Qualitative & Quantitative Characters

* history plant breeding is abaut 12000 yrs old.

Plant breeding - It is the art and science of genetic improvement of plants through the process of selection of various agronomically important characters.

Objectives - production
- tolerant / resistant variety
- agronomical characters → height, maturation time, photosensitivity, variety
- nutrient content

→ ek ya do objective le sakte hain.

Qualitative Traits :-

- character under simple genetic control. i.e governed by one or few genes. (oligo genes).
- eg - flower colour, fruit shape.

* Mendel gave → process of heredity He observed 7 traits in garden pea

character	dominant	recessive
1) seed shape	round	wrinkled
2) cotyledon colour	yellow	green
3) seed coat colour	grey	brown/white
4) pod shape	inflated	constricted
5) unripe pod colour	green	yellow
6) flower position	axial	terminal
7) stem length	long	short

- Every single character has two separate contrasting feature i.e two phenotypes (phenotypic difference) 1 one is dominant & other is recessive.
- Environmental factor have no effect on it.
- Such phenotypic difference is called as Qualitative difference arise from major allelic difference at one or two genes. These genes are called Major genes.

Quantitative Traits 6 — by Galton 1889 (↳ he observed taller parent produce tall individual at an avg.)

- character under complex genetic control i.e. governed by many genes (polygenes)
- eg - grain yield, drought tolerance.
- these genes have an additive effect
- Galton established that hereditary transmissions are equilinear from two parents leading to proposal of law of Ancestral Heredity
- correlation & regression techniques were developed by Galton
- Johannsen 1909 - demonstrate that both heritable and non-heritable factors are responsible for variations.
- Yule 1906 - proposed that continuous quantitative variation result from a large no. of genes each giving smaller effect on characters.
- Nilsson-Ehle (1909) → Kernel colour of wheat.
- The term multiple factor was replaced by polygene. by Mather 1941.

↓

genes with small effect on a particular character which supplement each other's effects to produce observable quantitative changes.

Qualitative

1. discrete classification possible
2. governed by few genes - major genes / oligogenes
3. effect of gene is detectable
4. decline in vigour due to inbreeding & regain in vigour due to hybridization cannot be seen

Quantitative

1. Variation is continuous
2. governed by many genes each with small additive effect
3. effect cannot be measured.
4. can be seen.

Classification of Plant Breeding methods :-

Basis of classification & type of methods.

Breeding methods

A.) Application in crop Improvement

1) General methods —
1) Plant introduction
2) pure line selection
3) progeny selection
4.) mass selection
5) clonal selection
6.) pedigree method
7) bulk method
8) back cross
9) heterosis breeding
10.) SSD.
11.) synthetics & composites

2) Special methods —
1) Resistant selection
2) disruptive "
3) 1.) Mutation breeding
2) molecular "
5) polyploidy "
4) transgenic "

3) Population Improvement —
1) Recurrent selection
2) disruptive selection
3.) diallel selective approaches mating system
4) biparental mating

B) Hybridization -

1) methods involving hybridization - ① pedigree ② bulk method ③ back cross ④ heterosis ⑤ SSD ⑥ molecular breeding ⑦ population improvement approaches

2) methods not involve hybridization -
① Plant introduction
② pure line
③ mass selection
④ progeny
⑤ clonal
⑥ mutation breeding
⑦ transgenic breeding

Methods of breeding in self pollinated / Autogamous plant

- Self pollinated plants are homozygous so we can start hybridization directly.
- we have to exploit homozygosity in self pollinated crop

For genetic improvement

1. plant introduction
2. pureline selection
3. pedigree
4. mass
5. bulk
6. SSD (Single seed descent)
7. backcross
8. heterosis breeding
9. mutation "
10. polyploidy breeding
11. distant hybridization
12. transgenic breeding

Population improvement → 4
1. Recurrent selection
2. biparental mating
3. Disruptive selection
4. diallel selective mating

For allogamous / cross pollinated -

- heterozygous so we cannot start direct hybridization
- we have to 1st develop inbred lines by selfing / inbreeding
- we have to exploit heterozygosity.

for genetic improvement -
1. plant introduction
2. mass selection
3. progeny
4. back cross
5. heterosis
6. synthetic & composite
7. polyploidy
8. distant
9. transgenic

for population improvement - → 3.
1. Recurrent selection
2. biparental mating
3. disruptive "

For Asexually propagated species -

1. plant intro
2. mass selection (rarely use)
3. clonal
4. heterosis
5. mutation
6. polyploidy
7. distant
8. transgenic.

* plant introduction use in all above 3 plants.
3 ways it is used
1. Directly as a variety
2. As a variety after selection
3. As a parent in hybridization for development of variety or hybrid.

Heterosis :- It is defined as the superiority of f_1 hybrid over both the parents in terms of yield or some other character. also called hybrid vigour

→ 1st used by Shull in 1914.

Types of heterosis :-

① **Average heterosis** .

when f_1 is superior to mid parent value
OR
f_1 superior to average of two parents.

f_1 superior $= \frac{\text{parent A} + \text{parent B}}{2}$.

② **Heterobeltiosis**

superiority of f_1 over better parent
→ better parent

~~Parent A~~ parent A × parent B
~~20%~~ yield ~~50%~~ yield

f_1 = superior to parent B

③. **Economic heterosis** :- superiority of f_1 compared to high yielding variety in a particular crop

parent A × parent B
20% 50% yield.

f_1 = superior parent B.

④ **Negative heterosis** -

performance of f_1 inferior to better parent.

parent A × parent B
20 50
↓
f_1
↳ 30.

Inbreeding → mating of plant with its common ancestory.
↳ when cross pollinated / asexually reproduced plant are subjected to selfing they loose their vigour
This is called inbreeding depression.

Back Cross method

Back cross - A cross b/w hybrid and one of its parents.

Back cross method - hybrid and the progenies in the subsequent generation are repeatedly back crossed to one of its parent.

↓ after 6-8 back cross

The progeny would almost identical to parent

Objective :- To improve one or two specific defects of a high yielding variety which is well adapted to our

recipient

eg - Malviya 12 → leaf rust (wheat variety)

donor ← sparrow → Rust resistant.

- Recurrent parent - Reciptent parent
- Non-recurrent parent - donor parent, it is used only once in breeding programme.

Applications:-

① Intervarietal transfer of simply inherited characters.
eg disease resistant, seed colour, etc.

② linkage drag → transfer of character fail due to linkage of gene being transfered.

③ Intervarietal (within variety) transfer of Quantitative character

④ Transfer of cytoplasm

⑤ Interspecific (within species) transfer of simply inherited gene.

⑥ Recovery of transgressive segregant

⑦ germplasm ~~conser~~ conversion.

⑧ production of near isogenic lines.

For dominant gene

1st year — Non-recurrent parent (B) × Recurrent parent (A)

rust resistant → RR × rr

RR × rr

resistant F_1 → Rr

(50%) of A & 50% of B.

2nd year

(50% A) (100% A)

Rr × rr

25% ↓ 50% ← create disease epiphytotic condition

Rr ; rr ⇒ BC_1

75% A

3rd year

75% A

Rr × rr (100%)

37.5% ↓ 50% ⇒ BC_2

Rr , rr

87.5%

4th year —

Rr × rr ↓50%

43.75% A ↓ ⇒ BC_3

Rr , rr × reject.

93.75%

5th year — 93.75

Rr × rr 100% ⇒ BC_4

46.8% ↓ ↓50%

Rr, rr

96.87% A

6th year — 96.87

Rr × rr 100% ⇒ BC_5

48.43% A ↓ ↓50

Rr, rr

98.43%

7th year — 98.43%

Rr × rr 100% ⇒ BC_6

49.21% ↓ ↓50%

Rr, rr ×

98.21%

8th years → ▭ → Individual plant selection

9th year — ▭ → grow in row → Best row are selected

10th year ▭ → Preliminary varietal trial

11-13 yr ▭ → Multilocation trial

14th yr — ▭ Multiplication

For recessive gene

→ expresses only in homozygous condition

non-recurrent B × Recurrent A.

rust resistant → rr × RR.

1st yr Rr → F_1 (No selection)

2nd yr. Rr × RR. → BC_1

× RR, Rr → No selection

selfing

3rd yr RR, RR, Rr, rr

selection

4th yr rr × RR → BC_2

Rr

5th yr Rr × RR → BC_3

× RR, Rr (No selection)

selfing

6th yr RR, RR, Rr, rr selection

7th yr rr × RR → BC_4

Rr

8th Rr × Rr → BC_5.

9th selfing

RR, RR, Rr, rr

10th → ▭ - Individual plant selection F_3.

11th → PVT

12th → Multilocation

13th → Multiplication.

Recurrent Selection (RS) → 1st coined by Hull in 1945

* 1st suggested by Hayes & Garber 1919.
* East & Jones → 1920
* mainly RS worked after 1945 when Hull suggested that RS may be useful improving SCA (Specific combining ability).

Recurrent selection → accumulation of desirable gene in population

reselection generation after generation with intermating of selected plant to produce population for next cycle of selection

population —RS→ superior inbreds → hybrid variety
→ synthetic variety

RS are variation of modification of progeny selection (ear to row method)

Type of RS →
1. Simple RS
2. RS for General combining Ability
3. RS for Specific " "
4. Reciprocal RS

1. Simple RS — does not include tester, also called as phenotypic RS.

objective →
1. increase frequency of desirable gene
2. most suited character with high heritability
3. more efficient mass selection with self pollination.

Procedure

original selecting cycle

1st yr — original population
1.) several superior phenotypic plant selected
2.) selected plant self pollinated
3) selfed seed harvest separately
4) selfed seed evaluated, superior seeds retained.
oil & protein content

2nd yr — intercross block
1) individual plant progeny planted
2) All possible intercross made
3) Equal amount of seed from all intercross composited

1st recurrent cycle

3rd yr — composited of intercross
1.) composite intercross seed planted.
2-4) same as in 1st yr.

4th yr — intercross block.
1) individual plant planted
2-4) same as in 2nd yr.

↓
may be repeated as in the 1st recurrent cycle. till superior inbreads are formed

General Combining Ability

Use –
- synthetic, composite variety
- additive gene action
- narrow sense heritibility
- homozygosity, self pollination
- selection of parents

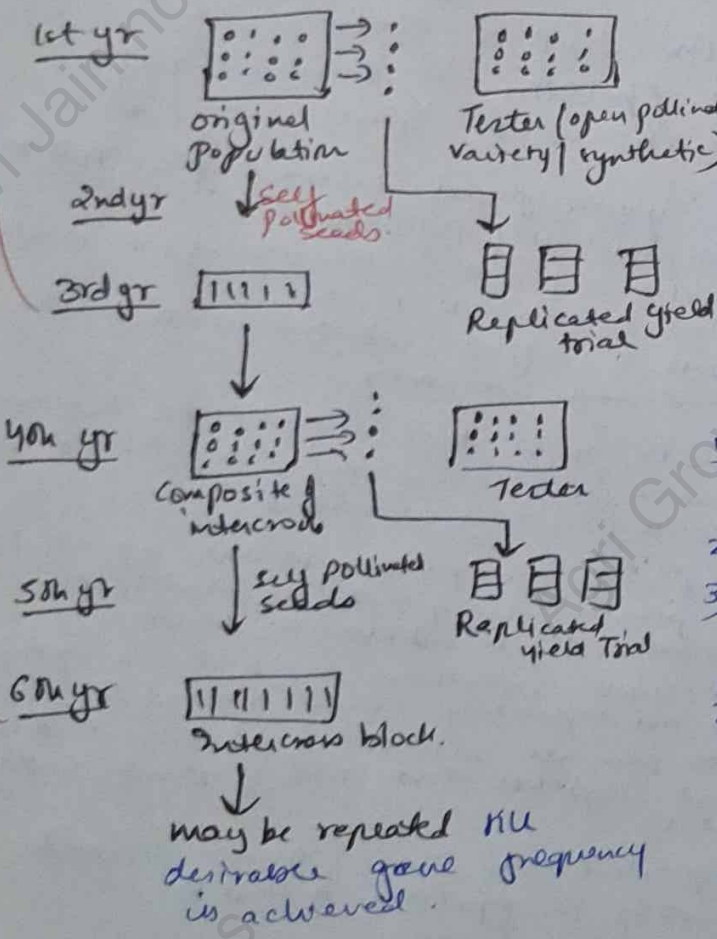
↳ A RS use for GCA of a population for a character & ~~thy~~ heterozygous tester is called as RSGCA.
↔ also half sib RS.

① Tester – for checking combining ability of line
② RSGCA – is directed outgrown of the early testing supported by Jenkins 1935.

Source population – open pollinated variety / synthetic variety

RSGCA → Improve yielding ability & agronomic character of population
→ use to concentrate gene for superior CGA.

Procedure



1) several phenotypically superior plants selected
2) selected plant self pollinated
3) Test cross as male to a no. of randomly selected plant from tester with broad genetic base
4) Test crossed seeds and selfed seeds from each selected plants harvest separately.

1.) RYT is conducted using test crossed seeds
2) Superior progenies identified.

1) selfed seeds from plants producing superior test cross progenies planted in intercross block.
2) all intercross block made
3) equal amount of seeds from all intercross composited.

1) composited seeds from intercross planted
2) same to do as in 1st yr

1) same as 2nd yr.

1) same as 3yr

tester is an inbred line which has narrow genetic base

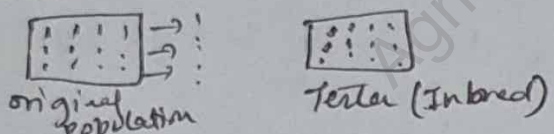
Specific Combining Ability

↳ use to improve SCA of population character by using homozygous tester → half sib.

* Hull 1945
* related to heterosis
** tester should be taken as an outstanding inbred.

objective – To isolate from a population such lines that combine well with a given inbreds.

procedure –



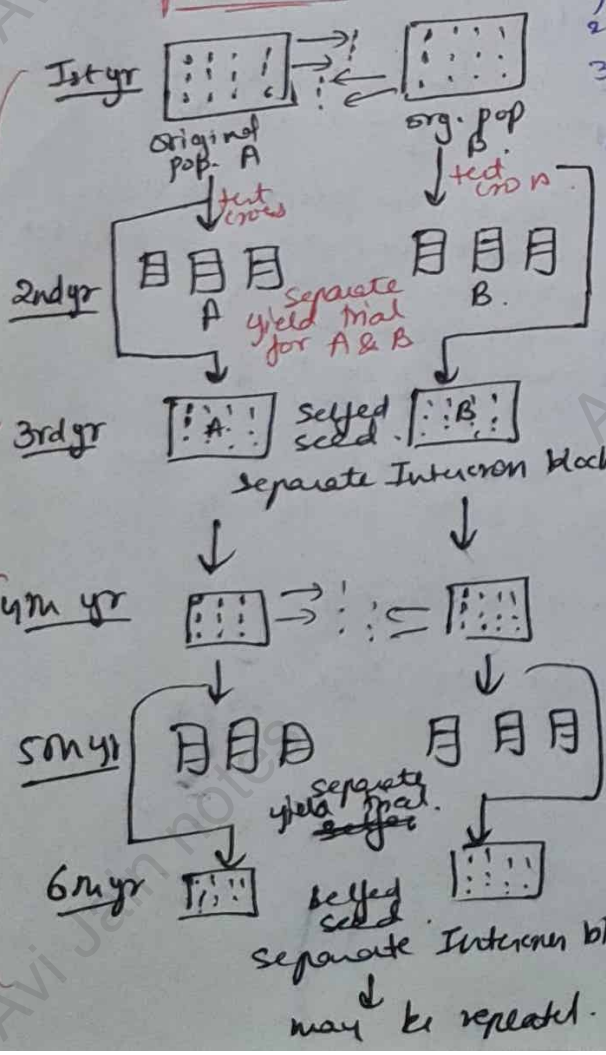
same as GCA.

Reciprocal RS → also called recurrent reciprocal half-sib → use heterozygous tester

* Proposed by Comstock, Robinson & Harvey in 1949.

objective – improve 2 different population in their ability to combine well with each other.

procedure



1) several superior plant selected from A & B
2) selected plant self pollinated
3) Each selected from A is test crossed with random selected B. and vice versa
4) Test cross & selfed seeds from each plants harvest ~~and~~ separately.

1) separate yield trial conducted for test cross progenies of selected population from A & B
2) superior progenies identified.

1) selfed seeds from plant produces superior test cross progenies and planted separately for population A & B in intercrossing block
2) all possible intercross are made among progenies of A and separately among those of B.
3) seeds from all intercross of population A & are mixed together and those of B are mixed together

1) Composited seeds from intercross planted separately in population A and B
2) ii – iv as in 1st yr

i – ii) same as 2nd yr

same as 3rd yr.

Main features of these methods :-

1. to improve polygenic characters
2. Selection on basis on ~~tester~~ test cross performance
3. Improving GCA & SCA population for specific characters
4. 2 heterozygous testers used as a source population
5. This method requires 3 seasons for completion of each cycle of selection
6. Improve those characters which are governed by both additive & non-additive gene action.
7. equally effective with complete, incomplete & over dominance

Merits

1. breaks repulsion phase of linkage
2. maintain high genetic variability due to repeated intermating of heterozygous population
3. increase frequency of superior genes for various economic characters.

Demerits

1. not directly use for development of new varieties
2. lot of selection crossing & selfing
3. selfing causes loss of genetic variability

variety is developed from cultivar of systemic breeding program

Date
Page

Crop Improvement

Kind of germplasm sum total of hereditary material.

1) **Land races** — These are primitive cultivars which were selected and cultivated by the farmers for many generations without systemic plant breeding efforts. land races have high level of genetic diversity which provides them high degree of resistance to biotic & abiotic stresses.

2) **Obsolete cultivar** —
There are the varieties developed by systemic breeding efforts which were popular earlier and now have been replaced by new varieties.

3) **Modern cultivar** — The currently cultivated high yielding varieties are referred to as modern cultivar. also called advance cultivar. and also improved cultivar.

4) **Advance breeding lines** — There are pre-released plants which have been developed by the plant breeder in modern scientific breeding program. also called advance breeding lines

5) **Wild relatives** :— Those naturally occuring plants species which have common ancestory with crop and on cross with crop species are called wild relatives or wild species.
or off type.

Type of gene pool / Classification of gene pool

1) Based on degree of relationship the gene pool of crops can be divided into 3 groups

→ Harland & David → gave gene pool. (1971)

Primary gene pool (GP-1)

- The gene pool in which hybridization is easy and leads to production of fertile hybrids is called primary gene pool.
- It includes plants of same spp or closely related spp.

Secondary (GP-2)

- The genetic material that leads to partial fertility on crossing with GP-1 is called secondary gene pool.

Tertiary

- The genetic material leads to production of sterile hybrid on crossing with primary gene pool is called tertiary gene pool.

procedure of single recurrent selection

all possible combinations (ARC) crosses $= \frac{n(n-1)}{2}$

n = total no. of progenies

② RGCA.

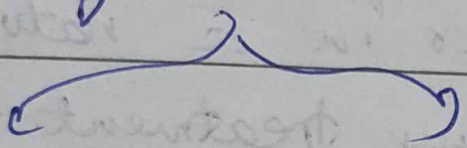
what is general combining ability.

Tester ⇒ A tester is the common parent mated to a number of lines, strains, plants. Such a set of crosses is used for the estimation of combining ability of the lines or plants.

MAM → Moderate Acute Malnutrition.

Crop Improvement → Ahasth yourself mandal

Combining ability (CA) — The ability of parent to combine amongst each other during the process of fertilization so that favorable gene or character are transmitted to their progenies.



general CA

specific CA.

Mutation Breeding → Freisleben & Lein 1944

↳ Hugo de Vries - suggest to use radiation for induced mutation → 1901-1904.

Mutation - is a sudden heritable change in a characteristic of an organism

- Mutation may be due to → ① change in gene
  ② change in chromosome no.
  ③ change in plasmagene
  ④ change in chromosome structure.

Mutation produced by change in base ~~pair~~ sequence of gene ~~like~~ like transition, deletion, duplication, inversion are called as gene / point mutation.

- bud mutation — mutation occur in bud
- somatic mutation — " " in somatic tissues] - use for propagation in clonal crop.

Mutations

Spontaneous

- mutation occur naturally
- at low rate
- frequency → 10^{-6} (one in 10 lakhs).
- different gene show different mutation rate

Induced

- artificially induced.
- by treatment with physical or chemical agents
- agents use for inducing mutation called Mutagens.
- The utilization of induced mutation for crop improvement is called mutation breeding.
- high advantage as they occur at high frequency

Characteristics of mutations? —

① generally recessive but dominant mutation also occur
② harmful to organism
③ have deleterious effect
④ are recurrent, may occur again & again
⑤ show pleiotropy
⑥ are random, may occur in any gene.

Mutagens – agents that induce mutations.

Mutagens

Physical

① Ionising radiation

a) Particulate radiation

α-rays, β rays, fast neutrons, thermal neutrons.

b) Non-particulate – electronic magnetic radiation

eg – X-rays.
γ-rays.

② Non-Ionising radiation → UV radiation

Chemical

① Alkylating agent – 1) sulphur mustard
2) nitrogen mustard
3) imines.
4) sulphates
5 sulphonates

② Acridine dyes – acridine orange, acridine yellow, ethidium bromide

③ Base analogues – 5-bromouracil
5-chlorouracil

④ others – 1) sodium azide,
~~1) nitrous a~~
2) nitrous acid.

Applications of Mutation breeding

① crop improvement
↓
high yield, nutritive value, drought, disease resistant –

② pest resistance

③ improve shelf life → fruit, vegetable

④ reduce post harvest losses

⑤ seedless varieties → grapes.

⑥ ornamental plant → unique flowers

⑦ environmental adaptation → extreme temp, saline ~~environment~~ soils

⑧ Oil & protein content.

⑨ herbicide tolerant

⑩ nutritional enhancement

⑪ Non-GMO approach

Limitation of mutation breeding

1) frequency of desirable mutation is low

2) has to screen large populations to select desirable mutations

3) produce pleiotropic effects

4) most mutations are recessive

5) registration of a mutant variety is difficult to demonstrate the new variety

6) desirable mutations associated with undesirable side effects due to other mutations

7) mutations in quantitative traits are usually in direction away from selection history of parent variety.

Micro mutation	macro mutation
① produce small phenotypic effect	
② cannot be recognize	
③ detected only in group of plant	
④ polygenic nature.	oligogenic nature.