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Chemical Study of Silica and Calcium in Rapeseed Dates

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ABSTRACT

This study investigates the chemical content of rapeseed and its effects on food industry. Rapeseed (Brassica napus L.) is one of the most important oil plants that has a major role in providing human edible oil and it is in the third place in terms of oil consumption in the world. The results indicated that effect of year on the number of silique in the plant, the number of seeds in silique, and anthocyanin were significant, and the second year was allocated with the highest level of these specifications. The best seed yield (2477.02 kg/ha) was belonged to one week after yellowing of silique. The silica spraying led to increase in number of silique in plant, the number of seeds in silique, and seed yield and soluble sugar by 11.8, 31.48, and 24.31%, respectively, and increase in silica and calcium concentrations by 98.64 and 66.55% in silique, respectively. Moreover, it reduced anthocyanin and electrolyte leakage by 55.79%. Silica spraying (6%) demonstrated the highest positive effect. As calcium concentration increased, the number of silique in plant, the number of seeds in silique, seed yield, biological yield, soluble sugar, silica, and calcium concentration in silique, and reduction of anthocyanin and electrolyte leakage increased. Calcium spraying No. 6 showed the highest positive effects in terms of the abovementioned features. The results showed that silica and calcium increased the yield and yield elements, physiological effects, silica and calcium nutrition elements, and reduced the electrolyte leakage. The best treatment was obtained by using 6% of silica and 6% of calcium.

GRAPHICAL ABSTRACT

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Introduction

Population growth, nutrition level, and increase of oil seed press cake in livestock and birds' food require producing oil seeds throughout the world; therefore, oil crops cultivation development is essential for self-sufficiency which needs systematic and long-term planning aiming at the achievement of the self-sufficiency goal [1-3]. *Brassica Napus* L. is one of the most important plant oil with significant roles in supplying human edible oils.

The seed harvest time is usually determined after the maturation level based on the seed humidity level and appearance. Thus, seeds have to be harvested after maturation for measuring seed weight which is at the late growth period and after the physiological maturation level [4].

Since the quality and quantity of bioactive components of the plants change extremely when the growth time is closed to the harvesting one, and considering that geographical and climate condition of each region is effective on harvest time of corps, it is of significant principle to determine the harvest time of each plant for a particular region [5]. Being aware of the suitable harvesting time, one can manage the crops use and plan for the plant to avoid undesirable environmental conditions. This is reported that identifying the physiological maturation and harvest maturation time of *Brassica Napus L.* is possible through the appearance to avoid over-maturation or under-maturation of silique at the harvesting time with its on-time doing.

Researchers reported that *Brassica Napus L.* harvesting two weeks before the maturation could be done without adverse effects on the qualitative and quantitative features of the seeds. Nevertheless, the humidity percentage of seed at this time is not suitable for the direct harvesting by combining harvester in terms of seed quality [6].

Optimal nutrition is also an effective factor in agricultural crops. Lack of Ca in acidic soils is particularly an important limiting factor in production. Ca plays an essential role in eggs fertilization, fruit formation, maturation and silique filling, seed and oil yield, and improves the nitrogen biological fixation [7]. As a divalent cation for cell wall and membrane structural activities, a cation is required for organic and non-organic anions in vacuole and as an intracellular receptor, bonding to the phospholipids, Ca stabilizes the lipid layers, and finally integrates the cell membrane structure [8]. Consumption of calcium silicate increases the yield of *Brassica Napus L.* and leaves the relative water content [9]. Different sources of calcium analysis in maze indicate that as calcium lactate concentration increases, antioxidant activity, anthocyanin content, and total phenol level increase [10].

Silica is the second most frequent element in soil, which contributes to the earth's crust by 28%. Nevertheless, silica is not considered as essential for plants, its applicability is proved for the healthy growth and development of plant organs in many agricultural crops [11]. Using silica increases the nutrients absorption like zinc, calcium zinc, potassium, phosphorus, and boron in plants [12]. Researchers found that consuming silica increases the silica concentration in leaves and using silica fertilizer increases the dry weight and yield of rice.

Material and Methods

Sample preparation and treatments

This experiment was conducted in District Aftab, Tehran, in a field in three iterations by using split factorial during two cropping years of 2018-2019 and 2019-2020. The experimental factors included the harvesting date in three levels of one week after yellowing of silique, two weeks after yellowing of silique, and complete yellowing, silica in levels zero (control), 3 and 6%, and calcium levels of 2, 4, and 6%, respectively.

The field was prepared in early September and fertilizers were employed based on soil test recommendations. Each plot included three rows 60 cm apart and each row has two planting lines. The canola seed (Okapi variety) was conducted by a lister planter. Foliar spraying treatments was done once during growth and once after the filling of siliques. At the stage of grain maturation, ten plants were randomly selected to measure traits. For measuring anthocyanin, 0.2 g of leaf was sampled and grained in 3 ml of acidic methanol composing of methanol and hydrochloric acid (rated 99:1) completely, and then the obtained essence was centrifuged. The upper solution was also stored in darkness overnight. The absorption level was read in 55 nm [12].

To measure the soluble sugar level, 10 mL ethanol (70%) was added to 0.1 g of the organ dried tissue and the product was stored in refrigerator for a week. Afterward, 0.5 mL as sample from the upper solution was extracted and was brought up to the volume required, and then 1 mL of phenol (5%) and 5 mL of concentrated sulfuric acid were added. The color intensity of solution resulted was read in wavelength of 485 nm by using spectrophotometer, UV100 Model, and the level of sugars was estimated in terms of mg/g dried weight using sugar standard curve. To measure membrane electrolyte leakage, 0.2 g of fresh leaf weight was taken from the replicates and washed. The samples were put in the enclosed glass vessels containing 10 mL of deionized water. The vessels were put in warm water bath with temperature of 30 °C for 3 hours. After 3 hours, the electrical conductivity of the sample was measured by EC meter. Then, the vessels containing leaf samples were put under temperature of 100 °C for 2 hours and their EC was measured for the second time after cooling. The EC percentage explains the level of electrolyte leakage, which is calculated based on the formula as follows were EC_1 and EC_2 are EC of solutions before and after boiling, respectively.

$$\%EC=(EC1/EC2)*100$$

To measure the elements, digestion, dry burning, and integration with 2-molar sulfuric acid were used. The plant limbs were ground and exposed to a temperature of 550°C and then they were solved into the 2-molar chloric acid, filtered, and brought up to volume to measure the less frequently used nutritional elements by using Shimadzu atomic absorption device, AA-670G model [14].

Statistical analysis

Data was subjected to two-way analysis of variance (ANOVA), and means of the traits were compared by Duncan's new multiple range test at a significance level of $P < 0.05$ using SAS ver. 9.2 software.

Result and Discussion

As the results of analysis of variance (ANOVA) implied, the effect of year, silica, and calcium were significant at the 1% level and the intraction effects of year on silica, year on calcium, silica on calcium, and triple effect of year on harvesting date and calcium was significant at the level of 5% in terms of the number of silique in the plant (Table 1). By using silica, the number of silique in plant increased and the silique maximum in plant was 108.26 in treatment No. 6 of silica which implied an increase of number in the plant by 11.8% compared to the control sample (Table 2). Comparing the mean number in plant under the influence of calcium, it was found that as calcium level increases, the plant height increases, too. The highest number in plant was 105.44 and 108.44 for treatments 4 and 6% of calcium and the lowest number of silique was 92.44 in treatment 2% of calcium (Tables 1, 2, and 3).

Based on the results of comparison in terms of silique number means under the influence of year and calcium, using silica and calcium increased the effects. The number of silique in plant was estimated to be 115.22 by using 6% of calcium with 6% of silica (Table 4). The results of comparing the mean number of silique in plant under the influence of harvesting date and calcium during two agricultural years explained that the highest number of silique was 108.78 and 112.78 by using 6% and 4% of calcium in harvesting a week after yellowing of the silique in the first year. This was 112.78 and 111.44 silique using 4% and 6% of calcium after complete yellowing in the second year (Table 5).

Table 1: Results of ANOVA of silica and calcium levels effects on qualitative and quantitative specifications of *Brassica Napus L.* in different harvesting dates

S.O.V	DF	No. of silique /plant	No. of seed /silique	Seed yield	Biological yield	Anthocyanin	Soluble sugar	Electrolyte leakage	Silique silica	Silique calcium
Year	1	1328.99**	129.78**	19862.2	1358.7	0.03**	0.000	10.6	0.33	21.9
Year*Block	4	573.79	109.73	143921.1	644225.9	0.009	0.002	59.21	0.99	139.9
Harvesting date (b)	2	114.13	4.34	2202624.1**	17736981**	0.01*	0.000	4.18	0.8	33.1
a*b	2	306.2	16.01*	3254.4	417254.2	0.0004	0.000	0.04	0.04	14.0
Error (a)	8	97.3	7.8	105500.5	3790691.7	0.002	0.0008	14.11	0.88	103.5
Silica (c)	2	1793.1**	662.08**	3479108.8**	5298310.3**	3.81**	5.72**	28768.3**	261.7**	20713.9**
Calcium (d)	2	3906**	415.6**	2709293.3**	51743743.9**	0.51**	0.45**	1887.44**	23.06**	2713.0**
a*c	2	6.6*	22.4*	64412.4*	88096.6	0.0003	0.000	0.09	0.04	192.3*
a*d	2	218.9*	22.9*	60633.2*	35750.6	0.001	0.000	0.01	2.37*	163.5*
b*c	4	20.4	12.6*	5711.1 ns	981302.1	0.002	0.000	0.38	0.14	51.9
b*d	4	17.5	1.39	24794.8 ns	441373.5	0.001	0.000	0.19	0.28	90.9 ns
c*d	4	242.2*	16.32*	114651.4**	2247200.3*	0.03**	0.09**	131.1**	1.67*	226.23**
a*b*c	4	87.84	1.37	14707.95	644525.2	0.0002	0.000	0.14	0.28	41.54
a*b*d	4	182.9*	4.55	17370.42	1344427.1	0.001	0.000	0.12	1.47*	67.06
a*c*d	4	6.79	2.25	51509.46*	2143458.9*	0.004	0.000	0.22	0.12	18.42
b*c*d	8	64.58	3.42	63208.89**	342665.1	0.001	0.000	0.33	0.32	45.39
a*b*c*d	8	47.16	2.11	17403.21	384278.4	0.001	0.000	0.09	0.54	35.39
Error	96	69.05	5.07	18935.59	842231.6	0.004	0.004	31.31	0.56	52.87
CV%		8.14	8.73	6.06	9.53	9.21	16.21	11.17	11.02	9.3

* and

** mean significance in probability of 5% and 1%. ns: insignificant effect. CV: coefficient of variation

Table 2: Comparison of mean silica effects on quantitative and qualitative specifications of *Brassica Napus L.*

Silica (%)	No. of silique in the plant	No. of seeds in the silique	Seed yield (kg/ha)	Biological yieldyield (kg/ha)	Anthocyanin (mg/gFW)	Soluble sugar (mg/gDW)	Electrolyte leakage (%)	Silique silica (mg/gDW)	Silique calcium (mg/gDW)
0	96.83c	22.11c	2050.9c	9279b	0.95a	0.15c	73.85a	4.4c	58.83c
3	101.24b	26.24b	2217.21b	9754.51a	0.69b	0.26b	48.76b	7.18b	77.76b
6	108.26a	29.07a	2549.44a	9870.59a	0.42c	0.76a	27.74c	8.74a	97.99a

Mean values with similar indices are not significantly different based on Duncan's test in 5%

Table 3: Comparison of mean calcium effects on quantitative specifications of *Brassica Napus L*.

Ca (%)	No. of silique /plant	No. of seed /silique	Seed yield (kg/ha)	Biological yield (kg/ha)	Anthocyanin (mg/gFW)	Soluble sugar (mg/gDW)	Electrolyte leakage (%)	Silique silica (mg/gDW)	Silique calcium (mg/gDW)
2	92b	22.8c	2020c	8504.6b	0.79a	0.3c	54.9a	6.04c	70.39c
4	105a	26.37b	2350.2b	10187.7a	0.67b	0.39b	51.95b	7b	79.95b
6	108a	28.26a	2447.3a	10211.9a	0.6c	0.48a	43.51c	7.28a	84.24a

Mean values with similar indices are not significantly different based on Duncan's test in 5%

Table 4: Comparison of mean calcium and silica effects on quantitative and qualitative specifications of *Brassica Napus L*.

Si (%)	Ca (%)	No. of silique in plant	No. of seed/ silique	Seed yield (kg/ha)	Biological yield (kg/ha)	Anthocyanin (mg/gFW)	Soluble sugar (mg/gDW)	Electrolyte leakage (%)	Silique silica (mg/gDW)	Silique calcium (mg/gDW)
0	2	87.67c	20.2e	1866.88f	8741.7bc	1.03a	0.11f	78.7a	3.91c	53.21e
0	4	97.39bc	22.5de	2121.5de	10640.6a	0.95ab	0.13f	76.91a	4.66c	59.37e
0	6	105.44ab	23.6de	2164.2cde	9881.1ab	0.88bc	0.19ef	65.93b	4.63c	63.9de
3	2	89.72c	22.5de	1949.4ef	8647.1bc	0.82c	0.2ef	53.21c	6.55b	72.44cd
3	4	109.33ab	27.2bc	2342.8c	10241.4a	0.68d	0.28de	52.58c	7.29b	78.88bc
3	6	104.67ab	29abc	2359.3c	10723.2a	0.56e	0.32d	40.49d	7.69b	81.96bc
6	2	99.94bc	25.6cd	2243.7cd	8124.9c	0.54e	0.59c	32.78de	7.66b	85.53b
6	4	109.61ab	29.4ab	2586.1b	9681.7ab	0.37f	0.75b	26.36e	9.05a	101.59a
6	6	115.22a	32.2a	2818.3a	10031.5ab	0.36f	0.93a	24.09e	9.53a	106.86a

Mean values with similar indices are not significantly different based on Duncan's test in 5%

Table 5: Comparison of year, harvesting date, and calcium on no. of silique in plant and silique silica

Year	Harvesting date	Calcium (%)	No. of silique in plant	Silique silica (mg/gDW)
First	One	2	88.56cd	6.2abc
First	One	4	108.78a	6.61abc
First	One	6	112.78a	7.7ab
First	Two	2	84d	5.97c
First	Two	4	103.33abc	6.73abc
First	Two	6	103.89abc	7.27abc
First	Complete	2	89.78bcd	6.02bc
First	Complete	4	96.44abcd	6.81abc
First	Complete	6	105.67abc	7.24abc
Second	One	2	98.11abcd	6.17bc
Second	One	4	104.67abc	7.9a
Second	One	6	108.56ab	6.89abc
Second	Two	2	97.78abcd	5.88c
Second	Two	4	106.67abc	6.89abc
Second	Two	6	108.33ab	7.42abc
Second	Complete	2	96.44abcd	5.98c
Second	Complete	4	112.78a	7.04abc
Second	Complete	6	111.44a	7.18abc

Mean values with similar indices are not significantly different based on Duncan's test in 5%.
(One; one week after yelloing, Two; two week after yelloing, Complete; complete yellowing)

The positive influence of calcium on the providing and absorption of nutrients can increase the number of leaves, leading to a higher light reception for photosynthesis and increasing the number of silique in plant and the number of seeds in silique [14-16]. Silica and silica-containing components enhance the plant and its organs yield through plant antioxidant systems which simulated higher nutrients absorption required for plant and immobility of poisonous metal ions in growth settings.

Number of seeds in Silique

Based on the results of ANOVA, the effect of year, silica, and calcium were significant at the 1% level and the bivariate effect of year on silica, year on calcium, silica on calcium, and tri-variate effect of year on harvesting date and calcium were significant at the level of 5% in term of the number of silique in the plant. By using silica, the number of the silique in the plant increased and the maximum of the seeds in the silique was 29.07 in treatment No. 6 of silica which implied an increase of seeds number in the silique by 31.48% compared with the control sample. As calcium levels increase, the number of seeds in the silique increased, too. As seen in comparison between the mean number of seeds in the silique under the impact of harvesting date and silica, the highest number of seeds was 28.89 by using 6% of silica in harvesting one week after yellowing, 28.89 seeds by using 6% of silica two weeks after yellowing, and 29.44 seeds by using 6% of silica in harvesting during the complete yellowing (Figure 1).

Based on the comparison of the results in terms of seeds number means under the influence of year and calcium, using silica and calcium increased the effects such that number of seeds in silique was estimated to be 4.61g by using 6% of calcium with 6% of silica.

Delay in harvesting date due to the excessive plant dryness led to seperate silique from plant due to the undesirable conditions of late-season particularly the hot and dry winds, or to the impacts of physical factors of covering wall of silique which resulted in the fact that all seeds in the silique shed. It was the main factor of reduction in number of silique in plant and number of seeds in silique, and finally seed yield reduction [17]. It seems that calcium improves the yield of elements through the improvement of plant photosynthetic process, carbohydrates production, and silique filling and number increase [18]. Silica reduced the plasma membrane infiltration and maintained the proxidation of the plasma membrane and its health. As a result, it leads to the growth of plant and an increase of the seed numbers [19].

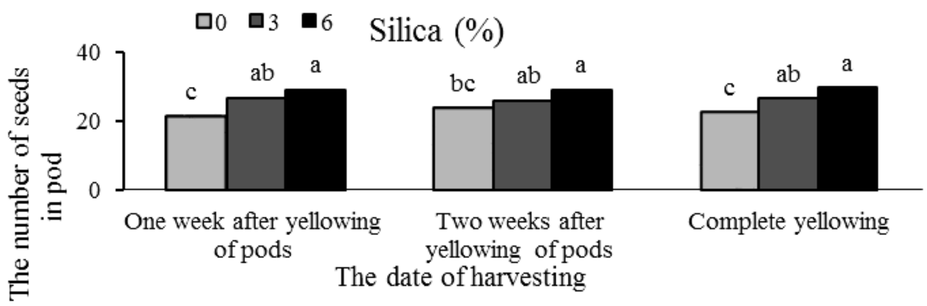

Figure 1: Comparison between mean number of seeds in silique under the effect of harvesting date and silica

Seed yield

The results of ANOVA implied that main effects of harvesting time, silica, and calcium on seed yield were significant in the probability of 1%. The effect of year and silica, year and calcium, silica and calcium, the effect of year, and silica and calcium were significant in the probability of 5%. In addition, the effect of harvesting time with silica and calcium was significant in the probability of 1%. The results of mean seed yield comparison under the influence of harvesting time implied that the highest level of seed yield was 2447.02 kg/ha in harvesting one week after yellowing of silique which reduced as harvesting delayed. Similarly, two weeks after silique yellowing and after complete yellowing, seed yield reduced by 8.46 and 16.3%, respectively (Table 6). Using silica increased seed yield relative to the control sample. The maximum number seed yield was 2549.44 kg/ha in treatment of 6% of silica, implying increase of seed yield by 24.31 relative to the control one. As calcium concentration increased, seed yield was enhanced. The highest seed yield was 2447.33 kg/ha was seed in treatment of 6% of calcium and the lowest one was estimated as 2020.03 kg/ha in the treatment of 2% of calcium. Using silica and calcium increased the effects such that the maximum seed yield was estimated to be 2818.37 kg/ha by using 6% of calcium with 6% of silica. The results indicated that seed yield under the influence of year, silica, and calcium, the maximum yield was 3123.34 kg/ha by using 6% of calcium and 6% of silica one week after yellowing of silique.

The main reason for this reduction can be silique opening and seed shedding increase [19]. The plant with the most desirable use of the conditions and accumulation of maximum photosynthesis products in their organs will be of higher yield [20]. The reason for lower seed yield in the late harvesting can be attributed to the early harvesting of shed seed [21].

Calcium is of low mobility in plant. Even if the soil is enriched of calcium, this is possible for the lower plant organs to lack calcium. Hence, solution spraying eliminates this issue because the nutrients are directly placed on the plant and increase the growth and yield. Additionally, calcium bonds to the cell wall, increases stability, and decreases seed shedding [22]. Calcium facilitates the photosynthetic materials in plant. Moreover, this element regulates many of the physiological activities such as division, development and differentiation of cells, stability and integration of cell membrane, and the activity of some enzymes which all will lead to the growth and yield [23]. Yield enhancement while using silica implies the improvement in minerals transfer processes to the seed. This generally increases potassium absorption and prevents sodium absorption which is one of the applicable techniques in promoting of agricultural plants' yield and growth [24]. Accelerating the growth, dry matter production, sweating reduction, and silica increases the quantity of seeds and yield [25].

Table 6: Effect of harvest date, silica and calcium on seed yield

Harvest date	Calsium(%)	Silica(%)	Seed yield(kg/ha)
One	2	0	2021.4hijk
One	4	0	2269.2defghi
One	6	0	2437.5bcdef
One	2	3	2087.7efghij
One	4	3	2705.8bc
One	6	3	2447.7bcde
One	2	6	2420.1bcdefg
One	4	6	2780.3b
One	6	6	3123.3a
Two	2	0	1918.2ijk
Two	4	0	2147.7efghij
Two	6	0	2105.72efghij
Two	2	3	1947.83ijk
Two	4	3	2281.78defghi
Two	6	3	2388.96cdefgh
Two	2	6	2247.46defghi
Two	4	6	2581.25bcd
Two	6	6	2787.21b
Complete	2	0	1661.08k
Complete	4	0	1947.76ijk
Complete	6	0	1949.51ijk
Complete	2	3	1812.77jk
Complete	4	3	2040.92ghij
Complete	6	3	2241.47defghi
Complete	2	6	2063.71fghij
Complete	4	6	2396.9cdefgh
Complete	6	6	2544.57bcd

Mean values with similar indices are not significantly different based on Duncan's test in 5%.
(One; one week after yelloing, Two; two week after yelloing, Complete; complete yellowing)

Anthocyanin

Based on the ANOVA, silica, calcium, silica with calcium effects in the probability level of 1%, and harvesting time effect in the probability level of 5% were significant on anthocyanin. By using silica, anthocyanin was reduced compared with control treatment. The minimum anthocyanin level was 0.42 mg/kg wet weight in treatment of 6% of silica, indicating the reduction of anthocyanin level compared with control sample by 55.79. The results of comparing the mean anthocyanin level under calcium influence implied that as calcium concentration increases, anthocyanin reduces. The maximum level of anthocyanin was 0.79 mg/kg wet weight was obtained by using 2% of calcium and the lowest level was 0.6 mg/kg wet weight by using 6% of calcium. The results of mean anthocyanin level implied that under the silica and calcium influence, these elements reduced the effects of each other such that the minimum anthocyanin levels were 0.37 and 0.36 mg/kg wet weight using 6% silica and 4 and 6% calcium, respectively. Anthocyanin synthesis is influenced by different environmental and nutritional factors. Calcium ion as a secondary messenger plays a role in pigment improvement. Cell pigments development and anthocyanin synthesis are directly related to the enhancement of carbohydrates and any factor increasing, absorbing, or making carbohydrates will influence on anthocyanin level. Minerals like calcium increase the carbohydrates, cell pigments, and anthocyanin synthesis. Moreover, calcium increases anthocyanin synthesis, and positively affects on phenyl alanine ammonia lyase [31]. The present study indicated that anthocyanin levels were reduced by using calcium and silica. In fact, under undesirable conditions, the plant increases anthocyanin level to prevent damage to the photosynthetic system. Thus, it seems that using calcium and silica, plants improve their conditions and their anthocyanin declines in level [32].

Soluble sugar

Based on the results of ANOVA, silica, calcium, and silica with calcium affected significantly on the soluble sugar in the probability of 1%. By using silica, soluble sugar increased compared with control sample and the maximum level reached 0.76mg/kg dry weight in treatment of 6% of silica. This demonstrates an increase in soluble sugar by 406.67% compared with the control sample. Comparing the mean soluble sugar level under the calcium influence, it was observed that calcium concentration increase enhanced the soluble sugar level. The maximum level of soluble sugar was 0.48 mg/kg dry weight in treatment of 6% of calcium, while the minimum level was 0.3 mg/kg dry weight in treatment of 2% of calcium. Silica and calcium increased the effects of each other such that the minimum soluble sugar was 0.93 mg/kg dry weight using 6% of silica with 6% of calcium. The soluble sugar accumulation in cells leads to the biological membranes stability, proteins, photosynthesis improvement, and undesirable conditions strength. The results of the present study are consistent with the previous studies such as Barickman *et al*. (2019).

Electrolyte leakage

As can be seen from the results of ANOVA, silica and calcium and the combined effects of silica and calcium on electrolyte leakage were significant with the probability level of 1%. By using silica, electrolyte leakage was reduced compared to the control sample. The maximum electrolyte leakage was 73.85% in the control sample and the minimum leakage was 27.74% in the treatment of 6% of silica. The results of mean electrolyte leakage comparison indicated that under the influence of calcium, electrolyte declined by increasing calcium. The maximum electrolyte leakage was 5.9% for the treatment of 2% of calcium and the lowest one was 43.51% for the treatment of 2% of calcium. As seen from the results of comparison between electrolyte leakage percentages, under the influence of silica and calcium, these elements reduced the effects of each other such that maximum electrolyte leakage was 78.7 and 76.91% in control and 2% of calcium treatment without silica. The minimum electrolyte leakage was 26.36 and 24.09% by using 6% of silica and 4 and 6% of calcium. Calcium plays a role in cell wall strength and reduces ion leakage. Calcium ions play the substantial roles in maintaining the cell membrane structure and cell wall stability. Reinforcing inter-molecular bonds, calcium stabilizes the pectin components in the middle wall [33].

Silique silica

The results indicated that effect of silica and calcium, the combined effect of the year with calcium, year with silica, and effect of year with harvest time and calcium were significant on silique silica at the 1% and 5% probability level, respectively. By using silica, silique increased silica compared with the control sample. The maximum silica was 8.7mg/g dry weight in treatment of 6% of silica and implied an increase of silica by 98.64 compared with the control treatment. As calcium increased, silica increased in silique. The maximum silica of silique was 7.28 mg/g dry weight by using 6% of calcium, while the minimum level was 6.04 mg/g dry weight by using 2% of calcium. Using silica and calcium in combination increase effects of each other such that the maximum silica of silique was obtained as 9.05 and 9.53 mg/g dry weight by using 4 and 6% of calcium with 6% of silica, respectively. As seen from the results of silique silica comparison under the influence of harvest time and calcium in two agricultural years, it was indicated that silica level was 7.9 mg/g dry weight by using 4% of calcium and harvesting one week after silique yellowing in the second year.

Silique calcium

Based on the results of analysis of variance effect of silica, calcium, and double effect of silica and calcium was significant at the 1% probability level on the amount of calcium in the silique and the combined effect of year with silica and year with calcium was significant at the 5% probability level. The results showed that using silica increased the calcium in silique compared with the control treatment. The maximum level of calcium was 97.99 mg/g dry weight in treatment of 6% of silica implying an increase of calcium by 66.56% compared with the control sample. Increasing the calcium concentration, siliquesilique enriched in calcium. The maximum calcium level was 82.24 mg/g dry weight in treatment of 6% of calcium, while the minimum level was 70.39 mg/g dry weight by using 2% of calcium. The results of mean siliquesilique calcium comparison under the combined effect of silica and calcium, using silica and calcium increased the effects of each other such that the maximum level of calcium was 101.59 and 106.86 mg/g dry weight by using 4 and 6% of calcium with 6% of the silica. Nutrients solution spraying, particularly under their lack of absorption through roots can result in desirable outcomes and increases their absorption [34]. The association of nutrients can influence the absorption, distribution, and yield of plants such that these elements can generate toxicity effects, while having positive effects on the plant growth [35]. Increase in use of silica improves the absorption of nutrients in seed and upper organs of rice [36]. It is reported that plant use of water increases in the vicinity of silica. Therefore, the nutrients are transported more rapidly [37]. It is found that silica increased the concentration of leaf and stem silica in wheat [38].

Conclusion

Based on the results, delayed harvest reduces the biological and seed yields and the most desirable time for harvesting the *canola* was one week after yellowing. The results implied that silica and calcium increased the effects on yield and yield elements, particularly the physiological features as well as the silica and calcium absorption, and decreased the effects on electrolyte leakage with the best treatment by using 6% of silica and 6% of calcium. Based on the results, silica and calcium spraying with certain concentrations on *Brassica Napus L.* can improve the growth and yield. Rapeseed is an ancient plant and the available information and documents about the cultivation of this plant in two thousand years BC in India. At that time, rapeseed oil was used as lamp oil, edible oil, and fodder plant in animal feed. Some researchers have mentioned the cultivation of winter rapeseed in Germany and use of rapeseed oil as a lamp oil and edible oil. In the late Middle Ages, canola oil was used to make soap and as a lightening oil. With the development of the steam engine industry, this oil was used as a lubricant in steam engines, and as a result, it led to the development of rapeseed cultivation in Canada. The appellant stated in 1972 that Brasica napos was first discovered in the Netherlands in the 17th century as an oily plant, and then spread to other parts of Europe. With the discovery of the beneficial nutritional properties of rapeseed oil, its condition has improved in the recent years. The beginning of the use of rapeseed oil as an edible oil date back to the 60s. Native rapeseed cultivars are rich in erosic fatty acids, which account for 75 to 80% of the total oil content. The presence of this fatty acid in oil and meal is undesirable. Before the outbreak of World War II, canola cultivation in Canada was done only for research purposes.

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All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

There are no conflicts of interest in this study.

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