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Response of Soybean Varieties to Silicon Foliar Spraying under Different Sowing Dates

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Abstract: A field experiment designed in the split-split plot design with three replicates was conducted at the research farm of Etay El-Baroud Agricultural Research Station, Agricultural Research Center, El-Beheira Governorate, Egypt, during the 2018 and 2019 seasons to evaluate the role of spraying soybean with three silicon concentrations, (50, 100 and 200 ppm) compared with the control (distillated water), on increase growth and seed yield of the three soybean varieties Giza 111, Line 105 and D 89-8940 under the three sowing dates of 1st May, 20th May and 10th June. Results confirmed that the three soybean cultivars differ in their response to silicon concentrations under the three sowing dates for all growth, seed yield and its components and leaf and seed chemical properties during the two seasons of the study. Sowing in 1stMay showed the highest plant height, branches number/plant, pods number/plant and seed content of silicon as well as leaf contents of total chlorophyll, nitrogen, phosphor and potassium. Moreover, sowing in 20th of May had the highest seed yield/fad and oil percentage. Giza 111 cv was the earliest among all tested cultivars in both seasons. Line 105 had the highest plant height and seed content of oil. D89-8940 had the highest branches number/plant, leaf contents of total chlorophyll, nitrogen, phosphor and potassium as well as seed yield/ faddan in both seasons. Results showed that spraying with the highest concentrations of silicon (200 ppm) scored the highest; plant height, branches number/plant, leaf content of; total chlorophyll, nitrogen, phosphor and potassium in addition to the highest; pods number/plant, 100-seed weight, seed yield/fad, seed content of silicon and oil percentage in both seasons. Giza 111 that sowing in 10th June under the control treatment had the lowest number of days to maturity, also, Giza 111 cv that spraying with 200 ppm of silicon in the early sowing date (1st May gave the highest pods number/plant, seed yield/fad in the first and second seasons. While, line 105 that sprayed with 200 ppm of silicon in the early sowing date (1st May) gave the highest plant height in both seasons. Also, line 105 that sprayed with 200 ppm of silicon in the recommended sowing date (20th May) had the highest seed content of oil in both seasons. D89-8940 that sprayed with 200 ppm of silicon in the early sowing date (1st May) showed the highest number of branches/plant, leaf contents of; total chlorophyll nitrogen, phosphor and potassium as well as the highest seed content of silicon in both seasons. It could be recommended to cultivate Giza 111 cv. form 1st May to 20th May with spraying 200 ppm of silicon to improve seed yield and its quality of soybean. In the late sowing date (10th June) spraying D89-8940 200 ppm of silicon cultivar was more suitable than both Giza 111 and Line 105 to maximized soybean yield.

Key words: Soybean · 5Sowing Dates · Silicon Levels · Growth and Yield Traits

INTRODUCTION

Soybeans [*Glycine max* (L.) Merrill] is one of the most important legume crops in the world, due to its great nutritional capabilities, as seeds contain about 20% vegetable oil and 40% protein [1]. The cultivated area of soybeans in Egypt was about 14, 000 hectares in 2019 [2]. As all field crops, soybeans are severely affected by climatic factors such as temperature and humidity. The problem of climate change has gained a great global completion in the last two decades because of its great danger to many economic sectors, including agriculture, which is strongly affected by changes in temperature, precipitation and humidity [3]. The climatic change especially temperatures and the length of the light period lead to a major imbalance in the physiological processes

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inside the plant, which causes a clear change in the different stages of plant growth, which decreases growth and yield [4]. Suitable temperatures for soybeans vary during its different growth stages, the appropriate temperature ranges between 15-22°C for germination, 20-25°C during the flowering period and 15-22°C at maturity [5]. A temperature rise above 35°C leads to a decrease in the number and viability of flowering, a decrease in the number of pods and the number of seeds per pod and in general, higher temperatures reduce plant growth [6]. Studies indicate that the average increase in the expected annual air temperature in the Middle East region, including Egypt, in the period 2000-2050 will range between 1.5 to 1.8°C [7], which necessitates the development long term strategies to face these effects. One of these strategies is to change the dates of planting crops, including soybeans, to avoid the risks of declining yields and to restore the balance between the different stages of plant growth. In Egypt soybeans sowing in the second half of May and this means that the crop exposed to extremely high temperatures in the vegetative and flower growth stage, which negatively affects growth and yield. Robinson *et al.* [8], found an increase in the yield of soybeans grown in late April compared to that of cultivated in the latter half of May, while Egli and Cornelius [9] found that soybeans grown in the latter half of May were more yields than cultivated in April. However, soybean planting in late April or early May usually produces a higher yield than sowing in late May and the yield usually decreases gradually with delay in sowing [10]. According to Elgi and Cornelius [9], the point of rapid decline in the soybean yield begins on May 30th. Sometimes, in order to avoid the effect of high temperatures on the plant, farmers resort to spraying crops with some chemicals that mitigate heat stress, such as silicon. Silicon has an important role in protecting plants from abiotic stresses such as high temperatures [11]. It leads to a fortification of dry matter and final yield [12]. Silicon was more effective in alleviating drought stress in soybeans, as it was found to significantly increase shoots, root weight and chlorophyll content with the application of 200 ppm silicon [13]. Therefore, the present study aims to study the effect of sowing date and silicon concentrations on yield and yield components of three soybeans varieties and their interaction to determine the best concentration and the best sowing date, which will increase the production and quality of seeds and avoid exposure of the crop to heat and drought stress at critical stages of soybean plants.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of Etay Al-Baroud Agricultural Research Station, Agricultural Research Center, El-Beheira Governorate, Egypt, during the 2018 and 2019 seasons to study the effect of spraying with three silicon concentrations, (50, 100 and 200 ppm) compared with the control (distillated water), on seed yield and growth of the three soybean varieties Giza 111(Crawford x Celest, maturity group IV), Line 105 (Giza 35 x Lamar, maturity group V) and D 89-8940 (Introduced from USA, maturity group VI) under the three sowing dates of 1st May, 20th May and 10th June. A split-split plot design with three replicates was used where sowing dates were placed in the main plots and the three soybean varieties were allocated in the sub-plots, while the silicon spraying treatments were randomly distributed to the sub-sub plots. The minimum and maximum temperature as well as relative humidity during the two growing seasons were presented in Table 1.

The experimental plot included five ridges each ridge was four meters long and 60 cm apart (12 m^2). Seeds were sowing on the two sides of the ridge with 20 cm hill space and two seeds per hill. The wet planting method called (Herati) was used and all the other cultural practices were followed as recommended. The comircial silicon from El-Gomhoureya Company – Cairo- Egypt were prepared in concentrations of 50, 100 and 200 ppm and spraying three times during the growing season after 45, 60 and 75 day from seed sowing.

Data Recorded

Growth, Seed Yield and Yield Components Traits:

- Maturity date was recorded as the number of days from seed sowing to 90 of plants maturity on plot base.
- Plant height (cm) and number of branches were measured as the average of height and branches number of ten plants randomly taken from each sub-sub plot at harvest.
- Number of pods/plant and 100-seed weight were measured as the average of pods number and weight of 100-seed of ten plants randomly taken from each sub-sub plot after harvest. Seed yield/fad (ton) was estimated by convert seed yield /plot to fad.

Table 1: Minimum, maximum temperature and relative humidity during the two growing seasons of 2018 and 2019 at Etay EL-Baroud Agricultural Research Station, EL-Behiera Governorate, Egypt

Month	Temperature (°C) 2018 Min.	2018 Max.	2019 Min.	2019 Max.	Relative humidity 2018	Relative humidity 2019
May	20.40	40.12	19.20	38.78	63.17	67.21
June	22.30	41.60	22.10	40.65	72.03	72.89
July	20.50	35.65	20.31	35.54	75.48	73.19
August	20.12	35.22	19.80	35.10	76.39	70.47
September	19.38	32.70	18.75	32.63	70.56	68.26

Leaf and Seed Chemical Properties
Leaf Chemical Properties:

- Total chlorophyll content: was determined three times at 60, 75 and 90 days from sowing by measuring the upper three trifoliate leaf chlorophyll content by using analytical apparatus; chlorophyll meter (Model SPAD- 502) Minolta camera Co. Ltd, Japan.
- N, P and K contents were determined at the upper three trifoliate leaf total nitrogen after 90 days from sowing was assayed according to Chapman and Pratt [14] and Cottenie *et al.* [15] using the micro kjeldahle apparatus. Phosphorus was determined spectrophotometers by Cottenie *et al.* [15]. Potassium was determined photometrically, using flame photometer [16].

Seed Content of Silicon and Oil:

- Silicon determination: Plant samples were collected in labeled bags, washed with distilled water to remove surface contaminants. The samples were air dried and subjected in oven at 100ºC until ashing. An aliquot of dried samples was digested by using sulphric and perchloric acids [17]. The prepared sample was examined for silicon content on Inductive Coupled Plasma (ICP). Optical Emission Spectroscopy (ICP-OES) (model Ultima 2JY Plasma) according to EPA [18].
- Determination of Oil %: Oil % was determined using soxcelt apparatus using n-hexan, according to AOAC [19].

Statistical Analysis: All data were subjected to the analyses of variance (ANOVA) for split split-plot design followed by compared means with LSD at level probability 5% according to Gomez and Gomez [20].

RESULTS AND DISSCUSSION

Effect of Sowing Dates on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: The obtained results in Table 2 and 3 confirmed that all soybean growth seed yield and its components as well as leaf and seed chemical properties significantly affected by the date of sowing during the two seasons of the study.

Growth, Yield and Yield Components Traits: Data in Table 2 indicated that the early sowing date in the first of May exceeded both the recommended sowing date (20th May) and the late sowing date (10th June) in all growth, seed yield and yield components traits where soybean sowing in 1st May showed the highest plant height (106.13 and 107.04 cm), branches number/plant (2.48 and 2.58) and pods number/plant (33.80 and 33.35). While, soybean plants that sowing in 20th of May had the highest seed yield/fad (1.33 and 1.37 ton). Also, soybean plants that sowing in 10th June expressed the lowest number of days to maturity (12.92 and 126.13 days) and the highest 100-seed weights with averages of 14.84 and 15.06 g in the first and second seasons, respectively. In the contrast of this, soybean plants that sowing in 10th June had the lowest plant height, branches numbers/plant and seed yield/fadin both seasons.

Determining the optimal date for sowing soybeans is very important to avoid plant exposure to heat stress during critical stages of growth. Silicon can also be sprayed to mitigate the effect of high temperature or choose the cultivar that fits the sowing date. Varieties of the fourth maturity group are most suitable for early planting in April and May. In the event that the planting date is delayed to the first half of June and with a rise in temperature, the varieties of the fifth and sixth maturity groups are the most suitable for these conditions.

In this study soybean plants sowing in early in 1st May showed the highest plant height, branches number/plant and pods number/plant. While, soybean plants that sowing in 20th of May had the highest seed yield/fad and the lowest number of days to maturity. Similar results were obtained before by Islami and Sugito [21] who found that the length of the growing season of soybean shortened with delayed sowing dates and duration of maturing decreases with later planting dates.Ahmed *et al.* [22] stated that the plant height, number of branches /plant was significantly affected by delay in sowing date.Robinson *et al.* [8] found an increase in the growth, leaf pigments yield as well as seed quality

Table 2: Effect of sowing dates on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

	Maturity date (days)		Plant height (cm)		No. of branches/plant		No. of pods/plant		100- seed Weight (g)		Seed yield/fed (ton)	
Sowing Dates	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st May	134.48a	134.03a	106.13a	107.04a	2.48a	2.58a	33.80a	33.35a	13.77b	13.99b	1.30b	1.33b
20th May	131.33a	131.42b	100.22b	100.68b	2.11b	2.23b	31.52b	31.66b	13.91b	14.23b	1.33a	1.37a
10th June	124.86b	126.13c	87.59c	86.87c	1.70c	1.79c	27.58c	28.11c	14.84a	15.06a	1.27c	1.31c
LSD 5%	3.22	2.39	5.62	6.12	0.23	0.23	1.87	1.59	0.34	0.33	0.02	0.02

Table 3: Effect of sowing dates on soybean leaf and seed chemical properties in 2018 and 2019 seasons

	Leaf contents								Seed contents			
	Totalchlorophyll (mg/100g fw.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si (mg/100g d.wt.)		Oil %	
Sowing Dates	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st May	42.15a	41.33a	1.50a	1.51a	0.20a	0.19a	0.60a	0.62a	45.75a	49.40a	18.40b	18.40b
20th May	38.72b	38.72b	1.39b	1.41b	0.16b	0.16b	0.52b	0.51b	23.05b	23.43b	20.31a	20.28a
10th June	37.17c	35.75c	1.39b	1.40b	0.14c	0.15c	0.43c	0.44c	12.66c	12.58c	16.62c	16.62c
LSD 5%	1.51	1.66	0.04	0.03	0.01	0.01	0.05	0.05	10.05	11.24	1.11	1.09

such as oil and protein of soybeans grown in late April compared to that of cultivated in the latter half of May, while Egli and Cornelius [9] found that soybeans grown in the last half of May were more yields than cultivated in April. However, soybean planting in late April or early May usually produces a higher yield than sowing in late May and the yield usually decreases gradually with delay in sowing [10]. Yansheng *et al.* [23] indicate that the sowing soybean after 15 May increased seed protein content by 4.1% to 7.5% and reduced growth yield for different cultivars. Morsy *et al.* [24] found that delayed sowing soybean from May 3 to June 4 significantly decreased plant height, branches number, pods number /plant, along with reducing of 100-seeds weight and seed yield / Faddan. Naoki *et al.* [25] found an increases in soybean growth, seed yield and seed quality with early sowing. Yohei *et al*. [26] found that soybean growth and yield were significantly reduced following late sowing.

Leaf and Seed Chemical Properties: The presented results in Table 3 revealed that soybean plants that sowing in the first of May had the highest leaf contents of;total chlorophyll (42.15 and 41.33 mg/100 g fw.), nitrogen (1.50 and 1.51mg/g fw.), phosphor (0.20 and 0.19mg/g fw.), potassium (0.60 and 0.62mg/g fw.) and seed content of silicon (45.75 and 49.40 mg/100g d.wt.) in both seasons, respectively. While, soybean plants that sowing in 20th of May had the highest seed content of oil (20.31 and 20.28%) in the first and second seasons, respectively. In the contrast of this soybean plants that sowing in 10th June had the lowest leaf contents of total chlorophyll, nitrogen, phosphor, potassium as well as the lowest seed content of oil and silicon in both seasons.

In this study soybean plants sowing in early in 1st May showed the seed content of silicon as well as leaf contents of total chlorophyll, nitrogen, phosphor and potassium While, soybean plants that sowing in 20th of May had the highest oil percentage. Similar results were obtained before by Lipiec *et al.* [27] they reported that heat stress coupled with water deficit decreases the net photosynthesis and, subsequently, can cause a reduction in the growth rate of the plant. Also, the high temperature during the early vegetative growth resulted in significant decrease of Nitrogen content in soybean leaves under delayed sowing dates (20th May and 10th June). The increase of air temperatures 5°C above the optimal temperature during grain filling might have an influence on NPK partitioning reducing the rate of N remobilization from vegetative parts to grow seeds in grain legumes. In the contrast of this Robinson *et al.* [8] found an increase in leaf pigments as well as seed quality such as oil and protein of soybeans grown in late April compared to that of cultivated in the latter half of May.

Effect of Cultivars on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: The presented data in Table 4 and 5 indicated that the three soybean cultivars significantly differ in their performances for all studied traits except seed content of silicon in the two seasons of the study.

Growth, Yield and Yield Components Traits: The results in Table 4 showed that Giza 111 cv was the earliest among all tested cultivars where it expressed the lowest number of days to maturity (120.26 and 120.55 days) in addition to

Table 4: Effect of cultivars on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

	Maturity date (days)		Plant height (cm)		No. of branches/plant		No. of Pods/plant		100- seed weight (g)		Seed yield/fed (ton)	
Cultivars	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Giza 111	120.26c	120.55c	91.14b	91.59b	2.07b	2.18b	30.33b	30.37b	15.19a	15.34a	1.29b	1.32b
Line 105	129.85b	130.12b	110.50a	111.13a	1.75c	1.82c	29.65b	29.80b	13.89b	14.20b	1.28b	1.31b
D89-8940	140.56a	140.91a	92.30b	91.87b	2.47a	2.59a	32.92a	32.95a	13.44c	13.75c	1.34a	1.37a
LSD 5%	3.46	3.28	4.45	4.69	0.16	0.17	1.30	1.17	0.38	0.37	0.05	0.05

the highest 100-seed weight (15.19 and 15.34 g) and seed yield/fad (1.29 and 1.32 ton) in both seasons, respectively. While, Line 105 had the highest plant height (110.50 and 111.13 cm) and D89-8940 had the highest branches number/plant (2.47 and 2.59) and pods number/plant (32.29 and 32.95) in the first and second seasons, respectively.

A wide differ in this study for all growth and yield traits were presented in the three tested genotypes in across the three sowing dates. Where, Giza 111 cv was the earliest among all tested cultivars in both seasons. While, Line 105 had the highest plant height. D89-8940 had the highest branches number/plant and seed yield/ fad in the first and second seasons. The differences between soybean genotypes may be due the wide genetic diversity of these genotypes. The diversity between soybean genotypes were observed before in some studies such as Attia [28] evaluated ten soybean genotypes and he found that the best genotype Etay El-Baroud Line 105 was at the first rank showing highest branches and bearing larger number of pods /plant could increase seed yield /plant (g) and 100-seed weight (g). Giza 22 was at the last rank with negative effect for earliness characters.Morsy *et al.* [24] evaluated some soybean genotypes under different sowing dates and they found that the soybean genotypes varied in all studied traits, that DR 101 was the latest in flowering and maturity (51.3 and 150.3 days, respectively) and produced the highest 100-seed weight (17.2g), while H30 was the earliest in maturity (115.00 days) and the lowest in 100-seed weight (12.14g). The commercial cultivar Giza 111 produced the highest seed yield (1.625t/fed.). Also, Morsy *et al.* [24]reveled that, Giza 111, Toano and DR 101 could produce acceptable seeds with more than 80% germination when planted during the first half of June, while the earlier genotypes H30, H32 and Giza 35 must be planted around mid-June to produce seeds with acceptable viability.

Leaf and Seed Chemical Properties: Data in Table 5 revealed that D89-8940 scored the highest leaf contents of total chlorophyll (42.73 and 42.03 mg/100g fw.), nitrogen (1.51 and 1.52mg/g fw.), phosphor (0.19 and 0.19mg/g fw.) and potassium (0.57 and 0.55mg/g fw.) in both seasons, respectively. While, Line 105 had the highest seed content of oil (19.03 and 18.89%) in both seasons, respectively. On the other side, Line 105 had the lowest leaf contents of nitrogen (1.32 and 1.33mg/g fw.), phosphor (0.14 and 0.13mg/g fw.) and potassium (0.48 and 0.47mg/g fw.) in the first and second seasons, respectively.

A wide differ in this study for all growth and yield traits were presented in the three tested genotypes in across the three sowing dates. Where, Giza 111 cv was the earliest among all tested cultivars in both seasons. While, Line 105 had the highest plant height and seed content of oil. D89-8940 had the highest branches number/plant, leaf contents of total chlorophyll, nitrogen, phosphor and potassium as well as the highest seed yield/ fad in the first and second seasons. The differences between soybean genotypes may be due the wide genetic diversity of these genotypes. The diversity between soybean genotypes were observed before in some studies such as Krisnawati and Adie [29] evaluated the stability of 12 soybean genotypes of soybean mega-environments for the growth and yield performance. They revealed that leaf content of nitrogen, phosphor and potassium and seed content of oil, protein and carbohydrate significantly differ in the different soybean genotypes. Genotypes 9 had the highest leaf content of nitrogen and seed content of both protein and carbohydrate while genotype 2 showed the highest leaf contents of phosphor and potassium and seed content of oil. Genotype 7 had the highest leaf pigments chlorophyll and carotene.

Effect of Silicon Concentrations on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: Data in Table 6 and 7 showed that all soybean traits significantly affected by silicon concentrations. All silicon concentrations resulted in significantly increase in all soybean traits compared to the control. Also, all soybean traits gradually increase by the increase of silicon concentrations in both seasons.

Table 5: Effect of cultivars on soybean leaf and seed chemical properties in 2018 and 2019 seasons

	Leaf contents								Seed contents			
	Total chlorophyll (mg/100g fw.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si		Oil %	
Cultivars	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Giza 111	40.29b	38.41b	1.43b	1.47b	0.17b	0.18b	0.52b	0.54a	24.82	26.00	18.47ab	18.41b
Line 105	35.02c	35.36c	1.32c	1.33c	0.14c	0.13c	0.48c	0.47b	28.92	30.41	19.03a	18.98a
D89-8940	42.73a	42.03a	1.51a	1.52a	0.19a	0.19a	0.57a	0.55a	27.73	29.00	17.95b	17.91b
LSD 5%	1.43	1.30	0.03	0.03	0.01	0.01	0.03	0.03	5.10	5.69	0.58	0.57

Table 6: Effect of silicon concentrations on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

Silicon conc. (ppm)	Maturity date (days)		Plant height (cm)		No. of branches /plant		No. of pods		100- seed weight (g)		Seed yield/fed (ton)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
50	128.66c	128.77c	93.85c	95.32c	1.87c	2.07c	30.28c	28.48c	13.68c	13.80d	1.13c	1.23c
100	131.85b	133.13b	102.98b	103.17b	2.21b	2.33b	33.49b	34.68b	14.57b	14.69b	1.45b	1.48b
200	135.14a	135.49a	110.12a	109.48a	2.68a	2.73a	37.25a	37.40a	15.07a	15.10a	1.61a	1.57a
Control	125.23d	124.72d	84.96d	84.84d	1.62d	1.65d	22.83d	23.60d	13.37d	14.13c	1.02d	1.06d
LSD 5%	1.69	1.66	2.62	2.69	0.10	0.10	1.08	1.05	0.21	0.21	0.05	0.04

Growth, Yield and Yield Components Traits: For growth traits, the presented data in Table 6 showed that soybean plants that sprayed with the highest concentrations of silicon (200 ppm) scored the highest; plant height (135.49 and 110.12 cm), branches number/plant (2.68 and 2.73), pods number/plant (37.25 and 37.40), 100-seed weight (15.07 and 15.10 g) and seed yield/fad (1.61 and 1.57 ton) followed by 100 ppm of silicon in all previous traits while the control treatment expressed the lowest desirable values for maturity date with averages of 126.86 and 124.72 days in both seasons respectively.

Our results confirmed the large effect of silicon in all soybean growth and yield traits. Wheresoybean plants that sprayed with the highest concentrations of silicon (200 ppm) scored the highest; plant height, branches number/plant, pods number/plant, 100-seed weight and seed yield/fad in both seasons. Si plays an important role in mitigate plants from heat stress [11]. Korndorfer and Lepsch [12] indicated positive effect of silicon on the plant growth and yield. Shen *et al*. [30] report that sprayed 1.7 mM Si significantly increased soybean growth and yield when subjected to -0.5 MPa of PEG stress.Tahir *et al*. [31] found that the significantly maximum economic yield (2.60 ton ha^{-1}) was observed when silicon was applied at 23kg ha^{-1} in sunflower. Silicon application significantly enhanced the plant height (223.92 cm), head diameter (23.83 cm), 1000-achene weight (62.27 g), biological yield (10.82 t ha^{-1}), protein content (21.97) and oil contents (44.05%). Meena *et al.* [32] suggested that depletion of plant available silicon from soil is the limiting factor contributing to declining yield. Vasanthi *et al.* [33] showed that silicon nutrition reverse the succulence induced by high nitrogen and enhance crop growth and yield. Kalandyk *et al*. [34] found that sprayed silicon three times in the field condition, three times, every 2 weeks starting from the six-leaf stage caused an increase in the number of pods/plant 14% and weight of seeds/ plant by 21% compared to the control. In another field experiment, the use of silicon increased number of pods in soybeans by 18% and the average seed yield per plant by 21% compared to the control treatment [35].

Leaf and Seed Chemical Properties: The results in Table 7 indicated that soybean plants that sprayed with 200 ppm of silicon showed the highest; leaf content of; total chlorophyll (43.86 and 42.21 mg/100g fw.), nitrogen (1.65 and 1.66mg/g fw.), phosphor (0.22 and 0.23mg/g fw.) and potassium (0.57 and 0.58mg/g fw.) in addition to the highest seed contents of; silicon (41.19 and 44.14 mg/100g d.wt.) and oil (21.53 and 21.50%) followed 100 ppm of silicon in all chemical traits in both seasons, respectively. On the other hand soybean plants under the control treatment had the lowest leaf contents of nitrogen, phosphor and potassium in both seasons.

Our findings indicated that soybean plants that sprayed with the highest concentrations of silicon (200 ppm) scored the highest; leaf content of; total chlorophyll, nitrogen, phosphor and potassium in addition to the highest; seed content of silicon and oil percentage in both seasons. Similar results were shown before by Bao-He *et al*. [13] indicated that sodium silicate enhanced leaf content of K by 105.4 %.Hamayun *et al.* [13] indicated that drought effect alleviated by adding 100 mg L^{-1} and 200 mg L^{-1} where these concentrations increase leaf contents of chlorophyll. Shen *et al*. [30] report that silicon slightly decreased antioxidant activity and had no effect on chlorophyll content. Saud *et al.* [36]

Table 7: Effect of silicon concentrations on soybean leaf and seed chemical properties in 2018 and 2019 seasons

	Leaf contents								Seed contents			
	Total chlorophyll (mg/100 g fw.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si (mg/100g d.wt.)		Oil %	
Silicon conc.	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
50 ppm	37.06^{c}	36.11^{b}	1.33^{c}	1.35^{c}	0.14^{c}	0.14^{c}	0.50^{c}	0.50^{c}	23.30^{c}	24.07^{c}	17.44^{c}	17.49^{c}
100 ppm	42.40^{b}	41.95^{a}	1.50^{b}	1.52^{b}	0.18^{b}	0.18^{b}	0.54^{b}	0.54^{b}	33.40^{b}	35.09^{b}	18.85^{b}	18.60^{b}
200 ppm	43.86^{a}	42.21^{a}	1.65^{a}	1.66^{a}	0.22^{a}	0.23^{a}	0.57^{a}	0.58^{a}	41.19^{a}	44.14^{a}	21.53^{a}	21.50^{a}
Control	34.07^{d}	34.14^{c}	1.22^{d}	1.23^{d}	0.12^{d}	0.12^{d}	0.46^{d}	0.45^{d}	10.72^{d}	10.58^{d}	16.12^{d}	16.14^{d}
LSD 5%	0.98	0.88	0.03	0.03	0.01	0.01	0.02	0.02	3.27	3.61	0.42	0.42

Table 8: Effect of the interaction between sowing dates and soybean cultivars on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

		Maturity date (days)		Plant height (cm)		No. of branches /plant		No. of pods		100-seed weight (g)		Seed yield/fed (ton)	
Sowing dates	Cultivars	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1^{st} May	Giza 111	125.85^{c}	125.20^{c}	103.32^{b}	104.73^{b}	2.43^{b}	2.48^{b}	36.52^{a}	35.95^{a}	14.25^{b}	14.59^{b}	1.54^{a}	1.56^{a}
	Line 105	131.81^{b}	131.86^{b}	117.13^{a}	118.06^{a}	2.15^{c}	2.30^{b}	30.41^{cd}	30.10^{cd}	13.02^{c}	13.12^{c}	1.17^{d}	1.20^{de}
	D89-8940	145.78^{a}	145.04^{a}	97.94^{bc}	98.34^{bc}	2.85^{a}	2.95^{a}	34.47^{ab}	34.02^{ab}	14.05^{b}	14.27^{b}	1.20^{d}	1.22^{de}
20^{th} May	Giza 111	118.91^{cd}	119.95^{cd}	95.85^{bc}	96.26^{c}	2.13^{c}	2.38^{b}	31.05^{c}	30.94^{cd}	14.69^{b}	14.57^{b}	1.22^{cd}	1.26^{cd}
	Line 105	132.99^{b}	132.30^{b}	112.25^{a}	113.07^{a}	1.70^{d}	1.80^{c}	29.95^{d}	30.34^{c}	14.09^{b}	14.88^{b}	1.38^{b}	1.42^{b}
	D89-8940	142.10^{a}	142.00^{a}	92.56^{cd}	92.72^{c}	2.50^{b}	2.50^{b}	33.55^{b}	33.70^{b}	12.95^{c}	13.25^{c}	1.41^{b}	1.45^{b}
10^{th} June	Giza 111	116.02^{d}	116.50^{d}	74.25^{e}	73.79^{e}	1.65^{de}	1.70^{c}	23.41^{e}	24.23^{e}	16.63^{a}	16.85^{a}	1.13^{d}	1.15^{e}
	Line 105	124.74^{c}	126.20^{c}	102.11^{b}	102.28^{bc}	1.40^{e}	1.35^{d}	28.59^{d}	28.96^{d}	14.56^{b}	14.61^{b}	1.29^{c}	1.32^{c}
	D89-8940	133.58^{b}	135.70^{b}	86.42^{d}	84.56^{d}	2.05^{c}	2.33^{b}	30.74^{cd}	31.14^{c}	13.32^{c}	13.71^{c}	1.40^{b}	1.44^{b}
LSD 5%		5.98	5.67	7.71	8.11	0.27	0.29	2.24	2.02	0.66	0.66	0.08	0.08

indicated that silicon might assist plants and maintain the photosynthesis ability under drought stress. The addition of silicon at 400 mg L^{-1} significantly increased the net photosynthesis by 40% and the total amount of NPK by 12%. Pati *et al.* [37] found that silicon (diatomaceous earth) fertilization significantly increased uptake of nitrogen, phosphorus and potassium in grain and straw of rice.Salar and Torabian [38] reported that nano-silicon oxide (nano-SiO2) increase in K+ concentration.

Effect of the Interaction Between Sowing Dates and Soybean Cultivars on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: The results in Tables 8 and 9 confirmed that all growth, seed yield and yield components traits as well as leaf and chemical properties of the three soybean genotypes significantly differ in the three sowing dates.

Growth, Yield and Yield Components Traits: The obtained data in Table 8 revealed that all soybean cultivars early matured in the late sowing date in compression with the recommended and early sowing dates. Thelowest number of days to maturity was recorded for Giza 111 that sowing in 10^{th} June (116.02 and 116.50 days) and the highest 100-seed weight (16.63 and 16.85 g). In the same line Giza 111 that sowing in 1^{st} May had the highest pods number/plant (36.52 and 35.95) and seed yield/fad (1.54 and 1.56 ton) in both seasons, respectively. Line 105 that sowing in 1^{st} May had the highest plant height (117.13 and 118.06 cm) followed by the same cultivar that sowing in 20^{th} May (112.25 and 113.07 cm) in both seasons, respectively. D89-8940 that sowing in 1^{st} May had the highest branches number/plant (2.85 and 2.50) in both seasons, respectively.

In the present work Giza 111 that sowing in 10^{th} June had the lowest number of days to maturity and the highest 100-seed weight. In the same line Giza 111 that sowing in 1^{st} May had the highest pods number/plant and seed yield/fad in both seasons. The diversity between soybean genotypes were observed before in some studies such as Morsy *et al.* [24] whom found that delayed sowing soybean from May 3 to June 4 significantly decreased plant height, branches number, pods number /plant , along with reducing of 100-seeds weight and seed yield / Faddan. They also, found that the soybean genotypes varied in all studied traits, that DR 101 was the latest in flowering and maturity (51.3 and 150.3 days, respectively) and produced the highest 100-seed weight (17.2g), while H30 was the earliest in maturity (115.00 days) and the lowest in 100-seed weight (12.14g). The commercial cultivar Giza 111 produced the highest seed yield (1.625t/fed.). Naoki *et al.* [25] found an increases in soybean growth, seed yield and seed quality with early sowing. Yohei *et al.* [26] found that soybean growth and yield were significantly reduced following late sowing.

Leaf and Seed Chemical Properties: The results in Table 9 showed that leaf contents of nitrogen, phosphor and potassium significantly affected by the interactions between sowing dates and the three tested cultivars. In all cases sowing soybean early in 1st May resulted in a large increase in leaf contents of nitrogen, phosphor and potassium in the three cultivars compared with the recommended and the late sowing dates. D89-8940 that sowing in 1st May scored the highest leaf contents of; total chlorophyll (44.91 and 44.67 mg/100g fw.), nitrogen (1.59 and 1.57mg/g fw.), phosphor (0.21 and 0.22mg/g fw.) and potassium (0.66 and 0.670 mg/g fw.) in addition to seed content of silicon (46.76 and 50.31 mg/100g d.wt.) followed by Giza 111 that sowing in 1st May in both seasons. On the other side, Line 105 that sowing in 20th May showed the highest seed content of oil (20.91 and 20.87%) in both seasons, respectively.

In the present work Giza 111 that sowing in 10th June had the lowest number of days to maturity and the highest 100-seed weight. In the same line Giza 111 that sowing in 1st May had the highest pods number/plant and seed yield/fad in both seasons. The diversity between soybean genotypes were observed before in some studies such asKrisnawati and Adie [29]they revealed that leaf content of nitrogen, phosphor and potassium and seed content of oil, protein and carbohydrate significantly differ in the different soybean genotypes. Genotypes 9 had the highest leaf content of nitrogen and seed content of both protein and carbohydrate while genotype 2 showed the highest leaf contents of phosphor and potassium and seed content of oil. Genotype 7 had the highest leaf pigments chlorophyll and carotene.

Lipiec *et al.* [27] reported that heat stress coupled with water deficit decreases the net photosynthesis and, subsequently, can cause a reduction in the growth rate of the plant. Also, the high temperature during the early vegetative growth resulted in significant decrease of Nitrogen content in soybean leaves under delayed sowing dates (20th May and 10th June). The increase of air temperatures 5°C above the optimal temperature during grain filling might have an influence on NPK partitioning reducing the rate of N remobilization from vegetative parts to grow seeds in grain legumes. In the contrast of this Robinson *et al.* [8] found an increase in leaf pigments as well as seed quality such as oil and protein of soybeans grown in late April compared to that of cultivated in the latter half of May.

Effect of the Interaction Between Sowing Dates and Silicon Concentrations on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: The obtained data in Table 10 and 11 confirmed that all used treatments differ in their effect in all growth, leaf chemical properties, seed yield and yield components according to sowing dates. Where all used treatments resulted in a large increase of all soybean growth, leaf chemical properties, seed yield and yield components traits in the first sowing date (1st May) compared with recommended and late sowing date in both seasons.

Growth, Yield and Yield Components Traits: All used treatment significantly delayed soybean maturity in all sowing dates (Table 10) where the lowest number of days to maturity was showed in soybean plant that sowing in 10th June under the control treatment (118.02 and 118.73 days). Soybean plants that sprayed with 200 ppm of silicon in the early sowing date (1st May) gave the highest plant height (116.44 and 116.01 cm), number of branches/plant (3.00 and 3.07), number of pods/plant (39.84 and 40.93) and seed yield/fad (1.58 and 1.57 ton) followed by applied 100 ppm of silicon in the same sowing date in both seasons, respectively.Also, soybean plants that sprayed with 200 ppm of silicon in the recommended sowing date (20th May) had the highest plant height (111.47 and 112.73 cm) and seed yield/fad (1.66 and 1.62 ton) in both seasons, respectively.

Similar results were obtained before by Morsy *et al.* [24] whom found that delayed sowing soybean from May 3 to June 4 significantly decreased plant height, branches number, pods number /plant, along with reducing of 100-seeds weight and seed yield / Faddan. Naoki *et al.* [25] found an increases in soybean growth, seed yield and seed quality with early sowing. Yohei *et al.* [26] found that soybean growth and yield were significantly reduced following late sowing.

Vasanthi *et al.* [33] showed that silicon nutrition reverse the succulence induced by high nitrogen and enhance crop growth and yield. Kalandyk, *et al.* [34] found that sprayed silicon three times in the field condition, three times, every 2 weeks starting from the six-leaf stage caused an increase in the number of

Table 9: Effect of the interaction between sowing dates and soybean leaf and seed chemical properties in 2018 and 2019 seasons

		Leaf contents								Seed contents			
		Total chlorophyll (mg/100g d.wt.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si (mg/100g d.wt.)		Oil %	
Sowing dates	Cultivars	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st May	Giza 111	44.78^{a}	41.16^{b}	1.53^{b}	1.55^{a}	0.19^{b}	0.20^{b}	0.60^{b}	0.62^{b}	44.14^{a}	47.48^{a}	18.38^{de}	18.33^{de}
	Line 105	36.77^{de}	38.16^{c}	1.38^{e}	1.37^{d}	0.16^{d}	0.16^{d}	0.54^{cd}	0.52^{c}	46.35^{a}	50.41^{a}	19.03^{cd}	18.97^{cd}
	D89-8940	44.91^{a}	44.67^{a}	1.59^{a}	1.57^{a}	0.21^{a}	0.22^{a}	0.66^{a}	0.67^{a}	46.76^{a}	50.31^{a}	17.96^{ef}	17.92^{ef}
20th May	Giza 111	38.68^{cd}	39.17^{bc}	1.41^{de}	1.45^{bc}	0.16^{d}	0.17^{cd}	0.58^{bc}	0.58^{b}	18.90^{cd}	19.16^{bc}	20.42^{ab}	20.30^{ab}
	Line 105	34.93^{ef}	35.39^{d}	1.29^{f}	1.31^{e}	0.13^{ef}	0.13^{e}	0.49^{e}	0.47^{d}	27.70^{bc}	28.21^{b}	20.91^{a}	20.87^{a}
	D89-8940	42.54^{ab}	41.61^{b}	1.46^{cd}	1.49^{b}	0.18^{bc}	0.17^{cd}	0.51^{de}	0.50^{cd}	22.56^{bc}	22.92^{bc}	19.77^{bc}	19.67^{bc}
10th June	Giza 111	37.42^{d}	34.91^{d}	1.37^{e}	1.41^{cd}	0.14^{e}	0.16^{d}	0.39^{g}	0.41^{e}	11.43^{d}	11.35^{c}	16.63^{gh}	16.61^{g}
	Line 105	33.36^{f}	32.55^{e}	1.31^{f}	1.31^{e}	0.12^{f}	0.13^{e}	0.42^{f}	0.42^{e}	12.69^{d}	12.61^{c}	17.15^{fg}	17.10^{fg}
	D89-8940	40.75^{bc}	39.81^{bc}	1.49^{c}	1.49^{b}	0.17^{cd}	0.18^{c}	0.48^{e}	0.48^{cd}	13.87^{d}	13.77^{c}	16.12^{h}	16.13^{g}
LSD 5%		2.47	2.25	0.06	0.06	0.02	0.02	0.05	0.05	8.82	9.85	1.00	0.98

Table 10: Effect of the interaction between sowing dates and silicon concentrations on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

		Maturity date (days)		Plant height (cm)		No. of branches/plant		No. of pods		100-seed weight		Seed yield/fed	
Sowing dates	Silicon conc. (ppm)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st May	50	132.30^{bc}	132.58^{cde}	101.40^{de}	103.08^{bc}	2.30^{cd}	2.50^{cd}	32.94^{cd}	29.91^{d}	13.37^{e}	13.39^{e}	1.15^{c}	1.26^{e}
	100	135.57^{b}	136.00^{ab}	110.29^{bc}	110.70^{a}	2.60^{b}	2.60^{c}	38.50^{ab}	38.23^{b}	13.97^{d}	14.51^{d}	1.46^{b}	1.47^{cd}
	200	139.81^{a}	138.18^{a}	116.44^{a}	116.01^{a}	3.00^{a}	3.07^{a}	39.84^{a}	40.93^{a}	14.62^{c}	14.81^{c}	1.58^{a}	1.57^{ab}
	Control	130.23^{cd}	129.36^{ef}	96.38^{ef}	98.37^{cde}	2.00^{de}	2.13^{e}	23.90^{g}	24.35^{f}	13.13^{e}	13.26^{e}	1.02^{d}	0.99^{g}
20th May	50	130.34^{cd}	130.08^{de}	95.87^{f}	97.40^{de}	1.83^{ef}	1.98^{e}	31.59^{d}	29.02^{d}	13.39^{e}	13.48^{e}	1.15^{c}	1.23^{e}
	100	132.30^{bc}	133.18^{bcd}	104.74^{cd}	105.05^{b}	2.16^{d}	2.43^{cd}	32.98^{cd}	35.14^{c}	14.40^{c}	14.20^{d}	1.48^{b}	1.54^{b}
	200	135.24^{b}	136.35^{ab}	111.47^{ab}	112.73^{a}	2.64^{b}	2.80^{b}	37.73^{b}	37.76^{b}	14.79^{c}	14.64^{c}	1.66^{a}	1.62^{a}
	Control	127.44^{d}	126.06^{fg}	88.80^{g}	87.55^{f}	1.80^{f}	1.69^{f}	23.77^{g}	24.73^{f}	13.06^{e}	14.62^{c}	1.05^{d}	1.11^{f}
10th June	50	123.35^{e}	123.64^{g}	84.29^{h}	85.48^{f}	1.47^{g}	1.73^{f}	26.31^{f}	26.50^{e}	14.29^{cd}	14.52^{cd}	1.08^{cd}	1.20^{e}
	100	127.68^{d}	130.21^{de}	93.93^{fg}	93.74^{e}	1.87^{ef}	1.97^{e}	29.01^{e}	30.69^{d}	15.35^{b}	15.35^{b}	1.42^{b}	1.44^{d}
	200 ppm	130.37^{cd}	131.94^{cde}	102.46^{d}	99.69^{cd}	2.40^{c}	2.33^{d}	34.17^{c}	33.52^{c}	15.79^{a}	15.85^{a}	1.60^{a}	1.53^{bc}
	Control	118.02^{f}	118.73^{h}	69.70^{i}	68.59^{g}	1.07^{h}	1.13^{g}	20.82^{h}	21.73^{g}	13.92^{d}	14.51^{cd}	1.00^{d}	1.06^{fg}
LSD 5%		3.39	3.31	5.24	5.38	0.2	0.2	2.15	2.1	0.42	0.41	0.09	0.08

pods/plant 14% and weight of seeds/ plant by 21% compared to the control. In another field experiment, the use of silicon increased number of pods in soybeans by 18% and the average seed yield per plant by 21% compared to the control treatment [35].

Leaf and Seed Chemical Properties: The presented data in Table 11 showed that soybean plants that sprayed with 200 ppm of silicon in the early sowing date (1st May) showed the highest leaf content of; total chlorophyll (45.98 and 46.04), nitrogen (1.79 and 1.79mg/g fw.), phosphor (0.25 and 0.26mg/g fw.) and potassium (0.63 and 0.65mg/g fw.) in addition to the highest seed content of silicon (69.02 and 76.46 mg/100g d.wt.) in the first and second seasons, respectively. Soybean plants that sprayed with 200 ppm of silicon in the late sowing date (20th May) gave the highest seed content of oil (23.68 and 23.66%) in both seasons, respectively. In the contrast of this soybean plants that sowing in 10th June under the control treatment gave the lowest leaf content of nitrogen (1.21 and 1.23mg/g fw.), phosphor (0.10 and 0.11mg/g fw.) and potassium (0.40 and 0.39mg/g fw.) as well as the lowest seed contents of; silicon (7.21 and 6.34 mg/100 g d.wt.) and oil (14.52 and 14.56%) in both seasons, respectively.

In the previous studies heat stress coupled with water deficit decreases the net photosynthesis and, subsequently, can cause a reduction in the growth rate of the plant. Also, the high temperature during the early vegetative growth resulted in significant decrease of Nitrogen content in soybean leaves under delayed sowing dates (20th May and 10th June). The increase of air temperatures 5°C above the optimal temperature during grain filling might have an influence on NPK partitioning reducing the rate of N remobilization from vegetative parts to grow seeds in grain legumes [27]. In the contrast of this

Table 11: Effect of the interaction between sowing dates and silicon concentrations on soybean leaf and seed chemical properties in 2018 and 2019 seasons

		Leaf contents of								Seed contents of			
		Total chlorophyll (mg/100 g fw.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si (mg/100g d.wt.)		Oil %	
Sowing dates	Silicon conc.	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st May	50 ppm	40.87^{c}	39.7^{b}	1.38^{d}	1.38^{f}	0.16^{c}	0.16^{c}	0.59^{b}	0.61^{b}	44.07^{c}	46.12^{c}	17.39^{d}	17.45^{gh}
	100 ppm	44.07^{ab}	44.3^{a}	1.55^{b}	1.56^{cd}	0.20^{b}	0.22^{b}	0.62^{a}	0.63^{ab}	56.42^{b}	60.21^{b}	18.82^{c}	18.57^{ef}
	200 ppm	45.98^{a}	46.04^{a}	1.79^{a}	1.79^{a}	0.25^{a}	0.26^{a}	0.63^{a}	0.65^{a}	69.02^{a}	76.46^{a}	21.51^{b}	21.50^{b}
	Control	37.69^{d}	35.20^{d}	1.27^{f}	1.26^{g}	0.13^{de}	0.13^{de}	0.55^{c}	0.52^{d}	13.47^{f}	14.80^{e}	16.10^{ef}	16.11^{ij}
20th May	50 ppm	37.46^{d}	37.21^{c}	1.30^{e}	1.33^{f}	0.14^{d}	0.14^{d}	0.49^{d}	0.49^{e}	11.99^{fg}	12.34^{e}	19.26^{c}	19.27^{de}
	100 ppm	41.33^{c}	40.75^{b}	1.47^{c}	1.51^{de}	0.17^{c}	0.16^{c}	0.56^{c}	0.55^{c}	29.29^{e}	30.16^{d}	20.78^{b}	20.45^{c}
	200 ppm	42.15^{bc}	41.04^{b}	1.59^{b}	1.62^{b}	0.21^{b}	0.21^{b}	0.61^{ab}	0.61^{b}	39.44^{d}	40.62^{c}	23.68^{a}	23.66^{a}
	Control	33.94^{e}	35.88^{cd}	1.17^{g}	1.19^{g}	0.12^{e}	0.12^{ef}	0.43^{e}	0.43^{fg}	11.49^{fg}	10.59^{ef}	17.75^{d}	17.75^{fg}
10th June	50 ppm	32.85^{e}	31.35^{e}	1.30^{e}	1.32^{f}	0.12^{e}	0.13^{de}	0.41^{ef}	0.41^{gh}	13.84^{f}	13.74^{e}	15.67^{f}	15.76^{j}
	100 ppm	41.79^{bc}	40.78^{b}	1.48^{c}	1.49^{e}	0.16^{c}	0.17^{c}	0.43^{e}	0.45^{f}	14.50^{f}	14.89^{e}	16.94^{de}	16.78^{hi}
	200 ppm	43.46^{b}	39.55^{b}	1.57^{b}	1.57^{bc}	0.20^{b}	0.21^{b}	0.47^{d}	0.49^{e}	15.10^{f}	15.34^{e}	19.39^{c}	19.35^{d}
	Control	30.59^{f}	31.33^{e}	1.21^{g}	1.23^{fg}	0.10^{f}	0.11^{f}	0.40^{f}	0.39^{h}	7.21^{g}	6.34^{f}	14.52^{g}	14.56^{k}
LSD 5%		1.96	1.76	0.06	0.06	0.02	0.02	0.03	0.03	6.55	7.22	0.85	0.83

Robinson *et al.* [8] found an increase in leaf pigments as well as seed quality such as oil and protein of soybeans grown in late April compared to that of cultivated in the latter half of May.

Silicon assessed plants and maintains the photosynthesis ability under drought stress. The addition of silicon at 400 mg L^{-1} significantly increased the net photosynthesis by 40% and the total amount of NPK by 12% [36]. Pati *et al.* [37] found that silicon (diatomaceous earth) fertilization significantly increased uptake of nitrogen, phosphorus and potassium in grain and straw of rice.Salar and Torabian [38] reported that nano-silicon oxide (nano-SiO2) increase in K+ concentration.

Effect of the Interaction Between Soybean Cultivars and Silicon Concentrations on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: Data in Tables 12 and 13 indicated that the three soybean cultivars significantly differ to silicon concentrations in all growth, leaf chemical properties, seed yield and yield components during the two seasons of the study. In the three soybean cultivars all studied traits gradually increased with the increase of silicon concentrations.

Growth, Yield and Yield Components Traits: The obtained results in Table 12 showed that Giza 111 cv under the control treatment showed the lowest number of days to maturity (115.54 and 114.66 days). Also, Giza 111 that sprayed with 200 ppm of silicon had the highest 100-seed weight (16.15 and 16.24 g) while Line 105 that sprayed with 200 ppm of silicon had the highest plant height (119.96 and 120.78 cm) and seed yield/fad (1.60 and 1.56 ton) in both seasons, respectively. On the other side D89-8940 variety that sprayed with 200 ppm of silicon gave the highest number of branches/plant (3.07 and 3.13), pods number/plant (39.44 and 39.69) and seed yield/fad (1.66 and 1.62 ton) in the first seasons, respectively.

In the study of Attia [28] a wide diversity between Egyptian soybean in all growth and yield traits was found where, Line 105 had highest branches and bearing larger number of pods /plant could increase seed yield /plant (g) and 100-seed weight (g). Giza 22 was at the last rank with negative effect for earliness characters. Also, Morsy *et al.* [24] found that the soybean genotypes varied in all studied traits, that DR 101 was the latest in flowering and maturity (51.3 and 150.3 days, respectively) and produced the highest 100-seed weight (17.2g), while H30 was the earliest in maturity (115.00 days) and the lowest in 100-seed weight (12.14g). The commercial cultivar Giza 111 produced the highest seed yield (1.625t/fed.).

Spraying silicon may elevated soybean plants the pad effect of heat stress and this resulted in increased all growth and yield traits. In this respect Kalandyk *et al.* [34] found that sprayed silicon three times in the field condition, three times, every 2 weeks starting from the six-leaf stage caused an increase in the number of pods/plant 14% and weight of seeds/ plant by 21% compared to the control. In another field experiment, the use of silicon increased number of pods in soybeans by 18% and the average seed yield per plant by 21% compared to the control treatment [35].

Table 12: Effect of the interaction between soybean cultivars and silicon concentrations on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

Cultivars	Silicon conc. (ppm)	Maturity date (days) 2018	Maturity date (days) 2019	Plant height (cm) 2018	Plant height (cm) 2019	No. of Branches /plant 2018	No. of Branches /plant 2019	No. of pods /plant 2018	No. of pods /plant 2019	100- seed weight (g) 2018	100- seed weight (g) 2019	Seed yield/fed (ton) 2018	Seed yield/fed (ton) 2019
Giza 111	50	118.32^{f}	118.15^{g}	85.57^{d}	88.94^{f}	1.80^{f}	2.08^{d}	29.38^{d}	27.87^{e}	14.67^{cd}	14.81^{c}	1.16^{d}	1.28^{e}
	100	122.39^{e}	123.88^{f}	94.60^{c}	94.58^{e}	2.22^{d}	2.30^{c}	33.22^{c}	34.03^{c}	15.59^{b}	15.81^{b}	1.43^{c}	1.45^{d}
	200	124.79^{e}	125.51^{ef}	104.17^{b}	102.58^{cd}	2.64^{b}	2.67^{b}	36.54^{b}	36.74^{b}	16.15^{a}	16.24^{a}	1.58^{ab}	1.54^{bc}
	Control	115.54^{f}	114.66^{h}	80.23^{e}	80.27^{g}	1.60^{g}	1.69^{e}	22.16^{ef}	22.85^{g}	14.35^{d}	14.48^{cd}	1.00^{f}	1.02^{h}
Line 105	50	128.48^{d}	128.09^{de}	108.14^{b}	109.52^{b}	1.47^{g}	1.67^{e}	29.07^{d}	27.43^{e}	13.40^{ef}	13.52^{f}	1.08^{def}	1.18^{f}
	100	131.06^{d}	132.10^{d}	115.46^{a}	115.72^{a}	1.93^{ef}	2.00^{d}	31.72^{c}	33.15^{c}	14.32^{d}	14.34^{d}	1.44^{c}	1.47^{cd}
	200	134.95^{c}	135.79^{c}	119.96^{a}	120.78^{a}	2.33^{cd}	2.40^{c}	35.76^{b}	35.78^{b}	14.77^{c}	14.76^{c}	1.60^{a}	1.56^{ab}
	Control	124.90^{e}	124.49^{f}	98.43^{c}	98.50^{de}	1.27^{h}	1.20^{f}	22.04^{f}	22.85^{g}	13.08^{fg}	14.19^{de}	1.01^{f}	1.05^{gh}
D89-8940	50	139.19^{b}	140.07^{b}	87.86^{d}	87.50^{f}	2.33^{cd}	2.47^{c}	32.39^{c}	30.14^{d}	12.98^{g}	13.07^{g}	1.13^{de}	1.23^{ef}
	100	142.10^{b}	143.41^{a}	98.89^{c}	99.19^{de}	2.47^{bc}	2.70^{b}	35.54^{b}	36.87^{b}	13.81^{e}	13.91^{ef}	1.50^{bc}	1.53^{bcd}
	200	145.69^{a}	145.17^{a}	106.24^{b}	105.07^{bc}	3.07^{a}	3.13^{a}	39.44^{a}	39.69^{a}	14.28^{d}	14.30^{de}	1.66^{a}	1.62^{a}
	Control	135.25^{c}	135.00^{c}	76.22^{e}	75.74^{g}	2.00^{e}	2.07^{d}	24.29^{e}	25.11^{f}	12.69^{g}	13.71^{f}	1.05^{ef}	1.10^{g}
LSD 5%		3.39	3.31	5.24	5.38	0.2	0.2	2.15	2.1	0.42	0.41	0.09	0.08

Table 13: Effect of the interaction between soybean cultivars and silicon concentrations on soybean leaf and seed chemical properties in 2018 and 2019 seasons

		Leaf contents of								Seed contents of			
		Total chlorophyll (mg/100g fw.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si (mg/100g d.wt.)		Oil %	
Cultivars	Silicon conc. (ppm)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Giza 111	50	37.86^{f}	35.23^{e}	1.35^{ef}	1.39^{d}	0.15^{ef}	0.15^{de}	0.51^{d}	0.53^{d}	22.22^{f}	22.97^{f}	17.45^{fg}	17.49^{ef}
	100	43.06^{c}	42.43^{b}	1.52^{d}	1.57^{b}	0.18^{d}	0.19^{c}	0.54^{c}	0.56^{bc}	28.93^{de}	30.46^{de}	18.83^{cd}	18.58^{cd}
	200	42.91^{c}	40.59^{c}	1.69^{b}	1.72^{a}	0.22^{b}	0.24^{a}	0.55^{bc}	0.58^{b}	37.75^{bc}	40.29^{bc}	21.51^{ab}	21.47^{ab}
	Control	37.32^{fg}	35.39^{e}	1.17^{h}	1.20^{fg}	0.12^{h}	0.12^{g}	0.48^{e}	0.48^{e}	10.38^{g}	10.26^{g}	16.10^{hi}	16.11^{hi}
Line 105	50	32.19^{h}	32.35^{f}	1.25^{g}	1.25^{f}	0.12^{h}	0.12^{g}	0.46^{e}	0.44^{f}	23.85^{ef}	24.64^{ef}	17.95^{ef}	18.03^{de}
	100	38.26^{ef}	38.29^{d}	1.40^{e}	1.41^{d}	0.14^{fg}	0.14^{ef}	0.51^{d}	0.49^{e}	36.69^{bc}	38.49^{bc}	19.41^{c}	19.12^{c}
	200	40.10^{de}	39.50^{cd}	1.49^{d}	1.50^{c}	0.18^{d}	0.19^{c}	0.55^{bc}	0.55^{cd}	44.33^{a}	47.88^{a}	22.15^{a}	22.13^{a}
	Control	29.53^{i}	31.31^{f}	1.17^{h}	1.17^{g}	0.10^{i}	0.10^{h}	0.42^{f}	0.40^{g}	10.78^{g}	10.64^{g}	16.61^{gh}	16.64^{gh}
D89-8940	50	41.12^{cd}	40.75^{bc}	1.39^{e}	1.40^{d}	0.16^{e}	0.16^{d}	0.53^{cd}	0.54^{cd}	23.83^{ef}	24.60^{ef}	16.92^{gh}	16.96^{fg}
	100	45.87^{b}	45.11^{a}	1.58^{c}	1.59^{b}	0.20^{c}	0.22^{b}	0.57^{b}	0.58^{b}	34.59^{cd}	36.31^{cd}	18.30^{de}	18.10^{de}
	200	48.57^{a}	46.54^{a}	1.78^{a}	1.76^{a}	0.25^{a}	0.26^{a}	0.61^{a}	0.62^{a}	41.48^{ab}	44.25^{ab}	20.92^{b}	20.91^{b}
	Control	35.37^{g}	35.71^{e}	1.32^{f}	1.31^{e}	0.13^{gh}	0.13^{fg}	0.48^{e}	0.47^{e}	11.01^{g}	10.84^{g}	15.65^{i}	15.66^{i}
LSD 5%		1.96	1.76	0.06	0.06	0.02	0.02	0.03	0.03	6.55	7.22	0.85	0.83

Leaf and Seed Chemical Properties: Data in Table 13 revealed that the soybean variety D89-8940 that sprayed with 200 ppm of silicon gave the highest leaf contents of; total chlorophyll (48.57 and 46.54 mg/100 g fw.), nitrogen (1.78 and 1.76mg/g fw.), phosphor (0.25 and 0.26mg/g fw.) and potassium (0.61and 0.62mg/g fw.) in the first and second seasons, respectively. Line 105 that sprayed with 200 ppm of silicon showed the highest seed contents of; silicon (44.33 and 47.88 mg/100g d.wt.) and oil (22.15 and 22.13%) in both seasons, respectively.

The differences between soybean genotypes in leaf and seed chemical properties has been showed before by Krisnawati and Adie [29] they revealed that leaf content of nitrogen, phosphor and potassium and seed content of oil, protein and carbohydrate significantly differ in the different soybean genotypes. Genotypes 9 had the highest leaf content of nitrogen and seed content of both protein and carbohydrate while genotype 2 showed the highest leaf contents of phosphor and potassium and seed content of oil. Genotype 7 had the highest leaf pigments chlorophyll and carotene.

Silicon play an important role in all plant chemical proses where it assessed plants and maintains the photosynthesis ability under drought stress. The addition of silicon at 400 mg L^{-1} significantly increased the net photosynthesis by 40% and the total amount of NPK by 12% [36]. Pati *et al.* [37] found that silicon (diatomaceous earth) fertilization significantly increased uptake of nitrogen, phosphorus and potassium in grain and straw of rice. Salar and Torabian [38] reported that nano-silicon oxide (nano-SiO2) increase in K+ concentration.

Table 14: Effect of the interaction between sowing dates, soybean cultivars and silicon concentrations on soybean growth, seed yield and yield components traits in 2018 and 2019 seasons

Sowing dates	Cultivars	Silicon conc. (ppm)	Maturity date (days) 2018	Maturity date (days) 2019	Plant height (cm) 2018	Plant height (cm) 2019	No. of Branches /plant 2018	No. of Branches /plant 2019	No. of pods 2018	No. of pods 2019	100- seed weight (g) 2018	100- seed weight (g) 2019	Seed yield/fed (ton) 2018	Seed yield/fed (ton) 2019
1st May	Giza 111	50	123.48^{r}	122.18^{pq}	95.70^{ij}	99.75^{h-l}	2.30^{f}	2.50^{ef}	35.07^{efg}	32.19^{i-l}	13.88^{h-l}	13.90^{ijk}	1.49^{def}	1.67^{bcd}
		100	128.38^{p}	127.72^{k-o}	107.80^{d-g}	106.83^{d-h}	2.60^{de}	2.40^{fg}	42.52^{ab}	41.46^{bc}	14.36^{fgh}	15.20^{def}	1.68^{bc}	1.66^{bcd}
		200	132.30^{l}	131.32^{h-m}	115.10^{bc}	116.00^{bc}	2.80^{c}	3.00^{bc}	43.10^{a}	44.44^{a}	15.12^{cde}	15.47^{de}	1.81^{a}	1.80^{a}
		Control	119.24^{u}	119.56^{qr}	94.68^{ijk}	96.33^{jkl}	2.00^{gh}	2.00^{hi}	25.38^{mn}	25.71^{q-u}	13.65^{i-l}	13.79^{jkl}	1.16^{ijk}	1.10^{q-t}
	Line 105	50	130.34^{n}	131.52^{h-l}	114.34^{bcd}	116.21^{bc}	2.00^{gh}	2.20^{gh}	30.16^{jkl}	27.04^{p-s}	12.60^{no}	12.62^{no}	0.97^{lmn}	1.04^{s-w}
		100	132.30^{l}	133.28^{g-j}	119.37^{ab}	120.11^{ab}	2.40^{ef}	2.40^{fg}	33.7^{f-i}	34.25^{g-j}	13.31^{lm}	13.54^{j-m}	1.33^{fgh}	1.36^{h-m}
		200	135.24^{i}	134.26^{f-i}	124.61^{a}	123.49^{a}	2.60^{de}	2.80^{cd}	35.8^{ef}	36.60^{d-h}	13.83^{h-l}	13.86^{jkl}	1.45^{ef}	1.45^{g-j}
		Control	129.36^{o}	128.38^{j-n}	110.19^{c-f}	112.41^{cd}	1.60^{ij}	1.80^{ij}	21.95^{op}	22.50^{u}	12.35^{o}	12.47^{o}	0.93^{mn}	0.93^{w}
	D89-8940	50	143.08^{c}	144.06^{abc}	94.17^{ijk}	93.28^{lmn}	2.60^{de}	2.80^{cd}	33.59^{f-i}	30.50^{l-o}	13.64^{i-l}	13.66^{j-m}	0.99^{lmn}	1.07^{r-w}
		100	146.02^{b}	147.00^{a}	103.70^{fgh}	105.17^{e-i}	2.80^{c}	3.00^{bc}	39.26^{cd}	38.99^{cd}	14.25^{ghi}	14.80^{fgh}	1.36^{fg}	1.40^{h-l}
		200	151.90^{a}	148.96^{a}	109.60^{c-f}	108.54^{d-g}	3.60^{a}	3.40^{a}	40.63^{bc}	41.74^{b}	14.91^{def}	15.11^{efg}	1.48^{def}	1.48^{e-i}
		Control	142.10^{d}	140.14^{cde}	84.28^{mno}	86.38^{nop}	2.40^{ef}	2.60^{def}	24.38^{nop}	24.83^{r-u}	13.39^{klm}	13.52^{klm}	0.95^{lmn}	0.95^{u-w}
20th May	Giza 111	50	118.58^{v}	119.85^{q}	92.00^{j-m}	95.00^{klm}	1.70^{i}	2.13^{h}	31.95^{ijk}	27.90^{o-r}	14.13^{g-j}	14.16^{h-k}	1.06^{j-m}	1.09^{r-u}
		100	119.56^{u}	122.40^{opq}	100.00^{hi}	101.72^{g-k}	2.27^{f}	2.70^{de}	32.40^{g-j}	34.65^{f-i}	15.21^{cde}	14.88^{efg}	1.35^{fg}	1.44^{g-k}
		200	121.52^{s}	123.48^{n-q}	109.73^{c-f}	108.33^{d-g}	2.73^{cd}	2.80^{cd}	36.45^{e}	36.90^{d-g}	15.61^{bc}	15.33^{def}	1.49^{def}	1.49^{e-h}
		Control	115.96^{x}	114.07^{rs}	81.67^{nop}	80.00^{pqr}	1.80^{hi}	1.87^{i}	23.40^{nop}	24.30^{s-u}	13.80^{h-l}	13.92^{ijk}	0.96^{lmn}	1.01^{t-w}
	Line 105	50	131.32^{m}	129.85^{i-m}	109.32^{c-f}	108.95^{def}	1.40^{j}	1.60^{j}	29.19^{kl}	28.27^{n-q}	13.57^{jkl}	13.74^{jkl}	1.18^{hij}	1.29^{l-p}
		100	134.26^{j}	133.08^{g-j}	114.73^{bc}	116.27^{bc}	1.80^{hi}	2.00^{hi}	31.43^{ijk}	33.35^{ijk}	14.58^{efg}	14.51^{ghi}	1.54^{de}	1.58^{def}
		200	138.18^{g}	140.14^{cde}	119.52^{ab}	122.38^{ab}	2.20^{fg}	2.40^{fg}	36.58^{e}	36.19^{e-h}	14.99^{c-f}	14.97^{efg}	1.73^{ab}	1.67^{bcd}
		Control	128.18^{p}	126.13^{m-p}	105.43^{e-h}	104.67^{e-i}	1.40^{j}	1.20^{k}	22.60^{nop}	23.56^{tu}	13.23^{lmn}	16.32^{bc}	1.09^{j-m}	1.15^{p-t}
	D89-8940	50	141.12^{e}	140.53^{b-e}	86.29^{l-o}	88.25^{mno}	2.40^{ef}	2.20^{gh}	33.63^{f-i}	30.90^{k-n}	12.46^{o}	12.55^{no}	1.20^{g-j}	1.31^{j-o}
		100	143.08^{c}	144.06^{abc}	99.48^{hi}	97.16^{jkl}	2.40^{ef}	2.60^{def}	35.11^{efg}	37.40^{de}	13.41^{klm}	13.22^{lmn}	1.56^{de}	1.60^{cde}
		200	146.02^{b}	145.43^{ab}	105.17^{fgh}	107.48^{d-g}	3.00^{b}	3.20^{ab}	40.17^{bc}	40.20^{bc}	13.77^{h-l}	13.63^{j-m}	1.76^{ab}	1.70^{b}
		Control	138.18^{g}	137.98^{d-g}	79.29^{op}	77.98^{qr}	2.20^{fg}	2.00^{hi}	25.30^{mn}	26.32^{p-t}	12.16^{o}	13.61^{j-m}	1.10^{i-l}	1.17^{o-s}
10th June	Giza 111	50	112.90^{y}	112.41^{s}	69.00^{qr}	72.07^{rs}	1.40^{j}	1.60^{j}	21.12^{pq}	23.51^{tu}	16.02^{b}	16.37^{b}	0.94^{lmn}	1.09^{r-u}
		100	119.24^{u}	121.52^{pq}	76.00^{pq}	75.20^{qr}	1.80^{hi}	1.80^{ij}	24.75^{no}	25.99^{p-t}	17.19^{a}	17.36^{a}	1.26^{ghi}	1.24^{m-q}
		200	120.54^{t}	121.72^{pq}	87.67^{k-n}	83.40^{opq}	2.40^{ef}	2.20^{gh}	30.06^{jkl}	28.89^{nop}	17.71^{a}	17.93^{a}	1.44^{ef}	1.34^{i-n}
		Control	111.43^{z}	110.35^{s}	64.33^{r}	64.47st	1.00^{k}	1.20^{k}	17.70^{q}	18.53^{v}	15.60^{bc}	15.74^{cd}	0.88^{n}	0.94^{vw}
	Line 105	50	123.77^{r}	122.89^{opq}	100.76^{ghi}	103.41^{f-j}	1.00^{k}	1.20^{k}	27.86^{lm}	26.99^{p-s}	14.02^{g-k}	14.19^{hig}	1.10^{i-l}	1.20^{n-r}
		100	126.62^{q}	129.95^{i-m}	112.29^{cde}	110.78^{cde}	1.60^{ij}	1.60^{j}	30.01^{jkl}	31.84^{j-m}	15.07^{cde}	14.99^{efg}	1.43^{ef}	1.47^{f-i}
		200	131.42^{m}	132.98^{g-k}	115.74^{bc}	116.48^{bc}	2.20^{fg}	2.00^{hi}	34.92^{e-h}	34.54^{f-j}	15.49^{bcd}	15.46^{de}	1.61^{cd}	1.55^{efg}
		Control	117.16^{w}	118.97^{qr}	79.66^{op}	78.43^{pqr}	0.80^{k}	0.60^{l}	21.58^{op}	22.49^{u}	13.67^{i-l}	13.79^{jkl}	1.01^{k-n}	1.08^{r-v}
	D89-8940	50	133.38^{k}	135.63^{e-h}	83.11^{nop}	80.96^{opq}	2.00^{gh}	2.40^{fg}	29.95^{jkl}	29.01^{m-p}	12.83^{mno}	12.99^{mno}	1.20^{g-j}	1.30^{k-o}
		100	137.20^{h}	139.16^{c-f}	93.50^{i-l}	95.25^{klm}	2.20^{fg}	2.50^{ef}	32.26^{hij}	34.23^{hij}	13.79^{h-l}	13.72^{jkl}	1.56^{de}	1.60^{cde}
		200	139.16^{f}	141.12^{bcd}	103.96^{fgh}	99.18^{i-l}	2.60^{de}	2.80^{cd}	37.54^{de}	37.13^{def}	14.18^{g-j}	14.15^{ijk}	1.75^{ab}	1.69^{bc}
		Control	125.47^{q}	126.87^{l-p}	65.10^{r}	62.86^{t}	1.40^{j}	1.60^{j}	23.19^{nop}	24.17^{stu}	12.51^{o}	14.00^{ijk}	1.10^{i-l}	1.17^{o-s}
LSD 5%			5.87	5.74	9.06	9.31	0.34	0.35	3.73	3.64	0.72	0.71	0.16	0.14

Effect of the Interaction Between Sowing Dates, Soybean Cultivars and Silicon Concentrations on Soybean Growth, Seed Yield and Yield Components Traits as Well as Leaf and Seed Chemical Properties in 2018 and 2019 Seasons: The obtained data in Tables 14 and 15 revealed that the three soybeans cultivars significantly differ in their response to silicon concentrations for all growth and yield traits in the three sowing dates.

Growth, Yield and Yield Components Traits: Data in Table 14 showed that Giza 111 that sowing in 10th June under the control treatment had the lowest number of days to maturity (11.43 and 110.35 days). Also, Giza 111 that sprayed with 200 ppm of silicon in the aerly sowing date (1st May) gave the highest pods number/plant (43.10 and 44.44) and seed yield/fad (1.81 and 1.80 ton) moreover Giza 111 that sprayed with 200 ppm of silicon in the late sowing date (10th June) had the highest 100-seed weight (17.71 and 17.93g) in both seasons, respectively. while Line 105 that sprayed with 200 ppm of silicon in the early sowing date (1st May) gave the highest plant height (124.61 and 123.49 cm) without any significant differ with the same cultivar that spraying with 100 ppm of silicon in 1st May in both seasons, respectively. On the other side, D89-8940 that sprayed with 200 ppm of silicon in the early sowing date (1st May) showed the highest number of branches/plant (3.60 and 3.40) in the first and second seasons, respectively.

Table 15: Effect of the interaction between sowing dates, soybean cultivars and silicon concentrations on soybean leaf and seed chemical properties in 2018 and 2019 seasons

			Leaf contents of								Seed contents of			
			Total chlorophyll (mg/100 g fw.)		N (mg/g fw.)		P (mg/g fw.)		K (mg/g fw.)		Si (mg/100g d.wt.)		Oil %	
Sowing dates	Cultivars	Silicon conc.	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1st May	Giza 111	50 ppm	42.40^{def}	38.3^{hij}	1.41^{h-l}	1.45^{jkl}	0.17^{ghi}	0.16^{hij}	0.61^{cde}	0.66^{bc}	43.07^{e}	45.07^{d}	17.32^{n-r}	17.38^{n-s}
		100 ppm	45.73^{bc}	44.4^{cde}	1.59^{de}	1.63^{b-e}	0.21^{de}	0.23^{cde}	0.62^{cd}	0.67^{bc}	54.60^{c}	58.27^{c}	18.74^{i-m}	18.50^{k-n}
		200 ppm	46.07^{bc}	45.9^{abc}	1.89^{a}	1.87^{a}	0.25^{ab}	0.27^{ab}	0.58^{def}	0.62^{cd}	65.53^{b}	71.91^{b}	21.42^{de}	21.40^{de}
		Control	44.90^{bcd}	35.8 $^{j-m}$	1.21^{pqr}	1.25^{p-s}	0.14^{jkl}	0.13^{klm}	0.56^{fgh}	0.54^{fgh}	13.34^{hij}	14.65^{g-j}	16.03^{r-u}	16.03^{t-u}
	Line 105	50 ppm	34.05^{l-o}	35.19^{k-n}	1.28^{m-p}	1.26^{pqr}	0.14^{jkl}	0.12^{lmn}	0.52^{hij}	0.48^{ijk}	44.36^{e}	46.42^{d}	17.93^{l-o}	18.02^{l-q}
		100 ppm	39.20^{ghi}	40.59^{fgh}	1.44^{h-k}	1.47^{ijk}	0.17^{ghi}	0.18^{gh}	0.56^{fgh}	0.54^{fgh}	57.33	61.18^{c}	19.41^{h-k}	19.11^{i-l}
		200 ppm	42.78^{def}	43.91^{cde}	1.57^{def}	1.55^{f-i}	0.22^{cd}	0.21^{ef}	0.61^{cde}	0.60^{de}	70.12	79.10^{a}	22.18^{cd}	22.11^{cd}
		Control	31.06^{op}	32.93^{nop}	1.24^{opq}	1.21^{rs}	0.10^{n}	0.11^{mn}	0.47^{klm}	0.44^{klm}	13.61^{ij}	14.94^{g-j}	16.59^{p-s}	16.63^{r-u}
	D89-8940	50 ppm	46.16^{bc}	45.71^{bc}	1.46^{g-j}	1.43^{j-m}	0.18^{fgh}	0.19^{fg}	0.65^{bc}	0.68^{ab}	44.79^{de}	46.87^{d}	16.92^{o-s}	16.95^{p-u}
		100 ppm	47.28^{ab}	47.91^{ab}	1.61^{cde}	1.59^{d-g}	0.22^{cd}	0.24^{cd}	0.68^{ab}	0.69^{ab}	57.33^{c}	61.18^{c}	18.31^{k-n}	18.09^{k-p}
		200 ppm	49.08^{a}	48.25^{a}	1.90^{a}	1.94^{a}	0.27^{a}	0.29^{a}	0.71^{a}	0.73^{a}	71.43^{a}	78.38^{a}	20.93^{efg}	20.98^{d-g}
		Control	37.12^{ijk}	36.81^{ijk}	1.37^{j-m}	1.33^{m-q}	0.16^{hij}	0.15^{ijk}	0.61^{cde}	0.59^{def}	13.47^{hij}	14.80^{g-j}	15.67^{s-v}	15.66^{uvw}
20th May	Giza 111	50 ppm	37.53^{h-k}	37.18^{ijk}	1.33^{l-o}	1.37^{k-o}	0.15^{ijk}	0.15^{ijk}	0.53^{ghi}	0.55^{e-h}	11.10^{ij}	11.43^{hij}	19.37^{h-k}	19.33^{h-k}
		100 ppm	41.43^{fg}	42.23^{ef}	1.50^{fgh}	1.55^{f-i}	0.18^{fgh}	0.18^{gh}	0.62^{cd}	0.60^{de}	19.10^{h}	19.67^{g}	20.82^{efg}	20.46^{e-h}
		200 ppm	40.20^{fgh}	39.13^{ghi}	1.62^{bcd}	1.67^{bc}	0.21^{de}	0.23^{cde}	0.65^{bc}	0.67^{bc}	34.10^{fg}	35.12^{ef}	23.72^{ab}	23.68^{ab}
		Control	35.57^{j-m}	38.13^{hij}	1.17^{qrs}	1.21^{rs}	0.12^{lmn}	0.12^{lmn}	0.50^{ijk}	0.52^{ghi}	11.30^{ij}	10.42^{hij}	17.75^{l-p}	17.72^{m-r}
	Line 105	50 ppm	32.31^{nop}	33.09^{mno}	1.21^{pqr}	1.24^{qrs}	0.11^{mn}	0.12^{lmn}	0.46^{klm}	0.44^{klm}	13.32^{hij}	13.72^{g-j}	19.72^{g-j}	19.81^{g-j}
		100 ppm	38.26^{hij}	37.42^{ijk}	1.38^{i-m}	1.40^{k-n}	0.13^{klm}	0.12^{lmn}	0.53^{ghi}	0.50^{g-j}	38.20^{f}	39.34^{e}	21.32^{def}	21.01^{def}
		200 ppm	39.11^{ghi}	38.68^{hi}	1.47^{g-j}	1.51^{hij}	0.17^{ghi}	0.18^{gh}	0.57^{efg}	0.56^{efg}	47.74^{d}	49.17^{d}	24.32^{a}	24.37^{a}
		Control	30.05^{pq}	32.36^{nop}	1.10^{s}	1.08^{t}	0.10^{n}	0.10^{de}	0.40^{nop}	0.39^{l-o}	11.53^{ij}	10.63^{hij}	18.29^{k-n}	18.30^{k-o}
	D89-8940	50 ppm	42.54^{def}	41.37^{fg}	1.37^{j-m}	1.39^{k-o}	0.16^{hij}	0.15^{jkl}	0.48^{jkl}	0.47^{ijk}	11.54^{ij}	11.89^{hij}	18.68^{j-m}	18.66^{j-m}
		100 ppm	44.29^{cde}	42.61^{def}	1.54^{efg}	1.57^{e-h}	0.20^{def}	0.18^{gh}	0.54^{f-i}	0.55^{e-h}	30.56^{g}	31.47^{f}	20.20^{fgh}	19.88^{f-j}
		200 ppm	47.15^{ab}	45.30^{c}	1.68^{bc}	1.69^{b}	0.24^{bc}	0.22^{de}	0.61^{cde}	0.60^{de}	36.49^{f}	37.58^{e}	23.00^{bc}	22.92^{bc}
		Control	36.19^{jkl}	37.14^{ijk}	1.25^{n-q}	1.29^{o-r}	0.13^{klm}	0.14^{jkl}	0.39^{op}	0.38^{no}	11.64^{ij}	10.73^{hij}	17.19^{n-r}	17.21^{o-t}
10th June	Giza 111	50 ppm	33.66^{l-o}	30.13^{pq}	1.30^{m-p}	1.34^{m-q}	0.12^{lmn}	0.13^{klm}	0.37^{p}	0.39^{mno}	12.49^{hij}	12.41^{g-j}	15.67^{s-v}	15.77^{uvw}
		100 ppm	42.03^{ef}	40.67^{fgh}	1.48^{f-i}	1.52g^{-j}	0.15^{ijk}	0.16^{hij}	0.38^{p}	0.40^{l-o}	13.09^{hij}	13.44^{g-j}	16.93^{o-s}	16.79^{q-u}
		200 ppm	42.47^{def}	36.67^{ijk}	1.57^{def}	1.62^{b-f}	0.19^{efg}	0.21^{ef}	0.43^{mno}	0.45^{jkl}	13.63^{hij}	13.85^{g-j}	19.39^{h-k}	19.32^{h-k}
		Control	31.50^{op}	32.17^{op}	1.12^{rs}	1.15st	0.11^{mn}	0.12^{lmn}	0.36^{p}	0.38^{no}	6.49^{j}	5.71^{j}	14.53^{vw}	14.59^{wx}
	Line 105	50 ppm	30.22^{pq}	28.76^{q}	1.25^{n-q}	1.26^{pqr}	0.10^{n}	0.11^{mn}	0.40^{nop}	0.39^{mno}	13.88^{hij}	13.79^{g-j}	16.19^{q-u}	16.26^{s-v}
		100 ppm	37.32^{ijk}	36.87^{ijk}	1.37^{j-m}	1.35^{l-p}	0.13^{klm}	0.12^{lmn}	0.43^{mno}	0.44^{klm}	14.55^{hij}	14.93^{g-j}	17.49^{n-q}	17.23^{n-t}
		200 ppm	38.42^{hij}	35.92^{jkl}	1.44^{h-k}	1.43^{j-m}	0.16^{hij}	0.17^{ghi}	0.47^{klm}	0.48^{ijk}	15.15^{hij}	15.38^{ghi}	19.96^{ghi}	19.92^{f-i}
		Control	27.47^{q}	28.64^{q}	1.17^{qrs}	1.21^{rs}	0.10^{n}	0.10^{n}	0.39^{op}	0.36^{o}	7.21^{j}	6.34^{ij}	14.95^{uvw}	14.99^{vwx}
	D89-8940	50 ppm	34.67^{k-n}	35.16^{k-n}	1.35^{k-n}	1.37^{k-o}	0.14^{jkl}	0.14^{jkl}	0.47^{klm}	0.46^{jk}	15.14^{hij}	15.04^{g-j}	15.17^{t-w}	15.26^{vwx}
		100 ppm	46.03^{bc}	44.81^{cd}	1.58^{de}	1.60^{c-f}	0.19^{efg}	0.23^{cde}	0.48^{jkl}	0.50^{hij}	15.87^{hij}	16.29^{gh}	16.40^{q-t}	16.33^{s-u}
		200 ppm	49.49^{a}	46.07^{abc}	1.69^{b}	1.66^{bcd}	0.24^{bc}	0.25^{bc}	0.52^{hij}	0.54^{fgh}	16.52^{hij}	16.78^{gh}	18.83^{i-l}	18.82^{i-m}
		Control	32.79^{m-p}	33.18^{l-o}	1.34^{k-o}	1.32^{n-q}	0.10^{n}	0.10^{n}	0.44^{lmn}	0.43^{k-n}	7.93^{j}	6.98^{ij}	14.09^{w}	14.11^{x}
LSD 5%			3.39	3.06	0.11	0.11	0.03	0.03	0.05	0.06	11.34	12.51	1.47	1.44

In the present study the three soybean genotypes differ in their response under the different sowing dates. These results in the same line with those obtained by Morsy *et al.* [24] whom found that delayed sowing soybean from May 3 to June 4 significantly decreased plant height, branches number, pods number /plant, along with reducing of 100-seeds weight and seed yield / Faddan. They also, found that the soybean genotypes varied in all studied traits, that DR 101 was the latest in flowering and maturity (51.3 and 150.3 days, respectively) and produced the highest 100-seed weight (17.2g), while H30 was the earliest in maturity (115.00 days) and the lowest in 100-seed weight (12.14g). The commercial cultivar Giza 111 produced the highest seed yield (1.625t/fed.). Naoki *et al.* [25] found an increases in soybean growth, seed yield and seed quality with early sowing. Yohei *et al.* [26] found that soybean growth and yield were significantly reduced following late sowing.

Siliconelevated soybean plants the pad effect of heat stress and this resulted in increased all growth and yield traits. In this respect Kalandyk *et al.* [34] found that sprayed silicon three times in the field condition, three times, every 2 weeks starting from the six-leaf stage caused an increase in the number of pods/plant 14% and weight of seeds/ plant by 21% compared to the control. In another field experiment, the use of silicon increased number of pods in soybeans by 18% and the average seed yield per plant by 21% compared to the control treatment [35].

Leaf and Seed Chemical Properties: D89-8940 variety that sprayed with 200 ppm of silicon in the early sowing date (1^{st} May) showed the highest leaf content of; total chlorophyll (49.08 and 48.25 mg/100g fw.), nitrogen (1.90 and 1.94mg/g fw.), phosphor (0.27 and 0.29mg/g fw.) and potassium (0.71 and 0.73mg/g fw.) as well as the highest seed content of silicon(71.43 and 78.38 mg/100g d.wt.) in the first and second seasons, respectively. The exceeded of D89-8940 in these traits did not differ significantly with those obtained by Giza 111 that sprayed with 200 ppm of silicon in the first sowing date for leaf content of nitrogen and phosphor in both seasons (Table 15). Line 105 that sprayed with 200 ppm of silicon in the recommended sowing date (20^{th} May) had the highest seed content of oil (24.32 and 24.37%) in both seasons, respectively.

In this study all leaf and seed chemical properties in the three soybean cultivars significantly increase by the increase of silicon levels across the three sowing date. The differences in leaf and seed chemical properties in the three cultivars may due to the diversity in weather conditions among the three sowing dates and the diversity between the three soybean cultivars. The diversity between soybean genotypes across the different environments were observed before in some studies such as Krisnawati and Adie [29] evaluated the stability of 12 soybean genotypes of soybean mega-environments for the growth and yield performance. They revealed that leaf content of nitrogen, phosphor and potassium and seed content of oil, protein and carbohydrate significantly differ in the different soybean genotypes. Genotypes 9 had the highest leaf content of nitrogen and seed content of both protein and carbohydrate while genotype 2 showed the highest leaf contents of phosphor and potassium and seed content of oil. Genotype 7 had the highest leaf pigments chlorophyll and carotene.

In the previous studies silicon used as heat stress migratorswhere it share in all plant chemical proses. Silicon assessed plants and maintains the photosynthesis ability under drought stress. The addition of silicon at 400 mg L^{-1} significantly increased the net photosynthesis by 40% and the total amount of NPK by 12% [36]. Pati *et al.* [37] found that silicon (diatomaceous earth) fertilization significantly increased uptake of nitrogen, phosphorus and potassium in grain and straw of rice. Salar and Torabian [38] reported that nano-silicon oxide (nano-SiO2) increase in K+ concentration.

It could be recommended with sowing Giza 111 in May and D89-8940 in June under 200 ppm of silicon foliar spraying three times from the beginning of flowering stage to obtained high seed yield and yield quality of soybean Nile Delta region.

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