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RESPONSE OF MAIZE AND ASSOCIATED WEEDS TO IRRIGATION INTERVALS, WEED MANAGEMENT AND NITROGEN FORMS

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ABSTRACT

Two field experiments were conducted during the 2005 and 2006 growing seasons at the Experimental Farm of the National Research Centre at Shalakan, Kalubia Governorate, Egypt, to study the response of maize yield and its components and associated weeds to two irrigation intervals (every 2 and 3 weeks), three weed management treatments (metribuzin herbicide, hoeing twice at 25 and 40 days from sowing and weedy check) and four N forms (ammonium sulfate, ammonium nitrate, urea and calcium nitrate).

Results showed that irrigation every 2 weeks significantly decreased grassy and total weeds and NK uptake by weeds. Providing maize plants by irrigation every 2 weeks significantly increased chlorophyll ***a*** leaf content, yield and its components, grain P content and protein yield/fed. Hoeing twice was more effective than metribuzin herbicide for controlling grassy and total weeds and lowering N, P and K uptake by weeds. Application of metribuzin markedly increased chlorophyll ***a*** leaf content, while hoeing twice was the effective treatment for increasing yield and its components, except ear diameter, and enhanced grain N content, protein % and protein yield/fed.

Calcium nitrate significantly decreased dry weight of grassy and total weeds and NK uptake by weeds. Adding ammonium nitrate markedly increased chlorophyll ***a*** leaf content, number of rows/ear, 100-kernel weight and grain yield/fed. Irrigation every 2 weeks with metribuzin treatment gave the maximum values of 100-kernel weight, ear yield and grain yield /fed when ammonium nitrate as nitrogen form was used.
Keywords: Maize, Weeds, Irrigation, Nitrogen

INTRODUCTION

In Egypt, maize is considered as one of the most important strategic cereal crops. The local production declined under self sufficiency level, resulting some serious problems. To overcome such deficiency, production per unit area must be maximized through good achievement of some agricultural practices, including irrigation, weed management and nitrogen fertilization .

Water is often primary limiting factor for maize production. Previous studies indicated that prolonging irrigation intervals led to decreased growth, yield and yield components of maize (Ibrahim *et al*., 1992; Atta-Allah, 1996 and Abd EL-Maksoud *et al*., 2008). EL-Marsafawy (1995) found that prolonging irrigation intervals produced shorter plants, lower number of leaves/plant, leaf area index and number of kernels/ear. Mahfouz (2003) reported that water stress treatment (irrigation every 25 days) caused significant reduction in growth parameters, yield and its components of maize.

Weeds are considered as a major problem in maize fields. They cause serious reduction in productivity. The reduction in maize yield due to weed competition reached 66-90 % (Dalley *et al*., 2006 and Abouziena *et al*., 2007). Several researchers have been reported that application of two hand hoeings significantly decreased weed growth and improved the growth, yield and its components of maize (Sharara *et al*., 2005; Abd EL-Lattief and Fakkar, 2006 and EL-Metwally *et al*., 2006). Krausz *et al*. (2003) stated that metribuzin herbicide controlled mouser chickweed and henbit by 100 and 97 %, respectively. EL-Metwally *et al*. (2006) found that application of metribuzin gave the best control of weeds and increased maize yield up to 74.52 % over the control.

Ammonium slfate, ammonium nitrate, urea and calcium nitrate are common used as N sources in Egyptian corn cultivation. Thus, the evaluation of these forms to choose the best of them with regard to their effect on maize productivity is of paramount importance. Plants supplied mixed N nutrition may expend less total energy than those supplied all NO_3^- because assimilation NH_4^+ requires one third as many ATP equivalent as dose NO_3^- (Salsac *et al*., 1987). But the previous researches did not exactly determine what is the favorable N form for maize. In this regard, Hassan *et al.* (1993) showed that no significance in ear length, number of rows/ear, zor ammonium nitrate. While, Hammam (1995) found that ammonium nitrate or urea showed favorable effect in improving yield components as compared with calcium nitrate. Also, Abd EL-Hameed (2005) reported that ammonium nitrate increased grain and biological yields as compared with using ammonium sulfate or urea.

The objective of this investigation was to study the effect of irrigation intervals, weed management treatments and nitrogen forms on maize and associated weeds.

MATERIALS AND METHODS

Two field experiments were conducted during the 2005 and 2006 growing seasons at the Experimental Farm of the National Research Centre at Shalakan, Kalubia Governorate, Egypt, to study the response of maize yield and its components and associated weeds to two irrigation intervals (every 2 and 3 weeks), three weed management treatments (metribuzin herbicide, hoeing twice at 25 and 40 days from sowing, and weedy check) and four N forms (ammonium sulfate, 20 % N {N1}, ammonium nitrate, 33.5 % N {N2}, urea, 46.5 % N {N3} and calcium nitrate, 15 % N {N4}).

Irrigation intervals were performed after the first irrigation. Metribuzin herbicide (Sencor 70 % WP, 4-amino-6-tert-butyl-3-methylthio-1,2,4-triazine-5(4H)-one) at the rate of 0.3 kg/fed was sprayed on the soil surface (pre-emergence) immediately before the sowing irrigation using knapsack sprayer with one nozzle boom and the carrier was 200 L water/fed. Each N form was applied at a rate of 90 kg N/fed at two equal portions before the first and second irrigations.

The experiments were established with split-split plot design using three replicates. The main plots included the two irrigation intervals, while the sub-plots occupied by weed management treatments and the sub-sub plots were devoted to the four nitrogen forms. The experimental unit area was 10.5 m^2, contained 5 ridges (3.0 m length and 0.7 m apart).

The soil texture of the experimental site was clay loam, with 1.1 % organic matter, 0.13 % total nitrogen and pH of 7.5. The preceding crop was wheat in both seasons.

Grains of maize (c.v. 30-K8, single cross) were drilled in one side of ridge in hills 25 cm apart at a rate of 10 kg/fed. The sowing date was May 8^{th} and 12^{th} in the 1^{st} and 2^{nd} seasons, respectively. At 25 days after sowing, plants were thinned to secure one plant/hill followed by the first irrigation. Phosphorus fertilizer in the form of calcium super phosphate, 15.5 % P_2O_5 was applied during the soil preparation at the rate of 100 kg/fed. All other recommended cultural practices were adopted throughout the two seasons.

Measurements:-

Weeds:

Weeds of one square meter from the middle ridge of each experimental unit were hand pulled at the 11^{th} week from sowing, then the biomass of broadleaf, grassy and total weeds expressed in dry weights were estimated. The dry weight was recorded after air drying for 6 days and oven drying at 70° C for 24 hours. Moreover, N, P and K percentages in total weeds were measured as described by Cottenie *et al* . (1982). Then, the uptake of such nutrients was computed by multiplying the element % x dry weight of total weeds.

Maize:

At the 11^{th} week from sowing total chlorophyll content (SPAD value) of the fourth maize leaf from top the plant was determined by Minolta Chlorophyll Meter 502, Soil Plant Analysis Department (SPAD) from Minolta Company. Then, chlorophyll *a* was calculated by transforming the SPAD units to mg/m^2 using the following equation: chlorophyll *a* = 80.05 + 10.4 x [SPAD] according to Monje and Bugbee (1992).

At harvest, ten guarded plants were chosen randomly from each experimental unit to measure plant height, ear length, ear diameter, number of rows /ear, number of kernels/row and 100-kernel weight. Moreover, whole plants of each experimental unit were harvested to estimate ear and grain yields/fed.

Also, N, P and K contents in grains of maize were estimated as described by Cottenie *et al* . (1982). In addition to the calculation of protein % and yield/fed.

Statistical analysis:

All the obtained data from each season were exposed to the proper statistical analysis of variance according to Gomez and Gomez (1984). The combined analysis of variance for the data of the two seasons was performed after testing the error homogeneity and LSD test at 0.05 level of significance was used for the comparison between means.

RESULTS AND DISCUSSION

I- Weeds:

Weed flora presented in the experimental area included common purslane (*Portulaca oleracea* L.) as broadleaf weed as well as barnyardgrass (*Echinochloa colonum* (L.) Link.) and crowfoot grass (*Dactyloctenium aegyptium*, (L.) P. Beauv.) as grassy weeds.

1-Effect of irrigation intervals:

Results in Table 1 indicate that the differences between irrigation every 2 and 3 weeks reached the significance level in dry weight of grasses and total weeds as well as NK uptake by weeds, while dry weight of broadleaf weeds and P uptake were not affected. In this connection, less value was obtained with irrigation every 2 weeks. It could be concluded that increasing irrigation intervals reduced the vegetative growth of maize plants which gave good chance for weeds to grow well under irrigation every 3 weeks.

2-Effect of weed management:

All weeded treatments reduced the dry weight of broadleaf, grassy and total weeds as well as nutrients uptake by weeds than weedy check (Table 1). Hoeing twice was more effective than metribuzin herbicide against grassy and total weeds. While, metribuzin along with hoeing significantly reduced the dry weight of broadleaf weeds as compared to weedy check. Consequently, the less values of N, P and K uptake by weeds were observed with hoeing twice followed by metribuzin. On the contrary, weeds in weedy check plots removed 74.7-306.1, 90-322.2 and 100.8-317.7 % of N, P and k, respectively than weeded treatments. Such results reveal that hand hoeing twice has a wide spectrum for weed elimination than metribuzin. However, metribuzin controls annual broadleaf and some grasses. Also, such herbicide absorbed through roots from soil and translocated to shoots and inhibits photosynthesis resulting in blocking electron transport leading to stopping CO_2 fixation and producing ATP and $NADPH_2$ (WSSA, 1994). Similar findings were reported by Abd EL-lattief and Fakkar (2006), EL-Metwally *et al.* (2006) and Abouziena *et al*. (2007).

3-Effect of nitrogen forms:

The available results show significant differences in dry weight of grassy and total weeds as well as NPK uptake due to nitrogen forms (Table 1). It is obvious that adding calcium nitrate produced the lowest dry weight of grassy and total weeds dry weight and NK uptake, while ammonium sulfate was the effective for decreasing P uptake. Contrarily, using ammonium nitrate gave the highest values in this respect. Similar results were obtained by Smiciklas and Below (1992) and Hussein and EL-Mergawi (1997). Results also indicated that there was no significant effect of nitrogen forms on broadleaf weeds**,** clearing their higher adaptability than grasses under various nitrogenous statuses.

Table 1: Effect of irrigation intervals, weed management and nitrogen forms on weed dry weight and nutrients uptake by weeds.

Trait / Treatment	Weed dry weight (g m^{-2})			Nutrients uptake by weeds (g m^{-2})		
	Broadleaf	**Grassy**	**Total**	**N**	**P**	**K**
Irrigation intervals						
2 weeks	11.2	54.2	65.5	2.49	0.22	3.43
3 weeks	4.9	75.7	80.7	3.19	0.23	4.45
LSD (0.05)	**NS**	**6.6**	**9.2**	**0.45**	**NS**	**0.54**
Weed management						
Metribuzin	2.8	76.7	79.6	2.65	0.20	3.39
Hoeing	6.4	24.3	30.7	1.14	0.09	1.63
Weedy check	14.9	93.6	108.9	4.63	0.38	6.81
LSD (0.05)	**5.4**	**7.8**	**8.1**	**0.40**	**0.02**	**0.51**
Nitrogen forms						
Ammonium sulfate	7.2	64.6	71.8	2.74	0.18	3.95
Ammonium nitrate	8.6	71.7	80.3	3.29	0.26	4.13
Urea	9.4	63.6	73.1	3.08	0.22	4.12
Calcium nitrate	7.1	59.9	67.0	2.25	0.24	3.55
LSD (0.05)	**NS**	**7.2**	**7.6**	**0.33**	**0.02**	**0.44**

4-Interaction effect:

Generally, all possible interactions among irrigation intervals, weed management and nitrogen forms had considerable impacts on dry weight of broadleaf, grassy and total weeds and their NPK uptake as presented in Tables 2 and 3.

a-Irrigation intervals x weed management:

Irrigation every 2 weeks produced the lowest dry matter of grassy weeds when hand hoed twice. Also, irrigation every 3 weeks with either metribuzin or hoeing twice recorded the lowest dry weight of broadleaf and total weeds, respectively. Moreover, the minimal values of N, P and K uptake by weeds were obtained with irrigation every 3 weeks x hoeing twice.

b-Irrigation intervals x nitrogen forms:

Irrigation every 2 weeks with adding calcium nitrate produced the lowest values of grassy and total weeds (Table 2). Using the same form of nitrogen and irrigation every 3 weeks gave the lowest dry weight of broadleaf weeds. Additionally, irrigation every 2 weeks with each of calcium nitrate, ammonium sulfate and ammonium nitrate showed the maximum reductions in N, P and K uptake by weeds, respectively.

c-Weed management x nitrogen forms:

Hoeing twice with calcium nitrate (for grassy and total weeds) and metribuzin with calcium nitrate (for broadleaf weeds) produced the lowest values of dry weight (Table 2). Also, weeds uptake the minimum values of N (with hoeing x calcium nitrate) and PK (with hoeing x ammonium nitrate).

d-Irrigation intervals x weed management x nitrogen forms:

In plots fertilized with calcium nitrate, irrigation every 2 weeks with metribuzin and irrigation every 3 weeks with metribuzin or hoeing were the efficient combinations for decreasing the dry weight of broadleaf weeds (Table 3). Plots hand hoed twice and fertilized with calcium nitrate produced the lowest dry weight of grassy weeds (with irrigation every 2 weeks) and total weeds (with irrigation every 3 weeks). The minimum values of N, P and K uptake by weeds were recorded with irrigation every 3 weeks x hoeing x ammonium nitrate.

Table 2: Effect of the first order interactions between irrigation intervals, weed management and nitrogen forms on maize weed dry weight and nutrients uptake by weeds.

Treatment	Trait	Weed dry weight (g m^{-2})			Nutrients uptake by total weeds (g m^{-2})		
		Broadleaf	Grassy	Total	N	P	K
Irrigation intervals x weed management							
2 weeks	Metribuzin	2.9	69.3	72.2	١,٩٢	٠,١٦	٢,٦٠
	Hoeing	9.8	21.1	31.0	١,٤٢	٠,١٠	١,٦٦
	Weedy check	20.8	72.3	93.2	٤,١٣	٠,٤٠	٦,٠٤
3 weeks	Metribuzin	2.8	84.1	86.9	٣,٣٨	٠,٢٤	٤,١٧
	Hoeing	3.0	27.4	30.4	١,٠٦	٠,٠٩	١,٥٩
	Weedy check	9.1	115.5	124.7	٥,١٤	٠,٣٦	٧,٥٨
LSD (0.05)		٧,٨	١١,٠	١١,٥	٠,٥٦	٠,٠٤	٠,٧٢
Irrigation intervals x nitrogen forms							
2 weeks	N1	8.7	58.4	67.2	٢,٣٥	٠,١٦	٣,٣٣
	N2	11.1	58.2	69.4	٢,٥٢	٠,١٩	٣,١١
	N3	13.2	51.4	64.7	٢,٩٨	٠,٢٣	٣,٨٧
	N4	11.6	49.0	60.6	٢,١٠	٠,٢٩	٣,٤٢
3 weeks	N1	5.6	70.8	76.4	٣,١٣	٠,٢٠	٤,٥٨
	N2	6.0	85.3	91.3	٤,٠٦	٠,٣٣	٥,١٦
	N3	5.7	75.8	81.6	٣,١٩	٠,٢١	٤,٣٧
	N4	2.5	70.8	73.3	٢,٣٩	٠,١٩	٣,٦٨
LSD (0.05)		٥,٤	١٠,٢	١٠,٨	٠,٤٨	٠,٠٣	٠,٦٣
Weed management x nitrogen forms							
Metribuzin	N1	3.6	80.2	83.8	٣,٠٥	٠,١٧	٣,٨٧
	N2	4.4	85.8	90.2	٣,٣٤	٠,٢٦	٣,٩٧
	N3	3.3	66.7	70.0	٢,٧٤	٠,٢١	٣,٦٤
	N4	0.0	74.2	74.2	١,٤٦	٠,١٥	٢,٠٧
Hoeing	N1	8.4	21.8	30.2	١,٠٤	٠,٠٨	١,٢٧
	N2	5.5	18.9	24.5	١,٠٢	٠,٠٧	١,٠٨
	N3	6.0	41.8	47.9	١,٩٢	٠,١٣	٢,٧٠
	N4	5.6	14.6	20.2	٠,٩٦	٠,٠٨	١,٤٥
Weedy check	N1	9.5	91.8	101.4	٤,١٣	٠,٢٩	٦,٧٢
	N2	15.7	110.6	126.3	٥,٥١	٠,٤٤	٧,٣٥
	N3	19.0	82.3	101.4	٤,٥٨	٠,٣١	٦,٠٢
	N4	15.6	90.9	106.6	٤,٣١	٠,٤٩	٧,١٣
LSD (0.05)		٦,٧	١٢,٥	١٣,٣	٠,٥٨	٠,٠٤	٠,٧٧
N1: Ammonium sulfate, N2: Ammonium nitrate, N3: Urea, N4: Calcium nitrate							

II-Maize:

Chlorophyll ***a*** leaf content yield and yield attributes of maize have been estimated under different treatments of irrigation intervals, weed management, nitrogen forms and their interactions as shown in Tables 4, 5 and 6.

1-Effect of irrigation intervals:

Irrigation intervals had a significant effect on chlorophyll ***a*** content, yield and yield attributes of maize (Table 4). In this connection, irrigation every 2 weeks increased significantly chlorophyll ***a*** content, plant height, ear length, ear diameter, number of rows/ear, number of kernels/row, 100-kernel weight, ear yield and grain yield/fed as compared to irrigation every 3 weeks. The increments in the previous characters exceeding irrigation every 3 weeks were 11.5, 12.1, 7.2, 5.6, 1.6, 8.5, 7.3, 24.1, 25.1 %, respectively. Maize is sensitive for the moisture lack (Mahfouz, 2003 and Abdel-Maksoud *et al*., 2008). So, sufficient water by irrigation every 2 weeks may helped the plant to absorb greater amount of water and nutrients enhancing internodes elongation since nutrients encourage cell division and enlargement and meristemic activity. Besides, the beneficial effect of water for improving pigments and photosynthetic process and accumulation of metabolites led to an increase in yield and its components. These results are in harmony with those obtained by Ibrahim *et al*. (1992), Atta-Allah (1996) and Abdel-Maksoud *et al*. (2008).

Table 3: Effect of the second order interaction among irrigation intervals, weed management and nitrogen forms on maize weed dry weight and nutrients uptake by weeds.

Treatment \ Trait			Weed dry weight (g m^{-2})			Nutrients uptake by total weeds (g m^{-2})		
			Broadleaf	**Grassy**	**Total**	**N**	**P**	**K**
2 weeks	**Metribuzin**	N1	4.0	69.2	73.2	٢,١٨	٠,١٦	٢,٤٢
		N2	3.2	74.7	77.9	١,٧٢	٠,١٣	٢,٥٤
		N3	4.4	68.5	72.9	٢,٤٥	٠,٢٢	٣,٥٦
		N4	0.0	64.9	64.9	١,٣٢	٠,١٢	١,٨٩
	Hoeing	N1	10.5	27.3	37.9	١,٠٠	٠,٠٧	١,٢٢
		N2	8.9	15.8	24.7	١,٣٧	٠,٠٨	١,٣٦
		N3	8.6	27.8	36.5	٢,١٠	٠,١٢	٢,٢٣
		N4	11.3	13.6	24.9	1.20	0.09	1.82
	Weedy check	N1	11.5	78.7	90.3	3.87	0.25	6.35
		N2	21.2	84.2	105.5	4.47	0.36	5.43
		N3	26.7	57.8	84.7	4.38	0.35	5.81
		N4	23.6	68.5	92.2	3.78	0.66	6.56
3 weeks	**Metribuzin**	N1	3.1	91.2	94.3	3.92	0.18	5.31
		N2	5.7	96.8	102.5	4.96	0.40	5.40
		N3	2.3	64.8	67.1	3.03	0.21	3.72
		N4	0.0	83.5	83.5	1.60	0.18	2.25
	Hoeing	N1	6.2	16.2	22.5	1.09	0.08	1.32
		N2	2.2	22.0	24.2	0.67	٠,٠٦	٠,٨١
		N3	3.5	55.8	59.4	1.74	٠,١٣	٣,١٦
		N4	0.0	15.5	15.5	0.73	٠,٠٧	١,٠٩
	Weedy check	N1	7.5	104.9	112.5	4.38	٠,٣٤	٧,١٠
		N2	10.1	137.0	147.2	6.54	٠,٥٢	٩,٢٨
		N3	11.3	106.9	118.2	4.79	٠,٢٧	٦,٢٤
		N4	7.7	113.3	121.0	٤,٨٤	٠,٣٢	٧,٧١
LSD (0.05)			**9.4**	**17.7**	**18.7**	٠,٨٣	٠,٠٦	١,٠٩

N1: Ammonium sulfate, N2: Ammonium nitrate, N3: Urea, N4: Calcium nitrate

Table 4: Effect of irrigation intervals, weed management and nitrogen forms on Chlorophyll a content of maize leaf, yield and yield components.

Trait / Treatment	Chlorophyll a content. (mg m^{-1})	Plant height (cm)	Ear traits				100-kernel wt. (g)	Yield (ton fed.$^{-1}$)	
			Length (cm)	Diameter (cm)	Rows No.	Kernels No.row^{-1}		Ear	Grain
Irrigation intervals									
2 weeks	624.9	230.9	18.63	4.69	13.35	44.6	27.9	3.76	3.24
3 weeks	560.5	206.0	17.38	4.44	13.14	41.1	26.0	3.03	2.59
LSD (0.05)	**20.8**	**15.7**	**0.48**	**0.06**	**0.17**	**2.7**	**0.7**	**0.25**	**0.17**
Weed management									
Metribuzin	601.4	222.3	17.88	4.56	13.12	42.7	27.0	3.54	3.06
Hoeing	593.9	227.7	18.42	4.60	13.58	43.6	27.5	3.62	3.10
Weedy check	582.8	205.3	17.70	4.54	13.02	42.2	26.4	3.03	2.59
LSD (0.05)	**12.5**	**11.6**	**0.47**	**NS**	**0.31**	**1.0**	**0.6**	**0.21**	**0.16**
Nitrogen forms									
Ammonium sulfate	596.8	218.1	17.63	4.60	13.19	42.0	27.2	3.35	2.81
Ammonium nitrate	601.1	221.0	18.11	4.59	13.51	42.6	27.3	3.51	3.02
Urea	597.4	219.8	18.12	4.53	13.24	43.4	26.0	3.39	2.87
Calcium nitrate	575.5	214.9	18.15	4.55	13.03	43.4	27.2	3.32	2.97
LSD (0.05)	**14.2**	**NS**	**NS**	**NS**	**0.23**	**NS**	**0.8**	**NS**	**0.17**

2-Effect of weed management:

According to results in Table 4, chlorophyll ***a***, yield and yield components of maize were significantly affected by weed management treatments, except ear diameter. Herein, hoeing twice was superior treatment for increasing ear length and number of rows/ear, Moreover, hoeing and metribuzin treatments were statistically leveled for improving each of chlorophyll ***a*,** plant height, number of kernels/row, 100-kernel weight, ear yield and grain yield /fed. Such enhancements due to weeded treatments might be attributed to their high efficiency in elimination of weeds (Table 1) and consequently, decreased their competitive with maize plants. In addition, the hoeing improves the soil structure, aeration, water penetration and the availability of some nutrients. These results are in good agreement with those reported by (EL-Metwally *et al.* (2001); Sharara *et al*. (2005) and Ahmed *et al*. (2008).

3-Effect of nitrogen forms:

Results in Table 4 reveal that nitrogen forms had marked effects on chlorophyll *a*, number of rows/ear, 100-kernel weight and grain yield/fed. It is obvious that addition of nitrogen in the form of ammonium nitrate produced the highest values of the aforementioned traits. Contrarily, calcium nitrate (for chlorophyll *a* and number of rows/ear), urea (for 100-kernel weight) and ammonium sulfate (for grain yield/fed) gave the lowest values. Lewis *et al.* (1982) reported that the assimilatory activities for NH_4^+ in roots plus NO_3^- in leaves appear to be greater for the NH_4^+ + NO_3^- treatments together than each of NH_4^+ or NO_3^- alone. Gentry and Below (1993) found that maize plants provided with NH_4^+ and NO_3^- gave higher dry matter and grain yield than plants received NO_3^- only. Also, ammonium nitrate possessed the highest value of maize grain yield as compared to calcium nitrate (Hammam, 1995) and ammonium sulfate and urea (Abd EL-Hameed, 2005). Herein, suitable N form which favor maize crop is also necessary for weeds as mentioned before (Table 1), so it is important to emphasize that the placement of N fertilizer neighboring maize plant is significance.

4-Interaction effect:

Chlorophyll ***a*** content of maize leaf, yield and its attributes were substantially responded to all types of interactions among the three studied factors (Tables 5 and 6), except ear diameter with the interaction between weed management x nitrogen forms.

Table 5: Effect of the first order interactions between irrigation intervals, weed management and nitrogen forms on Chlorophyll a content of maize leaf, yield and yield components.

Treatment \ Trait		Chlorophyll *a* content (mg m^{-1})	Plant height (cm)	Ear traits				100-kernel wt. (g)	Yield (ton fed^{-1})	
				Length (cm)	Diameter (cm)	Rows No.	Kernels No.row^{-1}		Ear	Grain
Irrigation intervals x weed management										
2 weeks	Metribuzin	635.9	234.5	18.68	4.70	13.36	45.4	28.3	4.10	3.53
	Hoeing	621.9	241.9	18.82	4.73	13.70	44.1	28.0	3.85	3.29
	Weedy check	616.8	216.2	18.39	4.65	12.98	44.3	27.5	3.33	2.91
3 weeks	Metribuzin	566.8	210.1	17.08	4.42	12.89	40.1	25.7	3.98	2.58
	Hoeing	565.8	213.5	18.03	4.47	13.46	43.1	27.0	3.38	2.92
	Weedy check	548.7	194.4	17.02	4.44	13.06	40.1	25.4	2.72	2.27
LSD (0.05)		**17.7**	**16.5**	**0.67**	**0.13**	**0.45**	**1.5**	**0.9**	**0.30**	**0.23**
Irrigation intervals x nitrogen forms										
2 weeks	N1	630.1	228.9	18.20	4.72	13.15	43.2	28.6	3.64	3.07
	N2	624.1	237.4	18.46	4.71	13.65	43.5	28.5	3.84	3.32
	N3	622.9	231.4	18.78	4.62	13.28	45.7	26.9	3.68	3.08
	N4	622.4	225.7	19.08	4.71	13.30	45.9	27.8	3.88	3.49
3 weeks	N1	563.4	207.3	17.06	4.47	13.23	40.7	25.9	3.05	2.55
	N2	578.0	204.6	17.76	4.47	13.36	41.7	26.1	3.19	2.72
	N3	571.8	208.1	17.47	4.45	13.19	41.1	25.1	3.10	2.65
	N4	528.6	204.1	17.22	4.39	12.76	40.9	26.9	2.77	2.45
LSD (0.05)		**20.2**	**12.2**	**0.63**	**0.09**	**0.33**	**1.8**	**1.2**	**0.26**	**0.24**
Weed management x nitrogen forms										
Metribuzin	N1	606.7	224.5	17.91	4.60	13.23	43.0	27.4	3.49	2.86
	N2	590.8	222.3	18.22	4.63	13.46	42.8	27.8	3.74	3.26
	N3	613.7	223.7	17.87	4.55	13.31	43.3	25.5	3.59	3.14
	N4	594.4	218.7	17.52	4.46	12.50	41.8	27.4	3.33	2.95
Hoeing	N1	614.9	226.2	18.31	4.60	13.43	43.9	28.2	3.89	3.28
	N2	596.8	225.3	18.60	4.62	13.66	43.2	27.2	3.66	3.21
	N3	575.3	231.9	18.34	4.54	13.52	43.4	26.7	3.48	2.86
	N4	588.5	227.3	18.45	4.65	13.70	43.9	28.0	3.43	3.06
Weedy check	N1	568.7	203.5	16.65	4.59	12.91	39.0	26.2	2.65	2.28
	N2	615.6	215.3	17.52	4.53	13.40	41.7	26.9	3.15	2.60
	N3	603.2	203.7	18.16	4.51	12.88	43.6	25.9	3.09	2.59
	N4	543.6	198.7	18.48	4.55	12.90	44.4	26.7	3.22	2.89
LSD (0.05)		**24.7**	**14.9**	**0.77**	**NS**	**0.41**	**2.3**	**1.4**	**0.32**	**0.29**
N1: Ammonium sulfate, N2: Ammonium nitrate, N3: Urea, N4: Calcium nitrate										

a-Irrigation intervals x weed management:

Results indicate that irrigation every 2 weeks with pre-emergence application of metribuzin gave the highest chlorophyll ***a*** content, number of kernels/row, 100-kernel weight, ear yield and grain yield/fed. Also, irrigation every 2 weeks with hoeing twice produced the highest values of plant height, ear length, ear diameter and number of rows/ear (Table 5).

b-Irrigation intervals x nitrogen forms:

Results in Table 5 clearly show that irrigation every 2 weeks with application of ammonium sulfate produced the maximum values of chlorophyll ***a***, ear diameter and 100-kernel weight. While, irrigation every 2 weeks with ammonium nitrate gave the maximum values of plant height and number of rows/ear. Using calcium nitrate with irrigation every 2 weeks achieved the highest values of ear length, number of kernels/row, ear yield and grain yield/fed.

Table 6: Effect of the second order interaction among irrigation intervals, weed management and nitrogen forms on Chlorophyll a content of maize leaf, yield and yield components.

Treatment (Trait)			Chlorophyll *a* content (mg m^{-1})	Plant height (cm)	Ear traits				100-kernel wt. (g)	Yield (ton fed^{-1})	
					Length (cm)	Diameter (cm)	Rows No.	Kernels No.row^{-1}		Ear	Grain
2 weeks	Metribuzin	N1	624.2	236.3	18.41	4.71	13.20	44.5	29.2	3.84	3.07
		N2	615.4	234.5	18.86	4.78	14.00	45.7	29.2	4.34	3.78
		N3	649.7	234.0	18.53	4.66	13.36	45.6	25.6	4.08	3.58
		N4	654.4	233.3	18.91	4.65	12.90	45.7	29.3	4.13	3.69
	Hoeing	N1	636.3	236.1	18.30	4.75	13.46	43.0	28.1	3.92	3.40
		N2	616.9	246.6	18.91	4.71	13.80	43.1	29.0	3.76	3.26
		N3	625.5	253.8	18.93	4.61	13.43	45.3	27.1	3.70	2.89
		N4	609.0	231.0	19.13	4.85	14.10	45.1	27.9	4.02	3.60
	Weedy check	N1	629.8	214.5	17.88	4.71	12.80	42.2	28.4	3.16	2.74
		N2	640.0	231.2	17.61	4.65	13.16	41.8	27.3	3.42	2.94
		N3	593.6	206.5	18.88	4.58	13.06	46.3	28.0	3.25	2.78
		N4	603.9	212.7	19.20	4.65	12.90	46.8	26.3	3.49	3.18
3 weeks	Metribuzin	N1	589.2	212.8	17.41	4.50	13.26	41.6	25.6	3.15	2.66
		N2	566.1	210.2	17.58	4.48	12.93	39.9	26.3	3.14	2.75
		N3	577.6	213.5	17.21	4.43	13.26	41.0	25.4	3.11	2.71
		N4	534.4	204.0	16.13	4.28	12.10	37.8	25.5	2.53	2.22
	Hoeing	N1	593.5	216.4	18.33	4.45	13.40	44.9	28.2	3.87	3.16
		N2	576.7	204.1	18.28	4.53	13.53	43.4	25.4	3.56	3.17
		N3	525.0	210.0	17.75	4.46	13.61	41.4	26.2	3.26	2.83
		N4	568.1	223.5	17.78	4.45	13.30	42.7	28.1	2.84	2.53
	Weedy check	N1	507.6	192.6	15.43	4.46	13.03	35.7	24.0	2.14	1.82
		N2	591.2	199.5	17.43	4.41	13.63	41.7	26.5	2.88	2.25
		N3	612.7	200.8	17.45	4.45	12.70	40.8	23.9	2.93	2.41
		N4	483.4	184.8	17.76	4.45	12.90	42.1	27.1	2.94	2.60
LSD (0.05)			**34.9**	**21.1**	**1.09**	**0.17**	**0.58**	**3.2**	**2.0**	**0.46**	**0.42**

N1: Ammonium sulfate, N2: Ammonium nitrate, N3: Urea, N4: Calcium nitrate

c-Nitrogen forms x weed management:

Available data in Table 5 illustrate that weedy check with either ammonium nitrate (for chlorophyll ***a***) or calcium nitrate (for number of kernels/row) produced the maximum values. Maize plants hoed twice possessed the highest increases for plant height (with urea), ear length (with ammonium nitrate), number of rows/ear (with calcium nitrate) as well as 100-kernel, ear yield and grain yield/fed (with ammonium sulfate).

d-Irrigation intervals x weed management x nitrogen forms:

The second order interaction among the three tested factors clearly showed the beneficial effects of weed management and nitrogen forms on chlorophyll ***a***, yield and yield attributes under shortening irrigation interval (Table 6). Plots irrigated every 2 weeks secured the highest values of chlorophyll ***a*** and 100-kernel (with metribuzin x calcium nitrate); plant height (with hoeing x urea); ear length and number of kernels/row (with weedy check x calcium nitrate); ear diameter and number of rows/ear (with hoeing x calcium nitrate) as well as ear and grain yields/fed (with metribuzin x ammonium nitrate).

III-Maize grains chemical composition:

Considerable effects of irrigation intervals on grain P content and protein yield/fed as well as weed management on grain N content, protein % and protein yield/fed were obtained in Table 7. In this respect, irrigation every 2 weeks and hoeing twice recorded the highest values of such traits, respectively. Shortening irrigation interval increased protein yield of maize (Ashoub *et al.,* 1998). Weeded treatments showed enhancements in protein % and N uptake for maize (Sinha *et al*., 2005 and Ahmed *et al*., 2008). Moreover, nitrogen forms had no significant effect on all grain chemical composition traits.

Table 7: Effect of irrigation intervals, weed management and nitrogen forms on grain nutrients and protein % and protein yield of maize.

Trait / Treatment	*Grain nutrients %*			*Protein*	
	N	**P**	**K**	**%**	**Yield (kg/fed)**
Irrigation intervals					
2 weeks	1.27	0.17	0.27	7.95	258.4
3 weeks	1.13	0.13	0.28	7.05	184.7
LSD (0.05)	**NS**	**0.01**	**NS**	**NS**	**27.2**
Weed management					
Metribuzin	1.19	0.11	0.24	7.43	228.6
Hoeing	1.33	0.15	0.29	8.31	258.1
Weedy check	1.08	0.18	0.29	6.76	177.8
LSD (0.05)	**0.14**	**NS**	**NS**	**0.89**	**28.9**
Nitrogen forms					
Ammonium sulfate	1.30	0.18	0.31	8.15	235.8
Ammonium nitrate	1.16	0.14	0.26	7.26	225.3
Urea	1.17	0.14	0.26	7.31	210.1
Calcium nitrate	1.16	0.13	0.28	7.27	215.0
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**

With the exception of irrigation intervals x weed management(for P and K contains)all maize grain chemical composition criteria were markedly affected by the first order interactions (Table 8) and the second order one (Table 9) among irrigation intervals, weed management and nitrogen forms.

In plots irrigated every 2 weeks, hoeing twice (for grain N content and protein %) as well as metribuzin (for protein yield/fed) produced the maximum values (Table 8).

Irrigation every 2 weeks with adding ammonium sulfate recorded the highest values of all studied traits of grain chemical composition (Table 8).

Hoeing x ammonium sulfate was the more efficient interaction for enhancing grain N content, protein % and protein yield/fed. While, weedy check x urea and metribuzin x ammonium sulfate gave the maximum grain P and K contents, respectively (Table 8).

Table 8: Effect of the first order interactions between irrigation intervals, weed management and nitrogen forms on grain nutrients and protein % and protein yield of maize.

Treatment \ Trait		Grain nutrients %			Protein	
		N	P	K	%	Yield (kg/fed)
Irrigation intervals x weed management						
2 weeks	Metribuzin	١,٢٥	٠,١٠	٠,٢١	٧,٨٤	٢٧٦,٩
	Hoeing	١,٣٤	٠,٢٢	٠,٣١	٨,٣٧	٢٧٥,١
	Weedy check	١,٢٢	٠,٢١	٠,٣٠	٧,٦٣	٢٢٣,١
3 weeks	Metribuzin	١,١٢	٠,١٢	٠,٢٧	٧,٠٢	١٨٠,٣
	Hoeing	١,٣٢	٠,١٠	٠,٢٧	٨,٢٦	٢٤١,١
	Weedy check	٠,٩٤	٠,١٦	٠,٢٩	٥,٨٨	١٣٢,٦
LSD (0.05)		**٠,٢**	**NS**	**NS**	**1.26**	**40.9**
Irrigation intervals x nitrogen forms						
2 weeks	N1	١,٤٥	٠,٢٦	٠,٣٤	٩,٠٥	٢٨١,٦
	N2	١,٣٠	٠,١٤	٠,٢٣	٨,١٦	٢٧٥,٠
	N3	١,١٤	٠,١٤	٠,٢٤	٧,١٣	٢١٩,١
	N4	١,١٩	٠,١٥	٠,٢٨	٧,٤٥	٢٥٧,٨
3 weeks	N1	١,١٦	٠,١٠	٠,٢٧	٧,٢٦	١٩٠,٠
	N2	١,٠٢	٠,١٣	٠,٢٩	٦,٣٧	١٧٥,٦
	N3	١,٢٠	٠,١٥	٠,٢٧	٧,٥٠	٢٠١,٠
	N4	١,١٣	٠,١٢	٠,٢٨	٧,٠٩	١٧٢,٢
LSD (0.05)		**٠,٢٧**	**٠,٠٧**	**٠,٠٧**	**١,٦٧**	**٥٣,٤**
Weed management x nitrogen forms						
Metribuzin	١N	١,١٥	٠,٢١	٠,٣٣	٧,١٨	٢٠٧,٧
	N2	١,٣١	٠,٠٥	٠,١٩	٨,٢١	٢٧٤,٨
	N3	١,٠٨	٠,٠٤	٠,١٩	٦,٧٩	٢١٣,٦
	N4	١,٢٠	٠,١٤	٠,٢٧	٧,٥٤	٢١٨,٤
Hoeing	N1	١,٦٢	٠,١٧	٠,٣١	١٠,١	٣٣٣,٩
	N2	١,١٧	٠,١٧	٠,٢٧	٧,٣٥	٢٣٦,٧
	N3	١,٣٩	٠,١٦	٠,٢٩	٨,٧١	٢٤٨,٧
	N4	١,١٣	٠,١٣	٠,٢٨	٧,٠٥	٢١٣,٢
Weedy check	N1	١,١٤	٠,١٧	٠,٢٨	٧,١٥	١٦٥,٨
	N2	٠,٩٩	٠,١٩	٠,٣٢	٦,٢٣	١٦٤,٤
	N3	١,٠٣	٠,٢٤	٠,٢٨	٦,٤٤	١٦٧,٩
	N4	١,٥٥	٠,١٤	٠,٣٠	٧,٢١	٢١٣,٣
LSD (0.05)		**٠,٣٣**	**٠,٠٩**	**٠,٠٩**	**٢,٠٥**	**٦٥,٤**
N1: Ammonium sulfate, N2: Ammonium nitrate, N3: Urea, N4: Calcium nitrate						

Concerning the second order interaction, i.e. irrigation intervals, weed management and nitrogen forms, irrigation every 2 weeks x hoeing twice x ammonium sulfate achieved the maximum grain N and P contents, protein %

and protein yield/fed. Moreover, irrigation every 3 weeks x weedy check x ammonium nitrate showed the highest grain K content value (Table 9).

Eventually, it could be concluded that applying irrigation every 2 weeks and pre-emergence application metribuzin for maize plants fertilized with ammonium nitrate was the best combination for enhancing yield and its attributes.

Table 9: Effect of the second order interaction among irrigation intervals, weed management and nitrogen forms on grain nutrients and protein % and protein yield of maize.

Treatment		Trait	Grain nutrients % N	P	K	Protein %	Yield (kg/fed)
2 weeks	Metribuzin	N1	1.30	0.24	0.32	8.12	249.2
		N2	1.52	0.09	0.21	9.50	359.1
		N3	1.09	0.04	0.17	6.81	243.7
		N4	1.11	0.06	0.17	6.93	255.8
	Hoeing	N1	1.80	0.28	0.36	11.2	382.8
		N2	1.27	0.21	0.27	7.93	258.5
		N3	1.25	0.13	0.23	7.80	225.5
		N4	1.04	0.22	0.37	6.49	233.7
	Weedy check	N1	1.24	0.27	0.35	7.77	212.9
		N2	1.13	0.14	0.22	7.06	207.5
		N3	1.08	0.25	0.32	6.77	188.3
		N4	1.43	0.17	0.32	8.93	283.9
3 weeks	Metribuzin	N1	1.00	0.19	0.35	6.25	166.2
		N2	1.11	0.02	0.17	6.93	190.5
		N3	1.08	0.05	0.22	6.77	183.5
		N4	1.30	0.22	0.37	8.15	181.0
	Hoeing	N1	1.44	0.06	0.27	9.02	285.1
		N2	1.08	0.13	0.28	6.78	214.9
		N3	1.54	0.18	0.36	9.61	272.0
		N4	1.22	0.04	0.19	7.62	192.7
	Weedy check	N1	1.04	0.06	0.21	6.52	118.7
		N2	0.86	0.25	0.42	5.40	121.4
		N3	0.98	0.22	0.25	6.12	147.4
		N4	0.88	0.12	0.28	5.49	142.8
LSD (0.05)			**0.46**	**0.13**	**0.13**	**2.90**	**92.4**

N1: Ammonium sulfate, N2: Ammonium nitrate, N3: Urea, N4: Calcium nitrate

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استجابة الذرة الشامية و الحشائش المصاحبة لفترات الري و مكافحة الحشائش و صور النيتروجين

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***** قسم الأراضى واستغلال المياة - المركز القومي للبحوث - الدقي - القاهرة - مصر.**

أقيمت تجربتان حقليتان خلال موسمي ٢٠٠٥ و٢٠٠٦ بمحطة تجارب المركز القومي للبحوث بشلقان محافظة القليوبية بهدف دراسة تأثير فترات الري (كل ٢ و ٣ أسابيع) و معاملات مكافحة الحشائش (ميتربيوزين، عزيق يدوي مرتين و المقارنة) و كذلك صور التسميد النيتروجيني (سلفات الأمونيوم، نيترات الآمونيوم، يوريا و نيترات الكالسيوم) و التفاعل بينهم على المحصول و مكوناته للذرة الشامية و الحشائش المصاحبة لها.

أوضحت النتائج أن الري كل أسبوعين كان له تأثير جوهرى في إنقاص الوزن الجاف للحشائش النجيلية و الحشائش الكلية و كذلك كمية النيتروجين و البوتاسيوم الممتصة بواسطة الحشائش. كما أدى ري نباتات الذرة الشامية كل أسبوعين إلى إحداث زيادة جوهرية في محتوى الأوراق من الكلوروفيل و زيادة المحصول و مكوناته و زيادة محتوى الحبوب من الفوسفور و محصول البروتين /فدان.

أظهرت النتائج أن العزيق مرتين كان أكثر كفاءة في خفض أوزان الحشائش النجيلية و الحشائش الكلية و كذلك كمية النيتروجين و الفوسفورالممتصة بواسطة الحشائش مقارنة بالميتربيوزين. أحدث الميتربيوزين زيادة معنوية في المحتوى الكلوروفيللي للأوراق، بينما كان للعزيق مرتين أفضل الأثر فى زيادة المحصول ومكوناته معنويا عدا صفة قطر الكوز، كما أدى الى زيادة محتوى الحبوب من النيتروجين و نسبة البروتين و محصول البروتين /فدان .

أدى استخدام نيترات الكالسيوم الى نقص جوهرى في الوزن الجاف للحشائش النجيلية و الحشائش الكلية و كمية النيتروجين و البوتاسيوم الممتصة بواسطة الحشائش. كان لنيترات الآمونيوم تأثير جيد فى احداث زيادة معنوية في المحتوى الكلوروفيللي للأوراق و عدد السطور بالكوز و وزن ١٠٠ حبة و محصول الكيزان و الحبوب / فدان.

كان للتفاعل بين العوامل تحت الدراسة تأثير معنوي على نمو الحشائش ومحصول الذرة ومكوناته. و يمكن التوصية بأن الرى كل أسبوعين ومكافحة الحشائش كيماويا بإستخدام مبيد الميتربيوزين مع تسميد الذرة بنيترات الآمونيوم هى أفضل التوافقات حيث حققت أعلى محصول حبوب / فدان.