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Impact of Foliar Application of Silicon and Selenium on Growth Characters, Yield, Physicochemical Characters, Oil Ingredients of Peanut (*Arachis hypogaea L.)* Variety Giza 6 under Different Planting Dates

Ahmed Khalaf[1*], Mohamed Sh. Hassan[2], Hamady A. Ismaeil[2] and Ahmed Awny[1]

[1]Central Laboratory for Agricultural Climate, Agriculture Research Center (ARC), Egypt.
[2]Department of Agriculture Chemistry, Faculty of Agriculture, Minia University, Egypt.

Authors' contributions

This work was carried out in collaboration among all authors. Author AK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MSH and HAI managed the analyses of the study. Author AA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at the Agricultural Research Center in Upper Egypt 2016-2017. We were aiming to see the effect of spraying Si (100 ppm) and Se (50 ppm) 4 times under different planting on productivity and oil quality oil variety Giza 6 under different planting dates. In this research; Si and Se with early sowing (1May) applications produced significant increases Length and branching, Attributes of productivity, oil quality of variety Giza 6.Results show that oil content ranged from 55.48% to 60.10%, The percentage of oil decreases with the delay of planting dates. There is a variation in the refractive index (1.464-1.468) with different dates or Si and Se. The acidity rate increases with the delay of cultivation. The peroxide value decreases with the first reset. And lower iodine number with first replant It contains Oleic (55.49- 60.05%). The oleic is

**Corresponding author: Email: ahmedclacarc9@gmail.com;*

reduced with delay in planting, while linoleic increases with the delay of planting and spraying with silicon and selenium. The highest value of O/L ratio was with early implantation and spraying with silicon and selenium. Unsaturated fatty acids exceed saturated fatty acids with silicon and selenium spray.

Keywords: Peanut; silicon; selenium; fatty acids.

1. INTRODUCTION

Peanut seeds contain 45-56% oil and 20-24% protein and 9.5-13.0% carbohydrate. Peanuts are an excellent source of oil for vitamins, proteins and food [1]. Silicon is an important component of plants. It Compensators 8.7% of the total oil production in the world. Belonging to Fabaceae family, is a legume native to South America but now cultivated in diverse environmental and agro-climatic conditions in six continents between latitudes 45ºN and 35ºS [2].

Silicon plays an important role in increasing productivity. Improves the reception of leaves to light, and it resists diseases, insects and different pressures. Silicon is applied to improve plant growth and yield, in particular, under stress conditions [3]. Several functions have been attributed to silicon: improvement of nutrient imbalance, reduction of mineral toxicities, improvement of mechanical properties of plant tissues and enhancement of resistance to other various abiotic (salt, metal toxicity, nutrient imbalance, and increases the resistance of the plant to high temperatures, cold and frost and biotic stresses [4].

Selenium is a sulfur-like component. Selenium is an essential micronutrient and has important benefits for plants nutrition Selenium (Se) is beneficial for plant growth particularly under stress conditions [5]. Se protects plants from various stress factors particularly drought, salinity and UV radiation [6]. Silicon nutrition improves light receiving posture of the plants thereby stimulates photosynthetic production capacity in plants [7].

Both silicon and selenium increase the growth of different plants under different climatic conditions [8]. Adatia and Besford [9] Reported that addition of silicon (100 mg/l) increased chlorophyll content, root fresh as well as dry weight and RuBP carboxylase in cucumber plants. Silicon increases crop productivity and improves crop quality while the lack of this element can reduce the plant's biological ability to withstand adverse environmental conditions [10]. Accumulation of silicon occurs in regions of maximum transpiration such as leaf epidermis near the stomatal guard cells, trichomes and thorns which mitigates the adverse effects of abiotic and biotic stresses [11]. This type of silicon fertilizer can easily penetrate the leaves and can form a thick silicate layer on the leaf surface. Research importance Overcome unsuitable conditions for peanuts using silicone spray and selenium to reduce losses and compensate for delays in agriculture.

2. MATERIALS AND METHODS

The experiment was carried out at the Agricultural Research Center in Upper Egypt 2016-2017 and the experiment was divided into complete randomized sectors and included three replicates and planted with three dates for planting potassium silicate spray 100 parts per million and sodium selenite parts per million and sprayed for a quarter of times after 40 days of cultivation and spraying every 15 days in a row Sprayed Knapsack with sprayer between 10.00 am and 2.00 pm. Water volume was estimated according to the growth stage of peanut plant to be 120, 130, 140 and 150 Liter/Fadden, sprayings schedule was started 30 days after planting (before first flower).

The plant length, branching, production characteristics and oil quality were measured by the oil components of the fatty acids

Content and physicochemical properties of peanut oil:

The oil percentage was estimated by the soxhlet device

Acidity, peroxide number and refractive index were estimated using the method [12]. Calculate the iodine number from fatty acids [13]. Iodine value= (% linoleic acid × 1.7321) + (% oleic acid × 0.8601) + (% eicosenoic acid × 0.7854).

2.1 Fatty Acid Composition

Determination of fatty acids [14]. The fatty acids of oils investigation were converted into their methyl esters according to the method of Rafi MM, et al. [10] as follows: 100 mg oil was placed

in conical flask attached to reflex condenser, 10 ml methanol was added by 0.5 ml 1 N methanolic potassium hydroxide solution, and reflexed for 10 min. the mixture was transferred to using 15 ml n-Heptane and 10 ml saturated sodium chloride solution was added, the lower layer was extracted with 10 ml n- Heptane and the compined organic layer were washed with water dried over anhydrous sodium sulphate Na_2SO_4 and filtterd. A suitable portion of filtrate was introduce into gas chromatography.

2.2 Statistical Analysis

The plant length, branching, production characteristics and oil quality of the oil components of the fatty acids statistically analyzed of (ANOVA) [15].

3. RESULTS

The results show that there is a difference in the length of the plants the height of the plants increased with the cultivation in the first planting, And decreased by the last planting date And the height of the plants by spraying with silicon exceeded the selenium, especially agriculture in the last planting The number of branches also increased with early cultivation and with silicon and selenium spraying.

On the other hand, results show that number0 of Pods per plant, 100-seed weight (g), Pods per plant (g) as well as Pod yield (Kg) fed were the lowest values at later sowing date (1 June) when compared with early or optimal planting dates (1May or 16May).

Results also show that early sowing produced 10.15% and 19.12% greater dry matter (Kg fedan) yield and 10.68% and 21.33% greater pod yields Pod yield (Kg fedan).than that of optimal or late sowing dates, respectively. The positive effects of Si or Se applications increased significantly dry matter (Kg fedan) in two seasons.

3.1 Oil Content and Physicochemical Characters

The oil content and its physicochemical characters are presented in Table 2 Results show that the oil contents values of peanut variety Giza 6 ranged from 55.48% to 60.10%. The highest content (60.10%) was produced in seeds of plants sown early (1 May) and sprayed with Si, followed by plants sown early and sprayed with Se (59.20%).

The lowest oil content (55.48%) were found in seeds of plants sown late (1 June). Such results are comparable to these reported by William, [40] who reported that The maximum oil content (58%) was achieved in the early planting and oil content tended to decline (42%) in late planting.

Results presented in Table 2 show that no significant differences in IR (1.464-1.468) was found to be present among all planting dates or mineral treatment in two seasons. However, other parameters i.e., acidity value, peroxide value and Iodine value were found to be statistically different. The highest acidity (1.30) was found in oils of plants sown late (1 June), while the lowest value (0.29) was found in plants sown early (1 May) and sprayed with Silicon. Peroxide value (3.50 m $Eq.O_2$/kg) was found in oils of plants sown late, and (0.55 m $Eq.O_2$/kg) in oil of plants sown early and received Si application.

However, Se applications seemed to reduce Peroxide value significantly in oils of plants sown late. Iodine value was found to be higher (99.68) in oils of plants sown late and sprayed with Se. IV were statistically different in other treatment where oils of plants sown early (1 May) had the lowest values (88.00). Our results are comparable to other investigations:

Data presented in Tables 3 and 4 show the effect of Silicon and Selenium under different planting dates on oil contents of peanut, saturated and unsaturated fatty acids. Results show that peanut oil of Giza 6 variety contained oleic acid a major monounsaturated fatty acids (55.49-60.05%) and Palmitic acid as major saturated fatty acids (9.00-11.90%) peanut seed oil contains 50.98%,29.53% and 10.10% (as average) of oleic (C18:1), linoleic C18:2 and Palmitic C16:0 respectively, These fatty acids represented ca 90.61 of total fatty acids. The distribution of other fatty acids is as follows: Stearic (2.44%), Arachidic (1.26%), Behenic (2.02%) and Caproic acid (1.39) representing total saturated fatty acids. On the other hand, results show that planting date and mineral treatment (Si and Se) affected significantly the levels of all fatty acids. Moreover, oils of plants sown early and sprayed with Se produced the highest values of oleic acid (50.10%) while the lowest value was obtained in oils of plants sown date (49.49%). Concerning linoleic acid, the highest value was found in plants sown

Table 1. Effect of Silicon and Selenium under different planting dates on growth characters of peanut seeds (variety Giza 6)

Planting date	Treatment	Plant height (cm)		No. of branches /plant		No of Pods per plant		100-seed weight (g)		Pods per plant (g)		Pod yield Kg fed		dry matter Kg fed	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
1 May	Control	40.10 g	40.50 f	7.50 e	7.80 e	40.00 f	41.31 f	76.00 e	76.54 e	80.12 f	80.64 e	2325 e	2337 e	1048 f	1062 e
	Silicon	48.00 a	48.60 a	9.43 a	9.80 a	58.64 a	58.11 a	95.20 a	94.86 a	109.8 a	110.3 a	2740 a	2722 a	1272 a	1255 a
	Selenium	44.30 c	45.00 b	8.86 b	9.25 b	51.43 b	50.88 b	90.60 b	90.17 b	101.6 b	102.2 b	2668 b	2629 b	1207 b	1186 b
16 May	Control	37.30 h	36.80 h	6.70 g	6.95 g	31.25 h	30.55 h	60.62 h	61.05 h	65.75 j	66.12 h	2134 g	2088 g	0950 h	960 g
	Silicon	45.00 b	44.50 c	8.33 c	8.60 c	49.61 c	50.05 c	83.73 c	84.21 c	88.56 d	88.09 c	2469 c	2443 c	1168 c	1180 b
	Selenium	43.20 e	42.70 d	7.68 d	7.88 d	44.72 d	45.16 d	81.19 d	81.73 d	82.72 e	83.14 d	2381 d	2349 d	1105 d	1119 c
1 June	Control	34.20 l	33.70 i	5.80 l	6.00 i	23.50 i	22.94 l	48.88 l	49.58 l	51.43 l	50.84 l	1920 l	1882 l	876 i	862 h
	Silicon	42.40 d	41.80 e	7.05 f	7.40 f	41.23 e	41.76 e	72.65 f	73.00 f	73.78 h	74.27 f	2146 f	2115 f	1061 e	1076 d
	Selenium	39.20 f	39.60 d	6.52 h	6.87 h	35.64 g	36.00 g	70.16 g	70.65 g	67.41 i	66.92 g	2066 h	2027 h	1004 g	1025 f
Average		41.86	41.47	7.54	7.84	41.78	41.86	75.45	75.75	80.13	80.28	2316.5	2288	1076.78	1080.56
L.S.D 0.05		0.03870	0.01224	0.01224	0.01224	0.1135	0.01224	0.1479	0.3329	0.0201	0.09481	4.327	2.460	0.01224	6.605

Within each column, Means of each variable having different liters are significant different at the level of probability, according to L.S.D test

Table 2. Effect of Silicon and Selenium under different planting dates on Physical properties of peanut oils (variety Giza 6)

Planting Date	Treatment	Oil %		Refractive Index		Acidity		Peroxide value		Iodine value	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
1 May	Control	58.00 d	58.12 d	01.466 a	1.466 a	0.65 cde	0.63 bc	2.63 c	2.43 c	88.00 i	89.60 g
	Silicon	60.00 a	60.10 a	1.468 a	1.468 a	0.39 e	0.29 c	0.74 a	0.55 a	96.60 d	96.00 d
	Selenium	59.20 b	59.11 b	1.467 a	1.468 a	0.43 de	0.48 bc	0.80 g	0.77 h	95.75 g	94.85 e
16 May	Control	56.50 h	56.40 h	1.465 a	1.466 a	1.04 b	0.86 ab	2.64 c	2.75 b	95.88 f	95.00 e
	Silicon	58.85 c	58.68 c	1.466 a	1.466 a	0.60 cde	0.63 bc	1.80 d	1.64 e	97.38 c	98.34 b
	Selenium	57.62 e	57.51 e	1.468 a	1.467 a	0.66 cd	0.47 bc	1.20 e	1.23 f	98.62 a	99.68 a
1 June	Control	55.48 i	55.50 i	1.464 a	1.465 a	1.30 a	1.14 a	3.33 a	3.50 a	94.76 h	93.83 f
	Silicon	57.28 f	57.30 f	1.466 a	1.466 a	0.46 de	0.44 bc	0.94 f	0.86 g	98.14 b	97.17 c
	Selenium	56.57 g	56.46 g	1.465 a	1.466 a	0.76 c	0.70 abc	2.82 b	1.97 d	96.07 e	94.82 e
Average		57.72	57.68	1.4661	1.4664	0.69	0.63	1.88	1.74	95.68	95.47
L.S.D 0.05		0.03057	0.05474	0.01224	0.01224	0.2386	0.4644	0.01224	0.03352	0.03631	0.2448

Within each column, Means of each variable having different liters are significant different at the level of probability, according to L.S.D test

Table 3. Effect of Silicon and Selenium under different planting dates on the saturated fatty acids composition of peanut oil (variety Giza 6) average of two seasons

Planting Date	Treatment	Palmitic acid (%)	Stearic acid (%)	Arachidic acid (%)	Behenic acid (%)	Caproic acid (%)
1 May	Control	11.90 a	03.12 a	01.20 d	02.84 a	01.18 ef
	Silicon	09.69 d	03.02 b	01.36 b	02.19 d	01.30 d
	Selenium	10.66 b	02.12 f	01.12 e	02.46 c	01.62 b
16 May	Control	10.12 c	02.41 d	01.31 c	02.59 b	01.29 d
	Silicon	09.00 f	02.10 g	01.30 c	01.75 f	01.17 f
	Selenium	09.01 f	02.00 h	01.03 f	01.24 h	01.21 e
1 June	Control	11.70 a	02.55 c	01.20 d	02.13 e	01.69 a
	Silicon	09.30 ef	02.31 e	01.42 a	01.47 g	01.51 c
	Selenium	09.56 de	02.31 e	01.41 a	01.48 g	01.61 b
Average		10.10	2.44	1.26	2.02	1.39
L.S.D 0.05		0.3418	0.01224	0.03057	0.02998	0.03622

Within each column, Means of each variable having different liters are significant different at the level of probability, according to L.S.D test

Table 4. Effect of Silicon and Selenium under different planting dates on oil content, unsaturated fatty acids composition of peanut oil (variety Giza 6) average of two seasons

Planting Date	Treatment	Oil content (%)	Oleic acid (%)	Linoleic acid (%)	O/L** ratio	Iodine value
1 May	Control	58.06 d	47.64 i	27.21 c	01.75 c	88.80 h
	Silicon	60.05 a	50.17 f	30.26 i	01.66 f	96.30 a
	Selenium	59.15 b	50.10 g	29.70 e	01.69 e	95.30 f
16 May	Control	56.45 g	51.10 e	29.40 g	01.74 c	95.44 d
	Silicon	58.76 c	53.07 d	29.90 d	01.77 b	97.91 b
	Selenium	57.56 e	53.20 a	30.48 a	01.74 c	99.15 a
1 June	Control	55.49 h	49.49 h	29.59 f	01.67 f	94.38 g
	Silicon	57.29 f	52.00 d	30.28 b	01.72 d	97.72 c
	Selenium	56.51 g	52.07 c	29.01 h	01.79 a	95.51 e
Average		57.70	50.98	29.53	1.72	95.61
L.S.D 0.05		0.1135	0.01224	0.06241	0.01224	0.06241

Within each column, Means of each variable having different liters are significant different at the level of probability, according to L.S.D test

late and sprayed with Si (30.28%). Results also show that early planting date (1 May) produced the highest percentages of Palmitic acid (09.69-11.90%) while the lowest was found in late sowing (9.30-11.70%).

Data presented in Table 5 show the effect of Silicon and Selenium under different planting dates on the fatty acid profile of peanut oil. The saturated fatty acids percent (17.21%) in peanut oil was strongly affected by planting dates and mineral treatments. Similar results were obtained for the percent of unsaturated fatty acids (82.35%). also results show that UFAs/ SFAs were affected significantly by these treatments (3.79-5.90).However, PUFAs to SFAs mean ratio recommended by the British Department of Health is more than 0.45 [16]. It is worth to note that linoleic acid (L) having two double bonds is more susceptible to oxidative than oleic acid (O) having one double bond. Hence, the oil containing higher MUFAs/ PUFAs ratio may be recommended nutritional supplements for better health. However, our results show that the highest O/L ratios and accompanied with lower IVs were obtained in oils of plants sown early and sprayed with either Si or Se(01.66-1.75 O/L and 88.80-96.30 IV) the opposite was true with oils of plants sown late (01.67-01.79 O/L and 94.38-97.72 IV).

4. DISCUSSION

Lower pod production may be due to reduced growth and exposure of plants to warmer and longer photoperiod (long day) after the late planting date [17]. Si or Se foliar applications improved the previous parameters and increased significantly dry matter production [18]. The obtained results are in accordance with the

Table 5. Effect of Silicon and Selenium under different planting dates on the fatty acid profile of peanut oil Giza 6 (two years average)

Planting Date	Treatment	SFAs (%)	UFAs (%)	MUFAs (%)	PUFAs (%)	UFAs/ SFAs	MUFAs/ PUFAs
1 May	Control	20.24 a	76.71 i	48.76 i	27.95 d	3.79 h	1.74 e
	Silicon	17.56 e	82.49 e	51.56 g	30.93 a	4.70 e	1.66 e
	Selenium	17.98 c	82.02 g	51.68 f	30.34 b	4.56 f	1.70 d
16 May	Control	17.72 d	82.28 f	52.13 e	30.15 h	4.64 e	1.73 ab
	Silicon	15.32 h	84.68 b	54.08 b	30.60 e	5.53 b	1.77 a
	Selenium	14.49 i	85.51 a	54.42 a	31.09 c	5.90 a	1.75 a
1 June	Control	19.27 b	80.73 h	50.52 h	30.21 g	4.19 g	1.67 c
	Silicon	16.01 g	83.99 c	52.99 d	31.00 d	5.25 c	1.71 bc
	Selenium	16.37 f	82.73 d	53.13 c	29.60 f	5.05 d	1.79 ab
Average		17.21	82.35	52.14	30.20	4.845	1.724
L.S.D 0.05		0.06235	0.1848	0.01682	0.01565	0.06428	0.03462

Within each column, Means of each variable having different liters are significant different at the level of probability, according to L.S.D test

findings of other researchers: yield of peanut [19] the number of seeds in the pods and 100-seed weight [20]. Stern [21] suggested that declining minimum temperatures in later plantings may have retarded or even prevented pod development. [22] Reported that use of silicon enhances the growth of plants under drought conditions by maintaining high leaf area, it ensures high assimilatory capability and thickening of the leaves which are beneficial to reduce transpiration and improves yield. [23] found that increase in silicon leads to increase in leaf area index, specific leaf weight, chlorophyll content, root and leaf dry weight and decrease in leaf water potential and shoot to root ratio in plants as compared to control. In this concern [36] reported that Silicon applications increases nitrogen and phosphorus in pods and Straw which results in increased in dry matter and yield. Harris, et al. [24] mentioned that high temperature during the development of the seed was associated with a reduction in total oil yield. However, under field conditions this effect was variable owing to confounding with other environmental factors such as moisture stress, which also influence the yield of oil through their effects on growth and development of seed. [25] found that silicon treatment improves dry matter, chlorophyll content, relative water content, dry matter and growth rate of crops under drought stress. Silicon increased dry weight, height of the plant and Increase in the leaf area enhances photosynthetic rate of the plants [26]. Weekly application of foliar spray (50-100mg/l) of sodium silicate on Gerbera jamesonii increased number of flowers, plant height and diameter [27]. The implementation of potassium metasilicate (200 mg/l) in plants resulted the increase in plant height and shoot dry matter [28]

The maximum oil content was achieved in the early planting and oil content tended to decline in late planting [29].

Acid values from 0.3 to 1.4 and Peroxide value ranged from 0.6 to 4.2 m Eq.O_2/kg [30, 31, 32] refractive index of other varieties did not significantly varieties [33, 34, 35, 36].iodine value of peanut varieties varies 98.83 to 105.3[37]. It is worth to note that the variation of different iodine value in different seasons due to variation of oleic and linoleic acids in oils. Silicon can mitigate the adverse impact of environmental stress in plants by decreasing plasma membrane permeability, lipid peroxidation and by maintaining the plasma membrane integrity and function [38].

Higher O/L ratio and lower IVs indicate the better oil stability and longer shelf life [39]. It has also increased citric and malic acids and fatty acids content in glycolipids and phospholipids as well as more membrane lipids were also observed [40].

5. CONCLUSION

The results showed that silicon and selenium spraying with the early date of cultivation gave the highest plant height and an increase in branching and an increase in the production characteristics of peanuts in Giza 6 compared to later cultivation and also found that acidity and peroxide decreased with spraying with silicon and selenium and increased iodine and oleic

acid and unsaturated fatty acids compared to not spraying.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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