Chapter 6

1)

In a study on the growth of melon ladybird beetles, y females were randomly assigned to 4 different vegetable leaf diets - cucumber, snake cucumber, squash and watermelon leaves. The number of eggs deposited by each female was recorded [Based on Ali and El-Saeady (1980)]:

عامل Host Plant Type

	Cucumber	Snake Cucumber	Squash	Watermelon	
	225	377	310	363	
	209	391	303	354	
	215	385	321	347	
	199	364	291	373	
	206	388	313	365	
Total	$T_{1.}=1054$	$T_{2.}=1905$	$T_{3.}=1538$	$T_{4.}=1802$	$T_{..}=6299$

a) Test whether there is a difference in host plant types on the average number of eggs deposited by female melon ladybird beetles. Use $\alpha = 0.05$.

b) If needed, make mean separation. Interpret.

2)

Samples were collected from three types of figs and the calcium (as a percent) was measured [Based on Saad et al. (1979)]:

Fig Type

1	2	3
0.594	0.561	0.569
0.632	0.573	0.585
0.626	0.580	0.605
0.587	0.559	0.583
0.592	0.593	0.552
0.587	0.608	0.562

a) Test whether the three fig types have different average levels of calcium. Use $\alpha = 0.01$.

b) If needed, make mean separation. Interpret.

3)

In a study on the effect of replacing cow's milk with fresh camel milk butterfat in the recipe of a layer cake, the moistness rating of each of 4 cakes in a level was determined by a group of panelists [Based on Al-Mana (1992)]

Replacement Levels				
0	25	50	75	100
10.0	9.5	9.7	8.5	6.6
9.9	8.9	9.8	7.9	7.0
9.9	9.3	9.3	7.5	6.7
9.7	9.1	9.6	8.1	6.9

a) Test whether the replacement levels have different effects on the average moistness rating of a layer cake. Use $\alpha = 0.05$.

b) If needed, make mean separation. Interpret.

4)

In a study, the interest was in the effect of four methods of irrigation on the fresh weight (in g) of lettuce plants. Available for use in the study were two lettuce varieties - Dark Green and Great Lakes. Four plants of each type were randomly assigned to the four treatments [Idea from Abdulla et al. (1981)]:

طريقة الري وعامل A

نوع الخس (نبات) — أخضر داكن — عامل B — بحيرات الكبرى

Variety	A Irrigation Method 1	2	3	4
Dark Green 1	8.14	9.24	16.36	4.79
Great Lakes 2	4.59	6.56	15.37	4.18

Assuming no interaction between irrigation methods and varieties, test whether there is a difference in irrigation methods on the average fresh weight of lettuce. Use $\alpha = 0.05$ and separate the means if necessary.

5)

Four types of fungi were used in an experiment to learn about the effect of cigarette smoke on fungal growth. Fungal cultures of the 4 types were randomly exposed to one of the smoke of 0, 2, 6, or 8 cigarettes. The rate of growth of the diameter (in mm) was measured [Based on Bokhary (1991)]:

	Number of Cigarettes Used			
Fungus	0	2	6	8
1	17.4	8.1	4.0	1.2
2	12.2	7.1	3.9	0.7
3	15.0	10.2	4.9	1.2
4	18.5	9.9	3.9	0.8

Assuming no interaction, test whether the four levels of the number of cigarettes used for smoke have different effects on the average diameter growth rate of fungi. Use $\alpha = 0.01$ and separate the means if necessary.

ch6 – For interaction

EXERCISES

مستوى الاسمدة   مسافة العرض بين النباتات

4.11. In a study on fertilizer levels and spacings between plants, plots were assigned to combinations and the yield of potatoes (in kg/plot) was measured [Based on Samman and Khalil (1979)]:

		Fertilizer level (in tons/ha) 1	2
Spacing Between Plants	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 and use mean separation as needed. Use $\alpha = 0.05$.

4.12. In a study, it was desired to know the effect of 4 species of a certain type of plant and 3 levels of water depletion on the forage yield (in kg). Twenty-four homogeneous plots were randomly assigned to the combinations and the following forage yields were obtained [Based on Abohassan and Habib (1985)]:

Species	Water Depletion 20%	40%	60%	Total
1	13.77	11.37	12.21	74.86
	14.17	11.71	11.63	
2	18.53	14.41	13.43	92.10
	19.09	13.75	12.89	
3	16.52	10.53	9.89	74.10
	15.80	11.09	10.27	
4	16.12	11.21	11.37	79.24
	16.60	11.95	11.99	

Make all appropriate tests and use mean separation as needed. Use $\alpha = 0.01$.

105 stat Exersises

4.13. In a study on a particular type of forage plant, plants were grown in 2 types of soil and given one of 4 nutrition treatments. The fresh weight (in g) at harvest gave the following [Modified from Zahran and Maghraby (1980)]:

Soil	Control	Complete Nutrition	Nutrient Minus Nitrogen	Nutrient Minus Phosphorus
Sandy	2.34	3.51	4.36	4.72
	2.59	3.64	2.70	2.48
	1.87	4.16	3.14	3.44
	4.13	3.90	9.12	2.58
	1.95	3.79	2.02	2.40
Silty	9.22	4.50	7.72	6.59
	3.72	4.78	8.18	6.76
	3.78	2.30	4.42	4.38
	5.16	3.86	5.12	8.56
	3.34	2.40	7.92	3.54

Make all appropriate tests and use mean separation if necessary. Use $\alpha = 0.05$.

4.14. In a study on alfalfa, two varieties of alfalfa and 3 harvest schedules (harvest every 20 days, every 30 days, and every 40 days) were used. Plots were randomly assigned to the combinations and the forage yield (in tons/hectare) was measured [Based on Ghandorah et al. (1986)]:

Variety	Time Between Harvests 20	30	40
1	32.57	42.07	47.95
	34.21	41.31	49.14
	33.87	39.89	48.83
2	29.42	36.98	44.17
	28.04	34.23	43.09
	30.62	35.20	45.40

Make all appropriate tests and use mean separation if necessary. Use $\alpha = 0.05$.

الفصل 4

حل

1، 4 ← تحليل التباين في اتجاه واحد

تحليل التباين في اتجاهين بدون تفاعل

و 4.11 ← تحليل التباين في اتجاهين مع تفاعل

واجب

2, 3, 5

4.12, 4.13, 9.14

تحليل التباين

يهتم بالمقارنة بين عدة متوسطات تتجاوز عددها عن 2 ، وعلى افتراض أن المتغير له توزيع طبيعي وتباينات مجهولة ومتساوية والعينات مستقلة .

تحليل التباين له عدة أنواع

تحليل التباين في اتجاه واحد

وهو دراسة أثر عامل واحد A على المتغير Y ، بحيث هذا العامل A له عدة أنواع (مستويات) مختلفة وتسمى بالمعالجات treat .

السؤال عليه يكون : هل يوجد فروقه معنوية (difference) بين المعالجات في التأثير على متوسط Y ؟!

تحليل التباين في اتجاهين

وهو دراسة أثر عاملين (عامل A ، عامل B) على المتغير Y ، بحيث مستويات العامل A تسمى بالمعالجات ومستويات العامل B تسمى بالقطاعات blocks .

السؤال عليه يكون: هل يوجد فروقه معنوية (difference) بين المعالجات في التأثير على متوسط Y ؟!
هل " " " القطاعات " " " " ؟!

- مع حد التفاعل بين العاملين
- بدون حد التفاعل بين العاملين

$\boxed{\text{تحليل التباين في اتجاه واحد}}$

Factor A (عامل) or treatments (معالجات) of factor A

	1	2		a	
	y_{11}	y_{21}		y_{a1}	
	y_{1n_1}	y_{2n_2}		y_{an_a}	
Total	$T_{1.}$	$T_{2.}$		$T_{a.}$	$T_{..}$

$$T_{..} = \sum_i \sum_j y_{ij} = \sum_i T_{i.}$$

$$T_{i.} = \sum_j y_{ij}$$

عدد المشاهدات الكلية $= N = n_1 + n_2 + \cdots + n_a$

مصدر الاختلاف Source	درجات الحرية DF	مجموع المربعات SS	متوسط مجموع المربعات MS	F	P-value
Factor A	$a-1$	SSA or SST_r	$MSA = \frac{SSA}{a-1}$ or MST_r	$F = \frac{MSA}{MSE}$	P
الخطأ Error	$N-a$	SSE	$MSE = \frac{SSE}{N-a}$		
Total	$N-1$	SST			

$$SST = SSA + SSE$$

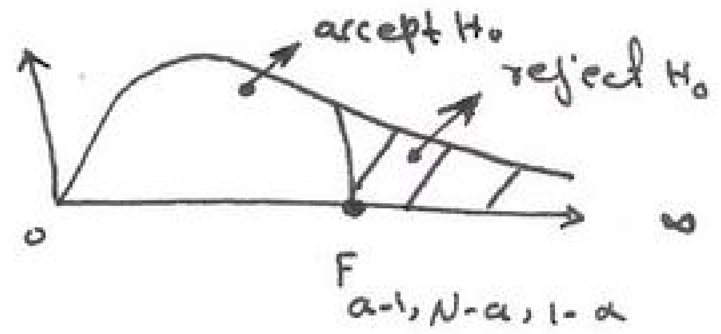
$$SSE = SST - SSA$$

$$SST = \sum_i \sum_j y_{ij}^2 - \frac{T_{..}^2}{N}$$

$$SSA = \sum_i \frac{T_{i.}^2}{n_i} - \frac{T_{..}^2}{N}$$

$H_0: \mu_1 = \mu_2 = \cdots = \mu_a$ VS H_1: not all μ_i are equal (على الأقل أحد المتوسطات يختلف)

$$F = \frac{MSA}{MSE} \sim F_{a-1,\,N-a}$$



عملياً: نأخذ نفس الجدول المعطاة ثم
stat → ANOVA → one-way (unstacked)
انتقل ثم اكتب عند confidence level $1-\alpha$ ، $(1-\alpha)100\%$
ثم ok

ي اتجاهين من دون تفاعل

Factor A or treatments of Factor A

Factor B or قطاعات blocks of factor B

	1	2	...	i	...	a	total
1	y_{11}	y_{21}				y_{a1}	$T_{.1}$
2	y_{12}	y_{22}				y_{a2}	$T_{.2}$
⋮							
j				y_{ij}			
⋮							
b	y_{1b}	y_{2b}				y_{ab}	$T_{.b}$
total	$T_{1.}$	$T_{2.}$				$T_{a.}$	$T_{..}$

$$T_{..} = \sum_i \sum_j y_{ij} = \sum_i T_{i.} = \sum_j T_{.j}$$

$$T_{i.} = \sum_j y_{ij}$$

$$T_{.j} = \sum_i y_{ij}$$

$N = a \times b =$ عدد المشاهدات الكلية

Source	DF	SS	MS	F	p-value
Factor A	$a-1$	SSA or SSTr	$MSA = \frac{SSA}{a-1}$ or MSTr	$F_A = \frac{MSA}{MSE}$	P_A
Factor B	$b-1$	SSB or SSbk	$MSB = \frac{SSB}{b-1}$ or MSbk	$F_B = \frac{MSB}{MSE}$	P_B
Error	$(a-1)(b-1)$	SSE	$MSE = \frac{SSE}{(a-1)(b-1)}$		
Total	$N-1 = ab-1$	SST			

$$SST = SSA + SSB + SSE$$

$$SST = \sum_i \sum_j y_{ij}^2 - \frac{T_{..}^2}{N}$$

$$SSA = \sum_i \frac{T_{i.}^2}{b} - \frac{T_{..}^2}{N}$$

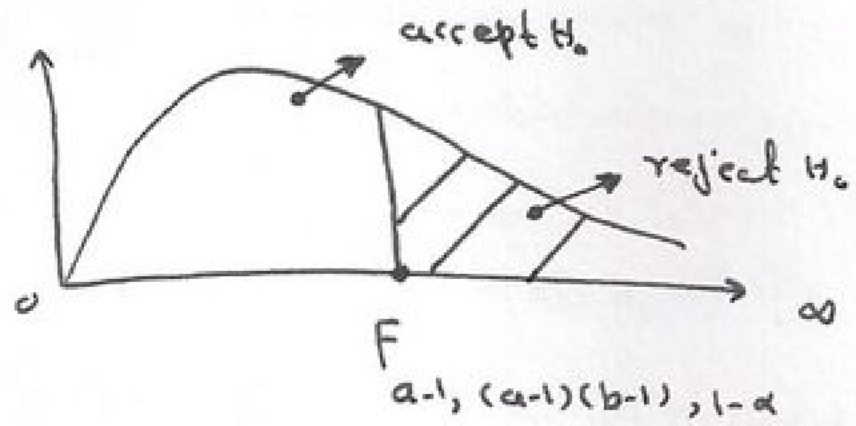
$$SSB = \sum_j \frac{T_{.j}^2}{a} - \frac{T_{..}^2}{N}$$

$$SSE = SST - (SSA + SSB)$$

For Factor A: $H_0: \mu_1 = \mu_2 = \dots = \mu_a$ vs H_1: not all μ_i are equal

على الأقل أحد المتوسطات يختلف

$$F_A \sim F_{a-1,\,(a-1)(b-1)}$$

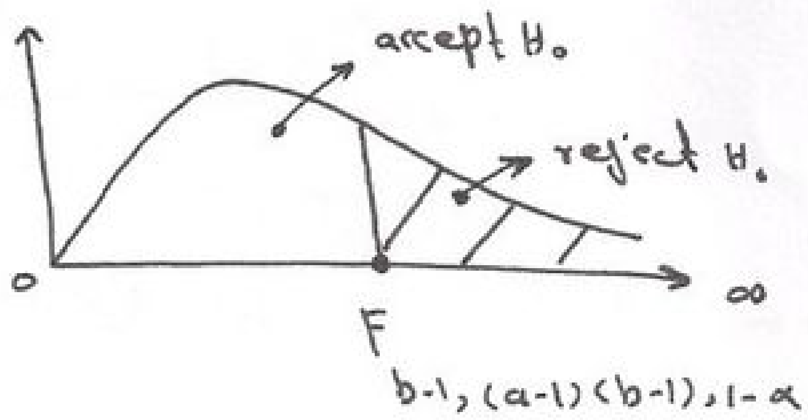


$F_{a-1,\,(a-1)(b-1),\,1-\alpha}$

For Factor B: $H_0: \mu_1 = \mu_2 = \dots = \mu_b$ vs H_1: not all μ_j are equal

على الأقل أحد المتوسطات يختلف

$$F_B \sim F_{b-1,\,(a-1)(b-1)}$$



$F_{b-1,\,(a-1)(b-1),\,1-\alpha}$

عملياً: لو كان لدينا الجدول التالي :

B \ A	1	2	3
1	1	3	5
2	2	4	6

يصبح على النحو التالي :

X	A	B
1	1	1
2	1	2
3	2	1
4	2	2
5	3	1
6	3	2

ثم Stat → ANOVA → Two way

انقل X إلى response

وانقل A إلى row factor

وانقل B إلى columns factor

ثم أكتب عند confidence level ← $1-\alpha$ ← $(1-\alpha)100\%$

ثم ok

جاهين مع تفاعل

Factor A

		1	2	. . .	a
Factor B	1	y_{111} y_{112} ⋮ y_{11n}	y_{211} y_{212} ⋮ y_{21n}		
	⋮				
	b				

في كل خلية توجد n قراءة

$N = abn$ = عدد او مجموع المشاهدات الكلي

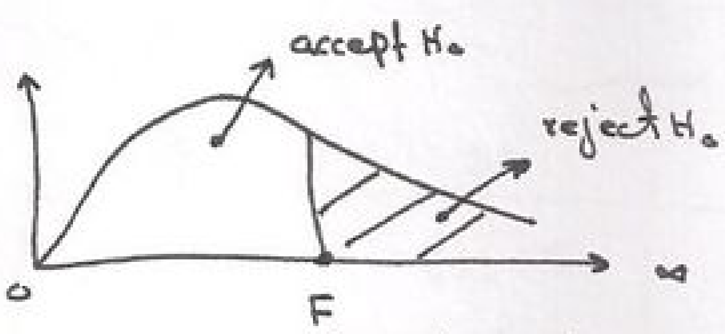
حيث n هي عدد القراءات في كل خلية

source	DF	SS	MS	F	P-value
Factor A	$a-1$	SSA	$MSA = \frac{SSA}{a-1}$	$F_A = \frac{MSA}{MSE}$	P_A
Factor B	$b-1$	SSB	$MSB = \frac{SSB}{b-1}$	$F_B = \frac{MSB}{MSE}$	P_B
interaction AB	$(a-1)(b-1)$	SSAB	$MSAB = \frac{SSAB}{(a-1)(b-1)}$	$F_{AB} = \frac{MSAB}{MSE}$	P_{AB}
error	$ab(n-1)$	SSE	$MSE = \frac{SSE}{ab(n-1)}$		
total	$abn-1$ $=N-1$	SST			

For interaction AB : H_0: There is no interaction between A and B Vs

H_1: " " ~~X~~ " " " "

$$F_{AB} \sim F_{(a-1)(b-1),\, ab(n-1)}$$



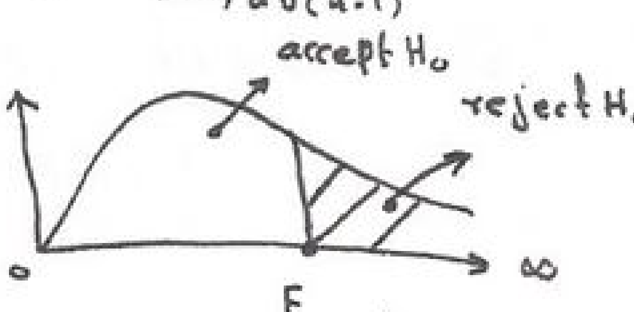
$F_{(a-1)(b-1),\, ab(n-1),\, 1-\alpha}$

ملاحظة: إذا رفضنا H_0 نتوقف هنا

وإذا قبلنا H_0 نكمل التالي

For Factor A : $H_0: \mu_1 = \mu_2 = \dots = \mu_a$ Vs H_1: not all μ_i are equal

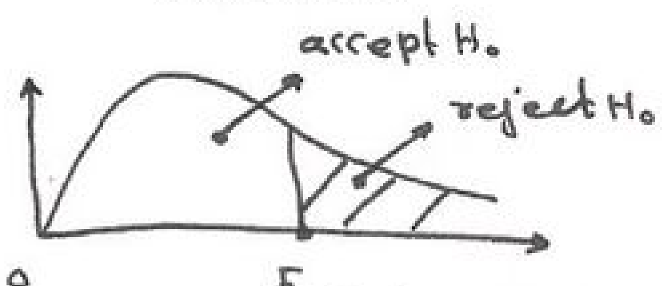
$$F_A \sim F_{a-1,\, ab(n-1)}$$



$F_{a-1,\, ab(n-1),\, 1-\alpha}$

For Factor B : $H_0: \mu_1 = \mu_2 = \dots = \mu_b$ Vs H_1: not all μ_j are equal

$$F_B \sim F_{b-1,\, ab(n-1)}$$



$F_{b-1,\, ab(n-1),\, 1-\alpha}$

عمليا: لو كان لدينا الجدول التالي :

A

		1	2
B	1	① ②	⑤ ⑥
	2	③ ④	⑦ ⑧

يعبأ على النحو التالي :

X	A	B
①	1	1
②	1	1
③	1	2
④	1	2
⑤	2	1
⑥	2	1
⑦	2	2
⑧	2	2

ثم

stat → ANOVA → two way

انقل X إلى response

وانقل A إلى raw factor

وانقل B إلى columns factor

ثم اكتب من confidence level → $1-\alpha$ / $(1-\alpha)100\%$

ثم ok

Ch. 6

حل الأسئلة

treatments of Factor A : host plant types أنواع النبات المضيف

1

	1	2	3	4 = a	
	$y_{11}=225$	$y_{21}=377$	$y_{31}=310$	$y_{41}=363$	
	$y_{12}=209$	$y_{22}=391$	$y_{32}=303$	$y_{42}=354$	
	$y_{13}=215$	$y_{23}=385$	$y_{33}=321$	$y_{43}=347$	
	$y_{14}=149$	$y_{24}=364$	$y_{34}=291$	$y_{4.}=373$	
	$y_{15}=206$	$y_{25}=388$	$y_{35}=313$	$y_{45}=365$	
total	$T_{1.}=1054$	$T_{2.}=1905$	$T_{3.}=1538$	$T_{4.}=1802$	$T_{..}=6299$

Y: # of eggs deposited by female melon ladybird beetles.

عدد البيوض التي أودعتها

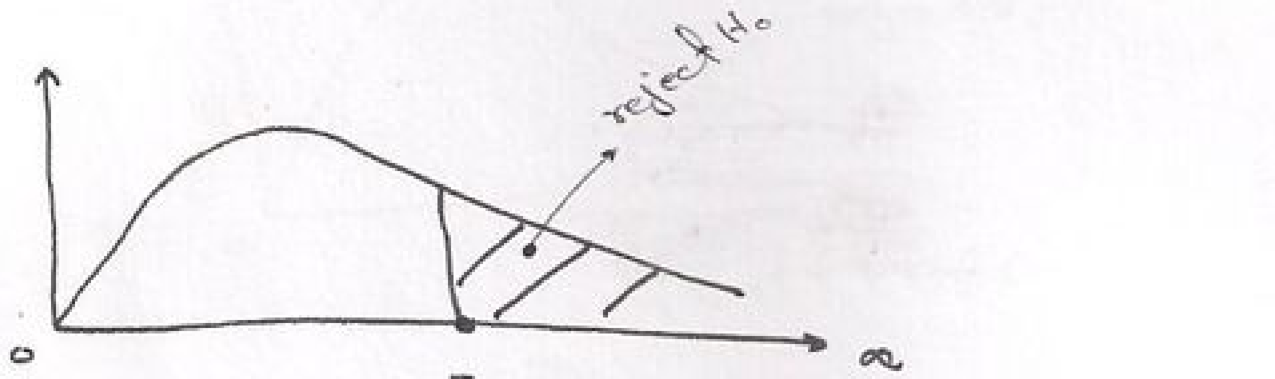
اسم حشرة الش

$\alpha = .05$

$N = 5+5+5+5 = 20$

$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$ vs H_1: not all μ_i are equal

$F = 260.61 \sim F_{3,16}$



$F_{4-1,20-4,.95} = F_{3,16,.95} = 3.23887$

$\therefore$ as $F = 260.61 > 3.23887$

so, we reject H_0

Source	df	SS	MS	F	P
factor A	3	86648	28883	260.61	0
error	16	1773	111		
total	19	88421			

$\sum_i \sum_j y_{ij}^2 = 2072291$

$SST = 2072291 - \frac{(6299)^2}{20} = 88420.95 \simeq 88421$

$SSA = \left[\frac{(1054)^2}{5} + \frac{(1905)^2}{5} + \frac{(1538)^2}{5} + \frac{(1802)^2}{5} \right] - \frac{(6299)^2}{20} = 86647.75 \simeq 86648$

$SSE = 88421 - 86648 = 1773$

4

طريقة الري

treatments of factor A: irrigation method

الوزن الطازج للخس

Y: fresh weight of lettuce.

$\alpha = .05$

$N = ab = 8$

blocks of factor B: Varieties of lettuce

أصناف أو أنواع الخس

	1	2	3	4 = a	total
1	$y_{11} = 8.14$	$y_{21} = 9.24$	$y_{31} = 16.36$	$y_{41} = 4.79$	$T_{.1} = 38.53$
b = 2	$y_{12} = 4.59$	$y_{22} = 6.56$	$y_{32} = 15.37$	$y_{42} = 4.18$	$T_{.2} = 30.7$
total	$T_{1.} = 12.73$	$T_{2.} = 15.8$	$T_{3.} = 31.73$	$T_{4.} = 8.97$	$T_{..} = 69.23$

* assume that there is no interaction

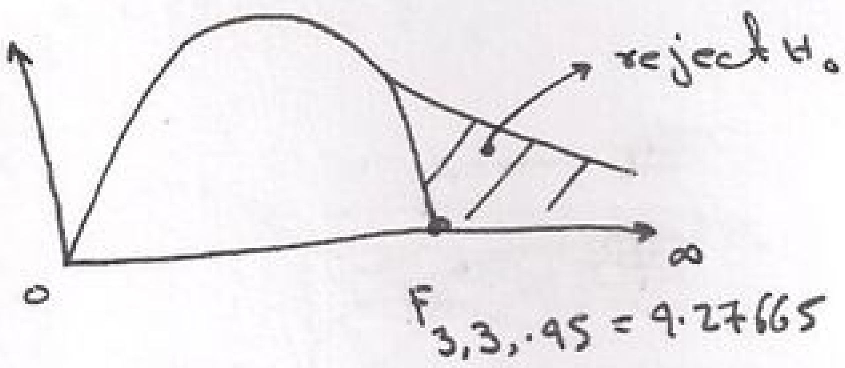
For factor A:

$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$ Vs H_1: not all μ_i are equal

$F_A = 51.77 \sim F_{3,3}$

$\therefore$ as $F_A = 51.77 > 9.27665$

so, we reject H_0



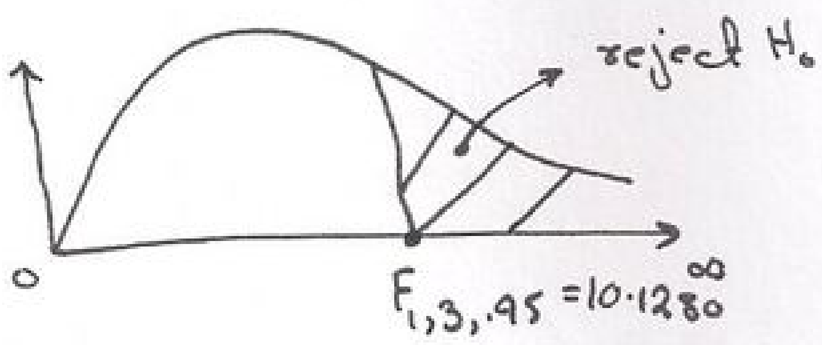
For factor B:

$H_0: \mu_1 = \mu_2$ Vs H_1: not all μ_j are equal

$F_B = 7.91 \sim F_{1,3}$

$\therefore$ as $F_B = 7.91 < 10.1280$

so, we accept H_0



source	df	SS	MS	F	P
factor A	3	150.374	50.1247	51.77	.004
factor B	1	7.664	7.6636	7.91	.067
error	3	2.905	.9683		
total	7	160.943			

$\sum_i \sum_j y_{ij}^2 = 760.042$

$SST = \sum_i \sum_j y_{ij}^2 - \frac{T_{..}^2}{N} = 160.943$

$SSA = \sum_i \frac{T_{i.}^2}{b} - \frac{T_{..}^2}{N} = 150.374$

$SSB = \sum_j \frac{T_{.j}^2}{a} - \frac{T_{..}^2}{N} = 7.664$

$SSE = SST - (SSA + SSB) = 2.905$

4.11

مستوى الأسمدة

treatments of Factor A: Fertilizer level

		1	2 = a
blocks of Factor B: spacings between plants	1	$y_{111} = 16.01$ $y_{112} = 16.78$ $y_{113} = 16.44$	$y_{211} = 15.89$ $y_{212} = 16.23$ $y_{213} = 16.18$
	b = 2	$y_{121} = 13.42$ $y_{122} = 13.25$ $y_{123} = 13.32$	$y_{221} = 13.32$ $y_{222} = 13.47$ $y_{223} = 13.26$

المسافة بين النباتات

وزن محصول البطاطس

Y: weight of potatoes in the yield

$N = abn = (2)(2)(3) = 12$, $n = 3$

For interaction AB: H_0: There is no interaction between A and B vs

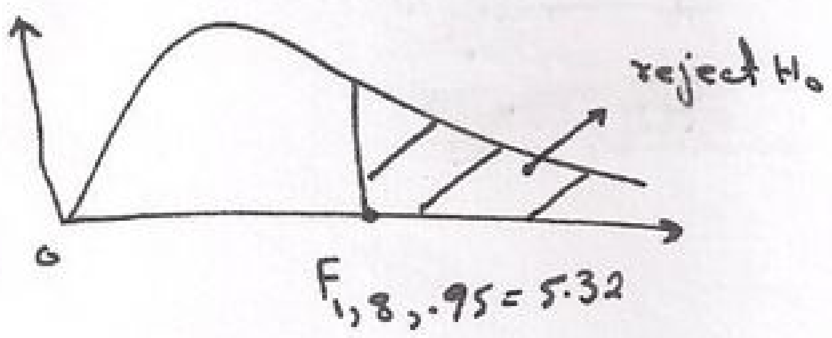
H_1: " " ~~no~~ " " "

من الجدول نأتي به ← $F_{AB} = 1.62 \sim F_{1,8}$

$\therefore$ as $F_{AB} < 5.32$

so, we accept H_0

إذن نستطيع إكمال الاختبارات التالية

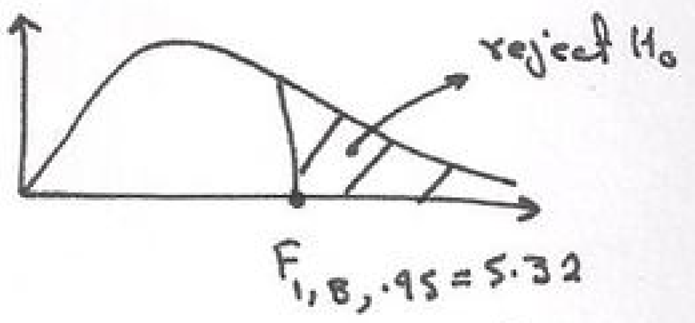


For Factor A: $H_0: \mu_1 = \mu_2$ Vs H_1: not all μ_i are equal $\cong \mu_1 \neq \mu_2$

من الجدول نأتي به ← $F_A = 1.25 \sim F_{1,8}$

$\therefore$ as $F_A < 5.32$

so, we accept H_0

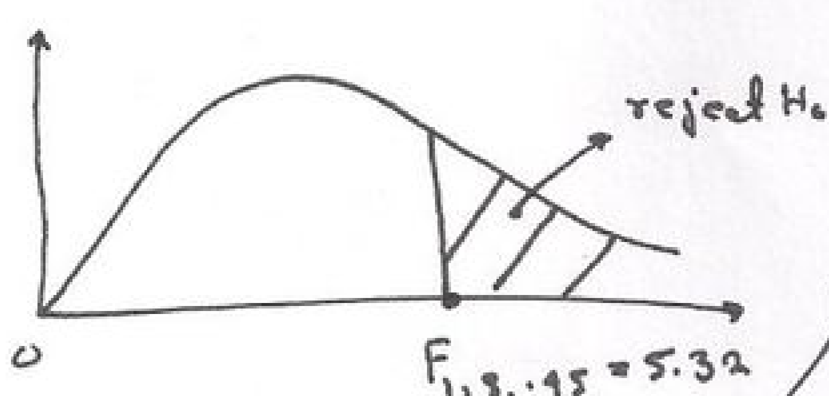


For Factor B $H_0: \mu_1 = \mu_2$ vs H_1: not all μ_j are equal $\cong \mu_1 \neq \mu_2$

من الجدول نأتي به ← $F_B = 505.78 \sim F_{1,8}$

$\therefore$ as $F_B > 5.32$

so, we reject H_0



يحسب هذا الجدول من البرنامج Minitab :

source	DF	SS	MS	F	P-value
Factor A	1	.0631	.0631	$F_A = 1.25$	$P_A = .296$
Factor B	1	25.4917	25.4917	$F_B = 505.79$	$P_B = 0$
interaction AB	1	.0817	.0817	$F_{AB} = 1.62$	$P_{AB} = .239$
error	8	.4032	.0504		
total	11	26.0396			