Using of Potassium Silicate to Alleviate Drought Stress Effect on Peanut as Grown in Sandy Soil

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ABSTRACT Two field Experiments were conducted at Abd El-Maneim Ryad, South Tahrir, El- Beheira Governorate, Egypt, during the summer growing seasons of 2017 and 2018 to study the role of foliar application of potassium silicate for alleviating drought stress effect on peanut grown in sandy soil. This experiment carried out in a split plot design with three replicates where the drought stress treatments (irrigation after depletion of 40%, 55%, 70% and 85% Available soil water were occupied main plot, while potassium silicate concentration (control, 500, 1000 and 1500mg/l silicate) was allocated in sub main plot.

Results revealed that irrigation after depletion of 55% available soil water recorded the highest mean values of yield and yield components i.e. (100-pods weight, no. of pods/plant, pods yield/fed, biological yield/fed and straw yield/fed during both seasons, while, the irrigation after depletion of 40% available soil water recorded the highest mean values of harvest index percentage during both seasons).

Foliar application of potassium silicate at 1500 mg/l silicate recorded the maximum 100-pods weight, no. of pods/plant, pods yield/fed, biological yield/fed and straw yield/fed, while, control treatment recorded the highest mean values of harvest index percentage during both seasons. Chemical compositions i.e. (oil percentage and oil yield/fed) recorded the best values with irrigation after depletion of 40% available soil water, while, proline content recorded the highest mean values at irrigation after 85% depletion of available water; in addition, potassium silicate at 1500 mg/l silicate recorded the highest percentages of oil and oil yield/fed, while, proline content recorded the best values with control treatment, during both seasons. Water use efficiency recorded the highest mean value with irrigation after depletion of 85%available soil water during both seasons; with regard, potassium silicate at 1500 mg/l silicate gave the highest mean values of water use efficiency as compared with control treatment which recorded the lowest mean values of WUE during both seasons.

Keywords: Peanut, drought stress, potassium silicate, yield and yield components.

INTRODUCTION

Groundnut or peanut (*Arachis hypogaea* L.) is considered to be one of the most important edible legume crops in Egypt, due to its seeds has high nutritive value for human and the produced cake as well as the green leafy hay for livestock (Abdalla *et al.,* 2009). Peanut is one of the most important cash crops, besides food crops and oil seed crops, in the world. However, most of the world's peanut production is grown mostly under rain-fed conditions, where unpredicted and inadequate rainfall or drought seriously affects peanut production (Icrisat, 2011). Peanut is the world's 4th most essential edible oil crop and 3rd most vital source of vegetable protein (CGIAR, 2005). Peanut is a vital legume crop grown in tropical and sub-tropical semi-arid regions of the world; the yield level is severely affected by deficiency of soil moisture. Peanut is a main seed legume in Egypt as compared with other oil crops (Arruda *et al.,* 2015).

Drought is the most limiting factor, resulting in low yields in many parts of the world (Songsri *et al.,* 2008). Drought during the pod filling phase of peanut is common and causes the greatest reduction in peanut pod yield (Ravindra *et al.,* 1990). Also, Girdthai *et al.* (2010) stated that drought reduced pod yield up to 35% and biomass by 21%.Water deficit stress is one of the main environmental restraints limiting agricultural productivity and acts avital role in the distribution of plant species across different types of environments (Ashraf, 2010). Drought stress has been the major environmental factor responsible to yield losses in numerous crops worldwide. The losses are highly flexible reliant on timing, intensity, and period coupled with other location-specific environmental stress factors such as temperature and salinity (Kambiranda *et al.,* 2012). Drought not only results in yield loss, but also is the chief reason for decrease innutritional quality of seed (Amir *et al.,* 2005) and rises in aflatoxin contamination (Girdthai *et al.,* 2010).

Silicon (Si) is one of the abundant elements in the lithosphere and it is the most abundant element in soil next to oxygen and comprises 28 percent of its weight and 3 - 7 percent in soil solution (Epstein, 1999). Si is most commonly found in soils in the form of solution as silicic acid and plants take up directly as silicic acid (Ma, *et al*., 2001). Application of silicon increased the shoot silicon concentration and dry matter production (Prakash, *et al*., 2011). Silicon can be enhanced plant resistance to manyabiotic stresses: salinity, drought, metal toxicity and ultra violet radiation (Balakhnina and Borkowska, 2013). Silicon spraying improved growth and physiological indices hence could increase the ability of plants to resistance water stress. Silicon application reduces transpiration leads to water stress tolerance (Asgharipour and Mosapour, 2016). The role of silicon in plant biology is to decrease various stresses such asbiotic and abiotic stresses. Si helps to protect crops from insect attack, disease and environmental stress. In organic farming system, the addition of silicon sources to crops may increase the yield and decreasing the use of chemical fertilizers, pesticides and fungicides (Patil, *et al*., 2017). Si can improve growth, biomass and yield of wide range of crops including monocotyledonous crops that have the capability to collect high amounts of Si in their organs (Shedeed,2018).

Foliar application of K- silicate has many benefits in enhancing leaf erectness and photosynthesis efficiency also decreasing capability to lodging in herbal crops (Ahmad *et al*., 2013). In addition, Si offers benefits in numerous agricultural applications e.g. increases growth and yield, improves strength, minimize climate stress and provides impedance to mineral stress. On this way Kandil *et al.* (2019) found that K- silicate increased yield, yield components and quality of soybean under environmental stress.Also, Gomaa *et al.* (2020) and Gomaa *et al.* (2021b) revealed that foliar application of K-silicate three times resulted in the highest growth, yield and grain characters can increase WUE of maize. On the other hand, under water-deficit stress, irrigation every fifteen days combined with application of K-silicate spraying in three times recorded the highest values of growth and grain yield and its components. Also, El-Naggar *et al.* (2020) indicated that using Si in Nanoparticles increased yield and its components of maize. Gomaa *et al.* (2021a) showed that application of Si increased yield and its components of maize.

The overall objective of the present research was to study the role of foliar application of potassium silicate for alleviating drought stress effect on peanut grown in sandy soil.

MATERIALS AND METHODS

Two field Experiments were conducted at Abd El-Maneim Ryad, South Tahrir, Beheira, Governorate, Egypt, in the summer growing seasons of 2017 and 2018 to study the alleviating drought stress effect on peanut grown in sandy soil using foliar application of potassium silicate.

The preceding crop was Potato (*Solanum tuberosum* L.) in the two seasons. The physical and chemical properties of experimental soil are presented in Table (1) according to the method described by Page *et al.* (1982).

Table (1). The initial physical and chemical properties of the experimental soil seasons of 2017 and 2018

Physical properties	**2017**	**2018**
Sand (%)	95.52	98.58
Silt (%)	----	----
Clay (%)	4.48	1.42
Textural class	Sand	Sand
Chemical properties		
pH	8. 7	7.58
EC (dS/m)	0. 39	0.27
O. M (%)	0. 31	0.32
$Ca\ CO_3$ (%)	0. 31	0.31
Soluble Cations (meq /L)		
Ca^{+2}	1. 50	1. 96
Mg^{+2}	3. 50	3. 75
Na^{+1}	1.85	1.83
K^{+1}	0.64	0.66
Soluble Anions (meq /L)		
HCO_3^{-1}	3. 20	3. 27
Cl^{-1}	2. 40	2. 31
SO_4^{-2}	1. 24	1. 26
Available nutrients (mg/kg soil)		
N	123. 13	175
P	37	59
K	250	217

Experimental layout

The experiments were carried out in a split plot design with three replicates, where the irrigation treatment i.e. (irrigation after depletion of 40 %, 55%, 70% and 85% available soil water) was applied after ten days from planting were arranged in the main plots, then the four potassium silicate (control=spray tap water, 500, 1000 and 1500 mg/l silicate) as applied after 35, 45, 55 and 65 days from planting and were allocated in the subplots.

Peanut (*Arachis hypogaea* L.) variety Giza 6 were planted on 20th April and harvested on 18th of August in the two seasons 2017 and 2018.

Table (2). Field capacity (FC), permanent wilting point (PWP), available soil water (ASW), and bulk density (BD) of the experimental soil.

Depth of Soil (cm)	Season							
	2017				**2018**			
	FC (%)	PWP (%)	ASW (%)	BD g /cm^3	FC (%)	PWP (%)	ASW (%)	BD g /cm^3
0-30	8.6	4.6	4.0	1.63	8.7	4.7	4.0	1.44

Determination of available water

AW(mm) = $(\theta_{fc} - \theta_{pwp})$ Dr

AW(%) = $(\theta_{fc} - \theta_{pwp})$

Where:

AW = depth of water available

θ_{fc} = volumetric field capacity

θ_{pwp} = volumetric permanent wilting point

Dr = depth of root zone

Determination of depletion (%)

Depletion of 40% available soil water = 0.40 x AW(%)

Depletion of 55% available soil water = 0.55 x AW(%)

Depletion of 70% available soil water = 0.70 x AW(%)

Depletion of 85% available soil water = 0.85 x AW(%)

Soil moisture content

Soil moisture (%) was measured using the following equation:

$$\text{Soil moisture (\%)} = \frac{\text{Weight before drying – weight after drying}}{\text{Weight after drying}} \times 100$$

To convert into volumetric moisture content, the dry weight fraction is multiplied by the bulk density, γ_b

Irrigation treatments

Irrigation after depletion of 40% available soil water

= field capacity - depletion of 40% available soil water

Irrigation after depletion of 55% available soil water

= field capacity - depletion of 55% available soil water

Irrigation after depletion of 70% available soil water

= field capacity - depletion of 70% available soil water

Irrigation after depletion of 85% available soil water

= field capacity - depletion of 85% available soil water

Fertilizer application

Before sowing were applied 300 kg/fed super phosphate calcium and 100 kg sulphur/fed during soil preparation. After sowing all experimental units were received fertilizer as 40 and 25 kg/fed of N and K, respectively. Sources of these fertilizers were ammonium nitrate (33.5% N) and potassium sulphate (50% K_2O), while, N fertilizer was added in four equal doses and K fertilizer were added in two equal doses during vegetative growth. The experimental units were hand hoed three times for controlling. Other agricultural practices were done as recommended by the Ministry of Agriculture and Land Reclamation.

Studied characters

Yield and yield components such as 100-pods weight (g), no. of pods/plant, pods yield (kg/fed), straw yield (kg/fed), biological yield (kg/fed), and harvest index (%) as well as chemical composition such as proline (mg/g) and oil (%) in addition to water use efficiency (Kg/m^3) were studied.

3.5 Statistical analysis

The obtained data were subjected to the proper method of statistical analysis of variance as described by **Gomez and Gomez (1984).** The treatment means were compared using the least significant differences (L.S.D.) at 0.05 level of probability by **SAS** (Statistical Analysis System) version 9.1 (2002).

RESULTS AND DISCUSSION

A) Yield and yield components

Result tabulated in **Table (3)** showed irrigation after depletion of 55% available soil water recorded the heaviest 100 pods weight (209.36 and 198.80 g), maximum number of pods/plant (43.25 and 39.81) and pods yield (2910.74 and 2374.46 kg/fed) in two seasons, respectively, as compared to irrigation after depletion of 40% available soil water which recorded the lowest 100 pods weight (162.70 and 154.56 g), minimum number of pods/plant (28.66 and 26.45) and pods yield/fed (2514.17 and 2114.01 kg), during both seasons, respectively. Number of pods per plant was the most vulnerable item damaged by drought stress **(Pandey *et al.*, 1984).** The effect of drought stress on the yield of three bean cultivars showed that stress at flowering stage reduced the number of pods per plant and seeds per pod in all three varieties **(Fienebaum *et al.*, 1991).** The number of pods/plant reduced due to drought stress **(Seyed *et al.*, 2011). Also, Gomaa *et al.* (2020)** and **Gomaa *et al.* (2021b)** reported the similar results, who found that water stress reduced growth and yield characters of maize.

The yield advantages due to moderate water deficit during the pre-flowering phase are associated with greater pod synchrony after the release of water stress, resulting in production of more mature pods **(Nageswara *et al*., 1988).** When stress is released, the plant try to set more fruiting sites with the existing assimilates as the vegetative site demanding assimilate supply are reduced. To improve the conventional irrigation management practices to enhance yield and water use efficiency in groundnut during summer seasons a field experiment was conducted by **Nautiyal *et al.* (2002)** where dry matter partitioning among various plant parts, and leaf area index (LAI) varied significantly under water deficit and more dry matter accumulated in petiole and stem under stress. The pod development are progressively inhibited by drought due to insufficient soil moisture and lack of assimilate **(Reddy *et al*., 2003). Girdthai *et al*. (2010)** found that peanut pod yield is decreased when subjected to drought stress due to reduction in the photosynthetic rate and disrupts the carbohydrate metabolism **(Farooq *et al*., 2009).** Moreover, most of stressed peanut genotypes had lower pod growth rate than peanut having Field capacity (FC) treatment, indicating that the assimilate portion may enhance to support the economic part. **Prabawo *et al.* (1990)** reported that re-watering after pod filling stages increased pod yields of Spanish type peanuts. Yield loss caused by moisture stress depends on genotype, plant developmental stage, severity and duration of water shortage **(Korte *et al.*, 1993).**Under drought conditions, the peanut agronomic characteristics and grain yield of all cultivars decreased and a significant reaction of the genotypes was observed **(Vorasoot *et al.*, 2003).**

In this respect, increasing the concentration of potassium silicate foliar application increased 100 pods weight, number of pods/plant and pods yield/fed,whereas, foliar application of potassium silicate at 1500 mg/l silicate recorded the maximum 100 pods weight (214.75 and 204.01 g), number of pods/plant (42.17 and 38.79)and pods yield/fed (2965.97 and 2610.04 kg), as compared to control treatment which recorded the lowest mean values of 100-pods weight (156.55 and 147.42 g), number of pods/plant (30.74 and 28.35) and pods yield/ fed (2420.99 and 1902.72 kg) during both seasons, respectively. These results are agreement with those results reported by **Gomaa *et al.* (2020) and Gomaa *et al.* (2021a)**

The interaction between irrigation treatments (A) and potassium silicate concentration (B) was significant on 100 pods weight, number of pods/plant and pods yield/fed during both seasons.The greatest values of these traits were recorded when peanut crop were irrigated after depletion of 55% available soil water under foliar application of potassium silicate at 1500 mg/l silicate, whereas the lowest values resulted from irrigation after depletion of 40% available soil water under tap water spray (control) during both seasons.

Table (3). Effect of irrigation levels (A), potassium silicate (B) and their interaction (A*B) on 100-pods weight, No. of pods/plant and of Pods yield peanut during 2017 and 2018 seasons

Treatments		100-pods weight (g)		No. of pods/ plant		Pods yield (kg/ fed)	
		2017	**2018**	**2017**	**2018**	**2017**	**2018**
A) Irrigation levels							
85 %		172.10c	163.49c	34.10c	31.36c	2589.99c	2188.61c
70 %		194.37b	183.35b	38.98b	35.86b	2734.12b	2298.87b
55 %		209.36a	198.80a	43.25a	39.81a	2910.74a	2374.46a
40 %		162.70d	154.56d	28.66d	26.45d	2514.17d	2114.01d
LSD$_{(0.05)}$		**6.11**	**5.56**	**1.82**	**1.25**	**57.58**	**46.07**
B) Potassium silicate							
Control		156.55d	147.42d	30.74d	28.35d	2420.99d	1902.72d
500 mg/l		173.95c	165.25c	34.13c	31.42c	2588.01c	2114.14c
1000 mg/l		193.28b	183.61b	37.95b	34.91b	2774.05b	2349.04b
1500 mg/l		214.75a	204.01a	42.17a	38.79a	2965.97a	2610.04a
LSD$_{(0.05)}$		0.40	1.93	0.15	0.21	10.91	2.44
The interaction (A*B)		*	*	*	*	*	*
Irrigation levels	**Potassium silicate (mg/l)**						
85 %	Control	145.93	138.63	28.91	26.54	2301.80	1855.76
	500	162.14	154.03	32.13	29.56	2475.01	2061.96
	1000	180.16	171.15	35.70	32.84	2690.34	2291.07
	1500	200.17	190.16	39.67	36.49	2892.79	2545.63
70 %	Control	164.81	151.36	33.05	30.40	2444.09	1949.26
	500	183.12	173.97	36.72	33.78	2628.06	2165.84
	1000	203.47	193.30	40.80	37.54	2825.77	2406.49
	1500	226.08	214.77	45.33	41.70	3038.56	2673.88
55 %	Control	177.52	168.65	36.69	33.75	2690.66	2013.35
	500	197.25	187.38	40.69	37.51	2832.42	2237.06
	1000	219.16	208.21	45.30	41.68	2981.46	2485.62
	1500	243.52	231.34	50.33	46.31	3138.41	2761.80
40 %	Control	137.96	131.06	24.30	22.69	2247.42	1792.51
	500	153.28	145.62	27.00	24.84	2416.54	1991.68
	1000	170.32	161.80	30.00	27.60	2598.62	2212.98
	1500	189.24	179.77	33.33	30.67	2794.10	2458.86
LSD$_{(0.05)}$		**0.46**	**2.23**	**0.18**	**0.24**	**12.60**	**2.81**

- Irrigation level: irrigation after depletion of 40 %, 55%, 70% and 85% available soil water.

Means followed by the same letter within each column are not significant different at 0.05 level of probability.

* *Denotes significant at 0.05 level of probability.*

The results in **Table (4)** illustrated that irrigation after depletion of 55% available soil water recorded the highest straw yield/fed (2598.52 and 2858.34 kg) and biological yield/fed (5509.26 and 5232.80 kg) during the two seasons, respectively, as compared to irrigation after depletion of 40% available soil water which recorded the minimum straw yield/ fed (1330.38 and 1463.33 kg) and biological yield/fed (3844.56 and 3577.34 kg), while, irrigation after depletion of 40% available soil water recorded the highest percentage of harvest index (48.50 and 49.05 %), respectively, as compared to irrigation after depletion of 55% available soil water which recorded the minimum harvest index (40.37 and 40.70%), during both seasons, respectively.

Toprope *et al.* (2004) reported that Harvest index (HI) was the critical measure of water use efficiency under water deficit stress conditions. Greater HI was observed at pegging and pod development stage under drought conditions. Yield loss caused by moisture stress depends on genotype, plant developmental stage, severity and duration of water shortage **(Korte *et al.*, 1993).**Under drought conditions, the peanut agronomic characteristics and grain yield of all cultivars decreased, and a significant reaction of the genotypes was observed **(Vorasoot *et al.*, 2003).**

Also, data in Table (4) indicated that all potassium silicate concentration significantly increased straw yield/fed and biological yield/fed, generally, potassium silicate concentration at 1500 mg/l silicate recorded the highest straw yield/fed (2230.47 and

2453.51 kg) and biological yield/ fed (5196.44 and 5063.55 kg), while, potassium silicate at control recorded the highest harvest index percentage (44.77 and 46.85%), respectively, as compared with all treatments during both seasons.

The interaction between irrigation treatments and potassium silicate concentration was highly significant for straw yield/fed, biological yield and not significant for harvest index percentage during both seasons. The maximum values of the straw yield/fed and biological yield/fed were recorded when peanut crop were irrigated after depletion of 55% available soil water under foliar application of potassium silicate at 1500 mg/l silicate in both seasons, whereas the lowest ones were given with irrigation after depletion of 40% available soil water under tap water spray (control) in both cropping seasons. Harvest index (%) under irrigation after depletion of 40% available soil water and tap water spray (control) recorded the maximum values, while, the minimum values recorded under irrigation after depletion of 55% available soil water and foliar application of potassium silicate at 1500 mg/l silicate during both cropping seasons.

Table (4). Effect of irrigation levels (A) potassium silicate (B) and their interaction (A * B) for straw, biological yield and harvest index during 2017 and 2018 seasons.

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Treatments		Straw yield (kg/ fed)		Biological yield (kg/ fed)		Harvest index (%)	
		2017	**2018**	**2017**	**2018**	**2017**	**2018**
A) Irrigation levels							
85 %		1662.98c	1829.33c	4252.97c	4017.93c	46.21b	46.86b
70 %		2078.71b	2286.61b	4812.83b	4585.48b	44.22c	44.17c
55 %		2598.52a	2858.34a	5509.26a	5232.80a	40.37d	40.70d
40 %		1330.38d	1463.33d	3844.56d	3577.34d	48.50a	49.05a
LSD$_{(0.05)}$		**46.42**	**51.01**	**76.88**	**67.99**	**0.52**	**0.50**
B) Potassium silicate							
Control		1626.04d	1788.61d	4047.01d	3691.33d	44.77a	46.85a
500 mg/l		1806.68c	1987.34c	4394.69c	4101.47c	43.90b	45.73b
1000 mg/l		2007.42b	2208.16b	4781.47b	4557.20b	43.02c	44.50c
1500 **mg/l**		2230.47a	2453.51a	5196.44a	5063.55a	42.16d	42.98d
LSD$_{(0.05)}$		**9.62**	**10.58**	**16.55**	**10.05**	**0.1**	**0.11**
The interaction (A*B)		**	**	**	**	**ns**	**ns**
Irrigation Levels	**Potassium silicate (mg/l)**						
85 %	Control	1410.08	1551.13	3375.50	3033.30	46.19	48.29
	500	1566.75	1723.47	3669.94	3337.34	45.26	47.77
	1000	1740.84	1914.97	3991.29	3744.82	44.35	45.94
	1500	1934.26	2127.74	4341.51	4160.91	43.46	44.46
70 %	Control	1762.58	1938.86	4894.00	4437.00	44.90	46.47
	500	1958.42	2154.30	5280.57	4929.99	44.01	44.98
	1000	2176.02	2393.66	5701.63	5477.77	43.13	43.52
	1500	2417.80	2659.63	6160.83	6086.42	42.27	42.12
55 %	Control	2203.34	2423.64	4206.66	3888.12	38.65	40.49
	500	2448.15	2692.93	4586.49	4320.13	37.90	39.19
	1000	2720.17	2992.15	5001.79	4800.15	37.14	38.61
	1500	3022.41	3324.61	5456.37	5333.50	36.40	37.10
40 %	Control	1128.06	1240.79	3711.88	3406.89	51.75	54.71
	500	1253.40	1378.66	4041.76	3785.43	50.72	53.62
	1000	1392.67	1531.84	4431.18	4206.04	49.98	52.35
	1500	1547.41	1702.05	4827.06	4673.37	48.15	50.67
LSD$_{(0.05)}$		**11.10**	**12.22**	**29.63**	**22.05**	**0.12**	**0.10**

- Irrigation level: irrigation after depletion of 40 %, 55%, 70% and 85% available soil water.

Means followed by the same letter within each column are not significant different at 0.05 level of probability.

*** Denotes significant at 0.01 level of probability.*

ns, Denotes not significant.

B) Chemical composition

The perusal of results in **Table (5)** indicated that irrigation after depletion of 85% available soil water recorded the highest proline content (236.08 and 219.55 mg/g) in two seasons, respectively, as compared to irrigation after depletion of 40% available soil water which recorded the minimum proline content (187.19 and 174.09 mg/g), during both seasons, respectively. The proline content enhances the drought stress progressed and reached a peak as obtained after 10 days stress, and then decreased under severe water stress as observed after 15 days of stress **(Anjum *et al.*, 2011).** Proline can act as a signaling molecule to modulate mitochondrial functions, influence cell proliferation or cell death and trigger specific gene expression, which can be essential for plant recovery from stress **(Szabados and Savoure, 2010).** Accumulation of proline under stress in many plants has been related with stress tolerance, and its concentration has been revealed to be generally higher in stress-tolerant than in stress-sensitive plants **(Demiral and Turkan, 2005).**

In another side, increasing potassium silicate concentration decreased proline content, during both seasons. However, potassium silicate at 1500 mg/lsilicate gave the lowest mean values of proline content (181.18and 168.96 mg/g), as compared to control treatment which recorded the highest mean values of proline content (249.22 and 231.77 mg/g), during both seasons, respectively. These findings may be related to the synergistic effect of the two studied factors on the different biochemical pathways in the plant cell. Silicon moderately offset the negative effects of drought stress by accumulation of proline and soluble protein content, thereby conferring stress tolerance **(Sapre and Vakharia, 2016).** In contrast, **Crusciol *et al.* (2009)** and **Pilon *et al.* (2014)** stated that proline (%) in leaves increased under water-deficit stress and higher silicon availability, which shows that silicon may be helpwith plant osmotic adjustment. **Mauad *et al.* (2016)** indicates that under water stress conditions, silicon application the proline content in the vegetative and reproductive phases of rice plants, which could be an indicator of stress tolerance.

The interaction between irrigation treatments and potassium silicate concentration was highly significant on proline content during both seasons. Irrigation after depletion of 85% available soil water recorded the highest proline content under the foliar spraying of tap water.

Results resented in **Table (5)** showed that irrigation after depletion of 40% available soil water recorded the highest oil percentage (45.31 and 42.14 %), as compared to irrigation after depletion of 85% available soil water which recorded the lowest oil percentage (34.36 and 31.95 %), during both seasons, respectively.

With regards to the effect of foliar application of different concentrations of potassium silicate increased oil percentage, during 2017 and 2018 seasons. Whereas, foliar application of potassium silicate at 1500 mg/l silicate recorded the best content of oil percentage (45.51 and 42.32 %), followed by potassium silicate at 1000 mg/l silicate (40.95 and 38.09 %), as compared to control treatment which recorded the lowest mean values of oil percentage (33.17 and 30.85 %), during both seasons, respectively.

The interaction between irrigation treatments and potassium silicate concentration was highly significant on oil percentage during both seasons. Oil content recorded the best results under irrigation after depletion of 40% available soil water with foliar spraying of potassium silicate at 1500 mg/l silicate in both seasons.

C) Water use efficiency

Results in **Table (6)** showed that increasing drought levels increased water use efficiency during both seasons. However, irrigation after depletion of 85% available soil water recorded the highest water use efficiency (0.835 and 0.706 Kg/m^3), followed by irrigation after depletion of 70% available soil water(0.779 and 0.655 Kg/m^3), as compared to irrigation after depletion of 40% available soil water which recorded the lowest mean value of water use efficiency (0.492 and 0.414 Kg/m^3), during both seasons.

Where water is the limiting factor to crop production, deficit irrigation can enhance WUE, so that the available water is better allocated. Water use efficiency (WUE) calculated as the harvested yield (kg) per volume of irrigation water (m^3) according to FAO recommendations **(Doorenbos and Kassam, 1979).** Out of several biotic and abiotic factors responsible, optimum water management is one of the most important factors that significantly influence productivity as well as the quality of the production **(Bhriguvanshi *et al*., 2012).**

In another side, increasing potassium silicate concentration increased water use efficiency (WUE), during 2017 and 2018 seasons. However, potassium silicate at 1500 mg/l silicate gave the highest mean values of water use efficiency (0.782 and 0.688 kg/m^3), as compared to control treatment which recorded the lowest mean values of water use efficiency (0.637 and 0.501 kg/m^3), during both seasons, respectively.

WUE under water stress may be due to the vital role of K-silicate in reducing water-deficit stress on plant growth and yield **(Gomaa *et al.* 2021b).**

The interaction between irrigation treatments and potassium silicate concentration was highly significant on water use efficiency during both seasons. WUE under irrigation after depletion of 85% available soil water and foliar spraying with K-silicate at 1500 mg/l silicate gave the highest values followed by irrigation after depletion of 70% available soil water under the same foliar spray of K-silicate.

Table (5). Effect of irrigation levels (A), potassium silicate and their interaction (A * B) on proline content, oil content and water use efficiency of peanut during 2017 and 2018 seasons

Treatments		Proline (mg/g)		Oil (%)		WUE (Kg/m^3)	
		2017	**2018**	**2017**	**2018**	**2017**	**2018**
A) Irrigation levels							
85 %		236.08a	219.55a	34.36d	31.95d	0.835a	0.706a
70 %		224.42b	208.71b	36.95c	34.36c	0.779b	0.655b
55 %		208.87c	194.72c	39.88b	37.08b	0.725c	0.592c
40 %		187.19d	174.09d	45.31a	42.14a	0.492d	0.414d
$LSD_{(0.05)}$		**4.76**	**4.12**	**0.39**	**0.36**	**0.01**	**0.01**
D) Potassium silicate							
Control		249.22a	231.77a	33.17d	30.85d	0.637d	0.501d
500 mg/l		224.30b	208.59b	36.86c	34.28c	0.681c	0.557c
1000 mg/l		201.87c	178.73c	40.95b	38.09b	0.731b	0.619b
1500 mg/l		181.18d	168.96d	45.51a	42.32a	0.782a	0.688a
$LSD_{(0.05)}$		**0.75**	**0.22**	**0.07**	**0.06**	**0.003**	**0.001**
The interaction (A*B)		**	**	**	**	**	**
Irrigation Levels	**Potassium silicate (mg/l)**						
85 %	Control	274.59	202.49	29.13	27.09	0.440	0.351
	500	247.13	182.23	32.37	30.10	0.473	0.390
	1000	222.42	164.01	35.97	33.45	0.509	0.433
	1500	200.19	147.61	39.96	37.17	0.547	0.481
70 %	Control	261.03	226.48	31.33	29.13	0.670	0.502
	500	234.92	203.83	34.81	32.37	0.706	0.557
	1000	211.43	183.45	38.68	35.97	0.743	0.619
	1500	190.29	165.10	42.97	39.96	0.782	0.688
55 %	Control	243.53	242.75	33.81	31.44	0.696	0.555
	500	219.17	218.48	37.57	34.93	0.749	0.617
	1000	197.26	196.63	41.74	38.82	0.805	0.686
	1500	175.53	176.97	46.38	43.13	0.865	0.761
40 %	Control	217.73	255.37	38.42	35.73	0.742	0.598
	500	195.95	229.83	42.69	39.70	0.798	0.665
	1000	176.36	206.85	47.43	44.12	0.868	0.739
	1500	158.72	186.16	52.71	49.02	0.933	0.821
$LSD_{(0.05)}$		**0.87**	**0.25**	**0.08**	**0.07**	**0.004**	**2.39**

- Irrigation level: irrigation after depletion of 40 %, 55%, 70% and 85% available soil water. Means followed by the same letter within each column are not significant different at 0.05 level of probability.

*** Denotes significant at 0.01 level of probability.*

CONCLUSION

The results can recommend that spraying the Giza 6 variety of peanut crop with potassium silicate at 1500 mg/l silicate four times as applied after (35, 45, 55 and 65 days from planting) to alleviate deleterious impacts of drought stress and irrigation after depletion of 55% available soil water to save water under water deficit conditions at South Tahrir El-Beheira Governorate as this combination has a significant effect and obtained high yield and its components under this study conditions and the similar conditions areas.

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الملخص العربي

استخدام سيليكات البوتاسيوم لتخفيف تأثير إجهاد الجفاف على الفول السوداني المنزرع في الأراضي الرملية

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الفول السوداني أحد أهم المحاصيل الزيتية والبروتينية الهامة، حيث يحتوي علي حوالي ٤٠:٥٠٪ زيت، ٢٥:٣٠٪ بروتين، ٢٠٪ كربوهيدرات، ٥٪ ألياف وأملاح. في مصر، يزرع علي نطاق واسع في التربة الرملية المستصلحة حديثاً. لذلك، إنه من الأهمية تحسين الإنتاجية وتخفيف الإجهادات البيئية التي تسبب إنخفاض في جودة وإنتاجية محصول الفول السوداني. ويعتبر إجهاد الجفاف أحد أهم الإجهادات البيئية التي تقلل من إنتاجية ومحصول الفول السوداني المنزرع في الأراضي المستصلحة حديثاً بمصر.

تم إجراء تجربتان حقليتان في مزرعة بمنطقة عبد المنعم رياض، جنوب التحرير، محافظة البحيرة، مصر، خلال موسمي الزراعة الصيفي (٢٠١٧ و ٢٠١٨) في تصميم القطع المنشقة بثلاث مكررات لكل معاملة لدراسة تخفيف إجهاد الجفاف علي الفول السوداني المنزرع في الأراضي الرملية عن طريق الرش الورقي بسيليكات البوتاسيوم. تم توزيع مستويات الري في القطع الرئيسية الري بعد إستنفاذ (٤٠٪ و ٥٥٪ و ٧٠٪ و ٨٥٪) من الماء الميسر، بينما خصصت القطع المنشقة لأربعة تركيزات من الرش الورقي بسيليكات البوتاسيوم (الكنترول و ٥٠٠ و ١٠٠٠ و ١٥٠٠ ملجم / لتر سيليكات).

ويمكن تلخيص اهم النتائج فيما يلي :

سجل الري بعد استنفاذ ٥٥٪ من الماء الميسر أعلي القيم في (وزن ١٠٠ قرن (جم)، عدد القرون/ نبات ، محصول القرون (كجم/ فدان)، محصول القش (كجم/ فدان) والمحصول البيولوجي (كجم/ فدان)، بينما سجل الري بعد استنفاذ ٤٠٪ من الماء الميسر إلى زيادة معنويه في دليل الحصاد (٪) ومحتوي الزيت (٪)، أيضاً سجل الري بعد استنفاذ ٨٥٪ من الماء الميسر أعلي القيم في محتوي البرولين (مجم/ جم) و كفاءة إستخدام المياه (كجم/ م٣) خلال الموسمين.

سجل الرش الورقي بسيليكات البوتاسيوم عند ١٥٠٠ ملجم/لتر سيليكات أعلى متوسط قيم في (وزن ١٠٠ قرن (جم)، عدد القرون/ نبات، محصول القرون (كجم/ فدان)، محصول القش (كجم/ فدان) والمحصول البيولوجي (كجم/ فدان)، محتوى الزيت (٪)، كفاءة إستخدام المياه (كجم/ م٣)، مقارنة بمعاملة الكنترول التي سجلت أقل القيم خلال الموسمين، بينما سجلت معاملة الكنترول أعلي القيم لدليل الحصاد (٪)، البرولين (مجم/ جم)، مقارنة مع معاملة ١٥٠٠ ملجم/ لتر سيليكات التي سجلت أقل القيم خلال الموسمين. كان التداخل بين مستويات الري وتركيز سيليكات البوتاسيوم معنوياً على (وزن ١٠٠ بذرة ، وزن ١٠٠ قرن (جم)، عدد القرون/ نبات ، محصول القرون (كجم/ فدان)، وعالى المعنوية لمحصول القش (كجم / فدان) والمحصول البيولوجي (كجم/ فدان)، محتوى البرولين (مجم/ جم)، محتوي الزيت (٪)، كفاءة إستخدام المياه (كجم/ م٣) خلال الموسمين ، كما لم يكن معنويا في دليل الحصاد (٪)، خلال الموسمين.

ختاماً، تشيرهذه الدراسة إلى أن سيليكات البوتاسيوم لها فاعلية في تخفيف الآثارالضارة للجفاف على محصول الفول السوداني المنزرع في الأراضي الرملية.

التوصية:

يوصي البحث برش محصول الفول السوداني صنف جيزة ٦ بسيليكات البوتاسيوم بتركيز ١٥٠٠ ملجم/ لتر سيليكات أربع مرات بعد ٣٥ و ٤٥ و ٥٥ و ٦٥ يوم من الزراعة لتخفيف الآثار الضارة للجفاف والري بعد استنفاذ ٥٥٪ من الماء الميسر لترشيد استهلاك المياه تحت ظروف نقص المياه حيث أن هذه التوليفه ذات تأثير معنوي علي المحصول ومكوناته تحت ظروف منطقة الدراسة والمناطق المماثلة.