Int. J. Adv. Res. Biol. Sci. (2019). 6(1): 33-49

International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG(USA) Volume 6, Issue 1 - 2019

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.01.004

Response of Giza 86 cotton cultivar to foliar feeding with lithovit and boron

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Abstract

Objective:
The aim of this study was to the effect of lithovit and boron as foliar feeding on Egyptian Cotton (Giza 86).
Methods:
Two field experiments were carried out on clay loam soil at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt for the two successive seasons of 2017 and 2018, using the Egyptian cotton cultivar Giza 86 (*Gossypium barbadense,* L.). These experiments were conducted to study the effect of seven treatments including foliar application with two rates of lithovit (2.5 and 5g lithovit/l), boron in the form of boric acid (17% Boron) at two rates (0.5 and 1g boric acid/l) , lithovit and boron application in two rates combinations (2.5 g lithovit+0.5 g boric acid/l, 5 g lithovit+1 g boric acid/l) three times (at squring stage, at flowering initiation and at the top of flowering) and control treatment (without spraying) on cotton leaf chemical composition and water relations, growth, earliness traits, seed cotton yield and its components and fiber quality. A randomized complete block design with 3 replicates was used in both seasons.
Results and Discussion:
Foliar feeding with the combination between lithovit and boric acid either at the low level (2.5g lithovit /l + 0.5g boric acid/l) or at the high level (5glithovi/l +1g boric acid/l) significantly increased water relations in cotton leaves TWC, RWC, PMI and leaf total soluble sugars, total carbohydrates, N, P and K concentrations. Also, they significantly increased number of sympodia/plant, number of total flowers/plant, fiber length and uniformity index in one season only and number of bolls set/plant, percentages of boll setting and earliness percentage, number of open bolls/plant, boll weight, seed index, lint percentage and seed cotton yield/feddan in both seasons. Meanwhile, there was a significant decrease in osmotic pressure, leaf water deficit, enzymes activity as peroxidase and phenoloxidase and proline content at the same combination. The reverse trend was recorded by untreated plants (the control) with regard to these traits. The two former combinations and untreated plants gave highest fiber strength, without significant differences among these treatments.

Keywords: Foliar feeding, Boron, Lithovit, Egyptian cotton.

Introduction

Cotton is the most important commercial crop playing key role in economic and social affairs of the world. It is backbone of Egyptian textile industry. Most of the applied chemical fertilizers are rendered unavailable to plants due to many factors, such as leaching, degradation by photolysis, hydrolysis and decomposition. Hence, it is necessary to minimize nutrient losses in fertilization and to increase the crop yield through the exploitation for new applications with the help of nanotechnology, where great attention has been paid to use this novel application, because nanoparticles have unique physicochemical properties, i.e. high surface area, high reactivity, tunable pore size and particle morphology (**Siddiqui *et al*., 2015**). Lithovit (a Nano- $CaCO_3$) is natural CO_2 foliar fertilizer. It is a new top quality nano technological fine powder created by tribodynamic activation and micronization. It has been given much attention as a natural safety fertilizer which releases CO_2 which reflected in improving net photosynthesis and causes various promoted effect on plants. **Kumar (2011)** reported that Nano fertilizers have emerged as an alternative to conventional fertilizers for slow release and efficient use of water and fertilizers by plants. Lithovit is a naturally occurring CO_2 foliar spray made from limestone deposits. It enhances the plant growth and results in high productivity by means of increasing the natural photosynthesis on supplying carbon dioxide (CO_2) at optimum concentration, which is much higher than in the atmosphere and at the same time does not result in an increase of the CO_2 in the atmosphere which might create a climatic problem particularly when the rate of global warming looms large over agriculture. All Lithovit particles do not penetrate the stomata at once. Most of them remain as thin layer on the leaves surface and penetrate frequently when they get wet by dew at night. **Attia *et al.* (2016)** reported that foliar CO_2 as a Nano-fertilizer in the form of lithovit enhanced cotton leaves chemical composition. **Hamoda *et al.* (2016)** found that applying CO_2 fertilizer as foliar spray at the four rates had a pronounced effect in increasing number of open bolls/plant, boll weight, seed cotton yield/plant and seed cotton yield/feddan in both seasons, in favor of applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying at the high rate of 7.5 g/l two times at 45 and 60 days after planting followed in ranking by the medium rate (5 g/l), the low rate (2.5 g/l) and untreated plants (without Lithovit) and **El-Shazly (2017)** found that foliar CO_2 fertilizer in the form of lithovit (a Nano-$CaCO_3$) three times [at the squaring stage (57 days old), flowering initiation (77 days old) and at the top of flowering (97 days old)] significantly increased number of open bolls per plant, boll weight, seed index and seed cotton yield /feddan in both seasons and lint percentage in the second season as compared with untreated plants.

Boron (B) is an essential trace element required for the physiological functioning of higher plants, where B is involved in the structural and functional integrity of the cell wall and membranes, ion fluxes (H^+, K^+, PO4 $^{3-}$,Rb^+, Ca^{2+}) across the membranes, cell division and elongation, nitrogen and carbohydrate metabolism, sugar transport, cytoskeletal proteins, and plasmalemma-bound enzymes, nucleic acid, indoleacetic acid, polyamines, ascorbic acid, and phenol metabolism and transport (**Fareeha Shireen *et al.*, 2018**). Boron (B) shortages are usually found in alkaline soils with a pH of about 8 to 8.5. B deficiency is considered as a nutritional disorder that adversely affects the metabolism and growth of plants. B deficiency affects photosynthesis indirectly by weakening vascular tissues responsible for ion transport (**Wang *et al.*, 2015**). B limitation negatively alters the reproductive performance of plants by causing abrupt changes in flowering and fruiting modes. This often results in empty and shriveled anthers, pollen tubes bursting, pollen viability loss, abscission of flower buds, failure of fruit setting, and premature fruit drop because of failure of photosynthetic transport resulting in yield loss (**Marschner, 2012**). Boron is involved in the pollen development, pollen germination and pollen tube growth (**Lee *et al*., 2009**). Its deficiency affects the pollen development and pollen tube growth resulting in male sterility and poor seed set. Moreover, the seeds and fruits abscise prematurely consequently leading to reduced crop yield (**Barker and Pilbeam, 2015**). **Ali *et al*. (2011)** reported that foliar applied B improved the number of bolls, boll weight and seed cotton yield as compared to control. **Rashidi and Seilsepour (2011)** conducted an experiment to determine the effect of foliar applied B on cotton and found that number of bolls, boll weight, seed cotton yield and leaf blade B concentration was increased. Moreover, foliar boron also improved the fiber length and fiber fineness of cotton. **Elayan *et al*. (2014)** revealed that application of B to cotton aside from improving the growth and seed cotton yield also enhanced the earliness in cotton. It was observed that yield increase was up to 30%, while earliness was increased up to 4% by the application of B, as compared to control.

The objective of this study was to assess the effect of using lithovit (a Nano- $CaCO_3$) as foliar application or boron in the form of boric acid as foliar application or together with regard to the leaves chemical composition, leaves water relations, growth traits, earliness traits, seed cotton yield and its components and fiber quality of the Egyptian cotton cultivar Giza 86 under the environmental conditions of El-Gharbia Governorate.

Materials and Methods

Two field experiments were carried out at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt for the two successive seasons of 2017 and 2018, using the Egyptian cotton cultivar Giza 86 (*Gossypium barbadense*, L.). These experiments were conducted to study the effect of seven treatments including foliar application with two rates of lithovit (2.5 and 5g lithovit/l), boron in the form of boric acid (17%B) at two rates (0.5 and 1g boric acid/l) , lithovit and boron application in two rates combinations (2.5 g lithovit+0.5 g boric acid/l, 5 g lithovit+1 gboric acid/l) three times (at squring stage, at flowering stage and at the top of flowering) and control treatment(without spraying)on cotton leaf chemical composition and water relations, growth, earliness traits, seed cotton yield and its components and fiber quality.

A randomized complete block design with 3 replicates was used in both seasons.

Natural CO_2 as a Nano-foliar fertilizer in the form of Lithovit® (a Nano $CaCO_3$) is a new top quality Nano-technological fine powder created by tribodynamic activation and micronization. The different constituents of Lithovit® were illustrated in Table 1.

Table 1: Main characteristics of Lithovit ® used in the study.

Components	Value (%)	Components	Value (%)
Calcium carbonate	79.19	Sulphate	0.33
Nitrogen	0.06	Iron	1.31
Phosphate	0.01	Zinc	0.005
Potassium oxide	0.21	Manganese	0.014
Magnesium carbonate	4.62	Copper	0.002
Selisium dioxide	11.41	Clay	0.79

Representative soil samples were taken from the experimental soil sites before sowing in both seasons and prepared for analysis according to **Jackson (1973).** Results of the soil analysis are shown in Table 2.

Table 2: Soil analysis of the experimental site.

Properties	2017	2018
Texture	Clay loam	Clay loam
pH	7.9	8.0
EC mmhos/ cm.	0.33	0.37
Organic matter %	1.6	1.23
Total N(mg/100g)	56	43.05
Available N (ppm)	29.9	28.5
Available P (ppm)	12.5	11.9
Available K (ppm)	333	215
Available Fe (ppm)	11.3	6.0
Available Mn (ppm)	3.1	2.1
Available Zn (ppm)	1.0	0.70
Available Cu (ppm)	3.4	0.9

Phosphorus fertilizer was applied during soil preparation in the form of calcium super phosphate (15.5 % P_2O_5) at a rate of 22.5 kg P_2O_5 /fed. Sowing took place on 8 April in both seasons. Seeds of cotton cultivar Giza 86 were sown using dry planting method in hills 25 cm apart with two plants/hill after thinning. All plots were fertilized at a rate of 45 kg N / fed in the form of ammonium nitrate (33.5 % N) in two equal doses, the first dose was added after thinning (before the first irrigation), while the second dose was applied before the second irrigation. Potassium fertilizer in the form of potasin-f at the rate of 1 liter/feddan was applied as foliar application three times (at squring stage, at flowering initiation and at the top of flowering).

The preceding crop was Egyptian clover (*Trifolium alexandrinum* L.) "Berseem" from which one cut was taken and sugar beets (*Beta vulgaris* L.) in the first and second seasons, respectively.

The plot size was 14 m^2, (3.5m x 4m) including 5 ridges 70 cm apart and the hills 25 cm apart with two plants/hill after thinning.

The other cultural practices were carried out as recommended for conventional cotton seeding in the local production district.

Studied characters: -

Ten leaves (fourth upper leaf) were randomly taken from plants of each plot after two weeks from the last spraying of lithovit and boric acid to determine the following traits:

A- Water relations: Total water content (TWC, %) **(Gosev, 1960 and Kreeb, 1990)**, leaf water deficit (LWD, %), relative water content (RWC, %) **(Barrs and Weatherley, 1962)**, osmotic pressure **(Gosev, 1960)**, plasma membrane integrity (PMI) **(Yan and Dai, 1996)**.

B- Photosynthetic pigments: The photosynthetic pigments were extracted from fresh leaf sample (fourth upper leaf) by 85 % acetone and determined according to the method described by **Wettestein's** formula in **A.O.A.C., 1995.**

C- Chemical analysis: Total carbohydrates and total sugars were determinate using the phenol sulfuric acid method as described by **A.O.A.C. (1995).** Antioxidant enzymes activities as peroxidase and phynoloxidase were determined according to **Fehrman and Dimond (1967)** and **Broesh (1954).** Proline concentration was measured according the ninhydrin method of **Bates *et al.* (1973).** N, P and K were determined as a described by **A.O.A.C. (1995)**.

D- Growth: plant height at harvest (cm) and number of fruiting branches/ plant.

E- Earliness traits: number of total flowers/plant, number of total bolls/plant, boll setting percentage, boll shedding percentage and first picking percentage.

F- Seed cotton yield and its components: number of open bolls per plant, boll weight (g), lint percentage and seed index **(**weight of 100 cotton seeds in grams**).** The seed cotton yield per feddan was estimated as the weight of seed cotton in kilograms picked twice from each plot and transformed to kentars per feddan (one kentar = 157.5 kg)

G- Fiber quality: Samples of lint were collected from each treatment at each replicate to determine the following characters at the laboratories of Cotton Research Institute, ARC, under standard conditions of test as reported by **A. S. T. M. (1986):** fiber length (2.5% span length in mm) and uniformity index(%) were determined by fibrograph, fiber fineness (micronaire reading), it was determined by Micronaire Instrument and fiber strength (Pressley index), it was determined by Pressley instrument.

Statistical analysis

The statistical analysis of the obtained data in the two seasons was done and performed according to **Le Clerg *et al*. (1966)** using M State-C microcomputer program and the treatments means were compared using LSD at 0.05 level of probability (**Waller and Duncan, 1969**).

Results

Water relations

Data in table (3) cited that, TWC, RWC and PMI were increased at all levels were used (lithovit, boron fertilizers and their interaction). Meanwhile, the all levels of lithovit, boron fertilizers and their interaction caused a significant decrease in osmotic pressure and leaf water deficit. The highest increase was recorded at level of 5g/l lithovit interacted with 1g/l boric acid fertilizer by about 7.08%, 3.87% and 12.19% respectively, when compared with the control plants.

Table 3: Effect of foliar spraying with lithovit and boron as well as their interaction on cotton leaf water relations in 2017 and 2018 seasons.

Treatments / Traits	TWC (%)	LWD (%)	RWC (%)	O.P. (bar)	Plasa. Memb. Perm. (%)
Season 2017					
Control	80.97	14.43	64.03	7.84	17.07
2.5g lithovit /l	83.65	14.39	64.61	7.69	18.25
0.5g boric acid/l	85.05	13.71	65.71	7.29	18.77
2.5g lithovit /l + 0.5g boric acid/l	86.10	13.27	66.44	6.97	19.01
5g lithovit /l	84.04	14.15	65.07	7.50	18.41
1g boric acid/l	85.24	13.52	65.90	7.20	18.93
5glithovi/l t +1g boric acid/l	86.70	12.41	66.51	6.37	19.15
LSD at 5%	**0.901**	**0.465**	**0.590**	**0.192**	**0.901**
Season 2018					
Control	83.48	16.05	66.77	7.54	21.51
2.5g lithovit /l	86.77	12.16	65.94	7.23	25.17
0.5g boric acid/l	88.34	11.53	68.55	7.02	25.28
2.5g lithovit /l + 0.5g boric acid/l	89.08	14.46	69.68	6.56	26.28
5g lithovit /l	86.88	14.15	67.34	7.68	23.34
1g boric acid/l	87.77	13.68	68.65	6.61	23.63
5glithovi/l t +1g boric acid/l	89.32	12.20	69.77	5.99	23.92
LSD at 5%	**0.532**	**0.566**	**0.807**	**0.682**	**0.489**

Photosynthetic pigments

Data in table (4) cleared that, the cotton plants fertilized by all different levels of lithovit and boron as well as its interactions increased the values of leaves chlorophyll a, b and carotenoids contents in both seasons. Whereas, at the interaction between 5g/l lithovit and 1g/l boric acid fertilizer produced the highest values of leaves plant pigments contents by about chl. a 13.95%, chl. b 36.71% and carotenoids 40.08%, when compared with the control plants.

Table 4: Effect of foliar spraying with lithovit and boron as well as their interaction on cotton leaf pigments in 2017 and 2018 seasons.

Treatments / Traits	Chl. A. (mg /g dwt)	Chl. B. (mg /g dwt)	Carotenoides (mg /g dwt)	Chl. A. (mg /g dwt)	Chl. B. (mg /g dwt)	Carotenoides (mg /g dwt)
	2017 season			**2018 season**		
Control	3.362	1.065	1.300	3.471	1.124	1.358
2.5g lithovit /l	3.582	1.179	1.412	3.678	1.241	1.488
0.5g boric acid/l	3.666	1.348	1.746	3.747	1.412	1.785
2.5g lithovit /l + 0.5g boric acid/l	3.765	1.420	1.809	3.915	1.492	1.869
5g lithovit /l	3.595	1.307	1.619	3.684	1.339	1.650
1g boric acid/l	3.703	1.365	1.759	3.811	1.408	1.795
5glithovi/l t +1g boric acid/l	3.831	1.456	1.821	3.946	1.500	1.899
LSD at 5%	**0.052**	**0.035**	**0.071**	**0.037**	**0.032**	**0.062**

Chemical composition

The results in table (5) showed that, in leaves of cotton plants fertilized by all levels of lithovit and boron as well as its interactions, there was an increase in total soluble sugars, total carbohydrates, N, P and K concentrations. Meanwhile, there was a significant decrease in enzymes activity as peroxidase and phenoloxidase and proline content at the same levels. In this side, the higher of increase in chemical constitutes was recorded at the interaction level of 5g/l lithovit interacted with 1g/l boric acid.

Table 5: Effect of foliar spraying with lithovit and boron as well as their interaction on cotton leaf chemical composition in 2017 season.

Traits / Treatments	Total carboh-ydrates (Mg/g d. wt)	Total sugars (Mg/g d. wt)	Per-oxidase O.D./g Fwt. after 2 min.	Phenol - oxidase O.D./g Fwt after 45 min.	Proline conc. µg lucine /gm d.wt	N %	P %	K %
Control	**95.76**	**40.71**	**147.21**	**63.08**	**318.21**	**1.925**	**0.177**	**2.276**
2.5g lithovit /l	**102.04**	**45.07**	**123.14**	**57.35**	**284.51**	**1.937**	**0.196**	**2.356**
0.5g boric acid/l	**158.94**	**78.72**	**120.41**	**54.89**	**278.99**	**2.182**	**0.264**	**3.186**
2.5g lithovit /l + 0.5g boric acid/l	**198.25**	**82.08**	**118.11**	**53.89**	**268.38**	**2.660**	**0.284**	**3.284**
5g lithovit /l	**137.15**	**60.48**	**122.66**	**57.09**	**280.86**	**1.982**	**0.251**	**2.559**
1g boric acid/l	**185.06**	**80.64**	**119.68**	**53.94**	**271.17**	**2.249**	**0.273**	**3.246**
5glithovi/l t +1g boric acid/l	**207.12**	**85.29**	**114.82**	**53.29**	**262.74**	**2.658**	**0.288**	**3.318**
LSD at 5%	**5.495**	**1.932**	**1.052**	**0.152**	**1.036**	**0.046**	**0.007**	**0.059**

Growth traits

The tested treatments gave a significant effect on plant height at harvest in both seasons (Table, 6). The tallest plants were recorded by untreated plants(control) followed by foliar feeding with the combination between lithovit and boric acid either at the low level (2.5g lithovit /l + 0.5g boric acid/l) or at the high level (5glithovi/l +1g boric acid/l), while the shortest plants were produced from foliar feeding with 0.5g boric acid/l. Also, the tested treatments gave a significant effect on number of symbodia/plant in the second season only, in favor of foliar feeding with the combination between lithovit and boric acid either at the low level (2.5g lithovit /l + 0.5g boric acid/l) or at the high level (5glithovi/l +1g boric acid/l) followed by foliar feeding with boric acid at the high level (1g boric acid/l) or at the low level, while the lowest number was obtained from the control.

Table 6: Effect of foliar spraying with lithovit and boron as well as their interaction on cotton growth traits in 2017 and 2018 seasons.

Traits / Treatments	Final plant height (cm)		No. of sympodia/plant	
	Season 2017	**Season 2018**	**Season 2017**	**Season 2018**
Control	158.50	149.40	15.92	14.30
2.5g lithovit /l	156.13	145.77	15.53	15.37
0.5g boric acid/l	154.60	144.00	15.25	15.90
2.5g lithovit /l + 0.5g boric acid/l	158.40	147.87	15.92	16.13
5g lithovit /l	158.41	147.73	15.85	15.73
1g boric acid/l	155.77	145.33	15.70	16.12
5glithovi/l t +1g boric acid/l	158.22	148.13	15.80	16.30
LSD at 5%	**2.54**	**1.43**	**NS**	**0.37**

Earliness traits

The tested treatments significantly affected number of total flowers/plant in the first season and number of bolls set/plant, percentages of boll setting and earliness in both seasons, in favor of foliar feeding with the combination between lithovit and boric acid either at the high level (5g lithovi/l +1g boric acid/l) or at the low level (2.5g lithovit /l + 0.5g boric acid/l). However, the lowest values of these traits were recorded by untreated plants (the control treatment).The two combinations between lithovit and boric acid significantly decreased boll shedding percentage as compared with the control.

Table 7: Effect of foliar spraying with lithovit and boron as well as their interaction on earliness traitsl in 2017 and 2018 seasons.

Treatments \ Traits	No. of total flowers/plant	No. of total bolls/ plant	Boll setting %	Boll shedding %	Earliness %
Season 2017					
Control	28.23	19.51	69.10	30.90	67.43
2.5g lithovit /l	29.17	22.32	76.51	23.49	69.70
0.5g boric acid/l	28.83	22.08	76.60	23.40	69.88
2.5g lithovit /l + 0.5g boric acid/l	30.00	24.12	80.39	19.61	72.64
5g lithovit /l	29.47	22.52	76.42	23.58	69.32
1g boric acid/l	29.77	23.17	77.83	22.17	70.51
5glithovi/l t +1g boric acid/l	30.93	25.04	80.95	19.05	72.75
LSD at 5%	**0.32**	**1.47**	**5.20**	**5.20**	**0.77**
Season 2018					
Control	25.67	18.00	70.13	29.87	68.10
2.5g lithovit /l	25.17	19.40	77.08	22.92	70.40
0.5g boric acid/l	25.84	19.92	77.10	22.90	70.67
2.5g lithovit /l + 0.5g boric acid/l	25.22	20.40	80.84	19.16	73.47
5g lithovit /l	26.12	19.64	75.16	24.84	70.27
1g boric acid/l	25.83	20.36	78.82	21.18	71.24
5glithovi/l t +1g boric acid/l	25.04	20.43	81.60	18.40	73.60
LSD at 5%	**NS**	**1.10**	**1.93**	**1.93**	**0.69**

Seed cotton yield and its component

The tested treatments gave a significant effect on number of open bolls/plant, boll weight, seed index, lint percentage and seed cotton yield/feddan in both seasons (Table 8). The higher number of open bolls/plant and heavier bolls were obtained from foliar feeding with the combination between lithovit and boric acid at the high level (5glithovi/l +1g boric acid/l) followed by the low level (2.5g lithovit /l + 0.5g boric acid/l). However, the lowest values of these traits were recorded by untreated plants (the control treatment). The highest values of lint % (42.11 and 43.95%) were obtained from foliar feeding with 5g lithovit /l in the first and second seasons, respectively, while the lowest values (39.9 and 39.86%) were obtained from foliar feeding with 2.5g lithovit /l in the first and second seasons, respectively. With regard to seed index, the highest values (11.17 and 10.61g)were obtained from foliar feeding with 1g boric acid/l and from the combination between lithovit and boric acid at the low level (2.5g lithovit /l + 0.5g boric acid/l)in the first and second seasons, respectively, while the lowest values (10.46 and 9.86g) were obtained from foliar feeding with 0.5g boric acid/l and from untreated plants (the control treatment)in the first and second seasons, respectively. With regard to seed cotton yield/feddan, the highest yield was obtained from foliar feeding with the combination between lithovit and boric acid either at the high level (5glithovit/l +1g boric acid/l), at the low level (2.5g lithovit /l + 0.5g boric acid/l), 1g boric acid/l, 0.5g boric acid/l, 2.5g lithovit /l and 5glithovit/l, respectively, but the lowest yield was obtained from untreated plants (the control treatment) in both seasons. The yield increase percentages over untreated plants (the control) amounted to 25.35, 25.12, 16.75, 14.98, 13.92 and 13.21% in the first season and 25.90, 24.20, 23.01, 21.31, 19.72 and 19.62% in the second season, in respective order.

Table 8: Effect of foliar spraying with lithovit and boron as well as their interaction on seed cotton yield and its component in 2017 and 2018 seasons.

Treatments \ Traits	No. of open bolls/plant	Boll weight (g)	Lint %	Seed index (g)	Seed cotton yield (kentar/ fed)
Season 2017					
Control	19.51	3.02	40.14	10.60	8.48
2.5g lithovit /l	22.32	3.19	39.90	10.91	9.66
0.5g boric acid/l	22.08	3.22	41.95	10.46	9.75
2.5g lithovit /l + 0.5g boric acid/l	24.12	3.27	40.16	10.48	10.61
5g lithovit /l	22.52	3.18	42.11	10.56	9.60
1g boric acid/l	23.17	3.19	41.41	11.17	9.90
5glithovi/l t +1g boric acid/l	25.04	3.30	41.60	10.83	10.63
LSD at 5%	**1.47**	**0.11**	**1.01**	**0.50**	**0.64**
Season 2018					
Control	18.00	3.12	40.85	9.86	10.04
2.5g lithovit /l	19.40	3.14	39.86	10.32	12.02
0.5g boric acid/l	19.92	3.19	42.38	10.15	12.18
2.5g lithovit /l + 0.5g boric acid/l	20.40	3.30	40.56	10.61	12.47
5g lithovit /l	19.64	3.20	43.95	10.15	12.01
1g boric acid/l	20.36	3.22	41.90	10.05	12.35
5glithovi/l t +1g boric acid/l	20.44	3.36	42.01	10.38	12.64
LSD at 5%	**1.10**	**0.05**	**1.05**	**0.08**	**0.27**

Fiber quality traits

Regarding the effect of the tested treatments on fiber quality, the results in Table 9 show that fiber length, uniformity index and fiber strength were significantly affected by the tested treatments in the second season only, where the longest fibers (34.05, 33.85 and 33.70 mm) were obtained from foliar feeding with the combination between lithovit and boric acid at the low level (2.5g lithovit /l + 0.5g boric acid/l), 2.5g lithovit /l and foliar feeding with the combination between lithovit and boric acid at the high level (5glithovit/l +1g boric acid/l), respectively, without significant differences among these treatnents. However, the shortest fibers (32.92mm) were recorded by untreated plants (the control treatment). Also, foliar feeding with the combination between lithovit and boric acid at the low level (2.5g lithovit /l + 0.5g boric acid/l) gave the highest uniformity index (86.8%), but the lowest uniformity index (85.20,85.30 and 85.3%) were obtained from 0.5g boric acid/l, the combination between lithovit and boric acid at the high level (5glithovit/l +1g boric acid/l) and untreated plants (the control treatment), respectively without significant differences among these treatments. The highest fiber strength (11.00, 10.95 and 10.85 Pressley units), resulted from untreated plants, foliar feeding with the combination between lithovit and boric acid at the high level (5glithovit/l +1g boric acid/l) and foliar feeding with the combination between lithovit and boric acid at the low level (2.5g lithovit /l + 0.5g boric acid/l), respectively, without significant differences among these treatments. However, the lowest values (10.35 and 10.45 Pressley units), resulted from applying lithovit or boron at the high level. Micronaire reading was insignificantly affected by the tested treatments.

Table 9: Effect of foliar spraying with lithovit and boron as well as their interaction on cotton fiber traits in 2017 and 2018 seasons.

Traits / Treatments	2.5% span length (mm)	Uniformity index (%)	Micronaire reading	Pressley index
Season 2017				
Control	34.90	85.80	4.50	10.50
2.5g lithovit /l	35.20	86.70	4.50	10.40
0.5g boric acid/l	35.60	86.90	4.60	10.20
2.5g lithovit /l + 0.5g boric acid/l	34.50	86.80	4.60	10.00
5g lithovit /l	33.80	86.10	4.60	10.10
1g boric acid/l	34.90	86.90	4.60	10.30
5glithovi/l t +1g boric acid/l	34.50	86.60	4.60	10.30
LSD at 5%	**NS**	**NS**	**NS**	**NS**
Season 2018				
Control	32.92	85.30	4.40	11.00
2.5g lithovit /l	33.85	85.35	4.60	10.60
0.5g boric acid/l	33.35	85.20	4.60	10.50
2.5g lithovit /l + 0.5g boric acid/l	34.05	86.80	4.55	10.85
5g lithovit /l	32.95	86.40	4.65	10.35
1g boric acid/l	33.40	86.35	4.65	10.45
5glithovi/l t +1g boric acid/l	33.70	85.30	4.50	10.95
LSD at 5%	**0.67**	**0.51**	**NS**	**0.18**

Discussion

From the above-mentioned results and by checking the chemical content of cotton leaves and it's treated with foliar with lithovit and boron. It was found that, there was an increase in the content of cotton leaves of total carbohydrates and total soluble sugars. This is due to that, the lithovit contains carbon dioxide, which directly enters the process of photosynthesis and affects the product of this process of glucose and the adoption of metabolism to form simple and complex carbohydrates, As well as the composition of proteins and fats. The second factor is an increase in the composition of chlorophyll A, B, and carotenoids, which in turn also affects the process of photosynthesis as explained earlier.

The positive effect in photosynthesis pigments due to lithovit application as compared with control is mainly referred to:

(1)- A reference to Table 5 indicates that, N, P and K percentages in leaves were significantly increased due to lithovit foliar application and thus improved flow of assimilates

(2)- A reference to Table 1 indicates that, nutrients content in lithovit were effective to increase photosynthesis pigments and enhance photosynthesis and hence more photosynthates.

(3)- Lithovet compound containing potassium oxide (0.21%), magnesium carbonate (4.62 %) and calcium carbonate (79.19 %) particles, extremely small, which gives them the ability to enter through the stomata in leaves of plants when foliar spraying with this compound. The positive effect of this compound in being contains magnesium, which is the central element in chlorophyll molecule. Potassium plays an important role in plants exposed to drought stress, mainly with respect to water relations and photosynthesis. **El-Shazly (2017)** found that foliar CO_2 fertilizer in the form of lithovit (a Nano-$CaCO_3$) at 7.5g/L significantly decreased leaf water deficient, osmotic pressure and plasma membrane permeability and significantly increased total water and relative water contents in leaves in both seasons.

Prior *et al,* (2011) pointed out that the application of more CO_2 can increase plant water use efficiency and result in less water use. **Shallan *et al.* (2016)** leaf relative water content of cotton plants were decreased under drought stress conditions in comparison with control plants of Giza 94 cultivar.

In this regard, **Shallan *et al* (2016)** found that, the obtained results showed that pretreatment of cotton plants under drought stress with nano-$CaCO_3$ caused increase of pigments content and enhancement of yield characteristics. **El-Shazly (2017)** found that foliar CO_2 fertilizer in the form of lithovit (a Nano-$CaCO_3$) three times at a rate of 7.5g/l significantly increased concentrations of photosynthetic pigments *i.e.,* chlorophyll a, chlorophyll b, total chlorophyll and carotenoids. **Attia *et al.* (2016)** reported that, leaves chlorophyll a, b and carotenoids contents were significantly increased in favor of applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying at the high rate of 7.5 g/L two times at 45 and 60 days after planting followed in ranking by the medium rate (5 g/L), the low rate (2.5 g/L) and untreated plants (without Lithovit).

The same results were obtained by **Prior *et al.* (2011**) pointed out that the elevated CO_2 stimulates photosynthesis leading to increased carbon (C) uptake and assimilation, thereby, as increasing total carbohydrates and total sugars concentration in leaves. For plants to use a higher level of atmospheric CO_2, they must have a means of storing the additional carbohydrates produced. **Attia *et al.* (2016)** reported that, leaves N, P, K and total carbohydrates contents were significantly increased in favor of applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying at the high rate of 7.5 g/L two times at 45 and 60 days after planting followed in ranking by the medium rate (5 g/L), the low rate (2.5 g/L) and untreated plants (without Lithovit). The inverse was true in leaf proline content and peroxidase activity. The decreases in these traits induced favorable plant conditions and reflected on reduce environmental stress effect. **Shallan *et al* (2016)** The obtained results showed that pretreatment of cotton plants under drought stress with nano-$CaCO_3$ caused increase of total soluble sugars, total free amino acids and enhancement of yield characteristics. **Attia *et al*. (2017)** reported that lithovit significantly increased leaves concentrations of N, P, K, photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll and carotenoids), total carbohydrates and total sugars in both seasons. However, the lowest concentrations of these traits were obtained from the control treatment (without Nano materials application). In relation to proline content, peroxidase and phenoloxidase activity in leaves, Nano materials treatments gave significant effect in both seasons, in favor of lithovit where it significantly decreased these traits in consideration which indicates favorable conditions and reduces environmental stress effect. However untreated plants recorded the highest values of these traits.

The positive effect in total carbohydrates and total sugars due to lithovit application as compared with control is mainly referred to:

(1)- A reference to Table 5 indicates that N, P and K percentages in leaves were significantly increased due to lithovit foliar application and thus improved flow of assimilates

(2)- A reference to Table 1 indicates that nutrients content in lithovit were effective to increase photosynthesis pigments and enhance photosynthesis and hence more photosynthates.

(3)- These traits could be stimulated by elevation of CO_2 therefore; lithovit fertilizer can significantly enhance photosynthesis because the external factor limiting photosynthesis is the natural content CO_2 in the air. The application of more CO_2 can increase plant water use efficiency and result in less water use (**Prior *et al.*, 2011**). Elevated CO_2 stimulates photosynthesis leading to increased carbon (C) uptake and assimilation, thereby, as increasing total carbohydrates and total sugars concentrations in leaves. However, as a result differences in CO_2 use during photosynthesis, plants with a C3 photosynthetic pathway often exhibit greater growth response relative to those with a C4 pathway (**Prior *et al.*, 2003** and **Prior *et al.*, 2011**). For plants to use a higher level of atmospheric CO_2, they must have a means of storing the additional carbohydrates produced (**Prior *et al.*, 2011**).

4- Lithovet compound containing potassium oxide (0.21%), magnesium carbonate (4.62%) and calcium carbonate (79.19%) particles, extremely small, which gives them the ability to enter through the stomata in leaves of plants when spraying this compound. The positive effect of this compound in being contains magnesium, which is the central element in chlorophyll molecule. Potassium oxide plays an important role in plants exposed to drought stress, mainly with respect to water relations and photosynthesis. Also, Calcium carbonate ($CaCO_3$)

decomposes to calcium oxide (CaO) and carbon dioxide (CO_2) in leaves stomata, and this carbon dioxide increases the intensity of photosynthesis.

In this respect, **Maswada and Abd El-Rahman (2014)** investigate the effect of foliar spray with lithovit "a Nano-$CaCO_3$-fertilizer" on growth, physiological of two wheat genotypes. Maximum increase of the total soluble sugars was recorded by lithovit treatment as compared to control.

The lower concentration of proline indicates that, the cotton plants grown under appropriate conditions, in general, the plants contains this amino acid (proline) under stress conditions to increase its resistance to any factor of environmental stress.

The low concentration of pyroxidase and phenoloxidase enzymes cleared that, the growth of cotton plants under suitable conditions in general, plants contain these enzymes under stress conditions or under less of a nutrition to increase the oxidation of substances harmful to plant cells such as phenols.

The superiority of using lithovit on reducing proline content, peroxidase and phenoloxidase activity in cotton leaves (which induced proper conditions for plant growth and reflect on reduce water stress effect) may be attributed to:

(1)- The role of lithovit as a source of calcium and carbonate which reduced inside plant cell to form carbon dioxide which accumulate in cells and increased the rate of photosynthetic assimilation and consequently increased total sugars and total carbohydrates.

(2)- The significant increase in leaves carotenoids content due to lithovit application gave positive effect in reducing stress effect, where the role of carotenoids in photosynthesis process are (i) protect chlorophyll against light oxidation, (ii) absorb light energy (blue and violet) and pass their absorbed energy to chlorophyll a, it acts as energy transferring and (iii) protect cell enzymes against harmful effect of light rays of short waves (blue and violet rays) by absorbing these rays.

(3)- Lithovet compound containing potassium oxide, which plays an important role in plants exposed to drought stress, mainly with respect to water relations and photosynthesis. Also, Calcium carbonate ($CaCO_3$) decomposes to calcium oxide (CaO) and carbon dioxide (CO_2) in leaves stomata, and this carbon dioxide increases the intensity of photosynthesis.

In this concern, **Attia *et al.* (2016)** reported that, leaves proline content and peroxidase activity were significantly reduced by using Nano-fertilizer (Lithovit).

The positive effect on NPK percentages in leaves due to lithovit application as compared with amino mineral and control or due to amino mineral application as compared with control could be explained on the basis that:

(1) - Experimental soil being low in organic matter and available nitrogen (Table 2) and the supplied of lithovit or amino mineral provided leaves with NPK.

(2)- There are many factors that affect the availability of P in soils. The high clay content probably contributed to more fixation of P by clay minerals, leading to reduction of its availability and consequently lowers leaf P content in untreated plants. Mg in lithovit compound is an important Co-factor for the production of ATP **(McCauley *et al.*, 2009).** It is very important for plants to absorb phosphorus.

(3) - There are many factors that affect the availability of K in soils. The high clay content probably contributed to more fixation of K by clay minerals, leading to reduction of its availability and consequently lowers leaf K content in untreated plants.

(4)- Such increases in chemical constituents as a result of foliar spray with lithovit may be due to their chemical constituents from macro and micro - nutrients (as shown in Tables 1) which affect positively on nutrient absorption and accumulation in plant cells.

(5)- When K was sufficient, cotton roots could transport K into leaves. However, when K was deficient, cotton did not absorb enough amounts of K to transport to reproductive organs **(Raza *et al.*, 2014)**. Similar results were obtained by other researchers included **Attia *et al.* (2016).**

There has been an increase in the concentration of nitrogen, phosphorus and potassium under the conditions of the used treatments in this work, indicating the good mineral nutrition of cotton plants under these conditions, the mineral balance led to water balance, allowing cotton plants to grow well.

All the previous factors combined positively affected on the growth of cotton plants in terms of mineral balance and water balance, which led to good chemical composition, all related to the division of plant cells and the formation of chlorophyll and good metabolism at the cellular level.

The following could be explaining the positive effect of lithovit on growth:

(1) - The increase in leaf relative water content and total water content due to lithovit application (Table 3) resulted in increasing leaves photosynthetic rates **(Lawlor and Cornic, 2002**).

(2)- Plants received lithovit (a Nano-$CaCO_3$) gave an increase in total soluble sugars, total carbohydrates, N, P and K concentrations in leaves (Table 5), and hence they would have a stimulating effect on increasing fruiting branches number.

In this respect, **Hatfield *et al.* (2011)** reported that increase in CO_2 significantly improved water use efficiency and enhanced plant growth**. El- Shazly (2017)** found that foliar CO_2 fertilizer in the form of lithovit (a Nano-$CaCO_3$) at a rate of 7.5 g/l three times resulted in significantly highest plant height and number of fruiting branches/plant in both seasons.

The positive response due to foliar feeding with the combination between lithovit and boric acid either at the high level (5glithovi/l +1g boric acid/l) or at the low level (2.5g lithovit /l + 0.5g boric acid/l). is mainly due to that:

(1)- foliar feeding with the two combinations between lithovit and boric acid to cotton plants on soils low in N and moderate in P and K significantly increased leaves NPK percentages (Table 5), which are directly linked to boll retention, either by themselves or as activators of nutrient concentrations. Also, these two combinations gave an increase in photosynthetic pigments (chlorophyll a, b and carotenoids) in cotton leaves (Table 4), and hence they would have a stimulating effect on increasing total soluble sugars and total carbohydrates. I n addition to promote effect of lithovit macro and micro nutrients contents (Table 1) which is critical for the production of photosynthates and the plants over all ability to produce higher fruiting organs and improving plant metabolism which surely reflected on increasing bolls setting and encouraging plant to accumulate more of its total dry weight in fruiting parts and this is coincided with higher boll retention/ plant and reduced shedding by mobilizing nutrients to fruiting organs.

(2)-Zinc in lithovit (Table 1) is required in the synthesis of tryptophan, a precursor of IAA synthesis, which is the major hormone that inhibits abscission of squares and bolls. Thus, the number of retained bolls per plant would be increased (**Sawan *et al.*, 2008**).

(3)- Potassium in lithovit (Table 1) increases both the quantity and the distance that photosynthate moved from the leaves (source) to fruiting organs (**Ashley and Goodson, 1972**).

(4)-B enhances carbohydrate transport through cells wall and consequently maximum production of starch and sugar, where in B absence the transport of sugar and nitrogenous compounds are stoped.

(5)- the disruption in chloroplast membranes, stomatal apparatus, the energy gradient across the membrane, and thylakoid electron transport is a major reason for photosynthetic reduction under B-deficient conditions (**Goldbach and Wimmer, 2007**), in addition B deficiency affects photosynthesis indirectly by weakening vascular tissues responsible for ion transport (**Wang *et al*., 2015**)

(6) During pollen tube growth and germination, B enhances the chances of fruit setting and improves seed production, leading to enhanced crop productivity.

(7)-B influences the availability and uptake of other plant nutrients from the soil. An apparent increase in the uptake and translocation of P, N, K, Zn, Fe, and Cu in leaves, buds, and seeds was noticed after B application in cotton (**Ahmed *et al.*, 2011**).

(8) B limitation negatively alters the reproductive performance of plants by causing abrupt changes in flowering and fruiting modes. This often results in empty and shriveled anthers, pollen tubes bursting, pollen viability loss, abscission of flower buds, failure of fruit setting, and premature fruit drop because of failure of photosynthate transport resulting in yield loss (**Marschner, 2012**)

(9)-B predominantly affects reproductive growth compared with vegetative growth in plants.

(10)-B limitation negatively alters the reproductive performance of plants by causing abrupt changes in flowering and fruiting modes. This often results in empty and shriveled anthers, pollen tubes bursting, pollen viability loss, abscission of flower buds, failure of fruit setting, and premature fruit drop because of failure of photosynthate transport resulting in yield loss (**Marschner, 2012**). Boron is involved in the pollen development, pollen germination and pollen tube growth (**Lee *et al*., 2009**). Its deficiency affects the pollen development and pollen tube growth resulting in male sterility and poor seed set. Moreover, the seeds and fruits abscise prematurely consequently leading to reduced crop yield (**Barker and Pilbeam, 2015**).

With regard to boron effect, **Dordas (2006)** assessed the effect of foliar applied B on cotton and found increase in boll retention due to B application, **Ali *et al.* (2011)** reported that foliar applied B improved the number of bolls, boll weight and seed cotton yield as compared to control, **Rashidi and Seilsepour (2011)** conducted an experiment to determine the effect of foliar applied B on cotton and found that number of bolls, boll weight, seed cotton yield and leaf blade B concentration was increased. Moreover, foliar boron also improved the fiber length and fiber fineness of cotton, **Elayan *et al.* (2014)** revealed that application of B to cotton aside from improving the growth and seed cotton yield also enhanced the earliness in cotton. It was observed that yield increase was up to 30% while earliness was increased up to 4% by the application of B, as compared to control.

With regard to lithovit effect, **Hamoda *et al.* (2016)** reported that applying CO_2 fertilizer as foliar spray at the four rates had a pronounced effect in increasing boll setting percentage and first picking percentage and reducing boll shedding percentage in both seasons, especially when CO_2 fertilizer was applied at the high rate (7.5 g/L) and **El-Shazly (2017)** reported that untreated plants with Nano-materials significantly increased number of total flowers/ plant in both seasons. The boll setting percentage and 1st picking percentage were found to improve considerably by applying CO_2 as foliar fertilizer in the form of lithovit, while untreated plants produced the lowest boll setting percentage and 1st picking percentage and the highest boll shedding % in both seasons.

The favourable effect of foliar feeding with the two combinations between lithovit and boric acid to cotton plants on seed cotton yield is mainly due to:

The principal functions of B, where: B plays in plants relate to the cell wall development and strengthening, cell division, sugar transport, hormone metabolism, fruit and seed formation and plasma membrane integrity (**Marschner, 1995),** B regulates the functioning of cell membrane and metabolic activities (**Bolanos *et al*., 2004**), Boron is involved in the pollen development, pollen germination and pollen tube growth (**Lee *et al*., 2009**). Its deficiency affects the pollen development and pollen tube growth resulting in poor seed set. Moreover, the seeds and fruits abscise prematurely consequently leading to reduced crop yield (**Barker and Pilbeam, 2015**), Boron directly affects the sugar synthesis and translocation in plants. Acute B deficiency increased the concentrations of reducing and nonreducing sugars but reduced activity of starch phosphorylase (**Chatterjee *et al*., 1990**). In addition to the positive effect of lithovit, where: macronutriens (Ca, Mg, K, N and P) and micronutrients (Fe, Mn, Zn and Cu) contained in lithovit influence plant physiology and increase the resistance, growth, vitality and quality of cotton, where: calcium acts as a base for neutralizing organic acids generated during the growing process and aids in enhancing and improving the translocation of carbohydrates from leaves to fruits and nitrogen absorption. It is an enzyme activator in the synthesis of nucleic acids (DNA and RNA). It regulates uptake of the other essential elements, serves as carrier of phosphate compounds through the plant, facilitates the translocation of carbohydrates (sugars and starches) and enhances the production of oils and fats. Phosphorus is essential for the biosynthesis of chlorophyll as pyridoxal which must be present for its biosynthesis. Phosphorus in lithovit compound decomposes carbohydrates produced in photosynthesis; and it is involved in many other metabolic processes required for normal growth, such as photosynthesis, glycolysis, respiration and fatty acid synthesis and it enhances early growth, where normal plant growth cannot be achieved without P. It is a constituent of nucleus acids, phospholipids, the coenzymes DNA and NADP, and most importantly ATP. It activates coenzymes for amino acid production used in protein synthesis; it decomposes carbohydrates produced in photosynthesis, glycolysis, respiration, and fatty acid synthesis. It stimulates blooming, enhances bud set, aids in seed formation and hastens maturity (**Tucker, 1999**). Plants require

P for the development of ATP (energy), sugars, and nucleic acids (**McCauley *et al*., 2009**). Sulfur in lithovit compound is an essential component in the synthesis of amino acids required to manufacture proteins. Sulfur is necessary in chlorophyll formation (though it isn't one of the constituents) and utilization of phosphorus and other essential nutrients. Crops that have high nitrogen requirements must have adequate sulfur to optimize nitrogen utilization (**Tucker, 1999**). Mg in lithovit compound assists the movement of sugars within a plant. Phosphorus is involved in phosphoglecric compounds and phosphoglycric acid which plays an important role in CO_2 conversion to sugar (**Uchida, 2000**). Zinc in lithovit compound is essential for several biochemical processes such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation and membrane integrity (**Uchida, 2000**). K which is a co-factor activating number of important enzymes which are involved in many processes in the plant such as: photosynthesis, respiration, carbohydrates metabolism, and translocation and stimulate the activity of nitrate reductase and promote the formation of peptides and proteins. potassium promotes the translocation of photosynthates (sugars) for plant growth or storage in fruits or roots and through its role assisting ATP production. Potassium is involved in protein synthesis (**Uchida, 2000).** N is an integral part of chlorophyll manufacture through photosynthesis and is important constituent of all proteins (**Tucker, 1999**). Nitrogen plays an important role in CO_2 conversion to sugar (**Uchida, 2000).**Cu in lithovit compound is part of the chloroplast protein plastocyanin, which forms part of the electron transport chain. Also, Cu may have a role in the synthesis and/or stability of chlorophyll and other plant pigments (**Uchida, 2000**). Cu is essential for chloroplast functions; deficiency normally promotes chlorosis in young growth. Consequently, Cu deficiency is most likely to be observed in high pH soils (**Hull, 2002**). Iron in lithovit compound is required for various reaction steps in the biosynthesis of chlorophyll, where iron plays a role in the formation of a precursor of chlorophyll synthesis, but it is not part of the chlorophyll molecule (**Curie and Briat, 2003**). Manganese in lithovit compound application increased the chlorophyll content (**Dordas, 2009**). Although Mn is not a constituent of chlorophyll, it helps in its formation where, manganese assists iron in chlorophyll formation (**Lohry, 2007**). Zinc in lithovit compound takes part in enzymatic activities, photosynthetic process as well as synthesis part of protein, carbohydrates and lipids. Zinc encourages green plastids enzymes and delays the senescence of plant through increasing rates of indole acetic acid (IAA) and chlorophyll. Zinc is necessary for chlorophyll synthesis and ATP/chlorophyll ratio **(Lohry, 2007).** Lithovit fed cotton plant leaves with CO_2 which converted by photosynthesis into the back bone of all plant parts (it constitutes over 90% of the plant's weight), thus enhancing the basic process of photosynthesis and plant growth which reflects on provide the best conditions for plant growth.Lithovit can considerably increase the photosynthesis rate, since the essential factor limiting photosynthesis is the natural CO_2 content of the air and lithovit particles, sprayed finely onto the leaf survace, are taken up directly through the stomata and converted into carbon dioxide.Also, the combination btween B and lithovit either at the low or high levels gave the significant increase of leaves photosynthetic pigments (chlorophyll a, b, total chlorophyll and carotenoids) as shown in Table 4 which reflects in significant increase in production of assimilates by the leaves (source) that enhance the resistance to adverse conditions as indicated by the significant decrease in enzymes activity as peroxidase and phenoloxidase and proline content (Table 5) and significant increase in boll setting percentage, retaining more bolls and reducing boll shedding % (Table 7). These two compinations reduced leaves water deficieny and osmotic pressure, since with lithovit the plants are able to keep the stomata closed longer in case of water stress. Also, these two compinations significantly increased leaves total water content, relative water content and plasma membrane permeability. The obtained results could be explained on the basis that experimental soil being low in organic matter and available nitrogen (Table 2) and the supplied of lithovit and boron combination increased leaves NPK content and the ingredients contained in lithovit provided plants with their requirements of macronutriens (Ca, Mg, K, N and P) and micronutrients (Fe, Mn, Zn and Cu) which reflects on high productively.

Thus, it is clear that applying foliar feeding with the combination between lithovit and boric acid either at the high level (5glithovit/l +1g boric acid/l) or at the low level (2.5g lithovit /l + 0.5g boric acid/l) three times (at squring stage, at flowering initiation and at the top of flowering) could be considered as the proper combinations for Giza 86 cotton cultivar under the environmental conditions of El-Gemmeiza region, where the yield per feddan was very close from these two combinations.

In this regard, foliar application of B improved the seed cotton yield and ginning out turn (**Ahmad *et al*., 2009**). **Ali *et al*. (2011)** reported that foliar applied B improved the number of bolls, boll weight and seed cotton yield. **Rashidi and Seilsepour (2011)** indicated that foliar application of B significantly (P = 0.05) increased boll number, boll weight, seed cotton yield and lint yield. **Elayan *et al.* (2014)** revealed that application of B to cotton aside from improving the growth and seed cotton yield also enhanced the earliness in cotton. It was observed that yield increase was up to 30% while earliness was increased up to 4% by the application of B, as compared to control. **Hamoda *et al.* (2016)** found that applying CO_2 fertilizer as foliar spray at the four rates had a pronounced effect in increasing number of open bolls/plant, boll weight, seed cotton yield/plant and seed cotton yield/feddan in both seasons, in favor of applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying at the high rate of 7.5 g/l two times at 45 and 60 days after planting followed in ranking by the medium rate (5 g/l), the low rate (2.5 g/l) and untreated plants (without Lithovit). **El-Shazly (2017)** found that foliar CO_2 fertilizer in the form of lithovit (a Nano-$CaCO_3$) three times [atthesquaring stage (57 days old), flowering initiation (77 days old) and at the topof flowering (97 days old)] significantly increased number of open bolls per plant, boll weight, seed index and seed cotton yield /feddan in both seasons and lint percentage in the second season as compared with untreated plants.

The positive effect of foliar feeding with the combination between lithovit and boric acid either at the high level or low level on fiber traits in consideration may be due to increased leaves NPK content and the ingredients contained in lithovit provided plants with their requirements of macronutriens (Ca, Mg, K, N and P) and micronutrients (Fe, Mn, Zn and Cu) which reflects in significant increase in photosynthetic pigments (chlorophyll a, b and carotenoids) in cotton leaves (Table 5), and hence they would have a stimulating effect on increasing total soluble sugars and total carbohydrates in addition to the significant increase in leaves total water content, relative water content and plasma membrane permeability which surely reflected on producing high fiber quality. In this concern, foliar application of B improved fiber length and micronaire of cotton (**Ahmad *et al*., 2009**). **Rashidi and Seilsepour (2011)** conducted an experiment to determine the effect of foliar applied B on cotton and found that foliar boron improved the fiber length and fiber fineness of cotton.

Conclusion

Under conditions similar to El – Gemmeiza location.it could be concluded the foliar feeding with CO_2 fertilizer in the form of lithovit (a Nano-$CaCO_3$) at a rate of 2.5 g / l in combined with 0.5 g boric acid/l three times (at squring stage, at flowering initiation and at the top of flowering), where this interaction treatment is optimum for active chemical composition and balanced water relations in leaves, earliness traits, high quality and productivity.

Acknowledgments

We extend our sincere thanks to all the employees of Botany Department, Agriculture Faculty, Menoufia University, Egypt, as well as Cotton Physiology Department, Cotton Research Institute, Agriculture Research Center, Giza, Egypt, including our professors and colleagues for their support and help us in ending this work.

References

A. O. A. C. (1995). Association of Official Agriculture Chemists. Official Methods of Analysis. 16th Ed. A.O.A.C. Virginia, D.C., USA.

A.S.T.M. (1986): American Society for Testing and Materials. Eastan, MD, USA.

Ahmad, S., L.H. Akhtar, S. Ahmad, N. Iqbaland M. Nasim. 2009. Cotton (*Gossypium hirsutum* L.) varieties responded differently to foliar applied boron in terms of quality and yield. Soil Environ. 28: 88-92.

Ahmed, N., M. Abid., F. Ahmad., A. AmanUllah., Q. Javaid and M.A. Ali (2011): Impact of boron fertilization on dry matter production and mineral constitution of irrigated cotton. Pak. J. Bot. 43: 2903-2910.

Ali, L., M. Ali and Q. Mohy-ud-din (2011): Effect of foliar application of zinc and boron on seed cotton yield and economics in cotton-wheat cropping pattern. J. Agric. Res. 49:173-180.

Ashley, D.A. and Goodson, R.D. (1972). Effect of time and plant potassium status on 14C-labeled photosynthate movement in cotton. Crop Sci. 12: 686-690.

Attia, A. N. E.; M. H. El-Hendi; S. A. F. Hamoda and Shiamaa O. S. El-Sayed (2016). Effect of Nano-Fertilizer (Lithovit) and Potassium on Leaves Chemical Composition of Egyptian Cotton Under Different Planting Dates. J. Plant Production, Mansoura Univ., Vol. 7 (9): 935 - 942, 2016.

Attia, A. N; M. S. Sultan; M. A. Emara and B. W, El-Shazly (2017) Effect of Foliar Spraying with Nano and Natural Materials under Water Stress Conditions on Cotton Leaves Chemical Composition. J. Plant Production, Mansoura Univ., Vol. 8(2):161 -169.

Barker A.V., Pilbeam D.J. (2015): Handbook of plant nutrition. Boca Raton: CRC Press, 2015.

Barrs, H. D. and Weatherley, P. E. (1962): Arc examination of the relative turgidity technique for estimating water deficits in leaves. Aust. J. BioI. Sci., 15: 413 - 428.

Bates, L. S.; Waldem, R. P. and Teare, 1. D. (1973): Rapid determination of free proline under water stress studies Plant and Soil, 39: 205 - 207.

Bolanos, L.; Lukaszewski, K.; Bonilla, I.; Blevins, D. (2004): Why boron? Plant Physiol. Biochem. 2004, 42, 907–912.

Broesh, S. (1954): Colorimetric assay of phenoloxidase. Bull. Soc. Chem., Biol., 36: 711-713.

Chatterjee, C; P Sinha and S C Agarwala(1990): Boron nutrition of cowpea. Proc. lndian Acad. Sci. (Plant Sci.), Vol. 100. No. 5, October 1990, pp. 311-318.

Curie, C. and J. F. Briat (2003): Iron transport and signaling in plants. Annu Rev. Plant Biol., 54: 183– 206.

Dordas C. (2006): Foliar boron application affects lint and seed cotton yield and improves seed quality of cotton grown on calcareous soils. NutriCyclAgroecosys 2006; 76:19-28.

Dordas C. (2009): Foliar application of Manganese increases seed yield and improves seed quality of cotton grown on calcareous soils. J. Plant Nutrition, 32: 160-176.

Elayan E. D. Sohair, M. Abdallah Amany, S. A. bd El-Gawad Nadia and S.A. YouniesShimaa (2014). Evaluation of Some Long Staple Cotton Genotypes Cultivated Under Different Environmental Conditions. American-Eurasian J. Agric. & Environ. Sci., 14 (6): 546-554.

El-Shazly, B. W. M. (2017): Using nano and natural materials for increasing cotton productivity and quality under water stress conditions. M. Sc. Thesis Fac. of Agric. Mansoura Univ**.**

FareehaShireen; MuhammadAzher Nawaz; Chen Chen; Qikai Zhang; Zuhua Zheng; Hamza Sohail; Jingyu Sun; Haishun Cao; Yuan Huang and ZhilongBie(2018). Boron: Functions and Approaches to Enhance Its Availability in Plants for Sustainable Agriculture. Int. J.Mol.Sci. 2018,19,1856;doi:10.3390/ijms1907185.

Fehrman, H. and Dimond, A. E. (1967): Peroxidase activity and phytophthora resistance in different organs of the potato. Plant pathology, 57: 69-72.

Goldbach, H.E. and Wimmer, M. A.(2007):Boron in plants and animals: Is there a role beyond cell wall structure? J. Plant Nutr. Soil Sci. 2007, 170, 39–48.

Gosev, N. A. (1960): Some methods in studying plant water relation. Leningrad Acad. of Sci. U.S.S.R.

Hamoda,S.A.F.;A.N.E. Attia;M.H.El-Hendiand ShiamaaO.S.El-Sayed(**2016**). Effect of nano-fertilizer (lithovit)and potassium on growth, fruiting and yield of Egyptian cotton under different planting dates. Int.J.Adv.Res.Biol. Sci., 3(12):29-49.

Hatfield, J. L.; K. J. Boote; B. A.Kimball; L. H. Ziska; R. C. Izaurralde; D. Ort; A. M.Thomson; and D. Wolfe (2011): "Climate Impacts on Agriculture: Implications for Crop Production". Agron. J., 103: 351-370.

Hull, R.J. (2002): Copper management demands attention. Plant Nutrition July 2002.

Jackson, M. L. (1973). Soil Chemical Analysis. Prentice Hall of Indian Private Limited, New Delhi.

Kreeb, K. H. (1990): MethodenZurPflanzenokologie und Bioindikation Gustav Fisher, Jena, 327 pp.

Kumar, P. (2011): Nanotechnology in agriculture. Financing Agriculture, 43(10): 8-10**.**

Lawlor, D. W. and G.Cornic (2002). Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants.P lant Cell Environ., 25: 275-24.

Lee SH, Kim WS and Han TH (2009): Effects of post-harvest foliar boron and calcium applications on subsequent season's pollen germination and pollen tube growth of pear (*Pyrus pyrifolia*). Scientia Horticulturae 122, 77-82.

Le Clerg, E. L.; W. H. Leonard and A. G. Clark (1966). Field Plot Technique. Burgess Pub. Co. Minneapolis, U.S.A**.**

Lohry, R. (2007). Micronutrients: functions, sources and application methods. Indiana CCA Conference Proceeding.

Marschner, H. (2012). Marschner's Mineral Nutrition of Higher Plants, 3rd ed.; Academic Press: London, UK, 2012; ISBN 9780123849069.

Marschner, H. 1995. Mineral nutrition of higher plants. 2nd. ed. Academic Press, London.

Maswada, H. F. and L. A. Abd El-Rahman (2014).Inducing salinity tolerance in wheat plants by hydrogen peroxide and lithovit "a nano-$CaCO_3$ fertilizer" J. Agric. Res. Kafr El-Sheikh Univ., 40 (4): 696-719.

McCauley, A.; C. Jones and J. Jacobsen (2009): Plant nutrient functions and deficiency and Toxicity symptoms. Nutrient Management, Montana State Univ., Extension 4449 – 9 May 2009.

Prior, S.A.; G. Brett; S. Runion; C. Marble; H. H. Rogers; C.H. Gilliam and H. A. Torbert (2011).A review of elevated atmospheric CO_2 effects on plant growth and water relations: Implications for Hort. Sci., 46(2): 158-162.

Prior, S. A.; H. A. Torbert; G. B. Runionand and H. H. Rogers (2003). Implications of elevated CO_2induced changes in agroecosystem productivity. J. Crop Prod., 8: 217–244.

Rashidi, M. and M. Seilsepour (2011): Effect of Different Application Rates of Boron onYield and Quality of Cotton (*Gossypium hirsutum* L.). Middle-East J. Sci. Res., 7:758-762.

Raza, M. A. S.; M. F. Saleem; G. M. Shah; I. H. Khan and A. Raza (2014): Exogenous application of glycine betaine and potassium for improving water relations and grain yield of wheat under drought. J. Soil Sci. Plant Nutr., 14: 348-364.

Sawan, Z. M.; M. H. Mahmoud and A. H. El-Guibali (2008). Influence of potassium fertilization and foliar application of zinc and phosphorus on growth, yield components, yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L.). J. of Plant Ecology, 1(4): 259-270.

Shallan, M. A.; H. M. M. Hassan; AliaA. M. Namich andAlshaimaa A. Ibrahim (2016): The influence of Lithovit fertilizer on the chemical constituents and yield characteristics of cotton plant under drought stress. Inter. J. of Chem. Tech. Res., 9(8): 01-11.

Siddiqui, M. H.; M. H. Al-Whaibi; M. Firoz and M. Y. Al-Khaishany (2015): Role of nanoparticles in plants. Nanotechnology and plant Sci., 2: 19 – 35.

Tucker, M. R. (1999): Essential plant nutrients: Their presence in North Carolina soils and role in plant nutrition.

Uchida, R. (2000): Essential nutrients for plant growth: nutrient functions and deficiency symptoms. Plant Nutrient Management in Hawaiis Soils. Approaches for tropical and Subtropical Agric., 3: 31-55.

Waller, R. A. and D. B. Duncan (1969). A bays rule for the symmetric multiple comparison problems. J. Amer. Stat. Assoc., 64:1485-1503.

Wang, N.; Yang, C.; Pan, Z.; Liu, Y. and Peng, S.(2015): Boron deficiency in woody plants: Various responses and tolerance mechanism. Front. Plant Sci. 6, 916.

Yan, B., and Dai, Q., (1996): **"**Flood-induced membrane damage, lipid oxidation and activated oxygen generation in corn leaves", Plant and Soil 179: 261-268.

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DOI:10.22192/ijarbs.2019.06.01.004	

How to cite this article:
M. W. EL Shazly and A. M. Abd El All. (2019). Response of Giza 86 cotton cultivar to foliar feeding with lithovit and boron. Int. J. Adv. Res. Biol. Sci. 6(1): 33-49.
DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.01.004