

Experiment: Designs used in plant breeding experiment, analysis of Randomized Block Design.

Aim: To provide an introduction to experimental design including different layouts and considerations for statistical inference of RBD

Experimental design is the process of choosing treatments, responses, and controls, defining experimental and sample units, and determining the physical arrangement, or layout, of experiment units. Experiments should be designed to control error and give reasonable assurance that the differences between treatments will be detected. Time and resources always limit experimental design, and in some instances there are ethical and legal constraints as well.

Principles of experimental designs

Principles of experimental designs help in reducing the experimental error and thus make the experiment more efficient. There are three basic principles of experimental designs are briefly discussed as follow.

1. **Replication:** The repetition of treatment under investigation is known as replication. Increase in replication increases the precision by reducing the error to a greater extent.
2. **Randomization:** The allocation of treatments to different plots in an experiment by a random process is known as randomization of treatments. Randomization provides equal chance to all treatments for being allotted to more fertile plot as well as to less fertile plot.
3. **Local control or error control:** The principle of making use of greater homogeneity in a group of experimental unit for reducing experimental error is called local control. The fertility of the field may be of two types (a) Gradient (can be reduced by dividing the field into homogeneous block or replication and (b) Patches (can be minimized by randomization of treatments within the block).

Experimental designs which are commonly used in plant breeding and genetics includes

1. Simple Experimental Designs
2. Augmented Design
3. Completely Randomized Design (CRD)
4. Randomized Block Design (RBD)
5. Latin Square Design (LSD)
6. Split Plot Design (SPD)
7. Lattice Design (LD)

Randomized Block Design (RBD)

The variability present in a population is of polygenic nature and these polygenic variations are three types *viz.* phenotypic, genotypic and environmental

The statistical procedure which separate (or) splits the total variation into different component is called analysis of variance or ANOVA .

ANOVA is useful in estimating the different components of variance. It provides basis to the test of significance and it is carried out only with replicated data obtained from standard statistical experimental results. The different components of variance are calculated as suggested by Lush in 1940.

ANNOVA Table

Source	df	Ss	Mss	F-value calculated
Replication	(r-1)	Rss	Msr = Rss / r-1	Msr/Msc
Treatment	(t-1)	Trss	Mst = Trss / t-1	Mst/Msc
Error	(r-1)(t-1)	Ess	Msc = Ess / (r-1)(t-1)	
Total	(rt-1)	Tss		

F (calculated) is compared with F (table) value by looking at the F-table for replication (r-1) & error df values (r-1)(t-1). If the calculated F value is greater than F (table value) then it is significant.

Genetic variance

It is the inherent variation which remains unaltered by the environment. It is variation due to genotypes. It is denoted by V_g & is calculated using the formula

$$V_g = \frac{Mst - Mse}{r}$$

Where, Mst = mean sum of squares of treatment

Mse = mean sum of square of error

r = number of replications

Co-efficient of variation

- (1) **Phenotypic co-efficient of variation:** It is defined as the ratio of phenotypic standard deviation to the mean, expressed as % and can be calculated using the formula.

$$PCV = \frac{\sqrt{V_p}}{\bar{x}} \times 100$$

- (2) **Genotypic coefficient of variation:** GCV is the ratio of genotypic standard deviation to the mean expressed as % and is calculated using the formula

$$GCV = \frac{\sqrt{V_g}}{\bar{x}} \times 100$$

- (3) **Environmental coefficient of variation:** It is the ratio of environmental standard deviation to the mean expressed as % and is calculated using the formula

$$ECV = \frac{\sqrt{V_e}}{\bar{x}} \times 100$$

Where, V_g , V_p and V_e are the genotypic, phenotypic and environmental variance and \bar{x} is mean.

Steps involved in ANOVA

The different steps involved in preparation ANOVA table can be illustrated by the following example.

Q. Yield per plant (g) of an experiment with 8 chickpea genotypes evaluated in RBD with three replications is given below in tabular form. Prepare the ANOVA table and workout components of variance, coefficient of variance and heritability (broad sense).

Variety	r1	r2	r3	Rep. total
V1	10	12	10	32
V2	9	8	10	27
V3	12	12	10	34
V4	8	10	7	25
V5	15	13	16	44
V6	13	12	12	37
V7	10	7	8	25
V8	10	11	12	33
Tret. total	87	85	85	257

Steps

1. Grand total=257
2. Grand mean= Grand total/no of observation=257/24=10.71
3. Correction factor (CF) = (G.T)²/N = (257)²/24=2752.04
4. Tss= Total sum of square of all observation-CF = 2875-2752.04 = 122.96
5. Trss= sum of square of treatment /no of replication-CF = 8533/3-2752.04 = 98.96
6. Rss= sum of square of replication/no treatment- CF = 22019/8- 2752.04= 0.34
7. Ess=Tss-Rss-Trss = 122.96-98.96-0.34= 23.67

ANOVA Table

Source	D.F	Ss	MSs	F cal.
Treatment	7	98.96	14.14	8.3626761
Block	2	0.33	0.17	0.0985915
Error	14	23.67	1.69	
Total	23	122.96		

8. $V_g = (Mstr - Mse)/r = 98.96 - 23.67/3 = 4.15$
9. $V_e = Mse = 1.69$
10. $V_p = V_g + V_e = 4.15 + 1.69 = 5.84$
11. $GCV = \sqrt{V_g/G.M} \times 100 = \sqrt{4.15/10.71} \times 100 = 19.02\%$
12. $PCV = \sqrt{V_p/G.M} \times 100 = \sqrt{5.84/10.71} \times 100 = 22.56\%$
13. $ECV = \sqrt{V_e/G.M} \times 100 = \sqrt{1.69/10.71} \times 100 = 12.14\%$
14. Heritability (Broad sense) = $V_g/V_p \times 100 = 4.15/5.84 \times 100 = 71.05\%$
15. Genetic Advance (GA) = $K\sqrt{V_p} \times H = 2.06 \times \sqrt{5.84} \times 0.71 = 3.54$

$$16. \text{G.A \% of mean} = \text{GA/Grand Mean} = 3.54/10.71 \times 100 = 33.03$$

Result Interpretation

- A. GCV And PCV** are classified as suggested by Sivasubramonium & Madhavarmenon in 1973 as
- < 10% Low
 - 10-20% Moderate
 - > 30% High

Interpretation of Coefficient of variance

- ❖ **If, GCV > PCV**, it means little influence of environment on the expression of character. Selection for improvement of such character would be rewarding.
- ❖ **If, PCV > GCV**, it indicates that apparent variation is not only due to genotype but also due to environment. Selection for improvement of such traits sometime may be misleading.
- ❖ **If, ECV > PCV & GCV**, it indicates that environment playing significant role in expression of such characters. Selection for improvement of such traits would be ineffective.

- B. Heritability:** Jonnesen *et. al.* (1995) categorized heritability as

- <30% = Low
- 30-60% = Moderate
- >60% = Higher

Other scale of broad sense heritability

- >40% = Low
- 40% - 60% = Medium
- 60% - 80% = High
- >80% = Very High

Interpretation of heritability

- ❖ **If it is high:** Means character less influenced by environmental effect, the selection for improvement of such character may not be useful because broad sense heritability includes both fixable (additive) and nonfixable (dominance and epistasis) genetic variance.
- ❖ **If it is low:** it reveals that character is highly influenced by environmental effect, and the genetic improvement through selection would be difficult due to masking effect of environment on the genotypic effect.

- C. Genetic Advance:** It is a measure of genetic gain under selection. It refers to the improvement of near genotype value of selection lines and families over the base population.

$$\text{GA} = (\text{K}) (\text{H}) (\text{SDP})$$

Where,

H=heritability

SDP=phenotypic standard deviation

K=selection differential = $(k) (v_p) (1/2V_g/V_p)$

K= $x_s - x_o$

Where- x_s = mean phenotypic value of selected plant population

x_o = mean phenotypic value of parental plant

Interpretation of Genetic Advance (GA)

- ❖ **If GA is high:** Means character is governed by additive gene action and selection will be rewarding for improvement of such character.
- ❖ **If GA is low:** It indicates that character is governed by non-additive gene action and Heterosis breeding may be useful

Interpretation of Both Heritability and genetic advance:

- a) **High heritability and High genetic advance** means heritability mainly due to additive gene effect and hence selection may be effective.
- b) **High heritability and low genetic advance** is indicative of non-additive gene action and hence selection may not be rewarding.
- c) **Low heritability with high genetic advance reveals** that character governed by additive gene. Selection may be effective in this case.
- d) **Low heritability and low genetic advance** shows that character is highly influenced by environment and so selection would be ineffective.