

Statement:-

Following 2^4 Factorial Experiment
where

M = manure K = Potassium

Total Possible Combination
are $2^4 = 16$

B) Also use Experiment method
and using Yield method
by using ANOVA Table.

Practical No 01 :-

For the following 2^{4-1} factorial experiment. Use sign table method to analyses the data.

Draw conclusion and interpret your result. (1) ad bd ab cd ac bc abcd
74 108 92 130 68 105 95 133

Practical No 02:-

For the following 2^{4-1} factorial experiment Use sign table method to analyse the data. Draw conclusion and interpret the result.

| | | | | | | | |
|-----|-----|----|----|----|----|----|------|
| (1) | ad | bd | ab | cd | ac | bc | abcd |
| 74 | 108 | 92 | 79 | 63 | 77 | 80 | 85 |

-: Practical No 03 :-

The experiment is a half replicate of 2^5 factorial.

Used Yates's method for the analysis of data.

| | | | | | | | |
|-----|-----|-----|------|------|------|------|-----|
| (1) | ab | ac | bc | ad | bd | cd | ae |
| 233 | 317 | 233 | 333 | 267 | 400 | 400 | 350 |
| be | ce | de | abcd | abce | abde | acde | |
| 283 | 400 | 267 | 317 | 383 | 350 | 367 | |
| bcd | e | | | | | | |
| 267 | | | | | | | |

Practical No 04 :-

The experiment is a half replicate of 2^5 factorial. Use Yates's method for analysis the data.

Practical No 05:-

For the following split plot layout consisting of two factors temperature and pressure each at 4 level only observation can be run in one day and a complete replicate is performed on each day. Analyse the data assuming the days as blocks.

-: Practical No 06 :-

Two row spacing on the
Yield of 4 Soyabean varieties
With 4 replications are tested.

Design is a split-plot with
Varieties as whole plots treatment
in a latin square. Row
spacing were applied to subplot

| C_1 | C_2 | C_3 | C_4 |
|----------|----------|----------|----------|
| A_1 | A_2 | A_3 | A_4 |
| B_1 33 | B_1 37 | B_1 34 | B_1 34 |
| B_2 28 | B_2 25 | B_2 28 | B_2 32 |

Question: Two Row spacing on the yield of 4 Soyabean Varieties with 4 replications are tested. Design is a split-plot with varieties as whole plots treatments in a Latin Square. Row spacing were applied to sub-plots.

| | C ₁ | C ₂ | C ₃ | C ₄ | Total |
|----------------|--|--|--|--|-------|
| R ₁ | A ₁ { 33 B ₁ 61 { 28 B ₂ | A ₂ { 37 B ₁ 62 { 25 B ₂ | A ₃ { 34 B ₁ 62 { 28 B ₂ | A ₄ { 34 B ₁ 66 { 32 B ₂ | 251 |
| R ₂ | A ₂ { 31 B ₁ 54 { 23 B ₂ | A ₃ { 34 B ₁ 60 { 26 B ₂ | A ₄ { 30 B ₁ 57 { 27 B ₂ | A ₁ { 29 B ₁ 54 { 25 B ₂ | 225 |
| R ₃ | A ₃ { 33 B ₁ 56 { 23 B ₂ | A ₄ { 29 B ₁ 55 { 26 B ₂ | A ₁ { 24 B ₁ 47 { 23 B ₂ | A ₂ { 30 B ₁ 53 { 23 B ₂ | 211 |
| R ₄ | A ₄ { 28 B ₁ 53 { 25 B ₂ | A ₁ { 28 B ₁ 56 { 28 B ₂ | A ₂ { 31 B ₁ 59 { 28 B ₂ | A ₃ { 32 B ₁ 57 { 25 B ₂ | 220 |
| Total | 224 | 228 | 225 | 230 | 907 |

Question

Given the 2^3 factorial experiment with four replication. Setup the ANOVA Table to Test the significance of the treatment effect when ABC is confounded in all the replication using

(i) Yates method

(2) Sign table method:

| Combination | R_1 | R_2 | R_3 | R_4 |
|-------------|-------|-------|-------|-------|
| (1) | 19.1 | 20.7 | 23.4 | 19.1 |
| a | 18.6 | 25.9 | 22.2 | 23.6 |
| b | 18.2 | 23.0 | 21.0 | 23.7 |
| ab | 19.2 | 22.1 | 20.4 | 21.9 |
| c | 19.0 | 24.9 | 23.6 | 21.0 |
| ac | 18.8 | 21.2 | 23.2 | 18.6 |
| bc | 19.4 | 23.4 | 20.3 | 21.5 |
| abc | 20.4 | 20.1 | 21.6 | 22.8 |
| | 162.7 | 181.3 | 175.7 | 172.2 |

Question

Set up a plan for a 2^4 factorial experiment by confounding mnP , nPk in block of four (4) units. Suggest a method for the calculation of treatment effects.

Solution:

(8)

Question: Give plan and ANOVA table of 2^5 factorial experiment in blocks of size 8, when complete confounding is used and $r=2$.

Solution: Let we have A, B, C, D, E five factors, Then $2^5 = 32$ treatment combinations are:

| w | c | d | cd | e | ce | de | cde |
|----|-----|-----|------|-----|------|------|-------|
| a | ac | ad | acd | ae | ace | ade | acde |
| b | bc | bd | bcd | be | bce | bde | bcde |
| ab | abc | abd | abcd | abe | abce | abde | abcde |

Question: Give plan and ANOVA table of 2^4 factorial experiment in blocks of size 8 with $k=3$ when

- (i) complete confounding is used.
- (ii) Partial confounding is used.

Question: Give plan of a 2^3 factorial experiment arranged in four replicate each divided into two blocks after confounding two and Three factors interactions. Outline ANOVA table and suggest a method for the calculation of treatment effects.

Solution: we are given $r = 4$ for 2^3 factorial experiment, total combinations are 8 as:

↓ a b ab c ac bc abc

Two and Three factors interactions are confounded so AB, AC, BC & ABC are confounded in Replicate 1, 2, 3, 4 respectively

| R_1 | | R_2 | | R_3 | | R_4 | |
|-------|-------|-------|-------|-------|-------|-------|-------|
| B_1 | B_2 | B_3 | B_4 | B_5 | B_6 | B_7 | B_8 |
| ↓ | a | ↓ | a | ↓ | b | ↓ | a |
| ab | b | b | ab | a | ab | ab | b |
| c | ac | ac | c | bc | c | ac | c |
| abc | bc | abc | bc | abc | ac | bc | abc |
| AB | | AC | | BC | | ABC | |

Question: What effects are confounded⁽¹²⁾ in each replicate. From what replicates these confounded effects are estimated. Also set up ANOVA table mentioning S.O.V and d.f.

| Rep I | | | | | |
|-------|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 | 1 |

| Rep II | | | | | |
|--------|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 | 1 | 1 |

| Rep III | | | | | |
|---------|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 | 1 | 1 |

| Rep IV | | | | | |
|--------|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 | 1 |

Question: Data given below is a 2^3 factorial experiment with 3 replicates and NPM confounded completely. Test the significance of the main effect and interaction.

| R_1 | R_2 | R_3 |
|-------------------|-------------------|-------------------|
| P_n 48, nm 50 | nm 50, (l) 40 | n 47, p 37 |
| Pm 46, (l) 52 | Pm 52, np 49 | npm 46, m 46 |
| m 40, npm 61 | p 33, npm 48 | Pm 39, nm 49 |
| p 32, n 55 | m 51, n 53 | (l) 39, np 51 |

Question: Given 2^3 factorial experiment with four replicates and ABC is confounded in all replicates. Set up ANOVA table to test the significance of treatments effects.

| R ₁ | | R ₂ | | R ₃ | | R ₄ | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| B ₁ | B ₂ | B ₃ | B ₄ | B ₅ | B ₆ | B ₇ | B ₈ |
| (1) 19 | a 18 | (1) 27 | a 25 | (1) 23 | a 22 | (1) 19 | a 31 |
| ab 19 | b 17 | ab 22 | b 23 | ab 20 | b 21 | ab 21 | b 23 |
| ac 18 | c 19 | ac 21 | c 24 | ac 23 | c 23 | ac 18 | c 21 |
| bc 19 | abc 20 | bc 20 | abc 23 | bc 20 | abc 21 | bc 21 | abc 22 |
| ABC | | ABC | | ABC | | ABC | |

Prac 04

(15)

Question: use sign table to calculate total effects and SS for different factors for the following two replications of 2^3 experiment arranged in four blocks.

Rep I

| Block I | Block II |
|---------|----------|
| a 15 | ab 10 |
| b 10 | ac 12 |
| abc 16 | (1) 15 |
| c 8 | bc 14 |

Rep II

| Block I | Block II |
|---------|----------|
| a 16 | ab 15 |
| ac 18 | (1) 10 |
| b 19 | abc 18 |
| bc 21 | c 20 |

Practical using

(167)

Question: Data given below is of 2^3 factorial experiment in which different factors are confounded in four replications. Analyse it.

| | R ₁ | | R ₂ | | R ₃ | | R ₄ | | | | | | | | |
|-------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------|----------|------|------|------|-----|------|
| | B ₁ | B ₂ | B ₃ | B ₄ | B ₅ | B ₆ | B ₇ | B ₈ | | | | | | | |
| (1) | 25.7 | a | 23.2 | (1) 27.6 | a | 25.6 | (1) 21.4 | b | 18.8 | (1) 23.9 | a | 25.4 | | | |
| ab | 21.1 | b | 21.0 | ac | 26.7 | c | 27.9 | bc | 18.6 | c | 16.0 | ab | 21.4 | b | 26.9 |
| c | 17.6 | ac | 18.6 | b | 26.2 | ab | 28.5 | a | 18.8 | ab | 16.4 | ac | 20.6 | c | 25.2 |
| abc | 17.5 | bc | 18.3 | abc | 22.0 | bc | 27.2 | abc | 18.2 | ac | 16.6 | bc | 22.4 | abc | 30.1 |
| Total | 81.9 | 81.1 | 102.5 | 109.2 | 77 | 67.8 | 88.3 | 107.6 | 9 | 715.4 | | | | | |
| | AB | | AC | | BC | | ABC | | | | | | | | |

9

Question ✓ For the following 2^3 factorial experiments in three blocks, Calculate the total treatment effects by Sign table method and test Their significance. *9/10/2021*

| Block | (1) | a | b | c | ab | ac | bc | abc | Total |
|--------|-----|----|----|----|----|-----|----|-----|-------|
| 1 | 6 | 7 | 7 | 4 | 7 | 5 | 6 | 6 | 48 |
| 2 | 10 | 9 | 8 | 7 | 8 | 6.5 | 5 | 5 | 57 |
| 3 | 5 | 6 | 3 | 4 | 7 | 5.5 | 4 | 5 | 40 |
| Totals | 21 | 22 | 18 | 15 | 22 | 16 | 15 | 16 | 145 |

Question: Analyse the following 2^3 experiment in 2 randomized blocks using Yates method, Discuss the results

| | a | b | c | ab | ac | bc | abc |
|-----|------|------|------|------|------|------|------|
| 7.5 | 10.6 | 12.7 | 10.6 | 12.9 | 16.1 | 15.5 | 18.6 |
| 9.8 | 13.5 | 14.2 | 11.5 | 15.6 | 10.9 | 16.1 | 15.9 |

Solution:

| <u>Solution:</u> | | | | | | | | |
|------------------|------|------|------|------|------|------|------|-------|
| | a | b | c | ab | ac | bc | abc | Total |
| R ₁ | 7.5 | 10.6 | 12.7 | 10.6 | 12.9 | 16.1 | 15.5 | 18.6 |
| R ₂ | 9.8 | 13.5 | 14.2 | 11.5 | 15.6 | 10.9 | 16.1 | 15.9 |
| Total | 17.3 | 24.1 | 26.9 | 22.1 | 28.5 | 27.0 | 31.6 | 34.5 |

(12)

Question: A fertilizers trial on strawberries consists of 4 replicates of 8 treatments (1), n, nP, K, nK, PK and nPK combinations of high and low levels of nitrogen, Phosphorus and Potash. The resulting crop yield per plot (in suitable units) are as follows:

| Blocks | (1) | n | P | nP | K | nK | PK | nPK |
|--------|-----|----|----|----|----|----|----|-----|
| 1 | 13 | 24 | 16 | 27 | 20 | 30 | 28 | 32 |
| 2 | 12 | 25 | 14 | 34 | 21 | 32 | 25 | 35 |
| 3 | 18 | 24 | 15 | 32 | 24 | 31 | 26 | 30 |
| 4 | 15 | 31 | 20 | 30 | 28 | 29 | 24 | 29 |

Correct ANOVA and discuss your findings.

Question: For the following 2^{4-1} fractional factorial experiment, use sign table method to analyse the data. Draw conclusions and interpret your results.

| results | ab dn | ac dp | ad dk | bc np | bd nk | cd pk | abcd. dnpk. |
|---------|----------|----------|----------|----------|----------|----------|----------------|
| (1) | ad | bd | ab | cd | ac | bc | abcd |
| 74 | 108 | 92 | 130 | 68 | 105 | 95 | 13.3 |
| | | | | Total | | | 80.5 |

Practical # 08: A 2^4 factorial confounding in blocks of 8 units. Field experiment on beans. Conducted by the experiment station in 1936. Factors were: D, N, P, K. With 16 P.C in blocks of 8 plots only one factorial effects. is Confounded. of a 2^4 factorial experiment given

R_1

R_2

| B_1 | P | K | d | npk | B_2 | npk | d | P | dnk |
|-------|-----|-----|-----|--------|-------|-----|-----|----|-------|
| | 45 | 55 | 53 | 36 | | 43 | 42 | 39 | 34 |
| | dnk | dnp | dpk | n | | n | dnp | K | dpk |
| | 41 | 48 | 55 | 42 375 | | 47 | 52 | 50 | 44 35 |

B_1

| | dp | nk | dk | pk | | nk | pk | (1) | np |
|--|------|-----|-----|--------|--|----|----|------|-----|
| | 50 | 44 | 43 | 51 | | 43 | 52 | 57 | 39 |
| | dnpk | (1) | dnp | np | | pk | dk | dnpk | dnp |
| | 44 | 53 | 41 | 50 376 | | 56 | 52 | 54 | 42 |

Statement:-

Perform the Anova to test the significance of treatments of mean for following 2^3 factorial experiment

By using sign test at $\alpha = 0.05$

| N ₀ | | | | N ₁ | | | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| K ₀ | | K ₁ | | K ₀ | | K ₁ | |
| P ₀ | P ₁ | P ₀ | P ₁ | P ₀ | P ₁ | P ₀ | P ₁ |
| 14 | 15 | 11 | 8 | 15 | 14 | 13 | 15 |
| 13 | 12 | 9 | 4 | 11 | 8 | 9 | 9 |
| 9 | 9 | 4 | 3 | 10 | 6 | 7 | 10 |
| 4 | 7 | 3 | 2 | 7 | 11 | 4 | 13 |
| | | | | | | | |

Statement.-

A Recutter is use to cut locating Nothes on a printed circuit board.

The vibration level at the surface of the board as T is cut consider to be a major surface of climensional Variation in the Notches. Two Factors throughout to influance vibration. But size A and cutting speed is B.

The data is given below:

| | A | B | 1 | 2 | 3 | 4 |
|-----|---|---|------|-------|------|------|
| (1) | - | - | 15.5 | 88.20 | 14.9 | 14.6 |
| a | + | - | 28.9 | 43.9 | 24.5 | 22.9 |
| b | - | + | 48.4 | 29.3 | 36.5 | 18.9 |
| ab | - | - | 54.5 | 30.20 | 42.3 | 14.5 |

Practical #5

Statement: -

Analyze the following 2^3 factorial experiment in to randomise block Using Yates method. Discuss the Result.

| # | (1) | a | b | c | ab | ac | bc | abc |
|-------|-----|------|------|------|------|------|------|------|
| R_1 | 7.5 | 10.6 | 12.7 | 10.6 | 12.9 | 16.1 | 15.5 | 18.6 |
| R_2 | 9.8 | 13.5 | 14.2 | 11.5 | 15.6 | 10.9 | 16.1 | 15.9 |

Also using Sign Table Method.

Statement:-

An experiment was performed to improve the yields of chemical process for factors were selected and two replacates of a completely Randomize Design. For some results are shown below:

| T.C | R ₁ | R ₂ |
|------|----------------|----------------|
| (1) | 90 | 93 |
| a | 74 | 78 |
| b | 81 | 85 |
| ab | 83 | 80 |
| c | 77 | 78 |
| ac | 81 | 80 |
| bc | 88 | 82 |
| abc | 73 | 70 |
| d | 98 | 95 |
| ad | 72 | 76 |
| bd | 87 | 83 |
| abd | 85 | 86 |
| cd | 99 | 90 |
| acd | 79 | 75 |
| bcd | 87 | 84 |
| abcd | 80 | 80 |

Statement:-

Analyze the following 2^3 Factorial experiment into randomized block using odd even method discuss the result for the factors A, B and ABC.

| | R_1 | R_2 |
|-----|-------|-------|
| (1) | 7.5 | 9.8 |
| a | 10.6 | 13.5 |
| b | 12.7 | 14.2 |
| ab | 10.6 | 11.5 |
| c | 12.9 | 15.6 |
| ac | 16.1 | 10.9 |
| bc | 15.5 | 16.1 |
| abc | 18.6 | 15.9 |

Statement:-

Data given below is a 2^3 Factorial experiment with three replicates and NPM confounded completely. Test the significance of main effect and interaction.

| | | |
|-------|--|--|
| R_1 | P_n 48 , nm 50 Pm 46 , (I) 52 | m 40, nPm 61 P 32 , n 55 |
| R_2 | nm 50, (I) 40 Pm 52, np 49 | P 33 , $npm = 48$ m 51 , n 53 |
| R_3 | n 47 , P 37 nPm 46, m 46 | Pm 39 , nm 49 (I) 39 , nP 51 |

Statement:-

Given 2^3 Factorial experiment with four replicates and ABC is confounded in all replicates set up ANOVA table to test the significance of treatments effects.

| R ₁ | | | |
|----------------|----|----------------|----|
| B ₁ | | B ₂ | |
| (1) | 19 | a | 18 |
| ab | 19 | b | 17 |
| ac | 18 | c | 19 |
| bc | 19 | abc | 20 |

| R ₂ | | | |
|----------------|----|----------------|----|
| B ₃ | | B ₄ | |
| (1) | 27 | a | 25 |
| ab | 22 | b | 23 |
| ac | 21 | c | 24 |
| bc | 20 | abc | 23 |

| R ₃ | | | |
|----------------|----|----------------|----|
| B ₅ | | B ₆ | |
| (1) | 23 | a | 22 |
| ab | 20 | b | 21 |
| ac | 23 | c | 23 |
| bc | 20 | abc | 21 |

| R ₄ | | | |
|----------------|----|----------------|----|
| B ₇ | | B ₈ | |
| (1) | 19 | a | 31 |
| ab | 21 | b | 23 |
| ac | 18 | c | 21 |
| bc | 21 | abc | 22 |

Statement:-

Data given below is of 2^3 factorial experiment in which different factors are confounded in four replications. Analyze it.

| R ₁ | |
|----------------|----------------|
| B ₁ | B ₂ |
| (1) 25.7 a | 23.2 |
| ab 21.1 | b 21.0 |
| c 17.6 | ac 18.6 |
| abc 17.5 | bc 18.3 |

| R ₂ | |
|----------------|----------------|
| B ₃ | B ₄ |
| (1) 27.6 a | 25.6 |
| ac 26.7 | c 27.9 |
| b 26.2 | ab 28.5 |
| abc 22.0 | bc 27.2 |

| R ₃ | |
|----------------|----------------|
| B ₅ | B ₆ |
| (1) 21.4 | b 18.8 |
| bc 18.6 | c 16.0 |
| a 18.8 | ab 16.4 |
| abc 18.2 | ac 16.6 |

| R ₄ | |
|----------------|----------------|
| B ₇ | B ₈ |
| (1) 23.9 a | 25.4 |
| ab 21.4 | b 26.9 |
| ac 20.6 | c 25.2 |
| bc 22.4 | abc 30.5 |