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IMPACT OF SPLITTING SOME SOURCES OF NITROGEN FRTILIZER ON WHEAT PRODUCTIVITY AND NITROGEN USE EFFICIENCY

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ABSTRACT

Maximizing nitrogen use efficiency (NUE) is an increasingly important aspect of crop management systems because of both economics and environment pressures. Studies to increase profitability and NUE in winter wheat (Triticum aestivum L.) production are needed to develop more sustainable systems in El-Sharkia Governorate. Two field experiments were carried out at an administration field at Sheiba Village, El-Zagazig District, El-Sharkia Governorate. Egypt during two winter seasons 2007/2008 and 2008/2009 to investigate the effect of splitting some sources of nitrogen fertilizer on wheat yield, yield components and nitrogen use efficiency. The study included nine treatments, which were the combinations of three nitrogen sources (urea, ammonium nitrate and ammonium sulfate) and three splitting of N (one split at sowing, two equal splits given at sowing and tillering stages and three equal splits given at sowing, tillering and jointing stages. A split plot design was followed with three replicates. The three nitrogen sources were allotted to the main plots, whereas the three nitrogen splitting treatments were distributed at random in the sub plots.

The results indicate that plant height, number of productive tillers/plant, flag leaf area, number of grains/spike, number of spikes/m^2, grain yield, straw yield and grain protein % were not significantly affected by nitrogen sources. No significant difference between urea and ammonium nitrate on spike length, grain weight/spike, 1000-grain weight and grain carbohydrate % were noted. Ammonium nitrate improved N recovery efficiency, contributing to improve N use efficiency. The results show that nitrogen splitting affected most characters under this study. The split of nitrogen into three equal doses was favorable than the other two treatments. However, no significant differences among nitrogen splitting treatments on number of productive tillers/plant, flag leaf area and 1000-grain weight. Nitrogen splitting improved N recovery *efficiency and N use efficiency over comparable all nitrogen fertilizer sources. Nitrogen recovery efficiency and N use efficiency were greatest when N applications were split into three equal doses. The interaction effects between nitrogen sources and their splitting were significant on flag leaf area, spike length, number of grains/spike, grain weigh/spike, grain yield and grain carbohydrate %. The grain yield, its components and N use efficiency were superior by the increase of nitrogen splitting under ammonium nitrate than the other nitrogen sources. It is apparent from this study that for maximum grain yield production of wheat and N use efficiency in dryland areas, such as in El-Sharkia Governorate, the N requirement should be applied in three split doses at sowing, tillering and jointing stages as ammonium nitrate.*

Keyword: N use efficiency, wheat, split, N source.

INTRODUCTION

Maximizing nitrogen use efficiency (NUE) is an increasingly important aspect of crop management systems because of both economics and environment pressures. Interventions to increase NUE and reduce N losses to the environment must be accomplished at the farm- or field scale through improved N technologies that contribute to the adoption of improved N management practices (Dobermann, 2008; Dobermann and Cassman, 2005). Lower NUE in farmer's fields is usually explained by a lower level of management under practical farming conditions and greater spatial variability of factors controlling the recovery efficiency of N (Cassman *et al.* 2002). Considering this, NUE achieved in research trials is a good indicator of what can be targeted with good management (Dobermann, 2008).

Improved understanding of nitrogen sources effects on wheat production and NUE is needed for optimal management of nitrogen in crop production systems (He *et al*.1999). Urea and ammonium sulfate are widely used in El-Sharkia Governorate and increasingly expensive input in wheat production and the efficiency of their use is thus an important consideration for agronomists and wheat producers. Effective use of urea and ammonium sulfate on crop requiring surface fertilizer application is limited by high ammonia NH_3 loss. Approximately 10-40% of N as urea and ammonium sulfate applied to soils is volatilized during the growing season, especially N from alkaline and calcareous soils (Gezgin and Bayrakll, 1995; Roelcke *et al*, 1996). Many studies have evaluated the effect of N source on wheat production. In general, ammonium nitrate has been shown to perform than urea and ammonium sulfate in sandy soils (Hassan and Gaballah, 2000; EL-Hindi *et al*., 1998). However, Mohamed *et al*. (1992) on sandy soil showed that ammonium sulfate performed better than ammonium nitrate while Gately (1994) found that calcium ammonium nitrate was better than urea. Moselhy (1995) recorded an increase in grain and straw yields of wheat due to addition of N-fertilizer in form of ammonium sulfate or calcium nitrate forms. Similar results were found by EL-Kayati *et al.* (1995), Abd EL-Maaboud (1991), Abdul- Galil *et al* (1997), Abd EL-Zaher (1997) Hassanein *et al.* (1997) and Zohry *et al.* (1998). Abdel-Hamid and Mohamed (2000) showed that urea and ammonium sulfate have been shown to perform equally as N-fertilizer source. Saleh (2001) showed that urea had favorable effect on yield and yield attributes of wheat compared with ammonium nitrate.

Splitting of nitrogen fertilizer is considered as a method for increasing the nitrogen fertilization efficiency. Extensive studies have reported the advantages of splitting N fertilizer on increasing yield components, grain, straw yields and grain protein yield of wheat (Sadek, 1990; Megahed, 1991; Mohamed and Tamman, 1998 and EL-Desoky and El-Far, 1999). Splitting of nitrogen fertilizer was found to increase grain yield of wheat due to the increases in the number of spikes / m^2 and grain weight / spike (Dawood, 1994 and Hanaa and Abdel-Mottaleb, 1998). Moselhey (1995), Abdel El-Hakeem (1996) and Abdul.Galil *et al* (2000) reported that each increase in number of N splits from five to seven increased significantly plant height, number of tillers / plant, number of spikes / m^2, spike length, 1000-grain weight, straw yield and grain yield. The same results were reported by Abd El-Maksoud and Maha Abd Alla (2003) in barley. EL-Hosary *et al.* (2000) and Saleh (2003) showed that, the application of N levels in four equal doses up to 75 kg N/fad and 100 kg N/fad gave significant values of protein and dry gluten %-age compared with adding N rate in three doses up to 75 kg/fad and added that application of nitrogen in four or five equal doses had favorable effect on number of grains / spike, grain yield and its attributes, except grain weight.

The objective of the present study was to improve wheat productivity and fertilizer nitrogen use efficiency through improved timing of N application and N fertilizer source that contribute to the adoption of improved N management practices.

MATERIALS AND METHODS

Soil characteristics

Two field experiments were carried out at an administration field at Sheiba Village, El-Zagazig District, El-Sharkia Governorate. Egypt during two winter seasons 2007/2008 and 2008/2009. Selected properties of the upper 30-cm layer of the experimental soil prior to conducting the study are presented in Table 1. Soil characteristics were carried out according to the recommended procedures of Baruach and Barthakur (1997).

Table 1. Selected properties of the studied soil.

Particle size distribution			Textural Class	Organic carbon	$CaCO_3$	pH 1:1	Forms of soil nitrogen		
Clay	Silt	Sand					Total-N	NH_4-N	NO_3-N
g kg^{-1}				g kg^{-1}			mg kg^{-1} soil		
550	250	200	Clay	15.70	42.0	7.89	856	12	8

Treatments and experimental design:

The study included nine treatments, which were the combinations of three nitrogen sources (urea 46% N, ammonium nitrate 33 % N and ammonium sulfate 20.5 % N) and three splitting of N (one split at sowing, two equal splits given at sowing and tillering stages, *i.e.* 0 and 30 days after sowing (DAS) and three equal splits given at sowing, tillering and jointing stages, i.e. 0, 30 and 60 DAS.

A split plot design was followed with three replications. The three nitrogen sources were allotted to the main plots, whereas the three nitrogen splitting treatments were distributed at random in the sub plots. The area of the sub-plot was 9 m^2 (3 x 3) including 15 rows, 3 m long and 20 cm between the rows. The preceding crop was maize in the two growing seasons.

Agronomic practices:

Winter wheat, Sakha 93 cultivar was sown on November 15 in both seasons at a rate of 80 kg fad^{-1}. Nitrogen fertilizer sources were applied to wheat plots uniformly top-dressing at the rate of 80 kg N fad^{-1}. The experimental plots were also fertilized with calcium mono-phosphate (15.5 % P_2O_5) at a rate of 100 kg fad^{-1}, before sowing. The other recommended cultural practices of growing wheat crop were followed.

Sampling and plant N determination:

Ten graded plants were labeled at seedling stage from each sub plot for recording yield attributes at harvest time, where the following plant growth attributes were determined: plant height, flag leaf area, number of productive tillers / plant, number of spikes / m^2, spike length, number of grains / spike, grain weight / spike, grain weight/plant and 1000-grain weight.

In addition, the central two rows of each sub-plot were harvested to measure grain yield, straw yield, grain protein content and grain carbohydrate content. Grain samples of the two seasons from plots of each treatment were mixed together for N determination.

The total N content was determined using the modified micro-Kjeldahl apparatus as described by A.O.A.C. (1988) and the obtained values were multiplied by 5.7 to calculate crude protein percentage. Total carbohydrate content was determined calorimetrically according to the method of Dubois *et al.* (1956).

The relationship between plant, soil N and grain yield was defined as nitrogen use efficiency which is comprised of the nitrogen uptake efficiency and nitrogen utilization efficiency were calculated as described by Huggins and Pan (1993) as follows:

Nitrogen use efficiency = [grains yield / N-supply] (1)

Nitrogen recovery efficiency = [total plant N uptake / N-supply] (2)

Nitrogen utilization efficiency = [grains yield / total plant N uptake] (3)

N-supply was estimated as the sum of (i) preplanting inorganic soil N, (ii) N fertilizer and (iii) mineralized N. The amount of N mineralized was estimated as the differences between preplanting inorganic soil N and post harvest plant and soil inorganic N in the control plots (0 N)

Statistical analysis:

Analysis of variance and combined analysis for the two seasons were carried out as described by Snedecor and Cochran (1990). For comparison between means, Duncan's multiple range tests were applied (Duncan, 1955).

RESULTS AND DISCUSSION

1. Plant growth characters:

1.1. Effect of N- source

Data reported in Table 2 show that plant height, flag leaf area and productive tillers per plant of wheat were not significantly affected by the tested nitrogen sources. This was a fact in both growing seasons and their combined. Similar results were reported by El-Hefnawy *et al*. (1991**)** and Moselhy (1995).

In spite of, the fact that spike length of wheat was significantly affected by nitrogen sources it is clear that the number of spikes /m^2 and the number of grains /spike were not affected significantly in the two growing seasons and their combined (Table 3). Both urea and ammonium nitrate gave longer spikes than those of ammonium sulfate. This was true in the first season and the pooled data, whereas in the second season, adding of ammonium nitrate fertilizer achieved the longest spikes while adding of ammonium sulfate recorded the shortest ones. Grain weights per spike and per plant were significantly influenced by nitrogen sources as shown in Table 3. Ammonium nitrate produced the heaviest grains per spike and per plant whereas; ammonium sulfate gave the lightest ones. This was clear in the combined analysis.

Table 2. Effect of splitting nitrogen fertilizer sources on some plant growth characters of wheat in the two growing seasons and their combined.

Main effects & interactions	Spike length (cm)			Number of grains/spike			Number of spikes/m^2		
	First season	Second season	Comb.	First season	Second Season	Comb.	First season	Second Season	Comb.
N sources (A)									
Urea	10.6^{a}	10.4^{b}	10.5^{a}	36.8	37.7	37.3	299.2	292. 9	296.1
Amm. sulphate	9.9^{b}	9.8^{c}	9.8^{b}	34.6	35.9	35.3	293. 6	283. 6	288.6
Amm. nitrate	10.7^{a}	10.7^{a}	10.7^{a}	36.5	36.7	36.6	288. 7	304.2	296.4
F-test	**	**	**	N. S.	N. S.	N. S.	N S	N. S.	N. S.
N splitting (B)									
One split	9.8 c	9.7^{c}	9.8^{c}	33.6^{b}	34.9^{c}	34.7^{c}	256.0^{b}	259.0^{b}	257.5^{c}
Two splits	10.3b	10.3 b	10.3 b	36.8 a	36.5'	36.6b	285.4^{b}	280.2^{b}	282.8^{b}
Three splits	11.2a	10.9a	11.7a	37.5^{a}	38.9^{a}	38.2^{a}	340.0^{a}	341.4^{a}	340.7^{a}
F-test	**	**	**	**	**	**	**	**	**
Interaction AxB	NS	NS	NS	*	NS	**	NS	NS	NS

Table 3. Effect of splitting nitrogen fertilizer sources on some spikes characters of wheat in the two growing seasons and their combined.

Main effects & interactions	Plant height (cm)			Flag leaf area (cm^2)			No. of productive tillers / plant		
	First season	Second season	Comb.	First season	Second season	Comb.	First season	Second season	Comb.
N sources (A)									
Urea	110.2	111.0	110.6	18.2	17.9	18.0	3.86	3. 8	3.8
Amm.sulphate	110.1	111.1	110.9	17.9	18.7	18.4	3.67	3.7	3.8
Amm. nitrate	108. 9	114.2	111.6	18.5	19.5	19.0	4.09	4.1	4.1
F-test	N.S.	N.S.	N.S.	N. S.	N. S.	N. S.	N.S.	N.S.	N.S.
N splitting (B)									
One split	106.1^{b}	108.7^{b}	107.4^{c}	18.6	18.8	18.7	3. 6	3. 9	3.7
Two splits	109.8^{ab}	111.3^{b}	110.6^{b}	17.8	19.0	18.4	3.9	3.9	3. 9
Three splits	114.0^{a}	116.3^{a}	115.2^{a}	18.1	18.5	18.3	4.2	3. 8	4.0
F-test	**	**	**	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.
InteractionAxB	N.S.	N.S.	N.S.	*	N.S.	N. S.	N.S.	N.S.	N.S.

1.2. Effect of N split:

The results presented in Tables 2 and 3 indicated that splitting of nitrogen fertilizer has highly significant effects on plant height and number of spikes / m^2 whereas, did not affect both flag leaf area and number of the productive tillers per wheat plant. In the first season, N splitting from one to two up to three splits gradually increased plant height, whereas in the second season wheat plants were taller by adding N at three splits comparing to the two N splitting. The later trend was observed for number of spikes / m^2 in the two growing seasons. However, the combined analysis revealed that the increase in N splitting was followed by a significant increase in plant height and number of spikes/m^2. Generally, it can be noted that spike length, number of grains/spike, grain weight per both spike and plant were positively and significantly responded to raising the N splitting from one to two or from two to three splits as shown in Tables 3 and 4. This was a fact in both growing seasons and their combined for the four yield components except number of grains / spike in the first season, so there is no significant difference between two and three N splits.

1.3. Effect of interaction:

The most important interaction effects of both factors of study were found in the case of number of grains / spike and grain yield. These were shown in Figure 1. Though there was no significant effect of nitrogen fertilizer source on number of grains / spike, yet it interacted significantly with splitting of the added fertilizer. As a general trend the number of grains / spike increased with increasing number of splitting irrespective of the source. On the other direction ammonium nitrate performed better than ammonium sulfate under any number of splitting. Urea was better than ammonium sulfate (one split); however, there were no significant differences when urea was splited.

2. Yield and yield attributes:

2.1. Effect of N source:

Using ammonium sulfate produced lighter 1000-grain comparing with those under the two other nitrogen fertilizer sources as shown for the combined in Table 4. In general, it can be noted that both grain yield and straw yield was not significantly influenced by nitrogen sources in the two growing seasons (Tables 4 and 5). Grain yield under application of ammonium nitrate was slightly increased by about 3.97% than that under application of ammonium sulfate. Also, harvest index took the same trend of grain and straw yields in the first season as well as the combined. Whereas, in the second season urea achieved higher value of harvest index than that

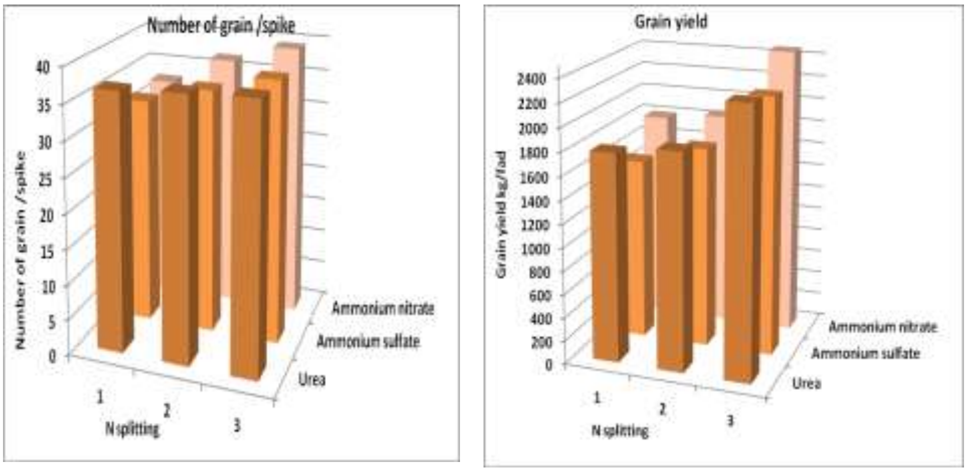

Figure 1. Interaction effect of nitrogen fertilizer sources and their splitting on N. of grains/spike and grain yield of wheat in the two seasons.

under addition of ammonium nitrate (Table 5). The same trend was confirmed by El-Hindi *et al*. (1998); Abd el-Hamid and Mohamed (2000); Hassan and Gaballah (2000); Saleh (2001) and (2003).

Data reported in Table 6 show that grain protein %-age was not affected by various nitrogen sources in both seasons and pooled data. Concerning carbohydrate percentage in wheat grains, it can be noted that ammonium nitrate produced higher percent comparing with ammonium sulfate in both seasons and pooled data; meanwhile, no significant difference was recorded between ammonium nitrate and urea in the second season and combined analysis.

In general, from the aforementioned results, it can be concluded that ammonium nitrate was a suitable fertilizer as nitrogen source for wheat crop in clay soils. This may be due to the superiority of ammonium nitrate over ammonium sulfate or urea as N source for wheat under conditions of this study due to one or more of the following reasons: Ammonium nitrate containing N in the readily available forms for plant absorption, i.e., NH_4^+ and NO^-_3 ions (Foth and Ellis, 1997). Urea-N becomes available for plant absorption only after its hydrolysis process to firstly NH_4^+ and then NO^-_3-N. These processes consumed more time that may be prolonged to more than 28 days in such studied soils (Abd El-Bary and Metwally, 2001). The greater losses of nitrogen through NH_3 volatilization from urea and ammonium sulfate compared with ammonium nitrate as the soil is alkaline (pH > 7.8). Ammonium ions released from ammonium sulfate or formed after urea hydrolysis are adsorbed on soil colloids and become available for plant uptake

Table 4. Effect of nitrogen fertilizer sources and their splitting on some yield attributes of wheat in the two seasons and their combined.

Main effects & interactions	Grain weight /spike, g			Grain weight /plant, g			1000-grain weight, g		
	First season	Second season	Comb.	First season	Second Season	Comb.	First season	Second Season	Comb.
N sources (A)									
Urea	1.66ab	1.78ab	1.72b	6.39b	6.72a	6.55b	45.00	47.32	46.16a
Amm. sulphate	1.44b	1,51b	1.47c	5.27c	5.6lb	5.44c	41.62	42.00	41.81b
Amm. nitrate	1.66 a	1.64a	1,67a	6.81 a	6.65a	6.73a	46.31	44.84	45.58a
F-test	*	*	**	**	*	**	N.S.	N.S.	*
N splitting (B)									
One split	1.52[c]	1.57[c]	1.54[c]	5.39[c]	6.09[c]	5.74[c]	45.24	44.94	45.09
Two splits	1.61[b]	1.64[b]	1.63[b]	6.23[b]	6.41[b]	6.32[b]	43.71	45.04	44.38
Three splits	1.62 [a]	1.72 [a]	1.68 [a]	6.79[a]	6.49[a]	6.64[a]	43.28	44.18	44.08
F-test	**	**	**	**	**	**	N.S.	N.S.	N.S.
InteractionAx B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 5. Effect of nitrogen fertilizer sources and their splitting on yield and harvest index of wheat in the two seasons and their combined.

Main effects & interactions	Grain yield, fad^{-1}			Straw yield, fad^{-1}			Harvest index		
	First season	Second season	Comb.	First season	Second season	Comb.	First season	Second season	Comb.
N sources (A)									
Urea	1.895	2.056	1.985	1.685	1.585	1.635	53.08	56.67a	54.88
Amm. sulphate	1.940	1.984	1.962	1.398	1.611	1.505	58.26	54.67[ab]	56.46
Amm. nitrate	1.983	2.097	2.040	1.415	1.912	1.663	58.36	52.11b	55.23
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.
N splitting (B)									
One split	1.670b	1.755b	1.712b	1.306[b]	1.553[b]	1.429[c]	53.41[b]	54.93 [b]	53.41[b]
Two splits	1.772b	1.847b	1.809b	1.418b	1.753b	1.585b	51.572b	51.81b	51.57b
Three splits	2.373a	2.535 a	2.455a	1.778a	1.801a	1.788a	58.475a	57.834a	58.48a
F-test	**	**	**	**	**	**	**	**	**
InteractionA x B	N.S.	*	**	N.S.	N.S.	N.S.	N.S.	*	N.S.

Table 6. Effect of nitrogen fertilizer sources and their splitting on protein and carbohydrate in wheat grains in the two seasons and their combined.

Main effects & interactions	Protein %-age			Carbohydrate %-age		
	First season	Second season	Combined	First season	Second season	Combined
Nitrogen sources (A)						
Urea	**15.411**	**16.056**	**15.733**	**59.889 b**	**63.889a**	**61.889a**
Amm. sulphate	**16.067**	**15.556**	**15.811**	**58.333 b**	**58.667b**	**58.500b**
Amm. nitrate	**15.233**	**15.189**	**15.211**	**64.000 a**	**62.778 a**	**63.389a**
F-test	**NS**	**NS**	**NS**	*****	*****	*****
Nitrogen splitting (B)						
One split	**14.733 c**	**14.833 c**	**14.783 c**	**54.556 c**	**54.556 c**	**54.556c**
Two splits	**15.733 b**	**15.689 b**	**15.711 b**	**61.000b**	**61.889 b**	**61.444b**
Three splits	**16.244 a**	**16.278 a**	**16.261 a**	**66.667 a**	**68.889 a**	**67.778a**
F-test	******	******	******	******	******	******
Interaction A x B	*****	***NS***	***NS***	***NS***	***NS***	***NS***

2.3. Interaction effect:

Regarding the grain yield, it showed almost similar behavior to that of grain number/spike. Ammonium sulfate was inferior to the other two sources when applied all at sowing, but it was better than the other two sources when split was done to 3 equal doses (Figure 1). On the other direction grain yield was higher when the splits were three and both application and two splits were statistically equal.

3. Nitrogen Recoveries

3.1 Effect of N source

Results presented in Table 7 demonstrated that N-content in grain and straw wheat were not significantly affected by the tested nitrogen sources. This was a fact in both growing seasons and their combined. However, N-uptake by grain and straw wheat was significantly affected by nitrogen sources. Both ammonium sulfate and ammonium nitrate gave higher uptake by grain than those of urea and this was true in the tow seasons. Urea gave higher uptake by straw in the first season, whereas in the second season, adding of ammonium nitrate fertilizer achieved the higher uptake by straw while adding of urea recorded the lowest ones. In general, it can be noted that total plant N-uptake was significantly influenced by nitrogen sources in the two growing seasons (Table 8). Total plant N-uptake ranked similarly to N-uptake by grain, the differences among nitrogen sources were significant.

Table 7. Effect of nitrogen fertilizer sources and their splitting on nitrogen content and uptake by wheat in the two seasons and their combined.

Main effects and interactions	Nitrogen concentrations, g kg^{-1}				Nitrogen uptake, kg fad^{-1}			
	Grain		Straw		Grain		Straw	
	First season	Second season	First season	Second Season	First season	Second Season	First season	Second Season
N sources (A)								
Urea	29.0	28.2	7.8	6.3	39.8b	47.9b	13.1a	9.9a
Amm. sulphate	28.2	27.3	7.2	8.0	52.7a	54.2a	10.1b	12.9b
Amm. nitrate	26.7	26.6	6.3	7.1	52.9a	55.8a	8.9c	13.6c
F-test	NS	NS	NS	NS	*	*	*	*
N splitting (B)								
One split	25.8	26.0c	6.3b	7.8	43.1c	45.6c	8.2b	12.1
Two splits	27.6	27.5b	8.0a	7.2	48.9b	50.1b	11.3a	12.6
Three splits	28.5	28.6a	6.9b	7.1	67.6a	72.3a	12.3a	12.8
F-test	NS	NS	NS	NS	*	**	*	NS
Interaction A x B	NS	NS	NS	NS	NS	*	*	*

Table 8. Effect of nitrogen fertilizer sources and their splitting on nitrogen recovery by wheat in the two seasons and their combined.

Main effects and interactions	Nitrogen Use Efficiency			Nitrogen Recovery Efficiency			Total nitrogen uptake, kg fad^{-1}		
	First season	Second season	Comb.	First season	Second Season	Comb.	First season	Second Season	Comb.
N sources (A)									
Urea	15.8b	16.5	16.2	43.6c	54.1	48.85	52.9[b]	57.8[b]	55.35b
Amm. sulphate	16.2a	15.9	16.1	53.3a	53.4	53.35	62.8[a]	67.1[a]	64.95a
Amm. nitrate	16.5a	16.8	16.7	51.3b	55.2	53.25	61.8[a]	69.4[a]	65.6a
F-test	*	NS	NS	*	NS	NS	*	*	
N splitting (B)									
One split	13.4c	14.0c	13.7b	44.8c	46.0c	45.4b	51.3c	57.7c	54.5c
Two splits	14.8b	14.8b	14.8b	49.6b	49.9b	49.75b	60.2b	62.7b	61.45b
Three splits	19.8a	20.3a	20.05a	65.8a	67.7a	66.75a	79.9a	85.1a	82.5a
F-test	*	**	*	**	**	*	*	*	*
InteractionAx B	NS	*	*	NS	NS	*	*	*	*

These data confirms the numerous reports in the literature (Dhugga and Waines, 1989) that dry matter accumulation pattern, rather than N concentration differences determine N uptake. Ammonium nitrate and ammonium sulfate improved N recovery efficiency rather than urea, contributing to improve N use efficiency in the first season, whereas in the second season was not affected significantly by various nitrogen sources.

These results were not consistent with other studies where relatively low soil pH values reduced volatilization losses from surface N fertilizer applications (Mahler *et al.*, 1994).

3.2. Effect of N split:

Analysis of variance indicates that N-content in grain and straw wheat were not significantly affected by the main effects of splitting of nitrogen fertilizer. However, N-uptake by grain and straw wheat was increased by increasing N splitting from one to three splits (Table 7). Total plant N-uptake ranked similarly to N-uptake by grain, the differences among nitrogen splitting were significant and this was true in the two growing seasons and their combined (Table 8). N splitting from one to two up to three splits gradually increased total plant N-uptake. Nitrogen splitting improved N recovery efficiency and N use efficiency over comparable all nitrogen fertilizer sources. Nitrogen recovery efficiency and N use efficiency were greatest when N applications were split into three equal doses. The differences among nitrogen splitting were significant and this was true in the two growing seasons and their combined (Table 8).

3.3. Effect of interaction:

The results depicted in Figure 2 demonstrate that splitting of nitrogen fertilizer into three equal doses improved N recovery efficiency and N use efficiency over comparable all nitrogen fertilizer sources. There was no significant effect of nitrogen fertilizer source on N use efficiency, yet it interacted significantly with splitting of the added fertilizer. As a general trend N use efficiency increased with increasing number of splitting irrespective of the source. On the other direction ammonium nitrate performed better than ammonium sulfate and urea under any number of splitting. The results suggest that for maximum N use efficiency the N requirement should be applied in three split doses as ammonium nitrate. The success of splitting in improving N use efficiency may be attributed to application of N in time prior to the rapid uptake that resulted in greater fertilizer recovery. Nitrogen fertilizer use efficiency by wheat is highest when applications are timed when crop use of N is high. Winter wheat N uptake is most rapid from tillering through booting developmental growth stages with 80% of the total accumulation occurring before grain filling (Allan, 2003).

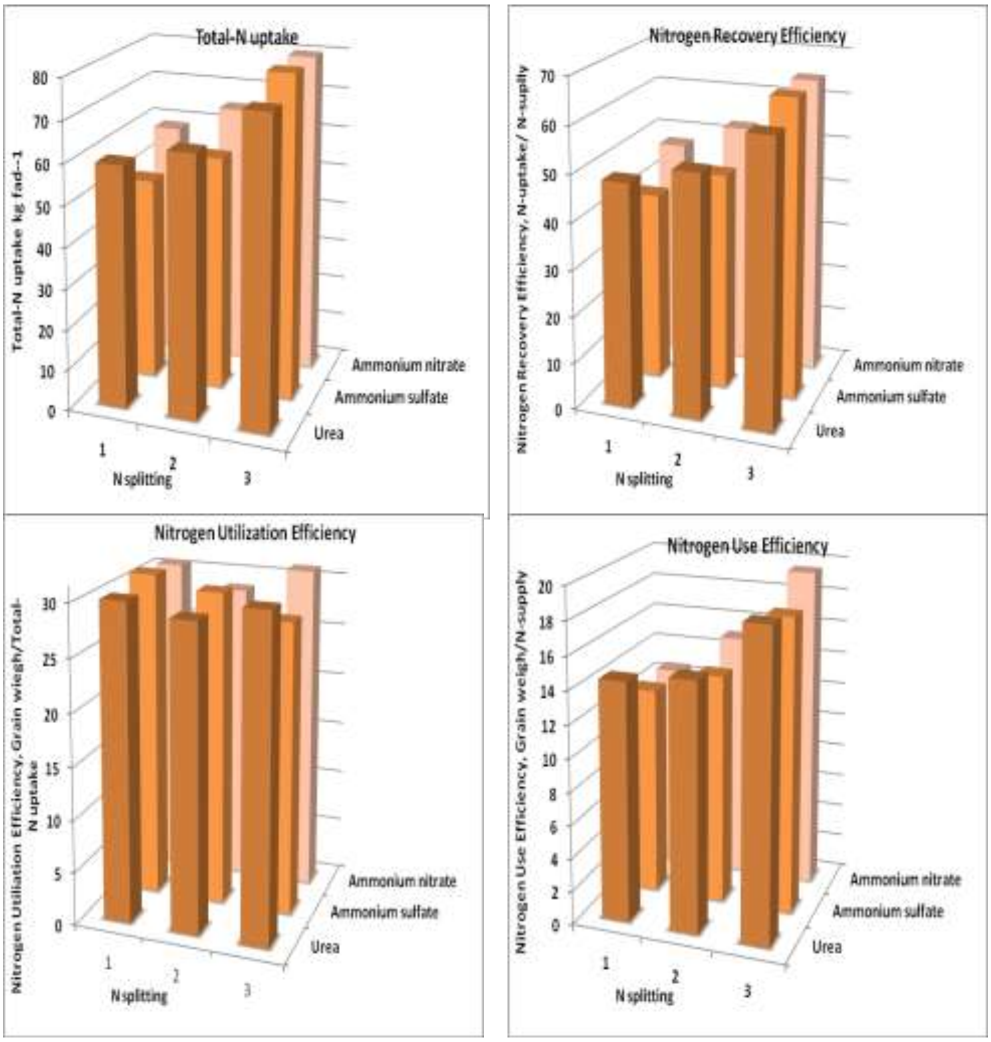

Figure 2. Interaction Effect of nitrogen fertilizer sources and their splitting on nitrogen recovery by wheat in the two growing seasons.

CONCLUSION

The results of the present study show that Ammonium nitrate improved N recovery efficiency, contributing to improve N use efficiency as well as grain yield production of wheat. Nitrogen splitting improved N recovery efficiency and N use efficiency over comparable all nitrogen fertilizer sources. Therefore, the results of this study suggest that for maximum grain yield production of wheat and N use efficiency in dryland areas, such as in El-Sharkia Governorate, the N requirement should be applied in three split doses at sowing, sowing and tillering stages and sowing, tillering and jointing stages as ammonium nitrate.

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تأثير تجزئة بعض مصادر السماد الآزوتى على إنتاجية القمح و كفاءة الإستفادة النيتروجين المضاف

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أُجريت تجربتان حقليتان فى حقل إرشادى بقرية شيبة- مركز الزقازيق- محافظة الشرقية- شرق وسط مصر تربتها طينية ثقيلة متوسطة القلوية فقيرة فى محتواها الميسر من النيتروجين خلال موسمى ٢٠٠٧/ ٢٠٠٨ و٢٠٠٩/٢٠٠٨ لدراسة تأثير تجزئة بعض مصادر السماد الآزوتى على كفاءة إمتصاص النيتروجين و صفات النمو والمحصول ومكوناته وكذلك صفات الجودة لمحصول القمح صنف سخا ٩٣. أُستخدم تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات حيث وزعت معاملات مصادر السماد النيتروجينى والتى شملت ثلاث معاملات هى اليوريا و سلفات الأمونيوم و نترات الأمونيوم على القطع الرئيسية، بينما وزعت معاملات التجزئة (إضافة السماد دفعة واحدة عند الزراعة - دفعتين عند الزراعة، عند مرحلة التفريغ - ثلاث دفعات متساويه عند الزراعة، عند بدء مرحلة التفريغ و عند بدء مرحلة امتلاء الحبوب) على القطع تحت الرئيسية.

أوضحت النتائج أن صفات ارتفاع النبات وعدد الأشطاء المنتجة/ نبات ومساحة ورقة العلم وعدد حبوب السنبلة وكذلك عدد السنابل/م^{2} ومحصول الفدان من الحبوب والمادة الجافة الكلية أعلى سطح التربة و نسبة البروتين فى الحبوب لم تتأثر معنوياً بمصادر النتيروجين المضافة بالرغم من ذيادة كفاءة الإستفادة من النيتروجين المضاف للتربة فى صورة نترات الأمونيوم . كما لم تسجل فروق معنوية بين تأثير كل من اليوريا ونترات الأمونيوم على طول السنبلة - وزن حبوب السنبلة - وزن الـ١٠٠٠حبة ونسبة الكربوهيدرات في الحبوب.

أثرت تجزئة مصادر النتروجين المختلفة تأثيراً معنوياً على معظم الصفات تحت الدراسة وكان التفوق لصالح التجزئ على ٣ دفعات ، بينما لم يكن هناك تأثير معنوى لمعاملات التجزئ الثلاثة على عدد الانشطاء المنتجة و مساحة ورقة العلم ووزن الـ١٠٠٠حبة.

أدت تجزئة مصادر النتروجين المختلفة إلى ثلاث دفعات إلى ذيادة كفاءة الاستفادة من السماد المضاف للتربة و كذلك كفاءة الأمتصاص. ومما تقدم يمكن استخلاص إنة عند زراعة القمح فى الأراضى الطينية الثقيلة متوسطة القلوية يفضل تسميده باستخدام نترات الأمونيوم بمعدل ٨٠ كجم ن/ فدان على أن يضاف ٣ دفعات متساوية (عند الزراعة، عند مرحلة التفريغ وكذلك عند مرحلة بداية امتلاء الحبوب) يمكن أن تعطى أعلى كفاءة الإستفادة من السماد المضاف للتربة و تحقيق أعلى إنتاجية من محصول الحبوب.