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EFFECT OF IRRIGATION INTERVALS, NITROGEN RATES AND SPRAYING WITH ZINC ON YIELD AND AGRONOMIC EFFICIENCY OF NITROGEN IN MAIZE

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ABSTRACT

Two field experiments were conducted at the Experimental Research Center of the Faculty of Agriculture at Moshtohor, during 2003 and 2004 seasons to asses the effect of three irrigation intervals i.e. every 10, 15 and 20 days, four nitrogen (N) rates i.e. control, 50, 100 and 150 kg N/fed and two spraying treatments with zinc (Zn) i.e. tap water (control) and 0.05 % Zn EDTA, 14% Zn (70 mg Zn/L) as well as their interactions on yield, uptake and agronomic efficiency of N in maize

The obtained results could be summarized as follows:-

Irrigation every 20-day recorded the lowest values of plant and ear height, ear length and diameter, No. of rows/ear, No. of grains/row, ear weight, grain yield/ear, shelling %, 100-grain weight, grain yield/fed, grain protein content (GPC), N uptake, agronomic N efficiency (AE_N) and apparent N recovery (AR_N).

The greatest values of all studied characters in both seasons were obtained by 150 kg N/fed, meanwhile, AE_N and AR_N decreased with increasing N application rates in both seasons. However, the difference between 100 and 150 kg N/fed on ear weight, grain yield/ear, shelling %, grain yield/fed and grain protein content were not significant.

Zinc application as foliar spray led to significant increase in the previous characteristics of yield , yield components, GPC, N uptake and AR_N. While, Zn showed insignificant effect on AE_N in both seasons.

Key words: Maize, irrigation, N rates, Zn , N uptake, N efficiency and N recovery

INTRODUCTION

Maize (*Zea mays,* L.) is one of the most important cereal crops in the world and in Egypt. It ranks the third position among the world cereal crops, surpassed only by wheat and rice. It is still a major traditional food and feed crop in many regions; Furthermore, the grain is a key industrial raw material for very diverse purposes.

Therefore, efforts are being focused on increasing the productivity of maize crop by growing high yielding varieties under the most favorable cultural treatments.

Irrigation is one of the most important factors which has always played the greatest role in maize production, that determines growth, availability of plant nutrients and ultimately crop yield. In this connection, Salem, (1993) showed that irrigation every 12 days increased ear length, 100- grain weight and grain yield/fed compared to irrigation every 18 days. Mokadem and Salem (1994) found that plant height, 100- grain weight and grain yield/fed were significantly increased with decreasing irrigation intervals from 20 days up to 10 days. Prolonging irrigation interval for maize cultivars from 12 to 17 days during vegetative growth stage, reduced significantly plant height, 100- grain weight, grain yield/fed and protein content of grain (Ashoub *et al.* 1998). Hamed (2003) using three irrigation intervals i.e. 15, 20 and 25 days indicated that decreased irrigation intervals lower than 25 days resulted in marked increments in ear length, ear diameter, number of rows/ear, grain and protein yields/fed. The improvement in maize yield and its components by decreasing irrigation intervals may be due to supplying the plants with adequate water required for growth demands, which reflected on yield and its components.

Nitrogen fertilization is an important factor for maximizing maize yield. Efficient use of N fertilizer for maize production is essential to maximize economic return to the grower, to minimize the potential impact on water quality, and to reduce the total energy required for manufacture of N. Several investigators reported positive effect of nitrogen application in enhancing growth characters of maize, dry matter content, grain yield, yield components and grain quality. Ma *et al.* (1999) using 100 and 200 kg N /ha indicated that increasing N fertilizer rates increased the grain yield by an average of 20 % and nitrogen use efficiency (NUE) by an average 17.5 %. Zaghloul (1999) and El-Gizawy (2000) found that application of 150 kg N /fed significantly increased plant height, ear height, stem diameter, ear length, ear diameter, number of kernels /row, number of row /ear , ear weight, kernels weight /ear, grain yield /plant, 100- grain weight, shelling %, grain, straw and biological yields/fed. However, the differences between 100 and 150 kg N /fed levels on most characters were not significant. Application of 150 kg N /fed gave the lowest values of N agronomic efficiency (AE_N) and N recovery in grain.

In the last two decades, several investigators reported appropriate response of different field crops for micronutrients fertilization in Egypt. This is mainly due to the construction of the High Dam at Aswan, which prevents a lot amount of micronutrients to reach the valley and the Delta. El-Sheikh (1993) reported that foliar application with Zn up to 42 ppm significantly increased plant height, 100- grain weight and grain yield/fed. Ashoub *et al.* (1996) indicated that zinc application as foliar spray resulted insignificant increases in ear length, ear diameter, number of grains/row, weight of 100 grains, shelling % and grain yield/fed This study was undertaken to investigate the effect of irrigation intervals, N rates and spraying with Zn on yield, uptake and agronomic N efficiency in maize.

MATERIALS AND METHODS

Two field experiments were carried out in the Agricultural Research and Experimental Center, Faculty of Agriculture at Moshtohor, Kalubia Governorate, Banha University, during 2003 and 2004 seasons. The aim was to assess the effect of irrigation intervals, N rates and spraying with Zn on yield, uptake and agronomic N efficiency in maize.

Experimental soil test and field information.

The soil was clay having an alkaline reaction. Results of soil test data from samples collected before treatments application are reported in Table 1, and the preceding crop was clover in both seasons.

Table 1. Experimental soil test

1-Physical analysis	
Sand (%)	25.0
Silt (%)	19.9
Clay (%)	55.1
Texture	clay
2- Chemical analysis	
E.C.(of saturated paste extract d Sm^{-1})*	1.30
pH (1:2.5 soil water suspension)	7.91
Organic matter (%)	1.98
$CaCO_3$ (%)	2.89
Available nutrients (mg $kg)^{-1}$	
N (Nitrate-N) KCl- extractable	16.30
P ($NaHCO_3$- extractable)	10.20
K (neutral NH_4- acetate extractable)	254.00
Zn (DTPA- extractable)	2.00

* E.C.: Electric conductivity measured as d Sm^{-1} " decissiemens /m, i.e. mmhos/ cm /25 ^{0}C ".

Each experimental included 24 treatments which were the combination of three irrigation intervals (every 10, 15 and 20 days), four N rates (0, 50, 100 and 150 kg N/fed) and two spraying treatments with Zn (tap water and 0.05% Zn EDTA ,14%Zn).

Ammonium nitrate (NH_4 NO_3-33.5 N%) was used as the nitrogen source in both seasons, which was applied in two equal doses, before the 1^{st} and 2^{nd} irrigation.

Zinc chelate (organic material) was used in the form of Ethylene Diamine Tetra Acetic Acid (EDTA) spraying was carried out only once, 35 days after sowing at the rate of 400 L/fed (*using hand sprayer 1 L.*).

Treatments were replicated four times in the split split-plot in a randomized complete block design. The three irrigation intervals were allocated to the main plots, the four N levels were randomly distributed in the sub- plots, while the two Zn level were allocated at random to the sub-sub plots. Plot size was 10.5 m^2 (3 x 3.5) having 5 ridges of 3 m in length and 0.7 m in width. Maize cv. S.C.122 was planted on 5^{th} June in 2003 and 2004 growing seasons. Phosphorus fertilizer was added before seeding during land preparation as Calcium super phosphate (15.5 % P_2O_5) at the rate of 150 kg /fed. Three kernels were hand drilled in each hill at 30 cm spacing. Thinning to one plant/hill before the first irrigation was practiced to give the population density of 20000 plants/fed. The plots were hand hoed twice for controlling weeds before the first and second irrigation. Soil test results indicated that levels for pH and K were within the optimal ranges for maize production. Therefore, no additional soil amendments were applied throughout the duration of the study. The other recommended agronomic practices of growing maize were applied in the manner prevailing in the region.

At harvest time, plant and ear height (cm) were measured as average of 10 plants.:

Also, 10 ears were taken at random from each sub sub-plot in four replications from inner ridges to record the following data:

1- Ear length (cm).
2- Ear diameter (cm)
3- Number of rows /ear
4- Number of kernels / row
5- Ear weight (g)
6- Grain yield / ear (g)
7- 100-kernel weight estimated as the average of four measurements
8- Shelling percentage % = (Grain weight / Ear weight) x100
9- Grain yield (ardab /fed.) was recorded on whole plot basis and adjusted to 15.5 % moisture content.
10- Grain protein content (GPC %) was reported as N% X 6.25 on dry weight basis (N % in grain was determined by the microkjeldahl method according to A.O.A.C. 1990).
11- Grain nitrogen uptake per unit area was obtained as a product of grain N content and grain yield per unit area (kg /fed).
12- Agronomic efficiency of Nitrogen fertilizer (AE_N)
    AE_N is defined as kg grain yield increase/ kg N applied
    AE_N - (Grain yield F – Grain yield C)/Fertilizer N applied
13- Apparent N recovery in grains (AR_N)
    AR_N is defined as grain N uptake per unit of N supply
    AR_N = (N uptake F – N uptake C)/Fertilizer N applied x 100

Where F = Fertilized plots, and C = non-fertilized plots (control).

These characters (12 & 13) were calculated according to Craswall and Godwin (1984)

Statistical analysis:

Data were statistically analyzed according to Gomez and Gomez (1983) using the MSTAT-C Statistical Software package (Michigan State University, 1983). Where the F- test showed significant differences among means Least Significant Differences (LSD) test was performed at the 0.05 level of probability to separate means.

RESULTS AND DISCUSSION

1- Effect of irrigation intervals:

Results in Tables (2 to 6) show that decreasing irrigation interval lower than 20 days resulted in marked increases in plant height, ear height, ear length, number of grains/row, number of rows/ear, ear diameter, ear weight, grain yield/ear, shelling %, 100 grains weight, grain yield/fed, N uptake, agronomic efficiency of N fertilizer (AE_N) and apparent N recovery (AR_N). The highest values were obtained by 10-day intervals. However, the differences between irrigation every 10 and 15 day in this traits were not significant except plant height in the 2nd season and grain yield/ear in both seasons.

The increases in the previous yield component characteristics may be due to the increases in dry matter/plant and water role in physiological processes i.e. it is the major constituent of physiological active tissue, it is a reagent in photo-synthesis and hydrolic processes such as starch digestion and it is the solvent in which salts, sugars and other solvents move from cell to cell and organ to organ and it is essential for the maintenance of the turgidity necessary for cell enlargement and growth. While, the grain yield is mainly affected by increases in yield components. Irrigation intervals were studied in maize. Salem (1993) indicated that irrigation intervals of 12, 15 and 18 days did not differ in affecting number of ear/plant, ear diameter and number of rows/ear. He added that the differences between irrigation every 12 and 15 days in ear length, 100- grain weight and grain yield were not significant. Similar results were also reported by Hamed (2003).

2-Effect of nitrogen rates:

As shown in Tables (2 to 5) all studied traits were significantly increased by increasing N fertilization rates from 0 to 50, 100 and 150 kg N/fed. Application of 150 kg N/fed significantly increased plant height, ear height, ear length, number of grains/row, number of rows/ear, ear diameter and 100-grain weight. However, the differences between 100 and 150 kg N/fed on ear weight, grain yield/ear, shelling % and grain yield/fed were not significant.

Applying 50, 100 and 150 kg N/fed increased grain yield/fed over control treatment by 5.2, 10.4 and 10.9 ardab/fed in 2003 season and by 6.5, 11.3 and 12.0 ardab/fed in 2004 season. These increases correspond to 39.6, 79.4 and 83.2 % in the 1st season and 52.4, 91.1 and 96.8 % in the 2nd season. These results may be attributed to the increase in plant growth and yield components. The present results indicated clearly the vital role of N in plant life and its contribution in increasing the grain yield. Such results clarified that N is essential for cell division and elongation as well as root growth and dry matter content of maize plants. The response indicates a progressive increase in plant growth and yield components. This reflects a need for high N to obtain high grain yield of maize.

Increased growth, grain yield and its components of maize due to application of high N rates were reported by Oikeh *et al.* (1998) who found that increasing N levels up to 120 kg N/ha led to increasing kerenal weight, grain and protein yields.

Results in Table (6) indicated clearly that N uptake markedly increased with the increase in N rates in both seasons. In 2003, applying N at 50, 100 and 150 kg/fed increased N uptake in grain by 76.8, 162.1 and 178.5 % compared with the uptake under the check treatment, respectively. In 2004, the same N rates increased N uptake by 79.4, 147.8 and 176.8 % , respectively. It is evident that the highest N rates i.e. 150 kg/fed caused a marked increase in N uptake compared with the lower rates.

Agronomic N efficiency decreased due to the increase in N rates. In 2003 season applying N at 50, 100 and 150 kg/fed produced AE_N of 14.5, 14.6 and 10.1 (kg grain/kg N applied), whereas the same N rates resulted in AE_N of 18.3, 15.8 and 11.2 (kg grain/kg N applied) in 2004 season, respectively. Moreover, further investigation are needed to study the efficient use of the higher N rates than had been used in the present work.

In 2003 season, N recovery was estimated as 27.2, 28.7 and 21.1 % for N rates of 50, 100 and 150 kg/fed, respectively. In 2004 season a decrease was observed with the increase in N rates , and the same rates of N produced N recovery values of 30.2, 28.1 and 22.3 %, respectively. Similar results were also reported by Nofal, Fatma, (1999), Zaghloul (1999) and El-Gizawy (2000) who found that AE_N , AR_N decreased and N uptake increased as N rate increased up to 150 kg/fed.

3-Effect of Zn application:

The data revealed significant differences due to foliar application with Zn in all studied traits (Tables 2 to 6). Grain yield increased due to applying Zn over control treatment by 5.73 and 6.21 % in the 1st and 2nd seasons, respectively. Apparent N recovery (AR_N) was estimated as 27.3 and 27.9 % in both growing seasons, respectively. However, foliar application with zinc showed insignificant effect on AE_N in both seasons. Zn has an essential role in carbohydrate metabolism, protein synthesis, tryptophan and IAA synthesis, since it activates number of enzymes for photosynthesis (Marschner, 1995). An adequate supply of Zn is associated with vigorous vegetative growth and consequently increasing the total dry matter content. It seems that there was a definite need for Zn since the control treatment showed lower values of the studied characters. Therefore, the 1.75 mg Zn soil (1.75 ppm) extracted by DTPA is most certainly low and means that the plants grown in such soil need Zn. Soil with pH 7.91 (alkaline soil) may reduce a great part of applied soluble Zn converted to unavailable forms. Similar results were obtained by El-Sheikh (1993). The non significant response to Zn application reported by Ashoub *et al.* (1996) may have been due to the sufficiency of Zn in their soil.

Table 2. Effect of irrigation intervals, nitrogen rates, spraying with zinc and their interactions on plant height, ear height and ear length

Traits	Plant height (cm)						Ear height (cm)						Ear length (cm)					
Seasons	2003 season			2004 season			2003 season			2004 season			2003 season			2004 season		
treatments	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean
N_0	202.3	208.5	205.4	201.8	210.2	206.0	89.3	101.1	95.2	93.3	101.8	97.5	15.2	15.7	15.4	14.5	15.4	15.0
I_{10} N_{50}	255.9	265.2	260.5	261.6	265.2	263.4	125.4	131.1	128.3	123.3	125.1	124.2	16.6	19.2	17.9	18.8	20.1	19.5
N_{100}	269.2	274.3	271.7	290.0	301.6	295.8	136.2	136.1	136.1	143.3	148.5	145.9	18.3	21.3	19.8	24.1	25.2	24.6
N_{150}	266.7	296.0	281.3	301.0	305.1	303.0	142.1	150.3	146.2	145.0	155.1	150.0	21.2	23.8	22.5	24.2	26.2	25.2
Mean	248.5	261.0	254.7	263.6	270.5	267.0	123.2	129.6	126.4	126.2	132.6	129.4	17.8	20.0	18.9	20.4	21.7	21.0
N_0	192.6	201.3	197.0	191.6	195.0	193.3	88.8	95.6	92.2	88.4	95.2	91.8	16.6	17.0	16.8	15.6	17.4	16.5
I_{15} N_{50}	252.6	253.6	253.1	261.6	265.0	263.3	123.7	126.6	125.1	126.6	130.0	128.3	17.0	18.4	17.7	17.9	19.3	18.6
N_{100}	266.0	270.1	268.0	285.0	295.1	290.0	138.1	141.0	139.5	135.0	138.3	136.7	20.5	20.9	20.7	22.3	25.0	23.7
N_{150}	276.1	282.9	279.5	288.3	298.3	293.3	142.8	145.0	143.9	141.6	150.1	145.9	21.0	22.3	21.7	24.4	25.0	24.7
Mean	246.8	252.0	249.4	256.6	263.3	260.0	123.3	127.0	125.2	122.9	128.4	125.7	18.8	19.6	19.2	20.0	21.7	20.9
N_0	182.8	191.2	187.0	178.3	190.0	184.2	81.3	89.4	85.3	75.0	86.8	80.9	15.0	14.8	14.9	15.1	16.1	15.6
I_{20} N_{50}	250.2	251.8	251.0	251.8	255.0	253.4	117.4	123.1	120.3	115.0	120.0	117.5	17.4	17.4	17.4	17.3	18.6	17.9
N_{100}	262.9	264.7	263.8	278.3	280.0	279.1	121.1	127.1	124.1	125.0	130.0	127.5	17.4	20.1	18.7	19.0	22.0	20.5
N_{150}	272.0	274.5	273.2	278.5	281.6	280.0	137.6	143.1	140.3	133.5	135.0	134.2	19.1	20.6	19.9	21.6	23.0	22.3
Mean	242.0	245.5	243.7	246.7	251.6	249.2	114.4	120.6	117.5	112.1	117.9	115.0	17.2	18.3	17.7	18.2	19.9	19.1
N_0	192.6	200.3	196.4	190.6	198.4	194.5	86.5	95.4	90.9	85.6	94.6	90.1	15.6	15.8	15.7	15.1	16.3	15.7
N_{50}	252.9	256.8	254.9	258.3	261.7	260.0	122.2	126.9	124.5	121.6	125.0	123.3	17.0	18.3	17.7	18.0	19.3	18.6
N_{100}	266.0	269.7	267.8	284.4	292.2	288.3	131.8	134.7	133.2	134.4	138.9	136.7	18.7	20.8	19.7	21.8	24.0	22.9
N_{150}	271.0	284.5	278.1	289.2	295.0	292.1	140.8	146.1	143.5	140.0	146.7	143.4	20.4	22.3	21.4	23.4	24.7	24.0
Mean	245.8	252.8		255.6	261.8		120.3	125.8		120.4	126.3		17.9	19.3		19.6	21.1	
LSD 5%																		
I	7.4			5.6			4.5			6.5			N.S			0.62		
N	5.7			4.7			4.6			6.1			0.91			1.05		
Zn	5.6			1.6			1.3			2.1			0.51			0.63		
I x N	N.S			N.S			N.S			N.S			N.S			1.85		
I x Zn	N.S			N.S			N.S			N.S			N.S			N.S		
N x Zn	N.S			N.S			2.7			N.S			N.S			N.S		
I x N x Zn	N.S			N.S			N.S			N.S			N.S			N.S		

Table 3. Effect of irrigation intervals, nitrogen rates, spraying with zinc and their interactions on number of grians/row, number of rows/ear and ear diameter (cm)

Traits	Number of grians/row						Number of rows/ear						Ear diameter (cm)					
Seasons	2003 season			2004 season			2003 season			2004 season			2003 season			2004 season		
treatments	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean
N_0	32.0	33.2	32.6	28.3	36.0	32.1	10.2	11.4	10.8	10.2	11.3	10.8	2.90	3.03	2.96	3.13	3.00	3.06
I_{10} N_{50}	36.9	41.9	39.4	42.3	45.3	43.8	12.0	13.0	12.5	11.4	13.3	12.4	3.30	3.60	3.45	3.33	3.76	3.55
N_{100}	40.7	45.4	43.0	44.3	52.4	48.4	13.0	14.6	13.8	14.4	16.1	15.2	4.10	4.36	4.23	4.03	4.50	4.26
N_{150}	47.3	50.8	49.1	45.0	51.8	48.4	15.2	16.8	16.0	16.4	17.3	16.8	4.50	4.63	4.56	4.60	5.36	4.98
Mean	39.2	42.8	41.0	40.0	46.4	43.2	12.6	13.9	13.3	13.1	14.5	13.8	3.70	3.90	3.80	3.77	4.15	3.96
N_0	28.0	32.6	30.3	29.3	34.3	31.8	10.4	11.0	10.7	10.3	10.6	10.4	2.93	3.13	3.03	3.03	2.93	2.98
I_{15} N_{50}	36.6	38.6	37.6	40.0	42.6	41.3	11.4	12.4	11.9	13.3	12.9	13.1	3.63	3.93	3.78	3.43	3.76	3.60
N_{100}	39.6	42.3	41.0	46.0	47.3	46.6	12.7	13.0	12.9	15.6	14.9	15.2	3.90	3.93	3.91	3.86	4.16	4.01
N_{150}	43.8	46.4	45.1	48.3	49.8	49.0	14.4	14.8	14.6	14.4	16.6	15.5	4.06	4.16	4.11	4.50	4.73	4.61
Mean	37.0	40.0	38.5	40.9	43.5	42.2	12.2	12.8	12.5	13.4	13.7	13.6	3.63	3.79	3.71	3.70	3.90	3.80
N_0	27.0	29.6	28.3	21.6	27.6	24.6	10.0	11.0	10.5	9.4	10.2	9.8	2.73	2.80	2.76	2.76	2.90	2.83
I_{20} N_{50}	27.3	32.3	29.8	29.3	34.3	31.8	10.2	11.4	10.8	11.6	12.6	12.1	3.16	3.63	3.40	7.76	3.06	2.91
N_{100}	32.6	35.3	34.0	34.3	39.3	36.8	11.7	12.6	12.1	14.0	14.2	14.1	3.16	3.76	3.46	3.50	3.60	3.55
N_{150}	36.6	41.2	38.9	39.3	42.3	40.8	12.7	12.4	12.5	13.7	14.6	14.2	3.70	3.93	3.81	3.60	3.93	3.76
Mean	30.9	34.6	32.7	31.1	35.9	33.3	11.1	11.8	11.5	12.1	12.9	12.5	3.19	3.53	3.36	3.15	3.37	3.26
N_0	29.0	31.8	30.4	26.4	32.6	29.5	10.2	11.1	10.7	10.0	10.7	10.3	2.85	2.98	2.92	2.97	2.94	2.96
N_{50}	33.6	37.6	35.6	37.2	40.7	39.0	11.2	12.3	11.7	12.1	12.9	12.5	3.36	3.72	3.54	3.17	3.53	3.35
N_{100}	37.6	41.0	39.3	41.5	46.3	43.9	12.5	13.4	12.9	14.6	15.1	14.8	3.72	4.02	3.87	3.80	4.08	3.94
N_{150}	42.0	46.1	44.4	44.2	47.9	46.1	14.1	14.7	14.4	14.8	16.2	15.5	4.06	4.24	4.16	4.23	4.67	4.45
Mean	35.7	39.1		37.3	41.9		12.0	12.9		12.9	13.7		3.50	3.74		3.54	3.81	
LSD 5%																		
I	3.2			2.3			0.93			0.46			0.27			0.15		
N	2.4			2.1			0.71			0.70			0.20			0.23		
Zn	0.72			1.3			0.25			0.44			0.08			0.14		
IxN	N.S			N.S			N.S			N.S			0.14			N.S		
IxZn	N.S			N.S			N.S			N.S			N.S			N.S		
NxZn	N.S			N.S			N.S			N.S			N.S			N.S		
IxNxZn	N.S			N.S			N.S			N.S			N.S			N.S		

Table 4. Effect of irrigation intervals, nitrogen rates, spraying with zinc and their interactions on ear weight, grain weight/ear and shelling %

Traits	Ear weight (g)						Grain weight/ear (g)						Shelling %					
Seasons	2003 season			2004 season			2003 season			2004 season			2003 season			2004 season		
treatments	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean
I_{10} N_0	142.2	151.1	146.6	177.6	183.5	180.5	99.9	105.0	102.4	131.5	140.0	135.7	70.2	69.5	69.9	74.2	76.8	75.5
N_{50}	203.3	216.0	209.6	216.6	220.0	218.3	163.3	171.0	167.1	143.3	174.0	158.6	80.3	79.1	79.7	66.2	79.1	72.7
N_{100}	210.3	225.1	217.7	251.8	255.2	253.5	186.6	193.4	190.0	216.6	218.3	217.5	88.9	85.9	87.4	86.0	85.6	85.7
N_{150}	211.8	231.0	221.4	248.3	255.2	251.7	185.0	196.4	190.7	220.0	221.5	220.7	87.3	85.0	86.1	88.6	86.7	87.6
Mean	191.9	205.8	198.8	223.6	228.4	226.0	158.7	166.4	162.6	177.8	188.4	183.1	81.7	79.9	80.8	78.7	82.0	80.4
I_{15} N_0	129.4	140.1	134.8	185.0	191.6	188.3	90.3	100.3	95.3	126.8	132.8	129.8	69.7	71.6	70.7	68.5	69.3	68.9
N_{50}	184.3	199.5	191.9	208.5	220.0	214.2	151.0	161.1	156.0	146.6	170.1	158.4	81.9	80.8	81.4	70.4	77.4	73.9
N_{100}	217.6	218.8	218.2	237.8	243.3	240.5	169.3	180.2	174.7	199.3	213.3	206.3	78.0	82.4	80.2	83.8	87.7	85.8
N_{150}	214.6	227.0	220.8	234.3	241.8	238.0	176.0	181.6	178.8	204.3	210.1	207.2	82.0	80.0	81.0	87.2	86.9	87.0
Mean	186.5	196.3	191.4	216.4	224.2	220.3	146.6	155.8	151.2	169.2	181.6	175.4	77.9	78.7	78.3	77.5	80.3	78.9
I_{20} N_0	125.9	131.0	128.4	131.6	143.5	137.6	83.6	93.3	88.5	85.6	100.0	92.8	66.5	71.2	68.8	65.2	69.9	67.5
N_{50}	183.3	192.8	188.0	177.0	185.0	181.0	141.0	145.0	143.0	133.3	143.3	138.3	77.0	75.2	76.1	75.3	77.4	76.4
N_{100}	201.0	206.0	203.5	206.8	211.6	209.2	157.6	162.6	160.1	165.0	170.0	167.5	78.6	79.0	78.8	79.9	80.3	80.1
N_{150}	208.4	214.0	211.2	205.2	216.6	210.9	167.6	175.0	171.3	146.6	171.0	158.8	80.5	81.7	81.1	71.5	79.0	75.2
Mean	179.6	185.9	182.8	180.1	189.2	184.6	137.5	144.0	140.7	132.6	146.0	139.3	75.6	76.8	76.2	73.0	76.6	74.8
N_0	132.5	140.7	136.6	164.7	172.9	168.8	91.3	99.5	95.4	114.6	124.2	119.4	68.8	70.8	69.8	69.3	72.0	70.7
N_{50}	190.3	202.7	196.5	200.7	208.3	204.5	151.7	159.0	155.4	141.1	162.5	151.8	79.7	78.4	79.1	70.6	78.0	74.3
N_{100}	209.6	216.6	213.1	232.1	236.7	234.4	171.2	178.7	175.0	193.6	200.5	197.1	81.8	82.5	82.1	83.2	84.5	83.8
N_{150}	211.6	224.0	217.8	229.2	237.9	233.5	176.2	164.3	180.2	190.3	200.9	195.6	83.2	82.2	82.7	82.4	84.2	83.3
Mean	186.0	196.0		206.7	213.9		147.6	155.4		159.9	172.2		78.4	78.5		76.4	79.7	
LSD 5%																		
I	8.9			9.3			6.9			6.2			3.4			5.8		
N	6.7			8.2			4.4			6.1			3.5			2.8		
Zn	2.16			3.7			1.8			2.4			N.S			1.3		
IxN	N.S			N.S			N.S			10.5			N.S			4.6		
IxZn	3.7			N.S			N.S			4.0			N.S			N.S		
NxZn	N.S			N.S			N.S			N.S			N.S			N.S		
IxNxZn	N.S			N.S			N.S			N.S			N.S			N.S		

Table 5. Effect of irrigation intervals, nitrogen rates, spraying with zinc and their interactions on 100-grain weight, grain yield/fed and GPC%

Traits	100- grain weight (g)						Grain yield (ardab/fed)						Grain protein content (GPC %)					
Seasons	2003 season			2004 season			2003 season			2004 season			2003 season			2004 season		
treatments	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean
N_0	26.2	28.0	27.1	24.4	27.7	26.1	13.5	14.7	14.1	11.9	13.0	12.4	5.62	6.25	5.93	6.04	6.87	6.45
I_{10} N_{50}	29.0	31.7	30.3	30.4	31.8	31.1	18.7	20.3	19.5	20.0	21.1	20.6	6.66	8.12	7.39	7.70	8.12	7.91
N_{100}	34.3	35.3	34.8	35.0	37.6	36.3	24.7	25.1	24.9	24.1	25.6	24.9	9.16	9.37	9.27	8.12	9.16	8.64
N_{150}	38.0	40.0	39.0	39.8	42.3	41.1	24.1	24.6	24.3	25.0	26.4	25.7	8.75	10.0	9.37	9.79	10.62	10.21
Mean	31.8	33.7	32.8	32.4	34.8	33.6	20.2	21.2	20.7	20.2	21.5	20.9	7.55	8.43	[illegible]	7.91	8.69	8.30
N_0	22.1	26.0	24.0	21.8	26.0	23.9	12.6	13.7	13.1	12.3	13.5	12.9	5.83	6.25	6.04	6.25	7.29	6.77
I_{15} N_{50}	25.0	28.0	26.9	27.3	28.6	28.0	17.6	19.2	18.4	18.6	20.4	19.5	7.70	8.12	7.91	7.70	8.12	7.91
N_{100}	32.0	35.8	33.9	34.3	38.1	36.2	23.4	24.2	23.8	23.3	24.3	23.8	8.33	9.38	8.85	8.54	9.16	8.85
N_{150}	35.3	36.5	35.9	36.4	38.5	37.4	24.6	25.4	25.0	24.4	25.4	24.9	8.12	10.0	9.06	9.16	9.37	9.27
Mean	28.6	31.8	30.2	29.9	32.8	31.4	19.5	20.6	20.1	19.6	20.9	20.3	7.50	8.43	7.96	7.91	8.49	8.20
N_0	23.3	27.6	25.4	20.0	23.0	21.5	11.5	12.7	12.1	11.9	11.9	11.9	5.62	6.45	6.04	6.45	7.91	7.18
I_{20} N_{50}	25.0	28.8	26.9	24.8	27.9	26.3	16.9	17.3	17.1	16.0	17.5	16.8	7.29	7.70	7.50	7.70	8.75	8.22
N_{100}	32.0	32.0	32.0	34.2	35.3	34.7	20.8	22.8	21.8	21.8	23.3	22.5	7.70	8.75	8.22	8.75	9.37	9.06
N_{150}	31.6	33.8	32.7	33.6	35.4	34.5	22.0	23.3	22.6	22.5	23.1	22.8	8.75	9.37	9.06	8.54	10.0	9.27
Mean	28.0	30.5	29.2	28.1	30.4	29.3	17.8	19.0	18.4	18.0	18.9	18.5	7.34	8.07	7.70	7.86	9.01	8.43
N_0	23.8	27.2	25.5	22.1	25.5	23.8	12.5	13.7	13.1	12.0	12.8	12.4	5.69	6.31	6.00	6.25	7.36	6.80
N_{50}	26.3	29.8	28.0	27.5	29.4	28.5	17.7	18.9	18.3	18.2	19.7	18.9	7.22	7.98	7.60	7.70	8.33	8.02
N_{100}	32.7	34.3	33.5	34.5	37.0	35.7	23.0	24.0	23.5	23.0	24.4	23.7	8.40	9.16	8.78	8.47	9.23	8.85
N_{150}	35.0	36.7	35.8	36.6	38.7	37.7	23.5	24.4	24.0	23.9	25.0	24.4	8.54	9.79	9.16	9.16	10.0	9.58
Mean	29.5	32.0		30.2	32.7		19.2	20.3		19.3	20.5		7.46	8.31		7.89	8.73	
LSD 5%																		
I	2.8			2.7			0.89			1.01			N.S			N.S		
N	1.4			1.5			0.61			0.91			0.62			0.85		
Zn	0.66			0.7			0.34			0.31			0.23			0.32		
IxN	N.S			N.S			N.S			N.S			N.S			N.S		
IxZn	N.S			N.S			N.S			N.S			N.S			N.S		
NxZn	N.S			N.S			N.S			N.S			N.S			N.S		
IxNxZn	N.S			N.S			N.S			N.S			N.S			N.S		

Table 6 Effect of irrigation intervals, nitrogen rates, spraying with zinc and their interactions on grain N uptake, agronomic N efficiency and apparent N recovery.

Traits	Grain N uptake (kg/fed)						Agronomic N efficieny (kg grains/kg N applied)						Apparent N recovery %					
Seasons	2003 season			2004 season			2003 season			2004 season			2003 season			2004 season		
treatments	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean	water	Zn	Mean
N_0	17.0	20.6	18.8	16.1	20.0	18.1	—	—	—	—	—	—	—	—	—	—	—	—
I_0 N_{50}	27.9	37.1	32.5	34.6	38.5	36.5	14.5	15.6	15.1	22.6	22.8	22.7	21.7	33.1	27.4	37.0	36.8	36.9
N_{100}	50.8	52.8	51.8	43.8	52.7	48.3	15.7	14.5	15.1	17.0	17.7	17.3	33.8	32.2	33.0	27.6	32.7	30.1
N_{150}	47.2	55.0	51.2	54.7	62.8	58.8	9.8	9.2	9.5	12.1	12.5	12.3	20.1	22.9	21.5	25.7	27.8	26.8
Mean	35.7	41.4	38.6	37.3	43.5	40.4	13.3	13.1	13.2	17.2	17.7	17.5	25.2	29.4	27.3	30.1	32.4	31.3
N_0	16.5	19.1	17.8	17.2	22.0	19.6	—	—	—	—	—	—	—	—	—	—	—	—
I_{15} N_{50}	30.4	34.8	32.6	32.5	37.3	34.9	14.0	15.3	14.6	17.7	19.4	18.5	27.7	31.4	29.5	30.4	30.4	30.4
N_{100}	43.8	50.7	47.3	44.4	49.9	47.1	15.5	14.7	15.1	15.3	15.1	15.2	27.3	31.6	29.4	27.1	27.8	27.4
N_{150}	44.8	56.9	50.8	50.1	53.4	51.8	11.2	10.9	11.0	11.2	11.1	11.2	18.8	25.2	22.0	21.9	20.9	21.4
Mean	33.8	40.4	37.1	36.0	40.6	38.3	13.5	13.6	13.6	14.7	15.2	15.0	24.6	29.4	27.0	26.4	26.4	26.4
N_0	14.5	18.2	16.3	17.2	21.2	19.2	—	—	—	—	—	—	—	—	—	—	—	—
I_{30} N_{50}	27.5	29.9	28.7	27.7	34.3	31.0	15.1	12.8	14.0	11.5	15.5	13.5	26.1	23.2	24.6	20.8	26.2	23.5
N_{100}	35.9	44.5	40.2	42.6	49.0	45.8	12.9	14.0	13.5	13.8	15.9	14.8	21.4	26.2	23.8	25.4	27.8	26.6
N_{150}	43.0	49.0	46.0	43.0	51.7	47.4	9.7	9.9	9.8	10.0	10.6	10.3	19.0	20.4	19.7	17.1	20.3	28.7
Mean	30.4	35.4	32.0	32.6	39.0	35.8	12.6	12.3	12.4	11.8	14.0	12.9	22.1	23.3	22.7	21.1	24.8	22.9
N_0	16.0	19.3	17.7	16.9	21.1	19.0	—	—	—	—	—	—	—	—	—	—	—	—
N_{50}	28.6	33.9	31.3	31.6	36.7	34.1	14.5	14.6	14.5	17.3	19.2	18.3	25.2	29.2	27.2	29.4	31.1	30.2
N_{100}	43.5	49.4	46.4	43.6	50.5	47.1	14.7	14.4	14.6	15.4	16.2	15.8	27.5	30.0	28.7	26.7	29.4	28.1
N_{150}	45.0	53.7	49.3	49.3	56.0	52.6	10.2	10.0	10.1	11.1	11.4	11.2	19.3	22.8	21.1	21.6	23.0	22.3
Mean	33.3	39.1		35.3	41.1		13.2	13.0		14.6	15.6		24.0	27.3		25.9	27.9	
LSD 5%																		
I		2.22			2.76			N.S			3.2			N.S			5.1	
N		2.8			2.99			1.3			2.4			3.9			6.1	
Zn		1.2			1.55			N.S			N.S			1.5			1.3	
IxN		4.8			5.10			N.S			N.S			N.S			N.S	
IxZn		2.0			N.S			N.S			N.S			N.S			N.S	
NxZn		2.36			N.S			N.S			N.S			N.S			N.S	
IxNxZn		N.S			N.S			N.S			N.S			N.S			N.S	

4-Effect of interactions:

The interaction between irrigation intervals and N rates in Tables (2 to 6) indicated that irrigation every 10-day gave the highest ear length (in 2nd season), ear diameter (1st season), grain yield/ear (2nd season) , shelling % (2nd season) and N uptake (in both seasons) with 150 kg N/fed.

The superior combination regarding the interaction between irrigation intervals and Zn application treatments was irrigating every 10-day with spraying Zn which recorded maximum ear weight in the 1st season, grain yield/ear in the 2nd season and N uptake in the 1st season.

N rates x Zn application data show that applying 150 kg N/fed plus 70 mg Zn/L produced the highest value of ear height (Table 2) and N uptake (Table 6) in the 1st season only.

Moreover, the interaction of (I x N x Zn) had no significant effect on all characteristic under study in both seasons.

CONCLUSIONS

This study showed the significant role of irrigation interval, N rates and foliar application with zinc in improving maize grain yield, agronomic efficiency of N fertilizer under the conditions of experiment. In both years, decreasing irrigation interval less than 20 days or increasing N fertilization rates from 50 to 150 kg/fed and spraying 70 mg Zn/L is recommended for maize production. In all cases, it is very important that soils should be analyzed to assess the need for their application and consideration showed be given to the preceding crop.

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تأثير فترات الري ، معدلات النتروجين والرش بالزنك علي المحصول وكفاءة استخدام النتروجين في الذرة الشامية

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أجريت تجربتان حقليتان بمزرعة محطة البحوث والتجارب الزراعية بكلية الزراعة بمشتهر خلال موسمي ٢٠٠٣ ، ٢٠٠٤ لدراسة تأثير ثلاث فترات للري (١٠ ، ١٥ و ٢٠ يوم) ، اربعة مستويات من النتروجين (صفر، ٥٠ ، ١٠٠ و ١٥٠ كجم نتروجين/فدان) ومعاملتين للزنك (بدون و الرش) علي المحصول وكفاءة استخدام النتروجين والممتص منة في الذرة الشامية. ويمكن تلخيص النتائج المتحصل عليها في الآتي:-

- سجل الري كل ٢٠ يوم اقل القيم معنويا لطول النبات وموقع الكوز، طول وقطـــر الكوز، عدد صفوف الكوز ، عدد حبوب الصف، وزن الكوز ، وزن حبوب الكوز، نسبة التفريط، وزن ١٠٠ حبة ، محصول حبوب /فدان، الممتص من النتـــروجين في الحبوب ، كفاءة استخدام النتروجين و نسبة المستفاد منة.
- أمكن الحصول علي اعلي القيم للصـــفات تحـــت الدراســـة مـــع زيـــادة التســـميد النيتروجيني حتى ١٥٠ كجم نتروجين/فدان ما عدا كفاءة استخدام النتروجين ونسبة المستفاد منة في الحبوب فكانت تقل بزيادة مستويات النتروجين.

أظهرت التغذية الورقية بالزنك زيادة معنوية في صفات المحصول ومكوناته ومحتوي الحبوب من البروتين والممتص من النتروجين ونســـبة المســـتفاد منـــة فـــي الحبوب بينما لم تتأثر كفاءة استخدام النتروجين معنويا بالرش بالزنك.