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IMPROVING WATER AND N-USE UTILIZATION FOR FIELD CROPS VIA LTERNATE- FURROW IRRIGATION ECHNIQUE. 1-MAIZE CROP

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ABSTRACT

Two field experiments were executed at the farm of Gemmeiza Agric. Res. Stn. during 2001and 200 seasons, to find out the extent to which alternate-furrow irrigation technique, affected water and N-utilization for maize crop.

Data revealed significant reductions in applied water, due to conveying the water through alternate- furrow irrigation at, 7 or 14 days interval. Increasing N-rate resulted in increased applied water values, under the adopted irrigation techniques , a similar trend was observed regardless irrigation techniques as well.

Alternate-furrow irrigation , at 14 days interval, seems to decrease the grain yield insignificantly, whereas, under alternate –furrow at 7 days interval, the figure was increased by 14,5%, as compared with every-furrow irrigation. Increasing N-rate gradually increased grain yield value, and this was true under the adopted irrigation techniques , regardless the irrigation effect too.

Water Use Efficiency(WUE) values were improved under alternate-furrow irrigation, either 7 or 14 days interval, comparable to every-furrow irrigation. Increasing N-rate resulted in increased WUE values, either regarding or regardless irrigation techniques. Nitrogen Use Efficiency(NUE) seems to decrease with alternate-furrow irrigation at 14 days interval, while the corresponding value with alternate-furrow irrigation at 7 days interval was increased, compared with every-furrow irrigation. Moreover, NUE was decreased as N-rate increased, this was true under the adopted irrigation techniques ,also regardless them.

Total grain-N%, grain N-uptake, grain N-recovery % and residual soil inorganic-N values, seemed to decrease under alternate-furrow irrigation at 14 days interval, compared to both alternate-furrow with 7 days interval, and every-furrow irrigation techniques. This may be due to less N- availability under the more drier conditions prevailing under such irrigation technique.

INTRODUCTION

Under common furrow irrigation, to replenish the root zone, overirrigation is inevitable, particularly in the upper part of a field, near the water source. Overirrigation leads to greater water losses, and leaches the fertilizers and pesticides into the ground water causing lower water and N-use efficiency, and environmental pollution problems as well . So, many research trials were conducted in order to optimize the water and N-utilization through irrigating the alternate furrows rather than irrigating every furrow. Milligan,1973 found large water savings, nearly 50%, due to applying water to the alternate rows, during a given irrigation and watering the missed rows at the next irrigation. The author reported that, the yields of grain sorghum, cotton and corn were normal or only slightly reduced. In addition, small yield reductions were found for sugar beet, sorghum and potato,Musick and Dusek,1974 and for soybean, Carbtree *et al.* (1985), due to applying alternate- furrow irrigation, but the irrigation water used was decreased by 30-50%. Benjamin *et al*. (1997) found that, placement of irrigation water either in every furrow, or only in alternate- furrow, had no effect on corn plant development, growth or grain yield. In Egypt, EL-Sherbeny *et al*. (1997) found that the irrigation water applied through alternate- furrow techniques, ranged from 2729 to 2838 m^3/fad., compared with 3724 m^3/fad. under traditional method.

The present work aims to compare the alternate- furrow irrigation with the traditional one, for maize production under different N rates. The consequent effects on water and N- use efficiencies, grain N-uptake and residual soil-N were considered.

MATERIALS AND METHODS

To achieve the experimental objectives, two field trials were conducted in 2001 and 2002 seasons, at Gemmeiza Agric. Res. Stn. farm. Soil of the experimental sites are clayey in texture.Some of its physical and chemical characteristics are shown in Table (1). The adopted treatments were assessed in split- plot design with 4 replicates, water placement occupied the main plots, while the sub ones were assigned to N- rates. The area of each sub plot was 48 m^2 i.e. 4 rows x 0.8 m apart x 15 m length. The tested treatments were as follows :-

1-Main plots Water placement

I- Every- furrow irrigation (Traditional furrow irrigation in 14 days interval) ---------------and

II- Alternate furrow irrigation i.e. irrigating the alternate furrows at 14 days interval

In 2nd Season, the treatment of irrigating the alternate furrow at 7 days Interval was studied too .

2-Sub plots : N-rates

a - Zero b - 75 kg N/fad.

c - 90 kg N/fad. and d - 105 kg/fad.

Seeds of maize (SC hybrid 10) were sown on June 28 and 20 at 1st and 2nd seasons ,respectively, in hills 25 cm apart within rows 80 cm in between. Before the Mohaya watering , the plants were thinned to one plant per hill to establish the recommended plant density (ca 21000 plants/ fad.). Urea fertilizer was used as N source, and the assessed N rate was divided into two equal doses, the first application before Mohaya irrigation and the second was before the next one. Harvesting was took place at 20 and 25,Octoberin 1st and 2nd seasons,respectively.

Irrigation water was conveyed to the plot through a circular orifice and its quantity was calculated using the equation of immersed orifice as follows:-

$Q = 0.61 \times 0.334 \times A \quad h$ after James, 1988)………….where

Q = quantity of irrigation water, L/sec.

A = area of the orifice ,cm^2 …………….and

h = effective water head over the orifice center, m.

The agronomic management i.e. sowing date, plant protection ,weed control……etc were done as recommended for maize production in the region.

Table (1) :Some physical and chemical properties of the experimental site.

	2001 season			2002 season		
1- Physical properties*						
Particle size	Clay	silt	sand	clay	silt	sand
distribution %	38,30	40,33	21,37	43,76	41,03	15,21
Textural class		Clayey			Clayey	
Bulk density, gm/cm^3		1,26			1,30	
Field capacity, % wt.		39,43			40,20	
Wilting point, % wt		21,20			22,30	
$CaCo_3$ %		4,11			3,32	
Organic matter %		1,55			1,60	
2-Chemical properties **						
Soluble ions, meq/100gm soil						
Ca^{++}		0,20			0,27	
Mg^{++}		0,16			0,19	
K^+		0,33			0,05	
Cl^-		0,01			0,29	
Na^+		0,08			0,30	
Co_3^{-2}		----			----	
HCo_3^-		0,60			0,41	
So_4^{-2}		0,02			0,11	
P^H (1:2,5)		7,9			8,1	
Soil available N, ppm		80,2			78,8	
Ec_{se} , dS/m		0,96			1,34	

*** Average of 4 layers, each 15 cm depth**

**** A surface soil sample to 40 cm depth.**

At harvest, the plants of the two inner rows were harvested and grain yield was calculated as ton/fad. Water Use Efficiency (WUE) was calculated for the adopted treatments as follows :-

Water Use Efficiency (kg grain/fad./mm) = Grain yield (kg/fad.) / Total applied water ,mm

Nitrogen Use Efficiency was calculated as kgs of the economical yield (grains) produced due to adding the unit of nitrogenous fertilizer. In 2nd season, grain total N % was determined using micro-Kjledahl method as described by Jackson,1962 and. grain N- uptake (kg N/fad.) was calculated by means of grain yield and grain N %. Grain N-recovery % was calculated by the following relationship :-

Grain N-recovery % = [N uptake (treatment) – N uptake(zero N treatment / N units added] x 100

Surface soil samples were collected to 40 cm depth of soil ,under the adopted treatments, in order to determine the total residual N as described by Chapman and Pratte,1961 . Data of quantity of applied water and grain yield were subjected to statistical analyses as described by Snedecor and Cochran,1969.

RESULTS AND DISCUSSION

Applied irrigation water

Data in Table (2) showed that ,regardless N rates effect, applying the water through alternate –furrow irrigation with 14 days interval saved about 32,69 and 28,78 % of applied water , comparable with every-furrow irrigation (Irrigated every furrow),in 1st and 2nd seasons, respectively. In addition ,under alternate furrow irrigation at 7 days interval, the same trend was noticed with reduction % in applied water reached about 8,00 less than under every-furrow irrigation. The reduction in irrigation water ,due to using alternate- furrow technique, was previously reported by Milligan ,(1973); Musick and Dusek, (1974) ; Fischbach and Mullinar ,(1974) and Carbtree *et al*,(1985). Moreover , EL-Sherbeny *et al*. (1997) stated that ,water applied to maize via alternate-furrow irrigation techniques, was lower by 26,7 to 23,8% than that applied using traditional furrow irrigation method.

It was also noticed that increasing N rate was accompanied with increased applied water value, this was true in the two seasons of study. In 1st season, the increase % in applied water ,due to increasing N rate, ranged from 26,44 to 52.36 under every-furrow irrigation and from 5,13 to 17,1 under alternate- furrow irrigation at 14 days interval. The same trend was observed in 2nd season, since the increase % in applied water ranged from 14,00 to 18,4 with irrigating every furrow and from 8,40 to15,27 and from 4,90 to 15.50 under alternate – furrow irrigation techniques at 14 and 7 days interval ,respectively.

Regardless the irrigation techniques, increasing N rate resulted in increased values of the applied water under the traditional and both alternate-furrow irrigation techniques. These results are in accordance with Reddy *et al*. (1980) and Abdel-Maksoud *et al*. (1999), whom stated that the water applied, and consumed soil moisture by maize plants were increased as N rate increased.

Grain yield

Data in Table (2) revealed that, maize grain yield was reduced insignificantly under alternate-furrow irrigation at 14 days interval by 5,06 and 10,88 %, as compared with every-furrow irrigation, in 1st and 2nd seasons, respectively. Musick and Dusek,(1974) with sugar beet ,sorghum and potato and; Carbtree *et al*. (1985) with soybean, observed a slight yield reduction due to applying alternate-furrow irrigation. Nevertheless, alternate-furrow irrigation at 7 days interval, proved to be superior to increase the grain yield by 14,50 and 28,40%, comparable with every-furrow and alternate-furrow irrigation at, 14 days interval, respectively. This may be attributed to the better availability of soil moisture during the irrigation cycle under alternate-furrow irrigation at 7 days interval, which enhanced water and nutrient uptake, which doubtless reflected on the final grain yield. Such result is in accordance with EL-Sherbeny *et al*.,(1997) whom stated that the average maize grain yield was slightly reduced due to applying irrigation water through alternate furrow irrigation ,as compared with traditional furrow one.

It is clearly observed that, increasing N rate was accompanied with increased grain yield value under the tested irrigation techniques. The increase % in grain yield,due to increasing N rate , ranged from 83.,8 to 122,8 and from 37,0 to 66,5 under every-furrow irrigation in 1st and 2nd seasons, respectively. The corresponding values ,,under alternate- furrow at 14 days interval, ranged from 73,7 to 113,5 and from 36,2 to 63,7% ,in 1st and 2nd seasons, respectively. Under alternate-furrow irrigation at 7 days interval, increasing N rate resulted in increase % in grain yield ranged from 47,2 to 57,7. Regardless irrigation techniques, increasing N-rate resulted in increased grain yield values, and these results are in harmony with those of Zhang, *et al*. (1993) and Abdel-Maksoud *et al*. (1999).

Water Use Efficiency (WUE)

Water use efficiency, in the current work, means kgs of grain yield produced per faddan due to applied 1 mm of irrigation water. On such basis, in 1st season and regardless N- rates, WUE values were improved under alternate-furrow irrigation at 14 days interval by 44,8% more than that under every-furrow irrigation. In 2nd season , similar trend was observed and WUE values under alternate-furrow irrigation, either at 14 or 7 days interval, were similar and exceeded that under every- furrow irrigation by about 24%. EL-Sherbeny *et al*.,(1997) found that WUE for maize crop ranged from 1.00 to 0,92 kg/m3 under alternate- furrow irrigation techniques, compared with 0,72 kg/m^3 under traditional furrow one.

Data in Table (2) also revealed that increasing N rate was accompanied with gradual increased WUE values, under alternate-furrow irrigation techniques, particularly in 2nd season. The same trend was noticed with traditional furrow irrigation with lesser values, and this was true in 1st and 2nd seasons. Regardless irrigation methods under study, WUE seems to increase as N- rate increased, and these results were true in the two seasons of study and are coincided with Abdel-Maksoud *et al*. (1999).

Nitrogen Use Efficiency (NUE)

Data in Table (2) showed that, values of NUE under alternate-furrow irrigation at 14 days interval, were lower by 5,60 and 10,90 % than those under every- furrow irrigation, in 1st and 2nd seasons, respectively. Nevertheless, alternate-furrow irrigation with 7 days interval surpassed both traditional and alternate- furrow irrigation with 14 days interval in this respect, since the increase % in NUE comprised 15,4 and 29,4 ,respectively. It is worthy mentioned that increasing N-rate resulted in gradual reduced NUE values either under every-furrow or alternate-furrow irrigation techniques. Moreover, regardless irrigation techniques, increasing N-rate seems to reduce NUE, and this trend was true in 1st and 2nd seasons. These results are in harmony with those obtained by Abd EL-Razek *et al. (*1999).

Table(2): Grain yield(ton/fad.),applied water(mm),Water Use Efficiency(Kg/fad/mm)and nitrogen Use Efficiency(kg/N unit) as affected by traditional and alternate furrow irrigation techniques

Treatments		2001 season				2002 season			
		Grain yield	Water applied	WUE	NUE	Grain yield	Water applied	WUE	NUE
Main plots									
Every-furrow irrigation		2,433	450,2	5,205	31,249	1,792	459,4	3,916	21,925
Alter-furrow irri.,14 days interval		2,310	303,0	7,537	29,505	1,597	327,2	4,846	19,536
Alter-furrow irri.,7 days interval		-	-	-	-	2,051	422,6	4,829	25,288
Sub-plots									
N0,without N fertilization		1,345	311,9	4,356	-----	1,309	366,3	3,605	
N1 ,75 kg/fad.		2,405	364,9	6,829	32,066	1,841	400,4	4,656	24,551
N2 ,90 Kg/fad.		2,800	304,3	7,275	31,111	1,977	418,7	4,768	21,463
N3 ,105 Kg/fad.		2,395	426,2	7,047	27,952	2,126	426,9	5,035	20,247
Interactions									
	N0	1,360	345,3	3,939		1,296	410,5	3,157	
Every-furrow irrigation	N1	2,500	436,9	5,772	33,333	1,776	468,1	3,794	23,680
	N2	2,840	492,3	5,769	31,556	1,939	472,9	4,100	21,544
	N3	3,030	526,1	5,390	28,857	2,158	486,0	4,440	20,552
	N0	1,330	278,6	4,774	-----	1,156	298,5	3,873	
Alternate-furrow irrigation	N1	2,310	292,9	7,887	30,800	1,575	323,7	4,866	21,000
14 days interval	N2	2,760	314,3	8,781	30,666	1,763	342,6	5,146	19,589
	N3	2,840	326,3	8,704	27,048	1,892	344,1	5,498	18,019
	N0	----		-----		1,476	390,0	3,785	
Alternate-furrow irrigation	N1	_		_		2,173	409,3	5,309	28,973
7 days interval	N2	----		-----		2,228	440,5	5,057	24,756
	N3	----		-----		2,328	450,6	5,166	22,171
Main plots	**NS**	**15,77**				**0,23**		**9,19**	
	LSD ,05								
	Sub plots			**0,28**	**8,93**	**0,89**		**12,83**	

Grain total-N%

Data in Table (3) revealed that grain N% was increased under alternate-furrow irrigation with 7 and 14 days interval by 10,67 and 4,67%, comparable with traditional furrow one, respectively. Moreover, it seems that increasing N-rate resulted in gradually increased grain N% values under both traditional and alternate- furrow irrigation techniques. In addition, and regardless irrigation techniques, increased grain total N% values were obtained due to increasing N-rate. These results are in accordance with those of Abd EL-Razek *et al*. (1999).

Grain N-uptake

Data in Table (3) cleared out that ,grain N-uptake value was decreased under alternate-furrow irrigation with 14 days interval by 6,94 % , while the corresponding value under alternate- furrow irrigation with 7 days was increased by 25,1%,as compared with traditional furrow irrigation . The same trend obtained with grain total N% was also recorded for grain N-uptake since its value was increased as N-rate increased, under traditional and both alternate-furrow irrigation techniques. Regardless irrigation methods under study, increasing N-rate resulted in increased grain N-uptake values. These results are in harmony with those of Abd EL-Razek *et al*. (1999).

Grain N- recovery %

Data of % N-recovered by maize grain yield are illustrated in Table (3). The percent of N-recovered by maize grain was decreased by 15,08 under alternate-furrow irrigation with 14 days interval, while the corresponding value under alternate-furrow irrigation with 7 days interval was increased by 25,30 %,comparable with the value under every furrow irrigation. Gradual and slight increase in % N-recovered by maize grain was observed due to increasing N-rate under every-furrow and both alternate-furrow techniques. Moreover and regardless irrigation techniques, increasing N-rate did not greatly influence N-recovery % by maize grains. These results are in accordance with results of Abd EL-Razek *et al. (*1999).

In general, under alternate-furrow irrigation with 14 days interval, a particular row of maize plants received water every 28 days. So, the soil was more drier thus decreased N-availability. Under alternate-furrow irrigation with 7 days interval i.e. shorter irrigation cycle, soil moisture and soluble nutrients were more available for plants which ,indubitable, increased N-uptake and N-recovered by maize grain yield.

Residual soil inorganic-N

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