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EFFECT OF DIFFERENT NITROGEN LEVELS ON PRODUCTIVITY OF THREE MAIZE HYBRIDS FERTIGATION

[31]

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ABSTRACT

Two field experiments were conducted in 2004 and 2005 seasons at El-Bosaily farm located at Beharia Governorate, Egypt, to study the effect of three nitrogen levels 60, 120 and 180 kg/feddan applied into irrigation water "fertigation" with drip irrigation system on vegetative growth, nutrient content (N, P and K) in leaves and grain and yield of three maize (*Zea mays* L.) hybrids (Single Cross 10, Three Way Cross 310 and Three Way Cross 324). The experiment design was a split plot with three replications where nitrogen fertilizer levels were distributed in the main plots and maize hybrids allocated in sub plots. The obtained results indicate that the increase of nitrogen level up to 180 kg /fed significantly increased plant height, number of leaves per plant, leaf area index, grain yield and straw weight. Single Cross 10 gave the significant highest vegetative growth and grain yield comparing with the other hybrids. The highest nitrogen level (180 kg /fed) combined with Single Cross 10 gave the significantly highest grain yield and straw weight. On the other hand, 60 kg N / fed gave the highest nitrogen use efficiency (NUE) value followed by 120 kg N / fed The regression analysis of nutrition content (N, P, and K %) between leaf and grain was estimated. The highest regression determination coefficient (r^2) was found in nitrogen percentage with r^2= 0.965 followed by potassium with r^2= 0.936. The lowest r^2 was found in phosphorus with r^2= 0.872.

INTRODUCTION

Maize grain used for both human and animal poultry feed. The local production of the crop is not sufficient to meet the continuous increase of consumption. Therefore, attempts to increase maize production are most important. Such attempts could be achieved through horizontal and vertical expansion. Nitrogen fertilizer is an important factor in increasing yield of maize. Many investigators reported that increasing nitrogen levels up to 120 kg N / fed. led to a significant increase in grain yield and its components **(Farghly, 2001 and El-Hassanin *et al* 2002).**

N-use efficiency (NUE) is defined as grain production per unit of N available in the soil. There are two primary components of NUE, the efficiency of absorption (uptake) and the efficiency with which the N absorbed is utilized to produce grain. Efficiency in uptake and utilization of N in the production of grain requires that those processes associated with absorption, translocation, assimilation, and redistribution of N operate effectively **(Moll *et al* 1982).**

In respect to the effect of nitrogen fertilizers on maize crop, **Omar *et al* (1982)** studied the effect of different doses of nitrogen fertilizer on grain yield of maize variety Giza-2. They indicated that the grain yield was increased by increasing nitrogen doses from 107 up to 214 kg N/ha. **Heggi *et al* (1992)** indicated that corn plants responded to inorganic nitrogen, phosphorus or potassium fertilizers at a rate of 120 kg N, 60kg P_2O_5 and 60kg K_2O/fed. They added that grain yield was increased by about 48% over than of control (80kg N/fed.), due to nitrogen application, while P and K addition tended to yield increment of 18.08% and 6.25% respectively. **Hegazi *et al* (1993)** showed that nitrogen content and uptake by corn plants were increases significantly as a result of nitrogen fertilizer rate of 200 and 400 µg/g soil added as ammonium sulphate. The positive effect of nitrogen application on growth and yield of maize were demonstrated also by several **investigators (El-**

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Hosary & Salwau, 1989; Mahgoub *et al* 1991 and El-Sheikh 1993). They generally reported that increasing application of N up to 80 kg N/fed. caused a significant increase in most growth characters and yield of maize and its components.

The maintenance of nutrients and water at optimum levels within the rhizosphere of plants is a primary factor to achieve high yield, to improve quality and to increase fertilizer and water use efficiencies. Therefore, the application of fertilizers through the irrigation water considered a beneficial practice in modern irrigated agriculture **(Papadopoulos, 1988)**.

Water soluble fertilizers at concentrations required by crops are conveyed with every irrigation event or periodically via the irrigation stream to the wetted volume of soil, where the active roots are concentrated **(Papadopoulos, 1985)**. Moreover, scheduling fertilizer applications on the basis of need potentially are reduced nutrient-element losses associated with conventional application method that depend on the soil as a reservoir for nutrients (**Schwarz and Klaring, 2002**).

Many investigators were of the opinion that maize hybrids differed in their grain yield and its components. In this respect **Salem (1993)** reported that Single Cross 10 and 9 recorded the highest number of kernels /row and seed index. **Ragheb *et al* (1993)** found that Single Cross 10 produced the highest grain yield followed by Single Cross 9 and Double Cross 204. In addition **Tantawy (1994)** mentioned that ear length; ear weight, number of kernels /row, 1000- kernels weight and grain yield/ fed were significantly affected by genotypes.

The current work aimed to evaluate the performance of the three maize hybrids Single Cross 10, Three Way Cross 310 and Three Way Cross 324 under different nitrogen levels applied with fertigation technique.

MATERIALS AND METHODS

The experiment was carried out in the two successive seasons of 2004 and 2005 at El- Bosaily Protected Cultivation Experimental Farm, Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, located at Behaira Governorate, Egypt. The treatments comprised three nitrogen levels (60, 120 and 180 kg N / fed) and three maize (*Zea mays* L.) hybrids (Single Cross 10, Three Way Cross 310 and Three Way Cross 324). Plants were irrigated by using drippers of 2 l/hr capacity. Ammonium nitrate was used as the source of nitrogen. The different nutrient solution concentrations were injected within irrigation water system by using fertilizer tanks (as a fertigation). The volume of nutrient solution applied to each treatment was adjusted at each irrigation event to meet measured evapotranspiration (ET) plus leaching fraction of 20%. Fertilizers other than treatments were applied to plants in the form of nutrient solution. This nutrient solution consisted of all needed macro and micro elements for maize growth. The nutrient solutions were adjusted for pH from 6.0 to 6.5.

The experimental design was a split plot with three replications where nitrogen fertilizer levels were distributed in the main plots and maize hybrids allocated in sub plots. Plot area was 150 m^2 (15 m length x 10 m width). The distances between rows were 70 cm and plant distances were 30 cm apart. A distance of 2 m was left as a border between each two nitrogen treatments.

Sowing dates were May 18 and 21 for the first (2004) and the second (2005) seasons, respectively. All other agriculture practices of maize cultivation were performed as recommended by the Ministry of Agriculture. Samples of ten plants of each experimental plot were taken to determine growth parameters after 95 days from sowing date as follows (plant height, number of leaves per plant and leaf area index). Leaf area index (LAI) was calculated as described by **Watson (1958)** as follows LAI =Leaf area per plant (cm^2)/surface area per plant (cm^2). Grain yield and straw weight were measured using a frame of 6.3 m^2 (2.1 × 3 m) and then calculated in kg/fed.

Plant samples were dried at 70 ºC in an air forced oven for 48 h. Dried leaves and grains were digested in H_2SO_4 and N,P and K contents were estimated in the acid digested solution by colorimetric method (ammonium molybdate) using spectrophotometer and flame photometer **(Chapman and Pratt, 1961).**

Chemical and physical properties of the soil of the experiment were analyzed before cultivation. The results are tabulated in **Table (1)**. Nitrogen use efficiency (NUE) was calculated as the yield obtained from the N (Yn) fertilized plot minus control (Yc), divided by a unit weight of the applied fertilizer (Nw for nitrogen by equation NUE= (Yn-Yc)/Nw (**Moll *et al* 1982).**

Analysis of data was done by computer, using ANOVA program for statistical analysis. The differences among means for all traits were tested for significance at 5 % level according to **Waller and Duncan (1969).**

The linear regression between each of nitrogen, phosphorus and potassium contents (%) in the leaves and nitrogen, phosphorus and potassium contents (%) in grain were steamed by using computer program Slide Write Plus® gives powerful technical graphing, curve-fitting and data analysis functions that can transform data into technical graphs and charts that are impressive and memorable.

Table 1. Chemical and physical properties of the soil of the experiment analyzed before cultivation.

Chemical properties							
EC dS/m	pH	Ca^{++} meq/l	Mg^{++} meq/l	Na^{+} meq/l	K^{+} meq/l	HCO_3^- meq/l	Cl^- meq/l
3.00	7.89	30	10	14.26	1.66	2.5	12.6
Physical properties							
Sand %	Clay %	Silt%	Texture	FC %	PWP %	Bulk density g/cm^3	
95.31	4.33	0.36	Sandy	16.77	5.65	1.44	

RESULTS AND DISCUSSION

Growth characters

The effect of different nitrogen levels on vegetative growth characters of the three maize hybrids are illustrated in **Table (2)**. Data showed that using 180 kg nitrogen level increased plant height, number of leaves and leaf area index of maize plant significantly followed by 120 kg treatment. The lowest values of vegetative trails were obtained by 60 kg nitrogen level treatment during the two studied seasons.

On the other hand, maize hybrids differed significantly with regard to their vegetable traits. Single Cross 10 hybrid had the highest vegetative growth parameters followed by Three Way Cross 310 hybrid with significant difference between them.

Regarding the interaction effect between different nitrogen levels and different hybrids, data showed that the highest values of vegetative growth characters were obtained by using 180 kg nitrogen level combined with Single Cross 10 hybrid followed by 180 kg nitrogen level with Three Way Cross 310 hybrid. The lowest vegetative growth characters were obtained by using 60 kg nitrogen level treatment with Three Way Cross 324 hybrid during the two successive seasons. The superiority of plant growth characters of 180 kg N/fed treatment may be due to the role of nitrogen in stimulating the build up of amino acids and growth hormones. This turn acts positively in cell division and enlargement. Many researchers obtained positive responses of maize growth traits to varying levels of nitrogen fertilization, such as, **Bedeer *et al* (1992); El-Hefinawy & El-Ashmony (1992) and Farghly (2001).**

Table 2. Effect of different nitrogen levels on plant height, number of leaves and leaf area, of three maize hybrids during 2004 and 2005 seasons.

Season		2004			2005		
Nitrogen levels Kg N/fed.	Hybrids	Plant height (cm/plant)	Number of leaves/plant	Leaf area index	Plant height (cm/plant)	Number of leaves/plant	Leaf area index
60	SC10	184 E	13.8 B	4.68D	173E	13.0C	4.83B
	TWC310	174 F	11.4 D	4.24F	160F	11.1D	3.96E
	TWC324	171 F	10.1 E	4.53E	159F	10.3E	4.02E
	Mean	177 C	11.8 C	4.48C	164C	11.5C	4.27C
120	SC10	200 C	13.7 B	5.54B	222B	15.3A	5.82B
	TWC310	194 D	12.3 C	5.54B	215C	13.7B	5.80B
	TWC324	183 E	11.5 D	4.60D	203D	12.8C	4.90D
	Mean	192 B	12.5 B	5.23B	214B	13.9B	5.50B
180	SC10	220 A	15.2 A	5.69A	226A	15.9A	5.93A
	TWC310	213 B	13.6B	5.62A	220B	14.0B	5.96A
	TWC324	203 C	12.7C	4.92C	212C	13.0C	5.16C
	Mean	212 A	13.8 A	5.41A	219A	14.3A	5.68A
Hybrids Mean	SC10	201 A	14.2 A	5.30A	207A	14.7A	5.52A
	TWC310	194 B	12.4 B	5.13B	198B	12.9B	5.24B
	TWC324	186 C	11.4 C	4.68C	191C	12.1C	4.69C

Grain yield and straw weight

The effect of different nitrogen treatments on grain and straw yields of the three maize hybrids are presented in **Table (3)**. Referring the effect of different nitrogen levels, data showed that using 180 kg nitrogen level gave the significantly highest grain and straw yields/fed in both seasons, followed by 120 kg nitrogen level comparing with 60 kg nitrogen level.

Grain and straw yields per feddan were significantly differed among the three studied hybrids. Data showed that the highest grain yield and straw weight was obtained by Single Cross 10 hybrid followed by Three Way Cross 310 hybrid with significant difference between them. The lowest grain yield and straw weight was obtained by Three Way Cross 324.

Regarding the interaction effect between different nitrogen levels and hybrids, data showed that the lowest grain yield and straw weight was obtained by 60 kg nitrogen level with all hybrids comparing with the other treatments. The highest grain yield and straw weight was obtained by 180 kg nitrogen level combined with Single Cross 10 followed by 120 kg nitrogen level with Single Cross 10 hybrid with significant difference between them. The increases in maize yield might be due to the increased utilization of N fertilizer in stimulating meristimatic activities. The accumulation of synthesized metabolites resulted in high dry matter accumulation and finally high grain weight. The obtained results are in good line with those reported by **Agroudy (1986) and El-Sheikh (1993).**

Nitrogen use efficiency in grain (NUE)

Data of nitrogen use efficiency (NUE) which is define as the economic production obtained per unit of nitrogen applied are presented in **Table (3)**. It is evident from the data obtained that the highest NUE was obtained by 60 kg nitrogen level followed by 120 kg nitrogen level with significant difference between them. The lowest NUE value was obtained by 180 kg nitrogen level.

On the other hand there are not significant differences between Three Way Cross 310 and Three Way Cross 324 in NUE, but Single cross 10 exceeded significantly the other two hybrids. The varieties showed gradual decline in or had almost similar values of NUE at increased nitrogen rates. Application of additional unit weight of N led to reduction or gave almost similar unit weight of maize grain. There is therefore much advantage to be derived from using economic rate that will enhance higher nitrogen use efficiency and maximize grain production. Based on the value of increased nitrogen input, the decline observed in NUE **(Kogbe and Adediran, 2003).**

Table 3. Effect of different nitrogen levels on grain yield, straw weight and nitrogen use efficiency (NUE) of maize hybrids during 2004 and 2005 seasons.

Season		2004			2005		
Kg N/fed.	Hybrids	Grain yield Kg / fed.	Straw weight Kg / fed.	NUE	Grain yield Kg / fed.	Straw weight Kg / fed.	NUE
60	SC10	4758D	3253F	79 A	4682G	3247E	78 A
	TWC310	4717 F	3378E	79 A	4474H	3140F	75 A
	TWC324	4507G	3022G	75 A	4395H	2920 G	73 A
	Mean	4661 C	3218 C	77.7 A	4517C	3102 C	75.3 A
120	SC10	5294 B	4053 B	44 B	5662B	4205B	47 B
	TWC310	5207B	3794D	43 B	5558D	4143 C	46 B
	TWC324	4691 E	3907C	39 B	4939F	4193 C	41 B
	Mean	5064 B	3918 B	42.2 B	5386B	4232 B	44.9 B
180	SC10	5611 A	4117 A	31 C	5730A	4360 A	32 C
	TWC310	5236 B	3897C	29 C	5603C	3967 D	31 C
	TWC324	5025 C	4033B	28 C	5270E	4150C	29 C
	Mean	5291 A	4016 A	29.4 C	5534A	4107 A	30.7 C
Hybrids Mean	SC10	5221A	3808A	51.5 A	5358A	3937A	52.4 A
	TWC310	5053B	3690B	50.4 B	5212B	3750B	50.7 A
	TWC324	4741C	3654C	47.4 B	4868C	3754C	47.9 B

Mineral contents

According to the effect of nitrogen levels, data in **Tables (4& 5)** showed that using 180 kg nitrogen per feddan led to increase N, P and K% significantly in maize leaf and grain followed by 120 kg nitrogen with significant difference between them. The lowest N, P and K % was obtained by 60 kg nitrogen.

Data in **Tables (4 & 5)** showed the difference in N, P and K % in maize leaf and grain of the three studied hybrids. The highest N, P and K % was observed by Single Cross 10 followed by Three Way Cross 310 with significant difference between them. The lowest N, P and K % in both leaves and grains were obtained by Three Way Cross 324 hybrid.

Data of the interaction between nitrogen levels and hybrids showed that using 180 kg nitrogen increased N, P and K % in all hybrids followed by 120 kg nitrogen treatment. The lowest N, P and K % exhibited by 60 kg nitrogen with Three Way Cross 310 treatment. These results are in agreement with those of **Heggi *et al* (1992)** who reported that N fertilizer influenced plant tissue concentration of N, P and K, where increase nitrogen level led to increase tissue concentration of N, P, Ca, Mg, and K and this may have been due to more active root growth to slight changes in soil availability of these nutrients due to the addition of N fertilizer to the soil. Nitrogen concentration in plant leaves declined with age, while P increased initially and then declined as the grain ripened. A small proportion of the N, and an even smaller proportion of the P and K, which has accumulated in the leaves and stem tends to be translocate into the grain. Meanwhile, **Fageria (2001)** reported that potassium could be involved with NO_3 uptake, the predominant from of soil N, through two processes. First, K has been found to co-transport in the tomato xylem with NO_3 as an accompanying action from the roots to aerial plant parts and then recycle down the phone with malate. Secondly, because NO_3 is take up by plant roots via an active process NO_3 uptake that may be affected through the influence of K on the translocation of photosynthetic assimilates, needed to support this active uptake process. On the other hand, phosphorus has positive significant interaction with N absorption and tomato growth. It is a commonly held view that increased growth required more of both N and P, the inference being that mutually synergistic effects result in growth simulation and enhanced uptake of both elements. The same author added that, these mechanisms involved are not well understood, but a number of both soil and plant related mechanisms have been proposed **(Fageria and Baligar, 1999).**

Table 4. Effect of different nitrogen levels on N, P and K % in leaves for maize during the 2004 and 2005 seasons.

				2004			2005
Kg N/fed.	Hybrids	N%	P%	K%	N%	P%	K%
60	SC10	1.2 F	0.54C	0.76E	1.06E	0.48C	0.67E
	TWC310	1.03 G	0.55C	0.71F	0.82F	0.44CD	0.57F
	TWC324	1.2 F	0.52C	0.60G	0.84F	0.36E	0.42G
	Mean	1.14 C	0.68 C	0.69C	0.91C	0.43C	0.55C
120	SC10	1.39 C	0.59 B	1.18B	1.32B	0.56B	1.12B
	TWC310	1.34 D	0.58 B	0.88D	1.13D	0.49C	0.74D
	TWC324	1.27 E	0.56BC	0.77E	0.97E	0.43D	0.59E
	Mean	1.33 B	0.92 B	0.94B	1.14B	0.49B	0.82B
180	SC10	1.70 A	0.65 A	1.34A	1.67A	0.64A	1.31A
	TWC310	1.48 B	0.64 A	1.02C	1.30B	0.56B	0.90C
	TWC324	1.47 B	0.63 A	0.99C	1.25C	0.54B	0.84C
	Mean	1.55 A	1.09 A	1.12A	1.41A	0.58A	1.02A
Hybrids Mean	SC10	1.42 A	1.06 A	1.09A	1.35A	0.56A	1.03A
	TWC310	1.28 C	0.85 B	0.87B	1.08B	0.50B	0.73B
	TWC324	1.32 B	0.77 C	0.79C	1.02C	0.44C	0.62C

Table 5. Effect of different nitrogen levels on N, P and K % in grain for maize during the 2004 and 2005 seasons.

		2004			2005		
Kg N/fed.	Hybrids	N%	P%	K%	N%	P%	K%
60	SC10	0.31 C	0.47 D	0.81E	0.27C	0.41D	0.75E
	TWC310	0.25 D	0.38 E	0.78F	0.20	0.30E	0.72F
	TWC324	0.25 D	0.28 F	0.70G	0.18D	0.20F	0.65G
	Mean	0.27 C	0.38 C	0.76C	0.22C	0.30C	0.70C
120	SC10	0.35 B	0.55 C	0.86D	0.33B	0.52C	0.80D
	TWC310	0.30 C	0.41 E	0.82E	0.25C	0.34E	0.75E
	TWC324	0.29CD	0.31 F	0.78F	0.22D	0.24F	0.72F
	Mean	0.31 B	0.42 B	0.82B	0.27B	0.37B	0.75B
180	SC10	0.39 A	0.73 A	1.08A	0.38A	0.72A	0.99A
	TWC310	0.36 B	0.69 B	1.01B	0.32B	0.61B	0.93B
	TWC324	0.26 D	0.50 D	0.91C	0.22D	0.43D	0.84C
	Mean	0.34 A	0.73 A	1.0 A	0.31A	0.58A	0.92A
Hybrids Mean	SC10	0.35 A	0.68 A	0.92A	0.33A	0.55A	0.84A
	TWC310	0.30 B	0.49 B	0.87B	0.26B	0.42B	0.80B
	TWC324	0.27 C	0.36 C	0.79C	0.21C	0.29C	0.73C

Linear regression between N, P and K in leaves and grains

Figures (1, 2 and 3) show the linear regression between nitrogen, phosphorus and potassium contents (%) in the leaves and nitrogen, phosphorus and potassium contents (%) in the grain during two seasons. Data indicating that there were high positive relationships between nitrogen, phosphorus and potassium content (%) in the leaves and nitrogen, phosphorus and potassium content (%) in the grain. The highest coefficient of determination value (r2) was obtained by nitrogen followed by potassium, while the lowest r2 value was preceded by phosphorus. From these results, we can determine the content (%) of N, P and K in the grain by use leaves contents according to the following equations.

1- Nitrogen

$$N_{Gr} = 0.6215 * N_{Le}^{4} - 3.5906 * N_{Le}^{3} + 7.4486 * N_{Le}^{2} - 6.2803 * N_{Le} + 1.9902$$

Where: N_{Gr} =Nitrogen content (%) in grain, N_{Le} =Nitrogen content (%) in leaves

$r^2 = 0.9653$

2- Phosphorus

$$P_{Gr} = -4090.3 * P_{Le}^{4} + 9919.3 * P_{Le}^{3} - 8983.8 * P_{Le}^{2} + 3604.2 * P_{Le} - 540.36$$

Where: P_{Gr} = Phosphorus content (%) in grain, P_{Le} =Phosphorus content (%) in leaves

$r^2 = 0.8726$

3- Potassium

$$K_{Gr} = 17.291 * K_{Le}^{4} - 64.018 * K_{Le}^{3} + 86.24 * K_{Le}^{2} - 49.642 * K_{Le} + 11.039$$

Where: K_{Gr} = Potassium content (%) in grain, K_{Le}= Potassium content (%) in leaves

$r^2 = 0.9368$

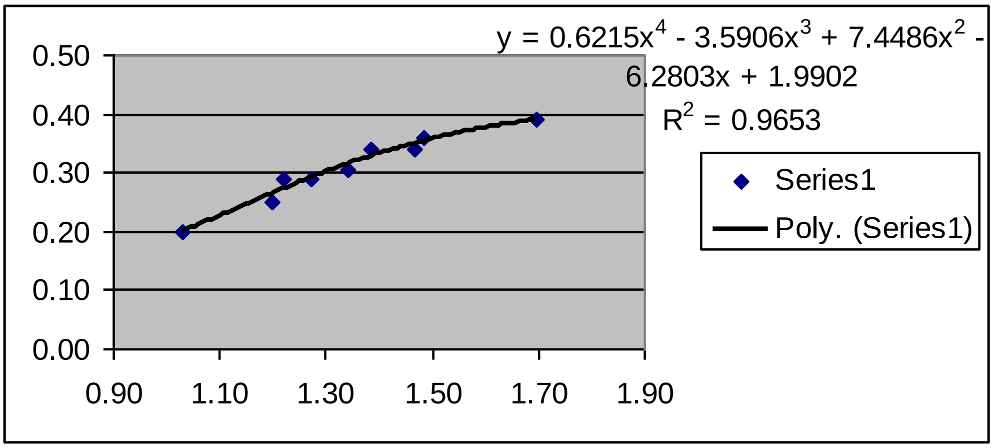

Figure 1. Relationship between average nitrogen content (%) in leaves of maize plants, and average nitrogen content in grain (%) during the two seasons.

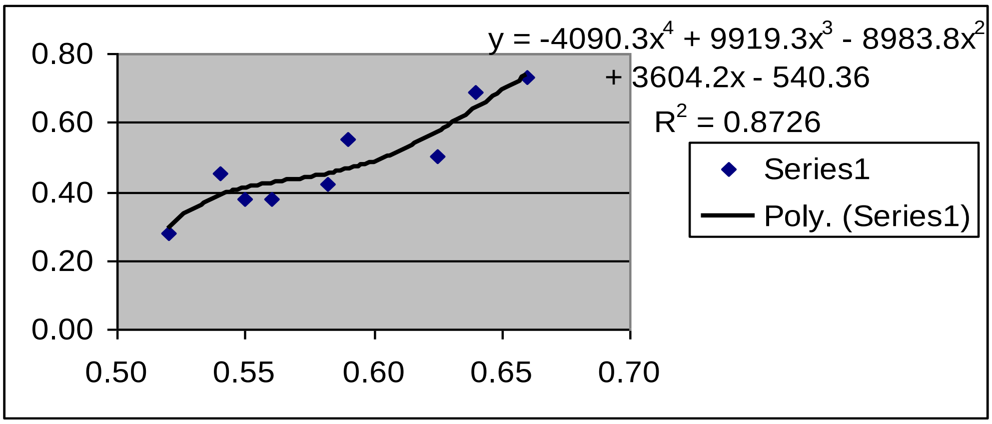

Figure 2. Relationship between average phosphorus content (%) in leaves of maize plants, and average phosphorus content in grain (%) during the two seasons.

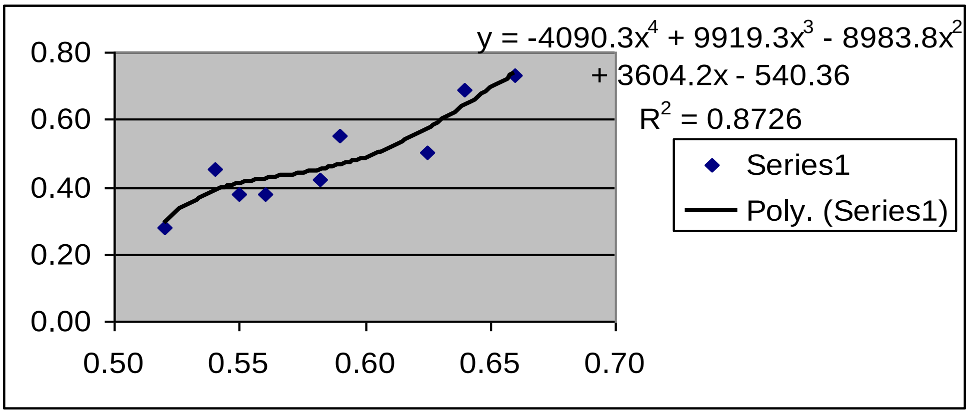

Figure 3. Relationship between average potassium content (%) in leaves of maize plants, and average potassium content in grain (%) during the two seasons.

CONCLUSION

The results of experiments led to conclude that in general, 180 kg/fed nitrogen level accompanied by Single Cross 10 hybrid was the best combination for maize production. Contrary NUE in the 60 kg/fed was the most effective treatments and there were no differences between hybrids in NUE. The regression between NPK% in leaf and grain were strong and it can be used as an indicator to predict the NPK % in grain by use of leaf analysis.

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تأثير مستويات التسميد الآزوتي المضافة مع ماء الري على إنتاجية ثلاث هجن من الذرة الشامية

[٣١]

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١. المعمل المركزي للمناخ الزراعي- مركز البحوث الزراعية- الدقي- الجيزة – مصر

تم إجراء تجربتان حقليتان خلال الموسمين ٢٠٠٤ و٢٠٠٥ بمنطقة البوصيلي محافظة البحيرة بهدف دراسة تأثير ثلاث مستويات من التسميد النتروجيني (٦٠ و١٢٠ و١٨٠ كجم/ فدان أضيفت مع مياه الري باستخدام الري بالتنقيط) على ثلاث هجن من الذرة الشامية (هجين فردى ١٠ وهجين ثلاثي ٣١٠ وهجين ثلاثي ٣٢٤) على النمو الخضري ومحتوى العناصر في الأوراق والحبوب (نتروجين وفوسفور وبوتاسيوم) وكذلك محصول الحبوب والقش. صممت التجربة في قطع منشقة مرة واحدة في ثلاث مكررات حيث وضعت مستويات التسميد في القطع الرئيسية والهجن في القطع الشقية. أشارت أهم النتائج إلى أن زيادة مستوى التسميد النتروجينى إلى ١٨٠ كجم/فدان أدى إلى زيادة ارتفاع النبات وعدد الأوراق للنبات ودليل مساحة الورقة وانعكس ذلك في زيادة المحصول من الحبوب والقش. تفوق هجين فردى ١٠ على باقي الهجن في النمو الخضري و المحصول . كانت كفاءة استخدام النتروجين مرتفعة لمستوى النتروجين ٦٠ كجم / فدان عن باقي المعاملات. أظهرت دراسة العلاقة بين محتوى الورقة من النتروجين والفوسفور والبوتاسيوم مع نفس المحتوى من الحبوب أن هناك علاقة طرديه قوية بين محتوى الورقة والحبوب من العناصر وكانت أقوى علاقة مع عنصر النتروجين بمربع معامل ارتباط = ٠,٩٦٥ تلا ذلك عنصر البوتاسيوم بمربع معامل ارتباط = ٠,٩٣٦ ثم الفوسفور بمربع معامل ارتباط = ٠,٨٧٢.

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