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Effect of Foliar Application with Bentonite on Growth and Productivity of Egyptian Cotton

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ABSTEACT

Two field experiments were carried out in El-Gemmeiza Agricultural Research Station Agricultural Research Center, El-Gharbiya Governorate in 2016 and 2017 seasons to study the effect of foliar application with bentonite (times of application and rates) on leaf chemical composition, plant growth, earliness traits, fiber quality and yield of Egyptian cotton (*Gossypium barbadense* L.), Giza 86 cultivar. A split-plot design with three replicates was used. The main plots included three intervals at (squaring stage and flowering initiation), at (flowering initiation and the top of flowering) and at (squaring stage, flowering initiation and the top of flowering). The sub plots involved four rates of bentonite; (control "without application", spraying with 2, 3 and 4 kg bentonite/fed). The important results could be summarized as follow: Times of foliar application with bentonite gave significant effect on nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves, in favor of foliar application with bentonite three times (at squaring stage, at flowering initiation and at the top of flowering). Leaves concentrations of nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids significantly increased with foliar application of 3kg bentonite /fed as compared with the other rates.The interaction between times of bentonite as foliar spraying and its rates had significant effect on chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves, where foliar spraying with 3kg bentonite per fed three times (at squaring stage, at flowering initiation and at the top of flowering) produced the highest values of these traits. While, leaves N, P and K concentrations did not affect by this interaction. Times of application did not affect plant height and number of fruiting branches/ plant at harvest in both seasons. Bentonite at the rate of 2kg/fed significantly increased cotton growth parameters, *i.e.,* plant height and number of fruiting branches/ plant at harvest as compared with the high rate of betonies(4kg/fed) in both seasons. The interaction significantly affected these two traits in the first season only, where the highest values of cotton growth parameters, *i.e.,* plant height and number of fruiting branches/ plant were, generally, recorded with foliar application of bentonite at the rate of 2kg/fed three times(at squaring stage, at flowering initiation and at the top of flowering). However, the lowest values were recorded with foliar application of bentonite at the rate of 4kg/fed three times (at squaring stage, at flowering initiation and at the top of flowering).Times of foliar application with bentonite gave insignificant effect on earliness traits (numbers of total flowers and total bolls / plant, boll setting % and boll shedding %) in both seasons.Bentonite at the rate of 2kg/fed and at the rate of 3kg/fed significantly increased earliness traits (numbers of total flowers and total bolls / plant and boll setting %) and significantly decreased boll shedding % without significant differences between them as compared with the high rate of bentonite (4kg/fed) and control in both seasons. The interaction between times of foliar application and rates of bentonite significantly affected earliness traits (number of total flowers/ plant, number of total bolls/plant and boll setting %) in both seasons, where the highest values of number of total flowers/ plant, number of total bolls/plant and boll setting % and the lowest value of the boll shedding % were, generally, recorded with foliar application of bentonite at the rate of 2kg/fed or at the rate of 3kg/fed two or three times as compared with foliar application of bentonite at the rate of 4kg/fed two or three times and control treatment. Foliar application with bentonite twice (at squaring stage and at flowering initiation) or three times (at squaring stage, at flowering initiation and at the top of flowering) significantly increased yield parameters (boll weight, seed cotton yield/plant and seed cotton yield/fed) in both seasons as compared with foliar application with bentonite twice (at flowering initiation and at the top of flowering).On the other hand, seed index and lint % did not affect by time of application in both seasons. Foliar application of 2 or 3 kg bentonite per fed significantly increased boll weight, number of open bolls/plant, seed index, seed cotton yield/plant and yield of seed cotton/fed as compared with the control and using 4kg bentonite /fed in the two seasons of study. The interaction between times of application and rates of bentonite as foliar application had a significant effect on boll weight, number of open bolls/plant, seed cotton yield/plant and seed cotton yield/fed in both seasons, in favor of foliar application of bentonite at the rate of 2kg/fed or at the rate of 3kg/fed two times (at squaring stage and at flowering initiation) or three times (at squaring stage, at flowering initiation and at the top of flowering). While, seed index and lint % did not affect by the interaction between times of application and rates of bentonite as foliar application in both seasons. The times of foliar application and rates of bentonite as well as their interactions had insignificant effect on Pressley index and micronaire reading in both seasons. Conclusion: it could be concluded that the best foliar application rate of bentonite was 3kg per fed two times (at squaring stage and at flowering initiation) for a significant positive effect on chemical composition, growth, boll setting and yield of cotton Giza 86 cultivar, under the conditions of El-Gemmeiza location.

INTRODUCTION

In recent years, there has been increasing interest in the application of natural aluminosilicates in agricultural technology. Several studies have demonstrated that bentonite has desirable properties and a large water holding capacity. The unique physical and chemical properties of natural aluminosilicates make it particularly suitable for agricultural use. Bentonite is naturally occurring structured with high cation exchange and ion adsorption capacities (Kojić *et al*., 2012). Bentonite is a 2:1 mineral, with a high surface area and cation exchange capacity. Each layer of bentonite is composed of 2 silica sheets and 1 octahedral sheet, with individual layers held together by van der waals forces. Because of the relatively weak nature of these interlayer forces water can easily penetrate between layers, while cations balance charge deficiencies present in the structure (Iskander *et al*., 2011). The primary effect of bentonite application is to improve the water holding capacity and moisture content of soil, contributing to the stimulation of biological activity.

Abiotic stress factors such as heat, drought and soil salinity cause significant agricultural yield losses and limit the growth and productivity factors of different plant species (Basal *et al*., 2006), Introducing bentonite and rich clay would lead to increase cations exchange capacity, increase reserves and capacity of water and minerals and improve the agricultural potential (Costa *et al*., 2004).

Yield of cotton plant is determined by combination factors: boll number, boll size, seed number/boll, and fiber/seed. These parameters are influenced by the physiological activity of the plant and its interaction with the environment. Due to the perennial nature of cotton, fruiting continues during its maturation, thus impacting any or all of these parameters.

One would assume that higher stomatal conductance increases CO2 diffusion into the leaf that would favor higher photosynthetic rates. If these higher photosynthetic rates are sustained they could in turn favor higher crop yield. El Midaoui *et al*., (2007) confirmed that osmotic adjustment is a major physiological trait of tolerance to environmental stresses. It was achieved through an accumulation of osmoregulatory compounds leading to a reduction of osmotic potential (Shukdeb, 2010).

The objective of this study was to assess the effect of times of foliar application with bentonite and determine the proper rate with concern to chemical composition, growth traits, boll setting, yield components, yield and fiber traits of Egyptian cotton (*Gossypium barbadense,* L.), cultivar Giza 86.

MATERIALS AND METHODS

Two field experiments were carried out on clay soil in El-Gemmeiza Agricultural Research Station, Agricultural Research Center, El-Gharbiya Governorate, Egypt during two successive seasons of 2016 and 2017, to study the effect of foliar application with bentonite (times of application and rates) on leaf chemical composition, plant growth, earliness and yield of Egyptian cotton (*Gossypium barbadense,* L.), cultivar Giza 86.

A split-plot design with three replicates was used. The main plots included three intervals at (squaring stage and flowering initiation), at (flowering initiation and the top of flowering) and at (squaring stage, flowering initiation and the top of flowering). The sub plots involved four rates of bentonite; (control "without application", spraying with 2, 3 and 4 kg bentonite/fed).

Bentonite ($Al_2O_3 \bullet 4SiO_2 \bullet 5H_2O$) contains elements that improve plant physiology.The chemical analysis of Bentonite is shown in Table 1 according to El-Ahram Company for Mining and Natural Fertilizers.

Table 1. Chemical analysis (%) of Bentonite Ore

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	MnO	P_2O_5	CaO	Na_2O	K_2O
56.10	0.56	12.50	2.99	1.17	0.33	0.06	0.82	10.18	1.07	1.21

Soil analysis for the two sites was carried out according to Page *et al*. (1982). The results are shown in Table 2.

The experimental plot area was 14 m^2 (5 rows, 4 m long and 70 cm apart). Sowing took place on 8th April in hills 25 cm apart leaving two plants/hill at thinning time in both seasons. Phosphorus fertilizer was added at the rate of 22.5 kg P_2O_5 /fed as calcium super phosphate (15.5 % P_2O_5) during land preparation. Nitrogen fertilizer at a rate of 45 kg N / fed as ammonium nitrate (33.5 % N) was applied in two equal doses, immediately before the first and the second irrigations. Potassium fertilizer in the form of potasin-f was applied as foliar application three times at the rate of 500cm^3/fed. The previous crop was Egyptian clover (berseem). Normal agricultural practices were followed during the two growing seasons.

Table 2. Chemical analysis of the experimental soil

Properties	Season 2016	Season 2017
pH	8.0	7.9
EC mmhos/ cm	0.54	0.33
Organic matter %	1.42	1.60
Total N (mg/100g)	49.7	56.0
Available N (ppm)	28.7	29.9
Available P (ppm)	11.1	12.5
Exchangeable K (ppm)	306	333
Available Fe (ppm)	11.0	11.3
Available Mn (ppm)	2.9	3.1
Available Zn (ppm)	0.90	1.00
Available Cu (ppm)	3.0	3.4

Studied characters:

A-Chemical composition of the leaf:

In 2017 season, after seven days from the third foliar application, a representative leaf sample (10 leaves) was taken from the upper 4th leaf on the main stem from each plot to determine the following chemical analysis:

1-Nitrogen, phosphorus and potassium concentrations in leaves were determined according to Chapman and Pratt (1978).

2- Chlorophyll a, chlorophyll b, total chlorophyll (a+b) and carotenoids contents in leaves were determined according to A.O.A.C. (1995).

In both seasons, plants of five guarded hills were taken at random from each sub-plot at harvest to study the following traits:

B- Growth traits; plant height (cm) and number of fruiting branches/plant.

C- Earliness traits: numbers of total flowers and total bolls/plant and percentages of boll setting and shedding.

D-Seed cotton yield and its components; number of open bolls/plant, boll weight (g), seed cotton yield/plant, lint percentage and seed index (g). The yield of seed cotton per feddan was estimated as the weight of seed cotton in kilogram picked twice from each sub- plot, then converted to yield per feddan in kentar (One kentar = 157.5 kg).

F-Fiber properties; micronaire reading and Pressley index were determined for the representative samples at the laboratories of cotton Research Institute according to A.S.T.M. (1975).

The obtained data were subjected to statistical analysis according to Snedecor and Cochran (1980) and L.S.D. values at 5% level were used for comparison between means.

RESULTS AND DISCUSSION

A- Chemical composition:

The effect of times of foliar application, rates of bentonite and their interactions on nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves is presented in Table 3.

Times of foliar application with bentonite gave significant effect on nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves, in favor of foliar application with bentonite three times (at squaring stage, at flowering initiation and at the top of flowering).

Rates of bentonite had significant effect on leaves concentrations of nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids (Table 3), where foliar application of 3kg/fed bentonite significantly increased these traits as compared with the other rates.

The interaction between times of bentonite foliar application and its rates had significant effect on chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves, where the highest values of these traits were recorded with foliar application with any amount of bentonite as compared with control treatment, with superity of using 3kg bentonite per fed three times (at squaring stage, at flowering initiation and at the top of flowering). While, leaves N, P and K concentrations did not affect by this interaction.

Table 3. Effect of times of foliar application, rates of bentonite and their interactions on cotton leaf chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, nitrogen, phosphorus and potassium contents in 2017 season.

Treatments		Chlorophyll a (mg/g dry w.)	Chlorophyll b (mg/g dry w.)	Total chlorophyll (mg/g dry w.)	Carotenoids (mg /g dry w.)	N %	P %	K %
A-Times of application:								
a_1 squaring stage +flowering initiation		2.69	1.74	4.43	1.32	3.29	0.246	3.54
a_2 flowering initiation+top of flowering stages		2.97	2.12	5.09	1.46	3.19	0.285	3.45
a_3 squaring +flowering initiation+ top of flowering stages		3.29	2.35	5.64	1.71	3.36	0.295	3.55
LSD at 5%		0.03	0.01	0.01	0.03	0.04	0.018	0.03
B-Rates of bentonite:								
b_1	Control	2.88	1.94	4.82	1.41	2.83	0.196	3.04
b_2	2kg/fed	2.99	2.12	5.11	1.52	3.45	0.313	3.70
b_3	3kg/fed	3.12	2.17	5.29	1.59	3.61	0.329	3.90
b_4	4kg/fed	2.93	2.04	4.97	1.47	3.23	0.263	3.42
LSD at 5%		0.02	0.03	0.03	0.03	0.10	0.028	0.04
Interaction:								
a_1	b_1	2.53	1.61	4.14	1.23	2.90	0.197	3.04
	b_2	2.78	1.72	4.50	1.37	3.41	0.290	3.73
	b_3	2.86	1.87	4.73	1.41	3.63	0.277	3.93
	b_4	2.59	1.74	4.33	1.27	3.22	0.220	3.47
a_2	b_1	2.87	1.93	4.80	1.35	2.82	0.190	2.99
	b_2	2.89	2.19	5.08	1.56	3.38	0.320	3.65
	b_3	3.16	2.28	5.44	1.50	3.42	0.363	3.81
	b_4	2.95	2.07	5.02	1.43	3.13	0.267	3.36
a_3	b_1	3.24	2.27	5.51	1.64	2.76	0.200	3.09
	b_2	3.30	2.45	5.75	1.63	3.56	0.330	3.72
	b_3	3.35	2.37	5.72	1.86	3.79	0.347	3.97
	b_4	3.26	2.32	5.58	1.72	3.33	0.303	3.42
LSD at 5%		0.06	0.05	0.05	0.05	NS	NS	NS

B- Growth parameters:

Data concerning the effect of times of foliar application, rates of bentonite and their interactions on cotton plant height and number of fruiting branches/ plant at harvest were presented in Table 4.

Obtained results indicated that times of application did not affect final plant height and number of fruiting branches/ plant in the two seasons of study.

Bentonite at the rate of 2kg/fed significantly increased final plant height and number of fruiting branches/ plant as compared with the other rates of bentonite in the two seasons of study.

Results also, revealed that the interaction significantly affected these two traits in the first season only, where the highest values of cotton growth traits, *i.e.,* plant height and number of fruiting branches/ plant were, generally, recorded with foliar spraying of bentonite at the rate of 2kg/fed three times. However, the lowest values were recorded with foliar application of bentonite at the rate of 4kg/fed three times.

The positive effect of foliar application of bentonite on plant growth may be due to:

1-Its positive effect on water holding capacity (Iskander *et al.* 2011), decreasing leaching of different nutrients through its higher colloid content (Sitthaphanit *et al.* 2010), stimulating the merestimatic activity for producing more tissues and organs, since it plays major roles in the synthesis of structural (Marisa *et al.* 2009) and its vital contribution in several biochemical processes that related to plant growth (Marschner, 1995).

2-Increase nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves as a result of bentonite application enhancing photosynthetic and other metabolic activity which led to an increase in various plant metabolites responsible for cell division and elongation.

Table 4. Effect of times of foliar application, rates of bentonite and their interactions on final plant height (cm), number of fruiting branches/plant, Pressley index and micronaire reading in 2016 and 2017 seasons.

Treatments		Final plant height(cm)		No. of fruiting branches/plant		Pressley index		Micronaire reading	
		2016	2017	2016	2017	2016	2017	2016	2017
A-Times of application:									
a_1 squaring stage +flowering initiation		162.22	157.75	16.21	15.71	10.1	10.1	5.0	4.8
a_2 flowering initiation+top of flowering stages		161.46	157.04	16.14	15.68	10.0	10.0	4.9	4.9
a_3 squaring+flowering initiation+ top of flowering stages		162.36	157.47	16.25	16.04	10.0	10.1	4.9	4.8
LSD at 5%		NS	NS	NS	NS	NS	NS	NS	NS
B-Rates of bentonite:									
b_1 Control		163.18	158.25	16.25	15.74	9.6	9.9	5.0	4.9
b_2 2kg/fed		163.65	158.75	16.40	15.95	10.4	10.1	4.9	4.8
b_3 3kg/fed		162.84	157.94	16.29	16.13	10.0	10.1	4.7	4.7
$_4$ 4kg/fed		158.40	154.73	15.87	15.41	10.1	10.1	5.0	4.8
LSD at 5%		3.08	2.89	0.29	0.27	NS	NS	NS	NS
Interaction:									
a_1	b_1	162.78	157.89	16.22	15.71	9.8	10.0	5.0	4.9
	b_2	161.67	157.25	16.20	15.71	10.4	10.3	5.0	4.8
	b_3	164.75	159.53	16.44	15.97	9.8	10.0	4.9	4.6
	b_4	159.71	156.33	15.98	15.43	10.4	10.1	5.0	4.8
a_2	b_1	163.08	158.17	16.21	15.67	9.4	9.8	5.0	5.0
	b_2	162.58	157.67	16.25	15.75	10.5	10.0	4.9	4.9
	b_3	162.36	157.72	16.25	15.75	10.3	10.2	4.6	4.8
	b_4	157.83	154.62	15.87	15.53	9.8	10.1	5.0	4.7
a_3	b_1	163.67	158.72	16.33	15.83	9.5	9.9	5.0	4.8
	b_2	166.71	161.33	16.75	16.40	10.3	10.1	4.8	4.7
	b_3	161.40	156.58	16.17	16.67	10.0	10.2	4.7	4.6
	b_4	157.67	153.23	15.75	15.25	10.0	10.1	5.0	4.9
LSD at 5%		5.32	NS	0.29	NS	NS	NS	NS	NS

C –Earliness traits:

Data concerning the effect of times of foliar application and rates of bentonite as well as their interactions on cotton earliness traits were presented in Table 5.

Times of foliar application with bentonite gave insignificant effect on earliness traits (numbers of total flowers and total bolls/plant, percentage of boll setting and boll shedding %) in the two seasons of study.

Bentonite at the rate of 2kg/fed and at the rate of 3kg/fed significantly increased earliness traits (numbers of total flowers and total bolls/plant and percentage of boll setting) and significantly decreased percentage of boll shedding in both seasons without significant differences between them as compared with the high rate of bentonite (4kg/fed) and control in both seasons.

The interaction between times of foliar application and rates of bentonite significantly affected earliness traits in the two seasons of study. The highest values of numbers of total flowers and total bolls / plant and boll setting % and the lowest value of the boll shedding % were, generally, recorded with foliar application of bentonite at the rate of 2kg/fed or at the rate of 3kg/fed two or three times as compared with foliar application of bentonite at the rate of 4kg/fed two or three times and control treatment.

D-Yield and its components:

Data concerning the effect of times of foliar application and rates of bentonite as well as their interactions on cotton yield and its components were presented in Table 6.

Data presented in Table 6 showed that foliar application with bentonite twice (at squaring stage and at flowering initiation) or three times (at squaring stage, at flowering initiation and at the top of flowering) significantly increased boll weight, seed cotton yield/plant and seed cotton yield/fed in the two seasons of study as compared with foliar application with bentonite twice (at flowering initiation and at the top of flowering).On the other hand, time of application did not exhibit any significant effect on seed index and lint % in the two seasons of study.

Bentonite at the rate of 2kg/fed and at the rate of 3kg/fed significantly increased boll weight, number of open bolls/plant, seed index, seed cotton yield/plant and yield of seed cotton/fed as compared with the control and using 4kg bentonite /fed in the two seasons of study (Table 6). These two rates of bentonite achieved the highest seed cotton yield/fed which recorded 11.70 and 10.51 kentars; 11.84 and 10.64 kentars in the first and second seasons, respectively. The increases over the control and using 4kg bentonite /fed were 17.00, 6.36, 18.40 and 7.64%; 16.13, 5.73, 17.57 and 7.04 % in 2016 and 2017 seasons, respectively.

The interaction between times of application and rates of bentonite as foliar application exhibited a significant effect on boll weight, number of open bolls/plant, yields of seed cotton per plant and per feddan, in favor of foliar application of bentonite at the rate of 2kg/fed or at the rate of 3kg/fed two times (at squaring stage and at flowering initiation) or three times (at squaring stage, at flowering initiation and at the top of flowering). On the other hand, seed index and lint % did not affect by the interaction between times of application and rates of bentonite as foliar application in both seasons.

Table 5. Effect of times of foliar application, rates of bentonite and their interactions on number of total flowers/plant, number of total bolls/ plant, boll setting % and boll shedding % in 2016 and 2017 seasons

Treatments		Number of total flowers/plant		Number of total bolls/plant		Boll setting %		Boll shedding %	
		2016	2017	2016	2017	2016	2017	2016	2017
A-Times of application:									
a_1 squaring stage +flowering initiation		29.23	28.33	22.65	21.95	77.70	77.18	22.30	22.82
a_2 flowering initiation+top of flowering stages		28.86	28.86	22.93	21.84	75.97	75.65	24.03	24.35
a_3 squaring+flowering initiation+ top of flowering stages		29.21	28.52	22.51	21.92	77.03	76.83	22.97	23.17
LSD at 5%		NS	NS	NS	NS	NS	NS	NS	NS
B-Rates of bentonite:									
b_1 Control		28.88	28.22	20.61	19.98	71.33	70.80	28.67	29.20
b_2 2kg/fed		29.91	28.92	23.60	22.86	78.90	79.03	21.10	20.97
b_3 3kg/fed		29.40	28.84	23.25	22.78	79.03	78.97	20.97	21.03
b_4 4kg/fed		28.20	28.29	22.00	21.99	78.33	77.40	21.67	22.60
LSD at 5%		0.88	0.56	0.67	0.83	2.10	2.31	2.10	2.31
Interaction:									
a_1	b_1	28.32	27.91	20.39	19.79	72.00	70.90	28.00	29.10
	b_2	30.71	29.32	24.26	23.43	79.00	79.90	21.00	20.10
	b_3	29.40	28.64	23.55	22.83	80.10	79.70	19.90	20.30
	b_4	28.48	27.44	22.41	21.73	79.70	78.20	20.30	21.80
a_2	b_1	29.30	28.48	20.89	20.25	71.30	71.10	28.70	28.90
	b_2	29.49	28.76	22.97	22.26	77.90	77.40	22.10	22.60
	b_3	29.05	28.78	22.51	22.22	77.50	77.20	22.50	22.80
	b_4	27.59	29.43	21.30	22.63	77.20	76.90	22.80	23.10
a_3	b_1	29.02	28.27	20.53	19.90	70.70	70.40	29.30	29.60
	b_2	29.52	28.68	23.56	22.89	79.80	79.80	20.20	20.20
	b_3	29.75	29.10	23.65	23.28	79.50	80.00	20.50	20.00
	b_4	28.54	28.01	22.29	21.60	78.10	77.10	21.90	22.90
LSD at 5%		1.01	0.78	1.15	1.20	3.62	4.11	3.62	4.11

The positive effect of bentonite on yield and its components may be attributed to:

1-Its beneficial effects on improving nitrogen, potassium, phosphorus, chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves which encouraged plant growth and yield due to improving photosynthesis, nitrogen, protein, enzyme and carbohydrate metabolism.

2-The positive effect on yield of seed cotton/fed is a result of increasing boll number and boll weight due to realizing more elements (phosphorus, potassium, calcium, sulphur, magnesium, iron, manganese, aluminum, silicon, titinum and sodium) from bentonite, that influence plant physiology where:

Magnesium is an essential element for chlorophyll molecule structure, which is the driving force of photosynthesis. It acts as an activator of many enzyme systems involved in nucleic acids synthesis and carbohydrates metabolism. Calcium aids in improving and enhancing the translocation of carbohydrates from leaves to fruits and nitrogen absorption and acts as a base for neutralizing organic acids generated during the growing process. (Jones *et al.*, 1991 and Tucker, 1999).

Phosphorus (P) is a constituent of phospholipids, nucleus acids, the coenzymes DNA and NADP, and most importantly ATP. It enhances early growth, where without P normal plant growth cannot be achieved. It activates coenzymes for amino acid production used in protein synthesis. It stimulates blooming, enhances bud set, hastens maturity and aids in seed formation (Tucker, 1999), Phosphorus is involved in phosphoglecric compounds and phosphoglycric acid which plays an important role in CO_2 conversion to sugar (Uchida, 2000).

Sulfur (S) is an essential component in the synthesis of amino acids required to manufacture proteins (Tucker, 1999).

Potassium (K) plays vital role in photosynthesis, translocation of photosynthates from sources to sinks, protein synthesis, control of ionic balance, activation of plant enzymes, inhibitory of ROS (Reactive Oxygen Spices) production during photosynthesis and NADPH oxidase, regulation of plant stomata and water use and many other processes. (Marschner, 1995; Reddya *et al.*, 2004 and Cakmak, 2005).

Curie and Briat (2003) mentioned that iron (Fe) plays a role in the formation of a precursor of chlorophyll synthesis.

Manganese (Mn) helps in chlorophyll formation where, it assists iron in chlorophyll formation (Lohry, 2007).

Titanium (Ti) is one of a plant biostimulators and presence of Ti in plant tissues improves plant enzyme activities, particularly those involved in the photosynthesis redox processes(as nitrate reductase, lipoxygenase, peroxidase, fructose-1,6-bisphosphatase). Plant supplementation with Ti stimulates their chlorophyll content, growth, pollination, fruit and seed formation (Radkowski *et al.*, 2015).

Elemental silicon (Si) alleviates the toxic effects caused by abiotic stresses, e.g., salt stress, drought and heavy metals. Si ameliorates the vigor of plants and improves their resistance to exogenous stresses (Hausman et al., 2017).

Table 6. Effect of times of foliar application, rates of bentonite and their interactions on boll weight(g), number of open bolls/plant, seed cotton yield / plant (g), lint %, seed index (g) and seed cotton yield/feddan (kentar) in 2016 and 2017 seasons

Treatments		Boll Weight (g)		Number of open bolls/plant		Seed cotton yield / plant (g)		Lint percentage		Seed index (g)		Seed cotton yield/feddan (kentar)	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
A-Times of application:													
a_1 squaring stage +flowering initiation		3.23	3.12	22.65	21.95	66.87	64.64	39.36	39.48	10.77	11.26	11.31	10.17
a_2 flowering initiation + top of flowering stages		3.26	3.15	22.93	21.84	63.51	60.97	40.19	39.83	11.03	10.58	10.62	9.64
a_3 squaring+ flowering initiation + top of flowering stages		3.33	3.21	22.51	21.92	67.82	65.34	39.95	39.68	10.80	11.02	11.48	10.29
LSD at 5%		0.06	0.06	NS	NS	1.26	1.03	NS	NS	NS	NS	0.43	0.41
B-Rates of bentonite:													
b_1 Control		3.13	3.03	20.61	19.98	58.86	56.71	39.03	39.20	10.38	10.67	10.00	9.05
b_2 2kg/fed		3.36	3.23	23.60	22.86	69.86	67.24	40.45	39.60	11.17	11.14	11.70	10.51
b_3 3kg/fed		3.39	3.27	23.25	22.78	70.17	67.58	39.31	39.83	11.29	11.20	11.84	10.64
b_4 4kg/fed		3.20	3.11	22.00	21.99	65.37	63.06	40.53	40.00	10.64	10.82	11.00	9.94
LSD at 5%		0.07	0.06	0.67	0.83	1.53	1.58	NS	NS	0.40	0.41	0.29	0.23
Interaction:													
a_1	b_1	3.14	3.04	20.39	19.79	57.59	56.28	38.74	39.10	10.44	10.85	9.85	8.86
	b_2	3.22	3.12	24.26	23.43	71.65	69.20	39.39	39.20	11.25	11.68	12.06	10.86
	b_3	3.30	3.19	23.55	22.83	70.57	67.97	38.79	39.40	11.48	11.27	11.97	10.77
	b_4	3.23	3.12	22.41	21.73	67.66	65.12	40.52	40.20	9.93	11.25	11.34	10.21
a_2	b_1	3.14	3.03	20.89	20.25	58.26	56.86	38.73	39.20	10.60	10.30	9.89	9.10
	b_2	3.32	3.18	22.97	22.26	67.82	65.01	41.39	40.00	10.38	10.43	11.30	10.17
	b_3	3.40	3.28	22.51	22.22	67.44	64.84	39.85	40.10	11.87	11.16	11.17	10.06
	b_4	3.19	3.10	21.30	22.63	60.50	57.17	40.77	40.00	11.30	10.44	10.11	9.24
a_3	b_1	3.11	3.02	20.53	19.90	60.73	57.00	39.62	39.30	10.11	10.86	10.24	9.20
	b_2	3.53	3.39	23.56	22.89	70.11	67.52	40.57	39.60	11.90	11.31	11.75	10.50
	b_3	3.48	3.33	23.65	23.28	72.50	69.94	39.30	40.00	10.51	11.16	12.37	11.08
	b_4	3.18	3.10	22.29	21.60	67.96	66.90	40.30	39.80	10.69	10.76	11.57	10.37
LSD at 5%		0.12	0.11	1.15	1.20	2.15	2.33	NS	NS	NS	NS	0.51	0.40

E-Fiber quality:

The results in Table 3 showed that the times of foliar application and rates of bentonite as well as their interactions had insignificant effect on fiber strength (Pressley units) and micronaire reading in both seasons.

CONCLUSION

Generally, it can be concluded that foliar application with 3kg bentonite/fed twice (at squaring stage and at flowering initiation) had a positive effect on chemical composition, growth, boll setting and productivity of Egyptian cotton (Giza 86 cultivar), under the conditions of El-Gemmeiza location.

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. (1975): American Society for Testing and Materials. Standard on textile materials (D1448-59) and (D1445-67). The Society, Washington, Philladelphia, U.S.A.

Basal, H.; J.K. Hemphill and C.W. Smith (2006). Shoot and root characteristics of converted race stocks accessions of upland cotton (Gossypium hirsutum L.) grown under salt stress conditions. Am. J. Plant Physiol., 1: 99-106.

Cakmak, I. (2005). Role of mineral nutrients in tolerance of crop plants to environmental stress factors. Int. symposium on Fertigation, Beijing / China, 20-24 September 2005, pp: 35 – 44.

Chapman, H.D. and P.P. Pratt (1978). Methods of analysis for soils, plants and water. Univ. of California, Div. of Agne. Sci. Priced Publ. 4034.

Costa, A.C.S.; J.M. Bigham; C.A. Tormena and J.C. Pintro (2004). Clay mineralogy and cation exchange capacity of Brazilian soils from water contents determined by thermal analysis. Thermochimica Acta, 413: 73-79.

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

Jones, I.B.; B. Wolf and H.A. Milles (1991). Plant analysis handbook. Micro-Macro
Publishing Inc., pp: 213.

Hausman, J.F.;S.Lutts and G. G.M. Luyckx(2017). Silicon and plants: current knowledge and technological perspectives. Front Plant Sci. 8: 411.

Iskander, A.L.; E.M. Khald and A.S.Sheta (2011), Zinc and manganese sorption behavior by natural zeolite and bentonite, Annals of Agric. Sci. 56, 43-48.

Kojić, D.; S. Pajević; A. Jovanović-Galović; J. Purać, E. Pamer; S. Škondrić; S. Milovac; Ž. Popović and G. Grubor-Lajšić (2012).Efficacy of natural aluminosilicates in moderating drought effects on the morphological and physiological parameters of maize plants (Zea mays L.) J. Soil Sci. Plant Nutr. 12 (1). Temuco 2012**.**

El Midaoui M., M. Benbella, A. AïtHoussa, M. Ibriz and A. Talouizte (2007). Contribution to study of some mechanisms salinity adaptation sunflower grown (Helianthus annus L.). Rev. HTE N° 136, pp.29-34.

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

Marschner, H. (1995). Functions of mineral nutrients: Macronutrients. In: Mineral Nutrition of Higher Plants 2 Edition, H. Marschner (Ed.). Academicnd Press, N.Y, pp: 299-312.

Marisa, B.M.M.; Paulor, A.P.P.; Alberto, C.C.B.; Nelio, V.; Milton, G.A.M.R.; Marcelo, B.F.; Helion, G.S., Helio S.A., and DE, S.B. Fernando (2009). Nutrient release by a Brazilian sedimentary zeolite. An Acad Bras Cienc, 81 (4) ISSN 0001-3765.

Page, A.L.; R.H. Miller and D.R. Keeney (1982). "Methods of soil analysis". Part 2: Chemical and microbiological properties. Amer. Soc. Agron., Madison, Wisconsin.

Radkowski, A.; I. Radkowska and T. Lemek (2015). Effects of foliar application of titanium on seed yield in timothy (Phleum pratense L.). Ecol Chem Eng S. ,22(4):691-701.

Reddya, AR.; K. V. Chaitanya and M. Vivekanandanb (2004). Drought induced responses of photosynthesis and antioxidant metabolism in higher plants. J. Pl. Physiol. 161:1189-1202.

Shukdeb, S. (2010). S-Nitrosylation Process Acts as a Regulatory Switch for Seed Germination in Wheat. American Journal of Plant Physiology, 5: 122-132.

Sitthaphanit,S.; W. Richard and V. Limpinuntan (2010). Effect of clay amendments on nitrogen leaching and forms in a sandy soil. World Congress of Soil Sci.

Snedecor, G.W. and W.G. Cochran. (1980). Statistical Methods. 6th Ed. Iowa State Univ., U.S.A. pp: 225 - 269.

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.

تأثير الرش بالبنتونيت على نمو وانتاجية القطن المصرى

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أجريت تجربتان حقليتان فى أرض طينية بمحطة البحوث الزراعية بالجميزة-مركز البحوث الزراعية- محافظة الغربية خلال موسمى٢٠١٦ و٢٠١٧م لدراسة تأثير الرش الورقى بالبنتونيت على التركيب الكيماوى لأوراق القطن،النمو، التبكير ،المحصول ومكوناته وجودة التيلة للقطن جيزة ٨٦.تم استخدام تصميم القطع المنشقة فى ثلاث مكررات حيث اشتملت القطع الرئيسية على ثلاث فترات للرش(فى مرحلة الوسواس +عند بداية التزهير، عند بداية التزهير +عند قمة التزهير، فى مرحلة الوسواس +عند بداية التزهير+عند قمة التزهير)واحتوت القطع الشقية على أربعة معدلات من البنتونيت(كنترول،٢كجم،٣كجم،٤كجم بنتونيت/الفدان).ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي:أعطى توقيت المعاملة بالبنتونيت تأثيرا معنويا على محتوى الأوراق من النيتروجين،الفوسفور،البوتاسيوم ،كلوروفيل أ،كلوروفيل ب ،الكلوروفيل الكلى، الكاروتينيدات فى الموسمين لصالح الرش الورقى ثلاث مرات (فى مرحلة الوسواس ،عند بداية التزهير،عند قمة التزهير). زاد محتوى الأوراق من النيتروجين،الفوسفور،البوتاسيوم ،كلوروفيل أ،كلوروفيل ب ،الكلوروفيل الكلى، الكاروتينيدات زيادة معنوية بالرش الورقى بالبنتونيت عند معدل٣كجم للفدان مقارنة مع المعدلات الاخرى.أعطى التفاعل بين توقيت المعاملة ومعدل البنتونيتت تأثيرا معنويا على محتوى الأوراق من كلوروفيل أ،كلوروفيل ب ،الكلوروفيل الكلى، الكاروتينيدات فى الموسمين لصالح الرش الورقى ثلاث مرات (فى مرحلة الوسواس ،عند بداية التزهير،عند قمة التزهير) للبنتونيت بمعدل ٣كجم للفدان بينما محتوى الأوراق من النيتروجين،الفوسفور،البوتاسيوم لم يتأثر معنويا بهذا التفاعل .لم يؤثر توقيت المعاملة بالبنتونيت على طول النبات عند الحصاد وعدد الافرع الثمرية/النبات فى الموسمين.اعطى البنتونيت عند المعدل٢كجم/الفدان زيادة معنوية لطول النبات عند الحصاد وعدد الافرع الثمرية/النبات فى الموسمين مقارنة بالمعدلات الأخرى. اعطى التفاعل تأثيرا معنويا على طول النبات عند الحصاد وعدد الافرع الثمرية/النبات فى الموسم الأول فقط حيث أعلى القيم تم الحصول عليها من الرش الورقى بالبنتونيت عند المعدل٢كجم/الفدان ثلاث مرات بينما اقل القيم تم الحصول عليها من الرش الورقى بالبنتونيت عند المعدل٤كجم/الفدان ثلاث مرات لم يؤثر توقيت المعاملة بالبنتونيت على صفات التبكير(عدد الازهار الكلية / نبات ، عدد اللوز الكلى / نبات، النسبة المئوية لعقد اللوز، النسبة المئوية لتساقط اللوز) فى الموسمين.أدت المعاملة بالبنتونيت عند المعدل٢كجم/الفدان والمعدل ٣كجم/الفدان الى زيادة معنوية لصفات التبكير(عدد الازهار الكلية / نبات ، عدد اللوز الكلى / نبات، النسبة المئوية لعقد اللوز) والى نقص معنوى فى النسبة المئوية لتساقط اللوزبدون فرق معنوى بين المعدلين وذلك مقارنة بالمعدل العالى (٤كجم بنتونيت/الفدان) ومعاملة الكنترول.أعطى التفاعل بين توقيت المعاملة ومعدل البنتونيتت تأثيرا معنويا على صفات التبكير(عدد الازهار الكلية / نبات ، عدد اللوز الكلى / نبات، النسبة المئوية لعقد اللوز، النسبة المئوية لتساقط اللوز) فى الموسمين حيث أعلى القيم من عدد الازهار الكلية / نبات ، عدد اللوز الكلى / نبات، النسبة المئوية لعقد اللوز وأقل قيمة من النسبة المئوية لتساقط اللوز تم الحصول عليها من الرش الورقى بالبنتونيت عند المعدل٢كجم/الفدان أوالمعدل ٣كجم/الفدان مرتين او ثلاث مرات وذلك مقارنة بمعاملة الكنترول وبالرش الورقى بالبنتونيت بالمعدل العالى (٤كجم بنتونيت/الفدان) مرتين او ثلاث مرات . أعطى توقيت المعاملة بالبنتونيت مرتين (فى مرحلة الوسواس ،عند بداية التزهير) او ثلاث مرات (فى مرحلة الوسواس ،عند بداية التزهير،عند قمة التزهير) زيادة معنوية فى عدد اللوز المتفتح / نبات ،وزن اللوزة، محصول القطن الزهر للنبات، محصول القطن الزهر للفدان فى الموسمين مقارنة بالمعاملة بالبنتونيت مرتين (عند بداية التزهير ، عند قمة التزهير) بينما لم تتاثرصفات معامل البذرة والنسبة المئوية للتيلة بتوقيت المعاملة فى الموسمين.أدت المعاملة بالبنتونيت عند المعدل٢كجم/الفدان أوالمعدل ٣كجم/الفدان الى زيادة معنوية فى وزن اللوزة، معامل البذرة ،محصول القطن الزهر للنبات، محصول القطن الزهر للفدان فى الموسمين وذلك مقارنة بمعاملة الكنترول وبالرش الورقى بالبنتونيت بالمعدل العالى (٤كجم بنتونيت/الفدان). أعطى التفاعل بين توقيت المعاملة ومعدل البنتونيتت تأثيرا معنويا على وزن اللوزة ،محصول القطن الزهر للنبات، محصول القطن الزهر للفدان لصالح الرش الورقى للبنتونيت بمعدل٢ كجم أو ٣كجم للفدان مرتين (فى مرحلة الوسواس ،عند بداية التزهير) او ثلاث مرات (فى مرحلة الوسواس ،عند بداية التزهير،عند قمة التزهير) بينما لم تتاثرصفات معامل البذرة والنسبة المئوية للتيلة بهذا التفاعل فى الموسمين.لم يعطى توقيت المعاملة ومعدل البنتونيتت والتفاعل بينهما اى تاثير معنوى على متانة التيلة وقراءة الميكرونير فى الموسمين.التوصية: يمكن التوصية بالمعاملة بالبنتونيت كرش ورقى بمعدل ٣كجم/الفدان مرتين (فى مرحلة الوسواس ،عند بداية التزهير) حيث تعطى هذه المعاملة تأثيرأ معنويا ايجابيا على التركيب الكيماوى للاوراق والنمو والعقد مما يؤدى الى انتاجية عالية للقطن المصرى جيزة ٨٦تحت ظروف منطقة الجميزة.