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Comparative Effect of Different Mineral Nitrogen Fertilizer Sources on Productivity and Quality of Some Egyptian Cotton Cultivars

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ABSTRACT

Developing cotton cultivars with a high yielding potential, nutrients extract and efficient, fiber attributes, earliness, high oil as well as protein cottonseed contents and pest resistance across variable environments is of great importance of cotton breeding programmer in Egypt. The field experiments were carried out at Agric. Res. and Exp. Stat., Fac. Agric., Cairo Univ., Giza, Egypt during 2017 season and repeated in 2018 season to evaluate the productivity and fiber technology response of three new released Egyptian cotton cultivars namely; Giza 93, Giza 94 and Giza 95 to three nitrogen fertilizer sources *i.e.* urea (U - 46.5%N), ammonium nitrate (AN- 33.5%N) and ammonium sulfate (AS - 20.5%N). The randomized complete block design with split-plot arrangement with three replications was used. The main plots were devoted to cotton cultivars and the nitrogen fertilizer sources was randomly distributed in sub-plots. Giza 93 cultivar had the superiority over other cultivars concerning growth attributes, yield and yield components, chemical and biochemical constituents of foliage and seeds of cotton as well as fiber technology parameters. Generally, nitrogen fertilizer sources had a significant effect on growth attributes, yield as well as its components, fiber technological parameters, chemical and biochemical constituents of foliage and seeds of cotton whereas, ammonium sulfate was superior in plant height, 1st sympodial node, no. sympodial branches plant^{-1}, no. total bolls plant^{-1}, boll weight, seed index, lint %, seed cotton yield fed^{-1}, fiber technological parameters, chemical as well as biochemical constituents of foliage and seeds of cotton. Significant cotton cultivars × nitrogen fertilizer sources interactions existed on most of studied traits.

***Keywords**:* Egyptian Cotton *(Gossypium barbadence* L.) - Cultivars - Urea - Ammonium nitrate - Ammonium sulfate - Productivity - Fiber Technology

INTRODUCTION

Cotton breeding research is directed to the development of cultivars with a high yielding potential, nutrients extract and efficiency, quality fiber, earliness and pest resistance across variable environments (Abdel-Samad, *et al.*, 2017). Globally, Cotton (*Gossypium spp.* L.) is the most important fiber crop meanwhile, as the same in Egypt. In addition to its fiber, cottonseed considers a source of oil as well as protein, and as such it represents significant economic value (Campbell, *et al.*, 2010). Large genotypic variations were remarked in morphological, physiological and biochemical traits of cotton, especially dry weight of shoot, root traits, and N-assimilating enzyme levels (Iqbal, *et al.*, 2020a). The NO_3^- anion and NH_4^+ cation are the primary inorganic forms for uptake in by plants. Mineral fertilizers provide nitrogen in one or both forms. Cultivars of cotton differ greatly in uptake of NH_4^+ and NO_3^- ion (Li, *et al.*, 2013). Nitrogen has a very dynamic cycle in the soil including the process of ammonification, nitrification, denitrification, and mineralization. Although nitrogen has more impacts on cotton yield, it is the most difficult nutrient to manage in irrigated cotton (Khan, *et al.*, 2017a). Nitrogen is an important nutrient, and as such it increases growth and prohibits abscission of squares and bolls, essential for photosynthetic activity and stimulates the mobilization and accumulation of metabolites in newly developed bolls, thus increasing number and weight of bolls (Reddy, *et al.*, 1996). Khan, *et al.*, (2017b) stated that nitrogen (N) is very important nutrient that play essential parts in enhancing photosynthesis and yield of lint in cotton, thus application of N fertilizer is an essential component of any successful integrated cotton production system. Increasing nitrogen efficiency through use best nitrogen sources is one of the most factors that limit productivity of cotton (McClanahan, *et al.*, 2020). Nitrogen fertilizers commonly supply in amide, ammonium or nitrate forms. Each form has characteristic pros and cons. Among various nitrogen fertilizer sources, urea, ammonium nitrate and ammonium sulfate are the most common mineral forms required for growth and yield of cotton plant. With the high cost of mineral fertilizers, the following must be taking into consideration by producers, the cost, effectiveness, and convenience of using the various commercial nitrogen sources that are currently available on the market (Mullins, *et al.*, 2003). Meanwhile, effective use of applied nitrogen by the crop will reduce input cost per unit of yield harvested (Fenn, and Hossner, 1985). The form in which nitrogen is applied to cotton plant may influence availability of nitrogen and nutrients relationship. Achieving nitrogen use efficiency management in the cropping systems, requires adequate rate, appropriate source and timing of application during crop growth stages (Fageria *et al.*, 2006). On the other hand, Quemada, *et al.*, (2016) stated that, plant preference for one or another form of mineral nitrogen fertilizer depends on the species, plant age, environmental conditions, and other factors. It was reported that ammonium fertilizers be

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assimilated more easily by plants than NO_3^- fertilizers and less mobile in the soil (Fageria, 2009). There is much confusion among researchers on the effectiveness of mineral nitrogen sources in cotton management practices thereby, some investigations reported a significant difference among nitrogen sources concerning growth, yield and technology of cotton plant (Reeves, *et al.,* 1988; Rickerl, *et al.,* 1989; Elbordiny, *et al.,* 2003; El-Basuony, 2009; Watts, *et al.,* 2014; Dai, *et al.,* 2015; Grant, *et al.,* 2017 and Watts, *et al.,* 2017). On the contrary, other investigations observed that there were no superior nitrogen sources on growth, yield and quality parameters of cotton crops (Amer, and Abuamin, 1969; Mullins, *et al.,* 2003 and Babaria, *et al.,* 2010). To our knowledge, few studies compare the effects of mineral nitrogen fertilizer source and efficacy of these fertilizer on Egyptian cotton (*Gossypium barbadence* L.) production under Egyptian conditions has not been well documented. Thus, the objective of this investigation to compare among three mineral nitrogen fertilizer sources (urea, ammonium nitrate and ammonium sulfate) and its effect on productivity and quality of some Egyptian cotton cultivars under Giza Governorate condition.

MATERIALS AND METHODS

The field experiments were carried out at Agric. Res. and Exp. Stat., Fac. Agric., Cairo Univ., Giza, Egypt (30° N, 31°: 28'E with an altitude of 19 m), during summer growing season of 2017 and repeated in 2018 season to study the comparative effect of nitrogen fertilizer sources on productivity and quality of three Egyptian cotton cultivars (*Gossypium barbadence* L.) namely Giza 93 (extra-long staple - grown at Lower Egypt), Giza 94 (long staple - grown at Lower Egypt) and Giza 95 (long staple - grown at Upper Egypt). The experiment included 9 treatments which were the combination of three cultivars and three nitrogen fertilizer sources *i.e.* urea ($NH_2.CO.NH_2$ - 46.5%N), ammonium nitrate (NH_4NO_3 - 33.5%N) and ammonium sulfate [$(NH_4)_2SO_4$ - 20.5%N]**.** The randomized complete block design with split-plot arrangement with three replications was used. The main plots were devoted to cotton cultivars and the nitrogen fertilizer sources was randomly distributed in sub-plots. Nitrogen(N) at the rate of 60 kg N fed^{-1} as recommended was split in two equal doses and side-dressed before the 2nd and 3rd irrigation from each source. Also, potassium (48 kg K_2O fed^{-1}) as potassium sulphate was split and side-dressed before the 2nd and 3rd irrigation. On the other hand, phosphorus (30 kg P_2O_5 fed^{-1}) as calcium super phosphate (15.5 % P_2O_5) was added during soil preparation. The preceding winter crop was barley (*Hordeum vulgare* L.) as a forage in both seasons. Each plot content six ridges. The ridge was five meters long, 60 cm apart. The hills was on one side of the ridge and 20 cm between each hill. The cotton seeds were planted during the beginning of April (the first week at maximum) every growing season. Before the first irrigation, thinning was carried out (two plants were left per hill). Common cultural practices were carried out according to recommendations of cotton fields. A composite soil samples on depth (0 - 30 cm) from the site of the experiment, were collected at time of sowing in both seasons to study the physical and chemical of soil properties according to standard methods described by Jackson (1973). Available manganese (Mn) and iron (Fe) were valued using Atomic Absorption Spectrophotometer (AAS) after extracting the soil with DTPA as outlined by Lindsay and Norvell (1978). The values of physical and chemical parameters are listed in Table 1.

In both growing seasons of cotton, four representative hills (8 plants plot^{-1}) were randomly determined and fifty open sound bolls were picked at random from the outer four ridges to determine growth attributes and some yield components respectively. Growth attributes included; plant height(cm), no. of sympodial branches plant^{-1}, position of 1st sympodial node (estimated as number of nodes below the first fruiting branch) and total no. of bolls plant^{-1}. While, yield components included; boll weight, seed index (weight of 100 seeds g) and lint % (sample lint weight to seed cotton weight expressed as percent). The interior four ridges of each plot were handily harvested (picking) twice to determine seed cotton in kg plot^{-1} and converted to kentar fed^{-1} (one kentar equal 157.5 kg). When more than 50 % bolls were opened, picking of cotton seed was started immediately.

Table 1. Some physical and chemical parameters of the experimental soil (0-30 cm depth) through (2017 - 2018) growing seasons of cotton.

Soil properties	Season	
	2017	2018
Physical analysis (%):		
Clay	33.7	33.3
Silt	30.6	31.9
Fine Sand	35.7	34.8
Coarse Sand	4.0	2.3
Texture	Clay loam	Clay loam
Chemical analysis:		
pH (paste extract)	7.76	7.80
EC (dS/m)	1.92	1.90
Organic matter (%)	2.31	2.21
Total calcium carbonate (%)	3.53	3.72
Available nitrogen (ppm)	39.6	38. 8
Available phosphorus (ppm)	8.76	8.93
Available potassium (ppm)	239	234
DTPA-extractable Mn (ppm)	0.85	0.79
DTPA-extractable Fe (ppm)	3.27	3.11

Fiber properties were measured as fiber length at upper half means (U.H.M) mm, length uniformity index (U.I), fiber strength in grams tex^{-1}, fiber elongation % (the percent of elongation, which occurs before a fiber bundle breaks), micronaire value (finesse) and color attributes values i.e. Reflectance (Rd %) and Yellowness (+b %). The previous fiber tests were determined by using high volume Instrument (HVI) according to (A.S.T.M: D 46050 – 1998). All fiber tests were carried out at the laboratories of the Cotton Res. Inst., Agric. Res. Cent.(ARC), under controlled conditions of 70° F ± 2 temperature and 65 % ± 2 of relative humidity.

Chemicals analysis

Ten fully expanded new leaves with petioles (fourth upper leaf) were randomly cut from plants of each plot after two weeks from the second dose of nitrogen fertilization. Samples of leaf were washed with distilled water and before oven dried at 70° C for 48h, blotted dry with tissue papers and finely ground to pass a 1 mm sieve. Total nitrogen (N) was determined by a modified Kjeldahl procedure (Eastin, 1978) which including the pretreatment with salicylic acid to aid in the reduction of NO_3. While phosphorus (P) was determined according to the procedure of vanadate-molybdate spectrophotometric (Jones *et al.,* 1991). Potassium (K) and Calcium (Ca) were determined using a flam photometer by method of Chapman, and Pratt, (1961). The concentration of zinc (Zn), manganese (Mn), iron (Fe) and copper (Cu) in leaf of cotton were determined as described by Jones *et al.*, (1999). Total Phenolics were estimated using the Folin−Ciocalteu colorimetric method of Swain, and Hillis,(1959). Total carbohydrate contents in the dried leaf samples were determined according to Herbert, *et al.*, (1971).

Sample of fuzzy seeds for each treatment in both seasons was used to estimate seed crude protein content (A.O.A.C., 1985) and seed oil content in which oil was extracted three times with chloroform/methanol (2:1, vol/vol) mixture (Kates, 1972). The oil and crude protein content were presented as percents of the fuzzy seed mass.

Data analysis: All data collected were subjected to the standard statistical analysis following the proceeding described by Gomez and Gomez (1984). Treatment means were compared ($P < 0.05$) based on least significant difference (LSD). Finally, all statistical analysis was carried out using "MSTAT-C" program 1991.

RESULTS AND DISCUSSION

Growth attributes

Cultivars, nitrogen fertilizer sources and their interaction had a significant effect on the most of growth attributes of cotton plant in the first and second seasons (Table 2). Plant height, position of 1st sympodial node and no. of sympodial branches plant^{-1} significantly varied among the three cotton cultivars while, the difference among cotton cultivars concerning no. of total bolls plant^{-1} was not significant in both seasons. With a few exceptions, Giza 93 cultivar significantly recorded the highest plants (141.69 and 142.80cm), position of 1st sympodial node (6.54 and 6.83) and no. of sympodial branches plant^{-1} (16.12 and 16.98) in 2017 and 2018 seasons, respectively. Whereas, generally Giza 95 cultivar performed the worst. Mainly, such results because of the differences in genetic make-up of the assessment of the three cotton cultivars. In this connection, de Oliveira Araújo, *et al.*, (2013), Zhang, *et al.*, (2018), Iqbal, *et al.*, (2020a) and Iqbal, *et al.*, (2020b) found varietal differences regarding growth attributes of cotton plant.

Table 2. Some growth attributes of three cotton cultivars as affected by nitrogen sources through (2017-2018) growing seasons of cotton.

Treatments		Plant height (cm)		Position of 1st sympodial node		No. of sympodial branches plant^{-1}		No. of total bolls plant^{-1}	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	Urea (U)	141.15	142.33	7.02	7.22	15.96	16.13	12.22	12.96
Giza 93	Ammonium Nitrate (AN)	141.88	142.95	6.60	7.10	16.33	17.06	12.94	13.11
	Ammonium Sulfate (AS)	142.03	143.12	6.01	6.17	16.08	17.75	13.42	14.83
Mean		141.69	142.80	6.54	6.83	16.12	16.98	12. 86	13.63
	Urea (U)	129.11	131.14	6.92	7.01	15.11	15.41	11.22	12.05
Giza 94	Ammonium Nitrate (AN)	131.46	132.57	6.22	6.31	16.45	16.84	12.37	13.57
	Ammonium Sulfate (AS)	132.18	133.02	6.15	6.17	16.98	17.13	12.98	14.09
Mean		130.92	132.24	6.43	6.50	16.18	14.46	12.19	13.24
	Urea (U)	127.35	128.22	6.82	7.91	13.24	13.77	11.12	11.87
Giza 95	Ammonium Nitrate (AN)	129.02	129.11	6.17	7.14	13.77	14.02	12.62	13.02
	Ammonium Sulfate (AS)	130.09	130.88	6.03	6.40	16.10	16.65	13.21	13.76
Mean		128.82	129.40	6.34	7.15	14.37	14.81	12.32	12.88
Means	Urea (U)	132.54	133.90	6.92	7.38	14.77	15.10	11.52	12.29
of Nitrogen	Ammonium Nitrate (AN)	134.12	134.88	6.33	6.85	15.52	15.97	12.64	13.23
Sources	Ammonium Sulfate (AS)	134.77	135.67	6.06	6.25	16.39	17.18	13.20	14.23
Mean		133.81	134.82	6.44	6.83	15.56	16.08	12.46	13.25
	A	1.97	2.09	0.08	0.08	0.44	0.51	ns	ns
L.S.D$_{0.05}$	B	2.10	2.16	0.11	0.14	0.34	0.41	1.58	1.65
	A×B	2.74	2.87	0.16	0.18	0.72	0.80	1.39	1.40

Results in Table 2 showed that nitrogen supplied as ammonium sulfate (AS) produced the highest plant (134.77 and 135.67cm), no. of sympodial branches plant^{-1} (16.39 and 17.18) and no. of total bolls plant^{-1} (13.20 and 14.23) in the first and second seasons, respectively. While, the application of urea (U) as nitrogen fertilizer recorded the highest position of 1st sympodial node (6.92 and 7.38) in the first and second seasons, respectively. It is not clear why some growth characters response the best with one of nitrogen source than other nitrogen sources under our investigation.

The interaction between cotton cultivars and nitrogen fertilizer sources had a significant effect on plant height, position of 1st sympodial node, no. of sympodial branches plant^{-1} and no. of total bolls plant^{-1} in both seasons (Table 2). The highest values of plant height (142.03 and 143.12cm) and no. of total bolls plant^{-1} (13.42 and 14.83) were obtained with the combination between Giza 93 cultivar and ammonium sulfate (AS) as nitrogen fertilizer source in 2017 and 2018 seasons, respectively meanwhile, the highest position of 1st sympodial node (7.02 and 7.22) obtained with the same cultivar but with urea (U) as nitrogen fertilizer source in the first and second seasons, respectively. The highest no. of sympodial branches plant^{-1} (17.75 and 16.98) was observed with the combination between ammonium sulfate (AS) and Giza 93 in the first season and Giza 94 cultivar in the second season, respectively (Table 2).

Seed cotton yield and yield components

Seed index, boll weight, lint percent and seed cotton yield significantly varied by cotton cultivars, nitrogen fertilizer sources and their interaction. This was true in both seasons (Table 3). Results presented indicated that varietal significant differences regarding previously mentioned above characters in both seasons. The weightiest seed index (10.10 and 10.18g), boll weight (2.30 and 2.34g) produced by Giza 93 cultivar. Also, the highest percentage of lint (35.15 and 35.64%) and seed cotton yield (9.70 and 9.85 kentar fed^{-1}) were obtained by the same cultivar in the season one and two respectively. Opposite trend was observed for yield and yield components with Giza 95 cultivar in both seasons. It clear that Giza 93 cultivar had the superiority over other cultivars concerning yield and yield components. These results may be due to the variation in genetic constitution of Giza 93, Giza 94 and Giza 95 cultivars. These results are in harmony with those reported by de Oliveira Araújo, *et al.,* (2013); Zhang, *et al.,* (2018) and Iqbal, *et al.,* (2020).

Generally, plants receiving ammonium sulfate (AS) or ammonium nitrate (AN) had higher seed index, boll weight, Lint % and seed cotton yield than those fertilized with urea in both seasons. Meanwhile, there was no significant difference among nitrogen sources concerning seed index in both seasons and boll weight in the first season only (Table 3). The application of nitrogen fertilizer in the form of ammonium sulfate significantly recorded the highest boll weight (2.22g), Lint % (33.26 and 34.02) and seed cotton yield (9.44 and 9.51 kentar fed^{-1}) in both seasons except boll weight in the first season only (Table 3). Application of both urea and ammonium nitrate were significantly at par with each other in terms of seed index, boll weight, Lint percent and seed cotton yield in 2017 and 2018 seasons.

Seed index, boll weight, lint percent and seed cotton yield significantly affected by the interaction between cotton cultivars and nitrogen fertilizer sources in both seasons whereas, the highest value of seed index (10.50 and 10.56 g), boll weight (2.41 and 2.43 g), lint percent (35.89 and 36.11%) and seed cotton yield (10.02 and 10.31 kentar fed^{-1}) were obtained when the plants of Giza 93 cultivar fertilized with ammonium sulfate (AS) in 2017 and 2018 seasons (Table 3). On the contrary, The lowest value of seed index (9.06 and 9.12 g), boll weight (2.07 and 2.11 g), lint percent (30.54 and 31.22%) and seed cotton yield (7.17 and 7.25 kentar fed^{-1}) were obtained when the plants of Giza 95 cultivar received urea as a nitrogen fertilizer source in 2017 and 2018 seasons, respectively (Table 3).

Table 3. Seed index (g), boll weight (g), lint (%) and seed cotton yield (kentar fed^{-1}) of three cotton cultivars as affected by nitrogen sources through (2017-2018) growing seasons of cotton.

Treatments		Seed index		Boll weight		Lint percentage		Seed cotton yield	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	Urea (U)	9.84	9.96	2.22	2.27	34.54	35.19	9.15	9.24
Giza 93	Ammonium Nitrate (AN)	9.95	10.02	2.28	2.31	35.03	35.62	9.92	10.01
	Ammonium Sulfate (AS)	10.50	10.56	2.41	2.43	35.89	36.11	10.02	10.31
Mean		10.10	10.18	2.30	2.34	35.15	35.64	9.70	9.85
	Urea (U)	9.47	9.72	2.13	2.15	32.25	33.14	8.42	8.53
Giza 94	Ammonium Nitrate (AN)	9.55	9.86	2.17	2.19	32.91	33.24	9.10	9.22
	Ammonium Sulfate (AS)	10.12	10.01	2.20	2.22	33.03	33.97	9.82	9.91
Mean		9.71	9.86	2.17	2.19	32.73	33.45	9.13	9.22
	Urea (U)	9.06	9.12	2.07	2.11	30.54	31.22	7.17	7.25
Giza 95	Ammonium Nitrate (AN)	9.22	9.56	2.10	2.13	31.12	32.37	8.1	8.13
	Ammonium Sulfate (AS)	9.52	9.95	2.17	2.18	31.72	32.48	8.58	8.61
Mean		9.27	9.54	2.11	2.14	31.13	32.02	7.95	8.00
Means of	Urea (U)	9.46	9.60	2.14	2.18	32.44	33.18	8.25	8.34
Nitrogen	Ammonium Nitrate (AN)	9.39	9.71	2.14	2.16	32.02	32.81	8.63	8.68
Sources	Ammonium Sulfate (AS)	9.86	9.99	2.22	2.24	33.26	34.02	9.44	9.51
Mean		9.57	9.77	2.16	2.19	32.57	33.34	8.77	8.84
	A	0.44	0.56	0.03	0.04	1.57	1.64	0.97	0.69
L.S.D$_{0.05}$	B	ns	ns	0.04	ns	1.21	1.16	0.51	0.62
	A×B	0.38	0.53	0.16	0.12	1.85	1.91	0.83	1.94

Fiber technology parameters

With the exception of brightness (Rd%) and yellowness (+b), results in Table (4 and 5) indicated that technology parameters studied in this experiment significantly affected by cotton cultivars, nitrogen fertilizer sources and their interaction in both seasons. Regarding the performance of cotton cultivars, varietal differences were detected in fiber length UHM**,** fiber uniformity index, fiber elongation, fiber strength and micronaire value (fiber fineness). Giza 93 cultivar showed its superiority of fiber length UHM (33.34 and 33.80mm), fiber uniformity index (86.85 and 87.64%), fiber elongation (7.09 and 7.18%) and fiber fineness (3.00 and 3.20) over the rest two cultivars in 2017 and 2018 seasons respectively. On the contrary, Giza 95 cultivar was inferior in all previously above-mentioned characters in both seasons. The differences in genetic constitution among evaluated cotton cultivars resulted in such difference in technological characters meanwhile, as previously mentioned Giza 93 is an extra-long staple cultivar while Giza 94 and Giza 94 are a long staple cultivars.

Results in Table (4 and 5) indicated that nitrogen fertilizer sources had a significant difference on fiber length UHM**,** fiber uniformity index, fiber strength and micronaire value meanwhile, fiber elongation, brightness (Rd%) and yellowness (+b) were not significantly affected by urea, ammonium nitrate and ammonium sulfate. This was true in both seasons. The highest values of fiber length UHM (31.83 and 32.15mm), fiber uniformity index (86.07 and 86.38%), fiber strength (39.71 and 40.09g tex^{-1}) and fiber fineness (3.39 and 3.33) obtained with ammonium sulfate reversely, the lowest values of the aforementioned traits obtained with the application of urea in 2017 and 2018 seasons. On the other hand, applying urea and ammonium nitrate was in the same level of significant concerning fiber length UHM**,** fiber uniformity index, fiber strength and micronaire value in the first and second seasons. Generally, these results are in harmony with those reported by Watts, *et al.,* (2014) who reported that nitrogen source affected fiber quality.

Results presented in Table (4 and 5) showed that the effect of cotton cultivars and nitrogen fertilizer sources was significant on fiber length UHM**,** fiber uniformity index, fiber elongation, fiber strength and micronaire value but, it was insignificant on brightness (Rd%) and yellowness (+b) in both seasons. The plant of Giza 93 cultivar recorded the highest value of fiber length UHM (34.12 and 34.57mm), fiber uniformity index (88.13 and 88.44), fiber elongation

(7.28 and 7.31%), fiber strength (43.86 and 43.94g tex^{-1}) and fiber fineness (3.10 and 2.95) when nitrogen applied in ammonium sulfate form in 2017 and 2018 seasons, respectively. On the contrary, the combination between Giza 95 cultivar and urea as nitrogen fertilizer source gave the lowest value of fiber length UHM (27.48 and 27.96mm), fiber uniformity index (83.05 and 83.92), fiber elongation (6.01 and 6.07%), fiber strength (33.21 and 33.56g tex^{-1}) and fiber fineness (4.31 and 4.24) in first and second seasons, respectively.

Table 4. Fiber length (mm), fiber uniformity index, fiber elongation (%) and fiber strength (g tex^{-1}) of three cotton cultivars as affected by nitrogen sources through (2017 - 2018) growing seasons of cotton.

Treatments		**Fiber length UHM**		**Fiber uniformity index**		**Fiber elongation**		**Fiber strength**	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	Urea (U)	32.74	32.89	85.27	86.56	6.86	6.97	42.98	43.17
Giza 93	Ammonium Nitrate (AN)	33.17	33.95	87.15	87.93	7.14	7.26	43.23	43.47
	Ammonium Sulfate (AS)	34.12	34.57	88.13	88.44	7.28	7.31	43.86	43.94
Mean		33.34	33.80	86.85	87.64	7.09	7.18	43.36	43.53
	Urea (U)	30.91	30.98	84.82	85.27	6.13	6.25	39.18	39.59
Giza 94	Ammonium Nitrate (AN)	31.43	31.86	85.14	85.65	6.33	6.57	40.14	40.85
	Ammonium Sulfate (AS)	32.04	32.77	85.59	86.16	6.96	7.05	41.05	42.01
Mean		31.46	31.87	85.18	85.69	6.47	6.62	40.12	40.82
	Urea (U)	27.48	27.96	83.05	83.92	6.01	6.07	33.21	33.56
Giza 95	Ammonium Nitrate (AN)	28.52	28.61	84.12	84.35	6.08	6.13	34.16	34.85
	Ammonium Sulfate (AS)	29.94	30.03	84.94	85.04	6.44	7.82	35.12	35.48
Mean		28.65	28.87	84.19	84.44	6.18	6.67	34.16	34.63
Means of	Urea (U)	30.38	30.61	84.53	85.25	6.33	6.43	38.46	38.77
Nitrogen	Ammonium Nitrate (AN)	30.85	31.28	85.64	86.14	6.61	6.70	38.70	39.16
Sources	Ammonium Sulfate (AS)	31.83	32.15	86.07	86.38	6.68	7.23	39.71	40.09
Mean		31.02	31.35	85.41	85.92	6.54	6.79	38.95	39.34
	A	0.45	0.53	1.27	1.33	0.36	0.48	0.78	0.82
$L.S.D_{0.05}$	B	0.90	0.99	1.35	1.21	ns	ns	0.65	0.77
	A×B	0.78	0.85	2.55	2.38	0.64	0.79	1.33	1.69

Table 5. Micronaire value, Brightness (Rd%) and Yellowness (+b) of three cotton cultivars as affected by nitrogen sources through (2017-2018) growing seasons of cotton.

Treatments		**Micronaire value (fineness)**		**Values of color**			
				Brightness (Rd%)		**Yellowness (+b)**	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	Urea (U)	3.35	3.21	75.90	76.92	9.12	9.16
Giza 93	Ammonium Nitrate (AN)	3.16	3.02	75.83	76.55	9.20	9.22
	Ammonium Sulfate (AS)	3.10	2.95	75.12	76.58	9.13	9.21
Mean		3.00	3.20	3.06	76.68	9.15	9.20
	Urea (U)	3.42	3.34	72.91	72.42	10.44	10.51
Giza 94	Ammonium Nitrate (AN)	3.26	3.28	72.83	72.07	10.50	10.32
	Ammonium Sulfate (AS)	3.12	3.17	72.07	72.26	10.51	10.53
Mean		3.39	3.27	3.26	72.25	10.48	10.45
	Urea (U)	4.31	4.24	68.91	68.11	11.88	11.68
Giza 95	Ammonium Nitrate (AN)	4.12	4.07	69.80	68.69	11.86	11.42
	Ammonium Sulfate (AS)	3.96	3.87	69.82	68.15	11.86	11.64
Mean		3.95	4.13	4.06	68.32	11.87	11.58
Means of Nitrogen Sources	Urea (U)	3.69	3.60	72.57	72.48	10.48	10.45
	Ammonium Nitrate (AN)	3.51	3.46	72.82	72.44	10.52	10.32
	Ammonium Sulfate (AS)	3.39	3.33	72.34	72.33	10.50	10.46
Mean		3.45	3.53	3.46	72.42	10.50	10.41
	A	0.10	0.15	ns	ns	ns	ns
$L.S.D_{0.05}$	B	0.12	0.17	ns	ns	ns	ns
	A×B	0.18	0.24	ns	ns	ns	ns

Nitrogen, phosphorus, potassium and calcium contents in leaves

The chemical content of nitrogen (N) and calcium (Ca) in leaves of cotton plants significantly affected by cotton cultivars, nitrogen fertilizer sources and their interaction meanwhile, phosphorus (P) and potassium (K) content in leaves of cotton plants significantly influenced only by nitrogen fertilizer sources and the interaction between the last factor and cultivars in 2017 and 2018 seasons (Table 6). Giza 93 cultivar surpassed the other two cultivars in N content (3.62%) in the first season only but, concerning Ca contents (3.01 and 3.06%) its superiority over the other two cultivars was in 2017 and 2018 seasons respectively. In contrast, Giza 95 cultivar recorded the lowest concentration of Ca content (2.21 and 2.29%) in both seasons and N content (3.04%) in one out of two seasons. Mainly, such results are attributed to the differences in genetic makeup of the evaluated cotton cultivars. The above-mentioned results agreed with those reported by de Oliveira Araújo, *et al.,* (2013), Zhang, *et al.,* (2018) and Iqbal, *et al.,* (2020).

Results in Table 6 showed that applying the nitrogen in ammonium sulfate form gave the significant highest content of nitrogen (3.57 and 3.62%), phosphorus (0.55 and 0.55%), potassium (1.76 and 1.79%) and calcium (2.98 and 3.07%) in leaves of cotton compared with urea without significance difference with ammonium nitrate in 2017 and 2018 seasons. Also, the difference between urea and ammonium nitrate was insignificant regarding the chemical content of N, P, K and Ca in leaves of cotton plant in both seasons. The differences in macro-elements composition of cotton plants may be due to that nitrogen forms have a strong impact on the uptake of other cations and anions, on cellular pH regulation and on rhizosphere pH. So, N form and N concentration have a great influence on nutrient accumulation and composition of plants. Because N is a nutrient of high metabolic demand, it affects the balance of anions and cations in plants (Harada, *et al.,* 1968; Fernandes, and Rossiello, 1995; He, *et al.,* 1998; Fageria *et al.,* 2006 and Feng, *et al.,* 2020).

The interaction between cotton cultivars and nitrogen fertilizer sources had a significant effect on the concentration of N, P, K and Ca in the leaves of cotton plants. This was true in both seasons (Table 6). The highest continent of N in leaves was observed with the application of ammonium sulfate in combination with Giza 93 cultivar (3.88%) and Giza 94 cultivar (3.84%) in 2017 and 2018 seasons, respectively. In terms of P, K and Ca the highest concentration of P (0.65 and 0.71%), K (1.98 and 2.07%) and Ca (3.54 and 3.62%) in leaves was obtained when the plant of Giza 93 cultivar fertilized with ammonium sulfate in first and second seasons respectively. While, the lowest continent of N (2.71 and 2.86%) and K (0.82 and 0.98%) in leaves produced by the Giza 95 cultivar and urea in 2017 and 2018 seasons, respectively. In this context, the lowest concentration of P (0.27 and 0.32%) obtained by Giza 94 cultivar and urea in both seasons while, the lowest concentration of Ca (2.08 and 2.13%) produced by Giza 95 cultivar and ammonium nitrate in 2017 and 2018 seasons, respectively.

Table 6. Nitrogen, phosphorus, potassium and calcium contents (%) in leaves of three cotton cultivars as affected by nitrogen sources through (2017-2018) growing seasons of cotton.

Treatments		**N**		**P**		**K**		**Ca**	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Giza 93	Urea (U)	3.25	3.08	0.36	0.38	1.78	1.85	2.71	2.75
	Ammonium Nitrate (AN)	3.72	3.13	0.52	0.48	1.82	1.93	2.78	2.81
	Ammonium Sulfate (AS)	3.88	3.32	0.65	0.71	1.98	2.07	3.54	3.62
Mean		3.62	3.18	0.51	0.52	1.86	1.95	3.01	3.06
Giza 94	Urea (U)	3.11	3.02	0.27	0.32	0.92	1.04	2.23	2.34
	Ammonium Nitrate (AN)	3.23	3.65	0.36	0.38	1.64	1.70	2.33	2.37
	Ammonium Sulfate (AS)	3.55	3.84	0.41	0.43	1.85	1.79	2.97	3.02
Mean		3.30	3.50	0.35	0.38	1.47	1.51	2.51	2.58
Giza 95	Urea (U)	2.71	2.86	0.33	0.38	0.82	0.98	2.12	2.19
	Ammonium Nitrate (AN)	3.14	3.33	0.38	0.41	1.17	1.22	2.08	2.13
	Ammonium Sulfate (AS)	3.27	3.70	0.58	0.51	1.46	1.52	2.42	2.56
Mean		3.04	3.30	0.43	0.43	1.15	1.24	2.21	2.29
Means of Nitrogen Sources	Urea (U)	3.02	2.99	0.32	0.36	1.17	1.29	2.35	2.43
	Ammonium Nitrate (AN)	3.36	3.37	0.42	0.42	1.54	1.62	2.40	2.44
	Ammonium Sulfate (AS)	3.57	3.62	0.55	0.55	1.76	1.79	2.98	3.07
Mean		3.32	3.33	0.43	0.44	1.49	1.57	2.58	2.64
L.S.D$_{0.05}$	A	0.41	0.24	ns	ns	ns	ns	0.48	0.37
	B	0.45	0.55	0.22	0.18	0.48	0.45	0.65	0.56
	A×B	1.28	1.46	2.47	2.32	1.21	1.32	1.38	1.51

Zinc, iron, manganese and cupper contents in leaves

Results in Table 7 indicated that cultivars, nitrogen fertilizer sources and their interaction had a significant effect on the chemical content of Zn, Fe, Mn and Cu in leaves of cotton plants in both seasons. Highly varietal differences were detected as Zn, Fe, Mn and Cu were concerned of the three tested cotton cultivars in both seasons. Likewise, Giza 93 cultivar had the highest concentration of Zn (38.66 and 39.82ppm), Fe (101.87 and 104.31ppm), Mn (91.13 and 94.16ppm) and Cu (15.27 and 16.18ppm) in leaves of cotton plants in 2017 and 2018 seasons, respectively. In contrast, Giza 95 cultivar recorded the lowest concentration of Zn (33.48 and 33.46ppm), Fe (89.78 and 91.04ppm), Mn (74.23 and 75.71ppm) and Cu (10.27 and 11.62ppm) in leaves of cotton plants in 2017 and 2018 seasons, respectively. Giza 94 cultivar came in the intermediate manner concerning previously above-mentioned traits. These differences may be due to the differences in the genetical structure and its interaction with the ecological conditions.

Nitrogen fertilizer sources had a significant effect on the chemical content of Zn, Fe, Mn and Cu in leaves of cotton plants in both seasons (Table 7). The chemical content of Zn, Fe, Mn and Cu in leaves of cotton plants were significantly higher for both ammonium nitrate and ammonium sulfate than urea in 2017 and 2018 seasons. The chemical content of Zn (42.35 and 44.13ppm), Fe (101.04 and 102.00ppm), Mn (87.60 and 89.72ppm) and Cu (14.33 and 15.51ppm) in leaves of cotton plants were the highest with the application of ammonium sulfate. On the contrary, they were the lowest with the application of urea in the first and second seasons. The differences in micro-nutrients composition of cotton plants may be due to that nitrogen forms have a strong impact on the absorption of other cations and anions, on cellular pH regulation and on rhizosphere pH. So, N form and N concentration have a great impact on nutrient accumulation and composition of plants. Because N is a nutrient of high metabolic demand, it influences the balance of anions and cations in plants (Harada, *et al.,* 1968; Fernandes, and Rossiello, 1995; He, *et al.,* 1998; Fageria *et al.,* 2006 and Feng, *et al.,* 2020).

The response of cotton cultivars significantly varied with the application of different nitrogen fertilizer sources in both seasons (Table 7). The continent of Zn (45.22 and 47.12ppm), Fe (108.21 and 109.31ppm), Mn (91.13 and 94.16ppm) and Cu (16.56 and 18.07ppm) in the leaves of

Giza 93 cultivar was the highest over other treatments with the application of ammonium sulfate in 2017 and 2018 seasons, respectively. While, the lowest continent of Zn (28.26 and 29.10ppm), Fe (86.73 and 87.20ppm), Mn (65.86 and 67.34ppm) and Cu (9.86 and 10.50ppm) in the leaves obtained with Giza 95 cultivar combination with urea as nitrogen fertilizer source in first and second seasons, respectively.

Table 7. Zinc, iron, manganese and cupper contents (ppm) in leaves of three cotton cultivars as affected by nitrogen sources through (2017-2018) growing seasons of cotton.

Treatments		**Zn**		**Fe**		**Mn**		**Cu**	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Giza 93	Urea (U)	33.91	34.88	96.17	98.21	89.11	91.83	13.94	14.03
	Ammonium Nitrate (AN)	36.85	37.46	101.24	105.55	90.17	93.42	15.32	16.43
	Ammonium Sulfate (AS)	45.22	47.12	108.21	109.18	94.11	97.24	16.56	18.07
Mean		38.66	39.82	101.87	104.31	91.13	94.16	15.27	16.18
Giza 94	Urea (U)	30.32	32.51	93.17	93.92	78.13	79.54	10.58	11.87
	Ammonium Nitrate (AN)	34.49	36.32	97.33	98.24	81.82	85.14	13.04	13.88
	Ammonium Sulfate (AS)	42.33	45.2	101.47	102.7	87.14	89.01	14.57	15.29
Mean		35.71	38.01	97.32	98.29	82.36	84.56	12.73	13.68
Giza 95	Urea (U)	28.26	29.10	86.73	87.20	65.86	67.34	9.86	10.50
	Ammonium Nitrate (AN)	32.68	31.19	89.15	91.80	75.27	76.88	10.95	11.17
	Ammonium Sulfate (AS)	39.50	40.08	93.45	94.11	81.55	82.91	11.87	13.18
Mean		33.48	33.46	89.78	91.04	74.23	75.71	10.89	11.62
Means of Nitrogen Sources	Urea (U)	30.83	32.16	92.02	93.11	77.70	79.57	11.46	12.13
	Ammonium Nitrate (AN)	34.67	34.99	95.91	98.53	82.42	85.15	13.10	13.83
	Ammonium Sulfate (AS)	42.35	44.13	101.04	102.00	87.60	89.72	14.33	15.51
Mean		35.95	37.10	96.32	97.88	82.57	84.81	12.97	13.82
L.S.D$_{0.05}$	A	0.76	0.53	1.27	1.32	0.57	0.74	0.79	0.82
	B	0.89	0.96	1.36	1.21	0.49	0.48	0.65	0.77
	A×B	1.78	1.84	2.57	2.39	1.48	1.37	1.34	1.69

Some biochemical contents

Results in Table 8 showed that, cotton evaluated cultivars, nitrogen fertilizer sources and their interaction had a significant effect on total phenolics, total carbohydrates, seed oil content and seed crude protein content in the first and second seasons. Results presented clearly indicated that total phenolics (4.34 and 3.94%), total carbohydrates (35.65 and 36.29 µg\g D.W), seed oil content (18.94 and 19.32%) and seed crude protein content (19.21 and 18.96%) were significantly higher with Giza 93 cultivar when compared with both Giza 94 and Giza 95 cultivars in the first and second seasons. Giza 94 cultivar occupied the second rank after Giza 93 cultivar while, Giza 95 cultivar behaved the worst in previously above-mentioned characters in 2017 and 2018 seasons. Such observed variation among cotton cultivars may be due to differences in genetic background as indicated by the high ability to metabolism and less catabolism rate of biochemical compositions and so on. These results are in general agreement with those obtained by Iqbal, *et al.,* (2020a).

Table 8. Some biochemical contents of three cotton cultivars as affected by nitrogen sources through (2017- 2018) growing seasons of cotton.

Treatments		**Total phenolics (%)**		**Total carbohydrates µg\g D.W**		**Seed oil content %**		**Seed crude protein content %**	
Cultivars (A)	**Nitrogen Sources (B)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Giza 93	Urea (U)	3.92	3.45	34.98	35.13	18.35	18.98	18.15	17.22
	Ammonium Nitrate (AN)	4.16	4.12	35.87	36.81	18.92	19.11	19.21	19.76
	Ammonium Sulfate (AS)	4.95	4.24	36.11	36.93	19.56	19.78	20.26	19.91
Mean		4.34	3.94	35.65	36.29	18.94	19.32	19.21	18.96
Giza 94	Urea (U)	3.11	2.99	30.14	28.23	16.86	16.57	16.65	17.84
	Ammonium Nitrate (AN)	3.38	3.12	31.78	31.83	17.53	18.15	17.56	18.91
	Ammonium Sulfate (AS)	3.87	3.99	32.81	32.03	18.05	19.78	18.11	19.72
Mean		3.42	3.37	31.58	30.70	17.48	18.17	17.44	18.82
Giza 95	Urea (U)	2.96	2.74	29.19	26.94	16.15	16.74	16.15	16.41
	Ammonium Nitrate (AN)	3.23	3.10	30.71	31.45	16.74	17.09	16.98	17.12
	Ammonium Sulfate (AS)	3.51	3.24	31.25	32.16	17.69	18.12	17.11	17.98
Mean		3.23	3.03	30.38	31.18	16.86	17.32	16.75	17.17
Means of Nitrogen Sources	Urea (U)	3.33	3.06	31.44	31.10	17.12	16.66	16.98	17.16
	Ammonium Nitrate (AN)	3.31	3.11	31.25	31.64	17.14	18.07	17.27	18.02
	Ammonium Sulfate (AS)	3.82	3.78	33.31	33.31	18.22	19.00	18.66	19.15
Mean		3.48	3.32	32.00	32.14	17.49	17.91	17.64	18.11
L.S.D$_{0.05}$	A	0.78	0.57	1.29	1.34	0.59	0.76	0.81	0.84
	B	ns	ns	1.38	1.28	0.52	0.50	0.68	0.79
	A×B	1.81	1.86	2.58	2.41	1.53	1.39	1.34	1.71

The differences among urea, ammonium nitrate and ammonium sulfate application were significant in terms of total carbohydrates, seed oil content and seed crude protein content but, they were insignificant regarding total phenolics in both seasons (Table 8). The highest values of total carbohydrates (33.31 and 33.31 µg\g D.W), seed oil content

(18.22 and 19.00%) and seed crude protein content (18.66 and 19.15%) were achieved with ammonium sulfate in 2017 and 2018 seasons. The superiority of ammonium sulfate over the other two sources of nitrogen in our investigation may be due to the role of sulfur element in synthesis of proteins, oils, vitamins, and flavored compounds in plants. Also, it is a constituent of three amino acids Methionine (21% S), Cysteine (26% S) and Cystine (27% S), which are the building blocks of protein (Youssif, 2017).

Significant cotton cultivars × nitrogen fertilizer sources interactions existed on total phenolics, total carbohydrates, seed oil content and seed crude protein content in 2017and 2018 seasons (Table 8). The plant of Giza 93 cultivar achieved the highest concentration of total phenolics (4.95 and 4.24%), total carbohydrates (36.11 and 36.93 µg\g D.W), seed oil content (19.56 and 19.78%) and seed crude protein content (20.26 and 19.91%) when fertilized with ammonium sulfate in 2017 and 2018 seasons, respectively. However, the lowest continent of total phenolics (2.96 and 2.74%), total carbohydrates (29.19 and 26.94µg\g D.W) and seed crude protein content (16.15 and 16.41%) obtained by Giza 95 cultivar fertilized with urea in first and second seasons, respectively. Meanwhile, the lowest of seed oil content (16.15 and 16.57%) produced by applying urea combined with Giza 94 and Giza 95 in 2017 and 2018 seasons, respectively.

CONCLUSION

In a broad sense, regarding mineral nitrogen sources our results could be helped in making decisions for nitrogen management practices. In a narrow sense, however more detailed studies on this subject are still needed for their substantiation according to these results, it could be concluded that the use of either ammonium sulfate or ammonium nitrate as nitrogen fertilizers could be recommended under the conditions of Giza locally but, usage is related to source advantages from the agronomic management practices, economic and availability standpoint.

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التأثير المقارن لمصادر مختلفة من أسمدة السماد النيتروجيني المعدنية على إنتاجية وجودة بعض أصناف القطن المصري

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إستنباط أصناف من القطن ذات قدرة محصولية عالية و، ذات كفاءة في إمتصاص العناصر الغذائية و، جودة الياف و، مبكرة النضج و، محتوى بذرة عالى من الزيت والبروتين ومقاومة للآفات من أهم إهتمامات برنامج تربية القطن المصري. لذا أجريت تجربة حقلية بمحطة البحوث والتجارب الزراعية - كلية الزراعة - جامعة القاهرة بالجيزة خلال موسم ٢٠١٧ و أعيدت موسم ٢٠١٨ لدراسة إستجابة وتقييم إنتاجية وجودة ثلاث أصناف جديدة من القطن المصرى وهى؛ جيزة ٩٣ ،جيزة ٩٤ وجيزة ٩٥ لثلاث مصادر مختلفة للأسمدة المعدنية النيتروجينية وهي اليوريا (N٤٦%) ، نترات الأمونيوم (N٣٣,٥%) و كبريتات الأمونيوم (N٢٠,٥ %). تم أستخدام تصميم القطاعات الكاملة العشوائية بتوزيع القطع المنشقة مرتين حيث خصصت القطع الرئيسية لأصناف القطن بينما وزعت مصادر الأسمدة النيتروجينة عشوئياً بالقطع المنشقة. تفوق الصنف جيزة ٩٣ علي باقي الأصناف في صفات النمو ، المحصول ومكوناته والمحتوى الكيميائي والبيوكيميائي للأوراق وبذرة القطن بالإضافة الي الصفات التكنولوجية للألياف. وبصفة عامة كان لمصادر النيتروجين المعدني تأثير معنوي على صفات النمو ، المحصول ومكوناته والمحتوى الكيميائي والبيوكيميائي لأوراق وبذرة القطن حيث تفوقت كبريتات الأمونيوم لصفات طول النبات ، أول عقدة للفرع الثمري ، عدد الأفرع الثمرية للنبات ، عدد اللور الكلي للنبات ، وزن اللوزة ، دليل البذرة ، تصافي الحليج ، محصول القطن الزهر للفدان ، الصفات التكنولوجية للألياف والمحتوى الكيميائي والبيوكيميائي للأوراق وبذرة القطن. أظهر التفاعل بين أصناف القطن والأسمدة المعدنية النيتروجينة معنوية لمعظم الصفات المدروسة.