Model Answer Set

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

Semester	:	**III (New)**	**Academic Year**	:	**2023-24**			
Course No.	:	**GPB 232**	**Title**	:	**Fundamentals of Plant Breeding**			
Credits	:	**2 (1+1)**						
Day& Date	:		**Time**	:		**Total Marks**	:	**40**

		SECTION "A"	Mark
Q.1		**Define self incompatibility, classify it and explain its utilization in plant breeding.**	
		Self incompatibility: Self Incompatibility has been defined as the prevention of fusion of fertile male and female gamets after self pollination.	1
		Classification of Self incompatibility: Lewis (1954) has suggested various classification. 1) Heteromorphic system 2) Homomorphic system a. Gametophytic control b. Sporophytic control.	1.5
		Utilization of Self incompatibility in Plant Breeding **1.Production of Hybrids:** Self incompatibility provides a way for hybrid seed production without emasculation and without restoring to genetic or cytoplasmic male sterility. Self incompatibility has been utilized for production of commercial hybrids in *Brassica* and sunflower. Tow Self incompatible lines are planted in alternate row for hybrid seed production. Harvest from both the lines would be hybrid seed. In Japan Self incompatibility is used for commercial seed production. **2.Combining desirable genes:** Self incompatibility 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 specifically in fruit crops, helps fruit growers to increase the yield of fruit providing suitable pollinators.	1.5

Q.2		Write short note (Any two)	
	a	**Transgenic Male Sterility (TrGMS):** • ***Barnase/Barstar*** system is good example of transgenlc male sterility. • The ***Barnase gene*** of *Bacillus amyloliquefaciens* encodes an **RNase**. When **Barnase gene** is driven by **TA29** promoter, it is expressed only in tapatum cell causing their degeneration. Transgenic plants expressing ***Barnase*** in their tapatum cells were completely male sterile. • Another gene ***Barstar*** in their from the same bacterium encodes a protien, which is highly specific inhibitor of ***Barnase RNase.*** • Therefore transgenic plants expressing both Barnase/Barstarare fully male fertile. • The *Barnase* gene has been linked to bar gene, which specifies resistance to the herbicide phoshinothricin. • This male sterile line can be maintained by crossing it with male fertile line. The progeny so obtain contain **1 male sterile(50%):1male fertile(50%),** later are easily eliminated at seedling stage by *phoshinothricin* spray. • The male sterile plants are crossed with homozygous ***Barstar*** line (it serve as restorer) to obtain male fertile progeny.	2
	b	**Landmark achievements of Plant Breeding:** **1.Production of Semi-dwarf cereal varieties:** Rice: Development of dwarf varieties by introducing gene "Dee gee woo gene". e.g. TN 1,Jaya, dwarf early maturing varieties of Japonica rice from Taiwan introduced in India (1966). Wheat: Kalyan Sona, Sonalika, Malvika etc. which are high yielding and disease resistance . Dr. Norman Borlaug used Japan variety" Norin 10" as a source of dwarfing genes in wheat. Semi-Dwarf /dwarf varieties are lodging resistant varieties, fertilizer responsive and high yielding, disease resistanant and photo insensitive. **2. Nobilization of Sugarcane:** Indian canes: Saccharum barberi (hard, poor in yield and sugar content). Tropical canes: S. officinarum (thicker stem,high yield and sugar content). Showing poor performance in North India due to low temperature. C.A. Barber and T.S. Venkatraman at Sugarcane Breeding Institute, Coimbatore made crosses between *Saccharum barberi X S. officinarum*.Transfered thick and high sugar contents from tropical noble cane to North Indian canes(Nobilization of Sugarcane). **3. Development of Hybrids and Synthetics.** **Sorghum** : CSH1, 5,6,8R,9,10,11,12R,13R,14 ,16R **Maize**: Deccan Hybrid, Ganga Safed,-2, Rajarshee. Composite:, Manjari ,Vikram,Sona,Vijay, Kisan Hunis, African Tall,Karvir,.	2

		Bajra : BK 560,and WCC 75 (composite)s, ICMS 7703 , ICTP8203,Dhanshakti(synthetic), PBH- 10,BJ 104,BK 560,Shraddha, Saburi, Shanti and Adishakti (Hybrids) **Cotton**: H4 (1970), JK Hy.1, H6, Varlaxmi, CBS 156, Savitri, RHH 492, RHC 388. **4.Molecular Breeding:** Marker aided Selection (MAS)-Improved Pusa Basmati-1 BLB resistance rice variety., Sambha Masuri, Submergence tolerance rice variety Swarna Sub-1, Maize hybrid Vivek QPM-9, Pearl Millet Hybrid Improved HHB-67,. Transgenic-BT cotton hybrid, Mustard hybrid DMH-111 Genome sequencing-Arabidopsis, pearl millet, wheat, chickpea etc.	
	c	**Heritability:** • The ratio of genotypic variance to phenotypic variance or total variance is known as heritability. • It is index of transmission of character from parent to offspring. **Types of heritability:** **1.Broad Sense heritability:** • It is ratio of genotypic variance to total or phenotypic variance. • It is calculated from total variance which consist of additive, dominance and epitasis variances. • It plays important role in animal breeding, but not much useful in plant breeding because in plants the environmental effects can not controlled. **2. Narrow sense heritability:** • It is the ratio of additive or fixable genetic variance to the total or phenotypic variance. • It is useful in both animal and plant breeding. • Ti is estimated from additive genetic variance. • It is useful in the selection of elite types from segregating populations.	2
Q.3		**What is panmictic population? Explain Hardy-Weinberg law and factors affecting gene frequency in population**	
		Panmictic population/random mating population mendelian populations : The population in which each individual of the population has equal opportunity of mating with any other individual of that population.	1
		Hardy-Weinberg law: This law states that gene and genotypic frequencies in Mendellan population remain constant generation after generation if there is no selection, mutation, migration or random drift.	1
		Factors affecting gene frequency in population: **1.Migration:** Movement of individual from one population into different population and participation in the reproduction of this population.	2

		2.Mutation: It is sudden heritable change in character of an organism and generally due to structural changes in concerned gene. It is ultimate source of variation preset in biological material. Mutation may produce new allele not present in population. **3.Random drift or genetic drift:** It is random change in gene frequency due to sampling error. Random drift is more important in small populations because sampling error is greater in smaller population than in larger one. **4.Inbreeding:** Mating individuals sharing common parents in their ancestry is known as inbreeding. In small population , certain amount of inbreeding is bound to occur. Inbreeding reduces the proportion of heterozygotes or heterozygosity and increases homozygotes or homozygosity. **5.Selection :** Differential reproduction rates of different genotypes is known as selection. In crop improvement, selection is very important because it allows the selected genotypes to reproduce, while the undesirable genotypes are eliminated.	
Q.4		**Enlist different breeding methods of self and cross pollinated crops.**	
		Plant Breeding methods for genetic improvement of self pollinated crop species 1.Plant Introduction and acclimatization 2. Selection : a) Pure line selection b) mass selection 3. Hybridization : a) Pedigree method , b)Bulk method, c) Single seed descent method, d) Back cross method 4. Heterosis Breeding 5.Mutation breeding 6. Polyploidy breeding 7. Distant hybridization 8. Transgenic breeding 9.Multiline varieties 10.Population approach	2
		Plant Breeding methods for genetic improvement of cross pollinated crop species 1.Introduction and Acclimitization 2.Selection: A.Mass selection, B. Progeny selection: Plant to row and ear to row C. Line breeding D. Recurrent selection: Simple recurrent selection, Recurrent selection for SCA; Recurrent selection for SCA, Reciprocal Recurrent selection 3.Backcross method 4.Heterosis breeding 5.Synthetic breeding 6.Composite breeding 7.Polyploidy breeding 8.Distant hybridization 9.Transgenic breeding	2

Q.5		**Define heterosis. Enlist different theories of heterosis and explain overdominance hypothesis of heterosis**	
		Heterosis.: Heterosis may be defined as the superiority of an F_1, hybrid over both its parents in terms of yield or some other character.	1
		Heterosis theories: There are three main theories to explain heterosis : (1) Dominance, (2) Over dominance, and(3) Epitasis hypotheses.	1
		Overdominace theory of heterosis: • The idea of overdominance *i*.e. hetrozygote superiority was initially put forth by Fisher in 1903. This some times known as single gene heterosis/Superdominance . • According to overdominance hypothesis, heterozyogets at least some of the loci are superior to both relavent homozygotes. Thus Aa would be superior to both AA & aa. i.e. Aa>AA & aa • Consequently hererozygosity is essential for and cause of heterosis, while homozygosity resulting from inbreeding produces inbreeding depression. It would , therefore be impossible to isolate inbreds as vigour's as F1 hybrids if heretosis were the consequences of overdominance. • In 1936 East proposed that hererozygotes for more divergent alleles would be more heterotic than those involving less divergent ones. • For example, A_1A_4 would be superior to A_1A_2, A_2A_3, A_2A_3 and A_3A_4. • i.e. $A_1A_4 > A_1A_2$, A_2A_3, A_2A_3 and A_3A_4.	2
Q.6		**Differentiate between the followings (any two). *Consider only 5-6 differences each.**	
	1.	**Cytoplasmic Male Sterility(CMS)**	**Cytoplasmic-Genic Male Sterility(CGMS)**	2
		Controlled by cytoplasmic genes	Controlled by nuclear and cytoplasmic genes	
		Consist of A and B lines	Consist of A,B and R lines	
		Used for development of hybrids in vegetatively propagated crops	Used for development of hybrids in both seed and vegetatively propagated crops	
		It can not be used in seed propogated plants because the F_1 is sterile.	It is used in seed propogated plants because the F_1 is sterile fertile..	
		Example : Onion,sugarcane,forage crops,castor,Tur etc.	Pearlmillet,Sorghum,cotton,maize, sugarbeet,sunflower,tobaco,tomato,wheat ,rice etc.	
		Maintain by crossing of A line with B line.	Maintain by crossing of A line with B line & r line seperalely.	
	2	**Pedigree method**	**Backcross method**	2
		F_1 and the subsequent generations are allowed to self pollinate	F_1 and the subsequent generations are backcrossed to recurrent parent	
		The new variety developed by this method is different from the parents in agronomic and other characteristics	The new variety is identical with the recurrent parent, except for the character under transfer	
		The new variety has to be extensively tested before release	Usually extensive testing is not necessary before release	
		The method aims at improving the yielding ability and other	The method aims at improving specific defects of a well adapted, popular variety	

		characteristics of the variety		
		It is useful in improving both qualitative and quantitative characters	It is useful for the transfer of both quantitative and qualitative characters provided they have high heritability	
		It is not suitable for genes transfer from related species and for producing substitution of addition lines	It is the only useful method for gene transfers from related species and for producing addition and substitution lines	
		Hybridization is limited to the production of the F_1 generations	Hybridization with the recurrent parent is necessary for producing every backcross generation	
		The F_1 and the subsequent generations are much larger than those in the backcross method	The backcross generations are small and usually consist of 20-100 plants in each generation	
		The procedure is the same for both dominant and recessive genes	The procedures for the transfer of dominant and recessive genes are different	
	3	**Mass selection**	**Pureline selection**	2
		Used both in self and cross pollinated crops	Practiced in self pollinated crops only	
		Large number of plants are selected	Comparatively less number of plants are selected	
		The produce of the selected plants is mixed and sown as such in next year	Produce of individual plants is kept separate and progeny rows are raised next year	
		No control of pollination	Pollination is controlled	
		Variety developed is heterozygous and not uniform	Variety is homozygous homogeneous and uniform	
		Due to heterozygosity the variety deteriorates quickly	Due to homozygosity the variety lasts long	
		The method has to be repeated once in 2-3 years to purify the variety	No need to repeat	
		Wider adaptability due to heterozygosity	Narrow adaptability due to homozygosity	
		No knowledge of science is required. It is more an art.	Knowledge of science and genetics is required	
		Selection within a variety is effective	Selection with in a pureline variety is	
		Selection within a variety is effective	Selection with in a pureline variety is not effective	
		The variety is relatively difficult to identify	It is relatively easy to identify in seed certification programmes	
Q.7		**What is wide hybridization? Describe applications of wide hybridization in crop improvement**		
		Hybridization between individuals from different species belonging to the same genus or two different genera, is termed as distant hybridization or **wide hybridization**, and such crosses are known as distant crosses or wide crosses		1
		Applications of wide hybridization in crop improvement **1.Alien addition lines**: Carries one chromosome pair from a different species in		3

		addition to somatic chromosome complement. For Eg. Disease resistance in Wheat, oats, tobacco **2.Alien substitution lines** : has one chromosome pair from different species in place of the chromosome pair of the recipient parent. **3.Introgression of genes** : Transfer of small chromosome segments with desirable genes. Eg. **A. Disease resistance** : In Cotton transfer of black arm disease resistance from G. arboreium to G. barbadense Wider adaptation : Cold tolerance has been transferred from wild relatives to Wheat, onion, potato, tomato and grape. **Quality :** Oil quality in oil palm was impr oved by genes from wild relatives. **Changing the mode of reproduction :** **Self-incompatibility** : S.I. genes from B.campestis to self compatible B.napus for hybrid seed production. **Yield :** **Other characters :** **4.Development of New crop species** : Eg. Triticale **5. Utilization as New hybrid varieties :** Eg. **F1 hybrids in cotton** Varalaxmi cotton(G.hirsutum xG. barbadense) **Sugarcane** : All the present day commercial varieties are complex interspecific hybrids involving S. officinarum & S. spontanium	
Q.8	**a)**	**Give characteristic feature of mutations**	2
		Characteristic feature of mutations 1 Mutations are generally recessive but dominant mutations also occur 2 Mutations are generally harmful to the organism. Most of the mutations have deleterious effects but small proportion (0.1%) of them are beneficial. 3 Mutations are random i.e. they may occur in any gene. However some genes show high mutation rates than the others. 4 Mutations are recurrent 5 Induced mutations commonly show pleiotropy often due to mutation in closely linked genes.	
	b)	**What is clone? Give the various characteristics of clones**	2
		Clone : A clone is a group of plants produced from a single plant through asexual reproduction **Characteristics of a clones :** 1. All the individual belonging to a single clone are identical in genetype 2. The phenotypic variation within a clone in due to environment only 3. The phenotype of a clone is due to the effects of genotype(g), the environment(e) and the genotype x environment interaction (GxE), over the population mean(M) 4. Theoretically clones are immortal. They deteriorate due to viral/bacterial	

infection and mutations.

5. Clones are highly heterozygous and stable
6. They can be propagated generation after generation without any change.

Q.9 **Define aneuploid. Describe in brief the types of aneuploids**

Define aneuploidy: The change in chromosome number which involves one or few chromosomes of the genome is called aneuploidy and such individuals are known as aneuploids . 1

In other words, an individual with other than exact multiple of the basic chromosome number is called aneuploid.

Describe in brief the types of aneuploids. 3

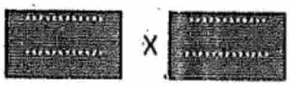
Types of Aneuploids	Definition/brief description
Aneuploid	Change in one or few chromosomes of genome (2n±few)
1.Hypoploidy	Loss of one to two chromosomes from a diploid
a.Monosomic b. Double monosomic	Loss of one chromosome from one pair (2n-1) Loss of one chromosome from each of two different chromosome pairs (2n-1-1)
c. Nullisomic	Loss of one chromosome pair(2n -2)
2. Hyperploidy	Addition of one or two chromosome to one pair or two different pairs
a.Trisomics b.Double trisomics	Addition of one chromosome to one pair(2n+1) Addition of one chromosome to each of two different chromosome pairs (2n+1+1)
c. Tetrasomic	Addition of two chromosome to one pair (2n+2) or two different pairs (2n+2+2)

Q.10 **What is synthetic variety? Discuss the various operations' in production of synthetic varieties.**

Synthetic Variety: By definition synthetic variety consists of all possible crosses among a number of lines (inbred lines/ open pollinated varieties or other population tested for GCA) that combine well with each other.

Various operations' in production of synthetic varieties:

1. Isolation of inbred lines : Jenkins (1940) suggested that inbred lines with one generation selfing can be used for development of a synthetic variety.

1st year  Tester

Harvesting top cross es seed seperately

Inbred lines/clones/OPV/material developed by recurrent selection

2 Evaluation of inbred lines for gca

2nd year 

3. Intermating of good general combining inbreds in all possible combinations

3rd year 

4. Mixing of seed of all F1 crosses in equal quantity

4th year & 5th year  Syn_1 and Syn_2

Seed is multiplied by open pollination for one or two generations

6th year Release as a new synthetic variety and distribution of seed to the farmers for commercial

		"SECTION B"	
Q.11	a)	**Spell out following abbreviations**	2
	1.	**CIMMYT**- International Centre for Wheat and Maize Improvement	
	2.	**NBPGR**- National Bureau of Plant Genetic Resources	
	b)	**Give the contribution of the following scientists.**	2
	1.	**C. T. Patel** - A famous cotton breeder who developed world's first cotton hybrid H_4 in 1970 for commercial cultivation in India.	
	2.	**Comstock, Robinson and Harvey**- Proposed Reciprocal recurrent Selection in 1949.	
Q.12		**Fill in the blanks**	4
	1.	**Bulk method** is called as evolutionary method of breeding.	
	2.	Wheat dwarfing gene Rht1 encode **DELLA domain** proteins that repress transcription of gibberellin responsive genes.	
	3.	**Single Seed Descent Method (SSD)** method is particularly suited for developing populations of recombinant inbred lines (RIL)	
	4.	**Inbred** is used as tester in Recurrent Selection for SCA (RSSCA).	