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Impact of Potassium Silicate on Growth, Productivity and Powdery Mildew Disease of Sugar Beet under Newly Reclaimed Soil Conditions

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ABSTRACT

Two field experiments were carried out in private farm (new reclaimed soil) at El Fayoum Governorate, Egypt during 2014/2015 and 2015/2016 growing seasons. These experiments amid to investigate the effect of foliar application of potassium silicate (P.S) and Eminent® fungicide, number of foliar spray and their interactions on growth, productivity and powdery mildew disease of sugar beet under new reclaimed soils. Data showed that: Plants sprayed with 16 cm^3/L potassium silicate showed superiority in all studied growth traits (after 150 and 180 days from sowing) i.e. leaves and root fresh weights (g/plant), root length and diameter (cm) and photosynthetic pigments (Chl "a", Chl "b" and carotenoids) followed by potassium silicate (8cm^3/L) and fungicide treatments. At harvest results indicated that the highest mean values of root yield (28.50 ton/fad), top yield (5.140 ton/fad), biological yield (33.64 ton/fad) and sugar yield (4.788 ton/fad) were recorded with 16 cm^3 potassium silicate followed by 8 cm^3 potassium silicate and fungicide treatments . On the contrary control treatment (tap water) gave the lowest values. Data also cleared that raising foliar spray number from two times to three times caused significant increases in root, top, biological and sugar yields for all spraying treatments. The highest values of sucrose percentage (18.72 and 18.25%), extractable sugar percentage (16.80 and 16.73 %) and purity percentage (93.08 and 93.07 %) were recorded with 16 and 8 cm^3/L potassium silicate respectively. Generally, fungicide was mere highly efficient significantly in reducing the disease comparing to all treatments of potassium silicate in both seasons. Potassium silicate at concentration 16 cm^3/L was the best treatment significantly than the other treatments in decrease disease incidence and diseases severity. Eventually its recommend using potassium silicate at 16 cm^3/L concentration as foliar fertilizer and at the same time it plays a bio pesticide role to control powdery mildew on sugar beet, which increase the yield and decrease use of fungicide.

Key words: Sugar beet, powdery mildew, silicon, foliar application, Tetraconazole, (root, top and sugar yields), quality.

Introduction

Sugar beet (*Beta vulgaris* L.) is considered as one of the two important sugar crops worldwide. In 1982, sugar beet has been introduced into Egypt as a new sugar crop and a second source for sugar production after sugar cane to minimize the gap between sugar production and sugar consumption. Recently sugar beet surpassed sugar cane in sugar productivity and became the first source of sugar production in Egypt compared to sugar cane. The balance between sugar production and consumption in Egypt shows already a drastic shortage and is far away from self-sufficiency. This gap reaches 34.8% during year 2015 according to Ministry of Agriculture Statistics. Bridging this gap is a real challenge with the vast growing population in Egypt (~1.2 million/Year). This goal can be realized by bringing new lands under cultivation. Egypt has a total cultivated area of 3.4 million hectare. Uncultivated land in Egypt, (deserts) occupy about 96% of the total area.

Powdery mildew of sugar beet is an important disease in several sugar beet growing countries caused by *Erysiphe betae* (Vanha) Weltzien. (Kontaxis *et al.,* 1974; Hills *et al.,* 1980). Powdery mildew of sugar beet is a serious fungal foliar disease resulting in sugar yield losses of up to 30%. The fungus occurs world-wide in anywhere sugar beet is grown and it also infects other edible beet

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crops, e.g. beetroots (garden beets) (Magyarosy, 1976 ; Francis, 2002).

The use of silicon in agriculture most likely began more than 2000 years ago in China (Matichenkov *et al*., 2001). Onodera in 1917 was probably the first scientist to demonstrate that silicon may play a role in reducing plant disease (Onodera 1917; Ishiguro 2001). Silicon plays a very important role in the reduction of the plants vulnerability to biotic and abiotic environmental stress (Ma and Yamaji, 2006; Liang *et al.* 2006; Gunes *et al*., 2007; Sacała, 2009). Ibrahim *et al.* (2017) found that after 90 days from sowing potassium silicate (8g/L) caused significant increases in top and root length, leaves and root fresh weight and root diameter compared with each of potassium silicate (4 g/L) and the control (without) treatments.

Powdery mildew (*Blumeria graminis* f. sp. tritici) on wheat can be efficiently controlled by silicon (Rodgers-Gray and Shaw 2000 , 2004). Foliar sprays of potassium silicate at and above 17 mM were effective in controlling powdery mildew (*P. xanthii*) on muskmelon and zucchini (Menzies *et al.* 1992). Other investigators in the 1930s also showed that the application of silicon increased rice resistance to blast (Ishiguro 2001). Suzuki and Shigematsu introduced the use of calcium silicate slag as a source of soluble silicon for controlling rice blast while improving yields at rates ranging from 0.2 to 16 t of product per ha; this application has become a common agricultural practice for rice production in Japan (Ishiguro, 2001).

The benzimidazoleis one of the most important systemic fungicides that became available for controlling powdery mildew on many plants and other fungal plant diseases (Georgopoulos and Dovas, 1973; He *et al.,* 1998 ; Miazzi *et al.,* 1997).

In this study, we investigate the effect of potassium silicate with different dosage (4, 8 and 16 cm^3/L) on plant growth, yield and sugar content also disease control option in comparison to application of fungicides i.e. Eminent® 16% EC for disease management.

Materials and Methods

Two field experiments were carried out during 2014/2015 and 2015/2016 growing seasons in private farm (new reclaimed soils) at El-Fayoum Governorate. These experiments aimed to study the effect of foliar application of potassium silicate (P.S) and Eminent® fungicide, number of foliar spray and their interactions on growth, productivity and powdery mildew disease of sugar beet under new reclaimed soils. Seeds of sugar beet (*Beta vulgaris* L.) variety Dema poly were obtained from the Institute of sugar crops, Agriculture Research Center (ARC), Ministry of Agriculture, El-Giza, Egypt. Each experiment included 10 treatments which were 5 spraying treatments i.e. control (spray with tap water), 4 cm^3/L potassium silicate, 8 cm^3/L potassium silicate, 16 cm^3/L potassium silicate and fungicide 1 ml/L and two treatments of spraying number (twice (II) and thrice (III) and their interaction. The spraying treatments were applied on sugar beet foliage after 90, 120 and 150 days from sowing for each treatment.

Eminent® fungicide (common name) its effective material is Tetraconazole (16% EC) and potassium silicate (PS) KSio3 content 30% silicon and 10 % potassium.

The experimental design was split plot design with 4 replications, Potassium silicate and fungicide treatments were arranged in the main plot and number of sprays was allocated in the subplots. The experimental unit area was 20 m^2 consisting of 8 rows (60 cm apart between rows and rows length 4 m) whereas, 25 cm apart between hills. Normal cultural practices for growing sugar beet crop were practiced properly as recommended in the region. Irrigation system was sprinkler irrigation.

The mechanical and chemical analyses of the experimental soil are shown in Tables (1 and 2) (as average of two growing seasons 2014/2015 and 2015/2016).

Table 1: Mechanical analysis of the experimental soil (%).

Depth (cm)	Sand	Silt	Clay	Soil texture
0-30	90.2	6.2	3.6	Sandy
30-60	91.1	5.8	3.1	Sandy

Table 2: Chemical analysis of the experimental soil.

Depth	Soluble cations and anions (me/L)						pH	EC	$CaCo_3$
(cm)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-			%
0 - 30	2.1	0.72	1.94	0.50	1.90	2.15	8.1	0.61	2.92
30 - 60	2.2	0.75	1.95	0.45	1.71	2.30	8.1	0.55	2.96

Data recorded:

Samples of 10 plants each were chosen at random from every treatment in the three replications (after 150 and 180 days from sowing) to determine the following traits:

1- Fresh weight of leaves (g/plant).
2- Fresh weight of root (g/plant).
3- Effective length of root (cm)
4- Root diameter (cm)
5- Photosynthetic pigments: which were determined in the fresh leaves according to Wettestien (1957).

Data recorded at harvest (after 205 days from sowing):

1- At harvest a sample of ten plants each were taken random from the gardening rows to determine the following traits: top weight (g/plant), root weight (g/plant), root diameter (cm) and root length (cm).
2- Top yield (ton/fad). (calculated from top weight of the experimental unit)
3- Root yield (ton/fad). (calculated from root weight of the experimental unit)
4- Biological yield (ton/fad) = Top yield (ton/fad) + Root yield (ton/fad).
5- Sugar yield (ton/fad): was calculated according to the following equation:
   Sugar yield (ton/fad) = extractable sugar % x root yield (ton/fad)/100.

Juice quality

The chemical contents were determined by taken random samples of roots tissues from the three replications to determine the following chemical components

1- Sucrose %, extractable sugar % and purity %.
2- Impurities (Na, K and – α amino nitrogen %).

The above chemical components were determined in El-Fayoum sugar company laboratories at El-Fayoum Governorate according to the method of Mcginnus (1971).

Disease assessment:

Treatments were evaluates when foliage was closing the rows. Evaluation was accomplished by examining a recently matured leaf on each of at least 50 plants and rating disease intensity as the extent of leaf area covered by fungus mycelium on a scale of 0 to 4 after one week from spraying of the last spray time of potassium silicate or the fungicide. Both sides of the leaf were examined and an average rating was given. Disease severity was determined according the scale by Whitney *et al.,* (1983) Scale ranged from 0-4, categories whereas 0= no mildew colonies observed 1=1-25%, 2=26-50%, 3=51-75% and 4=76-100% of matured leaf area covered by mildew and the average disease rating per treatment was calculated.

Efficiency of different treatments on powdery mildew severity on sugar beet plants is determined by:

$$\text{Efficiency (\%)} = \frac{\text{Disease severity in control} - \text{disease severity in treated}}{\text{Disease severity in control plant}} \times 100$$

Statistical analysis

The obtained data were exposed to the proper statistical analysis according to Snedecor and Cochran (1967). The least significant differences (LSR). Using Costat computer program V 6.303 (2004). LSR at 5% level as significance was used to differentiate between means. Data of 2014/2015 and 2015/2016 growing seasons were subjected to homogeneity variance test for running the combined analysis of the data except the data of disease severity which analysis for each growing seasons.

Results and Discussion

A. Data recorded after 150 days from sowing:

A-1. Leaves fresh weight (g/plant):

Data in Table (3) showed the significant effect of potassium silicate and fungicide treatments, number of spray and their interaction on leaves fresh weight of sugar beet plants (after 150 days from sowing).The highest value (828.2 g/plant) was recorded with16 cm^3/L potassium silicate while the lowest value (775.2 g/plant) was recorded with control (tap water) treatment. Increasing potassium silicate concentration increased to different extents the fresh weight of sugar beet leaves at this stage of growth. This last finding hold fairly true with the two and three times of spray. Results also showed that spraying three times (thrice III) for all foliar treatments gave the highest value (805.3 g/plant) of leaves fresh weight compared to spraying twice (793.1 g/plant). Concerning to the effect of the interaction between foliar spraying treatments and number of sprays on leaves fresh weight was not the same under the two treatments of spray number. The effect of 3-spray on this traits was significantly different than that of 2-sprays. Similar findings were obtained by Ibrahim *et al.* (2017). In respect to the effect of fungicide treatment on leaves fresh weight was not significantly affected by number of sprays.

A-2. Root traits:

Results in Table (3) demonstrated the significant effect of potassium silicate and fungicide treatments, number of sprays and their interactions on sugar beet root traits i.e., root fresh weight (g/plant), root diameter and root length (cm). The response of the studied root traits to foliar sprays treatments was very similar to that previously discussed on leaves fresh weight. Raising the number of sprays from twice to thrice as an average for all foliar treatments was not significant on both root fresh weight and root diameter but was significant on root length. Regarding the interaction effect on root traits data pointed out that spray sugar beet plants with 16 cm^3/L potassium silicate thrice and twice recorded the highest values (1086 and 1080 g/plant) of root fresh weight respectively. The effect of the highest rates of potassium silicate was not significant on root length under the two spraying treatments as well as on root diameter under 3-sprays. These results are in harmony with those obtained by Ibrahim *et al.* (2017).

A-3. Photosynthetic pigments (mg/g. fresh weight):

Leaf pigments substances refer to the contents of chlorophyll "a", Chlorophyll "b" and carotenoids. Data in Table (3) cleared that photosynthetic pigments were significantly affected by the foliar spraying treatments, number of sprays and their interaction. The highest mean values of spraying treatments of chlorophyll "a" (5.080 and 5.032 mg/g. fresh weight) were recorded with fungicide and 16 cm^3/L potassium silicate respectively. Meanwhile the control treatments recorded the lowest value (3.940 mg/g. fresh weight). As for the effect of spraying treatments on Chlorophyll "b" sugar beet plants treated with 16 cm^3/L potassium silicate gave the highest mean value (2.240 mg/g. fresh weight) while the control treatment recorded the lowest value (1.930 mg/g. fresh weight). Data also showed that the treatments 16 and 8 cm^3/L potassium silicate and fungicide showed superiority in carotenoids contents. Regarding to the effect of spraying number on photosynthetic pigments data cleared that spraying three times recorded the highest values (4.636, 2.290 and 1.580 mg/g. fresh weight) of chlorophyll "a", Chlorophyll "b" and carotenoids respectively, compared with spraying two times for all spraying treatments. The interaction between spraying treatments and number of sprays showed significant influence on photosynthetic pigments.

Table 3: Effect of potassium silicate and fungicide, foliar number and their interaction on shoot and root parameters after 150 days from sowing (average of 2014/2015 and 2015/2016 growing seasons)

Treatments		Leaves fresh weight (g/plant)	Root fresh weight (g/plant)	Root diameter (cm)	Root length (cm)	Photosynthetic pigments (mg/g. fresh weight)		
No. foliar	Spraying treatments					Chl "a"	Chl "b"	Carot.
Twice (II)	Control	762.7 f	873.3 d	11.97 c	16.30 b	3.910 h	1.907 e	1.170 e
	4 cm^3/L (P.S)	775.0 ef	886.7 d	13.40 b	16.67 cd	4.080 g	1.993 e	1.307 d
	8 cm^3/L (P.S)	809.3 bc	1015.0 c	14.10 b	19.37 a	4.790 e	2.243 cd	1.600 c
	16 cm^3/L (P.S)	825.0 ab	1080.0 ab	15.20 a	19.70 a	5.093 ab	2.510 a	1.740 b
	Fungicide	793.3 cd	894.3 d	13.37 b	16.40 cd	5.123 a	2.143 d	1.677 b
Mean		793.1 B	949.9 A	13.61 A	17.69 B	4.599 B	2.159 B	1.498 B
Thrice (III)	Control	787.7 de	897.0 d	12.13 c	16.70 c	3.970 h	1.953 e	1.210 e
	4 cm^3/L (P.S)	794.0 cd	880.0 d	13.40 b	17.27 b	4.300 f	2.270 c	1.333 d
	8 cm^3/L (P.S)	821.7 ab	1046.6 bc	15.03 a	19.63 a	4.903 d	2.420 ab	1.817 a
	16 cm^3/L (P.S)	831.3 a	1086.6 a	15.37 a	19.53 a	4.970 cd	2.470 a	1.827 a
	Fungicide	792.0 d	903.3 d	13.33 b	16.43 cd	5.037 bc	2.337 bc	1.717 b
Mean		805.3 A	962.7 A	13.85 A	17.91 A	4.636 A	2.290 A	1.580 A
Means of spraying treatments								
control		775.2 E	885.2 D	12.05 D	16.50 C	3.940 D	1.930 E	1.190 C
4 cm^3/L (P.S)		784.5 D	883.3 D	13.40 C	16.79 B	4.190 C	2.132 D	1.320 B
8 cm^3/L (P.S)		815.5 B	1030.8 B	14.57 B	19.50 A	4.847 B	2.330 B	1.708 A
16 cm^3/L (P.S)		828.2 A	1083.3 A	15.28 A	19.62 A	5.032 A	2.490 A	1.783 A
Fungicide		792.7 C	898.8 C	13.35 C	16.42 C	5.080 A	2.240 C	1.697 A

P.S.: potassium silicate

B- Data recorded after 180 days from sowing:

B-1. Leaves fresh weight (g/plant):

Data in Table 4 indicated clearly that leaves fresh weight of sugar beet plants was significantly affected by potassium silicate and fungicide treatments, number of spray and their interaction. Results revealed that application of 16 cm^3/L potassium silicate gave the highest value of leaves fresh weight (968.5 g/plant), and the lowest value (883.7 g/plant) was recorded with the control (tap water) treatment. The positive effect of potassium element on growth of sugar beet was investigated previously by (Makhlouf and Abd El-All (2017) they found that increasing potassium fertilizer levels caused significant increases in the values of leaf area index (LAI) of sugar beet plants and they attributed this to the role of potassium in increasing cell volume and hence increasing leaf area/plant. Meanwhile the thrice foliar application for all foliar treatments gave higher values of leaves fresh weight compared to spraying twice (II) only. The effect of interaction between spraying treatments and number of sprays was significant. This significant interaction means that the response of leaves fresh weight to foliar spraying treatment was not the same under the two or three sprays.

B-2. Root traits:

Sugar beet root traits (root fresh weight (g/plant), root diameter and root length (cm)) were significantly affected by potassium silicate and fungicide treatments, number of spray and their interaction. Data in Table (4) showed superiority of all foliar spraying treatments on the studied root traits compared to the control treatment. Moreover, increasing potassium silicate concentration increased to different extents the investigated root traits. The effect of the highest two rates of potassium silicate (16 and 8 cm^3/L) on root traits was not great enough to reach the significant level. These results hold fairy true with the two and three sprays. In respect to the effect of fungicide treatments on the investigated root traits was positive compared to the control treatment.

Table 4: Effect of potassium silicate and fungicide, foliar number of sprays and their interaction on shoot and root traits after 180 days from sowing (average of 2014/2015 and 2015/2016 growing seasons)

Treatments		Leaves fresh weight (g/plant)	Root fresh weight (g/plant)	Root diameter (cm)	Root length (cm)	Photosynthetic pigments (mg/g. fresh weight)		
No. foliar	Spraying treatments					Chl "a"	Chl "b"	Carot.
Twice (II)	Control	875.0 f	1156 d	17.33 d	21.27 d	3.110 h	1.407 e	0.870 e
	4 cm^3/L (P.S)	876.7 f	2141 b	18.33 c	22.60 b	3.280 g	1.493 e	1.007 d
	8 cm^3/L (P.S)	940.0 c	1287 a	21.50 a	23.57 a	3.990 e	1.743 cd	1.300 c
	16 cm^3/L (P.S)	968.7 a	1291 a	21.47 a	23.57 a	4.293 ab	2.010 a	1.440 b
	Fungicide	916.7 d	1211 b	20.40 b	22.77 b	4.323 a	1.642 d	1.377 b
Mean		915.4 B	1232 A	19.81 A	22.75 A	3.799 B	1.659 B	1.199 B
Three sprays (III)	Control	892.3 e	1172 c	16.73 d	21.70 c	3.170 h	1.453 e	0.910 e
	4 cm^3/L (P.S)	894.7 e	1210 b	18.83 c	22.40 b	3.500 f	1.770 c	1.033 d
	8 cm^3/L (P.S)	954.3 b	1291 a	21.60 a	23.47 a	4.103 d	1.920 ab	1.517 a
	16 cm^3/L (P.S)	968.3 a	1292 a	21.97 a	23.40 a	4.170 cd	1.970 a	1.527 a
	Fungicide	920.3 d	1213 b	20.83 b	22.60 b	4.237 bc	1.837 bc	1.417 b
Mean		926.0 A	1236 A	19.99 A	22.71 A	3.836 A	1.790 A	1.280 A
Means of spraying treatments								
control		883.7 D	1164 C	17.03 D	21.48 C	3.140 D	1.430 E	0.890 C
4 cm^3/L (P.S)		885.7 D	1212 B	18.58 C	22.50 B	3.390 C	1.632 D	1.020 B
8 cm^3/L (P.S)		947.2 B	1289 A	21.55 A	23.52 A	4.047 B	1.832 B	1.408 A
16 cm^3/L (P.S)		968.5 A	1292 A	21.72 A	23.48 A	4.232 A	1.990 A	1.483 A
Fungicide		918.5 C	1212 B	20.62 B	22.68 B	4.280 A	1.740 C	1.397 A

P.S.: potassium silicate

B-3.Photosynthetic pigments (mg/g. fresh weight)

Leaf pigments substances refer to the contents of chlorophyll "a", chlorophyll "b" and carotenoids. Data in Table (4) showed that the photosynthetic pigments were significantly affected by spraying treatments, number of spraying and their interaction. The highest mean values of chlorophyll "a" (4.280 and 4.232 mg/g. fresh weight)were recorded with fungicide and 16 cm^3/L potassium silicate treatments respectively, while maximum values of chlorophyll "b" and carotenoids (1.990 and 1.483 mg/g. fresh weight) were obtained with 16 cm^3/L potassium silicate respectively. Control treatments recorded the lowest values of chlorophyll "a"(3.140 mg/g. fresh weight), chlorophyll "b"(1.430 mg/g. fresh weight) and carotenoids (0.890 mg/g. fresh weight). Regarding to the effect of spraying number on photosynthetic pigments data in table 4 cleared that repeating spray three times recorded the highest values (3.863, 1.790 and 1.280 mg/g. fresh weight) of chlorophyll "a", Chlorophyll "b" and carotenoids respectively, compared with spraying two times for all spraying treatments. The interaction between spraying treatments and number of sprays showed a significant influence on photosynthetic pigments. Twice (II) foliar application of 16 cm^3/L potassium silicate recorded highest value of chlorophyll "a" (4.323mg/g. fresh weight), while Twice (II) foliar application of 8 cm^3/L potassium silicate recorded the highest value of chlorophyll "b" (2.010mg/g.

fresh weight). On the other hand, thrice (III) foliar application of 16 cm^3/L potassium silicate recorded the highest value of carotenoids (1.527 mg/g. fresh weight).

C- Data recorded at harvest (after 205 days from sowing)

C-1. Yield (ton/fad)

The available data in Table (5) demonstrated the significant effect of potassium silicate and fungicide foliar application, number of foliar sprays and their interaction on sugar beet productivity under new reclaimed soils. Effect of potassium silicate levels and fungicide treatments recorded the same trend for root, top, biological and sugar yield. The results indicated that the highest mean values of root yield (28.50 ton/fad), top yield (5.140 ton/fad), biological yield (33.64 ton/fad) and sugar yield (4.788 ton/fad) were recorded with 16 cm^3 potassium silicate. On the contrary control treatment (tap water) gave the lowest values of root yield (22.58 ton/fad), top yield (3.900 ton/fad), biological yield (26.48 ton/fad) and sugar yield (3,493 ton/fad). Results indicated that increasing potassium silicate levels increased to different extents the investigated root traits. Ibrahim *et al.* (2017) found that sugar beet plants treated with 8 g/L potassium silicate (soil additive) caused significant increase in root and top yield compared with the control treatment. Meanwhile, Artyszak *et al.* (2014) obtained respectively 13.1% and 21.8% increase of root yields as the effect of calcium and silicon foliar fertilization in two application times. Data also cleared that raising foliar sprays from two times to three times caused significant increases in root, top, biological and sugar yield. In respect to the effect of the interaction between spraying treatments and number of sprays was significant. The response of root, top, biological and sugar yields to spraying treatments were not the same under the number of sprays. While the effect of the highest two levels of potassium silicate on root, biological and sugar yields was not significantly by the number of sprays this was not the case with the other foliar treatments. The effect of fungicide treatment on root yield traits was significantly affected by number of sprays. In this study fungicide was the second or three treatments caused positive effect on sugar beet productivity (Root, top, biological and sugar yield). These results were in harmony with Gado (2013) he reported that Fungicide treatments came, in general in the second order after plant extracts.

Table 5: Effect of potassium silicate and fungicide, sprays number and their interaction on root, top, biological and sugar yield (ton/fad) of sugar beet (average of 2014/2015 and 2015/2016 growing seasons).

Treatments		Root yield (ton/fad)	Top yield (ton/fad)	Biological yield (ton/fad))	Sugar yield (ton/fad)
No. foliar	Spraying treatments				
Twice (II)	Control	22.57 g	3.887 e	26.45 g	3.406 f
	4 cm^3/L (P.S)	23.67 f	4.010 dc	27.68 f	3.732 e
	8 cm^3/L (P.S)	27.40 b	4.833 c	32.23 bc	4.566 b
	16 cm^3/L (P.S)	28.47 a	5.050 b	33.52 a	4.782 a
	Fungicide	26.13 d	4.937 bc	31.07 d	4.112 d
Mean		25.65 B	4.543 B	30.19 B	4.140 B
Thrice (III)	Control	22.60 g	3.913 e	26.51 g	3.481 f
	4 cm^3/L (P.S)	24.70 e	4.107 d	28.81 e	4.059 d
	8 cm^3/L (P.S)	27.57 b	4.933 bc	32.50 b	4.631 b
	16 cm^3/L (P.S)	28.53 a	5.230 a	33.76 a	4.793 a
	Fungicide	26.70 c	5.057 b	31.76 c	4.272 c
Mean		26.02 A	4.648 A	30.67 A	4.247 A
Means of spraying treatments					
Control		22.58 E	3.900 D	26.48 E	3.493 E
4 cm^3/L (P.S)		24.18 D	4.058 C	28.24 D	3.895 D
8 cm^3/L (P.S)		27.48 B	4.883 B	32.37 B	4.599 B
16 cm^3/L (P.S)		28.50 A	5.140 A	33.64 A	4.788 A
Fungicide		26.42 C	4.997 B	31.41 C	4.192 C

P.S.: potassium silicate

C-2. Quality measurements

Data in table (6) affirmed that potassium silicate and fungicide treatments, number of foliar and their interaction attained significant effects on sugar beet juice quality. The highest values of sucrose percentage (18.72 and 18.25%), extractable sugar percentage (16.80 and 16.73 %) and purity percentage (93.08 and 93.07 %) were recorded with 16 and 8 cm^3/L potassium silicate respectively. This result can be attributed to containment of these treatments on potassium element and its role in increasing rate of translocation process. Wang *et al.* (2015) reported that Potassium (K) is an essential nutrient required in higher amounts for plant metabolism especially for photosynthesis and assimilates transport. the highest values (1.816 and 1.700 %) of Na percentage (as impurities content) were recorded with control and fungicide treatments respectively and the highest values of K percentage (4.033 and 4.000 %) recorded with potassium silicate at the rate of 8 and 16 cm^3/L. Data also showed that variations in – α amino nitrogen percentage between the spraying treatments i.e., control, potassium silicate 4, 8 and 16 cm^3 and fungicide were not high enough to reach the significant level. The effect of foliar number reached the significant level only in purity and K%. and was non-significant in the other juice traits (sucrose, extractable sugar, Na and – α amino nitrogen%). Concerning the effect of interaction between foliar treatments and foliar number on sugar beet quality data cleared that increasing potassium silicate concentration from 4 to 8 and 16 cm^3/L continuously and significantly increased the values of sucrose, extractable, purity % and decreased Na %.

Table 6: Effect of potassium silicate and fungicide, sprays number and their interaction on quality measurements of sugar beet (average of 2014/2015 and 2015/2016 growing seasons).

Treatments		Sucrose %	Extractable sugar %	Purity %	Impurities %		
No. foliar	Spraying treatments				Na	K	– α A.N
Twice (II)	Control	17.50 cd	15.53 cd	90.47 h	1.800 a	3.100 ef	1.800 a
	4 cm^3/L (P.S)	17.70 c	15.77 cd	90.80 g	1.600 a	3.500 c	1.833 a
	8 cm^3/L (P.S)	18.40 ab	16.67 a	92.90 c	1.200 b	3.833 b	1.767 a
	16 cm^3/L (P.S)	18.70 a	16.80 a	92.70 c	1.167 b	3.700 b	1.700 ab
	Fungicide	17.80 c	15.73 cd	91.20 f	1.700 a	3.233 de	1.600 b
Mean		18.02 A	16.10 A	91.61 B	1.493 A	3.473 B	1.740 A
Thrice (III)	Control	17.23 d	15.40 d	90.53 h	1.833 a	3.000 f	1.767 a
	4 cm^3/L (P.S)	18.27 b	16.43 ab	92.13 d	1.300 b	3.833 b	1.767 a
	8 cm^3/L (P.S)	18.70 a	16.80 a	93.23 b	1.200 b	4.232 a	1.600 b
	16 cm^3/L (P.S)	18.73 a	16.80 a	93.47 a	1.133 b	4.300 a	1.600 b
	Fungicide	17.60 c	16.00 bc	91.43 e	1.700 a	3.400 cd	1.800 a
Mean		18.11 A	16.29 A	92.16 A	1.433 A	3.753 A	1.707 A
Means of spraying treatments							
Control		17.37 C	15.47 D	90.50 C	1.816 A	3.050 D	1.783 A
4 cm^3/L (P.S)		17.98 B	16.10 B	91.47 B	1.450 B	3.667 B	1.800 A
8 cm^3/L (P.S)		18.55 A	16.73 A	93.07 A	1.200 C	4.033 A	1.683 A
16 cm^3/L (P.S)		18.72 A	16.80 A	93.08 A	1.510 C	4.000 A	1.650 A
Fungicide		17.70 BC	15.87 C	91.32 B	1.700 A	3.317 C	1.700 A

P.S.: Potassium silicate

D- Diseases assessment:

D-1. Disease severity

Data in Table (7) illustrated that there were considerable differences between the values of the three concentrations; On the other hand, no significant difference was found between the values of two and three sprays in both seasons. In general, fungicide was mere highly efficient significantly in reducing the disease comparing to all treatments of potassium silicate in both seasons. Final determination of disease severity indicates clearly that three sprays gave the best results in management the disease (Table 7) than two sprays. Potassium silicate at concentration 16 cm^3/L was the best treatment significantly followed by 8 cm^3/L then 4 cm^3/L in descending order, and all treatments led to great reduction to the disease comparing to non-treated plants.

Table 7: Effect of potassium silicate and fungicide, foliar number and their interaction on powdery mildew diseases severity of sugar beet under field condition during two successive growing seasons, 2014/2015 and 2015/2016.

Treatments		Diseases severity %		
No. foliar	Spraying treatments	2014/2015	2015/2016	Average of 2 years
Twice (II)	Control	3.00 a	3.67 a	3.34
	4 cm^3/L (P.S)	2.33 abc	3.00 ab	2.67
	8 cm^3/L (P.S)	2.33 abc	1.67 d	2.00
	16 cm^3/L (P.S)	1.67 cd	2.00 cd	1.83
	Fungicide	0.67 d	0.67 e	0.67
Mean		2.00 A	2.20 A	2.10
Thrice (III)	Control	3.33 a	3.33 ab	3.33
	4 cm^3/L (P.S)	2.33 abc	2.67 bc	2.50
	8 cm^3/L (P.S)	2.00 bc	2.00 cd	2.00
	16 cm^3/L (P.S)	1.33 cd	1.67 d	1.50
	Fungicide	0.67 d	0.33 e	0.50
Mean		1.93 A	2.00 A	1.97
Means of spraying treatments				
Control		3.17 A	3.50 A	3.34
4 cm^3/L (P.S)		2.33 B	2.83 A	2.58
8 cm^3/L (P.S)		2.17 B	1.83 B	2.00
16 cm^3/L (P.S)		1.50 C	1.83 B	1.67
Fungicide		0.67 D	0.50 C	0.593

P.S.: potassium silicate

The averages of disease severity were reduced from 3.34 in non-sprayed plants to 1.67 in case of spraying 16 cm^3/L and 2.00 in 8 cm^3/L and 2.58 in case of spraying 4 cm^3/L potassium silicate. By calculating the efficiency of different concentrations of potassium silicate, data obtained indicated that 16 cm^3/L was the best concentration of the three treatment concentrations, it gave 45.2% in two sprays and 54.9 % in three sprays, followed by 8 cm^3/Lgave 40.1% in two sprays and 39.9 % in three sprays then the lowest treatment was 4 cm^3/L gave 20.0% in two sprays and 24.9% in three sprays. However, the greatest efficiency in general was fungicide it gave 79.9% in two sprays and 84.9% in three sprays (Table 8). These results are in harmony with the results obtained by Karaoglanidis and Karadimos (2006), as they found that fungicide effectively control powdery mildew disease in sugar beet and increased yield component. It is well established that rapidly usage of triazoles lead to reduce sensitivity of powdery mildew (Gado, 2013).

Therefore, in the present study three concentration of potassium silicate were tested on controlling powdery mildew under field condition compared with fungicide. Data obtained indicated clearly that potassium silicate at concentration 16 cm^3/L caused a great reduction in disease severity and effective than the other concentrations. The reduction of disease severity was reflected on yield components i.e. root,top, biological yield (Ton/ Fad), and sugar content, sucrose percentage, extractable sugar and decrease of some impurities, i.e. sodium, potassium and alpha amino acid contents. Also these results were in harmony with Tesfagiorgis *et al.* 2014, they found that silicon reduced powdery mildew by as much as 35 % and improved the efficacy of most of the biocontrol agents. Bowen *et al.* 1992, found that foliar sprays with potassium silicate concentration reduced the number of powdery mildew colonies by more than 60 % on grape. Also it was agreed with Carré-Missio *et al.,* 2010 they found that, foliar application of potassium silicate was as effective as Acibenzolar- S- Methyl, a known inducer of host resistance, in reducing the symptoms of *Pestalotia* leaf spot.

These results occurred may be due to, first proposed for that silicate play important role as a mechanical barrier resulting from silicon polymerization in plant tissue. However, in addition to this passive mechanical role played by silicon, a plethora of biological, physiological and molecular data suggests that this element may act as a modulator of host resistance against pathogen infection (Rodrigues and Datnoff, 2015).

Table 8: Average of efficiency (%) of different treatments with potassium silicate and fungicide on powdery mildew severity on sugar beet plants under field condition during two successive growing seasons, 2013/ 2014 and 2014/2015

Treatments	Average of efficiency (%)	
	Two sprays	Three sprays
Control	0	0
4 cm^3/L (P.S)	20.0	24.9
8 cm^3/L (P.S)	40.1	39.9
16 cm^3/L (P.S)	45.2	54.9
Fungicide	79.9	84.9

P.S.: potassium silicate

Conclusion

Under conditions of the present work, it was found that sprayed sugar plants with a solution of 16 cm^3/L potassium silicate can be recommended to get the highest root and sugar yields/fad and decrease powdery mildew disease.

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