Response of Maize to N Fertilization and Rotational Crop Sequences

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ABSTRACT

Six crop sequences, differing in legume/ nonlegume ratio and terminal crop, were sown in 2005 and 2006 seasons, followed by maize (*Zea mays* L.) fertilized with three N levels (N_1= 10, N_2 = 120 and N_3 = 135 kg /fed). Maize agronomic and grain yield characters were evaluated in 2007 and 2008 summer seasons. A split-plot design, with three replicates, was used, where the main plots and subplots were assigned to crop sequences and N levels, respectively.

Plant height, ear-leaf area, 100-grain weight and grain yield increased with the increase of legume percent in crop sequence and proximity of legume crop to maize. The 100% legume sequence gave the significantly highest values for these traits. A similar trend was found for these characters with increasing N application level from 105 to 135 kg /fed. However, plant height and 100-grain weight showed insignificant increase when applied N level increased from 120 to 135 kg /fed. The interaction effect of both crop sequences and N application level was significant for plant height and ear-leaf area in 2007 season, and for ear-grain weight and grain yield/fed in 2008 season. The highest values for these characters were obtained with 100% legume crop sequence and application of 135 kg N/fed.

Stepwise regression analysis indicated that ear grain weight was the main component that described the greatest portion of variations in grain yield/fed. (R^2 values of 0.956 and 0.899 in the two seasons, respectively). In addition, data showed highly and positive correlation between grain yield/fed and both of ear-grain weight and 100-grain weight.

Key Words: Crop sequence, Zea mays L., Nitrogen fertilizer level, Grain yield

INTRODUCTION

Suitable land areas for food production almost remain fixed or are diminishing, yet agronomists and farmers are faced with the task of increasing productivity. Raising land productivity, through a more effective use of land natural resources and resources added to land, is possible by wise management and choice of suitable crops in crop rotation. Crop rotation, an ordered succession of crops on the same field for a certain period, is not enough to optimize yield, but also, choice of rotation crops, growth habit of preceding crop and legume to non-legume planting ratios are agricultural decisions that should be considered to reach the maximum yield of the following crop (Copeland *et al*., 1993 and Khalil *et al.* 2004).

Residues amount and quality (C/N ratio) of a preceding crop affect the performance of the subsequent one. Narrow C/N ratio (below 20:1) increases N mobilization by microbial organisms and the reverse is true with wide (above 20:1) C/N ratio (Jones, 1987).

The value of legumes inclusion in a sequential cropping system would be attributed to the contribution they may make to the following crop; e.g., soil supply with organic matter and available organic N and reduction of its reliance on chemical N fertilizers (Echeverria *et al*., 1992). Holland and Herridge (1992) reported that legumes, grown in rotation with cereals, could slow the depletion of organic N rate, compared with only a cereal system, provided that the net amount of soil N, used by the legume; i.e., the difference between the amount of N removed as harvested product and the amount fixed, was less than the amount used by cereal crop.

The effects of crop growth habit and crop allocation into the crop sequence, that precedes the subsequent crop, were reported by several investigators. Khalil *et al.* (1999 and 2000) and Nawar (2004) showed that residues, left after clover, gradually decayed to establish a continuous supply of nitrogen to the subsequent crop. Khalil *et al.* (2004) studied the effect of different crop sequences on sunflower growth traits and found that such traits were proportionally increased to increase in legumes planting ratio in crop sequence and legume proximity to sunflower.

Maize, as one of the most important cereals in the world's agricultural economy, is greatly affected by rotational cropping sequence (Crookston *et al*., 1991). Nichel *et al.* (1995) attributed the positive effect of rotation on maize to the improvement of maize growth vigor. Meanwhile, Paul *et al.* (1997) attributed the beneficial effect of rotation on maize to the establishment of high yielding conditions for maize by rotation.

Several studies were conducted to study the effect of different preceding crops on maize traits, including plant height (Khalil *et al*., 2000), number of leaves/plant (Nawar, 2004), ear-grain weight, 100-grain weight and grain yield/fed. (Khalil *et al*, 1999 and 2000 and Nawar, 2004). These studies revealed the beneficial effect of legumes, as preceding winter crops, on agronomic and grain yield characters of maize.

In addition to natural organic nitrogen applied to the soil, as N fixed by legumes or as decay of preceding crop residues to organic N, the supplementation of chemical N increases crop growth and productivity. Nitrogen plays an important role in plant life, regarding the development of vegetative and reproductive organs (Sinclair and Horie, 1989). However, the practice of N application, more than the needs of the crop, might be a reason for N loss; i.e., transformation of N to NO_3 -N, followed by N leaching (Hooker *et al.*, 1983).

Different studies, related to maize response to N, were reported by Amer *et al.* (1995), Ali *et al.* (1999) and Nawar (2004) who showed that N supply to maize increased plant height, and the expansion of ear-leaf. However, McCullough *et al.* (1994), Uhart and Andrade (1995), Khalil *et al.* (2000) and Nawar (2004) attributed the increase in maize grain yield to increases in grain yield attributes as a result of increasing N level.

This study was carried out to investigate the contribution of six rotational cropping sequences to some agronomic traits and grain yield and its components of the following maize, treated with three chemical N levels.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Research Station, Alexandria University, Abbis, to investigate the effect of six crop sequences on maize agronomic characters and productivity. The first experiment was initiated from the winter season of 2005/2006 and terminated in summer season of 2007, whereas, the second experiment, was initiated from winter season of 2006/2007 and terminated in the summer season of 2008. In addition, the effect of three nitrogen levels (N_1= 105, N_2= 120 and N_3= 135 kg /fed), was investigated, with regard to their effect on grain yield, yield components and some agronomic traits of maize. Series of crop sequence, terminal crop and legume to non-legume ratios are presented in Table (1).

Table 1: Series of crop sequence, terminal crop and sowing ratio of legume and non-legume crops in crop sequence.

Series	Sequence number	Crop sequence				Terminal crop	Sowing ratio(%)	
							Legume	Non-legume
	S_1	F	So	B	F	F	100	0
1	S_2	F	So		F	F	100	0
	S_3	F	So	Fod	F	F	75	25
	S_4	W	So	B	W	W	50	50
2	S_5	W	So		W	W	33.3	66.7
	S_6	W	So	Fod	W	W	25	75

F = Faba bean Giza 716 cv.
So = Soybean Giza 111 cv.
B = One-cut type berseem (Alfahl).
Fod = Fodder maize (household).
W = Wheat Gemmeiza 10 cv

The soil, on which the experiments were conducted, was a clay loam soil with a pH value = 7.8, total organic matter = 1.08%, available N, P, K = 3700, 9.5 and 613.00 ppm, as an average of the two seasons, respectively. No application of cultural practices, regarding seedbed preparation, was applied, except for the manual cultivation of the preceding crop residues and weeds.

Seeds were drilled on the upper third of ridges side, in rows with inter-rows spacings of 30.0 and 60.0 cm for wheat (cv. Gemmeiza 10) and fodder maize (household seeds), respectively. Faba bean (cv. Giza 716) and soybean (cv. Giza 83), also, were sown in hills on the upper third of ridges side in rows at intra-row spacing of 30.0 and 20.0 cm, respectively, with thinning to two plants/hill. Maize (cv. 310, three- way cross) was sown on the two sides of the ridge at intraspacing of 30.0 cm, with thinning to one plant/hill. Berseem, one cut type (Alfahl), was broadcast on the whole area of the plot.

Nitrogen, as ammonium nitrate (33.5%N), was applied in equal split doses at first and second irrigations of maize.

A split-plot design, with three replicates, was used, where the main and sub-plots were assigned to crop sequence treatments and N levels, respectively. Each subplot comprised 5 wide ridges, each 4.0 m long and 1.2 m wide (24.0 m^2 , area), in both seasons.

The respective planting dates for crops in the two experiments were 5th and 10th November for faba bean and wheat, 10th and 15th September for berseem and fodder maize and 5th and 10th May for maize and soybean. All other cultural practices were uniformly applied to all crops, according to recommendations. A random sample of ten maize plants were taken from each experimental unit, at harvest, to estimate the following traits : plant height (cm), ear height (cm), number of leaves/plant, ear-leaf area (cm^2) and ear-grain weight (g). The average weight of five random 100-grain weight samples, from each treatment, was calculated to represent 100-grain weight (g). Grain yield was determined (kg) from the inner two ridges in each subplot then, converted to ardab/fed (Feddan= 0.42 ha, ardab=140 kg grains). Statistical analysis included the estimates of analysis of variance, stepwise regression and simple correlation coefficients among the studied traits, and was applied, according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A-Effect of crop sequences on maize characters:

The effect of crop sequences, as preceding crops, on maize traits in 2007 and 2008 seasons are presented in Tables (2 and 3) .

Differences in plant height, as affected by the preceding crop sequences, were significant in both seasons. As shown in Tables (2 and 3), plant height was influenced by legume/non-legume ratio in each series of crop sequences or within the sequences of each series. Data in the two tables indicated the existence of a positive association between both plant height and legume-nonlegume ratio in the different series of crop sequence, faba bean as a terminal crop, preceded by one-cut berseem, produced the tallest plants, compared to the crop sequences. Such increase in the growth vigor of maize in S_1 might be attributed to the increase in the amount and quality of residues returned to the soil, along with the increase of N fixation, which might be reflected in an increase of both availability and use of N by the succeeding crop. These results agreed with those of Khalil *et al* (1999 and 2000) and Nawar (2004) who concluded that the increase in the amount and quality of preceding crop residues increased N mobilization and uptake by maize plants, leading to the increase in plant height. The opposite results were obtained from S_6 sequence, due to continuous planting of crops with fibrous root systems (fodder maize, wheat and maize), which might be associated with soil fertility depletion and increased immobilized N followed by less N uptake and benefits, regarding the plant vegetative growth parts (Jones, 1987 and Nawar, 2004).

Response of maize growth to the preceding crop sequences was further illustrated in the significant effect of previous crops on ear leaf-area of maize, which was increased by increasing legume/non-legume ratio. When growing legumes at 75% or more in series 1 of crop sequences, maize plants produced the highest ear-leaf area compared to the lowest one when ratio was 50% or less as in series 2 of cropping sequences. In the first series, it was interesting to note that the previous full legume sequence (S1) produced the largest ear-leaf area, which was significantly greater than such area obtained from S_3. Also, as observed from sequences in the second series, increases in ratio of non-legume crops (S_6) was associated with reduction in the ear-leaf area to be the lowest value. Increases in N mobilization and uptake, as a result of legumes residues before maize, might be responsible for increasing photosynthesis, which was associated with increasing the length and width dimensions of the leaf, leading to the increase in the overall leaf expansion (Gardner *et al*., 1985, Rizivi and Rizivi, 1992 and Nawar, 2004).

Data analysis showed different contributions of preceding crop sequences to the following maize, regarding the ear-grain weight in both seasons. The beneficial effect of rotating maize on such trait varied according to the rotation crop structure. There was an additive rotation trend that reached maximum value when crop sequences included 100% legumes. However, the differences were not significant in 2007 season. The full effect of S_1 (maximum value) on ear grain weight resulted when faba and berseem directly preceded the following maize.The increase in quality and amount of berseem and faba bean residues returned to the soil with gradual decay ensured continuous supply of N to maize, which was enough for successful fertilization of ear ovules and reduction of the abortion of grains, in addition to ensure proper development and filling of grains (Jacobs and Pearson, 1991, Uhart and Andrade, 1995, Khalil *et al*., 2000 and Nawar (2004). However, opposite results were found as maize followed sequences of legumes less than 50% of preceded crops. When maize was directly preceded by fodder maize and wheat (S_6), ear-grain weight reached the minimum value, which was alleviated by the inclusion of berseem and soybean, as legume crops, into sequence before wheat (S_4 and S_5). High amount of residues, low in C/N ratio (fodder maize + wheat), decreased N mobility and uptake by the following maize, resulting in a decrease in ear grain weight (Jones, 1987).

The results obtained for grain yield/fed (Tables 2 and 3) indicated significant differences among the six crop sequences during the two successive seasons. Response of grain yield to crop sequence had the maximum value when maize followed the full legume crop sequence; i.e., soybean- berseem-faba bean. Meanwhile, the minimum value for such trait was obtained from maize planted after crop sequence of 25% legume crops and 75% cereal crops (S_6). The lower grain yields of maize, in the latter sequence, compared to the first one, might be due to greater N uptake by cereals with lower N carry over for the following maize (Khalil *et al* 2000 and 2004 and Nawar, 2004). Danso and Papastylianou (1992) reported that the magnitude of the increase in maize grain yield was greatly related to the amount of material returned to the soil. The more the amount of material returned to the soil by legumes compared to cereals, the greater the rotation effect on the following non-legume crop. As shown in Tables (2 and 3), the structure of crops, in addition to the terminal preceding crop in crop sequence, greatly affected the grain yield of the following maize. When maize directly followed faba bean, that was in the sequence preceded by berseem, maize produced significantly greater grain yields than maize grown in sequences of series 2 (following wheat). These results agreed with those reported by Zentner *et al*,. (1987) who reported that, including legume forage crops in the rotation with cereals, increased soil productivity because of the ability of legumes to fix nitrogen and to produce deep roots, which added active organic matter and scavenge nutrient from lower soil depths.

In conclusion, rotation effects have been reported to include improvements of soil moisture (Roder *et al*., 1989) and nutrients (Peterson and Varvel, 1989) in addition to the improvement of growth promoting conditions (Crookston *et al*., 1991). The nature of rotation effect was greatly affected by the preceding crop residues amount and quality, as well as the growth habit of terminal crops. Increase in the amount of residues, high in C/N ratio as berseem and faba bean, in addition to the proximity of legumes to maize, were associated with beneficial rotation effects. Hence, all maize traits reached the maximum values when maize was planted after the full legume sequence with the proximity of berseem and faba bean to maize. However, ear height, number of leaves/plant and 100-grain weight exhibited insignificant response to crop sequences.

B-Effect of nitrogen levels on maize traits :

Mean values for maize traits, as influenced by N levels, are presented in Tables (2 and 3). Data indicated significant responses of plant height, ear leaf area, 100-grain weight and grain yield/ fed for added N levels, in both seasons.

Data analysis revealed that maize plant height significantly responded to N application, where the increase in plant height was in proportion to N supply level in both seasons. When maize was supplied with 135 kg N/fed, it produced taller plants by 21 and 10 cm, in 2007, and 25.89 and 13.39 cm in 2008 seasons, compared to 120 and 105 kg N/fed., respectively. Increasing N supply enhanced plant-N uptake, which might be associated with raising the activity of intercalary meristem towards increasing internode length during the vegetative period. These results were in agreement with the conclusions of Amer *et al*., (1995), Ali *et al*. (1999), Khalil *et al*. (2000) and Nawar (2004).

Furthermore, data revealed that ear leaf area was significantly influenced by N fertilization. Increasing N application level led to an increase in N availability in soil and higher uptake by maize plants. That might have led to enhancement of leaves growth and increase in leaf area, especially that of ear-leaf, as concluded by Gardner *et al*., (1985) and Uhart and Andrade, (1995). Maize plants, supplied with 135 kg N/fed, were 22.7 and 52.2 cm^2 larger in ear leaf area, compared to plants, which received 120 and 105 kg N/fed in the first season, and were 38.1 and 53.1 cm^2 larger in the second season, respectively.

In addition, variations in 100-grain weight had a similar trend to that of ear-leaf area response to the applied N rate. The maximum and minimum values for this trait were obtained from plots applied with 135 and 105 kg N/fed, respectively. Nitrogen deficiency resulted in a decline in leaf area index (LAI), as a result of a decrease in leaf expansion, as well as an increase of earlier leaf senescence, resulting in lower photosynthesis and assimilates production and translocation into grains, leading to a decrease in grain weight. Such interpretation has been reported by Sinclair and Horie, (1989) and Uhart and Andrade (1995). The contribution of 120 and 135 kg N/fed, to 100-grain weight, were, respectively, 1.25 and 2.53 g, in 2007, and 1.36 and 2.92 g in the second season, compared to the 105 kg N/fed. These results were in agreement with those of Khalil *et al* (2000) and Nawar (2004).

Data analysis showed that variations in grain yield/fed, as influenced by nitrogen level, was significant in both seasons. Increasing N level up to 120 kg /fed, significantly increased grain yield, however, further N increase up to 135 kg/fed led to an insignificant increase in that trait. As an average of the two seasons, the maximum grain yield of 21.73 ardabs/fed and the minimum one (18.95 ardabs/fed) were obtained from the application of 135 and 105 kg N/fed., respectively. It could be concluded that low N application caused such reduction in grain yield because it tended to reduce ear-grain weight and 100- grain weight. The increase in N level, which was associated with the increase in leaf area, coupled with increases in photosynthesis and photoassimilates partitioning to grains, might have led to the increase in grain yield components and, finally, grain yield/fed, as

Table 2 : Means of plant height, ear height, number of leaves / plant, ear- leaf area, grain yield / ear,100- grain weight and grain yield / fed for maize during 2007season

Treatment	Plant height (cm)	Ear height (cm)	No. of leaves/ plant	Ear leaf area (cm^2)	Ear grain weight (g)	100-grain weight (g)	Grain yield/ fed (ardab)
Crop sequences:							
S_1: F- So- B- F- M	280.0	130.9	20.2	780.0	130.4	33.00	23.00
S_2: F- So- - F- M	276.0	132.0	20.4	764.4	128.7	32.70	21.90
S_3: F- So-Fod- F- M	272.7	131.9	20.3	740.0	128.0	32.44	21.80
S_4: W- So- B- W- M	271.9	131.0	20.3	708.9	118.8	32.50	20.10
S_5: W- So- - W- M	268.0	132.1	20.1	670.0	114.8	32.30	20.00
S_6: W- So-Fod- W- M	265.0	132.0	20.3	620.0	111.6	32.00	19.44
L.S.D. (0.05)	**4.19**	**-**	**-**	**9.88**	**-**	**0.97**	**0.26**
Nitrogen levels (kg/fed):							
N_1:105	262.7	131.7	20.2	686.7	119.8	31.47	19.34
N_2: 120	273.1	131.9	20.2	716.1	122.0	32.75	22.35
N_3:135	283.0	131.9	20.3	738.9	122.3	34.00	22.43
L.S.D. (0.05)	**2.00**	**-**	**-**	**3.90**	**-**	**0.47**	**0.11**

Table 3 : Means of plant height, ear height, number of leaves / plant, ear- leaf area, grain yield/ear,100- grain weight and grain yield / fed for maize during 2008 season

Treatment	Plant height (cm)	Ear height (cm)	No. of leaves/ plant	Ear leaf area (cm^2)	Ear grain weight (g)	100-grain weight (g)	Grain yield/ fed (ardab)
Crop sequences:							
S_1: F- So- B- F- M	273.0	132.1	19.00	760.3	126.6	34.04	22.29
S_2: F- So- - F- M	271.0	132.0	19.11	753.6	124.6	33.90	21.49
S_3: F- So-Fod- F- M	269.0	132.0	19.00	733.3	124.0	33.80	20.82
S_4: W- So- B- W- M	262.8	131.0	18.50	706.7	113.1	33.60	19.43
S_5: W- So- - W- M	260.0	133.0	19.50	682.2	109.2	33.50	18.83
S_6: W- So-Fod- W- M	260.0	131.8	18.85	630.0	106.1	33.10	18.28
L.S.D.(0.05)	**2.57**	**-**	**-**	**7.78**	**1.35**	**-**	**0.33**
Nitrogen levels (kg/fed):							
N_1:105	253.2	131.8	19.06	685.0	117.1	32.25	18.59
N_2: 120	265.7	132.0	18.89	710.0	117.2	33.81	20.95
N_3:135	279.1	132.3	19.06	738.1	117.4	35.17	21.03
L.S.D. (0.05)	**1.77**	**-**	**-**	**4.74**	**-**	**0.54**	**0.14**

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Table 4: Two-factor interaction for plant height and ear leaf area during 2007 season

Treatment	Plant height (cm)						Ear-leaf area (cm^2)					
	2006 N level (kg/fed)			2007 N level (kg/fed)			2006 N level (kg/fed)			2007 N level (kg/fed)		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
S_1: F- So- B- F- M	279.0	285.0	291.0	267.0	277.0	287.0	740.0	790.0	810.0	730.0	765.0	795.0
S_2: F- So- - F- M	268.0	278.0	288.0	255.0	270.0	285.0	735.0	765.0	793.3	730.0	740.0	781.7
S_3: F- So-Fod- F- M	256.0	276.0	286.0	256.0	266.0	276.0	710.0	740.0	770.0	710.0	725.0	765.0
S_4: W- So- B- W- M	255.0	266.7	285.0	246.0	261.0	281.3	690.0	706.7	730.0	680.0	710.0	730.0
S_5: W- So- - W- M	258.0	268.0	278.0	248.0	260.0	272.0	650.0	670.0	690.0	660.0	746.7	706.7
S_6: W- So-Fod- W- M	260.0	265.0	270.0	247.0	260.0	273.0	595.0	625.0	640.0	600.0	640.0	650.0
L.S.D. (0.05)	**5.45**			**4.33**			**9.56**			**28.44**		

Table 5: Two-factor interaction for ear grain weight and grain yield/fed during 2006 season

Treatment	Ear-grain weight (g)						Grain yield/fed (ardab)					
	2006 N level (kg/fed)			2007 N level (kg/fed)			2006 N level (kg/fed)			2007 N level (kg/fed)		
	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
S_1: F- So- B- F- M	121.9	135.5	142.6	118.1	132.0	138.6	21.00	23.40	24.60	20.30	22.70	23.87
S_2: F- So- - F- M	107.1	131.0	138.0	113.7	127.2	134.0	20.30	22.60	23.80	19.60	21.93	22.93
S_3: F- So-Fod- F- M	116.3	127.5	131.2	112.7	123.7	123.7	20.00	22.00	22.50	19.43	21.23	21.89
S_4: W- So- B- W- M	110.1	119.9	126.3	104.8	114.2	120.3	19.00	20.70	21.80	18.07	19.67	20.73
S_5: W- So- - W- M	104.3	112.7	127.5	99.4	106.9	121.4	18.17	19.17	22.17	17.13	18.43	20.93
S_6: W- So-Fod- W- M	103.4	109.7	122.5	98.2	103.6	116.3	18.03	19.00	21.30	16.93	17.87	20.03
L.S.D. (0.05)	**3.65**			**2.83**			**1.33**			**1.43**		

Table 6: Simple correlation coefficients between pairs of studied characters in maize, overall crop sequences and N application levels, in 2007 and 2008 seasons.

Character and season		Ear height	No. of leaves/ plant	Ear-leaf area	Ear-grain weight	100-grain weight	Grain yield/ fed
Plant height	2007	0.21	-0.01	0.77**	0.89**	0.79**	0.91**
	2008	0.54*	-0.12	0.70**	0.90**	0.75**	0.85**
Ear height	2007		-0.09	-0.03	0.14	0.04	0.13
	2008		-0.11	0.30	0.43	0.30	0.40
No of leaves/plant	2007			0.07	0.03	0.04	0.01
	2008			-0.05	-0.12	-0.12	0.05
Ear leaf area	2007				0.82**	0.80**	0.88**
	2008				0.83**	0.92**	0.77**
Ear grain weight	2007					0.82**	0.98**
	2008					0.92**	0.95**
100-grain weight	2007						0.89**
	2008						0.83**

**: Significant at 0.01 level of probability.

concluded by Gardner *et al.* (1985) and Sinclair and Horrie (1989). These results agreed with those reported by Amer *et al* (1995), Ali *et al.* (1999), Khalil *et al* (2000) and Nawar (2004).

C-The effect of crop sequence x N level interaction on some characters of maize:

The interaction of the two factors (crop sequence and N level) on maize plant height, ear-leaf area, ear-grain weight and grain yield/fed was significant in both seasons (Tables 4 and 5).

Variations in plant height and ear leaf area, as affected by the crop sequence, varied with N level. The higher legume planting ratio, associated with the greater N level, gave the highest values from the two traits, which were realized from S_1 and N_3 combined effect, while, the lowest values were obtained from application of S_6 and N_1 (Table 4). Increases in soil N amount and availability, due to the return of legumes residues (S_1 sequence) and the application of N_3 (135 kg/fed), were associated with greater N uptake by plants. That gave higher leaf area resulting in elevated photosynthetic rate and dry matter production, most of which was translocated to the shoot system, thus, increasing plant height and ear leaf-area during the vegetative period.

Response of ear-grain weight and grain yield/fed to the N level was influenced by the crop structure of sequence before maize, as well as the growth habit of the crop, which was in close proximity with maize (Table 5). Increases in legumes percentage, especially with faba bean preceded by berseem as a terminal crop before maize planting, produced greater values of both traits, compared to crop sequence of W-SO-Fod-W under any of the nitrogen levels. The maximum response of both traits was found when maize in S_1 crop sequence was supplied with 135 kg/fed, while, the minimum values were produced by S_6 crop sequence and application of 105 kg N/fed (Table 5). The magnitude of the increase in grain yield of the subsequent maize was related to the amount and quality of material returned to the soil, in addition to inorganic N supply to the soil. The more the amount of residues returned in soils by legumes (compared to cereals), the more the beneficial effect of legume residues on the following crop, regarding ear grain weight and grain yield/fed, under any of the N levels.

The increase in N uptake, due to legume residues and applied N, was associated with vigorous plant growth and enhanced leaf formation, which caused greater assimilation and translocation of most assimilates to ears, thus, increasing ear weight and, in turn, grain yield/fed. Conversely, seasonal alternation between graminious crops (fod-wheat-M), with increases of residues low in C/N ratio, was associated with nutrients depletion in the upper layer of soil and exposed N fertilizer to N immobilization, whatever the rate of nitrogen applied, and decreased N uptake by maize plants, causing a reduction in plant growth and influenced plant productivity.

Stepwise regression, in both seasons, indicated that grain yield/ear was the main component that described the greatest portion of variations in grain yield (R^2 values of 0.956 and 0.899 in the first and second season, respectively). This might elucidate the dependability on such character to sum up the effect of the different environmental factors on grain development in the ear and, finally, grain yield per unit area. One-hundred grain weight, in both seasons (R^2 = 0.188 and 0.171, respectively), and number of leaves per plant, in the second season (R^2 = 0.293), exhibited a minor, though significant, role in that aspect.

Simple correlation coefficients (Table 6) indicated that ear-leaf area was positively and highly significantly correlated, in both seasons, with ear weight, 100-grain weight and grain yield/fed. This indicated the important role played by the ear leaf in determining grain yield as the main source for photoassimilates translocated to the ear, hence, affecting grain filling and weight, ear weight and, finally, total grain yield/fed. The highly significant and positive correlation between grain yield per unit area and both ear-grain weight and 100-grain weight was concomitant with the role played by these two characters as important grain yield components.

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الملخص العربى

إستجابة محصول الذرة الشامية للتسميد النيتروجينى تحت تأثير تعاقبات محصولية دورية

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زرعت ستة تعاقبات من المحاصيل ، تختلف فيما بينها فى نسبة المحاصيل البقولية ، فى موسمى ٢٠٠٥ و ٢٠٠٦ واعقبها زراعة الذرة الشامية الذى سمد بثلاثة مستويات من النيتروجين (N_1= ١٠٥ ، N_2= ١٢٠ و N_3= ١٣٥ كجم/فدان) وتم تقييم الصفات المحصولية للذرة الشامية فى موسمى صيف ٢٠٠٧ و ٢٠٠٨ . وكان التصميم المستخدم القطع المنشقة مرة واحدةحيث وضعت التعاقبات فى القطع الرئيسية ومستويات التسميد النيتروجينى فى القطع الثانوية.

اوضحت النتائج تأثيرا معنويا لتعاقبات المحاصيل ، من حيث نسبة البقوليات فى التعاقب ، على ارتفاع النبات و مساحة ورقة الكوز و وزن المائة حبة ومحصول الحبوب للفدان ، حيث زادت قيم هذه الصفات بزيادة نسبة البقوليات فى التعاقبات. كما اوضحت النتائج ان زيادة مستوى التسميد النيتروجينى من ١٠٥ الى ١٣٥ كجم / فدان ادى الى زيادة معنوية لهذه الصفات ، بينما كانت الزيادة غير معنوية لصفتى ارتفاع النبات ووزن المائة حبة عند زيادة مستوى التسميد النيتروجينى من ١٢٠ الى ١٣٥ كجم N/ فدان.واظهرت النتائج وجود تفاعل معنوى بين التعاقبات المحصولية ومستوى التسميد الازوتى لصفات ارتفاع النبات ومساحة ورقة الكوز (فى موسم ٢٠٠٧) ولصفات وزن الحبوب بالكوز ومحصول الحبوب للفدان فى موسم ٢٠٠٨ ، وكانت اعلى القيم لهذه الصفات عند زراعة تعاقب محصولى مكون من ١٠٠% بقوليات وإضافة تسميد نيتروجينى بمعدل ١٣٥ كجم / فدان وقد اشارت نتائج الانحدار المتدرج الى ان صفة وزن الحبوب بالكوزتعتبر أهم مكون للمحصول حيث فسرت ٩٥,٦، ٨٩,٩% من الاختلافات فى صفة محصول الحبوب/فدان فى الموسمين على التوالى. كما اشارت النتائج الى وجود تلازم موجب وعالى المعنوية بين محصول الحبوب/فدان وكل من وزن الحبوب بالكوز ووزن المائة حبة.