. It should have yield advantage

Achievements in plant breeding: (Any 2-3 ...) 1

Multiline variety appears to be a useful approach to control disease like rusts where new races are continuously produced. In India, four multiline varieties have been released in wheat. Kalyan Sona and Sonalika, one of the most popular varieties during the late sixties were used as the recurrent parent to produce these varieties. Variety 'KSML3' consists of 8 lines having rust resistance genes from Robin, Ghanate, K1, Rend, Gabato, Blue Bird, Tobari, etc. Multiline 'MLKS11' is also a mixture of 8 lines ; the resistance was derived from E6254, E6056, E5868, Frecor, HS19, E4894, etc. The third variety, KML 7406, has 9 lines deriving rust resistance from different sources. In addition, Sonalika Multiline-1 was released for cultivation in Punjab state (six component lines).

Q.8. **What is hybridization?** 1
Explain in detail steps involved in hybridization.

Ans: **Hybridization:** Mating or crossing of two plants or lines of dissimilar genotype is known as hybridization. 1

Steps involved in hybridization: (point wise brief description is necessary)

1. Choice or selection of parents
2. Evaluation of parents *i.e.* by selfing and studying the progeny
3. Emasculation 2
4. Crossing or pollination
5. Bagging & Labelling
6. Harvesting of F1 seed
7. Raising F_1 generation

Q.9. Write short notes on
Plant introduction b) Mechanisms promoting cross pollination

Ans: a) **Plant Introduction:**

Plant introduction consists of taking a genotype or a group of genotypes of plants into new environments where they were not being grown before. Introduction may involve new varieties of a crop already grown in the area, wild relatives of the crop species or a totally new crop species. Mostly materials are introduced from other countries or continents. But movement of crop varietie s from one environment into another within a country is also introduction. Some examples of within the country introduction are popularization of grape cultivation in Haryana, Introduction of wheat in West Bengal, Rice in Punjab etc.

Primary Introduction : When the introduced variety is well suited to the new environment, it is released for commercial cultivation without any alteration in the original genotype, this constitutes primary introduction. Primary introduction is less common, particularly in countries having well organized crop improvement programmes. Introduction of semi dwarf wheat varieties Sonora 64, Lerma Roja and of semi dwarf rice varieties Taichung Native 1 (TN-1), IR-8 and IR-36 are some examples of primary introductions.

Secondary Introduction: The introduced variety may be subjected to selection to isolate a superior variety. Alternatively, it may be hybridized with local varieties to transfer one or few characters from this variety to the local ones these processes are known as secondary introduction. Secondary introduction is much more common than primary introduction.

Examples of secondary introduction are Kalyan Sona and sonalika wheat varieties selectedfrom material introduced from CIMMYT, Mexico.

Procedure of Plant Introduction:

Introduction consists of the following steps: **(point wise brief description is necessary)**

1. Procurement, 2. quarantine, 3. cataloguing, 4.evaluation,
5. multiplication and 6. distribution.

or

Purpose/ objectives of plant introduction:

- To obtain an entirely new crop plant.
- To serve as new varieties.
- To be used in crop improvement.
- To save the crop from diseases and pests
- For scientific studies
- For aesthetic value.
- Varieties selected from introductions.
- Varieties developed through hybridization .
- Other examples of varieties developed through hybridization

with introductions are pusa Ruby tomato obtained from a cross between Meeruti and Sioux ; Pusa Early Dwarf Tomato derived from the cross Meeruti x Red Cloud ; Pusa Kesar carrot, Pusa Kanchan turnip etc.

Merits:

It provides entirely new crop plants.

It provides superior varieties either directly or after selection & hybridization.

Introduction and exploration are the only feasible means of collecting germplasm and to protect variability from genetic erosion.

It is very quick & economical method of crop improvement, particularly when the introductions are released as varieties either directly or after a simple selection.

Plants may be introduced in new disease free areas to protect them from damage, e.g.,coffee and rubber.

Demerits:

The demerits of plant introduction are associated with the introduction of weeds, diseases and pests.

b) Mechanisms promoting cross pollination: (at least 4) 2

There are several mechanism that facilitate cross-pollination; these mechanisms are described briefly.

1. **Dicliny :** *Dicliny* or *unisexuality* is a condition in which the flowers are either staminate (male) or pistillate (female).

a) **Monoecy.** Staminate and pistillate flowers occur in the same plant, either in the same inflorescene, *e.g.,* Castor, mango and coconut, or in separate inflorescences, chestnut, strawberries, rubber, grapes and cassava.

b) **Dioecy.** The male and female flowers are present on different plants, *i.e.,* the plants in such species are either male or female, *e.g.,* papaya, date, hemp, asparagus, and spinach. In general, the sex is governed by a single gene, e.g., asparagus and papaya. In some cases, there are hermaphrodite plants in addition to males and females, and a number of intermediate forms may also occur.

2. Stamens and pistils of hermaphrodite flowers may mature at different timesfacilitating cross-pollination.

a) **Protogyny.** In crop species like bajra, pistils mature before stamens.

b) **Protandry.** in crops like Maize and sugarbeets, stamens mature before pistils.

3. In Lucerne or alfalfa, stigmas are covered with a waxy film. The stigma does not become receptive until this waxy film is broken. The waxy membrane is broken by the visit of honey bees which also effect cross-pollination.

4. A combination of two or more of the above mechanisms may occur in

some specie. This improves the efficiency of the system in promoting cross-pollination. For example, Maize exhibits both monoecy and protandry.

5. **Self-Incompatibility**. It refers to the failure of pollen from a flower to fertilize the same flower or other flowers on the same plant. Self-incompatibility is of two types : sporophytic and gametophytic. In both the cases, flowers do not set seed on selfing. Self-incompatibility is common in several species of Brassica, some species of Nicotiana, radish, rye and many grasses. It is highly effective in preventing self- pollination.

6. **Male Sterility.** Male sterility refers to the absence of functional pollen grains in otherwise hermaphrodite flowers. Male sterility is not common is natural populations. But it is of great value in experimental populations, particularly in the production of hybrid seed. Male sterility is of two types : genetic and Cytoplasmic. Cytoplasmic male sterility is termed Cytoplasmic-genetic when restorer genes are known. In view of the importance of self-incompatibility and male sterility, a more detailed discussion on them follows later.

Q.10 **Define Molecular marker.**
Enlist different types of molecular markers.
Describe any one in detail.

Ans: **Molecular marker:**

Molecular marker is a DNA or gene sequence within a recognized location on a chromosome which is used as identification tool. 1

Types of molecular markers: (atleast 4) 1

Non PCR based markers:

RFLP
DArt

PCR based markers:

RAPD
AFLP
ISSR
SSR
SNP

(Description of any 1 as...)

Randomly-amplified polymorphic DNA markers (RAPD): 2

In 1991 Welsh and McClelland developed a new PCR-based genetic assay namely randomly amplified polymorphic DNA (RAPD). This procedure detects nucleotide sequence polymorphisms in DNA by using a single primer of arbitrary nucleotide sequence. In this reaction, a single species of primer anneals to the genomic DNA at two different sites on complementary strands of DNA template. If these priming sites are within an amplifiable range of each other, a discrete DNA product is formed through thermocyclic amplification. On an average, each primer directs amplification of several discrete loci in the genome, making the assay useful for efficient screening of nucleotide sequence polymorphism between individuals. They are dominant markers and hence have limitations in their use as markers for mapping, RAPD assay has been used by several groups as efficient tools for identification of markers linked to agronomically important traits, which are introgressed during the development of near isogenic lines. The application of RAPDs and their related modified markers in variability analysis and individual-specific genotyping has largely been carried out, but is less popular due to problems such as poor reproducibility faint or fuzzy products, and difficulty in scoring bands, which lead to inappropriate inferences.

OR (Any other one)

SECTION 'B'

Q.11 **Define following.** terms :

1. **Acclimatization:** The process that leads to the adaptation of a variety to a new environment is known as acclimatization. 1
2. **Recurrent parent :** The recipient parent is repeatedly used in the backcross programme, it is also known as the recurrent parent. 1
3. **Heritability:** Heritability is defined as the proportion of the total variation in a given phenotype within a population that is attributable to genetic variance. 1
4. **Inbreeding depression:** Inbreeding depression refers to the decrease or loss of fitness and strength which is mainly caused due to inbreeding. 1

Q.12 **Fill in the blanks.**

1) CIMMYT stands for **Centro International de Majoramiento de Maize y Trigo (or International Centre for Wheat and Maize Improvement)** 1
2) **Dee geo woo gen** is a source of dwarfing gene in rice. 1
3) First artificial hybrid between carnation and sweet William was made by **Fairchild.** 1
4) Flower opens only after pollination is known as **Chasmogamy.** 1

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