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Deficit Irrigation and Nitrogen Fertilizers Effects on Crop Production and Environment Hazardous of Nitrate Leaching In Upper Egypt

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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° 12ˉ 16.67˭ N latitude and 31° 09ˉ 36.86˭ E longitude for two successive growing winter seasons of 2010/11 and 2011/12 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 wheat crop are 133, 158 and 178 ppm at 25, 50 and 75% SMD, respectively which increases by 19 and 34 % 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 ureaform 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 > ureaform. The amounts of leached nitrate as average values of two seasons of wheat crop are 193, 197 and 83 ppm under urea, ammonium nitrate and ureaform fertilizers, respectively which increased by about 135 % under urea or ammonium nitrate fertilizer compared to that under ureaform fertilizer.Wheat crop water use efficiency ($CWUE_w$) could be arranged in descending order of 50 > 25 > 75 % SMD. Regarding nitrogen sources it could be arranged in descending order of ureaform > urea > ammonium nitrate. The highest value of nitrogen use efficiency by wheat plants, NUE_w, (46.65 kg/ kg N) is recorded in treatment of 25 % SMD with ureaform fertilizer. 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, Nitrogen fertilizers, Nitrogen leaching, Water use efficiency, Nitrogen use efficiency, Wheat crop.

Introduction

Environmental protection is one of the priorities of the new aims of Egyptians agricultural policy; a compromise between the need to maximize yield and profit and an adequate use of irrigation water and nitrogen fertilizer is therefore required in order to reduce the impact of cultivation on the environment. There exist optimal, fertilizer/irrigation regimes which combine high yields, minimal leachates and reduced pollution risks; and such combinations are site, weather, crop-sequence and agronomic-practice dependent. The use of different levels of fertility additives in various practices will lead to unlike amounts of leachates and pollution risks, under dissimilar site-crops-managements combinations. One way to study these combinations is by monitoring long term fertilization experiments, in which various crops are maintained under several different combinations of added fertilizers, organic material and cultural practices. Recommended additives can be successful for a given set of conditions, and fail totally when applied in another set of conditions (e.g., equal fertilizer loads added in different forms). It is highly probable that there are no single, direct information-transfer functions available for dealing with intensive agricultural-practices, combined with reduced pollution risks. Each must be tested before its application is implemented (Hadasa *et al*., 1999).

Nutrient loss from ecosystems is among the top environmental threats to ecosystems worldwide, leading to reduced plant productivity in nutrient-poor ecosystems and eutrophication of surface water near nutrient-rich ecosystems. With increasing amounts of nitrogen (N) being added to farmland in the form of fertilizer to optimize crop yields, and more broadly, to meet the growing demands for food, feed and energy,

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there are public concerns regarding its possible negative impact on the environment. An optimal balance between N requirements for production versus efficient N use is required, so as to minimize N losses from the agricultural system. Increasing leached NO_3^--N may cause undesirable hazard consequences in terrestrial, freshwater and marine ecosystems, and detrimentally affect human health and work abilities. Accumulation of NO_3^- in water bodies, such as lakes and rivers and estuaries can result in eutrophication, over growth of algal bloom and death of aquatic life. Consumption of high concentrations of NO_3^- and its immediate reduced form, nitrite, may pose several human-health risks, including methemoglobinemia, gastric cancer, thyroid hypertrophy, reproductive toxicity and ulceration of mouth and/or lining of the stomach (Vitousek *et al*., 1997).

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. They also, stated that in order to avoid nitrogen loss, the amount of nitrogen fertilizer should be reduced in proportion to the amount of soil water available for plant water uptake under conditions of deficit irrigation. They also stated that the NO_3^--N leaching was 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. NO_3^--N leaching was affected by the amount of applied nitrogen fertilizer, initial soil nitrogen, leachate depth, crop growth stage, and crop N uptake. 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. N uptake decreased and final soil nitrogen increased for the deficit irrigation treatments as compared to the full irrigation treatments.

Therefore, in order to avoid nitrogen loss, the amount of nitrogen fertilizer should be reduced in proportion to the amount of soil water available for plant water uptake under conditions of deficit irrigation. Nitrate is leached down the soil profile with the downward movement of water. With optimum irrigation schedules and methods, water and N use efficiencies can be enhanced and nitrate leaching can also decrease further (Zotarelli *et al*., 2009). Adamtey *et al*. (2010) concluded that different sources of nitrogen 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-NH_4^+ and N-NO_3^- and to determine whether high crop yields can be attained, while minimizing risks of environmental impairment and aquifer contamination by lowering leachate 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 winter seasons of 2010/11 and 2011/12 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 ureaform 40% N as a slow nitrogen fertilizer).

In the winter seasons of 2010/11 and 2011/12, wheat seeds (*Triticum aestivum vulgar. CV Sids 1*) were sown on December 1st, in rows spaced 15 cm consuming 70 kg seed /fed. All the agronomic practices were applied as commonly used for growing wheat and carried out according to the recommendations set by the Ministry of Agriculture. Phosphorus fertilizer in the form of superphosphate (15.5% P_2O_5) was broadcasted during soil preparation processes at the rate of 100 kg superphosphate / fd. Potassium fertilizer was added in the form of potassium sulphate (48% K_2O) at the rate of 50 kg K_2O / fed. and it was divided in two equal doses added at the time of nitrogen fertilizer application. Ureaform slow release nitrogen fertilizer (100 kg N/ fd) was added to the soil before sowing. While urea and ammonium nitrate (100 kg N/ fd) 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. The plants were harvested 145 days after planting in each season. Four square meters from each plot were collected as samples for growth and yield measurements.

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:

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

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/fd)

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 (its diameter 10 mm and 175 cm length) embedded 10 cm into groundwater surface in the hole. 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:-

Four square meters (2m x 2m) from the centre of each plot were harvested to estimate the grain and straw yield of wheat while 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 wheat, ten plants were chosen randomly from each treatment to estimate the following characters.

I. Plant height (cm).	2. Seed index (g)	3. Grain yield (ton/ fed)
4. Straw yield (ton/ 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).

Results and Discussion

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. 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)

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 average of two successive growing seasons of wheat (2010/11 and 2011/12) 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 108 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. This is may be due to the nature of NO_3^- anion that is highly soluble makes it very easy to leach out of soil. While the NH_4 cation may adsorb on clay exchange sites. Nitrate is soluble and negatively charged and thus has a high mobility and potential for loss from the unsaturated zone by leaching (Chowdary *et al*., 2005). Through irrigation cycles No. 5-10 at 25% SMD, NO_3^--N concentration increases in ground water to reach up a value of 205 and 208 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 106 ppm for the corresponding fertilizers. Ureaform 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 value of NO_3^--N concentration in ground water ranges between 49 and 120 ppm. The NH_4-N concentration values in ground water show graduate decline slowly through consequent irrigation cycles and it ranges between 2 and 11 ppm. The little amounts of nitrogen in form of NH_4 which were detected in ground water may be explain on a basis of the fast changes of NH_4^+ form to NO_3^- form. Ammonium ions (NH_4^+) not immobilized or taken up quickly by higher plants are usually converted rapidly to NO_3^- ions by a process called nitrification. This is a two step process, during which bacteria called Nitrosomonas convert NH_4^+ to nitrite (NO_2^-), and then other bacteria, Nitrobacter, convert the $NO_2^-$to NO_3^-. This process requires a well aerated soil, and occurs rapidly enough that one usually finds mostly NO_3^- rather than NH_4^+ in soils during the growing season (Liu *et al*., 2003). Also, soil and climatic conditions on Upper Egypt soils are favorable for the processes of mineralization and nitrification.

Nitrogen concentration in ground water (ppm) in forms of ammonium (NH_4^+) and nitrate (NO_3^-) at different nitrogen sources with 50% SMD through different irrigation cycles as an average of two successive growing seasons of wheat (2010/11 and 2011/12) 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 ureaform. Under urea fertilization, NO_3^--N concentration values are 241, 224 and 149 ppm through irrigation cycles of 1-2, 3-5 and 6-8, respectively. NO_3^--N concentration values are 247, 229 and 154 ppm when soil fertilized by ammonium nitrate and they are 87, 60 and 38 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 1 and 11 ppm.

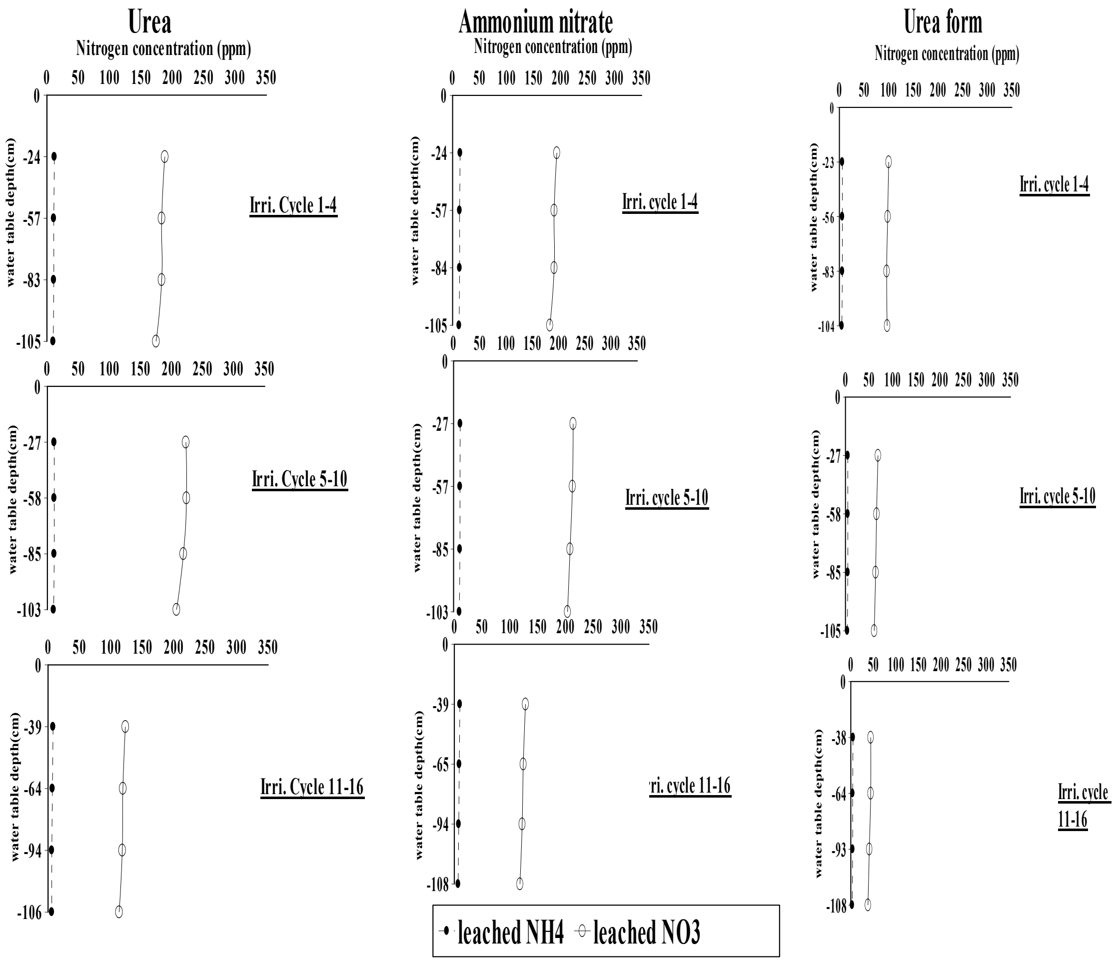

Fig.1: Nitrogen concentration (average of two seasons) in groundwater at different nitrogen sources through consecutive irrigation cycle at 25% SMD for wheat crop.

Nitrogen concentration in ground water (ppm) 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 wheat (2010/11 and 2011/12) 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 ureaform. Under urea fertilization, NO_3^--N concentration values are 248, 234 and 184 ppm through irrigation cycles of 1, 2-3 and 4- 5, respectively. NO_3^--N concentration values are 253, 251 and 195 ppm when soil fertilized by ammonium nitrate and they are 76, 54 and 21 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 1 and 12 ppm. It is worth while to mention that increasing the SMD % increases the NO_3^--N leaching when using urea or ammonium nitrate while the opposite trend is found when using urea form fertilizer. This may be due to urea or ammonium fertilizer is highly soluble or fast release fertilizer while urea form is slowly release fertilizer.

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 > urea form. 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 amounts of leached nitrate as average values of two seasons of wheat crop are 193, 197 and 83 ppm under urea, ammonium nitrate and urea form fertilizers, respectively. The leached amounts of nitrate increased by about 135 % 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. 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. 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).

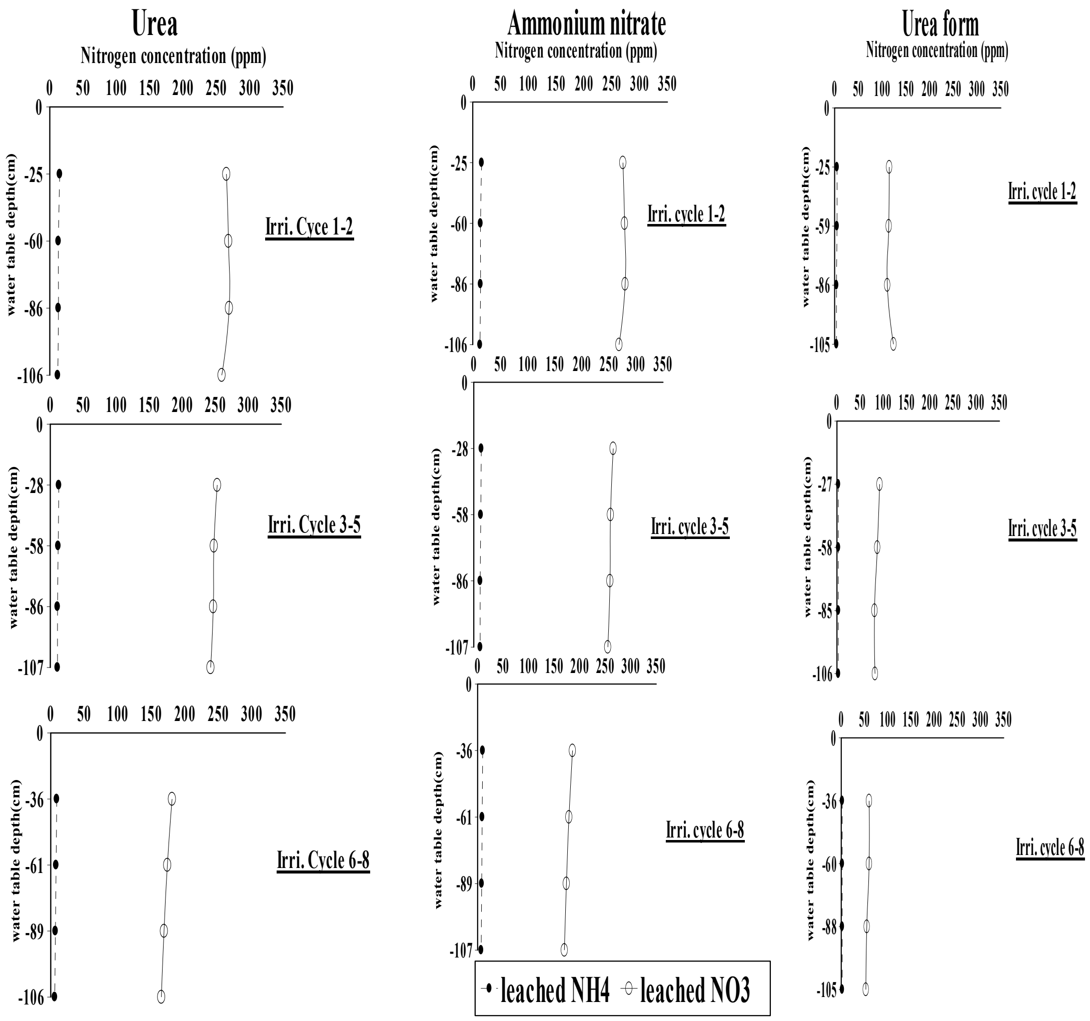

Fig.2: Nitrogen concentration (average of two seasons) in groundwater at different nitrogen sources through consecutive irrigation cycle at 50% SMD for wheat crop.

2- Water and nitrogen use efficiency

Irrigation water is becoming an increasingly limited resource in many areas especially in Egypt. Consequently, an appropriate choice of irrigation scheduling in order to maximize water use efficiency and profit is needed. An appropriate application of irrigation water and nitrogen fertilizer has the vital purpose of increasing water and nitrogen productivity and reducing environmental pollution risk. 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 wheat crop. Under all irrigation regime, wheat 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 $CWUE_w$ (1.58 kg/ m^3 water) is recorded in treatment of 50 % SMD with ureaform fertilizer. The minimum $CWUE_w$ (1.28 kg/ m^3 water) value is attained under ammonium nitrate with 75 % of SMD. In all soil moisture depletion, nitrogen use efficiency by wheat 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_w (35.91 kg/ kg N) is recorded in treatment of 25 % SMD with ureaform fertilizer. The minimum NUE_w value (26.87 kg/ kg N) is attained under ammonium nitrate with 75 % of SMD.

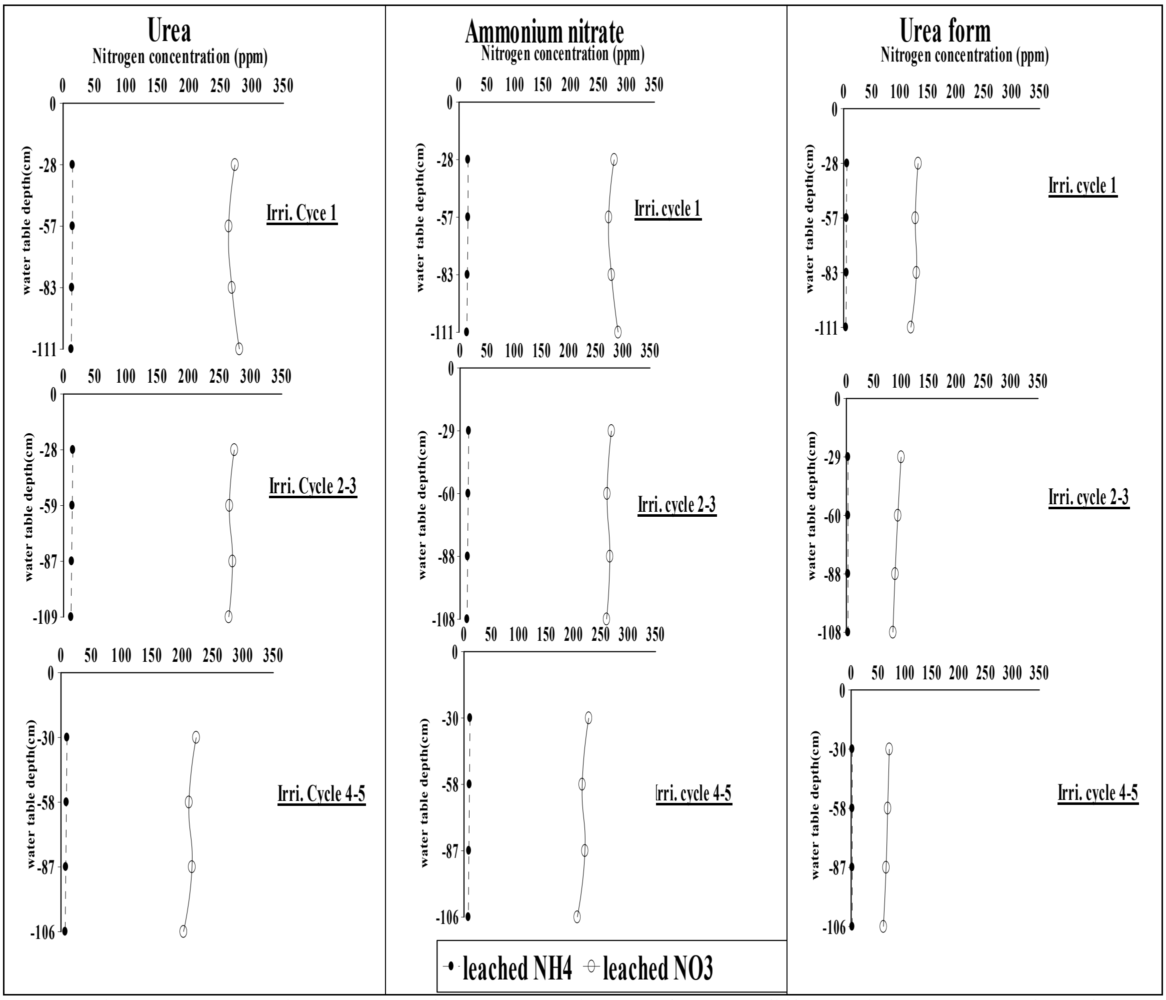

Fig.3: Nitrogen concentration (average of two seasons) in groundwater at different nitrogen sources through consecutive irrigation cycle at 75% SMD for wheat crop.

3- Monitoring changes in groundwater nitrate dynamics over two years

Nitrogen dynamics and N losses associated with mineral N applications to crop fields are complex and dynamic, with large year-to-year variability associated with climate, N management practices, and soil properties. 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.

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

Treatments		Water consumptive use (m^3/fed.)			Crop water use efficiency (kg/m^3)			Nitrogen use efficiency (kg/ kg N)		
Irrigation regime	Nitrogen fertilizer	2008/09	2009/10	mean	2008/09	2009/10	mean	2008/09	2009/10	mean
25% SMD	U	2290	2305	2298	1.48	1.46	1.47	34	33.68	33.84
50% SMD		2200	2220	2210	1.54	1.51	1.53	33.83	33.53	33.68
75% SMD		2070	2095	2083	1.30	1.28	1.29	27	26.75	26.88
mean		2187	2207	2197	1.44	1.42	1.43	31.61	31.32	31.47
25% SMD	AN	2295	2307	2301	1.46	1.44	1.45	33.50	33.30	33.40
50% SMD		2205	2225	2215	1.47	1.44	1.46	32.43	32.13	32.28
75% SMD		2072	2090	2081	1.28	1.28	1.28	27.05	26.68	26.87
mean		2191	2207	2199	1.41	1.39	1.40	30.99	30.70	30.85
25% SMD	UF	2295	2307	2301	1.57	1.55	1.56	35.98	35.83	35.91
50% SMD		2203	2220	2212	1.58	1.57	1.58	34.85	34.88	34.87
75% SMD		2080	2100	2090	1.40	1.37	1.39	29.13	28.83	28.98
mean		2193	2209	2201	1.52	1.50	1.51	33.32	33.18	33.25
L.S.D 0.05	A				0.058	0.07		0.95	0.97	
	B				0.030	0.031		0.93	0.931	
	AB				0.08	n.s		0.98	0.97	
Irrigation regime (A) Nitrogen fertilizer source (B)										

U= urea AN= ammonium nitrate UF= ureaform

Table 3: Mean nitrogen (ppm) in ground water as affected by irrigation regime and nitrogen source measured at different sampling dates through 4 seasons.

Treatments		Wheat grain (ton/ fed)	WTD (cm)	N losses (ppm)				Total N losses (kg/ fd)
SMD	Fertilizer source			Nov. 08	Apr. 09	Nov. 09	Apr. 10	
25 %	U	3.4	114.3	87.0	77.0	94.5	81.5	103.8
	AN	3.3	115.0	87.0	82.0	95.0	85.5	106.2
	UF	3.6	116.0	87.0	21.0	31.0	24.0	39.7
	Mean	3.43	115.10	87	60.0	73.50	63.67	83.23
50%	U	3.4	107.5	87.0	117.0	166.5	125.0	98.4
	AN	3.2	109.0	87.0	123.0	170.5	131.0	102.0
	UF	3.5	108.3	87.0	31.5	57.0	31.5	33.5
	Mean	3.36	108.27	87	90.50	131.33	95.83	77.97
75 %	U	2.7	111.3	87.0	180.5	248.0	184.0	88.4
	AN	2.7	113.8	87.0	161.5	259.0	189.0	93.3
	UF	2.9	119.8	87.0	49.0	89.5	48.0	31.7
	Mean	2.77	114.97	87	130.33	198.83	140.33	71.13

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

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.

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

Evaluating the response of crops to irrigation in combination with N fertilization could help identify the best allocation of available resources among crops in the farm in order to maximize profit and reduce groundwater pollution. Data presented in table (4) show the effect of irrigation regime and nitrogen fertilizer sources on wheat yield and its component. In general wheat yield and its component are high significantly affected by irrigation regimes and nitrogen sources. Plant height decreases as soil moisture decrease. The maximum plant height (121.60 cm) is recorded in treatment fertilized by ureaform when it irrigated at 25 % of SMD. The minimum value (112.90 cm) is shown in treatment fertilized by ammonium nitrate when it irrigated at 75 % of SMD. The highest value of seed index (46.30) realized in plot fertilized by ureaform at 25% SMD. The lowest one (41.90) is attained in plot fertilized by ammonium nitrate at 75% SMD. The greatest value of grain yield (3.59 ton/ fed) is achieved in plot fertilized by ureaform at 25 SMD. The lowest one (2.68 ton/ fed) is recorded in plot fertilized by ammonium nitrate at 75% SMD. The greatest value of straw yield (3.04 ton/ fed) is achieved in plot fertilized by ureaform at 25 % SMD. The lowest one (1.85 ton/ fed) is recorded in plot fertilized by ammonium nitrate at 75% SMD. The greater value of grain nitrogen (2.71 %) is achieved in plot fertilized by urea at 75 % SMD. The lowest one (2.20 %) is recorded in plot fertilized by ammonium nitrate at 25% SMD. The greatest value of straw nitrogen (1.19 %) is achieved in plot fertilized by urea at 75% SMD. The lowest one (1.08 %) is recorded in plot fertilized by ammonium nitrate or ureaform at 50% SMD. According to our study, the best agriculture management is to use ureaform fertilization at 25 % SMD since this practice gives the highest wheat production with a good quality as well as minimizes the hazardous effect from the environment point of view.

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

Parameter	Treatment	Wheat (100 kg N/ fd.)		
		Urea	Ammonium Nitrate	Ureaform
Plant height (cm)	25%SMD	120.3	118.7	121.6
	50%SMD	117.1	116.9	118.8
	75%SMD	114.2	112.9	114.8
	L.S.D 5%	A	B	AB
		0.43	0.32	0.55
Seed index (g)	25%SMD	44.3	43.2	46.3
	50%SMD	44.0	43.0	45.4
	75%SMD	42.4	41.9	43.0
	L.S.D 5%	A	B	AB
		0.4	0.33	0.6
Grain yield (ton/fed)	25%SMD	3.38	3.34	3.59
	50%SMD	3.37	3.23	3.48
	75%SMD	2.69	2.68	2.90
	L.S.D 5%	A	B	AB
		0.03	0.03	0.05
Straw yield (ton/fed)	25%SMD	2.39	2.16	3.04
	50%SMD	2.39	2.02	2.84
	75%SMD	2.15	1.85	2.31
	L.S.D 5%	A	B	AB
		0.10	0.07	0.13
Nitrogen % in grain	25%SMD	2.59	2.20	2.48
	50%SMD	2.30	2.32	2.38
	75%SMD	2.71	2.45	2.60
	L.S.D 5%	A	B	AB
		0.03	0.04	0.07
Nitrogen % in straw	25%SMD	1.14	1.15	1.14
	50%SMD	1.15	1.08	1.08
	75%SMD	1.19	1.15	1.12
	L.S.D 5%	A	B	AB
		0.26	0.04	n.s.

Average of two seasons *A= irrigation regime* *B= fertilizer sources*

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. 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 Ureaform fertilizer at 25 % SMD for wheat crop since this practice gave the highest yield with good quality as well as it minimized the hazardous effect on the environmental.

However, little attempt has been made so far to quantify mineral N dynamics under different crops. Such information will be relevant for further initializing work on N-use efficiency and improvement in N resource management for sustainable crop production. 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.

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