F-test (Fisher test)

¬ This test uses for comparing between two groups or more (Treatments)
¬ In this test treatments and replications must be available.
¬ Number of treatments must be ≥ 2, while number of replications ≥ 3.
¬ The results on statistical analysis can be written in ANOVA table (Analysis of Variance).

Types of F-Test

F-Test in case number of replications are equal

F-Test in case number of replications are unequal

¬ Statistical calculations are the follows:

Treatment	Replication					Sum of Treatment
t_1	Y_{11}	Y_{12}	Y_{13}	Y_{1j}	Y_{1r}	$Y_{1.}$
t_2	Y_{21}	Y_{22}	Y_{23}	Y_{2j}	Y_{2r}	$Y_{2.}$
t_3	Y_{31}	Y_{32}	Y_{33}	Y_{3j}	Y_{3r}	$Y_{3.}$
.	Y_{i1}	Y_{i2}	Y_{i3}	Y_{ij}	Y_{ir}	$Y_{4.}$
t_t	Y_{t1}	Y_{t2}	Y_{t3}	Y_{tj}	Y_{tr}	$Y_{t.}$
						Y.. or G

i = 1, 2, 3, ..., t   t = no. of treatment

j = 1, 2, 3, ..., r   r = no. of replication

Correction factor (C.F.) = $(\sum Yij)^2 / tr$ or $C.F. = \frac{(Y..)^2}{tr}$

Sum of Square Total (SS_T) = $\sum yij^2 - C.F.$

Sum of Square treatment (SSt) = $\frac{\sum yi.^2}{r} - C.F.$

$\text{Treat. SS} = \frac{\sum T^2_i}{r} - C.F. \quad \frac{T^2_1 + \ldots + T^2_n}{r} - C.F$ **in case number of replications are equal**

$SS_{treat} \left[\frac{\sum T_1^2}{r_1} + \frac{\sum T_2^2}{r_2} + \ldots \frac{\sum T_n^2}{r_n} \right] - CF$ **in case number of replications are unequal**

Sum of Square error $(SS_E) = SS_T - SS_{treat.}$

$$MS_{treat.} = \frac{SS_{treat.}}{df_{treat.}}$$

Degree of freedom = $df_{treat.} = t - 1$

$$MS_{error} = \frac{SS_{error}}{df_{error}}$$

$df_{Error} = t\,(r - 1)$ **in case number of replications are equal**

$df_{Error} = \Sigma ri - t$ in **case number of replications are unequal**

$$F \text{ calculate} = \frac{MS_{treat.}}{MS_{error}}$$

MS = mean of squre

F tabulated (from t- table)

S.O.V. (Source of variance).

Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) is a method for testing the hypothesis that three or more population means are equal. used to check the variability of group means and the associated variability in observations within that group.

What are the components of ANOVA table?

1. Source of Variation
2. Degree of freedom
3. Sum of square
4. Mean square
5. Calculation-F

S.O.V	df	SS	MS	Cal. F
Treat				
error				
total				

Example: the following data represent the effect of (4) levels of Phosphorus fertilizer on the number of active nodules/broad bean plant using pot experiment with (3) replicates, test the effect of phosphorus at level of significance = 0.01

Phosphorus levels	r1	r2	r3	∑treat.
t_1=0	3	4	2	9
t_2=2	4	5	6	15
t_3=4	7	6	5	18
t_4=6	8	9	6	23
				Y..=65

$$C.F. = \frac{(\sum y_{ij})^2}{tr} = \frac{G^2}{tr} = (66)^2 / 4*3 = 363$$

Total SS ($\sum yij^2$ – C.F.) $=3^2+4^2+\ldots+6^2-352=45$

Treat. SS ($\frac{\sum yi.^2}{r}$ – C. F) = $[(9^2+15^2+18^2+23^2)/3]-352=34.3$

Error SS (Total SS- Treat SS) =45-34.3=10.7

$MS_{treat.} = \frac{SS_{treat.}}{df_{treat.}}$ Degree of freedom = $df_{treat.} = t - 1$

$MS_{treat.}$ = 34.3/3=11.4

$MS_{error} = \frac{SS_{error}}{df_{error}}$ $df_{Error} = t\ (r - 1)$

MS_{Error} = 8/8=1

F calculate = $\frac{MS_{treat.}}{MS_{error}}$ = 11.4/1.3 = 8.76

ANOVA table

S.O.V.	df	SS	MS	Cal. F	Tab. F
Treatment	3	34.3	11.4	8.76	7.591
Error	8	10.7	1.3		
Total	11	45			

Due to cal. F is more than tab. F(0.01, 3,8) =7591 , it means there are significant differences between treatments or phosphorus levels affected significantly on number of nodules plants.

Example: Complete the ANOVA table for the following data that represents the impacts of three types of herbicides on wheat yield (tons/ha).

Herbicide	**R1**	**R2**	**R3**	**R4**	∑treats
Atlantis	**2**	**2**	**3**	**2**	**7**
Glyphosate	**1**	**3**	**2**		**6**
Bio Power	**3**	**3**			**6**
					G= 19

$C.F = \frac{(G)^2}{\sum ri} \Longrightarrow C.F = \frac{(19)^2}{9}$ = 361/9= 40.11

Total SS ($\sum yij^2$ – C.F.) =($2^2+2^2+3^2+2^2+1^2+3^2+2^2+3^2+3^2$) – 40.11 = 12.89

$SS_{treat} \left[\frac{\sum T_1^2}{r_1} + \frac{\sum T_2^2}{r_2} + \cdots \frac{\sum T_n^2}{r_n}\right] - CF$ Treat SS = $\frac{(7)^2}{4} + \frac{(6)^2}{3} + \frac{(6)^2}{2}$ - 40.11 = 2.14

Error SS (Total SS- Treat SS) =12.89 – 2.14=10.75

$MS_{treat.} = \frac{SS_{treat.}}{df_{treat.}}$ Degree of freedom = $df_{treat.} = t - 1$

$MS_{treat.}$ = 2.14/2=1.07

$MS_{error} = \frac{SS_{error}}{df_{error}}$ $df_{Error} = \Sigma ri - t$ **in case number of replications are unequal**

$df_{Error} = \Sigma 9 - 3 = 6$

MS_{Error} = 10.75/6=1.79

F calculate = $\frac{MS_{treat.}}{MS_{error}}$ = 1.07/1.79 = 0.6

ANOVA table

S.O.V.	df	SS	MS	Cal. F	Tab. F
Treatment	2	2.14	1.07	0.6	
Error	6	12.89	1.79		
Total	Σri -1= 8				

Note: When the calculated F is less than 1, no need to find Tabulated F because all Tabulated F values are greater than 1. It means there is no significant differences between herbicides effects on wheat yields.

Example: The study was conducted to determine the effect of 5 rates of biochar (0, 2.5, 5, 7.5 and 10%) on soil pH, using 4 replications. Check whether biochar rates effect on Soil pH or no? if you have the following information

Biochar rates	**R1**	**R2**	**R3**	**R4**	∑treats
To (0)	**7.5**	**7.6**	**7.3**	**7.7**	**30.1**
T1 (2.5)	**7.8**	**7.8**	**7.6**	**7.9**	**31.6**
T2 (5%)	**7.9**	**8.1**	**8.3**	**8**	**32.3**
T3 (7.5%)	**8.2**	**8.5**	**8.4**	**8.7**	**33.8**
T4 (10%)	**8.8**	**9**	**9.1**	**9.6**	**36.4**

Disadvantage of F-test

This test gives results in general not given the difference between treatments in detail. To overcome this issue, we should apply multiple comparison tests.

Example: Complete this table if the no. of treat. = 5 and total df =24

S.O.V.	**df**	**SS**	**MS**	**Cal. F**
Treat		80		10
Error				
Total				