Effect of the foliar application of Silicon and Selenium on growth characters, yield, physicochemical characters, fatty acid composition of peanut oil (*Arachis hypogaea* L.) variety Giza 6 under different planting dates

Abstract

This study was field experiments were conducted at Shandweel Form (Sohage governorate, Egypt) in 2016 and 2017. The objective of this study was to determinate the effect of spraying Si (100 ppm) and Se (50 ppm) 4 times under different planting dates on the growth characters and yield as well as the physico-chemical characters and Fatty acids compositions of peanut oil variety Giza 6 under different planting dates. In this research; Si and Se with early sowing (1May) applications produced significant increases plant height, no. of branches /plant, no. of Pods / plant, 100-seed weight (g), Pods / plant (g), Pod yield (Kg fed) and dry matter. Characteristics and fatty acids composition of variety Giza 6.Results show that oil content ranged from 55.48% to 60.10%, the lowest oil content was found in seeds of plants sown late. No significant differences in RI (1.464-1.468) were found among plant dates or mineral treatments. The highest acidity (1.30%) was found in plants sown late. Se application reduced the peroxide values in oils of plants sown late. The lowest IV was obtained in oils of plants sown early (88.0).Oil contained oleic acid as a major MUSFs (55.49-60.05%) and Palmitic acid as a major SFAs. The lowest value of oleic acid was obtained in plants sown late, while the highest value of linoleic acid was produced in plants sown late and sprayed with Si or Se. The highest O/L ratio which accompanied with lower IV were obtained in oils of plants sown early and sprayed with either Si or Se (1.75-1.69 O/L ratio and 88.80-96.30 IV)**.**

Key words: Peanut, Silicon, Selenium, Fatty acids.

1.0. Introduction

Peanut seeds contain 45-56% oil and 20-24% protein and 9.5-13.0% carbohydrate. In addition, they are a good source of mineral and vitamins. For this reason, it is an important source of edible oil and protein for human nutrition (**Chowdhury et al., 2015)**. Peanut (Arachis hypogaea L.) is an important oilseed crop for vegetable oil production. It contributes 8.7% of the total oil seeds production in the world. Peanut (*Arachis hypogaea* L.) 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 45°N and 35°S (**panhwar et al.,(2005).**

Silicon has been considered as beneficial element for the plants. The supplementation of silicon as nutrient to the plants may play a significant role which includes increase in crop growth and yield, improvement of leaf exposure to light, decreased susceptibility to pathogens and pests and amelioration to abiotic and biotic stresses. Silicon is applied to improve plant growth and yield, in particular, under stress conditions **(Hattori *et al.*, 2005).** Several functions have been attributed to silicon:

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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, lodging, drought, radiation, high temperature, freezing, UV) and biotic stresses **(Ma and Yamaji, 2006).**
The element selenium (Se) is chemically similar to sulfur (S), and as a result, plants and other organisms readily take up and metabolize Se via S transporters and pathways. Selenium is an essential micronutrient and has important benefits for plants nutrition Selenium (Se) is beneficial for plant growth particularly under stress conditions **(Feng et al. 2013).)**Se protects plants from various stress factors particularly drought, salinity and UV radiation (**Hajiboland 2012, Feng et al. 2013).**
The beneficial elements as Silicon and Selenium promote growth of various plant species under certain environmental conditions, their function and concentration varies for plant species (**Pilon-Smits et al. 2009).**

2.0. Materials and methods

This experiment was conducted in 2016 and 2017 at the Agriculture Research Center in Shandaweel (Sohage governorate, Egypt), using peanut seeds **(*Arachis hypogaea* L.) variety Giza 6.** A split plots design with three replications was used, three sowing dates (1May, 16 May and 1June) were assigned. Spraying of Silicon on leaves surface was as potassium silicate at rate 100 ppm while Selenium was sprayed as Sodium selenite at rage 50 ppm. Solution were sprayed 4times in the morning in the following growth periods: Control (top water),before flowering, 20 days, 40 days, 60 days after flowering. At harvesting stage, Plant height (cm), no. of branches /plant, no of Pods per plant, 100-seed weight (g), Pods per plant (g), Pod yield (Kg fed) and dry matter (Kg fed) were determined. The actual harvest time for each sowing date is after yellowing of leaves and some of them fall off.
Content and physicochemical properties of peanut oil:
Extraction of the oil was done by soxhlet apparatus using n-hexane as solvent. Refractive index (IR), Acidity and Peroxide value (PV) were determined according to the methods described in **A.O.A.C. (2005).**the Iodine value (IV) was calculated from fatty acids composition **(Chaiyadee. et.al. (2013).using the following formula:** IV= (% oleic acid × 0.8601) + (% linoleic acid × 1.7321) + (% eicosenoic acid × 0.7854).

2.1.Fatty acid composition:

Results were expressed as the percentage of each fatty acid with respect to the total fatty acids. Fatty acids composition, were determined by using Fatty acid methyl esters were prepared according to **AOCS (1989).**Fatty acids were converted into their methyl esters according to the method of **British Pharmacopoeia (2000)**. The fatty acids methyl esters were analyzed by gas chromatography PRO-GC. Packed column was used SP-2310, 55% Cyanopropyl phenyl Silicon Dimentio: 1.5X4mm.detector and injector temperatures were 250°C and 300 °C respectively.

2.2. Statistical analysis:

➢ **Growth characters :-** Growth characters, Physical Properties and Fatty acids composition were statistically analyzed according to technique of analysis of variance (ANOVA) for the split plot design by means of "MSTAT-C" computer software package and least significant differences (L.S.D.) between treatment means at 5% level of probability by **Gomez and Gomez (1984).**

3.0. Results and Discussions

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The average belonging to Plant height (cm), no. of branches /plant, numbero of Pods per plant, 100-seed weight (g), Pods per plant (g), Pod yield (Kg fed) and dry matter (Kg fed) have been presented in table (1).

Results show that there were significant differences in Plant height in two seasons, where early sowing resulted in higher Plant height, however, and such character was continuously decreased with delaying of planting date.itdate. It is worth to note that Si or Se foliar applications enhanced Plant height, Si application seemed to be more beneficial than Se application especially of late sowing (1June).Results also show that the highest no. of branches /plant(7.5-9.43)was produced in plants sown early(1May) while the least no. of branches /plant was related to late date 1June (5.80-7.40).However, Si or Se applications for both early or late planting dates resulted in significant and pronounced increases of no. of branches /plant.

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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

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On the other hand, results show that numbere 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 (1June) when compared with early or optimal planting dates (1May or 16May). 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 **(Caliskan, et al., 2008).** Si or Se foliar applications improved the previous parameters and increased significantly dry matter production **(Djanaguiraman et al., 2011).** The obtained results are in accordance with the findings of other researchers: yield of peanut (Hu et al., 2016) the number of seeds in the pods **(Li., 2015)** and 100-seed weight **(Irmak. 2017).**

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. In this concern **Singh et al., (2006)** reported that Silicon applications increases nitrogen and phosphorus in pods and Straw which results in increased in dry matter and yield.

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 (1May) 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(1June).Such results are comparable to these reported by William,(1984) 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 refractive index 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 (1June), while the lowest value (0.29) was found in plants sown early (1May) 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. .

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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.

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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 (1May) had the lowest values (88.00). Oeur results are comparable to other investigations: acid values **(Ethel et al., (2004), Shad et al., (2012), Farhan et al., (2015),**refractive index of other varieties did not significantly varieties (**Arya et al., 1969,Atasie et al., 2009,Brein et al., 2009 and Farhan et al., 2015).**Peroxide value: **(Ethel et al., (2004)** ranged from 0.6 to 4.2 m Eq.O_2/kg , **Shad et al., (2012)** reporting 3.58 and **Farhan et al., (2015**) reporting 2.5 and 3.5 m Eq.O_2/kg. **Chowdhury et al. (2015**) reported that iodine value of peanut varieties varies 98.83 to 105.3. **Bezard (1986)** reported 87 to107 and **Farhan et al., (2015)** reported 91.96-93.45.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.

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

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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

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

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 **(Wood et al., 2008).** 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. Higher O/L ratio and lower IVs indicate the better oil stability and longer shelf life **(Ahmed and Young, 1982).**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),**(Shad et al.,2012).**

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