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Irrigation and Fertilization Management for Crop Production and Environment Conservation of maize (*Zea mays* L.)

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ABSTRACT

A field experiments was conducted at the Experimental Farm, Faculty of Agriculture, Al-Azahar University, Assuit, Egypt which is located at 27° 12- 16.67= N latitude and 31° 09- 36.86= E longitude for two successive summer growing seasons of 2010 and 2011 in order to reach optimum management practices of both irrigation water amount and nitrogen application to attain high crop yields, while minimizing risks of environmental impairment and aquifer contamination. Three levels of soil moisture depletion (25, 50 and 75% of SMD) were assigned to the main plots. The split plots were assigned for three nitrogen fertilizers sources (Urea 46.5% N, Ammonium nitrate 33.5% N as a fast nitrogen fertilizer and ureaform 40% N as a slow nitrogen fertilizer).The amounts of leached nitrate increased as the soil moisture depletion increases. The leached nitrate as average values of two seasons of maize crop are 153, 179 and 218 ppm at 25, 50 and 75% SMD, respectively which increases by 17 and 43 % at 50 and 75 % SMD, respectively compared to that at 25% SMD. The leached amounts of nitrogen have no change whenever the nitrogen source is urea or ammonium nitrate and almost have the same distribution through 130 cm soil depth. While the leached amounts of nitrogen resulted from urea form fertilizer appears to be not as much as those of other nitrogen sources. The amounts of leached nitrate was more obviously under soluble fertilizers and it could be arranged in descending order of ammonium nitrate > urea > urea form. The amounts of leached nitrate as average values of two seasons of maize crop are 215, 225 and 89 ppm under urea, ammonium nitrate and urea form fertilizers, respectively which increased by about 147 % under urea or ammonium nitrate fertilizer compared to that under urea form fertilizer. Nitrogen use efficiency by maize plants (NUE_m) could be arranged in descending order of 25 ≈ 50 > 75 % SMD. Regarding nitrogen sources it could be arranged in descending order of urea form > urea > ammonium nitrate. The highest nitrogen leaching during the growing season was concurrent with the highest irrigation application and fertilization event. It is possible to control NO_3^- leaching out of the root zone during the growing season with a proper combination of irrigation and fertilizer management.

Key words: Deficit irrigation; fertilizers; Nitrogen leaching; Water use efficiency; Nitrogen; Maize

Introduction

Management and control of nitrate (NO_3^-) leaching are difficult because NO_3^- losses are often intermittent, and linked with seasonal land management, irrigation practices and fertilizer applications whether their types or levels. A high NO_3 concentration in the root zone is one of the major concerns in extensively irrigated areas, where excess water needs to be applied to control salinity that results in deep percolation, one of the sources of water to recharged groundwater aquifers beneath irrigated lands. Soil NO_3^- concentration and subsurface drainage water resulted by irrigation are two important factors that control NO_3^- leaching.

Nitrate leaching losses would be largely associated with soil textural and hydrologic properties rather than soil chemical and biological properties associated with differences in land use, because ultimately, leaching is dependent on water flow as there is no leaching of solutes without water flow. Applying nitrogen fertilizer at a rate less than optimal and/or using a variable deficit irrigation scheduling regime can reduce NO_3^- leaching (Barton and Colmer, 2006). High nitrate accumulation and the free flow of water in the soil profile are pre-conditions for nitrate leaching into the subsoil or groundwater. Residual nitrate can move continuously downwards and be lost even if it is not leached during the season of application (Ju *et al.,* 2006).

Berenguer *et al.* (2008) revealed that elevated soil residual NO_3^--N content could increase the risk of N leaching during autumn-winter, which in turn could constitute a potential source of environmental problems. Randall *et al.* (2008) observed that, under traditional management, the N lost by leaching can reach 1000 kg N/ ha/ y when there is high NO_3^-–N content in irrigation water (close to 180 mg/ L). Gheysari *et al.* (2009) found that the effect of irrigation on NO_3^- leaching was amplified by an increase in the amount of N applied. Adamtey

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et al. (2010) concluded that different sources of N- fertilizers increased transpiration efficiency, water use efficiency and minimizing N losses of maize differently as N application rate increases. Zhenling *et al.* (2010) found that adding more nitrogen beyond optimal N rate increased residual soil nitrate-N after harvest from 99 to 115 kg/ha., and estimated N losses from 29 to 40 kg/ha., at 130 % optimal N rate. Variation in land use, fertilizer N- application rates, soil type and climate affect the rate and timing of N losses below the root zone and into waterways (Bryant *et al*., 2011). The main objective is to study the effect of the interaction of irrigation-nitrogen management on nitrogen losses form $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$ and to determine whether high crop yields can be attained, while minimizing risks of environmental impairment and aquifer contamination by lowering leach ate loads.

Materials and Methods

A field experiments was conducted at the Experimental Farm, Faculty of Agriculture, Al-Azahar University, Assuit, Egypt which is located at 27° 12^- $16.67^=$ N latitude and 31° 09^- $36.86^=$ E longitude for two successive growing summer seasons of 2010 and 2011 in order to reach optimum management practices of both irrigation water amount and nitrogen fertilizer sources to attain high crop yields, while minimizing risks of environmental impairment and aquifer contamination. The relevant physical and chemical properties of the investigated area were determined according to Klute (1986) & Page (1982) and they are shown in Table (1). The experiment, were laid out in split plots design with four replicates. The plot was 4 m in length and 5 m in width with an area of 20 m^2 (almost 1/200 fed). The study included three levels of soil moisture depletion (SMD), with three nitrogen fertilizer sources at the recommended dose. The main plots were assigned for irrigation regimes (25, 50 and 75% of SMD) and they were bounded with buffer zone of 3 m width to avoid the horizontal seepage of irrigation water. The split plots were assigned for three nitrogen fertilizers sources (Urea 46.5% N, Ammonium nitrate 33.5% N as a fast nitrogen fertilizer and urea form 40% N as a slow nitrogen fertilizer).

In the summer seasons of year 2010 and 2011, maize grains (*Zea mays L.*) hybrid Three way cross (TWC) Nefertiti3 were planted in June 1st of both seasons. The plant lines were 60 cm apart and 25 cm plant sparse in the line consuming 25 kg/fed grains /fed. The maize plants were harvested after 120 days from planting in each season. The plants of two ridges from each plot were collected as samples for growth and yield measurements. All field management practices for growing maize were conducted following the recommendation of the Egyptian Ministry of Agriculture. All treatments received levels of PK at rates of 15.5 kg of P_2O_5 and 48 kg of K_2O / fed. Super phosphate was broadcasted during soil preparation processes. Potassium was added as K_2SO_4 at two equal doses, the 1st after 20 days and the second dose after 75 days from plantation. The desirable amounts of nitrogen fertilizer (120 kg N/fed.) in form of urea and ammonium nitrate were divided in two equal doses. The first one was added to soil before the 1st irrigation for all SMD and the second one was added before 5th, 3rd and 2nd irrigation at 25, 50 and 75% SMD treatment, respectively. Urea form slow release nitrogen fertilizer (120 kg N/fed.) was added to the soil before sowing.

Table 1. Some soil chemical and physical properties of the experimental site.

a- Chemical properties

Soil depth (cm)	O.M. (%)	$CaCO_3$ (%)	pH	SP %	ECe (dS/m)	Water soluble ions (meq/L) in the soil paste							SAR	Available nutrients (ppm)		
						CO_3 + HCO_3	Cl^-	SO_4	Ca	Mg	Na	K		N	P	K
0-30	1.20	3.50	7.87	85	1.05	2.50	1.25	6.15	2.70	1.35	5.74	0.11	4.03	77.0	9.70	337
30-60	1.10	3.20	7.88	83	1.00	2.34	1.16	6.00	2.60	1.15	5.53	0.22	4.04	68.5	9.55	353
60-90	0.95	2.70	7.91	83	1.01	2.2	1.25	5.55	2.45	1.12	5.24	0.19	3.92	58.0	9.35	358
90-120	0.85	2.35	7.94	82	1.27	3.4	3.00	6.10	3.20	1.30	7.75	0.25	5.16	50.0	9.15	362
120-150	0.69	2.25	7.91	82	1.36	3.6	3.30	6.60	3.50	2.20	7.53	0.27	4.46	45.0	8.95	368
Mean	0.90	2.68	7.90	83	1.13	2.86	2.23	6.58	3.37	1.90	6.24	0.21	4.02	59.7	9.34	356

O.M. = organic matter pH= soil reaction SP = saturation percent ECe = salinity in soil past extract SAR= sodium adsorption ratio

b- Physical properties

Depth (cm)	Percentage (%)			Texture class	Moisture content θ v%		A.W. (%)	B_d (g/cm^3)
	Sand	Silt	Clay		F.C.	W.P.		
0-30	25.00	39.65	35.35	Clay Loam	44.0	21.0	23.0	1.29
30-60	24.65	39.00	36.35	Clay Loam	43.8	21.0	22.8	1.30
60-90	25.90	38.80	35.30	Clay Loam	43.0	20.5	22.5	1.33
90-120	26.50	41.00	32.50	Clay Loam	41.8	20.0	21.8	1.37
120-150	25.85	40.70	33.45	Clay Loam	41.6	20.0	21.6	1.42
mean	25.48	39.78	34.74	Clay Loam	42.42	20.42	22.0	1.36

F.C. = field capacity W.P.= wilting point A.W.= available water B_d= bulk density

Actual evapotranspiration was estimated by the sampling method and calculated according to the technique used by the Ministry of Agriculture, Egypt, using the following formula:

$$C.U = \{D \times B_d \times (Q_2\text{-}Q_1)/100\}/P$$

Where: C.U. = actual evapotranspiration (cm). D = the irrigation soil depth (cm).

B_d = bulk density of soil (gm/cm^3). P = water density (gm/cm^3).

Q_2 = the percentage of soil moisture two days after irrigation (field capacity).

Q_1 = the percentage of soil moisture before next irrigation.

Soil samples for moisture determination were taken from each 10cm depth down to 60cm by soil auger. The samples were weighted and then oven dried. Percentage of soil moisture content at the six depths was calculated on oven dry basis. The amount of water consumed in each irrigation interval was obtained from the difference between soil moisture content before the following irrigation and two days after irrigation (field capacity).

Field capacity (FC) and permanent wilting point (PWP) were determined using the pressure cooker and pressure membrane apparatus. A saturated undisturbed and disturbed soil samples were equilibrated at suction pressures of 0.33 and 15 bar, respectively, according to Shawky (1967). The available water capacity (AWC) of a soil is the amount of water retained in the soil reservoir that can be removed by plants. This was calculated by the differences in water content at field capacity and permanent wilting point as follows: AWC = FC – PWP

Water use efficiency (WUE):

The water utilization efficiency is expressed as Kg seeds/m^3 of water consumed. It has been used to evaluate the different irrigation treatments in producing maximum yield per water unit consumed by the crop plants (Vites, 1965).

WUE (Kg/ m3) = Seed yield (Kg/fed.) / Seasonal crop consumptive use (m3/fed.)

Nitrogen use efficiency (NUE):

The nitrogen use efficiency is expressed as Kg seeds/ kg of nitrogen fertilization. It has been used to evaluate the different nitrogen forms in producing maximum yield per kg nitrogen consumed by the crop plants (Vites, 1965).

NUE (Kg / Kg N) = Seed yield (Kg/fed.) / Nitrogen fertilizer application (kg/fed)

Ground water samples:-

Water samples from ground water were collected through an observation well (PVC plastic pipe three inch in diameter and 50 cm in length that insert in soil hole of 130 cm depth set aside 20 cm to prevent water runoff into soil hole) in each treatment and its depth were recorded twice a week all over the irrigation cycles (15- 16 cycles). Watertable depth was measured with a sounder consisting of cupper tube 1.25 cm in diameter and 5.0 cm in length connected with a calibrated steel tape. The data were measured daily through the consecutive irrigation cycles during the growing season. The groundwater in the hole was sucked by transparent plastic pipe (10 mm diameter and 175 cm length) embedded 10 cm into groundwater surface. The groundwater samples were subjected to nitrate and ammonium analyzing according to Jackson (1973). Nitrogen concentration in ground water (NO_3^-& NH_4^+) was converted into kg/ fd by related hole area to the fedden area (0.005 m^2 the hole area).

Soil samples:

At the same time of ground water sampling, soil samples at watertable level were collected from each treatment. The collected soil samples were air-dried and prepared for chemical analysis. Available nitrogen was extracted by K-sulphate and determined using the microkjeldahl method according to Jackson (1973).

Yield and yield components:

The plants of two lines from the centre of each plot were harvested to estimate the grain and straw yield of maize. The obtained values were calculated for the whole feddan (grain or straw yield, ton / fad). At harvesting time of maize, ten plants were chosen randomly from each treatment to estimate the following characters.

I. Plant height (cm). 2. Seed index (g)
3. Grain yield (tons/ fed.) 4. Straw yield (tons/ fed)
5. Nitrogen content in grain and straw 6. Total nitrogen recovery (kg/fed.)

The obtained data of each season were statistically analyzed by using the statistical computer program of Crop & Soil Sciences Dept. Michigan State University (MSTAT, 1987).

Result and Discussion

The NO_3^--N leaching is dependent on both irrigation depth applied and on amount applied nitrogen and its source. NO_3^--N leaching increased in response to any additional N and, or water amounts applied. Leaching during the growing season could be controlled by practicing and implementing proper synchronized management of irrigation and fertigation, especially under conditions when rain is sparse.

1- Leaching nitrogen as affected by nitrogen sources and irrigation regime

Nitrogen concentration in ground water (ppm) in forms of ammonium (NH_4^+) and nitrate (NO_3^-) at different nitrogen sources with 25% soil moisture depletion (SMD) through different irrigation cycles as an average of two successive growing seasons of maize (2010 and 2011) are presented in figure 1. In general, there is a slight change in nitrogen concentration (NH_4 & NO_3^-) with the recession of water table level down to 116 cm depth. The leached amounts of nitrogen in form of NO_3^- are being much higher than those of nitrogen in form of NH_4^+. Through irrigation cycles No. 5-9 at 25% SMD, NO_3^--N concentration increases in ground water to reach up a value of 202 and 213 ppm when soil fertilized by urea and ammonium nitrate respectively with almost no changes with different water table depth through both seasons. This is as a result of adding the second dose of nitrogen fertilization then it starts to slow down to a value of 104 and 110 ppm for the corresponding fertilizers. Urea form fertilizer shows gradual decreasing of NO_3^--N concentration in ground water through the consecutive irrigation cycles with almost no change with water table recession. The values of NO_3^--N concentration in ground water range between 43 and 102 ppm. The NH_4^+-N concentration values in ground water show graduate decline slowly through consequent irrigation cycles and it ranges between 2 and 13 ppm.

Nitrogen concentration in ground water (ppm) in forms of NH_4^+ and NO_3^- at different nitrogen sources with 50% SMD through different irrigation cycles as an average of two successive growing seasons of maize are presented in figure 2. It is noticed that NO_3^--N concentration decreases during consecutive irrigation cycles. The NO_3^--N concentration under urea or ammonium nitrate is much higher than that under urea form. Under urea fertilization, NO_3^--N concentration values are 231, 246 and 188 ppm through irrigation cycles of 1-2, 3-5 and 6-7, respectively. NO_3^--N concentration values are 245, 259 and 184 ppm when soil fertilized by ammonium nitrate and they are 113, 86 and 63 ppm when soil fertilized by urea form for the corresponding irrigation cycles. The NH_4-N concentration values in ground water show graduate decline slowly through consequent irrigation cycles and it ranges between 2 and 13 ppm.

Nitrogen concentration (ppm) in ground water in forms of ammonium (NH_4^+) and nitrate (NO_3^-) at different nitrogen sources with 75% SMD through different irrigation cycles as an average of two successive growing seasons of maize (2010 and 2011) are presented in figure 3. It is noticed that NO_3^--N concentration decreases during consecutive irrigation cycles. The NO_3^--N concentration under urea or ammonium nitrate is much higher than that under urea form. Under urea fertilization, NO_3^--N concentration values are 265, 294 and 244 ppm through irrigation cycles of 1, 2 and 3- 4, respectively. NO_3^--N concentration values are 278, 301 and 251 ppm when soil fertilized by ammonium nitrate and they are 128, 106 and 88 ppm when soil fertilized by ureaform for the corresponding irrigation cycles. The NH_4-N concentration values in ground water show graduate decline slowly through consequent irrigation cycles and it ranges between 4 and 20 ppm.

In general, nitrogen is considered the most effective nutrients in crop production under Egyptian soil conditions. The leached amounts of nitrogen have no change whenever the nitrogen source is urea or ammonium nitrate and almost have the same distribution through 130 cm soil depth. While the leached amounts of nitrogen resulted from urea form fertilizer appears to be not as much as those of other nitrogen sources. This may be due to the high solubility of urea or ammonium nitrate fertilizers. As well as, urea form as a slow release nitrogen fertilizer may be available regular for nitrogen supply (El-Atawy, 2007).

Regardless soil moisture depletion, the amounts of leached nitrate was more obviously under soluble fertilizers and it could be arranged in descending order of ammonium nitrate > urea > ureaform. This trend could be explained on a basis of that urea as a fast release nitrogen fertilizer takes more time to change into nitrate form than ammonium nitrate and urea form is a slow release nitrogen fertilizer. The leached nitrate values as average of two seasons of maize crop are 215, 225 and 89 ppm under urea, ammonium nitrate and urea form fertilizers, respectively. The leached amounts of nitrate increased by about 147 % under urea or ammonium nitrate fertilizer compared to that under urea form fertilizer.

An excessive application of fertilizer N (organic and mineral) could result in high soil nitrate content at the end of the plant growth season, increasing contamination of both underground and surface water, due to nitrate remaining in the soil profile and possible leaching to the groundwater (Janzen *et al.*, 2003). Singer *et al.* (2004) reported that olive pomace compost could be used to sustain plant, yield in a controlled environment. Furthermore, the combination of olive wastes with N fertilizer is an interesting alternative to meet crop requirements with the possibility of utilizing waste and reducing the amount of inorganic fertilizer. It is also possible that fertilizing ability alone may not be responsible for the positive yielding responses but also could come from improved physical, chemical and biological properties in the soil amended with organic N.

Montemurro *et al*. (2006) indicated that the best N management, able to ensure good yield, quality, and to utilize the resources, could be the treatment of 100 kg /ha of organic N broadcasted before sowing and 100 kg/ha., of mineral N applied during maize plant growth. Berenguer et al. (2008) found that N losses (mainly probably due to N leaching) were influenced by N (organic and/or mineral) fertilization and by soil initial NO_3^-–N content. Adamtey *et al.* (2010) concluded that different sources of nitrogen fertilizers increased transpiration efficiency (TE), water use efficiency and minimizing N losses of maize differently as N application rate increases. Variation in land use, fertilizer N application rates, soil type and climate affect the rate and timing of N losses below the root zone and into waterways (Bryant *et al.,* 2011).

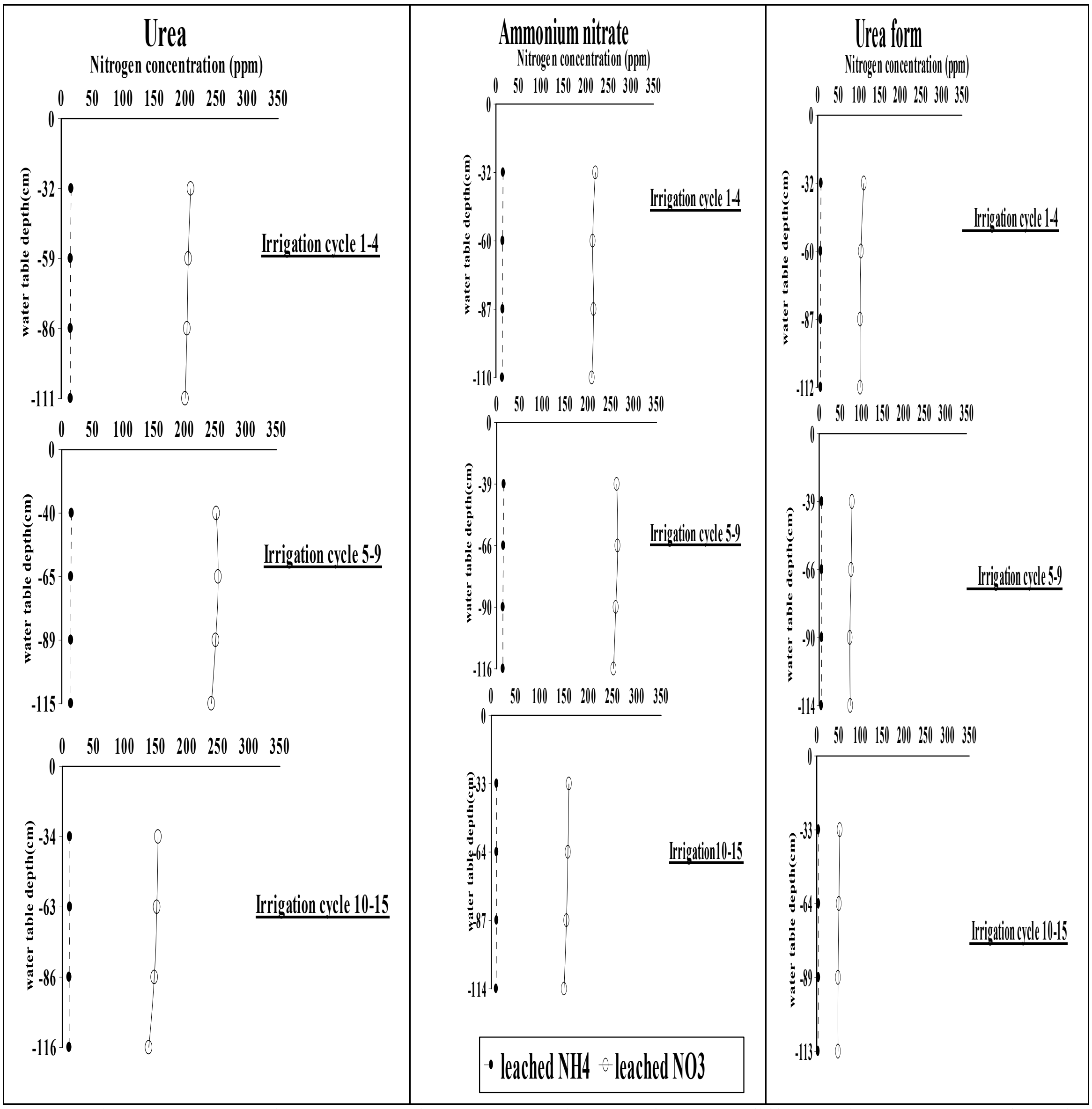

Fig.1: Nitrogen concentration (average of two seasons) in groundwater at different nitrogen sources through consecutive irrigation cycle at 25% SMD for maize crop.

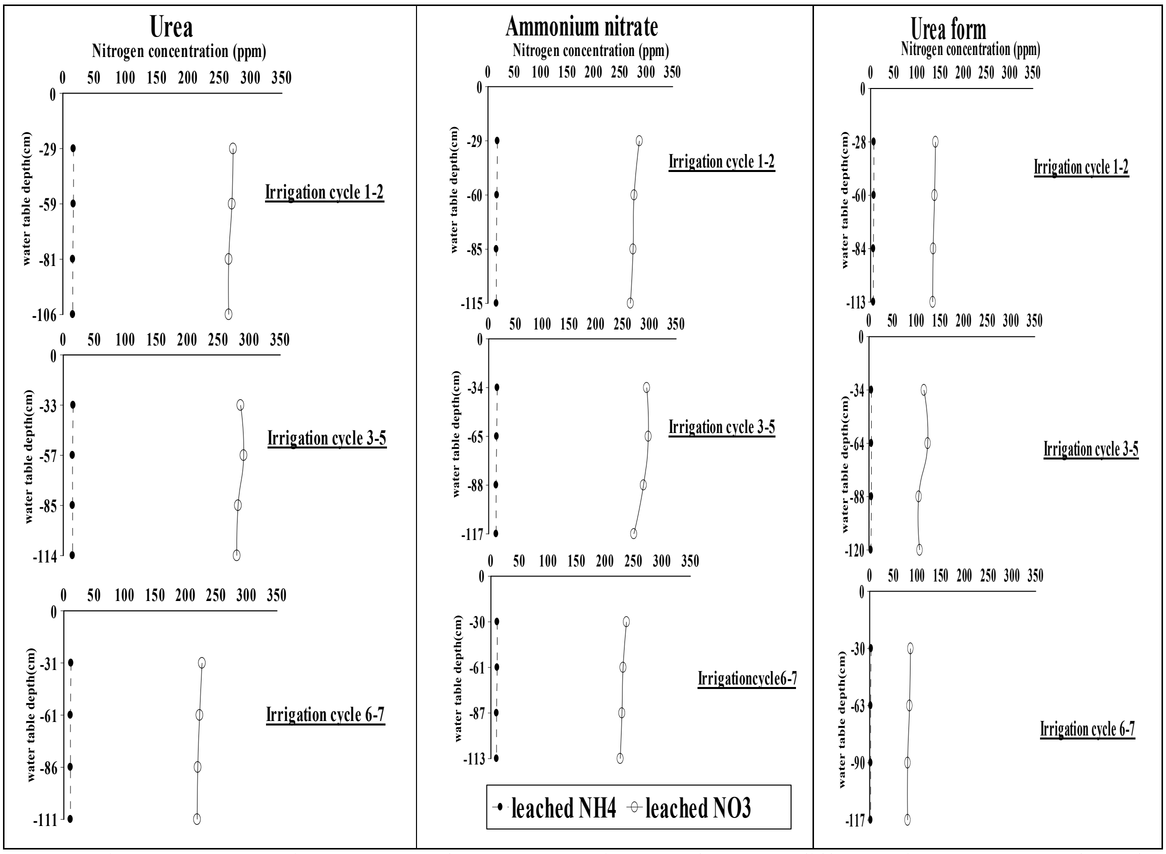

Fig.2: Nitrogen concentration (average of two seasons) in groundwater at different nitrogen sources through consecutive irrigation cycle at 50% SMD for maize crop.

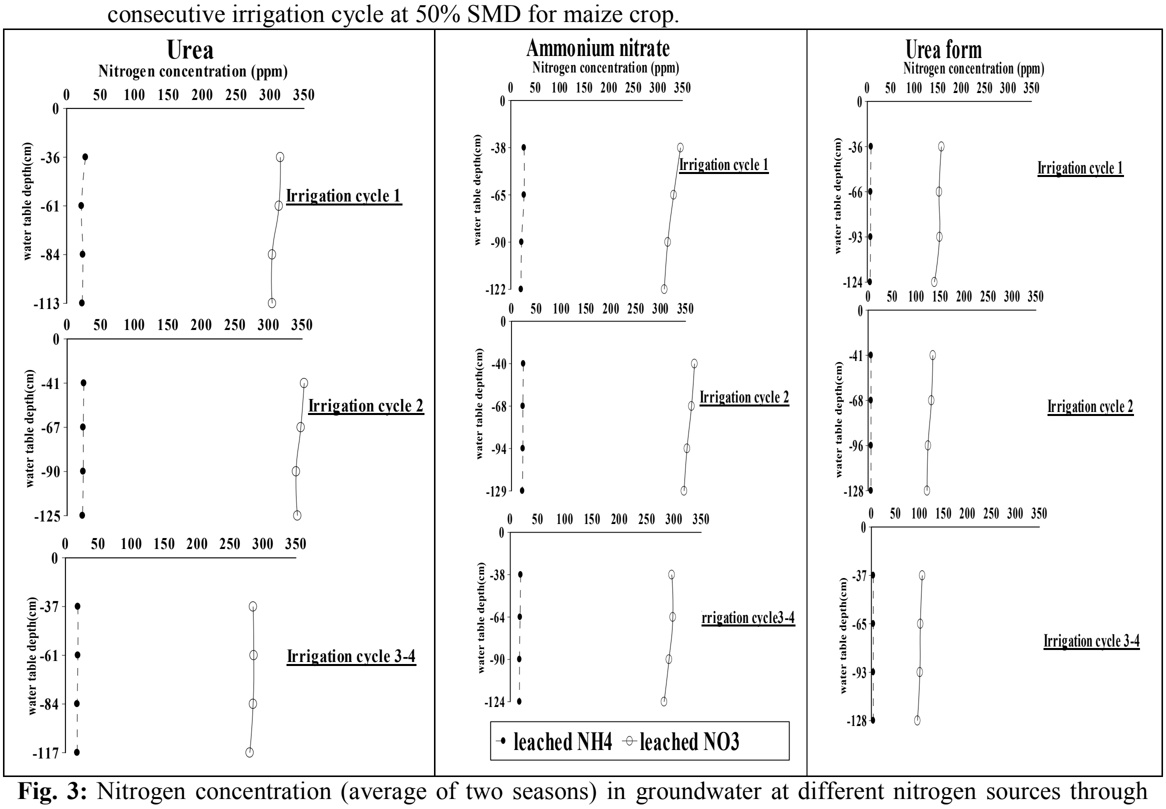

Fig. 3: Nitrogen concentration (average of two seasons) in groundwater at different nitrogen sources through consecutive irrigation cycle at 75% SMD for maize crop.

2- Water and nitrogen use efficiency

Data presented in Table (2) show the effect of irrigation regime and nitrogen sources on water and nitrogen use efficiency through two consecutive growing seasons of maize crop. Under all irrigation regime, maize crop water use efficiency ($CWUE_w$) could be arranged in descending order of ureaform > urea > ammonium nitrate. Regardless nitrogen sources, $CWUE_w$ could be arranged in descending order of 50 > 25 > 75 % SMD. The highest value of $CWUE_m$ (2.23 kg/ m^3 water) is recorded in treatment of 50 % SMD with ureaform fertilizer. The minimum $CWUE_m$ (1.51 kg/ m^3 water) value is attained under ammonium nitrate with 75 % of SMS. In all soil moisture depletion, nitrogen use efficiency by maize plants (NUE_w) could be arranged in descending order of ureaform > urea ≈ ammonium nitrate. Regardless nitrogen sources, NUE_w could be arranged in descending order of 25 > 50 > 75 % SMD. The highest value of NUE_m (36.51 kg/ kg N) is recorded in treatment of 25 % SMD with ureaform fertilizer. The minimum NUE_w value (20.87 kg/ kg N) is attained under ammonium nitrate with 75 % of SMD.

Wenlong *et al.* (2004) found that both soil water content and water use efficiency (WUE) (in terms of grain yield of maize) increased with increasing applied water. The mean WUE were 6.37, 5.61, 5.08 and 4.40 kg/ ha/ mm in 400, 300, 212 and 100 mm of water applied, respectively. WUE increased by increasing the applied N and P fertilizer. Despite many farmers still feeling that high N fertilizer rate is an ‘‘insurance’’ for crop yields,

Montemurro *et al*. (2006) highlighted the possibility to reduce the application of mineral fertilizer in the rotation maize–barley applying the N fertilizer (mineral and organic) only at the beginning of growth seasons, since good yields of both crops have been obtained. Therefore, the crop rotation could represent an important agronomical tool to increase N utilization and decrease the possible N losses, especially when high fertilizer levels are applied. Irrigation was more effective than nitrogen in increasing grain yield for both years and the irrigation water productivity was higher with irrigation regime.

Nitrogen use efficiency (NUE) of maize was high at deficit irrigation levels as compared to full and over irrigation levels (Gheysari *et al.,* 2009). N- use efficiency decreased with increasing amount of nitrogen applied and depended more on its applied level than on its interaction with P and water. At the same N level, N use efficiency increased with increasing irrigation level. NUE increased linearly with soil water availability and decreased with applied N. Adequate soil water availability led to both a better uptake and use of the N in the cell metabolic processes, increasing crop biomass and yield, and for this reason WUE and IRWUE were also positively affected by the amount of N fertilizer (Sun *et al*., 2009).

Table 2: Water and nitrogen use efficiency as affected by soil moisture depletion and nitrogen sources through two consecutive growing seasons of maize crop.

Treatment		Water consumptive use (m3/fed.)			Crop water use efficiency (kg/m3)			Nitrogen use efficiency(kg/kgN)		
Irrigation regime	Nitrogen fertilizer	2010	2011	Mean	2010	2011	mean	2010	2011	mean
25% SMD	U	2143	2158	2151	2.04	1.95	2.00	36.35	35.10	35.73
50% SMD		1905	1925	1915	2.24	2.14	2.19	35.52	34.27	34.90
75% SMD		1654	1679	1667	1.73	1.62	1.68	23.85	22.60	23.23
mean		1901	1921	1911	2.00	1.90	1.95	31.91	30.66	31.29
25% SMD	AN	2148	2160	2154	1.86	1.78	1.82	33.33	32.08	32.71
50% SMD		1910	1930	1920	2.09	1.99	2.04	33.23	31.98	32.61
75% SMD		1656	1674	1665	1.56	1.45	1.51	21.56	20.17	20.87
mean		1905	1921	1913	1.84	1.74	1.79	29.38	28.08	28.73
25% SMD	UF	2148	2160	2154	2.07	1.99	2.03	37.13	35.88	36.51
50% SMD		1908	1925	1917	2.27	2.18	2.23	36.15	34.90	35.53
75% SMD		1664	1684	1674	1.83	1.71	1.77	25.31	24.06	24.69
mean		1907	1923	1915	2.06	1.96	2.01	32.86	31.61	32.24
L.S.D 0.05	A				0.108	0.12		1.058	1.07	
	B				0.08	0.081		1.03	0.8	
	AB				0.13	0.12		1.08	n.s	
		Irrigation regime (A)			Nitrogen fertilizer source (B)					

U= urea *AN= ammonium nitrate* *UF= ureaform*

3- Monitoring changes in groundwater nitrate dynamics over two years

Field studies are critical for documenting N dynamics and losses; however, large-scale, multi-year studies are expensive and may not fully capture the range of the processes involved.

Data presented in table (3) show the effect of irrigation regime and nitrogen sources on nitrogen concentration in ground water through two consecutive years. Nitrogen losses is more pronounced under high soil moisture depletion and it could be arranged in descending order of 25 > 50 > 75 % SMD. The highest value of nitrogen loses is recorded in the treatment of using ammonium nitrate or urea with 75 % SMD causing a harmful effect of environmental conditions as a result of ground water pollution by nitrate losses. The lowest value of nitrogen loses is attained at ureaform treatment with 25 % SMD which is consider an environmental friendly as it has no risk to cause ground water pollution. The highest grain yield is recorded in treatment of using ureaform as nitrogen fertilizer at 25 % SMD which is complied with the main objective of environmental protection. The obtained yield could be arranged in descending order of ureaform > urea > ammonium nitrate under 25 > 50 > 75 % SMD.

Oikeh et al. (2003) have shown significant differences among temperate field crops (wheat and maize) in N uptake into the aboveground parts, and nitrate depletion particularly in the subsoil under the conditions of high N supply. The highest mineral N contents were found in the 60–90 cm soil layer, indicating considerable downward movement and accumulation of NO_3^- in subsoil in the preceding dry season. They found that mineral N losses is 35–122 kg/ ha from the 0 to 90 cm soil profile. They observed higher N losses in the high N treatments than that in the low one. N losses were not influenced by N application. Appropriate technology involving deep rooting plant species (e.g., legume–cover crops) that could survive the dry season to utilize this subsoil mineral N and serve as green manure in the following wet season need to be identified to overcome leaching losses. The recovery of mineral N from soil layers depends on the availability of soil mineral N and moisture, and the ability of the crop to take up mineral N from these layers more rapidly as the crop matures.

Table 3: Mean nitrogen (ppm) in ground water as affected by irrigation regime and nitrogen source measured at different sampling dates through two seasons.

Treatment		maize grain (ton/ fed)	WTD (cm)	N losses (ppm)			Total N losses (kg/ fd)
SMD	Fertilizer source			Apr. 09	Sep. 09	Sep. 10	
25 %	U	4.3	114.3	87.0	94.5	90.0	103.8
	AN	3.9	115.0	87.0	95.0	91.0	106.2
	UF	4.4	116.0	87.0	31.0	26.0	39.7
	Mean	4.20	115.10	87.0	73.50	69.00	83.23
50%	U	4.2	107.5	87.0	166.5	164.0	98.4
	AN	3.9	109.0	87.0	170.5	161.0	102.0
	UF	4.3	108.3	87.0	57.0	60.0	33.5
	Mean	4.13	108.27	87.0	131.33	128.33	77.97
75 %	U	2.8	111.3	87.0	248.0	241.0	88.4
	AN	2.5	113.8	87.0	259.0	254.0	93.3
	UF	3.0	119.8	87.0	89.5	86.0	31.7
	Mean	2.77	114.97	87.0	198.83	193.67	71.13

U= urea AN= ammonium nitrate UF= ureaform WTD= water table depth

4- Effect of water and fertilization management on yield and its component

Data presented in table (4) show the effect of irrigation regime and nitrogen fertilizer sources on maize yield and its component. In general, maize yield and its component are high significantly affected by irrigation regimes and nitrogen sources. Plant height decreases as the soil moisture decrease. The maximum plant height (256.75 cm) is recorded in treatment fertilized by ureaform when it irrigated at 50 % of SMD. The minimum value (234.80 cm) is realized in treatment fertilized by ammonium nitrate when it irrigated at 75 % of SMD. The highest value of seed index (38.65) is realized in plot fertilized by urea at 50% SMD. The lowest one (32.39) is attained in plot fertilized by ammonium nitrate at 75% SMD. The greatest value of grain yield (4.38 ton/ fed) is achieved in plot fertilized by of ureaform at 25 or 50% SMD. The lowest one (2.50 ton/ fed) is recorded in plot fertilized by ammonium nitrate at 75% SMD. The highest value of straw yield (5.47 ton/ fed) is achieved in plot fertilized by ureaform at 25 % SMD. The lowest one (3.90 ton/ fed) is recorded in plot fertilized by ammonium nitrate at 75% SMD. The greatest value of grain nitrogen (1.62 %) is achieved in plot fertilized by ureaform at 25 or 50% SMD. The lowest one (1.41 %) is recorded in plot fertilized by ammonium nitrate at 75% SMD. The greatest value of straw nitrogen (0.81 %) is achieved in plot fertilized by ureaform at 25 or 50% SMD. The lowest one (0.72 %) is recorded in plot fertilized by ammonium nitrate at 75% SMD. According to our study, the best agriculture management is to use ureaform fertilization at 50 % SMD since this practice gives the highest maize production with a good quality as well as minimizes the hazardous effect from the environment point of view.

Gheysari et al. (2009) found that when the corn's irrigation requirement cannot be satisfied, the amount of N fertilizer applied should be adjusted accordingly, as there is a smaller amount of N required to obtain optimum growth under water-limited conditions. Applying fertilizers without considering water availability could encourage N loss. Sun et al. (2009) found that the combined application of nutrients and irrigation exerted a synergistic effect on the grain yield of maize plants. They also, indicated that the plant biomass was always higher in the treatments with higher nitrogen supply, and under the same nitrogen supply level the plant biomass increased with improvement in the soil water condition, which implied that soil nitrogen did play a key role in the accumulation of plant biomass.

Productivity and resource-use efficiency in corn (Zea mays L.) are crucial issues in sustainable agriculture, especially in high-demand resource crops such as corn. Nitrogen fertilization of maize (*Zea mays* L.) has become an important economic and environmental issue, especially in high-yielding irrigated areas. Producers have traditionally applied more nitrogen fertilizer than required and, as a result, some environmental problems have appeared in recent decades. Nitrogen fertilization recommendations based only on plant nitrogen uptake were not correct and that nitrogen initial in soil should always be taken into account. It is known that nutrients uptake by plants is controlled by the external and internal ionic concentration, selectivity and plant energy levels as well as water absorption.

It is well known that plant roots extract more soil water from greater depths under moderate or long stress than plants irrigated at wet levels. Thus the water stored in soil of moderate or long irrigation can be used with more efficiency. Although, water use efficiency is not clearly depend on the water available if the supply is within evapotranspiration limit the crop yield and the opportunity to increase crop yield to depend on the adequacy of water supply. Water stress affects plant growth especially at critical periods of crop growth (flowering and grain filling periods). This water stress usually affects many important plant traits as plant height and seed index. These traits positively correlated with grain yield. The results suggest that best agriculture management is to use Urea form fertilizer at 50 % SMD for maize crop since this practice gave the highest yield with good quality as well as it minimized the hazardous effect on the environmental.

Table 4: Effect of irrigation regime and nitrogen fertilizer sources on maize yield and its component.

Treatments		maize yield and its component					
Fertilizer	Irrigation	Plant height (cm)	Seed index (g)	Grain yield (ton/fed)	Straw yield (ton/fed)	Nitrogen % in grain	Nitrogen % in straw
Urea	25%SMD	246.75	38.37	4.29	4.82	1.49	0.75
	50%SMD	247.0	38.65	4.19	5.27	1.48	0.75
	75%SMD	241.25	32.97	2.79	4.28	1.44	0.73
Ammonium nitrat	25%SMD	240.0	35.92	3.93	4.48	1.45	0.73
	50%SMD	247.0	34.8	3.91	4.42	1.45	0.73
	75%SMD	234.8	32.39	2.5	3.9	1.41	0.72
Ureaform	25%SMD	256.25	36.67	4.38	5.47	1.62	0.81
	50%SMD	256.75	37.75	4.26	5.41	1.62	0.81
	75%SMD	241.75	36.2	2.96	4.56	1.56	0.79
L.S.D 5%	A	0.75	1.01	0.114	0.075	0.022	0.01
	B	1.169	0.65	0.061	0.061	0.023	0.011
	AB	2.025	1.13	n.s.	0.105	0.04	0.019

Data average of two seasons A= irrigation regime B= fertilizer sources

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