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Non-statistically Significant Interactions between Treatments and an Approach for Dealing with these Statuses

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Abstract

A field experiment on cotton yield resulted in a non-statistically significant interaction. An approach for follow-up examination between treatments based on least significant difference values was suggested to identify the effect regardless of insignificance. It was found that the classical formula used in calculating the significance of interactions suffers a possible shortage that can be eliminated by applying a suggested revision.

Keywords: cotton yield; Mepiquat Chloride; Nitrogen; Non-significant interactions; Potassium

Introduction

Managing the balance of vegetative and reproductive growth is the essence of managing a cotton crop

It is known from numerous fertilizer experiments that the yield of field crop is strongly dependent on the supply of mineral nutrients [1-3]. Several approaches have been used to break this yield plateau, among them the application of Plant Growth Regulators (PGR's), particularly Mepiquat Chloride (MC) has received much attention recent years [4,5]. Also, a statistical approach for dealing with the non-significant interactions between treatments depending on least significant differences, regardless of statistical insignificance is suggested [6].

Methodology

In (30oN, 31o: 28'E and 19m altitude) Egypt using the cotton cultivar Giza 86 (Gossypium barbadense L.) in I and II seasons. The soil texture in both seasons was a clay loam with an alluvial substratum, (pH = 8.10, 44.75% clay, 27.40% silt, 20.00% fine sand, 3.00% coarse sand, 2.85% calcium carbonate and 1.85% organic matter).

Each experiment included 16 treatment combinations of:

Two N rates (95 and 143 kg N per hectare), which were applied as ammonium nitrate (NH4NO3, 33.5% N) at two equal doses, 6 and 8 weeks after planting. Each application (in the form of pinches beside each hill) was followed immediately by irrigation. The K and MC were applied to the leaves with uniform coverage using a knapsack sprayer. The application was carried out between 9.0 and 11.0 h [6].

A randomized complete block design with four replications was used for both experiments. Seeds were planted on 3 April in season I and 20 April in season II. Hills were spaced 25 cm apart on one side of the ridge, with seedlings thinned to two plants hill-1 six weeks after planting. The total amount of surface irrigation applied during the growing season was about 6,000-m3 per hectare. Plots were irrigated every two weeks until the end of the season (October 11, in season I and October 17 in season II), for a total of nine irrigations. Phosphorus (P) fertilizer was applied at the rate of 24 kg P per hectare as calcium super phosphate during land preparation. The K fertilizer was applied at the rate of 47 kg K per hectare as potassium sulfate before the first irrigation (the recommended level for semi-fertile soil). Fertilization (P and K), along with pest and weed management was carried out during the growing season according to the local practice performed at the experimental station [6]. In both seasons, ten plants were randomly taken from the center ridge of each plot to determine the seed cotton yield in g per plant. Total seed cotton yield of each plot (including ten plant sub samples) was used to determine seed cotton and lint yield (kg per hectare) [6].The least significant difference (LSD) test method at 5% level of significance was used to verify the significance of differences among treatment means and the interactions to determine the optimum combination of N, K and MC [6] (Table 1).

(Table 1): Mean squares for combined analysis of variance for yield in cotton during seasons I and season II.

Source	d.f.	Seed cotton yield (g per plant)	Seed cotton yield	Lint yield
			(kg per hectare)	(kg per hectare)
Year	1	147.21**	1415571.4**	332917.8**
Replicates within years	6	40.27*	404859.0*	50458.4*
Treatments	15	75.94**	714189.8**	83868.9**
Nitrogen (N)	1	456.74**	4325402.3**	500162.5**
Potassium (K)	3	132.53**	1223590.9**	145491.8**
Mepiquat Chloride (MC)	1	261.15**	2504937.5**	294768.0**
N × K	3	3.47	31778.5	3934.8
N × MC	1	0.17	1463.4	298.6
K × MC	3	4.19	36432.4	4632.6
N × K ×MC	3	0.18	1879.3	209.1
Treatments × Year	15	2.5	24239.8	3070.9
Error	90	14.36	135377	16752.8
SD		3.79	367.9	129.4
CV %		12.04	12	12

* Significant at P = 0.05; ** Significant at P = 0.01 [6]

Results

Effects of main treatments on yield

Seed cotton yield per plant, as well as seed cotton and lint yield per hectare, were increased by as much as 12.8, 12.8, and 12.3 %, respectively, when the nitrogen rate was increased (Table 2) [6]. N is an important nutrient for control of new growth and preventing abscission of squares and bolls and is also essential for photosynthetic activity [7,8]. When K was applied at all three rates (319, 638 and 957 g K per hectare), seed cotton yield per plant and seed cotton and lint yield per hectare also increased [6]. These increases could be attributed to the favorable effects of K on yield components, that is, the number of opened bolls per plant and boll weight leading consequently to higher cotton yield [9,10]. Mepiquat Chloride (MC) significantly increased seed cotton yield per plant, as well as seed cotton and lint yield per hectare (by 9.5, 9.6 and 9.3%, respectively), compared to the untreated control [6] that lead to yield enhancements of both boll retention and boll weight [10,11].

(Table 2): Effect of N-rate and foliar application of K and MC on yield in cotton combined over seasons I and II*.

Treatment	Seed cotton yield	Seed cotton yield	Lint yield
	(g per plant)	(kg per hectare)	(kg per hectare)
N rate (kg per hectare)			
95	29.58b	2882.3b	1020.0b
143	33.36a	3250.0a	1145.0a
LSD (0.05)	1.33	128.9	45.4
K rate (g per hectare)			
0	28.61b	2792.5b	988.2b
319	31.51a	3068.6a	1083.4a
638	32.51a	3163.0a	1115.2a
957	33.25a	3240.7a	1143.1a

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LSD (0.05)	1.88	182.3	64.1
MC rate (g per hectare)			
0	30.04b	2926.3b	1034.5b
48 + 24	32.90a	3206.1a	1130.5a
LSD (0.05)	1.33	128.9	45.4
SD	3.79	367.9	129.4
CV %	12.04	12	12

Values followed by the same letter in a column are not significantly different at P = 0.05 [6]

Effects of interactions between treatments on yield

No significant interactions were identified among the variables in this study (N rates, K rates and MC) with respect to the characters under investigation. Generally, interactions indicated that the favorable effects accompanied the application of N; spraying cotton plants with K combined with MC on cotton productivity was more obvious by applying N at 143 kg per hectare and combined with spraying cotton plants with K at 957 g per hectare and also with MC at 48 + 24 g active ingredient per hectare.

Regarding the non-significant interaction effects, increases were observed in seed cotton yield

(Table 3): Effect of interaction between N rate and foliar application of K on cotton yield combined over seasons I and II*.

Character	Seed cotton yield		Seed cotton yield		Lint yield	
	(g per plant)		(kg per hectare)		(kg per hectare)	
K rate	N rate (kg per hectare)					
(g per hectare)	95	143	95	143	95	143
0	27.04d	30.18c	2639.2d	2945.8c	936.0d	1040.3c
319	29.73c	33.28ab	2896.6c	3240.5ab	1025.3c	1141.5ab
638	30.16c	34.86a	2935.5c	3390.4a	1037.2c	1193.3a
957	31.38bc	35.11a	3058.0bc	3423.3a	1081.4bc	1204.7a
†LSD (0.05)	2.66		257.8		90.7	

*Values followed by the same letter in columns under every character head are not significantly different at P = 0.05; † LSD, Least Significant Difference; [6].

per hectare (about 40%) as a result of applying the same combination [6]. Differences were observed between the interactions in this study, that is, the first order (Tables 3-5) and the second order (Table 6); however, these interactions were not statistically significance. Because it is possible that experimental error could mask the pronounced effects of the interactions [6] a statistical approach for dealing with the non-significant interactions between treatments is suggested. Differences between treatment combinations regardless of the non-significance of the interaction effects from the ANOVA.

(Table 4): Effect of interaction between N rate and foliar application of MC on cotton yield combined over seasons I and II*.

Character	Seed cotton yield		Seed cotton yield		Lint yield	
	(g per plant)		(kg per hectare)		(kg per hectare)	
N rate	MC rate (g per hectare)					
(kg per hectare)	0	48 + 24	0	48 + 24	0	48 + 24
95	28.11c	31.04b	2739.1c	3025.6b	970.4c	1069.5b
143	31.96b	34.75a	3113.5b	3386.5a	1098.5b	1191.4a
†LSD (0.05)	1.88		182.3		64.1	

*Values followed by the same letter in columns under every character head are not significantly different at P = 0.05; † LSD, Least Significant Difference;[6].

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(Table 5): Effect of interaction between K rate and foliar application of MC on cotton yield combined over seasons I and II*.

Character	Seed cotton yield		Seed cotton yield		Lint yield	
	(g per plant)		(kg per hectare)		(kg per hectare)	
K rate	MC rate (g per hectare)					
(g per hectare)	0	48 + 24	0	48 + 24	0	48 + 24
0	27.22c	29.99b	2655.0c	2930.0b	941.1c	1035.3b
319	29.66bc	33.35a	2891.3bc	3245.8a	1022.0bc	1144.9a
638	31.00b	34.03a	3014.1b	3311.8a	1064.2b	1166.3a
957	32.28ab	34.21a	3144.7ab	3336.6a	1110.7ab	1175.5a
†LSD (0.05)	2.66		257.8		90.7	

*Values followed by the same letter in columns under every character head are not significantly different at P = 0.05; † LSD, Least Significant Difference;[6].

(Table 6): Effect of interactions between N rate, foliar application of K and MC on cotton yield combined over seasons I and II*.

Treatment		yield	Seed cotton	Seed cotton	Lint
			yield	yield	
N rate (kg per hectare)	K rate	MC rate	(g per plant)	(kg per hectare)	(kg per hectare)
	(g per hectare)	(g per hectare)			
95	0	0	25.54e	2490.4e	884.4e
		48 + 24	27.85de	2716.3de	963.2de
	319	0	28.71de	2793.6de	987.6de
		48 + 24	30.36cd	2956.1cd	1046.7cd
	638	0	28.54de	2788.0de	987.6de
		48 + 24	31.62bcd	3077.0bcd	1087.4bcd
	957	0	31.62bcd	3077.4bcd	1086.7bcd
		48 + 24	32.40bc	3160.0bc	1116.2bc
143	0	0	28.91cd	2819.7cd	997.8cd
		48 + 24	31.48bcd	3066.3bcd	1080.8bcd
	319	0	33.28ab	3234.7ab	1140.8ab
		48 + 24	34.20ab	3333.4ab	1174.7ab
	638	0	31.45bc	3072.0bc	1082.9bc
		48 + 24	35.08ab	3414.7ab	1202.3ab
	957	0	36.44a	3546.2a	1245.8a
		48 + 24	36.03a	3513.2a	1234.8a
†LSD (0.05)			3.76	364.6	128.3

*Means followed by the same letter in a column are not significantly different at P = 0.05; † LSD, Least Significant Difference; [6].

Results show that, if no significant differences are identified between the different levels of any main factor (N, K or MC) when the LSD is calculated, then the significance does not exist. Conversely, if the significance of the interactions between the main factors (first and second order interactions) is not identified, then the estimation of the LSD of the interactions between the main factors could provide a significant result [6]. For these reasons, the formula used in calculating the significance of interactions suffers a possible shortage.

Study results indicate that it could be useful to modify or add to the original formula used for calculating F values of interactions via:

F = Mean Square for Interaction / Mean Square for Error

In this connection, calculating the significance of interactions could proceed as:

F = Mean square for interaction × n / Root of mean square for error

Where n = number of main factors in the interaction.

Based on findings from this study, it may be concluded that the use of the suggested formula could secure the disclosure of any significant effects among interactions regardless of experimental error [6].

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