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INTERACTION AMONG IRRIGATION INTERVALS AND N LEVELS IN CORN *Zea mays* L. NEW APPROACH FOR EVALUATING INTERACTION

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ABSTRACT

Two field experiments were carried out in Belcas, Dakhalia governorate, Egypt, during 1998 and 1999 on corn S.C. 10, to study the effect of four irrigation intervals 7, 12, 17 and 22 days, and four N levels, viz 80, 90, 100, 110 kg/fed. And their interaction. A strip plot design with four replicates was used, where the whole and sub plots were devoted to the levels of irrigation and N, respectively.

Results showed that, mostly positive effects were detected as intervals were shortened and N levels were increased. The highest yield was observed on combination gathered irrigation every 12 day with N_{110}, which yielded 33.3 and 33.7 ard/fed. in 1998 and 1999, respectively.

Equilibirity among combinations of the interaction was achieved. A scale was suggested for classifying studied traits according to their response percentage to the interaction. Such scale included five categories A,B,C,D and E. Days to 50% silking, 100-kernel weight, P% and K% in grains showed high response % category “A”, meanwhile, no. of rows/ear showed no response %, category “E”. Grain yield/fed. was arranged in “B” category, “medium response”. Water use efficiency seemed to be increased as irrigation interval was shortened. Water utilization efficiency was 1.09, 1.10, 0.93. 0.82 kg/m^3 for intervals 7, 12, 17 and 22 days, respectively.

Key words: Maize, Irrigation interval, N fertilization, Interaction, I x N.

INTRODUCTION

Maize *Zea mays* L. is one the major field crops either in Egypt or overall the world. The local production declined under self sufficiency level, resulting some serious problems. To overcome the gap between maize production and consumption, production per unit area must be maximized through good achievement of some agricultural practices, including irrigation intervals and nitrogen fertilization.

Many investigations showed that irrigation interval greatly affected growth and yield of maize. However, El Marsafawy (1995) reported that prolonged irrigation interval produced shorter plants, lower no. of leaves/plant, leaf area index and no. of kernels/ear. On the other hand, Khedr (1986) found no effect due to irrigation interval on plant height, no.of rows/ear, no. of kernels/row, no. of kernels/ear and 100 kernel weight. As prolonged interval means skipping irrigation causing water stess, El Ganayni *et al*. (2000) stated that flowering stage is the most sensitive stage to irrigation skipping. In addition, Soliman (1986) agreed that water deficit shortened the effective filling period and reduced grain yield.

No promoting effect is believable as the effect of N on maize growth and yield. The differences among the results concerning these respects lie in N quantity used. However, some works accepted N application up to 140 kg/fed., El-Marsafawy (1995), to 150 kg/fed. Hassan, (1999), Soliman *et al.* (1999) , and to 180 kg/fed., Tag Eldin and Ashmawi (1999). Different nitrogen additions enhanced plant height, Abd El-Halem *et al*. (1990), no. of leaves/plant , El-Marsafawy (1995) leaf area index, El-Shafeei (1993) , 100 kernel weight and ear yield/fed., El-Marsafawy (1995).

Interaction among irrigation intervals and nitrogen levels showed insignificant effect with respect to plant height, no. of leaves/plant, no. of rows/ear, and 100 kernel weight, Abd El-Halem *et al*. (1990) , El-Marsafawy (1991) and El-Shafeei (1993). Grain yield/plant and per fed were significantly affected by the interaction , El-Marsafawy (1995).

Since water and nitrogen are managable and extremly interlinked inputs and however, maize response to N depends upon the availability of water, the present study was carried out to study the effect of water intervals, nitrogen levels and their interaction on the growth and yield of maize. A new approach was proposed for interaction evaluation.

MATERIALS AND METHODS

Two field experiments were carried out on corn, SC 10, during the two successive seasons 1998 and 1999, at a private farm in Belcas, Dakhalia governorate. The soil was clay loam containing 2.3% organic matter and 30 ppm available N. El-Mohayah irrigation was applied three weeks after seeding as the same for all treatments. When irrigation, **I**, at all intervals, water was applied up to well irrigated. Watering amount per each irrigation was measured then the seasonal water quantity was calculated. Table 1 summarizes the relative data.

Table 1: Irrigation intervals, II, day, distribution date, and number* of irrigations, as well as seasonal water quantity S.W.Q. m^3/fed, over the two seasons.

II	Distribution of irrigations				Irrig. No.	S.W.Q M^3/fed.
day	June	July	August	September		
7	22, 29	6,13,20,27	3,10,17,24,31	7, 14	13	3900
12	22	4,16,28	9, 21	2, 16	8	4078
17	22	8,25	11,28	14	6	4100
22	22	13	4, 26	17	5	4150

*** Including El-Mohayah irrigation.**

Water discharge was measured by using trianglular weirs V-notch. The height of flowing water was fixed at 30 cm. Water discharge was counted according to the equation of Hansen *et al.* (1980) as follows:

$Q = 0.0138 \times h^{25} \times 3.6$, where

Q = Water discharge m^3/hr.
0.0138 and 3.6 are constant values, where 3.6 was added to the original equation for obtaining Q in m^3/hr.
h = Water height or pressure head (cm).

Nitrogen was added in the form ammonium nitrate 33.5% at two equal amounts, firstly before soil furrowing and secondly directly before El-Mohayah irrigation. In both seasons, corn was seeded on furrows (6.m. long) and in hills 30 cm. apart. Seeding was on June 1^{st}. Before El-Mohayah irrigation, thinning was done to secure one plant/hill. Harvest was on October $1^{st.}$ The preceded crop was faba bean. All the remainder agricultural practices, including insect control were carried out as recommended.

A strip plot design with four replicates was used. Four irrigation intervals, viz, 7, 12, 17 and 22 days occupied the whole plots while N treatments, viz. 80, 90, 100 and 110 kg/fed. were randomly distributed at the sub plots. Experimental unit area was 36.0 m^2 (6x6m). Borders between strips were wided to 1.5 m to reduce the effect of lateral movement of irrigation water. At harvest, the two outer ridges were left and from the other two sides 2 meters were also discarded in order to eliminate the border effects.

Studied topics:

A- Analysis of variance:

Just before male inflorescence a random sample of 10 guarded plants was taken from the two inner ridges of each experimental unit to measure flowering traits, then at harvest such sample was use for estimating some traits as follows:

1-Days to 50% silking, D-50% S.
2-Plant height, cm, P.l..H.
3-No. of leaves/plant, L.Pl.
4- Leaf area index cm^2, L.A.I.
5-Number of ears/100 plant, E/100 Pl.
6- Number of rows/ear, R/E.
7-Number of kernels/row , K/R.
8-Number of kernels/plant K/Pl.
9-100-kernel weight, gm. 100K/W.
10-Grain yield/plant, gm GY/Pl.
11-Grain yield/fed. ard, GY/fed., on plot basis.

All analysis of variance processes were carried out according to Le.Clerg *et al*. (1966). Least significant difference (L.S.D.) was used for comparing means, at the level of 0.05 of significance.

B- Interaction analysis:

Another eleven traits were used in order to generalize the findings of the analysis as possible . The other eleven traits were:

Stem diameter, cm
Ear position, cm
3- Ear length, cm
4- Ear diameter, cm
5- Ear yield /fed , ard
6- Grain shelling %
7- Cob yield/fed, kg
8- N% in grains
9- P % in grains
10- K % in grains
11- Crude protein % in grains

Nitrogen content was determined by using the modified micro-kjeldahl methods as described by Peach and Tracey (1956). Phosphorus was determined photometrically as described by A.O.A.C. (1975). A flam photometer was used for determining K, according to Eppendorf *et al*. (1970). Crude protein % was calculated by multiplying N% by 6.25.

The author suggests a new method for evaluating interaction effect. Such method states that the responses of a trait to the interaction combination are expressed as percentage, which is calculated by the following equation:

$$\text{Response \%} = \frac{Obn}{Thn} \times 100, \text{ where :}$$

Obn = observed no of significant differences among the interaction combinations for each trait.

Thn = Theoretical no. of all possible significant differences among the interaction combinations within the trait. Such theoretical value would be estimated as follows:

$$Thn = \frac{n\,(n-1)}{2} \quad \text{where,}$$

n = Number of interaction combinations.

A scale for classifying the studied traits, according to their response % to the effect of interaction was proposed. Such scale depends upon the distribution of traits at five categories:

1- Category "A", High response, 76.0 – 100 %.
2- Category "B", Medium response, 51.0 – 75.0 %.
3- Category "C", Low response, 26.0 – 50.0 %.
4- Category "D", Very low response, 1.0 – 25.0 %.
5- Category "E", No response, 0.0 %.

C- Water utilization efficiency, W.Ut.E:

In the present study, water used was the applied quantity, not the consumed one. Therefore, the term utilization (Ut.) is used. Hence, W.UtE. was callculated according to Vites (1965). as follows:

$$W.Ut.E = \frac{\text{Grain yield , kg/fed.}}{\text{Water applied } m^3\text{/fed.}}$$

RESULTS AND DISCUSSION

A: Analysis of variance:

Irrigation intervals effect:

Means, of the studied traits in the two seasons are presented in Table 2. In both seasons, days to 50% silking were gradually and significantly increased as irrigation interval decreased. In other words, short irrigation intervals delayed silking. Such delay may be contributed to the enhancing effect of short intervals on vegetative growth which consequently continued for a longer time and hence silking was delayed. The present results are in line with those of El-Ganayni *et al*. (2000) who stated that silking appeared to be one of the most sensitive stages to irrigation, in opposite to Khedr (1986) who found insignificant effect on silking time due to irrigation interval. Plant height trended the same in both seasons, however, it was gradually and significantly increased as irrigation interval was shortened, except the excess was insignificant for irrigation of 7 over 12 day. Such taller plants may be

attributed to the promoting role of enough watering, supplied in time needed for division, expansion and enlargement of cells and consquently internodes length. The present results confirmed those were found by some researchers of them; Attallah (1996).On the contrary, Khedr (1986) found no significant effect of irrigation interval on plant height. In both seasons, no. of leaves/plant was significantly and gradually increased as irrigation interval increased, where the trate was ranged between 13.6 to 14.7 and 13.2 to 14.0 in the first and second season, respectively. It seemed that no. of leaves/plant followed different trend than plant height, however, plants may tended to produce higher no. of leaves under water stress which may be prevailing with prolonged irrigation intervals. El-Marsafawy (1991) reported similar results.

In 1998, it was observed that, no. of ears/100 plant, at irrigation of 12-day interval, i.e. 119 did not significantly vary with that either 7, i.e. 124 or 17-day, i.e. 110, which themselves significantly surpassed the product of irrigation at 22- day, i.e. 103. Similar trend was observed in 1999 season, except significant excesses were detected for irrigation at 7-day over the remainder intervals. These results mean that shortening irrigation interval may enhanced ear formation. The present findings are in full agreement with those reported by Attallah (1996). In both seasons, a gradual and significant increase on no. of kernels/row was noticed as irrigation intervals were shortened, however, insignificant difference was detected between 7- and 12- day intervals. The latter interval did not significantly vary than 17-day one. This means in other words, that the high availability of watering at intervals of 7 and 12 days is necessary for producing higher no. of kernels/row, which may be attributed to the proper successful fertilization of silks under enough moisture in time. Khedr (1986) reported that irrigation intervals had no effect on no. of kernels/row. Fo no of kernels/ear, it appeared, in both seasons, that irrigation at 7-day interval significantly surpassed the other treatments and gave, 660 and 625 kernels/ear, in 1998 and 1999, respectively. On the oposite, prolonging irrigation interval to 22 days significantly reduced no. of kernels/ear to 450 and 500 as compared to product of irrigation at 12-day, i.e. 630 and 610 or 17-day, i.e. 510 and 580, in the two successive seasons. This means that formation of kernels on ear was promoted by shortening irrigations. In addition, it seemed that no. of kernels/ear may be controlled by no. of kernels/row rather than no. of rows/ear which did not show any significant response for varying irrigation intervals. Khedr (1986) concluded different results. As the 100-kernel weight is usually in a negative relation with no. of kernels/ear, the former trait was gradually decreased as irrigation intervals was shortened, where the differences were insignificant only in 1999 season. The range for such trait was 10.8 and 2.2 gm, in 1998 and 1999, respectively. In other expression, heavier kernels may be formed under prolonged irrigation intervals. Garin yield/plant reflected all the progressive effects previously mentioned, since irrigation at 12-day interval outyielded those of 7, 17 and 22-day by about 3.64, 14.0 and 21.3%, in the first season and by about 1.46, 3.5 and 9.47 in the second one, respectively. The results herein are in harmony with those of Attallah (1996) who found that prolonged irrigation interval resulted in a remarkable reduction in grain yield/plant.

Grain yield/fed gathered all previous effects, however, irrigation at 12 days achieved the highest yields/fed, viz 32.3 and 30.3 ard in the two successive seasons. Such superior product significantly exceeded those of 17 and 22 days intervals which produced 27.8 and 24.0 in 1998 and 25.2 and 23.5 ard/fed. in 1999, receptively. The lower grain yield of 7 day versus that of 12-day interval may be attributed to the wet soil around root which may affect its spread and function, Jensen, (1968).

It is known that the tested irrigation intervals reflect degrees of water stress, with the intervals of 17 and 22-day. Since water stress effect seemed to be extended through a period from early vegetative growth to grain filling stages, no surprise herein that prolonging irrigation interval could subjected corn plants to water stress in one or more stage. With this respect, Chapman, *et al.* (1996) stated that maize crop was found to be susceptible to drought several weeks before and after flowering. Therefore, irrigation at 17 and 22-day intervals prevented watering in some sensitive stages, resulting in detrimental effects on different traits. No doubt that interval of 17-day did not supply watering during flowering stage which was between 1-10 August. Similarly, the regime of 22-day prevented watering during the period from July 13^{th} to August 4^{th} which covered late vegetative growth and flowering stages, Table 2. Moreover, as maize root is shallow, it would not be able to uptake withdrawn water and soluble nutrients , under prolonged watering intervals. In such case, photosynthesis and efficiency of some biological processes which greatly affect the accumulation of dry matter within the plant may be negatively affected, Slatyer, (1957). Therefore, it may be generalized that favourable effects, in terms of plant height, no. of ears/plant, no. of kernels/row, no. of kernels/ear and grain yield/plant, were turned in grain yield/fed. Many investigators reported similar results of them Attallah, (1996).

Nitrogen fertilizer effect:

Table 2 gives the obtained means of thestudied traits as affected by nitrogen levels in the two seasons. In both seasons, most of traits were significantly affected by N levels, however, insignificant effects were detected only on leaf area index, no. of rows/ear, no. of kernels/row and 100 kernel weight. Days to 50% silking trait was gradually and significantly increased by any addition of nitrogen, indicating that such additions may retarded silking. Such delay may be a result of the enhancing effect on vegetative growth which continued for a longer time, and delayed flowering. The resutls herein are in full agreement of those of Ashoub *et al*. (1996). Typical trends were observed on plant height, no. of leaves/plant and no. of ears/plant, where gradual decreases in the measurements of such traits were detected as N levels decreased. No significant difference was calculated when comparing the level 100 with both 110 and 90 kg/fed. Nitrogen fertilization by 80 kg/fed. gave the lowest value on the three traits previously mentioned. Similar results with minimum deviation were observed in 1999.

These results mean that additional N supplies may enhanced plant height, no. of both leaves and ears/plant. El-Shafeei (1993) found similar resutls with respect to plant height and on of leaves/plant. Also, the present results on no. of ears/plant are in line with those of Salwau (1985). Number of kernels/ear was gradually increased by any increment in N element. However, in 1998 no significant difference was detected between each pair of treatments (N_{100} and N_{110}) and (N_{90} and N_{80}) kg/fed. In 1999 N_{100} surpassed most treatments meanwhile N_{80} did the opposite. These mean that the greatest no. of kernels/ear is available by increasing N levels up to 100 kg/fed. The recent findings are in accordance with those reported by El-Marsafawy (1995), who stated that N fertilization up to 140 kg/fed. increased no. of kernels/ear. In a descendant arrangement nitrogen addition at 100, 110, 90 and 80 kg/fed. yielded 219, 214, 206 and 200 as well as 210, 205, 200, 187 gm/plant, in 1998 and 1999, respectively. It seemed that grain yield/plant was greatly affected by no. of ears/plant and no. of kernels/ear. El-Marsafawy (1995) found similar results.

Grain yield/fed., as the final result of all contributions, showed, in 1998, that the difference between N_{90} and N_{100} was insignificant. These two levels significantly exceeded N_{80} by about 2.16 and 4.32% , respectively. Moreover, N application at 110 kg/fed. significantly exceeded products of 90, 100 and 80 kg/fed by about 2.41, 4.58 and 6.83%, respectively. In 1999, only N_{110} treatment significantly exceeded the others, which themselves did not significantly differ from each other. This means that remarkable grain yield/fed. may be produced by N application at 110 kg/fed. Such overyield might be a natural result of the corresponding progressive effects previously mentioned on aspects of plant height, no. of leaves/plant, no. of ears/plant, no. of kernels/ear and grain yield/plant. Generally, nitrogen has major roles in plant nutrition namely; component of chlorophyll, component of amino acids, essential for carbohydrates utilization , component of enzymes, vitamins and hormones, stimulative of root development and activity and supportative the uptake of other nutrients, Stevenson (1986). The present results are in full agreement with those were reported by many researchers of them, Ashoub *et al*. (1997), Tag Eldin and Ashmawi, (1999) as well as Soliman, *et al.* (1999).

B- Interaction effect :

Table 2 illustrates the significancy of interaction on the studied traits. Abd El-Halem *et al*. (1990) found similar results on 100 kernel weight and no. of kernels/ear. it is clear that the differences among irrigation intervals under the same level of N were higher than those of N under the same level of irrigation interval. This means that water plays a limiting role and exceeds N for promoting maize yield. This finding is logic, however, plant can grow without N fertilization, while the opposite is not true in the case of water absence.

Table 3 gives means of grain yield/fed. as affected by interaction combinations. The trait was significantly affected interaction. The highest yields in the two successive seasons, viz, 33.3 and 33.7 ard/fed. were recorded on the combination (II_{12} x N_{110}), Table 3. El Marsafawy, (1995) found different results,

Table 3 : Means of grain yield ard/fed., as affected by combinations among irrigation intervals (II), days, and N levels, kg/fed., in 1998 and 1999 seasons.

Season	1998				1999			
N levels Kg/fed. / II, days	80	90	100	110	80	90	100	110
7	29.6 def	30.3 cde	31.2 bcd	32.0 abc	28.0 ef	29.2 cde	30.1 cd	32.2 ab
12	31.3 abcd	32.0 abc	32.7 ab	33.3 a	29.1 cde	30.4 bcd	31.0 bc	33.7 a
17	27.1 g	27.5 g	27.8 fg	28.6 efg	26.5 gh	26.8 fg	27.3 efg	28.7 def
22	23.3 h	23.8 h	24.3 h	24.7 h	23.4 j	24.2 Ij	24.7 hIj	25.8 ghI

Means followed the same letters are insignificantly different at the 0.05 level of significance.

Equilibrity among interaction combinations:

The equilibrity among some combinations within the interaction may gives a helpful mean for plant maize production under the use of irrigation intervals and levels of N . To explain the previous assumption, Table 3 shows in 1998 that the combinations (II_7 x N_{110}) and (II_{12} x N_{90}) were not significantly different from each other, indicating that reducing nitrogen level from 110 to 90 kg/fed. was associated by prolonging irrigation interval from 7 to 12 days. This means that the effect of applying 20 kg of N over 90 kg/fed may be compensated by shorteninging irrigation interval from 12 to 7 days.

Similar results were also observed in 1999, where the equilibrity was also detected among the combinations (II_7 x N_{110}) and (II_{12} x N_{190}). Such results suit a wide chance of preferability of each factor over the other for forming a combination. Such preferability would be depended on their economic availability.

A proposed scale for interaction evaluation :

The studied traits varied from each other with respect to their response to the effect of the sixteen combinations. To explain how can we do the proper scale, let us to view the following steps:

a- The insignificantly affected traits had response % of 0.0-% , since the Obn value in the equation = 0.0 and no significant differences at all, consequently they are arranged in the category “E”, no response .

b- For the traits which were significantly affected by interaction, their response % would be depend upon the summation of significant differences between each combination and the other ones within the interaction. The calculated response % would arrange the traits in certain category except “E” one, of the other four proposed ones.

c- For example, the category of response of grain yield/fed.in 1998,

Table 3 would be attained as follows:

1- No. of observed significant differences Obn among combination of :

(II_7 x N_{80}) of	def	letters and other combinations	= 10
(II_7 x N_{90}) of	cde	letters and other combinations	= 9
(II_7 x N_{100}) of	bcd	letters and other combinations	= 9
(II_7 x N_{110}) of	abc	letters and other combinations	= 8
(II_{12} x N_{80}) of	abcd	letters and other combinations	= 8
(II_{12} x N_{90}) of	abc	letters and other combinations	= 8
(II_{12} x N_{100}) of	ab	letters and other combinations	= 8
(II_{12} x N_{110}) of	a	letters and other combinations	= 8
(II_{17} x N_{80}) of	g	letters and other combinations	= 4
(II_{17} x N_{90}) of	g	letters and other combinations	= 4
(II_{17} x N_{100}) of	fg	letters and other combinations	= 4
(II_{17} x N_{110}) of	efg	letters and other combinations	= 4
(II_{22} x N_{80}) of	h	letters and other combinations	= 0
(II_{22} x N_{90}) of	h	letters and other combinations	= 0
(II_{22} x N_{100}) of	h	letters and other combinations	= 0
(II_{22} x N_{110}) of	h	letters and other combinations	= 0
Total of significant differences Obn			= 84

2- The theoriticalno. of all possible significant differences, Thn, is calculated as :

Thn = n (n-1) / 2, where

n = no. of combinations within the interaction = 16.

Thn = 16 (16-1)/2 = 120

3- Response % = Obn /Thn x 100

= 84/ 120 x 100 = 70.0%

4- Such response % is arranged in “B” category, medium response, 51.0 - 75.0.

Response % was calculated for all studied traits in 1998 then they were arranged in the five categories. With this respect traits of days to 50% silking, 100 kernel weight, P % in grains and K % in grains were classified in “A” category of high response. Plant height, ear position, ear yield/fed., grain yield/fed., cob yield/fed. and N% in grains were arranged in “B” category of medium response. The category “C” (low response, included no. of leaves/plant, leaf area index, ear length and grain yield/plant. Traits of no. of ears/100 plant, no. of kernels/row and / ear, occupied “D” category of very low response category “E” of no response included all traits which were insignificantly affected by the interaction including stem diameter, ear diameter, no. or rows/ear and grain shelling %. In 1999 season, similar scale was obtained except with respect to two traits; plant height which was arranged in “A” instead of “B” category and leaf area index which was classified in “E” category instead of “C” one.

However, maximizing variation is the most important goal and tool in plant breeding programs, consequently all traits of “A” or “B” categories would be directly considered, oppositely to traits of “E” or “D” categories which show no or lesser response to the environments and hence the chance of causing variation is too limited. But, such traits would be considered for selection, however they are good inherited traits. In addition, such scale may be somewhat useful for planning programs of corn production under the availability of watering N fertilizer. It may be stated herein that such new approach depends upon no. of factors, nature of factors, no. of levels, variation degree among levels and all expected factors affecting ANOVA , in general.

C- Water utilization efficiency :

Water utilization efficiency, W.Ut.E, over the two seasons was 1.09, 1.10, 0.93 and 0.82 kg/m^3 for irrigation intervals; 7, 12, 17 and 22 days, respectively. This means that W.Ut.E decreased as irrigation interval was prolonged. An interesting notice that W.Ut.E was approximately the same for both irrigation intervals 7 and 12 days. This mean that irrigation at 12 days may be recommended herein because of its highest grain yield, i.e. 32.3 and 31.5 ard/fed., in 1998 and 1999, respectively, Table 2, and for its highest W.Ut.E , i.e. 1.10 kg/m^3. El Marsafawy (1995) found different results. Such difference may be due to the method used for estimating seasonal water quantities.

From all the above mentioned results the following may be concluded:

Irrigation intervals showed significant effects on most studied traits, Shortening intervals delayed flowering , decreased, no. of leaves/plant and 100 kernel weight, meanwhile, increased the remainder other traits. Irrigation every 12 days yielded the highest grain yields/fed, viz. 32.3 and 31.5 ard, 1998 and 1999, respectively.

Nitrogen had insignificant effect only on leaf area index, no. of row/ear, no. of kernel/row and 100 kernel weight. Nitrogen application retarded flowering and gradually enhanced the remainder traits, except no.of kernels/ear and grain yield/plant which were increased up to only 100 kg/fed. The maximum grain yields/fed., vis, 29.7 and 30.1 ard. was given by applying 110 kg N, in the two successive seasons.

Interaction significantly affected all studied traits except no. of rows/ear in both seasons and leaf area index in 1999. The combination between II_{12} and N_{110} yielded the pronounced product. Such combination could be recommended.

The equilibrity among combinations within interaction was achieved. Such equilibrity allows the replacement of a level of one factor by a level of the second one in a combination. Such replacement would be controlled by the economic point.

The new scale for interaction evaluation showed that studied traits were distributed in a scale according to their response % to the interaction. High response was detected on days to 50% silking , 100 kernel weight , P%

and K% in grains.Water utilization efficiency seemed to be increased as irrigation interval was shortened.

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التفاعل المتبادل بين فترات الرى والأزوت فى الذرة الشامية "طريقة جديدة لتقييم التفاعل المتبادل"

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أجريت تجربتان حقليتان بناحية بلقاس – دقهلية لدراسة تأثير 4 فترات للرى (7، 12، 17، 22 يوما) ، 4 معدلات أزوت (110، 100, 90, و 80 كجم أزوت/فدان) وكذلك التفاعلات المتبادلة على الذرة الشامية (هجين فردى 10) وذلك خلال 1998، 1999 . ولقد أضيفت مياه الرى فى مواعيد الدراسة باستخدام V. notch لحساب كمية المياه المضافة فى كل رية وبالتالى خلال الموسم ، وأضيف الازوت على دفعتين متساويتين، الأولى قبل تخطيط الأرض والثانية قبل رية المحاياه مباشرة وقد استخدم تصميم الشرائح المنشقة فى أربع مكررات ، حيث وزعت معاملات الرى على الشرائح الرئيسية و معدلات الازوت على القطع المنشقة . وكانت النتائج كما يلى :

1- بينت فترات الرى تأثيرا معنويا على جميع الصفات ما عدا دليل مساحة الورقة وعدد الصفوف على الكوز . ولقد سببت فترات الرى القصيرة ، تأخير التزهير وتناقص عدد الأوراق على النبات ووزن المائة حبة . وعلى النقيض من ذلك ، كان لهذه الفترات المتقاربة تأثيرا إيجابيا على باقى الصفات . ولقد أعطى الرى كل 12 يوم أعلى محصول/فدان وقدره 3ر32 ، 5ر31أردب /فدان فى 1998 و 1999 على التوالى .
2- كان تأثير الازوت غير معنوى على صفات دليل مساحة الورقة ، عدد الصفوف بالكوز ، عدد الحبوب /الصف ووزن المائة حبة فى حين كان معنويا على باقى الصفات ولقد تسبب زيادة التسميد الازوتى حتى 110 كجم أزوت/فدان فى تأخير التزهير وتشجيع عطاء باقى الصفات ، فيما عدا صفة عدد الحبوب على الكوز التى استجابت معنويا حتى معدل 100كجم /فدان . حيث أعطت المعاملة 110كجم /أزوت أعلى محصول للفدان وقدره 7ر29 و 1ر30 أردبا فى الموسمين المتعاقبين .
3- أظهر التفاعل المتبادل بين فترات الرى ومعدلات الازوت تأثيرات معنوية على معظم الصفات . ولقد أعطى التفاعل بين الرى كل 12 يوم ، الازوت بمعدل 110كجم/فدان أعلى محصول للحبوب بالفدان وذلك فى موسمى 1998 (4ر33 أردب) و 1999(7ر33 أردب)
4- أمكن تحقيق استبدال عامل بعامل آخر فى داخل التوافيق العاملية. ويفيد هذا الاستبدال عند ندرة أو قلة توافر عامل معين دون آخر ، ومن التوافيق التى يمكن استبدالها (الرى كل 7 أيام × 110 كجم أزوت) مع (الرى كل 12 يوم × 90 كجم أزوت) .
5- أمكن إنجاز طريقة جديدة لتقييم التفاعلات المتبادلة ، وتعتمد هذه الطريقة على حساب عدد الفروق المعنوية داخل الصفة ثم قسمتها على العدد النظرى المتوقع لهذه الفروق وضرب الناتج × 100 ليعطى ما سمى بالاستجابة % - ثم ترتب كل صفة فى طبقة من خمس طبقات A, B, C, D, E تبعا لاستجابتها % حيث تثمل "A"أعلى استجابة ، ""E"غياب الاستجابة تماما أى عدم تأثر الصفة معنويا بالتفاعل موضع الدراسة . ولقد بينت الدراسة أن صفة عدد الايام حتى ظهور 50% من الحراير يمثل الصفات العالية الاستجابة "A "، فى حين وزعت صفات قطر الكوز ، عدد صفوف الكوز ونسبة التفريط على طبقة "E" وهى التى لم تتأثر معنويا (معدل الاستجابة = صفر) . وتمثل مثل هذه الصفات أهمية خاصة فى برامج الإنتخاب ، فى حين تمثل طبقة A الصفات التى يمكن زيادة عطائها لتحسين بيئة النمو مثل الرى والتسميد.
6-أظهرت الدراسة أن كفاءة استخدام المياه المضافة تزداد بتقصير فترات الرى، حيث بلغت الكفاءة الاستعمالية للمياه المضافة عند الرى كل 7 ، 12 ، 17، 22 يوما حوالى 09ر1 ، 10ر1 ، 93ر و 82ر كجم /متر3 على التوالى .

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Table 2: Means of the studied traits, as affected by irrigation interval, II, day, N levels, kg/fed. and their interactions, in 1998 and 1999

Traits / Treatments	D-50% S. days	P1.H. cm	L./P1	L.A.I. cm^2	E/100P1	R/E	K/R	K/E	100K.W gm.	GY/P1 gm.	GY/fed. ard.
					1998						
I. I. day											
7	63.0 A	263 a	13.6 d	5.7	124 a	14.3	43.0 a	660 a	33.4 c	220.0 b	30.8 b
12	62.2 b	257 a	13.9 c	5.6	119 ab	14.0	41.9 a	630 b	36.2 bc	228.0 a	32.3 a
17	61.1 c	250 b	14.2 b	5.3	110 b	14.0	36.0 b	510 c	39.9 ab	200.0 c	27.8 b
22	60.0 d	240 c	14.7 a	5.4	103 c	14.0	31.0 c	450 d	44.2 a	188.0 d	24.0 c
N levels (kg/fed.)											
110	63.2 a	260 a	14.5 a	5.4	127 a	14.1	40.1	585 a	36.0	214.0 b	29.7 a
100	62.2 b	255 ab	14.3 ab	5.6	118 ab	14.2	38.7	565 a	37.8	219.0 a	29.0 b
90	61.4 c	249 b	14.2 b	5.2	113 b	14.1	37.1	555 b	40.9	206.0 c	28.4 b
80	60.4 d	246 c	13.4 c	5.2	98 c	13.9	36.0	545 b	39.0	200.0 d	27.8 c
Interaction	*	*	*	*	*	n.s.	*	*	*	*	*
					1999						
I. I. day											
7	62.5 a	258 a	13.0 d	5.5	117 a	14.0	39.0 a	625 a	36.8	205 ab	29.9 b
21	61.8 b	250 a	13.2 c	5.4	110 ab	14.0	36.0 ab	610 b	38.7	208 a	31.5 a
17	61.1 c	244 b	13.6 b	5.4	105 b	14.0	35.0 bc	580 c	38.0	199 b	27.1 c
22	60.1 d	238 c	14.0 a	5.3	98 b	14.0	32.0 c	500 d	39.0	190 c	24.5 d
N levels											
110	62.5 a	254 a	14.0 a	5.5	113 a	14.0	38.0 a	590 b	37.0	205 b	30.1 a
100	61.6 b	250 b	13.4 b	5.4	107 a	14.0	37.2 a	601 a	37.6	210 a	28.3 b
90	60.4 c	243 c	13.2 c	5.4	105 b	13.9	36.0 a	584 b	38.8	200 c	27.7 b
80	60.0 d	243 d	13.2 c	5.3	105 c	14.1	30.8 b	540 c	39.1	187 d	26.8 b
Interaction	*	*	*	n.s.	*	n.s.	*	*	*	*	*

Means followed the same letters are not significantly different at the 0.05 level of significance.