

- ANOVA two ways with Replication

2) In a study on fertilizer levels and spacing between plants, plots were assigned to combinations and the yield of potatoes (in kg/plot) was measured

Spacing between plants	Fertilizer level (in tons/ha)	
	1	2
25 cm	16.01	15.89
	16.78	16.23
	16.44	16.18
33 cm	13.42	13.32
	13.25	13.47
	13.32	13.26

Make all appropriate tests ($\alpha=0.05$)

1		Fertilizer level		Anova: Two-Factor With Replication			
2	Spacing between plants	1	2				
3	25 cm	16.01	15.89	SUMMARY	1	2	Total
4		16.78	16.23	25 cm			
5		16.44	16.18	Count	3	3	6
6	33 cm	13.42	13.32	Sum	49.23	48.3	97.53
7		13.25	13.47	Average	16.41	16.1	16.255
8		13.32	13.26	Variance	0.1489	0.0337	0.10187
9							
10				33 cm			
11				Count	3	3	6
12				Sum	39.99	40.05	80.04
13				Average	13.33	13.35	13.34
14				Variance	0.0073	0.0117	0.00772
15							
16				Total			
17				Count	6	6	
18				Sum	89.22	88.35	
19				Average	14.87	14.725	
20				Variance	2.9084	2.28691	
21							

ANOVA						
Source of Variati	SS	df	MS	F	P-value	F crit
Sample	25.49168	1	25.49168	505.7872	1.62E-08	5.317655
Columns	0.063075	1	0.063075	1.251488	0.295732	5.317655
Interaction	0.081675	1	0.081675	1.620536	0.238762	5.317655
Within	0.4032	8	0.0504			
Total	26.03963	11				

$\alpha = 0.05$.

A

1) Hypotheses testing:

$$H_0: \alpha_{25cm} = \alpha_{33cm} \quad VS \quad H_1: \text{at least one of means is different}$$

2) Test statistic:

$$F = 505.7872$$

3) Critical region:

$$F_{crit} = 5.317655$$

4) P-value = 0.000

Reject H_0 if $F > F_{crit}$

Or

p-value $\leq \alpha$

Decision:

Therefore, we reject the null hypothesis. There are difference in the means of the yield of potatoes between the two spacing between plants 25 cm and 33 cm.

B

1) Hypotheses testing:

$$H_0: \beta_1 = \beta_2 \quad VS \quad H_1: \text{at least one of means is different}$$

2) Test statistic:

$$F = 1.251488$$

3) Critical region:

$$F_{crit} = 5.317655$$

4) P-value = 0.295732

Reject H_0 if $F > F_{crit}$

Or

p-value $\leq \alpha$

Decision:

Therefore, we not reject the null hypothesis. There was no significant difference between the mean yield of potatoes of the two fertilizer levels.



1) Hypotheses testing:

$$H_0: \alpha\beta_{25\text{ cm},1} = \alpha\beta_{25\text{ cm},2} = \alpha\beta_{33\text{ cm},1} = \alpha\beta_{33\text{ cm},2}$$

VS

H_1 : at least one of means is different

2) Test statistic:

$$F = 1.620536$$

3) Critical region:

$$F_{crit} = 5.317655$$

4) P-value = 0.238762

Reject H_0 if $F > F_{crit}$

Or

p-value $\leq \alpha$

Decision:

Therefore, we not reject the null hypothesis. There is no interaction between the two factors (spacing between plants, fertilizer levels).

- ANOVA two ways without Replication

2) Suppose that interest is in 5 growth regulators. Baladi orange trees were randomly sprayed with one of the growth regulators, at harvest, 3 orange from each treatment were randomly assigned to a storage temperature. After a period of storage, the percent weight loss was measured.

Temperature	Growth regulator				
	1	2	3	4	5
5°C	9.2	11.3	9.1	10.4	12.3
10°C	18.2	17.6	18.4	16.5	17.8
25°C	21.3	24.4	24.8	21.2	24.1

Assuming no interaction, test if there is a difference in the effects of the five growth regulators on the percent weight loss of oranges. Also test if there a difference in the effects of the three storage temperature ($\alpha=0.05$)

F	G	H	I	J	K	L	M	N	O	
			Anova: Two-Factor Without Replication							
			<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>			
			5C	5	52.3	10.46	1.883			
			10C	5	88.5	17.7	0.55			
			25C	5	115.8	23.16	3.103			
				1	3	48.7	16.23333	39.50333		
				2	3	53.3	17.76667	42.92333		
				3	3	52.3	17.43333	62.32333		
				4	3	48.1	16.03333	29.32333		
				5	3	54.2	18.06667	34.86333		
			ANOVA							
			<i>Source of Variati</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>	
		Temperature	Rows	405.8653	2	202.9327	135.1983	6.82E-07	4.45897	
		growth regulators	Columns	10.136	4	2.534	1.688208	0.244786	3.837853	
			Error	12.008	8	1.501				
			Total	428.0093	14					

A

1) Hypotheses testing:

$$H_0: a_{5C} = a_{10C} = a_{25C} \quad VS \quad H_1: \text{at least one of means is different}$$

2) Test statistic:

$$F = 135.1983$$

3) Critical region:

$$F_{crit} = 4.45897$$

4) P-value = 0.000

Reject H_0 if $F > F_{crit}$

Or

 $p\text{-value} \leq \alpha$ **Decision:**

Therefore, we reject the null hypothesis. There are difference in the means of the weight loss of oranges between three storage temperature .

B

1) Hypotheses testing:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 \quad VS \quad H_1: \text{at least one of means is different}$$

2) Test statistic:

$$F = 1.688208$$

3) Critical region:

$$F_{crit} = 3.837853$$

4) P-value = 0.244786

Reject H_0 if $F > F_{crit}$

Or

 $p\text{-value} \leq \alpha$ **Decision:**

Therefore, we not reject the null hypothesis. There are no difference in the means of the weight loss of oranges between the five growth regulators.