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The Possibility of using Feldspar as Alernative Potassium for Cotton Fertilization Combined with Silicate Dissolving Bacteria, Humic Acids and Farmyard Manure and its Effect on Soil Properties

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ABSTRACT

Two field experiments were preformed at the Experimental Farm of Sids Agricultural Reseasrch Station, ARC, Beni-Suef Governorate, Egypt to study the possibility of using feldspar as potassium source along with some bio-stimulants namely, silicate dissolving bacteria (SDB), humic acids and farmyard manure and its effect on cotton productivity and soil properties after harvest. The results indicate that added 400 kg feldspar/feddan, 10 kg humic acid or 10 m^3 FYM/feddan improved plant height, number of fruiting branches/plant, number of open bolls/plant, boll weight, seed cotton yield, earliness%, seed index and leaf chemical contents, i.e.; N, P and K%, chlorophyll A and/or B as well as soil available N and K. Feldspar increased the soil available N and K, while FYM or humic acid improved soil pH, O.M, soil available N, P and K. On the other hand, soil salinity was increased as FYM application. The results of the interaction between treatments show that the best results were found when cotton plants were treated with 400 kg feldspar/feddan + 10 m^3 FYM/feddan or 10 kg humic acid/feddan in combined with silicate dissolving bacteria. Furthermore, the effect of SDB on cotton productivity is more pronounced when combined with feldspar, FYM or humic acids

Keywords: Cotton, growth, yield and its components, leaf chemical contents, soil properties

INTRODUCTION

In Egypt, it should be used large amount of K-chemical fertilizers to maximize crop yield per unit area and to compensate K-decreases in soils due to crop uptake, runoff, leaching and soil erosion (Shams and Fekry, 2014). Also, the high price of these fertilizers is responsible for increasing production cost and environmental pollution. The use of natural potassium fertilizer and/or bio-fertilizer is low cost resources for providing plants with K which could alternate the expensive applied K-chemical fertilizers (Manning, 2010 and Labib *et al*., 2012). The main natural sources of K come from the weathering of minerals (K-feldspar, leuctie, K-mica and illite (Hellal *et al*., 2009). Many authors reported that K-feldspar may be valuable as a low releasing K and cheaper source of potassium (Shafeek *et al*., 2005; Abou-el-Seoud and Abdel-Mageed, 2012).

Microorganisms play a key role in natural K cycle. Some species of rhizobacteria are capable of mobilizing potassium in accessible form in soil. There are considerable population of K solubilizing bacteria (KSB) in soil and rhizosphere (Vessey, 2003 and Dawwam *et al*., 2013). Similarly, KSB are able to solubilize rock K mineral powder, through production and excertion of organic acids (Friedrich *et al*., 1991 and Ullman *et al*., 1996). In this concern, Liu *et al*. (2006) demonstrated that polysaccharides adsorbed the organic acids and attached to surface of the mineral, resulting in an area of high concentration of organic acids near the mineral.

Organic manures can play an important role in sustaining the productivity by not only acting a source of nutrients but also, through modifying soil physical behavior as well as increasing the efficiency of applied nutrients (Reddy and Aruna, 2008). Farmyard manure has always been an important organic source of nutrients due its significant influence in increasing yield through its positive effects on physical, chemical and biological properties of soil (Badugu, 2012). Moreover, Mohanty *et al*. (2006) mentioned that the organic materials play an important role to enhance the physical properties of soil, such as bulk density, improve microbial activities, water absorption and nutrient availability to plant.

Humic acids are characterized as a heterogeneous natural resource, ranging in colour from yellow to black, having high molecular weight, and resistance to decay (Ismail *et al*., 2016). Humic acid as a commercial product contains 44–58% carbon (C), 42–46% oxygen (O), 6–8% hydrogen (H), and 0.5–4% nitrogen (N) as well as many mineral elements (Larcher, 2003). It mainly produced from nitrogenous compounds containing decomposed amino acids and organic complex (Andriess, 1988). Those organic complexes affect soil properties and physiological properties of plants due to carboxyl ($COOH^-$) and phenolic (OH^-) groups (Schnitzer, 1992). It enhances plant growth by chelating unavailable nutrients and buffering pH (Tahir *et al*., 2011). Many workes stated that humic acids increase the uptake of mineral elements (Khaled and Fawzy, 2011), promote root length (Akinic *et al*., 2009).

The objective of this investigation is to evaluate the effect of bio-stumulants, such as FYM, humic acids and silicate dissolving bacteria on cotton productivity as well as its effect on solubility of natural potassium fertilizer, i.e., feldspar and in turn on cotton growth.

MATERIALS AND METHODS

Two-year study was carried out at the Agricultural Farm of Sids Agricultural Research Station, ARC, Beni-Suef Governorate, Egypt during 2016 and 2017 seasons. The soil was clay in texture, having 7.9 and 8.0; 1.20 and 1.13; 2.1 and 2.5% as well as 21 and 19.5; 11.3 and 10.5, and 170 and 180 ppm pH, EC, soil organic matter as well as soil available N, P and K in the two seasons, respectively (according to Page, 1982). The experiment was laid out in split pot design in completely randomized block, comprising two factors, feldspar level, i.e., 0.0 and 400 kg/feddan and four bio-stimulants, namely, 0.0, silicate dissolving bacteria, humic acids (potassium humate) and farmyard manure. The feldspar treatments were laid out in main plot and bio-stimulants were set up in sub plot. The experiment aimed to study the bossibility of using the natural potassium fertilizer under some bio-stimulants on growth, yield and yield components and some leaf chemical content of cotton plant as well as some soil properties after harvest. The farmyard manure used in the experiment was chemically analysed according to Klute (1986) and the results are listed in Table 1.

Cotton seeds, variety Giza 95 [Tri-hybrid (Giza 83 x (Giza 75 x line 5844) x Giza 80] Egyptian cotton variety (Gossypium barbadense L.) obtained from Cotton Research Institute were sowin on 4th and 5th April in the two seasons, respectively.

K-feldspar powder contains about 10.5% K2O and humic acids (10 kg/feddan) were added to soil before planting during land preparation. Whereas, silicate dissolving bacteria (*Bacillus circulans*) was supplied by Micro. Dept., Soil, Water and Environment, ARC, Egypt and inoculated the cotton seed directly before sowing. Other cultural practices of growing cotton were carried out as commonly followed in the district.

Table 1. Some chemical content of farmyard manure used in the experiment.

Characteristic	Seasons 2016	Seasons 2017
pH*	7.7	7.8
EC(dS m^{-1})**	4.5	4.6
Organic carbon (%)	28.90	26.71
Organic matter (%)	49.83	46.05
Total N%	1.55	1.51
Total P%	0.34	0.37
Total K%	1.32	1.46
C/N ratio	1:18	1:17

***pH was measured in a soil-water suspension (Ratio 1:2.5).**
****EC= Electrical conductivity was measured in a manure-water extract (Ratio 1:5).**

Representive leaves sample from each plot was taken randomly from the top fourth node leaves, 15 days after full flowering stage to determine N, P and K concentration (according to Chapman and Pratt, 1961); chlorophyll A and B (according to Arnon, 1949). Also, in both seasons, ten representative plants were randomly taken from each plot to determine: plant height (cm), number of fruiting branches/plant, number of open bolls/plant, boll weight (g), 100-seed weight (g), earliness percentage, limt percentage, and seed cotton yield (kentar/feddan). After harvest, surface soil samples (0.0-30 cm) were taken to determine soil properties, i.e., pH, EC, O.M and soil available N, P and K according the method described by Klute (1986).

The obtained data were subjected to proper analysis according to methods of Snedecor and Cochran (1980). The least significant differences (L.S.D.) at significance of 0.05 level was used to verify the significance of differences between treatments.

RESULTS

1- Growth and yield and its components

The data given in Table 2 represent the response of plant height, number of fruiting branches, number of open bolls/plant, boll weight and seed cotton yield to feldspar application along with some bio-stimulants. The data clearly show that added 400 kg feldspar/feddan was significantly increased plant height, number of fruiting branches, number of open bolls, boll weight and seed cotton yield in both seasons. The relative increasing in these triats caused by 400 kg feldspar/feddan over without feldspar reached to 0.6, 2.5, 12.4, 4.7 and 14.5% in the first season, respectively. Similar trends were obtained in the second season.

Table 2. Effect of feldspar under some bio-stimulants on growth and yield and its components of cotton plants.

Feldspar	Bio-stimulants	Plant height (cm) 2016	Plant height (cm) 2017	No. of fruiting brances/plant 2016	No. of fruiting brances/plant 2017	No. of open bolls/plant 2016	No. of open bolls/plant 2017	Boll eight (g) 2016	Boll eight (g) 2017	Seed cotton yield (ken/fed.) 2016	Seed cotton yield (ken/fed.) 2017
0.0	0.0	123.7	123.0	15.3	15.2	17.5	17.7	2.81	2.97	9.73	10.96
	S. D. B	123.8	123.1	15.3	15.2	17.4	17.7	2.82	2.96	9.74	10.94
	10 kg/fed. humic acid	124.6	124.2	15.6	15.4	18.2	18.4	3.06	3.08	10.40	11.73
	10 kg humic/fed+S. D. B.	124.5	124.2	15.6	15.4	18.2	18.3	3.07	3.07	10.40	11.73
	10 m3/fed. FYM	125.9	125.6	15.9	15.8	19.9	20.1	3.09	3.11	11.49	12.12
	10 m3 FYM/fed+ S. D. B.	126.1	126.0	16.3	16.1	20.2	20.4	3.10	3.13	11.55	12.74
Mean		124.8	124.4	15.7	15.5	18.6	18.8	2.99	3.05	10.55	11.62
400 kg/fed	0.0	124.1	123.8	15.5	15.3	20.1	20.4	3.00	3.08	11.64	12.40
	S. D. B	124.9	124.2	15.8	15.6	20.4	20.8	3.05	3.12	11.73	12.45
	10 kg/fed. humic acid	125.3	125.0	16.0	15.9	20.7	21.1	3.11	3.14	11.79	12.61
	10 kg humic/fed+S. D. B.	125.7	125.3	16.3	16.1	20.9	21.4	3.16	3.19	11.86	12.83
	10 m3/fed. FYM	126.4	126.1	16.2	16.0	21.4	21.7	3.20	3.24	12.12	13.21
	10 m3 FYM/fed+ S. D. B.	126.8	126.5	16.7	16.4	21.7	22.0	3.23	3.27	12.32	13.71
Mean		125.5	125.2	16.1	15.9	20.9	21.2	3.13	3.17	12.08	12.87
Mean of bio-stimulants	0.0	123.9	123.4	15.4	15.3	18.8	19.05	2.91	3.03	10.69	11.68
	S. D. B	124.4	123.7	15.6	15.4	18.9	19.25	2.94	3.04	10.74	11.70
	10 kg/fed. humic acid	125.0	124.6	15.8	15.7	19.5	19.75	3.09	3.11	11.10	12.17
	10 kg humic/fed+S. D. B.	125.1	124.8	16.0	15.8	19.6	19.85	3.12	3.13	11.13	12.28
	10 m3/fed. FYM	126.2	125.9	16.1	15.9	20.7	20.90	3.15	3.18	11.81	12.67
	10 m3 FYM/fed+ S. D. B.	126.5	126.3	16.5	16.3	21.0	21.20	3.17	3.20	12.44	12.98
L. S. D. at 5%											
(A)		0.09	0.08	0.05	0.05	0.07	0.07	0.02	0.01	0.03	0.02
(B)		0.08	0.08	0.04	0.05	0.07	0.06	0.02	0.01	0.03	0.02
(A x B)		0.12	0.13	0.09	0.08	0.10	0.11	0.06	0.03	0.05	0.04

As for the bio-stimulants effect, the results indicate that all studied triats were significantly affected by the used bio-stimulants comparing with without treated. It could be arranged the effect of bio-stimulants on growth and yield and its components in the descending order as follow: 10 m3/feddan FYM + SDB > 10 m3/feddan FYM > 10 kg humic acids + SDB > 10 kg/feddan humic acids > SDB > without bio-stimulants. It is obvious to notice that biofertilizer (SDB) enhanced the effect of humic acid and FYM application on seed cotton yield by about 0.3 and 5.3% in the first season, respectively. Same trends were obtained in the second season.

Regarding the interaction effect, the data reveal that all studied parameters were responded to the interaction between feldspar and bio-stimulant treatments in both seasons, where in absence of feldspar, silicate dissolving bacteria application did not affect growth and yield and its components of cotton whether added alone or in combined with humic acids. On the other hand, in presence of feldspar, SDB had a promotive effect of cotton growth and yield and its components in case of application alone or in combined with humic acids or FYM. This means that the effectiveness of SDB is mainly refer to solubilizing feldspar and organic fertilizer. In general, from results of the interaction, the highest values of plant height, number of fruiting branches/plant, number of open bolls/plant, boll weight and seed cotton yield were produced for plants supplied with 400 kg feldspar/feddan, 10 m^3 FYM/feddan and inoculated with silicate dissolving bacteria. Whereas, the plants without feldspar and bio-stimulants recorded the lowest studied growth and yield and its components of cotton.

Earliness %, seed index, lint% and some fiber properties:

The data of the effect of feldspar and some bio-stimulants on earliness%, seed index, lint% and some fiber properties, i.e., Micronair reading and Pressely index are given in Table 3. The obtained results show that earliness and seed index was only responded to the studied treatments, while lint% and fiber propertied did not affect in both seasons. The main effect of feldspar application indicate that added 400 kg/feddan feldspar enhanced the percentage of the first picking to seed cotton yield and 100-seed weight over without feldspar by about 2.0 and 3.9% in the first season, respectively. The corresponding increasing in the second season were 1.1 and 2.6% in the abovrmentioned order.

Table 3. Effect of feldspar under some bio-stimulants on earliss%, seed index, lint% and fiber properties.

Feldspar	Bio-stimulants	Earliness (%)		Seed index (g)		Lint (%)		Micronair reading		Pressly index	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
0.0	0.0	74.20	75.11	9.98	10.79	38.91	38.79	4.7	4.6	8.4	8.6
	S. D. B	74.25	75.23	9.97	10.78	38.82	38.80	4.7	4.6	8.3	8.5
	10 kg/fed. humic acid	77.40	78.19	10.04	10.90	38.83	38.81	4.6	4.5	8.3	8.4
	10 kg humic/fed+S. D. B.	77.43	78.20	10.07	10.94	38.90	38.79	4.5	4.5	8.4	8.5
	10 m3/fed. FYM	79.11	80.25	10.26	11.12	38.87	38.80	4.7	4.7	8.4	8.5
	10 m3 FYM/fed+ S. D. B.	80.24	82.00	10.30	11.23	28.90	38.80	4.6	4.6	8.5	8.6
Mean		77.11	78.16	10.10	10.96	38.87	38.80	4.6	4.6	8.4	8.5
400 kg/fed.	0.0	75.81	76.21	10.12	10.97	38.85	38.83	4.5	4.6	8.6	8.7
	S. D. B	76.90	77.23	10.31	11.05	38.86	38.85	4.5	4.5	8.6	8.7
	10 kg/fed. humic acid	78.13	78.45	10.45	11.13	38.81	38.81	4.6	4.5	8.6	8.8
	10 kg humic/fed+S. D. B.	79.03	79.36	10.54	11.25	38.83	38.79	4.6	4.5	8.7	8.8
	10 m3/fed. FYM	80.35	80.78	10.66	11.46	38.79	38.86	4.7	4.6	8.7	8.6
	10 m3 FYM/fed+ S. D. B.	81.61	81.96	10.83	11.60	38.85	38.82	4.6	4.6	8.6	8.6
Mean		78.64	79.00	10.49	11.24	38.83	38.83	4.6	4.6	8.6	8.7
Mean of bio-stimulants	0.0	75.01	75.66	10.05	10.88	38.88	38.81	4.6	4.6	8.5	8.7
	S. D. B	75.58	76.23	10.14	10.92	38.84	38.83	4.6	4.6	8.5	8.6
	10 kg/fed. humic acid	77.77	78.23	10.25	11.02	38.82	38.81	4.6	4.5	8.5	8.6
	10 kg humic/fed+S. D. B.	78.23	78.78	10.31	11.10	38.87	38.79	4.6	4.5	8.6	8.7
	10 m3/fed. FYM	79.73	80.52	10.45	11.29	38.83	38.83	4.7	4.7	8.6	8.6
	10 m3 FYM/fed+ S. D. B.	80.93	81.98	10.57	11.42	38.88	38.81	4.6	4.6	8.6	8.6
L. S. D. at 5%											
(A)		0.13	0.14	0.11	0.12	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.
(B)		0.12	0.10	0.10	0.09	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.
(A x B)		0.14	0.15	0.14	0.13	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.

Concerning the bio-stimulants effect, the data show that earliness % and seed index were significantly affected by the studied bio-stimulants. Whereas, lint%, Micronair reading and Pressly index did not respond to bio-stimulants treatments. It could be arranged the effect of the studied bio-stimulants on earliness% and 100-seed weight in the descending order as follow: FYM+SDB > FYM > humic acids +SDB > humic acids > SDB > without bio-stimulants. Mixed SDB with FYM or humic acids enhanced its effect on earliness% and seed index by about 1.5 and 1.1% in the first season and 1.8 and 1.2% in the second one.

With regard to the interaction, the data indicate that, only earliness% and seed index were significantly affected by the interaction between the two studied factors. Silicate dissolving bacteria affected earliness% and seed index only under 400 kg feldspar/feddan, which means that the promotive effect of SDB on these traits is only due to its effect on releasing potassium from the natural rock feldspar.

Leaf chemical contents

Results in Table 4 show the response of some chemical contents of leaf at 15 days after flowering stage to feldspar and some bio-stimulants. The results reveal that feldspar application had a positive effect on the studied leaf chemical contents, except phosphorus content, which did not affect. Added 400 kg/feddan feldspar increased N%, K%, chlorophyll A and/or chlorophyll B over without feldspar by about 6.2, 13.9, 7.0, 13.9 and 10.0%, respectively in the first season. Same trends were obtained in second season.

Table 4. Effect of feldspar under some bio-stimulants on some leaf chemical contents.

Feldspar	Bio-stimulants	N (%)		P (%)		K (%)		Chlorophyll A (mg/g dry.w.)		Chlorophyll B (mg/g dry.w.)		Chlorophyll A + B (mg/g dry.w.)	
		2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
0.0	0.0	2.63	2.60	0.76	0.78	2.75	2.73	3.11	3.13	2.34	2.35	5.45	5.48
	S. D. B	2.63	2.61	0.75	0.77	2.75	2.73	3.11	3.12	2.35	2.35	5.46	5.47
	10 kg/fed. humic acid	2.79	2.73	0.87	0.86	2.92	2.90	3.15	3.16	2.43	2.44	5.58	5.60
	10 kg humic/fed+S. D. B.	2.79	2.73	0.87	0.86	2.98	2.96	3.15	3.16	2.48	2.49	5.63	5.65
	10 m3/fed. FYM	2.83	2.80	0.92	0.90	3.14	3.13	3.17	3.19	2.53	2.53	5.70	5.72
	10 m3 FYM/fed+ S. D. B.	2.89	2.84	0.99	0.94	3.20	3.19	3.20	3.21	2.56	2.57	5.76	5.78
Mean		2.75	2.71	0.86	0.85	2.96	2.94	3.15	3.16	2.45	2.46	5.60	5.62
400 kg/fed.	0.0	2.74	2.71	0.76	0.78	3.22	3.20	3.21	3.22	2.66	2.67	5.87	5.89
	S. D. B	2.75	2.71	0.76	0.79	3.30	3.28	3.28	3.29	2.75	2.76	6.03	6.05
	10 kg/fed. humic acid	2.81	2.80	0.88	0.89	3.33	3.32	3.24	3.24	2.77	2.76	6.11	6.00
	10 kg humic/fed+S. D. B.	2.89	2.85	0.89	0.90	3.37	3.35	3.39	3.39	2.79	2.80	6.18	6.19
	10 m3/fed. FYM	3.12	3.10	0.93	0.94	3.44	3.43	3.46	3.46	2.85	2.85	6.31	6.31
	10 m3 FYM/fed+S. D. B.	3.22	3.21	0.98	0.97	3.53	3.51	3.51	3.50	2.89	2.89	6.40	6.45
Mean		2.92	2.89	0.87	0.87	3.37	3.24	3.37	3.35	2.79	2.78	6.16	6.14
Mean of bio-stimulants	0.0	2.69	2.63	0.76	0.77	2.99	2.98	3.16	3.17	2.50	2.51	5.66	5.69
	S. D. B	2.69	2.63	0.76	0.78	3.03	3.01	3.20	3.21	2.55	2.55	5.75	5.76
	10 kg/fed. humic acid	2.80	2.75	0.88	0.88	3.13	3.11	3.25	3.27	2.60	2.61	5.85	5.80
	10 kg humic/fed+S. D. B.	2.84	2.79	0.88	0.89	3.18	3.16	3.27	3.27	2.64	2.65	5.91	5.92
	10 m3/fed. FYM	2.98	2.93	0.93	0.94	3.29	3.27	3.32	3.32	2.69	2.70	6.01	6.02
	10 m3 FYM/fed+ S. D. B.	3.06	3.00	0.99	0.99	3.37	3.26	3.36	3.37	2.73	2.73	6.08	6.12
L. S. D. at 5%													
(A)		0.03	0.03	N. S.	N. S.	0.04	0.03	0.04	0.04	0.04	0.04	0.06	0.07
(B)		0.04	0.03	0.02	0.02	0.04	0.03	0.03	0.03	0.04	0.03	0.06	0.06
(A x B)		0.08	0.07	0.06	0.07	0.07	0.06	0.05	0.06	0.05	0.06	0.08	0.09

Put the bio-stimulants in consideration, the results reveal that all studied leaf chemical contents were significantly affected by the bio-stimulants used in the experiment. It could be arranged its effects as the descending order as follow: FYM + SDB > FYM > humic acids + SDB > humic acids > SDB > without bio-stimulants. It is obvious to notice that the effect of SDB is more pronounced when combined with humic acids or FYM. Mixed FYM with SDB gave the highest leaf chemical contents, namely, N%, P%, K%, chlorophyll A and/or B, which surpassad that without bio-stimulants by about 13.8, 30.3, 12.7, 6.3, 9.2 and 7.4%, respectively in the first season. The corresponding values in the second season were 14.1, 28.6, 9.4, 6.3, 8.8% and 7.6% in the abovementioned respect.

As for the interaction between treatments, the results indicate that leaf chemical contents were significantly affected by the interaction between the two factors. In general, silicate dissolving bacteria did not effect these triats under without feldspar. The highest values of leaf chemical contents were obtained for plants fertilized with 400 kg feldspar/feddan + 10 m^3 FYM/feddan and treated with SDB. On the other hand, the plants without feldspar and without bio-stimulants, recorded the lowest leaf chemical contents.

Soil properties

The data in Table 5 represent the effect of feldspar application and some bio-stimulants on some soil properties after harvest cotton plants. The results clearly reveal that feldspar application did not effect all studied soil properties, except soil available nitrogen and potassium. Logically, added 400 kg feldspar/feddan had a positive effect of the residual potassium in soil after harvest. The relative increasing in soil available N and K due to feldspar treatment reached to 1.6 and 30.7 % when compared to without feldspar treatment in the first season, respectively. Same trends were obtained in the second season.

Regarding the effect of bio-stimulants, the results show that soil reaction and organic matter after harvest were significantly improved due to FYM application, except soil salinity which increased by FYM application, which mainly due to relatively high salinity content in FYM used (Table 1). On the other hand, soil available N, P and K after harvest were significantly affected by humic acids and farmyard manure application. It is obvious to mention that silicate dissolving bacteria did not affect the soil properties after harvest in both seasons.

Concerning the effect of the interaction between feldspar and bio-stimulant treatments, the obtained dat clearly show that soil available N and K were significantly affected by the interaction between treatments, while other soil properties did not affect. Silicate dissolving bacteria enhanced the effect of FYM under feldspar fertilization on the availability of nitrogen and potassium. Application of FYM with or without feldspar or SDB gave the best pH and greatest EC, O.M and soil available P. Moreover, the highest values of soil available N and K were recorded for plants treated with feldspar + FYM + SDB. On the other hand, the plants without both feldspar and bio-stimulants gave the lowest values of EC, O.M%, N, P and K as well as higher pH values in both seasons.

Table 5. Effect of feldspar under some bio-stimulants on some soil properties after harvest.

Feldspar	Bio-stimulants	pH		E.C (dS m^{-1})		O.M %		Soil available nutrients (ppm) N		P		K	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
0.0	0.0	7.93	8.01	1.21	1.15	2.23	2.67	22.3	20.5	11.0	10.6	173	186
	S. D. B	7.94	8.01	1.22	1.16	2.24	2.67	22.5	22.4	11.1	10.7	186	191
	10 kg/fed. humic acid	7.90	7.96	1.22	1.15	2.26	2.70	24.3	24.0	14.2	14.9	191	199
	10 kg humic/fed+S.D. B.	7.90	7.96	1.22	1.16	2.26	2.71	24.4	24.1	14.3	15.0	195	210
	10 m3/fed. FYM	7.83	7.91	1.53	1.60	2.53	2.95	30.7	30.1	20.4	21.3	210	219
	10 m3 FYM/fed+S. D. B.	7.83	7.91	1.53	1.61	2.53	2.96	30.6	30.2	20.5	21.4	216	226
Mean		7.89	7.96	1.32	1.31	2.34	2.78	25.8	25.2	15.3	15.7	195	205
400 kg/fed.	0.0	7.93	8.1	1.21	1.15	2.23	2.67	22.3	22.5	11.1	10.7	210	215
	S. D. B	7.94	8.1	1.22	1.15	2.23	2.68	22.4	22.4	11.0	10.7	240	250
	10 kg/fed. humic acid	7.90	7.96	1.22	1.15	2.27	2.70	24.4	24.0	14.3	15.0	252	260
	10 kg humic/fed+S.D. B.	7.90	7.96	1.22	1.16	2.27	2.71	24.5	24.1	14.4	15.1	258	266
	10 m3/fed. FYM	7.82	7.91	1.54	1.61	2.54	2.95	30.7	30.1	20.5	21.4	271	280
	10 m3 FYM/fed+S. D. B.	7.84	7.91	1.53	1.61	2.54	2.96	32.8	33.2	20.4	21.5	285	290
Mean		7.89	7.96	1.32	1.31	2.35	2.78	26.2	25.9	15.3	15.7	253	260
Mean of bio-stimulants	0.0	7.93	8.01	1.21	1.15	2.23	2.67	22.3	20.5	11.1	10.7	192	201
	S. D. B	7.94	8.01	1.22	1.16	2.24	2.68	22.5	22.4	11.1	10.7	213	221
	10 kg/fed. humic acid	7.90	7.96	1.22	1.15	2.27	2.70	24.4	24.0	14.3	15.0	222	230
	10 kg humic/fed+S.D. B.	7.90	7.96	1.22	1.16	2.27	2.71	24.5	24.1	14.4	15.1	227	238
	10 m3/fed. FYM	7.83	7.91	1.54	1.61	2.54	2.95	30.7	30.2	20.5	21.4	241	250
	10 m3 FYM/fed+S. D. B.	7.84	7.91	1.53	1.61	2.54	2.96	31.7	31.7	22.5	24.5	251	258
L. S. D. at 5%													
(A)		N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	0.06	0.06	N. S.	N. S.	3.95	4.16
(B)		0.02	0.02	0.04	0.05	0.03	0.04	0.06	0.05	0.06	0.06	3.11	4.05
(A x B)		N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	0.11	0.10	N. S.	N. S.	4.72	4.96

DISUCUSSION

Nitrogen, phosphorus and potassium are major essential macronutrients for plant growth and development. To enhance crop yields, nitrogenous, phosphatic and potassium fertiliers are applied at high rates. Therefore, direct application of rock phosphate and rock potassium materials may be agronomically more useful and environmently safer than soluble P and K (Rajan *et al*. 1996). However, potassium is released slowly from natural rock materials and their use as fertilizer often causes insignificant increases in the yield of crops (Sindhu *et al*., 2010). Therefore, concerted efforts are made to understand the combined effects of feldspar addition and some bio-stimulants such as silicate dissolving bacteria (SDB), humic acids and farmyard manure on growth, yield and its components, some leaf chemical contents and some soil properties after cotton harvest.

On basis of the experimental results, it was stasted that plant height, number of fruiting branches, number of open bolls/plant, boll weight, seed cotton yield, earliness% and 100-seed weight as well as N%, K% and chlorophyll A and/or B in cotton leaf were positively affected by addition of 400 kg feldspar/feddan, while lint% and fiber properties, i.e., Micronair reading and Pressely index as well as P% in leaf did not affect. The promotive effect of 400 kg feldspar/feddan on growth and development of cotton plant than without feldspar is mainly due to potassium (feldspar about 10% K2O) plays an important role in the growth and development of plants. It activates enzymes, maintains cell turgor, enhances photosynthesis, reduces respiration, helps in transport of sugar stars, helps in nitrogen uptake and is essential for protein synthesis (Mengel and Kirkby, 1987). These results are agreement with those obtained by Shafeek *et al*. (2005), Abdel-Hak *et al*. (2012), Ismail *et al*. (2014) and Merwad (2016).

The obtained results, clearly show that humic acids application improved all studied growth, yield and yield components as well as earliness% and seed index and leaf chemical contents which mainly due to induce microbiological stimulation (Petrovic *et al*., 1982). In this concern, Malik and Azam (1985) reported that, soaking wheat seeds in a solution of humic acids increased seedling growth, improved root development and enhanced uptake of water by roots. Humic acids influence plant growth both in direct and indirect ways. Indirectly, it improves physical, chemical and biological conditions of soil. While, directly, it increases chlorophyll content, accelerates plant respiration and hormonal growth responses, increases penetration in plant membrances (Rajpar *et al*., 2011). Similar results were obtained by Khaled and Fawzy (2011), Tahir *et al*. (2011), Boogar *et al*. (2014) and Ismail *et al*. (2014).

The beneficial effect of FYM on improving the growth of cotton plants and its development as well as some chemical contents in leaf is mainly due to it play an important role in sustaining productivity by not only acting as a source of nutrients, but also through modifying soil physical behavior as well as increasing the efficiency of applied nutrients (Reddy and Aruna, 2008). These results are in accordance with those obtained by Ali *et al*. (2009), Sayed (2009) and Ahmad (2017).

As for silicate dissolving bacteria, the results reveal that SDB had a positive effect on growth of cotton and its development as well as K%, chlorophyll A and/or B only by increasing the solubility of rock feldspar, consequently released available K to plants. Moreover, it enhances the effect of humic acids and FYM by increasing the decomposition of them. In this concern, Zakaria (2009) mentioned that SDB plays an important role in the formation of humus in soil, the cycling of other mineral tied up in the organic matter. Also, it can able to solubilize rock-K mineral powder (feldspar) through production and excretion of organic acids or chelate silicon ions to bring K into solution (Ullman *et al*., 1996 and Bennett *et al*., 1998). These results are in line with those obtained by Badr *et al*. (2006) and Verma *et al*. (2016).

The results clearly show that soil properties after harvest not affected by feldspar application, except soil available N and K. The benefical effect of feldspar on increasing soil available nitrogen is mainly due to the synergestic effect between potassium and nitrogen (Jones *et al*., 1991). Since feldspar contains about 10% K. Hellal *et al*. (2009) and Abou-el-Seoud (2012) reported that natural rock potassium may be valuable as a slow releasing source for potassium. Moreover, humic acids and FYM had a positive effect on soil pH, O.M, available N, P and K which maily due to organic acids and nutrients released throughout its decomposition as discussed before. On the other hand, FYM application increased soil salinity due to its relatively high saline content (Table 1). These results are in line with those obtained by Sayed (2009) and Ahmad (2017).

CONCLUSION

In respect to results of this investigation, due to the high price of potassium fertilizer it could be concluded to supply cotton plants with 400 feldspar/feddan as a potential supplement to chemical potassium fertilizer in combined with some bio-stimulants such as silicate dissolving bacteria, humic acids (10 kg/feddan) and/or farmyard manure (10 m3/feddan) to improve cotton productivity and soil properties.

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امكانية الاستفادة من سماد الفلسبار كبديل للتسميد البوتاسي لنبات القطن بخلطها بالبكتريا المذيبة للسليكات وحامض الهيوميك والسماد البلدي وتأثيرهم علي خواص التربة

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أجريت تجربتان حقليتان بالمزرعة البحثية بمحطة البحوث الزراعية بسدس, مركز البحوث الزراعية , محافظه بني سويف, مصر لدراسة امكانية استخدام الفلسبار كمصدر للتسميد البوتاسي مع استخدام بعض المنشطات الحيوية (بكتريا مذيبة للسليكات , حامض الهيوميك , السماد البلدي) وتاثيرها علي انتاجية القطن وخواص التربة بعد الحصاد. وقد اوضحت نتائج الدراسة ان:-ادت اضافة 400 كجم فلسبارات/فدان او 10 كجم حامض الهيوميك/فدان او 10 م^3/فدان سماد بلدي الي تحسين طول النبات, عدد الافرع الثمرية للنبات, عدد اللوز المتفتح للنبات, وزن اللوزة, محصول القطن الزهر , نسبة التبكير , وزن 100-حبة , نسبة النيتروجين والفوسفور والبوتاسيوم وكلوروفيل أ ,كلوروفيل ب وكلوروفيل أ + ب في اوراق القطن , صلاحية النيتروجين والبوتاسيوم في التربة بعد الحصاد.ادت اضافة 400 كجم فلسبار /فدان الي زيادة صلاحية النيتروجين والبوتاسيوم.ادي اضافة السماد البلدي او حامض الهيوميك الي تحسين خواص التربة ونسبة المادة العضوية بالتربة وصلاحية النيتروجين والفوسفور والبوتاسيوم , بينما زادت ملوحة التربة باضافة السماد البلدي.اوضحت نتائج التداخل بين المعاملات الي ان افضل نتائج تم الحصول عليه كان عند تسميد نبات القطن بالفلسبار بمعدل 400 كجم/فدان + 10 م^3/فدان سماد بلدي او 10 كجم حامض هيوميك مع التلقيح بالبكتريا المذيبة للسليكات.لم يؤثر التلقيح بالبكتريا المذيبة للسليكات علي انتاجية القطن الا في حالة خلطها مع الفلسبار او السماد البلدي او حامض الهيوميك.من نتائج الدراسة وبسبب ارتفاع اسعار الاسمدة البوتاسية الكيميائية يمكن التوصية باستخدام الفلسبار كمصدر طبيعي للبوتاسيوم مع خلطة بالاسمدة العضوية او حامض الهيوميك مع التلقيح بالبكتريا المذيبة للسليكات للحصول علي اعلي انتاجية من القطن مع تحسين خواص التربة.