**Randomized Block Design (RBD)**

This is the design which uses all the principles of design of experiment. In CRD we allocate the treatment at random to the experimental unit. But in RBD treatment are allocated at random within the block. Each treatment must once occur either in each row or in each column. So here we study the effect of treatment and blocks. So this is the case two way classification.

**Layout:** Let us consider the treatment ‘t’ with replication r times each, so that there are N = r t experimental units.

Let us assumes three treatments A, B, C and each has four replication. The layout of RBD is

|  |  |  |  |
| --- | --- | --- | --- |
| A | C | A | C |
| B | A | C | B |
| C | B | B | A |

The treatments are allocated in the blocks.

**Mathematical model RBD:**

Let the linear model be

= μ + α i + j +; =; =

Where,  = unit or block of treatment.

μ = general mean effect (constant effect).

i = effect due to treatment.

j = effect due to block.

= error due to chance.

**Assumptions of RBD:**

1. All the observations are independent.
2. All the observations should be drawn from normal population having constant variance.
3. All the treatment should be homogeneous as for as possible.
4. Various treatments and environmental effects are additive in nature.
5. eij are independent of N(0, σe2 ).

**Problem:** To test

H 0T: μ1 = μ2 = ………. =; there is no significance difference between treatments.

H 1T: At least one treatment is different.

And,

H 0B: μ1 = μ2 = ………. =; there is no significance difference between blocks.

H 1B: At least one block is different.

**Statistical Analysis:**

Let us assume that there are all together‘t’ treatment and each treatment occurs the same number of replication ‘r’. Therefore total number of observations is N = t r.

Let the linear model be

= μ + α i + j +; =; = ……………………………. (1)

The parametersand are determined by using the principle of least square by minimizing error (residual) sum of square.

Total sum of square = Sum of square due to treatment + Sum of square due to block + Sum of square due to error.

TSS = SST + SSB + SSE

**Degree of freedom for various sum of square of RBD:**

Degree of freedom of TSS = r t – 1

Degree of freedom of SST = t – 1

Degree of freedom of SSB = r – 1

Degree of freedom of SSE = (t-1) (r-1)

**Mean sum of squares:**

Mean sum of square due to treatment (MST) =

Mean sum of square due to block (MSB) =

Mean sum of square due to error (MSE) =

**ANOVA Table:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source of variation |  |  |  |  |  |
| Due to treatment | t – 1 | SST | MST = | FT = |  |
| Due to block | r - 1 | SSB | MSB = | FB = |  |
| Due to error | (t – 1) (r – 1) | SSE | MSE = |  |  |
| Total | r t - 1 | TSS |  |  |  |

**Critical region:**

The tabulated value of F at α% for treatment isand for block is.

**Decision:**

If, we accept. Otherwise reject H0.

**Computation formula:**

TSS =

= - C.F.

SST = r

=

SSB = t

=

SSE = TSS – SST – SSB

Where, =

**Advantage of RBD:**

1. It is controls the variability in the experimental materials and give the treatment an equal chance to show their effects.
2. The layout and analysis of design is simple and easy to understand.
3. There is no restriction on the number of treatments but at least two replications is necessary.
4. The statistical analysis remains simple if some observations are missing.

**Disadvantage of RBD:**

1. It is suitable for only small number of treatments.
2. Unequal no. of replication for each treatment cannot be used.
3. It controls the variability in one direction only, i.e. either row or column.

**Uses of RBD:**

1. In agricultural experiments this design is used if the variations in the soil fertility gradient are in the one direction only.
2. This design is considered the back-bone of the science of experimental design.
3. It is applicable to moderate number of replication.

**Example:** Three varieties of A, B, C of a crop are tested, in a randomized block design with four replications, the layout being given as below.

|  |  |  |  |
| --- | --- | --- | --- |
| A6 | C5 | A8 | B9 |
| C8 | A4 | B6 | C9 |
| B7 | B6 | C10 | A6 |

Analysis the experimental yields and state your conclusion.

**Solution:** Here,

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatment | Block | | | | Row total () |
| I | II | III | IV |
| A | 6 | 4 | 8 | 6 | 24 |
| B | 7 | 6 | 6 | 9 | 28 |
| C | 8 | 5 | 10 | 9 | 32 |
| Column total() | 21 | 15 | 24 | 24 | G = 84 |

t = 3, r = 4, N = t r = 3 4 = 12

C.F. = = = 588

= (6)2 + (4)2 + (8)2 + (6)2 + (7)2 + (6)2 + (6)2 + (9)2 + (8)2 + (5)2 + (10)2 + (9)2

= 624

TSS = - C.F. = 624 – 588 = 36

SST = = [(24)2 + (28) 2 + (32)2] – 588 = 8

SSB = = [(21)2 + (15) 2 + (24)2 + (24)2] – 588 = 18

SSE = TSS – SST – SSB = 36 – 8 – 18 = 10

**ANOVA Table:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source of variation | d f | SS | MS | F-Ratio | F Tab. |
| 1. Due to treatment 2. Due to block 3. Due to error | 2  3  6 | 8  18  10 | 4  6  1.67 | FT = 3.395  FB = 3.593 | F 0.05, (2, 6) = 19.33  F 0.05, (3, 6) = 8.94 |
| Total | 11 | 36 |  |  |  |

**Decision:**

Since, F Cal < F 0.05, (2, 6); we accept H0; there is no significance difference between treatments.

Since, F Cal < F 0.05, (3, 6); we accept H0; there is no significance difference between blocks.

**Question:** The following table gives the result of the experiment on four varieties of a crop in 5 blocks of plot.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Block-I | Block-II | Block-III | Block-IV | Block-V |
| A32 | B33 | D30 | A35 | C36 |
| B34 | C34 | C35 | C32 | D29 |
| C31 | A34 | B36 | B37 | A37 |
| D29 | D26 | A33 | D28 | B35 |

Analysis the above result to test whether there is significant difference between yields of varieties and replications. [Ans: FT = 18.982, FB = 2.207, F0.05, (3, 12) = 3.49, F0.05, (4, 12) = 3.26]

**Question:** Three varieties A, B, C were tested in RBD each with six replications. Analyze the experimental yield and state your conclusion.

I II III IV V VI

A17 C35 B23 C29 A34 B19

C33 B23 C29 A17 B23 A33

B19 A29 A25 B15 C37 C27

**Missing value in RBD:**

Let us consider the RBD involving t treatment with r replication each. Let one of the observation in it h treatment of the j t h block is missing. Let the missing observation be x. That is

x =

Where, r = No. of replications or blocks.

t = No. of treatments.

= Sum of remaining value of block within the missing observations.

= Sum of remaining value of treatment within the missing observations.

= Grand total of remaining value of all the observations within the missing observations.

Substitute the value of x in place of missing value and carry out analysis as usual except that one degree of freedom is subtracted from total and consequently from error. Because of change in level of degree of freedom, we obtain an upward bias in SST. Hence to get better result subtracted an adjustment factor from SST.

Adjustment factor (k) =.

Adjusted SST (SSTA) = SST – k.

**Example:** The table given below represents the yield of 8 varieties in 4 replicate experiments for which one observation is missing. Estimate the missing value and analyze the data.

|  |  |  |  |
| --- | --- | --- | --- |
| A 18.1 | B ? | A 15.2 | C 13.2 |
| C 16.0 | A 12.1 | B 17.5 | A 16.6 |
| B 16.3 | C 13.4 | C 16.3 | B 18.1 |

**Solution:** Here, Let missing value be x.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatment | Block | | | | Row total (T i .) |
| 1 | 2 | 3 | 4 |
| A | 18.1 | 12.1 | 15.2 | 16.6 | 62.0 |
| B | 16.3 | x | 17.5 | 18.1 | 51.9 + x |
| C | 16.0 | 13.4 | 16.3 | 13.2 | 58.9 |
| Column total(T. j) | 50.4 | 25.5 + x | 49.0 | 47.9 | G = 172.8 + x |

t = 3, r = 4, = 51.9, = 25.5, and = 172.8

Missing value is

x = = = 14.15

**Problem:** To test

H 0T: μ1 = μ2 = μ3; there is no significance difference between treatments.

H 1T: At least one treatment is different.

And,

H 0B: μ1 = μ2 = μ3 = μ4; there is no significance difference between blocks.

H 1B: At least one block is different.

Then,

G = 172.8 + x = 172.8 + 14.15 = 186.95

N = t r = 3 4 = 12

**Computation formula:**

C.F. = = = 2912.525

= (18.1)2 + (12.1)2 + (15.2)2 + (16.2)2 + (16.3)2 + (14.15)2 + (17.5)2 + (18.1)2 + (16.0)2 + (13.4)2 + (16.3)2 + (13.2)2 = 2955.8825

TSS = - C.F. = 2955.8825 - 2912.525 = 43.354

SST = = [(62)2 + (51.9 + x) 2 + (58.9)2] – 2912.525 = 6.428

SSB = = [(50.4)2 + (25.5 + x) 2 + (49.2)2 + (47.9)2] – 2912.525 = 23.372

Adjustment factor (k) = = = 1.306

Adjusted SST (SSTA) = SST – k = 6.428 – 1.306 = 5.121

SSE = TSS – SSTA – SSB = 43.543 – 5.121 – 23.372 = 14.861

**ANOVA Table:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source of variation | d f | SS | MSS | F-Ratio | F Tab. |
| 1. Due to treatment 2. Due to block 3. Due to error | 2  3  5 | 5.121  23.372  14.861 | 2.56  7.97  2.972 | FT = 0.861  FB = 2.62 | F 0.05, (2, 5) = 5.79  F 0.05, (3, 5) = 5.41 |
| Total | 10 | 43.354 |  |  |  |

**Decision:**

Since, F Cal < F 0.05, (2, 5); we accept H0; there is no significance difference between treatments.

Since, F Cal < F 0.05, (3, 5); we accept H0; there is no significance difference between blocks.

**Question:** The table gives below are yields of 3 varieties in a 4 replicate experiment for which one observation is missing. Estimate the missing value and then carry out the ANOVA.

|  |  |  |  |
| --- | --- | --- | --- |
| P 19 | R 29 | P 23 | Q 33 |
| Q 26 | P ? | Q 27 | R 26 |
| R 21 | Q 19 | R 22 | P 26 |

**Efficiency of RBD relative to CRD**

The precision of RBD is compared to precision of CRD is called efficiency of RBD relative to CRD, then

Efficiency (E) = = = = =

Interpretation:

If then RBD less efficient than CRD

If then RBD more efficient than CRD

If then RBD and CRD are equally effective

Example: From the following ANOVA table of RBD, determine it’s efficiency with respect to CRD.

|  |  |  |  |
| --- | --- | --- | --- |
| SV |  | SS | MSS |
| Between treatment | 5 | 750 | 150 |
| Between blocks | 3 | 180 | 60 |
| Error | 15 | 200 | 13.33 |
| Total | 23 | 1130 |  |

Solution: Given,

of treatments = 5 ⇒ t – 1 = 5 = 6

of blocks = 3 ⇒ r – 1 = 3 = 4

MSB = 60

MSE = 13.33

Efficiency (E) =?

Now,

Efficiency (E) = = = = 1.456

Hence, RBD is 45.6% efficient than CRD.

**Numerical problems:**

11. Carry out ANOVA of following output of wheat per field obtained as a result of 3 varieties of wheat A, B and C.

|  |  |  |  |
| --- | --- | --- | --- |
| A 10 | B 5 | A 20 | C 15 |
| B 6 | A 15 | C 11 | B 10 |
| C 22 | B 12 | C 18 | A 16 |

[Ans: = 4.793, reject]

12. Carry out ANOVA for following design.

|  |  |  |  |
| --- | --- | --- | --- |
| A 8 | C 10 | A 6 | B 10 |
| C 12 | B 8 | B 9 | A 8 |
| B 10 | A 8 | C 10 | C 9 |

Also calculate the relative efficiency of the design with respect to CRD. [Ans: = 796, reject = 1.59, accept, efficiency = 1.1625]

13. Set up analysis of variance for the following results of a design.

|  |  |  |
| --- | --- | --- |
| A 10 | B 15 | C 20 |
| B 25 | C 10 | A 15 |
| C 25 | A 20 | B 15 |

Also calculate the efficiency of the design over (i) RBD, and, (ii) CRD. [Ans: = = 0.241, = 0.142, Accept and, efficiency = 0.74, 0.74, and 0.62]

14. The table given below is yields of 3 varieties in a 4 replicate experiment for which one observation is missing. Estimate the missing value and then analysis the data.

|  |  |  |  |
| --- | --- | --- | --- |
| P 19 | R 29 | P 23 | Q 33 |
| Q 26 | P ? | Q 27 | R 26 |
| R 21 | Q 28 | R 22 | P 26 |

[Ans: 23.5, = 4.69, = 4.72, Rejectand]

**Thank you!!!**