International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 4 Issue 9, September-2015

Effect of Factors Locations on the Results of Split-Plot Design

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ABSTRACT

When performing a split-plot design experiment, there must be data that determine factors location, whereas one of the factors in the main plots and the factor or the other factors may put in sub plots, from this point, the current research aims at determining effects on the statistical analyzes results and making the right decision about the laboratory hypotheses through differences significant among the levels of each factor, factor location and overlaps among the factors in split-plot designs, practical application was made depending on agricultural field experiment (a study conducted on barley) where data were analyzed according to statistical system (SAS V. 9.00).

Keywords: Factorial experiments, Split-plot design, Effect of factor location, SAS.

1. INTRODUCTION

The idea of split-plot was found to add practical advantages into the advantages and specifications of the factorial experiments lies in concentrating and improving the accuracy and the importance of studying effects of factors and interactions among them since they are containing more than one resource for random error because this idea obtained expansion and added more things in both theoretical and practical fields which took part in varying and developing adopted designs. So, to explain and understand the importance of the practical fields of these additions, the research aims at conducting an analytical study for many designs as the factorial experiments design and split-split-plot design to explain the effect of significant differences among the factor levels on the selected design results, as well as, the factor location in the experiment and overlaps among the factors and what it may be produced from their ideas designs with practical advantages.

2. FACTORIAL EXPERIMENTS

In many experiments, there is a great desire to study the effect of two variables or more on response variable, for example, when studying the effect of different methods of teaching and different levels of students on learning level or studying the effect of age groups according to gender of being infected with certain tumors and so on. This kind of experiments when two variables or more are analyzed are called factorial experiments [1].

Factorial is defined as a type of treatment which contains multi divisions called levels, and interest is usually made in the factorial experiments with the main effects of factors, as well as, with interaction among them, where the main effect of the factor is defined as the alteration which is made in the responsive according to the changing in the factor level and called the main, because it is acquired more interest in the experiment, while the simple effect of factor is defined as the difference in response between two certain factor levels and a certain level for another factor, then, the main effect of a certain factor equals the simple effects average of it, while interaction is defined as the difference in response among certain factor levels as a result according to a change of another factor levels [1,6].

Treatments in the factorial experiments are (Combinations) from different levels of these factors, they are experiments in designs, in other words, they are used with the main designs, and they are more used with the randomized complete block design (RCBD), where each factor level mustn't be less than two, where it is possible to make a combination from the different factors as a factor carries out with the same way and the desired accuracy of effect measurement of the two factors is equal, the mathematical model of one factorial experiment with three factors applied with the randomized complete block design is:[4,7].

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \rho_l + \varepsilon_{ijkl} \qquad \dots(1)$$

$$i = 1, 2, \dots, a$$
$$j = 1, 2, \dots, b$$
$$k = 1, 2, \dots, c$$
$$l = 1, 2, \dots, r$$

y_{ijkl}: Observation value of experimental unit (l) which took level (i) from the factor (A) and level (j) from the factor (B) and level (k) from the factor (C).
μ : Effect of general arithmetic mean.
α_i :Effect of the level (i) from the factor (A).
β_j :Effect of the level (j) from the factor (B).
γ_k :Effect of the level (k) from the factor (C).
$(\alpha\beta)_{ij}$:Effect overlapping between level (i) from the factor (A) and level (j) from the factor (B).
$(\alpha\gamma)_{ik}$:Effect overlapping between level (i) from the factor (A) and level (k) from the factor (C).
$(\beta\gamma)_{jk}$:Effect overlapping between level (j) from the factor (B) and level (k) from the factor (C).
$(\alpha\beta\gamma)_{ijk}$:Effect overlapping between level (i) from the factor (A) and level (j) from the factor (B) and level (k) from the factor (C).
ρ_l :Effect of block (l).
e_{ijk} :Effect of random error.

Table 1: refers to variance analysis of three factors (A,B and C) [6].

Table 1: Variance Analysis for the Design of Factorial Experiment with Three Factors Applied Using Randomized Complete Block Design

S.O.V	D.F	S.S
Blocks	r-1	$SSr = R - C.F$
A	a-1	$SS(A) = A - C.F$
B	b-1	$SS(B) = B - C.F$
C	c-1	$SS(C) = C - C.F$
AB	(a-1)(b-1)	$SS(AB) = AB - A - B + C.F$
AC	(a-1)(c-1)	$SS(AC) = AC - A - C + C.F$
BC	(b-1)(c-1)	$SS(BC) = BC - B - C + C.F$
ABC	(a-1) (b-1)(c-1)	$SS(ABC) = ABC - AB - AC - BC + A + B + C - C.F$
Error	(r-1)(abc-1)	$SSe = RABC - R - ABC + C.F$
Total	abcr-1	$SST = RABC - C.F$

3. EFFECT OF IMPORTANCE AND LOCATION OF FACTOR ON THE SPLIT-PLOT DESIGN

When applying factorial experiment it is impossible to find what is the more effective factors on the analysis results because the factorial experiments analyzed factors with the same level, so we resort to split experiments to show difference extent and importance of each factor and its effect on other factors and on the analysis results and also studying the effect of location for each factor on the other factors and overlaps among factors, and do factor location and difference significant among its levels average effect difference significant among factors averages, in other words, taking into consideration factor location and also former factor location and their influence extent on other factors, and this is will be explained theoretically and supported practically.

4. SPLIT-PLOT DESIGN

The idea of split-plot design and its widening depends on the number factors inserted in the experiment and what is the factor or the factors which need more accuracy, and what is the less important factor and type of design and type of the filed in which the experiment will be made (laboratory, agricultural, medical), as well as, the factor location and the effect of the former factors on significant or insignificant of the factor [3].

Also this design is considered one of the common designs in the two variables agricultural experiments, since it is used to study the effect of two factors on two types of experimental plots, one of them is called (Main plots), and the other is called (Sub plots), which represent parts of each main plot, and the current factors, one of them is distributed inside the main plots and called (Main plot factor), and the other factor is distributed inside the sub plots and called (Sub plot factor), hence, each main plot becomes a block for the factors distributed inside the sub plots (sub factor levels), and the measurement the effect of factor accuracy effect in the main plots is usually be less in designing the split plots, and the purpose of this is to improve the factor measurement accuracy which will be distributed on the sub plots, and also measuring the main effect of the factor in the sub plots and its overlapping with the factor in the main plots which is more accuracy of that obtained in the factorial experiment, from other part, measuring effects of factor levels found in the split-plots is less accuracy than those used in the randomized complete blocks [4,5].

When three factors or more with their interactions with each other are wanted to be studied (The split-split plot design) is used, and it is used when the researcher interest differs with the wanted factors to be studied and needs to obtain more accurate information of one of the factors then the other less accurate and the third less and so on, or cases that need great (Experimental units) areas to apply one of the factors, where in this case, split-split-plot designs are used and this design is an expansion of spit-plot design where third factor is added in the (Sub sub plots), which are considered the smallest spaces, and their accuracy is larger than the two factors in the (Main plots) and the (Sub plots), also this design is considered one of the common designs in the field experiments, and the mathematical model of the three factors factorial applied with the split-split- plot design by using randomized complete blocks design is:[2].

$$\boldsymbol{y_{ijkl} = \mu + \rho_l + \alpha_i + \varepsilon_{il} + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijl} + \gamma_k + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \varepsilon_{ijkl}} \quad \dots (2)$$

$$\boldsymbol{i = 1, 2, \dots, a}$$
$$\boldsymbol{j = 1, 2, \dots, b}$$
$$\boldsymbol{k = 1, 2, \dots, c}$$
$$\boldsymbol{l = 1, 2, \dots, r}$$

$\boldsymbol{y_{ijkl}}$: Observation value of experimental unit (l)) which took level (i) from the factor (A) and level (j) from the factor (B) and the level (k) from the factor (C).
$\boldsymbol{\mu}$: Effect of general arithmetic mean.
$\boldsymbol{\rho_l}$:Effect of block (I)
$\boldsymbol{\alpha_i}$:Effect of the level (i) from the factor (A).
$\boldsymbol{\varepsilon_{il}}$: Effect of random error of the main plots.
$\boldsymbol{\beta_j}$:Effect of the level (j) from the factor (B).
$\boldsymbol{(\alpha\beta)_{ij}}$: Effect of overlapping between level $(i)$from the factor (A) and level (j) from the factor (B).
$\boldsymbol{\varepsilon_{ijl}}$: Effect of random error of the sub plots.
$\boldsymbol{\gamma_k}$:effect of the level (k) from the factor (C).
$\boldsymbol{(\alpha\gamma)_{ik}}$:Effect of overlapping between level (i) from the factor (A) and level (k) from the factor (C).
$\boldsymbol{(\beta\gamma)_{jk}}$:Effect of overlapping between level (j) from the factor (B) and level (k) from the factor (C).
$\boldsymbol{(\alpha\beta\gamma)_{ijk}}$:Effect of overlapping between level (i) from the factor (A) and level (j) from the factor (B) and level (k) from the factor (C).

$\boldsymbol{e_{ijk}}$: Effect of random error of the sub sub plots.

5. RANDOM DISTRIBUTION AND EXPERIMENT PLAN

Random distribution and experiment plan of the current model is done by dividing the experiment land into divisions according to the number of blocks, where each block is divided into divisions according to the number of the first factor levels and their levels are distributed randomly on all the main plots inside each block alone, and each main plot is divided into number of divisions according to the number of the second factor levels inside the sub plots and their levels are distributed inside each main plot then each experimental split plot is divided in to a number of divisions as the number of third factor level and distributing levels of this factor randomly inside each split plot to be distributed as factorial experiments in the split-split-plot design by using randomized complete block design (R.C.B.D), when three factors are not equal in importance. Table (2) shows variance analysis for this experiment [2,5].

Table 2: Variance Analysis for Split-Split-Plot Design by Using Randomized Complete Block Design

S.O.V.	D.F.	S.S.
Blocks	(r-1)	$SSr = R - C.F$
A	(a- 1)	$SS(A) = A - C.F$
Error(a)	(a-1)(r-1)	$SSe(A) = RA - R - A + C.F$
B	(b-1)	$SS(B) = B - C.F$
AB	(a-1)(b-1)	$SS(AB) = AB - A - B + C.F$
Error(b)	a(b-1)(r-1)	$SSe(B) = RAB - RA - AB + C.F$
C	(c-1)	$SS(C) = C - C.F$
AC	(a-1)(c-1)	$SS(AC) = AC - A - C + C.F$
BC	(b -1)(c-1)	$SS(BC) = BC - B - C + C.F$
ABC	(a-1)(b-1)(c-1)	$SS(ABC) = ABC - AB - AC - BC + A + B + C - C.F$
Error(c)	ab(c-1)(r-1)	$SSe(C) = RABC - RAB - ABC + AB$
Total	abcr-1	$SST = RABC - C.F$

To explain the theoretical part, a factorial experiment contains three factors is being supposed, first (A) with levels (a), second (B) with levels (b), third (C) with levels (c) carried out according to split-split-plot design by using randomized complete block design with (r) of repetitions of each factor which represents harmony among the three factors levels, so, results or responses of these factors can be expressed by symbols as in table (3): [3].

Table 3: Responses with Symbols of the Applied Experiment Observations According to the Split-Split-Plot Design by Using Randomized Complete Block Design

A	B	C	R_1	. R_l .	R_r
	b_1	c_1 . c_k . c_c	y_{1111} y_{11k1} y_{11c1}	y_{111l} y_{11kl} y_{11cl}	y_{111r} y_{11kr} y_{11cr}
a_1	. b_j .	c_1 . c_k . c_c	y_{1j11} y_{1jk1} y_{1jc1}	y_{1j1l} y_{1jkl} y_{1jcl}	y_{1j1r} y_{1jkr} y_{1jcr}
	b_b	c_1 . c_k . c_c	y_{1b11} y_{1bk1} y_{1bc1}	y_{1b1l} y_{1bkl} y_{1bcl}	y_{1b1r} y_{1bkr} y_{1bcr}
. a_i .	. .	. .	. .	. .	. .
	b_1	c_1 . c_k . c_c	y_{a111} y_{a1k1} y_{a1c1}	y_{a11l} y_{a1kl} y_{a1cl}	y_{a11r} y_{a1kr} y_{a1cr}
a_a	. b_j .	c_1 . c_k . c_c	y_{aj11} y_{ajk1} y_{ajc1}	y_{aj1l} y_{ajkl} y_{ajcl}	y_{aj1r} y_{ajkr} y_{ajcr}
	b_b	c_1 . c_k . c_c	y_{ab11} y_{abk1} y_{abc1}	y_{ab1l} y_{abkl} y_{abcl}	y_{ab1r} y_{abkr} y_{abcr}

6. PRACTICAL PART

This part dealt with analyzing factorial experiment data applied in randomized complete block design, and this part is divided into two axes: the first one deals with analyzing applied experiment data, while the second one deals with analyzing split-split-plot experiment data by using randomized complete block design, data were analyzed by using SAS V. 9.00.

6-1) Description of the Experiment and Data Collecting

An applied factorial experiment data with randomized complete block design 2*3*3 were obtained from department of field yields, college of agriculture and forest, university of mosul for season (2008) and they are showed in table (4).

Table 4: Data of Barley Quantity with Factors

A	B	C	BLOCK 1	BLOCK 2	BLOCK 3	$Y_{ijk.}$
a_1	b_1	c_1	450	455	440	1345
		c_2	456	457	468	1381
		c_3	465	475	487	1427
	b_2	c_1	489	490	490	1469
		c_2	410	410	415	1235
		c_3	430	435	425	1290
	b_3	c_1	400	405	405	1210
		c_2	480	490	486	1456
		c_3	440	450	460	1350
a_2	b_1	c_1	500	510	505	1515
		c_2	530	540	535	1605
		c_3	576	564	587	1727
	b_2	c_1	590	590	526	1706
		c_2	546	578	529	1653
		c_3	490	501	508	1499
	b_3	c_1	520	525	540	1585
		c_2	570	590	560	1720
		c_3	500	550	525	1575
$Y_{...i}$			8842	9015	8891	26748

The experiment contains three different locations, each one represents a complete block contains (18) experimental units, cultivated with barely, the experiment includes three factors: First (A): used two types of plows (reversible site, reversible disk), and the second factor (B): includes three depths (10 cm, 15 cm, 20 cm) and the third factor (C) includes three types of barely (local black, Arifat, white).

6-2) Statistical Analysis of the Experiment

A. First Axis: Factorial Experiment Applied in Randomized Complete Block Design

Experiment data table (4) were analyzed by using (SAS) program for being a factorial experiment applied in randomized complete block design, depending on applying the mentioned forms in table (1), variance analysis results were obtained as shown in table (5).

Table 5: Variance Analysis of Applied Factorial Experiment 2*3*3

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	2.37
A	1	108631.185	108631.185	583.43**
B	2	641.779	320.889	1.72
C	2	1536.444	768.222	4.13*
AB	2	1070.37	535.185	2.87
AC	2	875.259	437.629	2.35
BC	4	31617.111	7904.278	42.45**
ABC	4	6855.852	1713.963	9.21**
Error	34	6330.555	186.193	
Total	53	158442		

Table (5) shows that factors and overlapping (A**, C* , BC**, ABC**) with significant statistical sign with significant level ($\alpha = 0.05 *, \alpha = 0.01 **$) in other words, there is a significant difference among the factor levels (A**) in their effect on the yield quantity and also there are differences among the factor levels (C*), and there are insignificant differences among the factor levels ($B^{n.s}$) and that overlapping among the factors showed significant differences in their effect on the yield quantity with different levels of each factor.

B. Second Axis

In this axis data in table (4) were analyzed by using (SAS) program for being split-split-plot experiment applied in randomized complete block design, where factors changing in locations was taking into consideration (main plots, sub plots , sub sub plots), for all arrangement possibilities of the three factors for each location, in other words, the three factors multiplicand according to the location to be six different analyses (3! = 6) to show the effect of location and the former factors, besides the overlapping among the factors on the analysis results, follows results of the statistical analyses of the six cases depending on the mentioned form application in table (2).

1. First Case:

Table 6: Variance Analysis of Split (A) Experiment Factor in the Main Plots and Factor (B) in the Sub Plots and Factor (C) in Sub Sub Plots

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	1.57
A	1	108631.185	108631.185	386.26**
Error(a)	2	562.481	281.241	
B	2	641.778	320.889	1.47
AB	2	1070.37	535.185	2.45
Error(b)	8	1749.407	218.676	
C	2	1536.444	768.222	4.59*
AC	2	875.259	437.629	2.61
BC	4	31617.111	7904.278	47.21**
A*B*C	4	6855.852	1713.963	10.24**
Error(c)	24	4018.667	167.444	
Total	53	158442		

Table (6) results show that factors and overlapping (A**, C* , BC**, ABC**), with significant statistical sign with significant level ($\alpha = 0.05 *, \alpha = 0.01 **$), and these results are the same in the factorial experiment in table (5).

2. Second Case:

Table 7: Variance Analysis of Split (A) Experiment Factor in the Main Plots and Factor (C) in the Sub Plots and Factor (B) in Sub Sub Slots

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	1.57
A	1	108631.185	108631.185	386.26**
Error(a)	2	562.481	281.241	
C	2	1536.444	768.222	4.74*
AC	2	875.259	437.629	2.7
Error(c)	8	1296.519	162.065	
B	2	641.778	320.889	1.72
AB	2	1070.37	535.185	2.87
CB	4	31617.111	7904.278	42.42**
ACB	4	6855.852	1713.963	9.2**
Error(b)	24	4471.556	186.315	
Total	53	158442		

Table (7) results show that factors and overlapping (A**, C* , BC**, ABC**), with significant statistical sign with significant level ($\alpha = 0.05*, \alpha = 0.01 **$), and these results are the same in the first case in table (6) although the location changing between the two factors (B) and (C) but the factor (B) levels don't show significant differences although putting in the sub sub plots.

3. Third Case:

Table 8: Variance Analysis of Split (B) Experiment Factor in the Main Plots and Factor (A) in the Sub Plots and Factor (C) in Sub Sub Plots

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	1.5
B	2	641.778	320.889	1.09
Error(b)	4	1178.778	294.694	
A	1	16502.518	16502.518	123.15**
AB	2	7085.481	3542.741	26.44**
Error(a)	6	804	134	
C	2	616.333	308.167	1.7
BC	4	16444.222	4111.056	22.69**
AC	2	93924.037	46962.019	259.23**
BAC	4	16013.629	4003.407	22.1**
Error(c)	24	4347.778	181.157	
Total	53	158442		

Table (8) results show that factors and overlapping (A**, AB**, AC**, BC**, ABC**), with significant statistical sign with significant level ($\alpha = 0.05*, \alpha = 0.01 **$), in other words, there are significant differences among the factor (A**) levels in their effect on the yield quantity, besides insignificant difference among the factor ($C^{n.s}$) levels although putting in the sub sub plots because of the effect of the former significant factor (A**), and that overlapping among factors shows significant differences in their effect on yield quantity with difference of levels for each factor, although the insignificant of factor ($B^{n.s}$) and the factor ($C^{n.s}$) but the overlapping between them was significant, where their levels overlapping showed a significant effect on the yield quantity.

4. Fourth Case:

Table 9: Variance Analysis of Split (B) Experiment Factor in the Main Plots and Factor (C) in the Sub Plots and Factor (A) in Sub Sub Plots

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	1.5
B	2	641.778	320.889	1.09
Error(b)	4	1178.778	294.694	
C	2	1536.444	768.222	4.8*
BC	4	31617.111	7904.278	49.42**
Error(c)	12	1919.444	159.954	
A	1	108631.185	108631.185	604.94**
AB	2	1070.37	535.185	2.98
AC	2	875.259	437.629	2.44
BAC	4	6855.852	1713.963	9.54**
Error(a)	18	3232.333	179.574	
Total	53	158442		

Table (9) results show that factors and overlapping (A**, BC**, C*, ABC**), with significant statistical sign with significant level ($\alpha = 0.05*, \alpha = 0.01 **$), in other words, there are significant differences among the factor (A**) levels besides significant difference among the factor (C*) levels in their effect on the yield quantity, besides there are insignificant differences among the factor ($B^{n.s}$) levels and that overlapping among the factors showed significant differences in their effect on the yield quantity with different levels of each factor.

5. Fifth Case:

Table 10: Variance Analysis of Split (C) Experiment Factor in the Main Plots and Factor (A) in the Sub Plots and Factor (B) in Sub Sub Plots

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	1.5
C	2	641.778	320.889	1.09
Error(c)	4	1178.778	294.694	
A	1	16502.518	16502.518	123.15**
CA	2	7085.481	3542.741	26.44**
Error(a)	6	804	134	
B	2	616.333	308.167	1.7
CB	4	16444.222	4111.056	22.69**
AB	2	93924.037	46962.019	259.23**
CAB	4	16013.629	4003.407	22.1**
Error(b)	24	4347.778	181.157	
Total	53	158442		

Table (10) results show that factors and overlapping (A**, AB**, AC**, BC**, ABC**), with significant statistical sign with significant level ($\alpha = 0.05 *, \alpha = 0.01 **$), in other words, there are significant differences among the factor (A**) levels in their effect on the yield quantity, besides there are insignificant differences among the factor ($B^{n.s}$) levels and the factor ($C^{n.s}$) levels, but the overlapping among them was significant, where their levels overlapping showed a significant effect on the yield quantity, and that overlapping among the factors showed significant differences in their effect on the yield quantity with different levels of each factor.

6. Sixth Case:

Table 11: Variance Analysis of Split (C) Experiment Factor in the Main Plots and Factor (B) in the Sub Plots and Factor (A) in Sub Sub Plots

S.O.V.	D.F.	S.S.	M.S.	F
Blocks	2	883.444	441.722	1.99
C	2	1536.444	768.222	3.47
Error(c)	4	885.778	221.444	
B	2	641.778	320.889	1.74
CB	4	31617.111	7904.278	42.87**
Error(b)	12	2212.44	184.37	
A	1	108631.185	108631.185	604.94**
CA	2	875.259	437.629	2.44
BA	2	1070.37	535.185	2.98
CBA	4	6855.852	1713.963	9.54**
Error(a)	18	3232.333	179.574	
Total	53	158442		

Table (11) results show that factors and overlapping (A**, BC**, ABC**), with significant statistical sign with significant level ($\alpha = 0.05 *, \alpha = 0.01 **$), in other words, there are significant differences among the factor (A**) in their effect on the yield quantity, besides there are insignificant differences among the factor ($B^{n.s}$) levels and the factor ($C^{n.s}$) levels, but the overlapping among them was significant, where their levels overlapping showed a significant effect on the yield quantity, and that overlapping among the factors showed significant differences in their effect on the yield quantity with different levels of each factor.

6-3) Results Discussion

In this item, theoretical part results were discussed, table (12) summarizes practical part results.

Table 12: A summary of Analysis Results of the First and Second Axes According to the Location of Each Factor

Transactions Location / Type Experiment	Main Plot	Sub Plot	Sub Sub Plot	Overlapping Between Factors			
1. Factorial experiment	A**	$B^{n.s}$	C*	BC**	ABC**		
2. Split experiment (First case)	A**	$B^{n.s}$	C*	BC**	ABC**		
3. Split experiment (Second case)	A**	C*	$B^{n.s}$	CB**	ABC**		
4. Split experiment (Third case)	$B^{n.s}$	A**	$C^{n.s}$	AB**	BC**	AC**	ABC**
5. Split experiment (Fifth case)	$B^{n.s}$	C*	A**	BC**	ABC**		
6. Split experiment (Fourth case)	$C^{n.s}$	A**	$B^{n.s}$	AC**	AB**	BC**	ABC**
7. Split experiment (Sixth case)	$C^{n.s}$	$B^{n.s}$	A**	BC**	ABC**		

According to table (12) we can discuss results as follows:

1. According to the factorial experiment, there were significant differences of the factor (A) and the factor (C*) and there was insignificant of the factor ($B^{n.s}$) and that overlapping (BC**) and (ABC**) showed significant differences in their effect on barely yield quantity, in other words, difference of barely yield quantity response with difference of significant overlapped factors levels.

2. Comparing the first case and the second case in case of changing factor (C) location and factor (B) in the sub plots and the sub sub plots showed that the factor (C*) was significant in the two cases and that factor ($B^{n.s}$) wasn't significant although changing of locations of each factor, in other words, changing factors (B) and (C) locations between the main plots and the sub sub plots didn’t effect on the results, but they led to a change in (Mse) value of each factor according to the location, where (Mse) value of the factor (B) dropped and (Mse) value of the factor (C) dropped too because of effect of the significant (A**) factor.

3. Third case showed that although putting the factor (C) in the sub sub plots but it didn’t show significant differences in comparison to the first and second cases which showed significant in the sub plots and the sub sub plots due to the insignificant of factor ($C^{n.s}$) in the third case was the former (A**) factor effect, so we conclude that not the factor location only effect on the factors significant but also the former factor effect, where the former factor effect (A**) overtopped on the factor (C) location effect in this case, besides the insignificant of factor ($B^{n.s}$), but it led to a change in (Mse) value of each factor according to the location, where (Mse) value of factor (B) raised in the main plots and that (Mse) value of factor (A) dropped in the sub plots and that (Mse) value of factor (C) raised although putting factor (C) in the sub sub plots because of the former factor (A**) effect in the sub plots.

4. The fourth case showed the clear location effect on the factor (C*) significant in the sub plots, in other words, location effect played a role in showing these differences in comparison with the third case in which the former factor (A) effect was overtopped on location effect, besides there was insignificant of factor ($B^{n.s}$), but it led to a change in (Mse) value of each factor according to the location, where (Mse) value of factor (A) raised although putting the factor (A) in the sub sub plots because of the former factor (C*) effect and that (Mse) value of factor (C) dropped due to location effect and non-effect of the former ($B^{n.s}$) factor as in the third case.

5. The fifth case showed the clear location effect on the factor ($C^{n.s}$) insignificant in the main plots, and although also putting the factor (B) in the sub sub plots which didn't show any significant because of the former factor (A**) effect which played a role in not showing these differences of factor (B) as in the third case, but it led a change in (Mse) value of each factor according to location, where (Mse) value of factor (A) dropped because of there was no effect of the former factor as in the fourth case and that (Mse) value of factor (C) raised due to effect of the location and that (Mse) value of factor (B) dropped due to location effect.

6. The sixth case showed that factor (A**) was significant and that both factors ($B^{n.s}$) and ($C^{n.s}$) were insignificant which means that factor location effect played a role in showing and not showing factors significant.

7. CONCLUSIONS

According to the previously mentioned, we can put the following important conclusions:

1. Not only location affects the significant and insignificant of factors but also there are former factors and overlapping among factors.

2. Factor (B) is insignificant in all cases, where it didn't affect by former factor effect or location effect, in other words, factor location of (A) affected factor (C) but there wasn't differences in factor (B) which couldn't be showed by location.

3. (Mse) value changing of each factor when changing among locations due to location effect or former significant factor effect.

4. Variation of results, significant and insignificant of factor (C) due to location effect of factor, as well as, to former factor effect.

5. In case of insignificant of one of the main factors in the factorial experiment, this factor stays insignificant even if it is treated in split-plot design as a main plot factor or sub plot factor.

8. RECOMMENDATIONS AND FUTURE STUDIES

According to the former conclusions we can recommend the following:

1. Taking into consideration the location effect when applying split-split-plot design.

2. We recommend studying each factor alone and observing the significant differences among its levels because its existence effects on the experiment results besides its locations and overlapping with other variables where it may have significant effects in the experiment, but some data of the other factors effect it, from this point we recommend studying factors significant to bring in these equal factor differences.

3. We recommend studying effect of factor and significant differences effect among levels of each factor on a factorial experiment within split-plot design, and split-plot design within a factorial experiment and comparing results.

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