Exercise.12
Formation of ANOVA table for Randomised blocks design (RBD) and comparison of means using critical difference values

Randomized blocks design (RBD)

When the experimental material is heterogeneous, the experimental material is grouped into homogenous sub-groups called blocks. As each block consists of the entire set of treatments a block is equivalent to a replication.

If the fertility gradient runs in one direction say from north to south or east to west then the blocks are formed in the opposite direction. Such an arrangement of grouping the heterogeneous units into homogenous blocks is known as randomized blocks design.

Layout of RBD

Each block consists of as many experimental units as the number of treatments. The treatments are allocated randomly to the experimental units within each block independently such that each treatment occurs once. Each treatment is replicated as many times as the number of blocks or the number of blocks are chosen to be equal to the number of replications for the treatments.

The analysis of variance model for RBD is

$Yij = \mu + ti + rj + eij$

where

μ = the overall mean

t_i = the ith treatment effect

r_j = the jth replication effect

eij = the error term

Analysis of RBD

The results of RBD can be arranged in a two way table according to the replications (blocks) and treatments.

There will be r x t observations in total where r stands for number of replications and t for number of treatments. .

The data are arranged in a two way table form by representing treatments in rows and replications in columns.

Treatment	**Replication**					**Total**
	1	2	3	……	r	
1	Y11	Y12	Y13	……	Y1r	T1
2	Y21	Y22	Y23	……	Y2r	T2
3	Y31	Y32	Y33	……	Y3r	T3
t	Yt1	Yt2	Yt3	…….	Ytr	Tt
Total	R1	R2	R3		Rr	G.T

In this design the total variance is divided into three sources of variation viz., between replications, between treatments and error

$$\text{C.F} = \frac{(GT)^2}{rt}$$

$$\text{Total SS} = \sum\sum Y_{ij}^{\ 2} - \text{C-F}$$

$$\text{Replication SS} = \frac{1}{t}\sum Rj^2 - \text{C-F}$$

$$\text{Treatments SS} = \frac{1}{r}\sum Ti^2 \ - \text{C-F}$$

Error SS = Total SS – Replication SS – Treatment SS

The skeleton ANOVA table for RBD with t treatments and r replications

Sources of variation	d-f	SS	ms	F Value
Replication	r-1	R S S	R M S	R M S/ E M S
Treatment	t-1	Tr S S	Tr M S	Tr M S/E M S
Error	(r-1) (t-1)	E S S	E M S	
Total	Rt –1	T S S		

CD = SE (d) X t

Where S.E (d) = $\sqrt{\frac{2EMS}{r}}$

t = critical value of t for a specified level of significance and error degrees of freedom

Based on the CD value the bar chart can be drawn.

From the bar chart conclusion can be written.

Problem

The yields of six nitrogen treatments on a crop in kgs along with the plan of the experiment are given below. The number of blocks is five and the nitrogen treatments have been represented by A, B, C, D, E and F.

Block I	**Block II**	**Block III**	**Block IV**	**Block V**
D 17 C 12	B 12 C 15	E 23 A 30	A 28 F 64	F 75 C 14
F 70 B 6	E 26 A 26	C 16 D 20	B 9 D 23	D 20 B 7
A 20 E 28	D 10 F 62	F 56 B 10	E 33 C 14	E 30 A 23

It is required to analyse the data.

Analysis

i) Tabulation of the data

The first step in the analysis of data is to tabulate yield figures according to block and treatments in the follow manner.

Varieties	**Blocks**					**Treatment totals**	**Treatment means**
	I	**II**	**III**	**IV**	**V**		
A	20	26	30	28	23	1277 (T_1)	25.4
B	9	12	10	9	7	47 (T_2)	9.4
C	12	15	16	14	14	71 (T_3)	14.2
D	17	10	20	23	20	90 (T_4)	18.0
E	28	26	23	35	30	142 (T_5)	28.4
F	70	62	56	64	75	327 (T_6)	65.4
Totals	**156 (B1)**	**151 (B2)**	**155 (B3)**	**173 (B4)**	**169 (B5)**	**804 (GT)**	

ii) Sums of squares for different sources

a. Correction factor (CF) = $\frac{(GT)^2}{bxt}$ Where GT is the grand total; 'b' blocks; 't'

No of treat ments = $\frac{(804)^2}{5x6}$ = 21547.2

b. Total S.S = S.S of all the observation – CF

= $20^2 + 9^2 +$ -------- + 75^2-21547.2 = 10466.8

c. S.S. due to blocks (Bss) = $\frac{B_1^2 + B_2^2 + \ldots + B_5^2}{t}$ -CF

$$= \frac{156^{2} + 151^{2} + + \ldots + 169_{2}}{6} - 21547.2$$

$$= 61.4$$

d. S.S due to treatments (tss) $= \frac{T_1^2 + T_2^2 + \ldots + T_5^2}{r} - CF$

$$= \frac{127^2 + 47^2 + \ldots\ldots + 327^2}{6} - 21547.2$$

$$= 10167.2$$

e. S.S. due to error = Total SS – Bss –tss = 10646.8-61.4-10167.2

$$= 418.2$$

iii) Table of analysis of variance

Now these values will be set down in a table of analysis of variance as given below:

Analysis of variance table

Source of variation	**D.F**	**S.S**	**M.S**	**Variance ratio 'F'**	**F 15%**
Blocks	4	61.4	15.35		
Treatments	5	10167.2	2033.44	97.24*	2.71
Error	20	418.2	20.19		
Total	29	10646.8			

* Significant at 5% level of significance

It is clear from the table that this observed value of 'F' is significant at 5% level of significance which proves that there are significant differences between the treatment means. Now, we have to test the significance of the difference between the individual treatments, and this will be done with the help of C, D as usual.

iv) Critical difference

S.E. of the difference between any two treatment means is

$$SE_d = \sqrt{\frac{2XEMS}{r}} = \sqrt{\frac{2 \times 20.91}{5}} = 2.89$$

∴ Critical difference $= SE_d \times t5\% = 2.89 \times 2.086 = 6.03$

v) Conclusions represented symbolically

The treatments have been compared by setting them in the descending order of their mean yields in the following manner

Varieties	F	E	A	D	C	B
Mean yield	65.4	28.4	25.4	18.0	14.2	9.4

The treatments which do not differ significantly have been underlined by a bar. The treatment 'F" has been found to be the best.

Learning Exercise

1) The yield of rice (in kg) with five fertilizers tested in four blocks using RBD is given the following layout. Analysis the data & interpret your conclusion.

Block 1	Block 2	Block 3	Block 4
B 10	C 13	A 19	D 20
C 16	A 21	D 24	E 36
A 20	D 21	E 32	B 9
D 23	E 31	B 10	C 13
E 33	B 11	C 14	A 24

2) An experiment was conducted in RBD to study to comparative performance of yield of six varieties of oranges (kg/plot) are given below. Analyse the data and give your conclusion.

Treatments	Blocks				
	B1	**B2**	**B3**	**B4**	**B5**
V1	5.5	5.9	6.3	6.5	6.7
V2	7.4	7.7	7.9	7.5	8.1
V3	4.6	5.1	5.3	4.9	4.7
V4	5.0	5.8	5.6	6.1	5.3
V5	6.7	6.2	6.9	6.8	6.0
V6	8.2	7.9	7.5	7.2	6.9