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Impact of foliar spraying with potassium silicate and planting dates on the productivity and quality of canola plants (*Brassica napus* L.)

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Abstract

This experiment was conducted to evaluate the effect of planting dates and foliar spraying with different rates of potassium silicate on characteristics of canola production under Egyptian conditions. The experiment was conducted in the research farm at the Faculty of Agriculture, Al-Azhar University, Assiut, Egypt during the winter seasons 2020/2021 and 2021/2022. The experimental design used was the split plot design in three replicates, where the dates were set (October 10, October 20 and October 30) in the main plots while, spraying with different concentrations of potassium silicate (0, 200, 400 and 600 ppm) were in the sub- plots. The cultivar (Serw-6) was also cultivated. The results showed the superiority of the second planting date (October 20) and the highest values were given for the characteristics of plant height (cm), number of branches per plant, number of pods per plant, 1000-seeds weight (g), seed yield/plant (g), biological yield (kg/feddan) (feddan= 4200 m^2), seed yield (kg/feddan) and oil yield (kg/feddan), while the third planting date was given the highest of protein percentage and oil percentage. Also, spraying with potassium silicate at a concentration of 600 ppm was superior to others were given the highest values for plant height (cm), number of branches per plant, number of pods per plant, 1000-seed weight (g), seed yield/plant (g), biological yield (kg/feddan), seed yield (kg/feddan), oil yield (kg/feddan), protein percentage and oil percentage. So, using foliar spraying with potassium silicate with planting at the appropriate dates could be improve seed yield and reducing the need for chemical fertilizers and this will lead to sustainable agriculture.

Keywords: canola, potassium silicate, planting dates.

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1. Introduction

Oil crops are considered strategic and important crops, both in Egypt and countries of the world, because they represent a major source of food. Canola (*Brassica napus* L.) is one of the most important annual oil and protein crops in the world. Generally, canola plant oil has the lowest saturated fatty acids content among vegetable oils and thus presents an increasing demand for consumers of diet conscious. In Egypt, canola has a bright future for contributing to reducing the oil shortage gap between production and consumption of edible oil, especially since it can be successfully grown during winter in newly reclaimed lands outside the ancient Nile Valley to overcome competition with other crops that occupied the old cultivated area (Sharaan *et al*., 2002). In light of the different climatic changes, it is necessary to update the planting dates to suit the climatic changes to obtain the highest productivity per unit area to bridge the food gap between consumption and production. Several studies reported that planting dates of canola has proven a key to maximize yield potential and reduce risk. Planting date is one of the most important and manageable agricultural practices that affect growth, dry matter production, quality and yield of crops (Ozer, 2003). Sharief and Keshta (2002) found that the second planting date (Nov. 5) was gave the highest rate of plant height, number of branches per plant, seed yield/plant, seed yield (kg/feddan), biological yield (kg/feddan) and total oil yields (kg/feddan) Compared to other planting dates (October 15 and November 25) in both seasons. While the first planting date (October 15) gave the highest oil percentage (%) in both seasons. Silicon (Si) is the second most abundant constituent in soil. Recent research revealed that Si can enhance plant tolerance against drought stress. In addition to, the use of Si can increase seed germination, underground and aboveground biomass, photosynthetic pigments, grain quality and yield (Pang *et al.*, 2019). It plays an important role in plant tolerance to environmental stresses (Gong *et al*., 2003). Potassium (K) is an important nutrient that has positive effects on the metabolism of nucleic acids, proteins, vitamins and growth materials. Moreover, K plays an important role in the transmission of PV structures from sources to basins (Morteza *et al*., 2005). Merwad (2018) found that foliar of spraying potassium silicate concentration (500 mg/L) proved to be outperformed over other concentrations (0.0, 250, 750, and 1000 mg /L) by the highest values of plant height, number of pods per plant, 1000-seed weight (g), biological yield (kg ha^{-1}) seed yield (kg ha^{-1}) and protein percentage in seeds (%). Therefore, the present study aimed to investigate the effect of three sowing dates and foliar application with potassium silicate on the production and quality of canola plant under Assiut governorate conditions, Egypt.

2. Materials and methods

2.1 Experimental site

A field experiment was held at the farm of the Faculty of Agriculture, Al-Azhar University, Assiut, Egypt during the two agricultural seasons 2020/2021 and 2021/2022, with the aim of study the effect of planting dates and spraying with potassium silicate in the presence of new climatic changes and its impact on yield, yield components and quality of canola cultivar (Serw-6) under the conditions of Assiut governorate, Egypt.

2.2 Studied factors

2.2.1 Planting dates

The experiment was planted on three planting dates (October 10, October 20 and October 30).

2.2.2 Foliar spraying with potassium silicate

Foliar spraying with potassium silicate K_2SiO_3 (27.5% silicon and 15% potassium commercial name H silicate). It was sprayed with four concentrations as follows: (0, 200, 400 and 600 ppm). It was sprayed twice at a rate of 250 (L/feddan) after 25 and 50 days of sowing, respectively.

2.3 Experimental design and field management

The experiment was an arrangement to split plot design with three replications. The planting dates served as main plots and the sub-plots were spraying with four concentrations of potassium silicate. The cultivar (Serw-6) was also cultivated. Sowing was done on hill spaced 15 cm apart along the row seeding were thinned secure two plants/hill before the first irrigation. The sub-plot area was 10.5 m^2 (3×3.5 m), *i.e.*, 1/400 feddan in both seasons, no diseases, and pests other than aphids insects.

2.4 Soil analysis

Some mechanical and chemical properties of the soil of the experimental site were analyzed according to the methods described by Blak (1965) for available nitrogen, Jackson (1973) for PH and E.C., and Olsen (1954) for available phosphorus and potassium (Table 1).

Table (1): Mechanical and chemical analysis of soil field experiment.

Characteristics	Seasons		Characteristics	Seasons	
Mechanical analysis	2020	2021	Chemical analysis	2020	2021
Sand	26.42	25.00	Available N (ppm)	77.00	70.05
Silt	35.23	34.33	Available P (ppm)	120.67	118.30
Clay	38.35	40.67	Available K (ppm)	105.40	95.53
Soil texture	Clay loam		Organic matter (%)	1.09	0.93
			PH (sp. m^{-1})	7.82	7.91
			E.C. (ds. m^{-1})	1.05	1.15
			Total $CaCO_3$ (%)	2.43	2.63

2.5 Meteorological data

Meteorological data (monthly temperature C^{o}, rate humidity percentage and wind speed) in Assiut governorate during the growing seasons, 2020/2021 and 2021 2022.

2.6 Studied characters

At harvest, five plants from 3 inner rows of every treatment in three replications were chosen to determine the following data:

- Growth characters
  - Plant height (cm)
  - Number of branches/plant
- Yield and its components
  - Number of pods/plant
  - 1000–seeds weight (g)
  - Seed yield/plant (g)
  - Seed yield (kg/feddan)
  - Biological yield (kg/feddan)
  - Oil yield (kg/feddan)
- Seeds chemical analyses
  - Oil percentage (%) was determined according to AOAC (1984) by using soxhelt.
  - Protein percentage (%): The nitrogen content in the seeds was determined by using the modified Kjeldahl method according to AOAC (1984).

Table (2): Meteorological data of Assiut district during the two growing seasons of 2020/2021 and 2021/2022.

Monthly	Seasons 2020/2021				Seasons 2021/2022			
	Maximum temperature	Minimum temperature	Relative humidity (%)	Speed wind (km/h)	Maximum temperature	Minimum temperature	Relative humidity (%)	Speed wind (km/h)
October	34.06	20.9	49.03	17.07	32.35	17.58	47.24	14.98
November	24.6	13.3	56.55	14.82	28.33	13.87	52.87	9.98
December	22.9	9.94	55.82	14.32	20.06	8	56.49	10.73
January	20.94	7.06	61.07	13.49	16.71	4.94	59.01	10.23
February	21.5	7.14	59.28	16.13	19.86	6.68	53.1	13.81
March	26.58	10.94	45.84	18.86	22.48	8.86	41.8	18.04
April	32.03	15.13	37.2	17.2	34.1	16.73	29.14	15.64

2.7 Statistical analysis

The Collected data were statistically analyzed using the computer MSTAT-C statistical Freed *et al* (1989). The analysis of variance and level of significance along with the least significant difference (LSD) test were done following Gomez and Gomez (1984).

3. Results and discussion

3.1 Growth characters

3.1.1 Effect of planting dates

Through the results presented in Table (3) show that in the two growing seasons. Planting dates treatments exhibited significantly differences in plant height

and number of branches per plant both seasons, the second planting date (October 20) the highest values were given for the characteristics of plant height (225.06 and 201.86 cm) and number of branches per plant (7.85 and 7.21) in both seasons, respectively, compared to other planting dates, due to the availability of optimum temperatures during the growing seasons. These results are in the same direction with those he found by Rameeh (2014), Dinda *et al*. (2015), Barekati *et al*. (2019) and Hashim and Mahmood (2021).

Table (3): Effect of planting dates, spraying with potassium silicate and their interaction on (plant height and number of branches per plant) in 2020/2021 and 2021/2022 seasons.

Planting dates (D)	Potassium silicate (ppm) (S)	Plant height (cm)		Number of branches per plant	
		Seasons			
		2020/2021	2021/2022	2020/2021	2021/2022
October 10	0	213.33	183.67	6.77	6.2
	200	217.33	190.0	7.2	6.63
	400	227.0	196.67	7.53	6.96
	600	230.4	203.33	7.77	7.13
Mean		222.02	193.42	7.32	6.73
October 20	0	217.6	192.3	7.2	6.5
	200	222.0	198.0	7.83	7.03
	400	228.63	206.33	7.97	7.3
	600	232.0	210.56	8.43	8.0
Mean		225.06	201.86	7.85	7.21
October 30	0	201.93	160.0	5.33	4.8
	200	202.07	171.3	5.53	5.0
	400	204.2	177.33	6.07	5.5
	600	207.87	182.87	6.27	6.0
Mean		204.02	172.98	5.8	5.33
All means of potassium silicate	0	210.96	178.74	6.43	5.83
	200	213.8	186.58	6.85	6.22
	400	219.94	193.44	7.18	6.59
	600	223.42	198.9	7.48	7.04
LSD at 5%					
D		1.65	4.96	0.08	0.15
S		2.23	3.25	0.09	0.07
D × S		3.87	N.S	0.17	0.12

3.1.2 Effect of spraying with potassium silicate

The data in the Table (3) showed that increasing with potassium silicate rates from 0, 200, 400 and 600 ppm, significantly increased plant height and number of branches per plant both seasons, spraying with a concentration of 600 ppm gave the highest values for plant height (223.42 and 198.9 cm) and number of branches per plant (7.48 and 7.04) in two seasons, respectively. This may be due to the effect of potassium silicate on growth. These results agree well with those obtained by Moustafa *et al.* (2018), Abdel-Latif *et al*. (2019) and Abd Allah *et al.* (2021).

3.1.3 The interaction effect

Regarding the interaction effect, the data presented in Table (3) focused on the presence of a significant interaction

between dates and spraying with potassium silicate for plant height in the first season only. Also, there is a significant interaction between the number of branches per plant in both seasons obtained from planting on the date (October 20) and spraying with a concentration of 600 ppm potassium silicate.

3.2 Yield and its components

3.2.1 Effect of planting dates

The results presented in Tables (4 and 5) the effect of planting dates on number of pods per plant, 1000-seeds weight, seed yield/plant, biological yield/feddan, seed yield/feddan and oil yield/feddan, results revealed that there were significantly effects on this characters in both seasons, it was found that the second planting date (October 20) was the best, as the largest values was given to the number of pods per plant (705.42 and 594.75), 1000-seeds weight (4.263 and 4.067 g), seed yield/plant (40.97 and 38.24 g), biological yield (7562.3 and 6995.3 kg/feddan), seed yield (1606.5 and 1475.1 kg/feddan) and oil yield (717.4 and 666.6 kg/feddan) in two seasons, respectively.

Table (4): Effect of planting dates, spraying with potassium silicate and their interactions on (number of pods per plant, 1000–seeds weight and Seed yield /plant) in 2020/2021 and 2021/2022 seasons.

Planting dates (D)	Potassium silicate (ppm) (S)	Number of pods per plant		1000 – seeds weight (g)		Seed yield /plant (g)	
		Seasons					
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
October 10	0	513.87	466.67	3.987	3.793	29.95	27.78
	200	552.27	505.0	4.092	3.931	33.64	31.44
	400	582.67	528.33	4.203	4.004	35.48	32.81
	600	635.07	588.67	4.306	4.106	37.1	34.94
Mean		570.97	522.17	4.147	3.96	34.04	31.74
October 20	0	608.67	520.33	4.065	3.867	34.97	32.31
	200	659.33	571.33	4.166	3.963	38.74	36.08
	400	718.33	593.0	4.31	4.112	42.15	39.22
	600	835.33	694.33	4.512	4.328	48.02	45.35
Mean		705.42	594.75	4.263	4.067	40.97	38.24
October 30	0	509.8	465.33	3.53	3.34	28.93	24.74
	200	554.33	495.0	3.622	3.425	30.24	26.69
	400	569.73	516.4	3.721	3.526	32.43	27.85
	600	612.73	545.33	3.818	3.62	35.46	31.8
Mean		563.9	505.52	3.673	3.478	31.76	27.78
All means of potassium silicate	0	544.11	484.11	3.86	3.667	31.28	28.28
	200	588.64	523.78	3.96	3.773	34.21	31.4
	400	623.58	545.91	4.074	3.883	36.69	33.29
	600	697.38	609.44	4.211	4.018	40.19	37.34
LSD at 5%							
D		15.24	10.44	0.059	0.027	0.44	0.48
S		16.02	15.37	0.043	0.024	0.83	0.87
D × S		27.75	26.63	0.097	0.054	1.45	1.51

This is due to the availability of suitable temperatures during the flowering period, which led to the lack of flowering and an increase in the yield and its components. These results are similar to Sharief and Keshta (2002), Nazeri *et al*. (2018),

Monfared *et al*. (2020) and Ranabhat *et al*. (2021).

Table (5): Effect of planting dates, spraying with potassium silicate and their interactions on (biological yield, seed yield and oil yield) in 2020/2021 and 2021/2022 seasons.

Planting dates (D)	Potassium silicate (ppm) (S)	Biological yield (kg/feddan)		Seed yield (kg/feddan)		Oil yield (kg/feddan)	
		Seasons					
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
October 10	0	6135.0	5610.0	1356.5	1226.5	546.7	518.6
	200	6837.0	6261.0	1481.6	1358.2	634.4	584.1
	400	7020.0	6438.0	1596.9	1395.2	701.3	621.6
	600	7191.0	6642.0	1674.2	1480.6	742.3	671.9
Mean		6795.8	6237.8	1520.5	1365.1	656.2	599.1
October 20	0	6621.0	6093.0	1448.2	1334.8	622.9	582.5
	200	7242.0	6639.0	1538.7	1418.7	679.2	635.3
	400	7779.0	7230.0	1637.2	1520.5	740.1	692.3
	600	8607.0	8019.0	1802.1	1626.4	827.3	756.4
Mean		7562.3	6995.3	1606.5	1475.1	717.4	666.6
October 30	0	5814.0	5364.0	1061.6	874.9	464.4	389.4
	200	6336.0	5793.0	1140.2	933.5	503.8	417.1
	400	6750.0	6213.0	1236.9	1053.6	560.3	480.9
	600	6852.0	6372.0	1311.9	1191.9	615.2	558.3
Mean		6432.0	5935.5	1187.6	1013.5	535.9	461.4
All means of potassium silicate	0	6190.0	5689.0	1288.8	1145.4	544.7	496.8
	200	6805.0	6231.0	1386.8	1236.8	605.8	545.5
	400	7175.0	6627.0	1490.3	1323.0	667.2	598.3
	600	7550.0	7011.0	1587.1	1432.9	728.3	662.2
LSD at 5%							
D		280.9	93.8	16.87	5.72	9.2	4.2
S		279.9	186.04	17.55	10.5	9.8	6.8
D × S		483.9	322.23	40.11	24.0	22.5	15.5

3.2.2 Effect of spraying with potassium silicate

The results presented in Tables (4 and 5) revel that increasing application concentration potassium silicate to canola plants significantly in all criteria in both seasons, the spraying concentration of 600 ppm is the best, as the largest values was given to the number of pods per plant (697.38 and 609.44), 1000- seeds weight (4.211 and 4.018 g), seed yield/plant (40.19 and 37.34 g), biological yield (7550 and 7011 kg/feddan),seeds yield (1587.1 and 1432.9 kg/feddan) and oil yield (728.3 and 662.2 kg/feddan) in the first and the second seasons, respectively, This is due to the ability of potassium silicate to raise the efficiency of the plant to withstand inappropriate conditions and thus increase the yield and its components. These results are in the same direction with those obtained by Merwad (2018), Fani *et al.* (2019), Abd Allah *et al.* (2021), Hafez *et al.* (2021) and Sirisuntornlak *et al.* (2021).

3.2.3 The interaction effect

Through the data presented in Table (4 and 5), it is clear that there is a significant interaction between date (October 20) and spraying with

potassium silicate (600 ppm), where the highest value was obtained for both the number of pods per plant (835.33 and 694.33), 1000-seeds weight (4.51 and 4.33 g), seed yield/plant (48.02 and 45.35 g), biological yield (8607 and 8019 kg/feddan), seed yield (1802.1 and 1626.4 kg/feddan) and oil yield (827.3 and 756.4 kg/feddan) in two seasons, respectively, the increase may be due to the availability of appropriate environmental conditions with spraying with potassium silicate (600 ppm) at the time of planting (October 20), which led to an increase in the efficiency of photosynthesis and transport in the plant and an increase in the yield.

3.3 Seeds chemical analyses

3.3.1 Effect of planting dates

Looking at the planting dates in Table (6) results indicated that there was significant effect on seeds protein and oil percentage in both seasons. We find that the third planting date is October 30, which is the highest in protein percentage (21.58 and 23.47%) and oil percentage (45.03 and 45.42%) in both seasons, respectively compared to the other dates. This is due to the high temperatures during the month of April during the ripening of the seeds, which leads to a decrease in the fullness of the seeds and an increase in the oil and protein content. Similar results have been obtained by Monfared *et al*. (2019) and Sevgi and Aydın (2021).

Table (6): Effect of planting dates, spraying with potassium silicate and their interactions on (Protein % and Oil percentage) in 2020/2021 and 2021/022 seasons.

Planting dates (D)	Potassium silicate (ppm) (S)	Protein percentage		Oil percentage	
		Seasons			
		2020/2021	2021/2022	2020/2021	2021/2022
October 10	0	19.57	19.93	40.3	42.28
	200	19.27	19.53	42.82	43.0
	400	20.47	20.97	43.92	44.55
	600	20.53	21.3	45.07	45.38
Mean		19.96	20.43	43.03	43.81
October 20	0	19.03	19.47	43.02	43.64
	200	20.63	20.77	44.14	44.78
	400	20.7	20.9	45.21	45.53
	600	20.97	21.5	45.91	46.51
Mean		20.33	20.66	44.57	45.11
October 30	0	20.07	22.47	43.74	44.5
	200	21.1	23.77	44.19	44.68
	400	21.7	23.77	45.29	45.64
	600	23.43	23.87	46.89	46.85
Mean		21.58	23.47	45.03	45.42
All means of potassium silicate	0	19.56	20.62	42.35	43.48
	200	20.33	21.36	43.72	44.15
	400	20.96	21.87	44.81	45.24
	600	21.64	22.22	45.96	46.24
LSD at 5%					
D		0.33	0.26	0.25	0.17
S		0.32	0.26	0.31	0.32
D × S		0.72	0.59	0.72	0.73

3.3.2 Effect of spraying with potassium silicate

As for the use of foliar spraying of potassium silicate, treatment results reveal that they had significant effect on seeds protein and oil content during two seasons. We find that spraying with a concentration of 600 ppm, which is the highest in protein percentage (21.64 and 22.22 %) and oil percentage (45.96 and 46.24%) in both seasons, respectively, compared to other concentrations. This is due to the effect of potassium silicate on increasing dry matter formation during vegetative growth, which led to an increase in oil and protein content. Similar results have been obtained by Merwad (2018), Moustafa *et al.* (2018) and Fani *et al.* (2019).

3.3.3 The interaction effect

Through the data in Table (6), it is clear that there is a significant interaction between dates and spraying with potassium silicate, which gave the highest value for protein percentage (23.43 and 23.87%) and oil percentage (46.89 and 46.85) in both seasons, respectively, obtained from the planting date of (October 30) and spraying concentration of 600 ppm.

4. Conclusion

Through the data and results, the study recommends planting the canola crop on the planting date of October 20 with potassium silicate spraying at a concentration of 600 ppm to achieve the highest yield in terms of quantity or quality in the study area.

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