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Response of some Egyptian Cotton Cultivars Growth, Yield and Fiber Quality to Different Sources of Nitrogen Fertilizers and Foliar Zinc Application

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ABSTRACT

Two field experiments were carried out in Agricultural Research and Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt (2019 and 2020) to study the response of Egyptian cotton cultivars (Giza 92, Giza 94 and Giza 95) growth, yield and fiber properties to foliar zinc (Zn) rates (0, 100 and 200 ppm) and nitrogen (N) fertilizers sources; urea (U), ammonium nitrate (AN) and ammonium sulfate (AS). Cultivars, N sources and foliar Zn led to a significant effect on plant height, number of sympodial branches plant^{-1}, total and open bolls plant^{-1}, boll weight, seed index, seed cotton yield plant^{-1}, seed cotton yield fed^{-1}, fiber strength, and fineness. While, cultivars had a significant effect on the position of the 1st sympodial node, lint%, fiber length and uniformity index. Giza 95 was a superior in above parameter except seed index and fiber quality. While, Giza 92 was a superior in fiber quality. Significant of two and three interactions between studied factors existed on most of studied traits. Whereas, the highest values were obtained from plots treated with AS with foliar Zn at 200 ppm in most cases. Significant relationships were found between total boll and percentage of open boll plant^{-1}; R^2 = 0.76 (Giza 92), 0.89 (Giza 94) and 0.91 (Giza 95). Also, seed cotton yield fed.$^{-1}$ with open bolls plant^{-1}, boll weight and lint% (R^2 = 0.862, 0.632 and 0.619, respectively). In such experimental soil conditions ammonium sulfate and foliar Zn at 200 ppm could be recommended to improve the cotton properties.

Keywords: Cotton, *Gossypium barbadense* L., cultivars, zinc, nitrogen fertilizers, growth parameters, fiber quality.

INTRODUCTION

Cotton is the most important fiber crop as a source of textile natural fiber in the world (Constable and Bange, 2015). As well as in Egypt, it is an important cash crop by earning significant foreign exchange, through use as a textile fiber crop in textile industries as well as second most important oil seed crop (El-Sabagh *et al.*, 2018).

Nitrogen has contributed greatly for cotton production, because it plays a pivotal role in increasing cotton yield by enhance growth, prevents abscission of squares and bolls, essential for photosynthetic activity, stimulates the mobilization and accumulation of metabolites in newly developed bolls, thus increasing their number and weight (Niu *et al.*, 2021 and Sawan, 2021). Ammonium (NH_4^+) and nitrate (NO_3^-) only two forms uptake by plants. The NH_4^+ form is held in the soil by negatively charged soil clays or colloids, however, NO_3^- form is repelled by soil particles and is subject to movement with water in the soil profile. The conversion of N from one form to another involves the generation or consumption of acidity. The uptake of ammonium or nitrate by plants will also affect acidity of soil, that ammonium-based fertilizers will acidify soil as they generate two H^+ ions for each ammonium molecule nitrified to nitrate (Reddy *et al.*, 1996). Different types of N-fertilizers can be used to secure the needs of the plant during growth, but it is important to select the appropriate type. The common N fertilizers are urea (U) [$CO(NH_2)_2$ (about 46% N), and ammonium nitrate (AN) [NH_4NO_3], (34% N) and ammonium sulfate (AS) [$(NH_4)_2SO_4$] (21% N), in addition, ammonium sulfate also contains about 24% sulfur (Fageria *et al.*, 2003). There are many potential agronomic benefits for AS compared with U and AN such as; no potential toxicity of aqueous NH_3 and nitrite to plants in alkaline soils, a better N source for saline soils by decreasing the negative specific effects of NaCl on plant growth and for saline sodic calcareous soils by improving soil structure and positive effects of soil acidification on increasing availability of soil phosphorus and applied phosphate rock and soil micronutrients (Chien *et al.*, 2011)

Although, zinc as nutrient element is extremely important for plant production, its uptake from the soils can be easily blocked depending on many factors and its quantity decreased continuously. The total concentration of Zn in soil ranges from 10 to 300 mg Zn kg^{-1} soil, with an average 55 mg Zn kg^{-1} soil. However, most Zn forms complexes with soil colloids which reducing Zn bioavailability for plants. Therefore, a very small amount of Zn is normally available for plant uptake (Alloway, 2008). Zinc is a structural component or cofactor of various enzymes involved in many biochemical processes. In plants, it is involved in photosynthesis, carbohydrate metabolism, protein metabolism, pollen formation, auxin metabolism, maintenance of membrane integrity, and induction of tolerance against various stresses (Imran *et al.*, 2016, Tahir *et*

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al., 2018 and Tariq *et al*., 2020). Rathinavel *et al* (2000). Foliar Zn application significantly affected cotton plant height, number of sympodial branches, number of bolls/plants, yield and fiber quality (Abdallah and Mohamed, 2013 and Elayan *et al.*, 2014).

In Egypt, soil fertilization is the primary limiting factor affecting growth and production under intensive land use for two or more crops per year. Furthermore, recently released cotton varieties have high yielding ability, which largely depends on ensuring the plant's essential nutritional requirements (Sawan, 2021).

Therefore, this study aimed to evaluate the effect of foliar zinc application and different nitrogen fertilizers on growth characters, yield, yield components and fiber properties of some Egyptian cotton cultivars.

MATERIALS AND METHODS

Field experiment

A field experiment was carried out in Agricultural Research and Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt (31º 11' 33.43'E, 30º 1' 36.16' N) during two consecutive successive summer seasons (2019 and 2020) to evaluate the response of Egyptian cotton (*Gossypium barbadense* L.) growth, yield, yield components and fiber properties to foliar different rates of zinc (Zn) and different nitrogen (N) fertilizer sources application. The experiments were laid out in a split-split-plot based on a Randomized Complete Block Design (RCBD) with three replications. Treatments included three cotton cultivates (Giza 92 extra-long staple and Giza 94 long staple are grown at lower Egypt, and Giza 95 long staple grown at upper Egypt) in main-plots, three sources of N as soil fertilizer are urea (U) ($CO(NH_2)_2$ - 46% N), ammonium nitrate (AN) (NH_4NO_3 - 34% N) and ammonium sulfate (AS) ($(NH_4)_2SO_4$ - 21% N) in sub-plots and three foliar Zn applications rates (0, 100 and 200 ppm) were applied in sub-sub-plots. Nitrogen fertilizer at a level of 60 kg N fed^{-1} as above-mentioned different N fertilizers sources, potassium fertilizer at 48 kg K_2O fed^{-1} as potassium sulphate (48% K_2O) and phosphorus fertilizer at 30 kg P_2O_5 fed^{-1} as calcium super phosphate (15.5% P_2O_5) were partly split and side dressed directly before the 1st and 2nd irrigation. Foliar Zn solution rate was 400-liter fed^{-1}. Surfactant (super film ®) was added according to the recommendation of its label. To prevent contamination, each plot was vertically protected with a plastic sheet during spraying Zn as zinc sulphate ($ZnSO_4.7H_2O$). The application was carried out between 9 and 11am, using a knapsack sprayer. Spraying took place twice; it began at the beginning of flowering and 15 days later. The control treatment (0 ppm Zn) only received water spray. Each plot (experimental unit) had six ridges, each of 0.6 m in width and 4.0 m in length, occupying an area of 14.4 m^2. The seeds were planted on the first week of April in both seasons in rows in hills 20 cm apart where two plants per hill were left after thinning. The other agricultural practices were carried out according to the usual practices in the cotton fields. The preceding crop was Berseem (*Trifolium alexandrinum* L.).

Analytical procedures

A composite soil samples were collected from 0-30, 30-60 and 60-90 cm depth during the study years before planting and were prepared for analyses in laboratory. The particle size distribution, pH, EC, total $CaCO_3$, organic matter (OM), total and available nitrogen (N), Phosphorus (P), Potassium (K) according to standard methods outline by Jackson (1973) and Keeney and Nelson, (1982). Available Zn was determined by atomic absorption spectrophotometer (AAS) after extracting the soil with DTPA as proposed by Lindsay and Norvell (1978). Details of soil properties are given in (Table 1).

Table 1. Some physical and chemical properties of the site of experiments soil during 2019 and 2020 of cotton growing seasons.

Soil characteristics	Seasons					
	2019			2020		
	Soil depth (cm)			Soil depth (cm)		
	0-30	30-60	60-90	0-30	30-60	60-90
Physical properties:						
C. Sand%	4.15	5.25	6.25	4.72	5.58	6.05
F. Sand%	36.50	33.52	37.50	35.54	34.15	38.41
Silt%	27.95	26.69	29.15	29.52	27.30	27.54
Clay%	31.42	34.55	27.25	30.25	33.05	28.15
Texture*	C. L.	C. L.	C. L.	C. L.	C. L.	C. L.
Soil bulk density (gcm^{-3})	1.18	1.35	1.38	1.15	1.31	1.35
Chemical properties:						
pH (paste extract)	7.72	7.84	7.97	7.75	8.02	8.12
EC (dS m^{-1})	1.95	2.27	2.48	1.96	2.48	2.87
Calcium carbonate (%)	3.17	3.52	4.96	3.27	3.38	3.97
Organic matter (%)	2.03	1.89	1.51	2.25	1.75	1.45
Plant available nutrients (mg kg^{-1})						
Nitrogen	35.65	28.55	20.26	33.52	25.25	18.56
Phosphorus	9.15	7.24	6.48	8.99	8.24	7.17
Potassium	255	238	225	248	235	215
Zinc DTPA-extractable	0.38	0.32	0.25	0.40	0.30	0.28
Total nutrients content						
Nitrogen (mg kg^{-1})	989	756	515	930	740	635
Phosphorus (mg kg^{-1})	710	533	510	740	620	560
Potassium (%)	2.33	2.24	2.12	2.35	2.25	2.10

***C.L. = clay loam**

Collection of experimental data

Growth parameters

Ten plants from each treatment were selected at 120 days after sowing (DAS) at random from each plot to determine growth attributes; plant height (cm), position of 1st sympodial node.

Yield and yield components

Ten guarded plants were taken at random from each plot to determine; number of sympodial branches per plant, number of total and open bolls per plant, boll weight (g), seed index (g), lint % (calculated from lint weight to seed cotton weight expressed as percentage), seed cotton yield per plant and seed cotton yield per feddan (kentar =157 kg and feddan = 4200 m^2) were calculated from the two central rows of each plot.

Fiber Properties

The following fiber properties were measured; fiber length (mm) and uniformity ratio (%) by the digital fibrograph, fiber strength (Presley index) by using the pressely tester at zero-gauge length and fiber fineness (micronair reading) by micronair apparatus. All fiber tests were carried out at the Laboratories of the Cotton Research Institute, Agricultural Research Center, Giza, Egypt, under controlled conditions of 70º F± 2 temperature and 65% ± 2 of relative humidity.

Statistical Analysis

The obtained data were subjected to statistical analysis of variance for each season, for all characters under study according to the procedure described by Snedecor and Cochron (1981). Significance of differences among variables were done according to Least Significant Differences test (LSD) at 5% level of probability. Finally, all statistical analyses were carried out using "MSTAT-C" computer software package (Freed *et al*., 1989).

RESULTS AND DISCUSSION

Plant growth attributes

Plant height

Results indicated that, the main effect of cotton cultivars (A), N sources (B) and foliar zinc rates (C) was associated with a significant increase in plant height (Fig.1). In both seasons as an average, cultivars recorded 147.6 (Giza 92) > 140.1 (Giza 95) > 127.9 cm (Giza 94). Also, different N fertilizers led to increase plant height sequentially; AN (134.7 cm) < U (138.3 cm) < AS (143.2 cm). The highest increase was recorded with AS (6.3%), followed by U (2.7%) compared with AN treatment. As well as Zn applied at different rates enhanced plant height from 137.8 to 144.3 cm for 100 and 200 ppm, which represent 2.8 to 7.6% increases, respectively comparing with control treatment (zero ppm Zn). Obtained results in agreement with those obtained by Brar *et al.* (2008), Elayan *et al.* (2014) and Korejo *et al.* (2015) whose reported that plant height was increased significantly by increasing level of foliar application of zinc. Data in Table (2) cleared that, there were insignificant effect of two factor interactions (AB, AC and BC) with respect to plant height. While, the interaction of three factors (ABC) significantly effect on plant height, Giza 92 cultivar recorded the highest plant height (163.8 cm) at AS with 200 ppm zinc Application. This may be due to significant increase in each of main stem internodes and/or internodes length. In this respect, application of nitrogen improved plant height in cotton (Shuaib *et al.*, 2015). As well as, zinc is necessary for the synthesis of tryptophan (a precursor of auxin) and thus involved in auxin synthesis which involved in elongation. This result agrees with those obtained by Yaseen *et al* (2013) and Elayan *et al.*(2018)

Position of first sympodial node

Neither N fertilizers sources nor foliar zinc rate applications and their interactions between them had a significant effect on position of the first sympodial node (Fig. 1 and Table 2). On the other hand, cotton cultivars led to a significant effect in both seasons, the lowest average value in both seasons was recorded in Giza 95 (6.50) that closed to Giza 94 (6.54), While the highest one (7.37 cm) was recorded in Giza 92. This effect was rather expected as the foliar Zn application treatments were tried at flowering where the position of the first sympodial node was already defined, this in agreement with Elayan *et al.* (2018).

Seed cotton yield and its components

Sympodial branches per plant

Sympodial branches bear bolls which directly involving in producing seed cotton on the plants. Data in both seasons as an average (Fig. 1 and Table 2) indicated that, the main effect of each of the cotton cultivars, N sources and foliar zinc rates was caused a significant increase in number of sympodial branches per plant. Whereas, cultivars recorded; 17 (Giza 92) > 16.5 (Giza 95) > 14.4 (Giza 94). Different N sources application led to an increase in sympodial branches per plant as descending order; U (15.5) < AN (15.9) < AS (16.5). The highest increase was recorded at AS (6.5%), followed by AN treatment (4.1%) compared with U treatment. Foliar Zn rates increased sympodial branches per plant from 15.98 to 17.03 for 100 and for 200 ppm, which represent 7.6 to 14.8%, respectively compared with control treatment. Researchers also stated that increasing of Zn application rates might have increased the production of metabolites synthesized and thus the plant had the chance to bear more fruiting branches (Abdallah and Mohamed (2013) and Sohair *et al.* (2014). Only interaction between cultivars and foliar Zn rates (AC) and between cultivars, N sources and Zn rates (ABC) being significant in both seasons (Table 2). The highest number of sympodial branches (18.11) was recorded in Giza 95 and AS with foliar Zn application at 200 ppm. Fig. (2) cleared a significant relationship (R^2 = 0.696) between plant height and the number of sympodial branches per plant. Higher number of sympodial branches per plant is an indication of higher potential of cotton crop for high production of seed cotton because these are considered the boll bearing branches (Hussien *et al.,* 2015).

Total and open bolls per plant

Data in both seasons cleared that, the main effect of cotton cultivars, N sources and foliar zinc rates was associated with a significant increase in total and open bolls per plant (Fig.1 and Table 2). Whereas, cotton cultivars recorded increases in total bolls number as the following order; Giza 92 (21.9) < Giza 94 (24.1) < Giza 95 (27.3). The percentage of open boll as a general; Giza 95 ranged from 77.1 to 93.7 with an average 85.4 ± 3.4% > Giza 94 ranged from 52.3 to 93.4 with an average 79.7 ± 7.5% > Giza 92 from 67.9 to 83.5 with an average 75.64 ± 3.1%. Data in Fig. (2) cleared a significant relationship (R^2 = 0.76, 0.89 and 0.91 for Giza 92, Giza 94 and Giza 95, respectively) between total bolls and % of open boll per plant. Also, N sources application led to a significant effect in total and open bolls per plant sequentially; AN (22.5 and 17.8) < U (24.8 and 20.2) < AS (25.99 and 21.1). The highest increase of open boll number per plant was recorded with AS (19%), followed by U (14%) compared with AN treatment. As well as Zn applied at different rates significantly enhanced total and open bolls per plant (24.5 and 19.8 for 100 ppm and 26.4 and 21.5 for 200 ppm). Open bolls represent 11.2 and 20.7% increase for 100 and 200 ppm, respectively as an average of both seasons comparing with zero Zn treatment. A high percentage of open bolls obtained where a high foliar Zn fertilizer was applied for both cropping seasons, but the lowest percentage where zero levels with different N sources fertilizer. Shuaib *et al.* (2015) reported similar increasing trend in number of bolls per plant due to application of Zn to cotton plants. The interaction between study factors cleared insignificant effect on total bolls per plant except the interaction between cultivars and N sources (AB) and between cultivars, N sources and Zn rates (ABC). However, the interaction between study factors with open bolls per plant cleared a significant effect except AB and AC in second season.

Boll weight

In both seasons the analysis of variance for boll weight (g) was being significant influenced by cotton cultivars (A), N sources (B), foliar Zn application rates (C) and the interaction between them except the interaction BC in first and AB in second season only (Fig.3 and Table 3). Cultivar Giza 95 recorded the highest value (2.42) and Giza 92 (2.31) closely to Giza 94 (2.32 g). Also, N sources led to sequentially increases; AN (2.25) < U (2.31) < AS (2.35 g), the highest increase was recorded with AS (4.4%), followed by U (1.7%) compared with AN treatment. This may be due to the decrease soil pH which increase the availability of many nutrients for plant, specially, phosphorus. Our results confirmed the findings of Upadhyaya *et al.* (2017) and Meena *et al.* (2017) they mentioned that P is essential for the biosynthesis of chlorophyll as pyridoxal must be present for its biosynthesis which ameliorated the mobilization of photosynthates and directly influenced boll weight. As well as applied foliar Zn at different rates significantly enhanced boll weight (2.15, 2.31 and 2.49 for 0, 100 and 200 ppm, respectively), the highest increase was recorded with 200 ppm Zn (16.1%), followed by 100 ppm (7.5%) compared with zero treatment. Maximum boll weight (2.70 g) was recorded for cultivar Giza 95 closely to Giza 94 at AS with foliar application Zn 200 ppm and minimum one (2.03 g) was recorded for Giza 92 at U with foliar application Zn zero ppm while each increment of Zn rates increased boll weight.

Seed index

Results cleared that, in both seasons seed index (g) was being significant influenced by cotton cultivars (A), N sources (B), foliar Zn application rates (C) and the interaction between them in both seasons except, the interaction BC only (Fig. 3 and Table 3). Cultivar Giza 94 recorded the highest ones (10.10 g) and Giza 92 (8.53) closely to Giza 95 (8.89). Also, N sources application led to sequentially increase; AN (9.02) < U (9.23) < AS (9.56 g), the highest increase was recorded with AS (2.3%) compared with AN treatment. As well as Zn applied at different rates enhanced seed index (8.87, 9.08 and 9.57 for 0, 100 and 200 ppm, respectively), the highest increase was recorded with 200 ppm Zn (7.8%), followed by 100 ppm (5.4%) compared with zero treatment. Maximum seed index for the interaction (10.85 g) was recorded for cultivar Giza 94 at AS with foliar application Zn 200 ppm and minimum one (8.16 g) was recorded for Giza 92 at U with foliar application Zn zero ppm while each increment of Zn rates increased seed index.

Lint percentage

lint percentage was being significant influenced by cotton cultivars (A), Zn application rates (C), however, nitrogen sources insignificant in both seasons (Fig. 3 and Table 3). The interactions were significant in both seasons except AB in both seasons and AC in first season only (Fig.3 and Table 3).

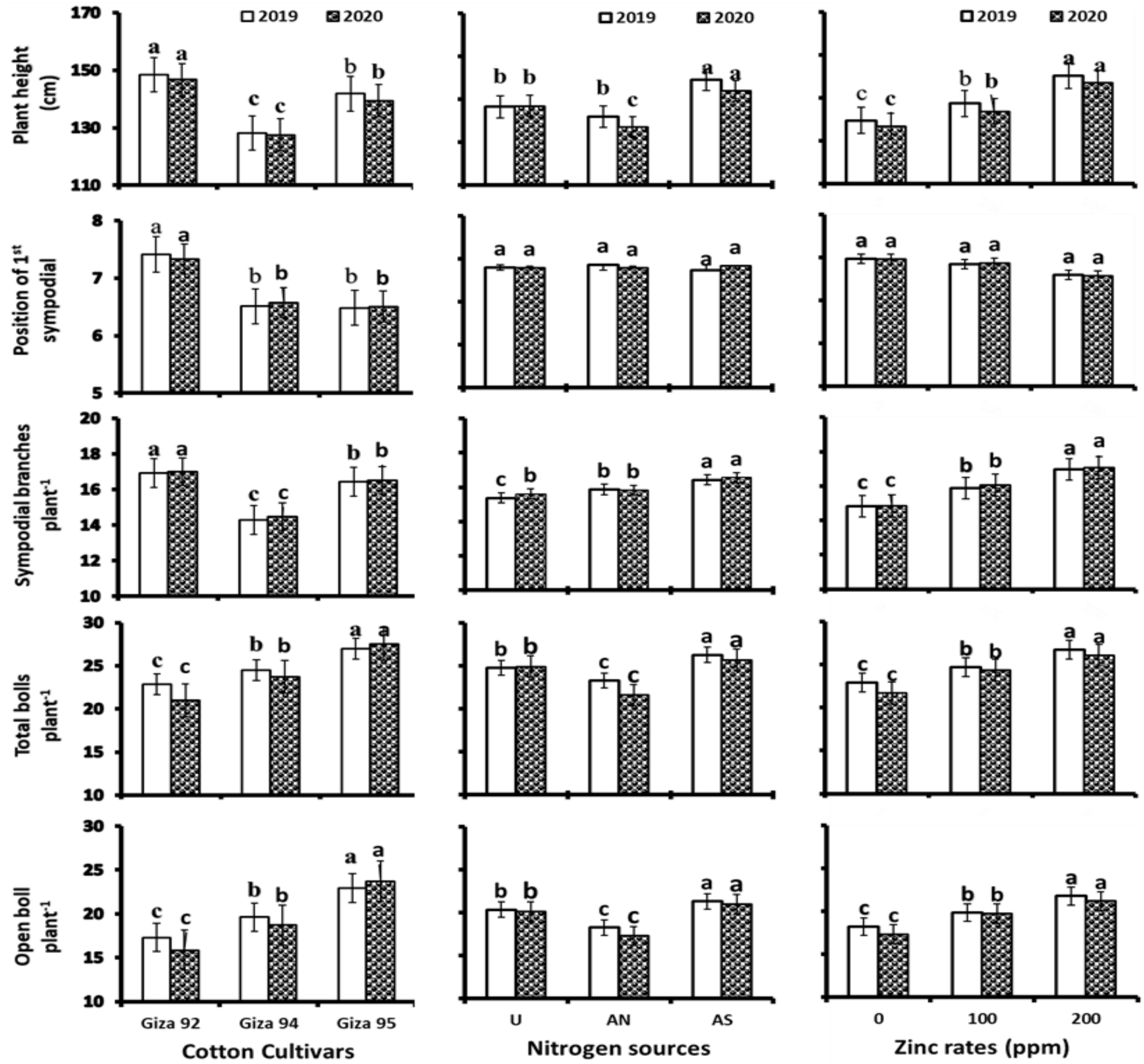

Fig. 1. Main effect of cultivars, N fertilizer sources (U = urea, AN = ammonium nitrate, AS = ammonium sulfate) and foliar Zn rates on some growth attributes of cotton during 2019 and 2020 seasons. The means followed by different letters are significantly different at the 0.05 probability level within a column.

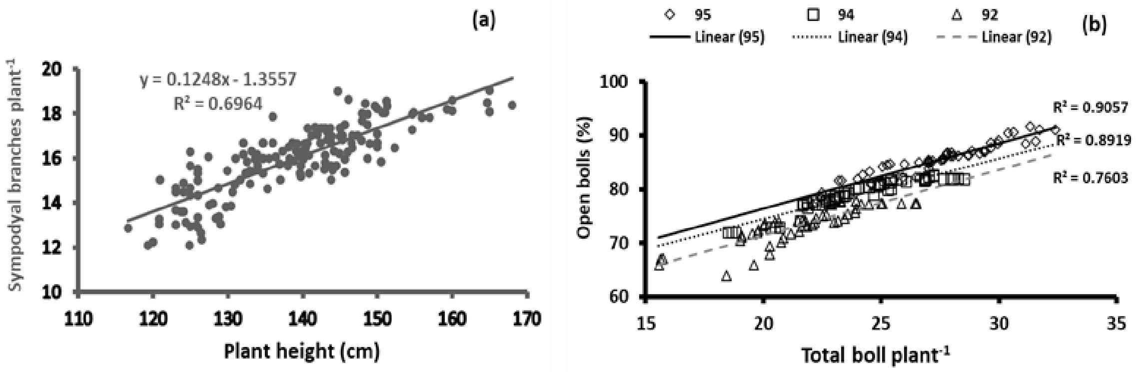

Fig. 2. Relationships between plant height and sympodial branches per plant (a); Total bolls per plant and open boll (%) in different cotton cultivars (b) during 2019 and 2020 growing seasons.

Table 2. The interaction between cultivars, N fertilizer sources and foliar Zn rates on some growth attributes of cotton during 2019 and 2020 seasons.

Treatments			Plant height (cm)		Position of 1st Sympodial node		Sympodial branches plant^{-1}		Total Bolls plant^{-1}		Open Bolls plant^{-1}	
Cultivars (A)	N sources (B)*	Zn (ppm) (C)	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Giza 92	U	0	143.6	141.4	7.45	7.34	15.64	15.67	21.37	20.65	16.50	15.63
		100	145.8	148.7	7.17	7.17	16.47	16.49	23.08	22.69	17.96	17.17
		200	152.3	155.8	7.00	6.83	16.94	18.19	25.30	23.31	19.72	17.85
		Mean	147.2	148.6	7.21	7.11	16.35	16.78	23.25	22.22	18.06	16.88
	AN	0	141.8	136.0	8.18	7.57	15.81	15.66	19.60	15.65	14.03	11.51
		100	145.4	139.2	7.67	7.50	17.00	17.07	21.52	19.75	15.56	14.56
		200	147.8	145.3	7.33	7.17	18.40	17.14	22.08	21.01	16.46	15.49
		Mean	145.0	140.2	7.73	7.41	17.07	16.62	21.07	18.80	15.35	13.85
	AS	0	144.7	142.3	7.23	7.40	16.06	16.02	22.28	19.32	16.97	14.71
		100	149.2	150.0	7.50	7.67	17.82	18.19	24.38	22.13	18.59	17.05
		200	165.9	161.7	7.17	7.33	18.31	18.58	26.32	24.31	19.93	18.78
		Mean	153.3	151.3	7.30	7.47	17.40	17.60	24.33	21.92	18.50	16.85
Mean			148.5	146.7	7.41	7.33	16.94	17.00	22.88	20.98	17.30	15.86
Giza 94	U	0	119.6	125.2	6.66	6.66	12.66	12.52	22.94	22.18	18.09	17.38
		100	126.0	127.4	6.50	6.50	13.35	14.13	23.88	25.38	18.98	20.00
		200	134.9	132.4	6.50	6.50	15.75	15.67	25.81	27.27	21.03	21.85
		Mean	126.8	128.3	6.55	6.55	13.92	14.11	24.21	24.94	19.37	19.74
	AN	0	123.3	121.8	6.54	6.76	12.95	13.31	21.87	18.66	17.07	14.34
		100	126.0	123.7	6.33	6.50	14.27	14.50	24.04	20.51	18.92	15.97
		200	125.7	125.0	6.50	6.33	15.33	15.56	25.57	22.66	20.48	17.92
		Mean	125.0	123.5	6.46	6.53	14.18	14.46	23.83	20.61	18.82	16.08
	AS	0	126.6	128.4	6.72	6.72	13.07	13.27	23.07	22.73	18.13	17.76
		100	133.3	130.7	6.67	6.67	14.83	14.83	25.05	26.45	20.57	21.03
		200	138.7	133.3	6.17	6.50	16.44	16.50	28.06	27.45	23.27	22.08
		Mean	132.9	130.8	6.52	6.63	14.78	14.87	25.39	25.54	20.66	20.29
			128.2	127.5	6.51	6.57	14.29	14.48	24.48	23.70	19.62	18.70
Giza 95	U	0	136.8	134.0	6.83	7.08	15.16	15.12	24.43	25.25	21.85	21.52
		100	138.8	136.0	6.73	6.88	15.79	15.93	26.47	27.75	23.23	24.29
		200	145.8	144.2	6.35	6.17	16.67	16.78	29.66	29.66	25.46	25.30
		Mean	140.5	138.1	6.64	6.71	15.87	15.94	26.85	27.55	23.51	23.70
	AN	0	134.4	132.4	6.56	6.56	15.75	15.75	22.45	23.58	18.35	19.56
		100	136.2	134.2	6.50	6.50	16.33	16.33	25.06	24.82	20.61	22.08
		200	142.5	143.3	6.17	6.17	17.00	17.17	27.54	27.60	22.64	23.85
		Mean	137.7	136.6	6.41	6.41	16.36	16.42	25.02	25.33	20.53	21.83
	AS	0	141.5	139.3	6.55	6.55	16.27	16.43	28.36	27.50	23.12	23.76
		100	147.7	141.7	6.50	6.50	17.06	17.11	28.73	29.58	24.08	25.67
		200	152.5	149.7	6.17	6.17	18.00	18.11	30.37	31.70	26.95	27.58
		Mean	147.2	143.6	6.41	6.41	17.11	17.22	29.15	29.59	24.72	25.67
Mean			141.8	139.4	6.48	6.51	16.45	16.53	27.01	27.49	22.92	23.73
LSD at 0.05	AB		ns	ns	ns	ns	ns	ns	1.18	0.68	0.79	0.52
	AC		ns	ns	ns	ns	0.38	0.31	ns	ns	0.47	ns
	BC		ns	ns	ns	ns	ns	ns	ns	ns	0.47	ns
	ABC		5.35	6.12	ns	ns	0.65	0.54	1.31	1.26	0.81	0.99

•U= Urea, AN= Ammonium Nitrate, AS= Ammonium Sulfate

Data in both seasons as an average cleared that, lint percentage of cultivars Giza 95 (39.97%) and with Giza 94 (39.21%) however, Giza 92 recorded (35.33%) the lowest one. As well as Zn applied at different rates significantly enhanced lint percentage (36.8, 38.9 and 38.8 for foliar Zn applications at 0, 100 and 200 ppm), the higher increase was recorded at 200 ppm Zn (5.5%), at par with 100 ppm (5.6%) compared with zero treatment. Maximum lint percentage (41.13) was recorded for the interaction of cultivar Giza 95 at AN with foliar application Zn 200 ppm while the minimum one (34.27) was recorded for Giza 92 at U with foliar application Zn at zero ppm.

Seed cotton yield per plant

Seed cotton yield per plant (g) was being significant influenced by cotton cultivars (A), N sources (B), Zn application rates (C) and the interaction between them in both seasons except, the interaction BC in first season only (Fig. 3 and Table 3). Whereas, an average of both seasons, cotton cultivars Giza 92 recorded the lowest value (33.17) followed by Giza 94 (38.8) however, Giza 95 recorded the highest ones (47.9 g). Also, N sources application led to sequentially increase; AN (38.2) < U (39.8) < AS (41.9 g), As recorded 9.9 and 5.5% increase compared with AN and U treatments, respectively. As well as Zn applied at different levels enhanced seed cotton yield per plant (38.3, 39.9 and 41.8 g for 0, 100 and 200 ppm, respectively), the highest increase was recorded with 200 ppm Zn (9.2%), followed by 100 ppm (4.1%) compared with zero Zn treatment. Maximum seed cotton yield per plant (52.56 g) was recorded for cultivar Giza 95 in AS with foliar application Zn at 200 ppm and minimum one (31.6 g) was recorded for Giza 92 in AN with foliar application Zn at zero ppm while each increment of Zn rates increased seed cotton yield per plant.

Seed cotton yield per feddan

Data in both seasons showed that, seed cotton yield per feddan (ken.) was being significant influenced by cotton cultivars (A), N sources (B), foliar Zn application rates (C) and the interaction between them in both seasons except, the interaction BC (Fig. 3 and Table 3).

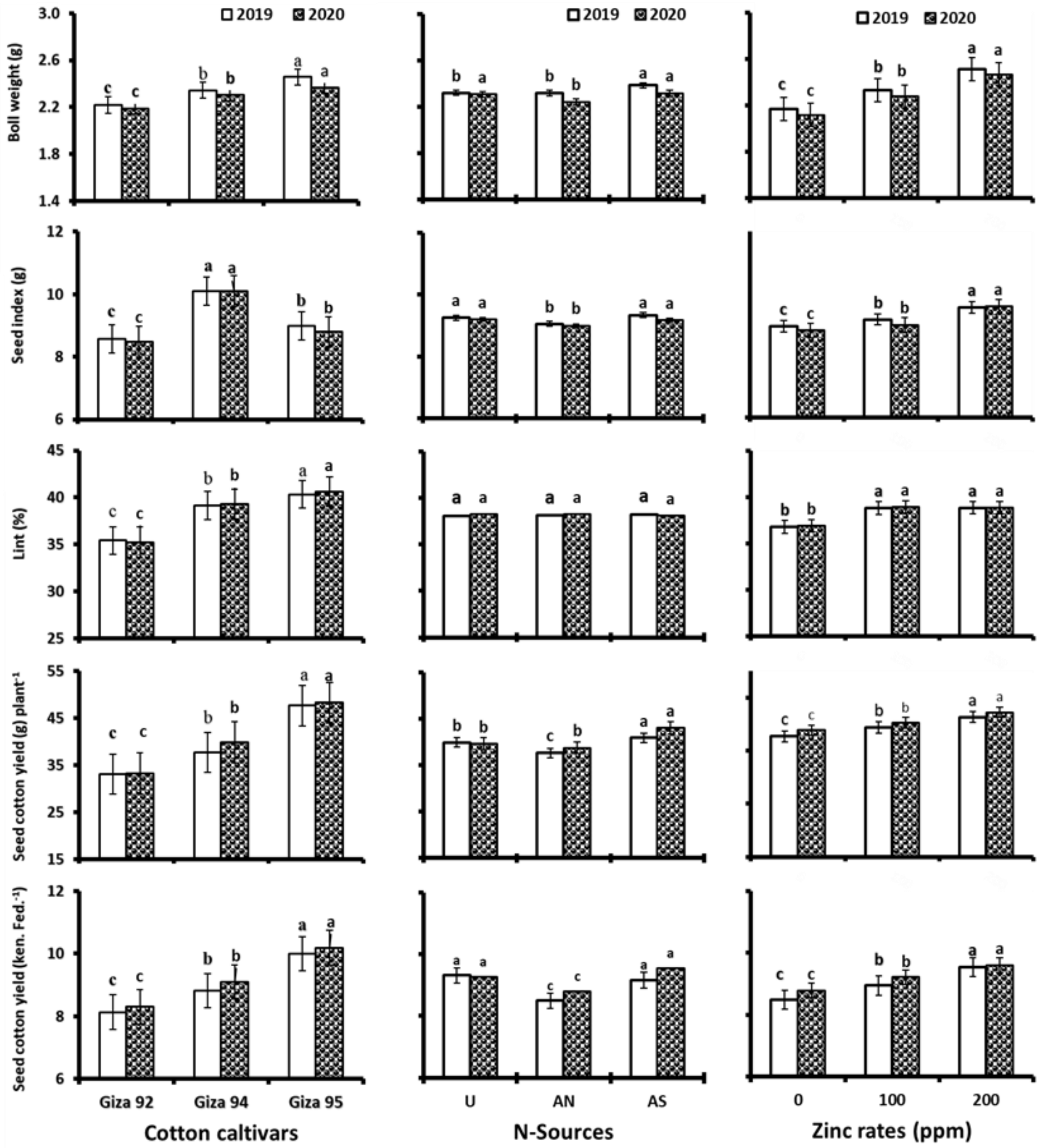

Fig. 3. Main effect of cultivars, nitrogen fertilizer sources (U = urea, AN = ammonium nitrate, AS = ammonium sulfate) and foliar Zn fertilizers rates on some growth attributes of cotton during 2019 and 2020 seasons. The means followed by different letters are significantly different at the 0.05 probability level within a column.

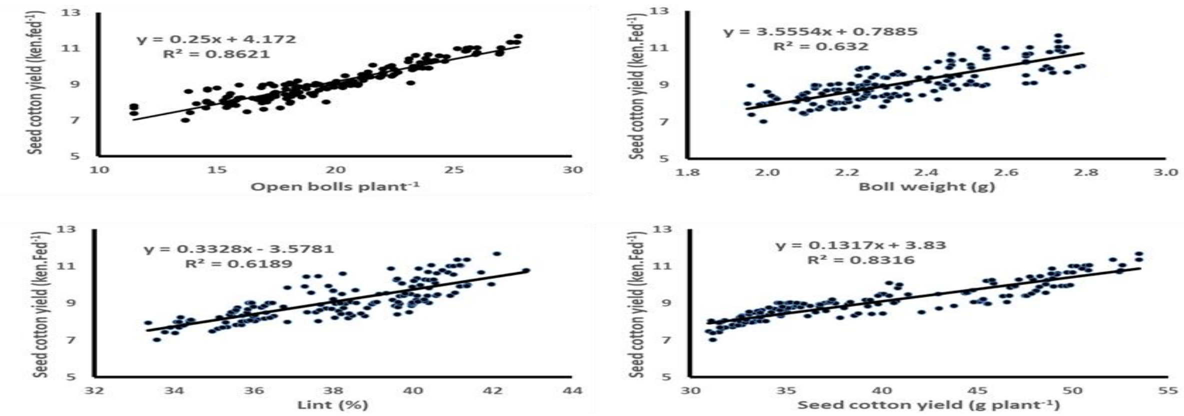

Fig. 4. Relationships between both of open bolls per plant, boll weight, lint (%) and seed cotton yield per plant with seed cotton yield per fed. during 2019 and 2020 seasons .

Table 3. The interaction between cultivars, N fertilizer sources and foliar Zn rates on some growth attributes of cotton during 2019 and 2020 seasons.

Treatments			Boll weight (g)		Seed index (g)		Lint (%)		Seed cotton yield plant^{-1} (g)		Seed cotton yield fed^{-1} (Ken.)	
Cultivars (A)	N Sources (B)*	Zn (ppm) (C)	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Giza 92	U	0	2.07	1.99	8.64	8.66	34.42	34.12	31.74	31.97	8.07	8.08
		100	2.23	2.14	8.86	8.80	35.86	35.54	33.05	33.41	8.41	8.51
		200	2.47	2.50	9.06	8.86	35.83	35.95	35.12	34.12	8.92	8.87
	Mean		2.26	2.21	8.85	8.77	35.37	35.20	33.30	33.17	8.47	8.49
	AN	0	2.09	2.06	8.11	8.22	33.75	34.14	31.46	31.75	7.39	7.64
		100	2.30	2.27	8.42	8.34	35.53	35.93	32.45	32.82	7.78	8.04
		200	2.29	2.17	8.62	8.43	36.26	36.01	33.36	33.67	8.17	8.38
	Mean		2.23	2.17	8.38	8.33	35.18	35.36	32.42	32.75	7.78	8.02
	AS	0	2.11	2.12	8.38	8.23	35.13	34.38	31.49	32.43	7.60	8.00
		100	2.20	2.20	8.48	8.35	36.21	35.45	33.61	34.24	8.01	8.42
		200	2.21	2.26	8.55	8.41	35.76	35.57	35.53	34.80	8.87	8.78
	Mean		2.17	2.19	8.47	8.33	35.70	35.13	33.54	33.82	8.16	8.40
Mean			2.22	2.19	8.57	8.48	35.42	35.23	33.09	33.25	8.14	8.30
Giza 94	U	0	2.09	2.12	9.63	9.57	37.40	37.54	36.61	37.79	8.47	8.96
		100	2.23	2.25	9.93	9.87	39.79	39.93	38.54	38.39	8.92	9.10
		200	2.48	2.46	10.41	10.78	39.05	39.99	40.17	40.41	9.70	9.43
	Mean		2.27	2.28	9.99	10.07	38.75	39.15	38.44	38.86	9.03	9.16
	AN	0	2.11	2.15	9.65	9.52	37.62	37.96	33.45	34.41	8.07	8.69
		100	2.20	2.24	9.90	9.72	39.60	39.96	34.85	35.85	8.41	8.96
		200	2.44	2.43	10.38	10.88	39.96	39.93	36.68	37.35	8.94	9.07
	Mean		2.25	2.27	9.98	10.04	39.06	39.28	34.99	35.87	8.47	8.91
	AS	0	2.31	2.09	10.01	9.69	38.41	38.39	38.40	40.09	8.33	8.64
		100	2.54	2.30	10.24	9.90	40.01	39.99	40.34	46.34	8.96	9.29
		200	2.69	2.71	10.74	10.96	40.59	39.69	40.42	48.27	9.64	9.80
	Mean		2.51	2.37	10.33	10.18	39.67	39.36	39.72	44.90	8.98	9.24
Mean			2.34	2.31	10.10	10.10	39.16	39.26	37.72	39.88	8.83	9.10
Giza 95	U	0	2.25	2.27	8.57	8.29	38.58	39.19	46.50	44.32	9.79	9.54
		100	2.44	2.47	8.84	8.54	41.04	41.69	47.65	45.80	10.53	10.25
		200	2.60	2.54	9.38	9.43	40.59	40.41	50.11	50.00	11.02	10.67
	Mean		2.43	2.43	8.93	8.75	40.07	40.43	48.09	46.71	10.45	10.15
	AN	0	2.26	2.13	8.52	8.34	38.24	38.27	42.97	46.55	8.71	8.99
		100	2.40	2.26	8.69	8.52	41.12	41.15	45.24	47.59	9.16	9.47
		200	2.75	2.46	9.25	9.02	40.96	41.00	48.25	49.00	9.79	9.93
	Mean		2.47	2.28	8.82	8.63	40.11	40.14	45.49	47.71	9.22	9.46
	AS	0	2.24	2.14	8.94	8.71	37.34	37.73	46.89	50.50	9.90	10.50
		100	2.46	2.35	9.08	8.85	40.15	40.57	48.84	48.31	10.31	10.94
		200	2.71	2.68	9.61	9.45	40.38	40.96	52.52	52.60	10.84	11.46
	Mean		2.47	2.39	9.21	9.00	39.29	39.75	49.42	50.47	10.35	10.97
Mean			2.46	2.37	8.99	8.79	39.82	40.11	47.66	48.30	10.01	10.19
	AB		0.11	ns	0.18	0.15	ns	ns	0.96	1.56	0.20	0.19
	AC		0.08	0.07	0.19	0.11	0.40	0.49	0.72	1.80	0.16	0.15
	BC		ns	0.07	ns	ns	0.40	ns	ns	0.81	ns	ns
	ABC		0.14	0.12	0.19	0.18	0.69	0.85	1.25	1.40	0.24	0.26

•U= Urea, AN= Ammonium Nitrate, AS= Ammonium Sulfate, ken.= kentar

Cultivars seed cotton yield (ken fed^{-1}) gave 8.22 (Giza 92) < 8.97 (Giza 94) < 10.1(Giza 95). Also, N sources application recorded 8.65 (AN) < 9.29 (U) < 9.35 ken. fed^{-1} (AS). These results are supported by Saleem *et al.* (2010). As well as Zn applied at different levels enhanced seed cotton yield (8.63, 9.08 and 9.57 ken fed^{-1} for 0, 100 and 200 ppm, respectively), the highest increase was recorded with 200 ppm Zn (10.9%), followed by 100 ppm (5.2%) compared with zero Zn treatment. Moreover Li *et al*. (2008) and Niaz et al. (2019) found that zinc ($ZnSO_4$) application promoted nutrient (N, P, and K) uptake, utilization, and metabolism, slightly increased root and shoot growth, bloom, dry matter production, and improved cotton quality as a result yield increased with the increase in foliar application of zinc level up to 15 kg ha^{-1} as compared with control plots. Maximum seed cotton yield (11.15 ken fed^{-1}) was recorded for cultivar Giza 95 in AS with foliar application Zn at 200 ppm and minimum one (7.52 ken fed^{-1}) was recorded for Giza 92 in AN with foliar application Zn at zero ppm, while each increment of Zn rates increased seed cotton yield per plant. Hence the application of Zinc to cotton for better yield and quality is inevitable. Seed cotton yield was dependent on the previous studied parameters, especially, number of open bolls, boll weight, lint percentage which directly affect. Figure (4) cleared that, a significant relationship between seed cotton yield (ken fed^{-1}) with open bolls (R^2 = 0.862), boll weight (R^2 = 0.632) and lint% (R^2 = 0.619).

Cotton Fiber properties

Fiber length

Results indicated that, the main effect of cotton cultivars and foliar zinc rates was associated with a significant increase in fiber length (mm) while nitrogen sources represented insignificant effect in fiber length (Fig. 5 and Table 4), this agreement with (Watts *et al.,* 2014) they reported that the cotton fiber length unaffected by nitrogen sources application. In both seasons as an average, cultivars recorded 33.94 (Giza 92) > 31.38 (Giza 94) > 30.83 (Giza 95), cultivar Giza 92 represented 8.2 and 10.2% increases comparing with Giza 94 and Giza 95, respectively. Giza 92 is an extra-long staple cultivar while Giza 94 and Giza 95 are a long staple cultivar according to Cotton Inc. (2013) classification (fiber lengths from 27.9 to 32.0 mm are considered long, and above 32 mm are extra-long). As well as foliar Zn applied at different rates enhanced fiber length; 32.16 and 32.64 mm for 100 and 200 ppm. obtained results agreement with those obtained by Brar *et al.* (2008), Elayan *et al.* (2014) and Korejo *et al.* (2015) whose reported that fiber length was increased significantly by foliar application of zinc levels increased.

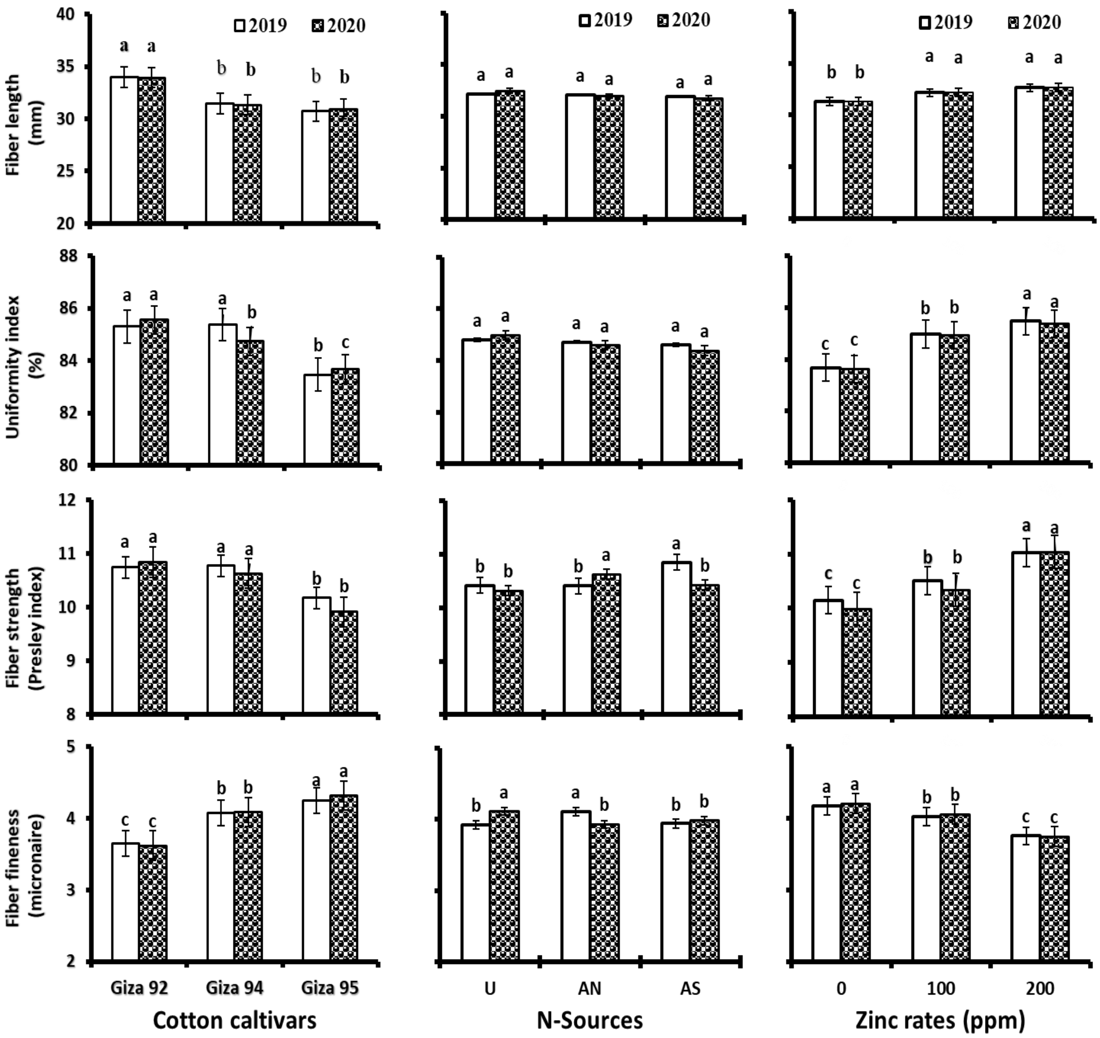

Fig. 5. Main effect of cultivars, nitrogen fertilizer sources (U = urea, AN = ammonium nitrate, AS = ammonium sulfate) and foliar Zn fertilizers rates on studied cotton fiber properties during 2019 and 2020 seasons. The means followed by different letters are significantly different at the 0.05 probability level within a column.

Table 4. The interaction between cultivars, N fertilizer sources and foliar Zn rates on some growth attributes of cotton during 2019 and 2020 seasons.

Treatments			Fiber length (mm)		Length uniformity index (%)		Fiber strength (Presley index)		Fiber fineness (micronaire)	
Cultivars (A)	**N Sources (B)***	**Zn (ppm) (C)**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Giza 92	U	0	34.09	34.64	84.97	85.17	9.82	10.17	3.76	3.97
		100	34.40	34.95	86.00	86.20	10.05	10.40	3.65	3.85
		200	34.80	35.85	86.45	86.75	11.30	11.50	3.55	3.55
	Mean		34.43	35.15	85.81	86.04	10.39	10.69	3.65	3.79
	AN	0	33.12	33.03	84.12	84.71	10.14	10.43	3.98	3.67
		100	33.80	33.70	85.40	86.00	10.45	10.75	3.90	3.60
		200	33.85	33.80	86.30	86.25	11.00	11.30	3.35	3.35
	Mean		33.59	33.51	85.27	85.65	10.53	10.83	3.74	3.54
	AS	0	33.50	32.90	83.79	84.03	10.91	10.62	3.68	3.68
		100	33.70	33.10	85.15	85.40	11.25	10.95	3.50	3.50
		200	34.30	33.40	85.50	85.45	11.75	11.40	3.45	3.40
	Mean		33.83	33.13	84.81	84.96	11.30	10.99	3.54	3.53
Mean			33.95	33.93	85.30	85.55	10.74	10.84	3.65	3.62
Giza 94	U	0	30.82	30.78	84.55	84.69	10.37	9.94	4.26	4.37
		100	31.77	31.73	85.40	85.55	10.80	10.35	4.10	4.20
		200	31.98	32.10	85.90	85.90	11.25	11.10	3.75	4.00
	Mean		31.52	31.54	85.28	85.38	10.81	10.46	4.04	4.19
	AN	0	30.68	30.28	84.57	83.30	10.19	10.33	4.32	3.95
		100	31.96	31.54	86.30	85.00	10.50	10.65	4.15	3.80
		200	32.06	31.97	86.10	85.50	10.85	11.20	3.95	3.75
	Mean		31.57	31.26	85.66	84.60	10.51	10.73	4.14	3.83
	AS	0	30.21	29.91	83.99	83.06	10.37	10.08	4.21	4.47
		100	31.63	31.16	85.70	84.75	10.80	10.50	4.05	4.30
		200	31.96	31.93	85.85	84.80	11.80	11.55	3.95	3.95
	Mean		31.27	31.00	85.18	84.20	10.99	10.71	4.07	4.24
Mean			31.45	31.27	85.37	84.73	10.77	10.63	4.08	4.09
Giza 95	U	0	29.69	30.14	82.42	82.62	9.70	9.46	4.38	4.69
		100	30.30	30.75	83.25	83.45	10.10	9.85	4.25	4.55
		200	31.30	31.25	84.30	84.50	10.40	10.10	3.60	3.85
	Mean		30.43	30.71	83.32	83.52	10.07	9.80	4.08	4.36
	AN	0	30.05	30.10	81.98	82.12	9.99	9.89	4.58	4.63
		100	31.30	31.35	83.65	83.80	10.30	10.20	4.40	4.45
		200	31.65	31.70	84.00	84.50	10.30	10.95	4.40	4.15
	Mean		31.00	31.05	83.21	83.47	10.20	10.35	4.46	4.41
	AS	0	29.68	30.11	82.74	82.94	9.83	8.98	4.49	4.49
		100	30.60	31.20	84.00	84.20	10.35	9.45	4.30	4.30
		200	31.80	31.87	84.80	84.80	10.60	10.30	3.85	3.75
	Mean		30.69	31.06	83.85	83.98	10.26	9.58	4.21	4.18
Mean			30.71	30.94	83.46	83.66	10.17	9.91	4.25	4.32
	AB		ns	ns	ns	ns	0.28	0.42	ns	ns
	AC		ns	ns	ns	ns	0.27	0.32	ns	ns
	BC		ns	ns	ns	ns	ns	ns	ns	ns
	ABC		ns	ns	ns	ns	ns	ns	0.29	0.14

•U= Urea, AN= Ammonium Nitrate, AS= Ammonium Sulfate

Length uniformity index (%)

Fiber uniformity is important because it reduces waste and yarn breakage (Glade *et al.*, 1981). In both seasons, length uniformity index insignificantly influenced by studied factors and interactions between them except main effect of cotton cultivars, and foliar Zn application rates (Fig. 5 and Table 4), this agreement with Watts *et al.* (2014) they reported that the cotton fiber uniformity unaffected by nitrogen sources application. Cultivar showed that, Giza 92 (85.43) > Giza 94 (85.05) > Giza 95 (83.36%). According to Cotton Inc. (2013), the studied cultivars ranged between high (Giza 95) and very high fiber uniformity (Giza 92 and Giza 94). Benson *et al.* (1998) and Weir *et al.*(1996) , also found no differences in fiber uniformity due to nitrogen applications. As well as foliar Zn applied at different rates enhanced fiber uniformity; 84.96 and 85.43% for 100 and 200 ppm, represents 1.6 and 2.1% increases, respectively comparing with control treatment (83.66%). Obtained results in agreement with those obtained by Elayan *et al.* (2014).

Fiber strength

Fiber strength (Presley index) is an important trait in determining yarn spinning ability, cotton varieties which produce weak fiber (low strength), are difficult to be handled in manufacturing process. In both seasons, the analysis of variance was being significant influenced by cotton cultivars (A), N sources (B), foliar Zn application rates (C) and the interaction between them except the interaction AC and ABC (Fig. 5 and Table 4). Cultivars showed 10.79 (Giza 92) > 10.7 (Giza 94) > 10.04 (Giza 95). This trend agrees with Subhan *et al.* (2001) and Bednarz *et al.* (2005) they mentioned that, cotton fiber quality is mainly influenced by genotype of the cultivars but agronomic practices and environmental conditions are the secondary factors influencing fiber quality. Also, N sources led to sequentially increases; U (10.37) < AN (10.52) < AS (10.64), the highest increase (2.6 and 1.4%) was recorded for AS compared with AN and U treatments, respectively. our results are in garment with those reported by Watts, *et al.*, (2014 and 2017) who reported that nitrogen source affected fiber quality. foliar Zn applied at different rates enhanced fiber strength 10.43 and 11.04 for 100 and 200 ppm, represents 3.5 and 9.6% increases in fiber fineness, respectively comparing with control treatment, this results agreement with those obtained by Elayan *et al.* (2014).

Fiber fineness (micronaire)

In both seasons, fiber fineness (micronaire reading) significantly influenced by cotton cultivars (A), N sources (B), foliar Zn application rates (C) and only three factors interaction (ABC) (Fig. 5 and Table 4). Cultivars gave micronaire reading 3.64 (Giza 92) < 4.09 (Giza 94) < 4.29 (Giza 95). Therefore, the most fineness cultivar is Giza 92. Similar differences in micronaire values due to cultivar have also been reported by Faircloth *et al.* (2004). Also, N sources showed micronaire reading U (4.02) at par with AN (4.02) > AS (3.96), the highest fineness found in plots received AS compared with AN and U treatments. However, foliar Zn applied at different rates enhanced fiber fineness (decreasing micronaire reading); 4.05 and 3.76 for 100 and 200 ppm, represents 3.7 and 11.7% increases in fiber fineness, respectively comparing with control treatment. This results agreement with those obtained by Elayan *et al.* (2014).

CONCLUSION

This research was conducted to evaluate the effect of nitrogen sources and foliar application of Zn on growth, yield and fiber quality of some Egyptian cotton cultivars. Cotton cultivars, N sources and foliar Zn led to a significant effect on plant height, number of sympodial branches plant-1, total and open bolls plant-1, boll weight, seed index, seed cotton yield plant-1, seed cotton yield fed-1, fiber strength, and fineness. Cotton cultivars had a significant effect on position of the 1st sympodial node, lint%, fiber length and uniformity index. Giza 95 was a superior in above parameter except seed index and fiber quality. Significant of interactions between studied factors existed on most of studied cotton properties. In such experimental soil conditions, usage of ammonium sulfate and foliar Zn at 200 ppm could be recommended to improve the cotton properties.

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استجابة نمو ومحصول وجودة ألياف بعض أصناف القطن المصري لاضافة مصادر مختلفة من الأسمدة النيتروجينية والرش بالزنك

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أجريت تجربتين حقليتين في محطة التجارب والبحوث الزراعية ، كلية الزراعة ، جامعة القاهرة ، الجيزة ، مصر (2019 و 2020) لدراسة استجابة نمو ومحصول وجودة ألياف بعض أصناف القطن المصري (جيزة 92 ، وجيزة 94 ، وجيزة 95) لاضافة مصادر مختلفة من الأسمدة النيتروجينية (اليوريا ونترات الأمونيوم وكبريتات الأمونيوم والرش بالزنك بتركيزات 0 ، 100 و 200 جزء في المليون. واضحت النتائج ان الأصناف ومصادر النيتروجين والزنك أدت إلى تأثير معنوي على طول النبات ، عدد الأفرع الثمرية للنبات ، عدد اللوز الكلي والمتفتح للنبات ، وزن اللوز ، وزن 100 بذرة ، محصول القطن الزهر النبات والفدان ، قوة ونعومة الألياف. بينما كان للأصناف تأثير معنوي على ارتفاع اول عقدة تمرية ونسبة التيلة وطول الألياف ومعامل الانتظام. تفوقً صنف جيزة 95 في الصفات السالفة الذكر أعلاه باستثناء وزن 100 بذرة وجودة الألياف. بينما تفوق جيزة 92 في صفات جودة الألياف. واظهرت كلا من التفاعلات الثنائية والثلاثية بين العوامل المدروسة معنوية في معظم الصفات. وجدت أعلى القيم فى القطع التجريبية المعاملة بكبريتات الأمونيوم مع الزنك الورقي بمعدل 200 جزء في المليون في معظم الحالات. وكانت هناك علاقات معنوية بين عدد اللوز الكلي والنسبة المئوية لتفتح اللوز على النبات فكانت للصنف جيزة 92 ($R^2 = 0.76$) وللصنف جيزة 94 ($R^2 =0.89$) وللصنف جيزة 95 ($R^2 = 0.91$). كذلك كانت هناك علاقات معنوية بين محصول القطن الزهر مع عدد اللوز المتفتح للنبات ($R^2 = 0.862$) ، وزن اللوزة ($R^2= 0.632$) ونسبة التيلة ($R^2 = 0.619$) على التوالي. في مثل هذه الظروف التجريبية للتربة ، يمكن التوصية بكبريتات الأمونيوم والزنك الورقي بمعدل 200 جزء في المليون لتحسين الصفات المختلفة القطن.