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Evaluating Nitrogen Fertilizer Sources and Scheduling for Cotton

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ONE METHOD of reducing nutrient loss by leaching is scheduling applications of fertilizer with small amounts at frequent intervals. Under field conditions, urea and ammonium nitrate fertilizers were scheduled into two and three doses with and without organic manure which applied to cotton (*Gossypium barabadense, varity* Giza 75) grown on clay soil (*Vertic torrifluvents*).

Both, available soil nitrogen and NO_3-N increased due to application of ammonium nitrate fertilizer at two doses. Also, a positive correlation was found between available soil nitrogen and organic manure application. Moreover, cotton yield increased with application of urea fertilizer more than ammonium nitrate fertilizer. The fertilizer scheduling into three doses resulted increasing in cotton yield regardless the type of N-source.

Keywords: Urea, Ammonium nitrate, Organic manure, Cotton yield, Fertilizer scheduling.

Nitrogen fertilizer is economically an expensive input. In many instances less than 60% of the added N is recovered in the crop and soil with the remainder being lost by volatilization, denitrification and leaching (Smith *et al.*, 1989 and Yusron & Philips, 1997). Thus, it is necessary to develop fertilizer management practices that can reduce losses and increase the efficiency of fertilizer use (Yusron and Philips, 1997). More efficient use of fertilizer N may result when the application coincides with the period of rapid plant uptake (Keeney, 1982 and McConnell and Baker, 1998). Source and timing of N fertilizer can affect crop utilization by influencing N form, positional availability and leaching or volatilization losses of N (Reddy and Patrick, 1978). However, Khalil (1998) found no significant differences in cotton yield due to urea or ammonium nitrate addition. In that concern, Maples and Frizzell (1985) declared that applying N closer to the stage of peak demand can improve N utilization, particularly on light textured soil where leaching is expected. Therefore, time of nitrogen application is of prime importance for high crop production. Akkaya (1994) obtained best wheat yield and protein content when applying half of fertilizer at sowing and the other half at stem elongation. Similar results were also obtained by Sowers *et al.* (1994), McConnell and Baker (1998) and Sawan *et al.* (1998). In contrast, Greenfield (1992) in grian yield, McConnell *et al.* (1993) and Bryce *et al.* (1999) in cotton yield found no significant response to splitting applied nitrogen rates. It is well known that addition of organic manure can considerably increase crop yield and exert significant influence on the physical, chemical and biological properties of soil. Rameshwar and Singh (1998) reported that the direct effect of farmyard manure during the first year of experimentation in maize improved the growth parameters.

The objective of the current work is to test if split applications could improve the utilization of N fertilizer and lead to improve cotton yield and environment.

Material and Methods

A field experiment was established at the Agricultural Experimental Station of the Faculty of Agriculture, Ain Shams University, Egypt. The soil is clay (*Vertic torrifluvents*) with pH 7.81 in the blow layer (0-40cm), orgamc matter content of 1.31% and total soluble salts of 1.42 dS/m in the soil paste extract. This layer contained 0.41% total Kjeldahl-N, 6.59 mg R/kg soil extracted by 0.5 M $NaHCO_3$ adjusted to pH 8.5 (Watanabe and Olsen,1965), 167mg K /kg soil extracted by ammonium acetate (Knudsen *et al.*, 1982) and 25.6 mg/kg available nitrogen which was extracted by KCl (Keeney and Nelson, 1982).

Two forms of nitrogen (Urea 46.5% N and Ammonium Nitrate 33.5%N) were used. The experiment was split split plot with three replicates. The main plots were treated with or without organic manure at a rate of 20 m^3/fed and well thoroughly mixed with the blow layer during the tillage. The sub-plots were treated with the two nitrogen sources at a rate of 87kg N/fed. Different doses from the two sources of N occupied the sub-sub plots in the next split applications into two or three equal doses with second, third and fourth irrigations corresponding to 45, 60 and 75 days from sowing cotton seeds. The plot area was 3mx7m with two guard rows on each side to protect against border effects. Phosphorus fertilizer was added to the investigated plots during the blowing of soil at a rate of 30 kg P_2O_5/fed in the form of superphosphate. Cotton (*Gossypium barabadense*, varity Giza 75) seeds were sown as band along the rows of the experimental area.

Soil samples were collected from 0 to 20, 20 to 40 and 40 to 80 cm after two weeks from application of any dose of N fertilizer. Nitrate and ammonium were determined according to Keeney and Nelson (1982). Fully expanded leaves (4^{th} from the apex) were collected from the different treated plants at the same time of soil sampling. They were oven dried at 65C° weighed and ground for nitrogen determination. In addition, cotton yields were weighed and recorded just after harvesting.

Analysis of variance was conducted using the GLM procedure of SAS (SAS Institute, 1985).

Results and Discussion

Soil available nitrogen

Data presented in Table 1 show the effect of nitrogen source, time of application and organic manure addition on the available nitrogen in soil. Significant increase was noticed in the available nitrogen with application of ammonium nitrate fertilizer than with urea. The calculated relative increases of available nitrogen at the upper layer (0 to 20 cm), when ammonium nitrate was used, were 80, 73 and 69% of urea after 45, 60 and 75 days from sowing, respectively. Moreover, available nitrogen increased gradually by going deeper to reach (at 40 to 80 cm) about 46% of that at the top layer (0 to 20cm) with application of ammonium nitrate. While, available nitrogen decreased with application of urea fertilizer gradually by going deeper layer. This may be due to slow rate of urea hydrolysis, beside urea holding on the soil colloids by weak forces giving better chance for hydrolysis and nitrification. In contrast, the available N with ammonium nitrate was high at the top layer and decreased by going downwards. Of course, ammonium nitrate can undergo faster changes in soil than did urea. Similar conclusion was drawn by Musa (1968).

TABLE 1. Mean values of available soil nitrogen (mg kg^{-1}) at different sampling times as affected by different treatments.

Soil depth (cm)	With Organic matter				Without Organic matter			
	Urea		Ammonium Nitrate		Urea		Ammonium Nitrate	
	Two doses	Three doses	Two doses	Three doses	Two doses	Three doses	Two doses	Three doses
				After 45 days				
0-20	115	80	539	353	30	20	150	119
20-40	103	71	773	504	27	18	215	167
40-80	95	66	1011	640	25	17	281	218
mean	104	72	774	499	27	18	215	168
				After 60 days				
0-20	159	144	694	456	48	42	193	153
20-40	145	126	997	640	42	38	277	216
40-80	138	120	1256	834	41	37	363	273
mean	147	130	982	643	44	39	278	214
				After 75 days				
0-20	87	182	192	472	23	36	148	159
20-40	80	159	281	665	21	33	123	224
40-80	76	153	479	865	20	31	108	291
mean	81	165	317	667	21	33	126	225

	After 45 days	After 60 days	After 70 days
Nitrogen Source (NS)	*	*	*
Number of N doses (ND)	*	*	*
Addition of organic manure (AO)	*	*	*
(NS) vs. (ND)	*	*	*
(NS) vs. (AO)	*	*	*
(ND) vs. (AO)	*	*	*
(NS) vs. (ND) vs. (AO)	*	*	*

*Significant at the $P = 0.05$ level.

Concerning the effect of number of fertilizer applications on the available nitrogen in soil, data in the same table reveal that after 45or 60 days from cultivating, the two doses gave more significant increase than three doses. On average, the available nitrogen at the upper layer treated with two doses after 45 or 60 days from cultivating represents about 29.5 and 19.3% of the corresponding layer treated with three doses, respectively. While, increases in the available nitrogen were obtained at the upper layer in case of three doses after 75 from sowing to show about 44% higher than with two doses. This is expected because the amount of nitrogen fertilizer added at each time of the two doses (50% of the whole amount) is of course more than that of the three doses application (33% of the whole amount). Also, the last dose of fertilizer (one third) was applied after 30 days from addition of the last half of the fertilizer in the case of two doses application. Thus, the effect of two doses on the available nitrogen was more with urea than with ammonium nitrate.

Application of organic manure to the soil increased the amount of available nitrogen by about 3.7 folds. The beneficial effect of organic manure could be due to its direct effects on the physical and chemical properties of the soil as well as its indirect effects on the microbial activity in the soil, particularly on nitrifying and nitrogen fixing bacteria. Data in Table 1 show that application of urea fertilizer at two doses and with organic manure resulted in the highest available nitrogen at comparable layers. While, using ammonium nitrate fertilizer at two doses and without organic manure gave the lowest available nitrogen in the soil.

Soil nitrate-nitrogen

Total NO_3-N at the 40-80 cm soil profile shows statistical correlation with nitrogen source, time of application and addition of organic manure (Table 2). After ammonium nitrate fertilizer application, soil NO_3-N peaked in continuous with two doses, while declined through three doses application. Nitrate was accumulated at the deeper layer (40 to 80 cm) of the soil than at the top one (0 to 20 cm). The differences in nitrate content among different treatments are very noticeable. Ammonium nitrate treatment showed the highest nitrate content followed (in a decreasing order) by urea treatment. Also, high amounts of nitrate were found at the deepest layer (40 to 80 cm) of soil, which represent 1.1 and 1.8 folds of that at the upper layer with application of urea and ammonium nitrate, respectively. The high nitrate content as a result of ammonium nitrate application may be explained by the fact that half of its total nitrogen is in the form of ammonium and the other half is in the form of nitrate. This finding is in accordance with the results of Adetunji (1994) who found that 29.5% lost below the root zone from plots receiving ammonium nitrate fertilizer. Also, ammonium nitrate is known to be more water soluble than urea and can consequently undergo faster leaching (Bauder and Montgomery, 1980). The process of urea transformation in the soil include a hydrolytic step brought about by enzyme urease which may take some time in soil beside the fact that NH_4-N and not NO_3-N can be fixed on clay particles (Anghinoni and Barber,1988). Moreover. urea contribute little to NO_3-N leaching which reflects on minimizing the leaching of mineralized NO_3-N as mentioned by Balba *et al.* (1969). Application of nitrogen fertilizer into two doses was found to increase NO_3-N in soil profile especially at the deepest layer after 45 and 60 days from planting. These increases represent about 52 and 50% of that at upper layer after 45 and 60 days from planting with application of ammonium nitrate into two doses, respectively. But, the nitrate content of soil from two doses treatment decreased to some

TABLE 2. Mean values of soil nitrate-N (mg kg^{-1}) at different times as affected by different treatments.

Depth	With Organic matter				Without Organic matter			
	Urea		Ammonium Nitrate		Urea		Ammonium Nitrate	
	Two doses	Three doses	Two doses	Three doses	Two doses	Three doses	Two doses	Three doses
After 45 days								
0-20	27.4	18.3	346.0	233.3	7.8	5.3	96.3	78.6
20-40	29.8	19.9	552.7	369.3	8.4	5.7	153.7	122.1
40-80	31.4	21.0	719.0	420.0	8.9	6.1	200.0	143.7
mean	29.5	19.7	539.2	340.9	8.4	5.7	150.0	114.8
After 60 days								
0-20	47.6	33.1	446.0	302.0	13.5	12.4	124.0	101.5
20-40	52.1	33.7	712.0	466.3	14.7	12.8	198.0	157.0
40-80	57.4	40.0	879.7	550.3	16.3	15.0	258.3	177.0
mean	52.4	35.6	679.2	439.5	14.8	13.4	193.4	145.2
After 75 days								
0-20	26.1	43.0	124.0	313.0	7.4	8.4	96.7	105.2
20-40	28.6	44.0	224.5	485.3	8.1	10.0	80.1	163.0
40-80	31.6	52.1	329.0	569.7	9.0	11.7	70.3	191.7
mean	28.8	46.4	225.8	456.0	8.2	10.0	82.4	153.3

	After 45 days	After 60 days	After 70 days
Nitrogen Source (NS)	*	*	*
Number of N doses (ND)	*	*	*
Addition of organic manure (AO)	*	*	*
(NS) vs. (ND)	NS	NS	NS
(NS) vs. (AO)	*	*	*
(ND) vs. (AO)	*	*	*
(NS) vs. (ND) vs. (AO)	NS	*	*

*Significant at the P = 0.05 level: NS = not significant at the 0.05 level.

extent after 75 days, while that from three doses application was increased. The calculated relative increases in the NO_3-N with two-doses application at the deeper layer recorded 33.5 and 26.3% over those with three-doses treatment after 45 and 60 days from planting, respectively. While, the amounts of NO_3-N at the deepest layer with two doses treatment decreased by about 1.9 folds compared to three doses treatment after 75 days from planting. Amounts of NO_3-N were always higher in the presence than in the absence of organic manure. Data indicate also that the amounts of NO_3-N with application of organic manure after 45, 60 and 75 days from planting were about 70.3, 68.3 and 60.0% of that without organic manure, respectively.

Nitrogen content in cotton plant

Data in Table 3 clearly show significant increase in cotton leaves content of N fertilized by urea than by ammonium nitrate. The calculated relative increases

TABLE 3. Mean values of nitrogen concentration in cotton leaves (%) at different sampling times as affected by different treatments.

With Organic matter				Without Organic matter			
Urea		Ammonium Nitrate		Urea		Ammonium Nitrate	
Two doses	Three doses	Two doses	Three doses	Two doses	Three doses	Two doses	Three doses
After 45 days							
4.30	3.12	3.62	2.15	3.15	2.46	2.87	2.24
After 60 days							
5.01	3.76	4.45	2.84	2.69	2.56	2.40	1.52
After 75 days							
2.63	3.74	2.06	2.29	2.41	2.92	1.29	1.63

	After 45 days	After 60 days	After 70 days
Nitrogen Source (NS)	*	*	*
Number of N doses (ND)	*	*	*
Addition of organic manure (AO)	*	*	*
(NS) vs. (ND)	NS	*	NS
(NS) vs. (AO)	*	NS	NS
(ND) vs. (AO)	*	*	NS
(NS) vs. (ND) vs. (AO)	*	*	NS

*Significant at the $P = 0.05$ level: NS = not significant at the 0.05 level.

of nitrogen concentration in the cotton leaves incase of urea, were 16.0 and 21.8% over those of ammonium nitrate after 45 or 60 days from sowing, respectively. In contrast, the N concentration in cotton leaves after 75 days from sowing decreased with urea application by 19.5% compared to ammonium nitrate treatment. This may be attributed partially to the higher utilization of nitrogen from urea than from ammonium nitrate, which is readily subjected to losses from soil faster than urea as previously discussed. The increase in fertility doses clearly reflected a consistent and significant increase of N % in cotton plant. The N concentrations associated with two doses treatment were 28.0 and 25.5 more than that of three doses after 45 and 60 days from planting, respectively. Moreover, addition of organic manure with either urea or ammonium nitrate increased significantly N content in cotton plants. However, values of nitrogen concentration with all treatments decreased after 75 days from planting. These findings could be attributed to the fact that nitrogen in the vegetative parts of cotton plant is translocated to the flowers beside the possible dilution effect resulting from the progress in plant growth.

Cotton yield

Cotton yield was higher with application of urea fertilizer than of ammonium nitrate fertilizer (Table 4). Cotton yield due to application of urea fertilizer was 10.8% higher that that of ammonium nitrate fertilizer. However, this difference was not significant. The fertilizer schedule into three doses had also no significant effect on cotton yield regardless the type of N-source. The obtained data indicated that the cotton yield with application of the fertilizer schedule into three doses increased by 10.3% over that of the two doses. This can be attributed to the increase in plant growth when all amounts of nitrogen fertilizer were added incase of three doses. This in turn contributed more to the accumulation of dry matter as it was translocated to the reproductive organs. The yield was significant higher with organic manure addition which increased the available soil nitrogen and profitable for soil characteristics to represent 26% over that without organic manure treatment. Similar conclusion was drawn by Khalil (1998).

TABLE 4. Mean values of cotton yield (kentar fed^{-1}) at different times as affected by different treatments.

With Organic matter				Without Organic matter			
Urea		Ammonium Nitrate		Urea		Ammonium Nitrate	
Two doses	Three doses	Two doses	Three doses	Two doses	Three doses	Two doses	Three doses
5.46	6.26	5.01	5.35	3.98	4.65	3.70	4.03

	cotton yield
Nitrogen Source (NS)	NS
Number of N doses (ND)	NS
Addition of organic manure (AO)	*
(NS) vs. (ND)	NS
(NS) vs. (AO)	NS
(ND) vs. (AO)	NS
(NS) vs. (ND) vs. (AO)	*

*Significant at the $P = 0.05$ level; NS = not significant at the 0.05 level.

Therefore, the study advising to use urea instead of ammomuin nitrate and adding it with irrigation water in three doses during cotton cultivation in clay soil which should be pre-treated with an organic manure.

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تقييم مصادر الاسمده النيتروجينيه وعدد دفعات إضافته على محصول القطن

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أجريت تجربه حقليه (فى قطع منشقة بثلاثة مكررات) فى مزرعة كلية الزراعة جامعة عين شمس بشلقان بهدف تقييم تأثير مصدر السماد النيتروجينى (يوريا أو نترات الأمونيوم) وعدد دفعات إضافته مع ماء الرى (دفعتين أو ثلاثة) فى وجود وغياب السماد العضوى على كل من النيتروجين الميسر والصورةالنتراتيه منه وكذلك محتواه بالنبات بالاضافه إلى محصول القطن الزهر.

أوضحت النتائج زيادة كيمية النيتروجين الميسر بالتربة بدرجة اكبر عند استخدام سماد نترات الامونيوم عن اليوريا وكانت هذه الزيادة أعلى عند الاضافه على دفعتين عنها فى حالة الاضافه على ثلاث دفعات كما اتضح وجود علاقة معنوية موجبة بين النيتروجين الميسر بالتربة وإضافة السماد العضوى بعكس الحال مع النيتروجين النتراتى حيث كانت العلاقة سالبه.

أظهرت النتائج زيادة المحتوى النيتروجينى بالنباتات المسمدة باليوريا عن تلك المسمدة بنترات الأمونيوم وكان هذا التأثير أكثر وضوحا فى وجود السماد العضوى.

انعكست النتائج السابق ذكرها على محصول القطن الزهر الناتج من المعاملات المختلفة حيث كان أعلى ما يمكن (٦.٢٦ قنطار/ فدان) فى معاملة اليوريا على ثلاث دفعات وفى وجود السماد العضوى بينما كان اقل ما يمكن (٤.٠٩ قنطار/فدان) فى حالة التسميد بنترات الأمونيوم على دفعتين وغياب التسميد العضوى.

ولهذا أوصت الدراسة باستخدام سماد اليوريا وإضافته مع ماء الرى على ثلاث دفعات عند زراعة نباتات القطن فى ارض طينيه يجب معاملتها بسماد عضوى لانتاج أعلى محصول من القطن الزهر.