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Effect of different stages and times of silicon foliar spray on yield and yield components of bean

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Abstract

Sometimes in agriculture, simple and inexpensive operation can cause significant augmentation in plant yield. Studies have shown that foliar spray of silicon in number of plants can lead to substantially increase in growth and yield of plant but its effect on plants almost has been overlooked. This investigation was performed in order to study effect of silicon foliar spray with different concentrations (0, 2, 4 per thousand of silicon) at different growth stages of beans (stem elongation, before flowering and pod production) on growth and yield of two beans varieties (Talash and Mahali) with three replications. According to the obtained results from the study, concentration of 2 per thousand of silicon had no effect on grain yield per area unit but concentration of 4 per thousand of silicon during stem elongation and before flowering caused to significant increase in yield of bean. Foliar spray of silicon in stages of stem elongation and beginning of flowering increased substantially grain yield in comparison with control treatment up to 38% and 21%, respectively. According to the survey results, foliar spray at stem elongation had greater impact on plant. Based on results, augmentation in grain yield was affected by increasing of two main components: seeds number per plant and 100-seeds weight. Increment in number of seeds per plant was achieved by increasing of seeds number per pod, whereas at concentration of 4 per thousand of silicon had no effect on total number of bean pods. It seems augmentation of yield and yield components affected by concentration of 4 per thousand are because of increase in leaf area and chlorophyll content of leaves in beans. In general, according to the results of this study, usage of silicon had positive impact on growth and yield of beans. No significant differences were found among studied bean cultivars from the view point of grain yield, in the highest level of yield.

Keywords: bean, silicon, foliar spray, concentration, growth stages, yield

1. INTODUCTION

In the today world that science and technology with world-wide growth and development are considered as a major factor in the process of economic ,social and cultural growth and development of human societies, training institutions gained a very important role. Increasingly attention and interest in type and development of education is undeniable necessity associated to Annually, world population is increasing about 1.6 – 1.7% therefore every year; 90 million people are augmenting to the worldwide that need food. This means that amount of food increases to provide the growing population. Crop production is directly related to consumption of resources such as water, light and efficiency of resources transforming to biological material [1] Augmentation of world price in fertilizers, necessity of more economic production, pollution of ground waters and degradation of soil structure due to excessive and uncontrolled usage of fertilizers and irrational consumption of chemical fertilizers are problems which must be corrected by various methods [2] Nutrient elements of soil are exposed to wash, volatility and denitrification [3]

There are indicators which demonstrate, extremely fertile fertilizer and introduced technologies of seed may have reached to tipping point over the past three decades. Prospects for irrigation with low-costs also are limiting. In addition, new techniques such as genetic manipulation seem to be not an important factor in augmentation of crop yield at future decades. Also, concerns are

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rising about the long-term sustainability of agriculture. Both high and low usage of fertilizer and poor management of resources damage environment. So that, intensive cultivation of farm lands, introduction of high yielding varieties and augmentation in usage of fertilizers without micro elements such as nitrogen and phosphorus lead to shortage of micro-nutrients in soil [3].
Most of the micro-nutrients are associated with the enzyme systems of plants. In case of any shortage of nutrient elements, plant growth reduces and sometimes leads to be eliminated of plant. In terms of severe shortage, flowers and seeds don't form [4] Nonetheless, soils with deficit of nutrient elements scattered throughout the world but mainly, this lack occurs by low mobility of these elements in soils as compared with shortage of definite amount of these elements in soil [5] Usually, essential elements of plants are added to the soil. Usage of elements in high doses at soil is the most effective way. However, under specific conditions; foliar spray is more economical and more effective method as compared with application in soil [6]. Silicon is an essential element in plant nutrition, nonetheless researchers often overlook its importance, especially in defense of plants against factors of biotic and abiotic stresses will be important Silicon constitutes 28% of the Earth's surface. Amount of silicon is similar to rates of macro elements in plant [7, 8].
Silicon fertilization by natural silicate reduces the effect of stress factors and declines consumption amount of chemical fertilizers [9] Silicon is used in several methods. One of the important methods of silicon application is in form of foliar spray [10] Few investigations have been done about effect of foliar spray of silicon. In one probe, it was observed that foliar spray of silicon increases resistance to pathogens in plant species which can not absorb silicon effectively [7].
Silicon is an essential element in plant nutrition, nonetheless researchers often overlook its importance, especially in defense of plants against factors of biotic and abiotic stresses will be important Growth and production of further biomass in crop plants by usage of silicon are in relation to alteration of plant structure, vertical plants, improvement of leaves angle and receiving of light, prevention of shading, delay in senescence, augmentation in stiffness of tissues structure, improvement of lodging and increase of photosynthesis. These beneficial effects are associated with silicon deposition in cell wall of different organs of plant and other silicon mechanisms [11].
Huang and et al [12] reported that silicon application increases gibberellin levels in plants. Salt tolerance in relation to usage of silicon is dependent to reduction in sodium absorption, improvement of water reserve in plant, photosynthesis increase and augmentation in antioxidant system of the plant. Deposited sodium in roots absorbs sodium and reduces its absorption and transfer to shoot. Also, deposited silicon in shoot reduces evaporation and water reserve of plant. In addition, deposited silicon in shoot reduces evaporation and improves water reserve of plant, which leads to dilution of solutes and reduction in salt effect [13] Accumulation of silicon on surface of leaves, inside of cell walls in epidermal cells, middle lamella and intracellular space reduces fungal penetration [11] According to the above content, the purpose of this investigation was to evaluate effect of silicon foliar spray on growth and yield of bean.

Materials and Methods

The experiment was conducted during cropping year of 2014. This location had longitude of =˚=′E and latitude of =˚=′N with altitude of = meters above sea level. According to Domarten climatic classification, the area has cold semi-arid climate. Average of annual temperature was = °C, average of maximum annual temperature was = °C and average of minimum annual temperature was = °C. Average of annual rainfall of this area was about = mm, pH of the area soil was in range of alkaline to moderate and significant risk of salinity in surface soils does not exist. The trial was performed in form of factorial based on randomized complete block design with three replications and three factors.
The experimental factors were included: 1. cultivars (Talash and Mahali). 2. The concentrations of silicon for foliar spray (zero, two and four per thousand). 3. Times of fertilizers application at three levels (stem elongation, before flowering and pod emergence).

Plowing was done in late May 2011 and then after sampling from the field soil, a superficial tillage was carried out to control weeds. On date of =/=/= in May, first irrigation was done for moisten of soil (which is required to activate the bacteria in bio-fertilizers). Each experimental plot consisted of = planting row with = length and distance between planting rows was = centimeters. Area of experimental plots was = square meters. In total, experimental design was conducted in an area of = meters. Distance between seeds on rows was = cm and planting depth was considered 3cm. Distance between the blocks was 1 meter. Sowing was done by hand. Required basic fertilizers were used based on results of soil analysis. With consideration to soil test, merely nitrogen fertilizer was used due to high levels of phosphate and potassium fertilizers in crisis rang. Nitrogen fertilizer was applied at planting time with rate of 100 kg per hectare.

After planting and plant establishment, thinning and weeding were carried out in plants with 2-4 leaves and weeding was continued until the end of vegetative growth. In each experimental plot after removing marginal effects, harvesting in form of green was done from area of 1 square meter during pod filling period in four moving. After harvesting in each plot by removing margin rows and 0.5 m from beginning and terminal of middle rows as marginal effect, 10 plants under competition were selected for measurement of traits in each plot.

Before statistical analysis, normality test was done for the data and then by using Mstat-c software, statistical analyses were performed for the data obtained from the measured traits. Duncan's multiple range test at 5% probability level was used for mean comparisons. Excel software was used for drawing charts.

Results and Discussion

According to the results obtained from the analysis of variance for studied traits, there were significant difference at 1% probability level among cultivars from the view point of leaves number, plant height, number of subsidiary stems, leaf area, total dry weight of plant, harvest index and pod length, also significant difference at 5% probability level was observed among cultivars from the view point of seeds number per pod, seed yield per area unit and silicon concentration. Concentration of sprayed silicon had significant effect at 1% probability level from the view point of leaves number, number of subsidiary stems, index of chlorophyll content, leaf area, harvest index, pod length, number of seeds per plant, number of seeds per pod, seed yield per area unit and silicon concentration, also significant difference at 5% probability level was observed in 100-seeds weight and number of total pods per plant (Table 1).

In this probe, time of silicon foliar spray had significant effect at 1% probability level from the view point of subsidiary stems number, index of chlorophyll content, harvest index, pod length, number of seeds per plant, number of seeds per pod and seed yield per area unit, also significant difference at 5% probability level was observed in number of leaves, stem height and leaf area. Interaction of cultivars×fertilizer application time was significant at 1% probability level from the view point of seeds number per pod, also significant difference at 5% probability level was observed in number of seeds per plant, seed yield per area unit and harvest index. Interaction of silicon concentration× silicon application time was significant at 1% probability level from the view point of subsidiary stems number, leaf area, harvest index, pod length, number of seeds per plant, number of seeds per pod and seed yield per area unit, also significant difference at 5% probability level was observed in index of chlorophyll content. Tripartite interaction of cultivars×silicon concentration× silicon application time was significant at 1% probability level from the view point of 100-seeds weight and for index of chlorophyll content and number of seeds per pod was significant at 5% probability level (Table 1).

Table 1: Analysis of variance for the studied traits in bean

Sources of variance	Degree of freedom	Number of leaf	Plant height	Number of subsidiary stem	Chlorophyll content index	Leaf area	Total dry weight of plant
Replication	2	0.318	48.397	0.337	0.821	880.816	3.695
Cultivar	1	3.490**	195.580**	4.105**	2.252	2162.243**	308.241**
Silicon concentration	2	6.474**	21.985	1.686**	18.675**	8136.137**	17.403
Cultivar *Silicon concentration	2	0.246	14.052	0.343	3.285	530.978	53.789*

application time	2	0.841*	98.936*	2.429**	22.667**	1054.859*	9.441
Cultivar *application time	2	0.144	54.073	0.386	3.409	215.496	2.517
concentration* application time	4	0.322	30.605	1.632**	7.261*	1176.322**	3.014
Cultivar * concentration * application time	4	0.145	19.738	0.158	7.285*	156.642	16.946
Error	34	0.185	24.728	0.173	2.033	286.667	11.466
Coefficient of variation (%)		4.82	9.86	13.56	5.67	7.14	7.4

** And *: significant at 1% and 5% probability level, respectively.

Table 1

Sources of variance	Degree of freedom	Harvest index	Pod length	Number of seeds per plant	100- seeds weight	Number of total pods per plant	Number of seeds per pod	Seed yield per area unit	Silicon concentration
Replication	2	14.2	0.037	17.749	0.762	0.385	0.044	3627.1	0.028
Cultivar	1	299.807**	14.981**	45.719	1.581	0.598	0.344*	13525.400*	1.932*
Silicon concentration	2	149.286**	20.336**	159.641**	35.581*	3.400*	0.941**	62285.978**	19.470**
Cultivar *Silicon concentration	2	0.873	1.365	20.087	0.726	1.286	0.004	6054.252	0.592
application time	2	90.903**	11.418**	130.526**	1.059	0.559	0.768**	32388.951**	0.511
Cultivar *application time	2	23.295*	2.307	46.437*	1.178	1.716	0.444**	9497.256*	0.047
concentration* application time	4	90.506**	4.896**	106.940**	1.128	1.077	0.353**	24420.125**	0.494
Cultivar * concentration * application time	4	11.599	1.864	30.062	2.278**	1.948	0.165*	5166.636	0.639
Error	34	5.37	0.886	12.745	0.488	0.962	0.054	2674.444	0.466
Coefficient of variation (%)		7.89	10.01	10.55	1.77	6.78	9.4	10.28	16.38

Plant height

In this study, no significant differences among cultivars were observed for plant height. According to the results, Mahali variety had greater plant height than Talash cultivar. Plant height in Mahali variety was 52cm which was higher about 8.3% as compared with Talash (Table 2). In various studies, differences have been observed among bean cultivars. Avan et al [14] in their study found that, there are significant differences among cultivars from the view point of plant height. These researchers observed differences of 87cm in plant height between cultivars. Based on results of variance analysis, time of acid Saliscan application had significant effect on Plant height of bean (Table 1). Mean comparisons of plant height affected by time of silicon application indicated that the highest plant height with rate of 52.7cm was related to silicon application before flowering and the least amount of plant height (48cm) was belonged to treatment of silicon application in stage of stem elongation. Hence, silicon usage in stage of stem elongation had negative effect on plant height of bean (Table 5). Use of silicon deposits in cell wall and thus strengthens wall structure [15] Therefore it can be concluded that with consumption of silicon, cell growth decreases due to greater strength of cell wall. In a survey conducted by Vrublska and Dbisiz [16] also observed that foliar spray of silicon reduces plant height of Argyranthemum frutescens. Similar results were obtained by Hagg et al [17] in different ornamental plants.

Number of subsidiary stem

In this study, there was significant difference among studied varieties from the view point of subsidiary stem number. Mean comparisons for number of subsidiary stem demonstrated that Talashs had further number of subsidiary stem as compared with Mahali. In Mahali cultivars, number of subsidiary stem was 18.1% less than Talash (Table 2). Significant differences between cultivars in terms of subsidiary stem number have been observed in many investigations. Avan et al [14] conducted a study on bean genotypes and observed substantially difference in different cultivars from the view point of subsidiary stem number. According to the obtained results of this study, only silicon application with concentration of 4 per thousand at stage of stem elongation caused to significant increase in number of subsidiary stem. Silicon application with concentration of 4 per thousand at stage of stem elongation increased number of subsidiary stem up to 66% as compared with control treatment (Table 7). Studies have shown that consumption of silicon produces stronger and more direct plants and thus shading reduces which can lead to augmentation in plant photosynthesis [11] Increment of photosynthesis can be a factor for further increase in plant growth.

Number of Leaf

In this probe, significant difference was observed among studied varieties from the view point of leaf number (Table 1). Mean comparisons for number of leaf in evaluated cultivars, represented that in Mahali cultivar greater number of leaves was obtained as compared with Talash. In Mahali cultivar, number of leaves was 5.8% higher than in Talash. (Table 2). Existence of differences among numerous varieties of bean from the view point of leaf number has been proven in various studies. Tryndadh et al [18] found that there are significant differences between cultivars from the view point of leaf number.

Mean comparisons for number of leaf influenced by foliar spray of silicon showed that both concentrations of 2 and 4 per thousand caused significant augmentation in number of bean leaves. With increasing concentrations of foliar spray, rate of increment in number of leaves was higher. Therefore, maximum number of leaves with amount of 9.6 compound leaves was obtained in concentrations of 4 per thousand which was higher about 14.2% as compared with treatment of non-foliar spray with rate of 8.4 leaves. Also, silicon concentration of 2 per thousand increased number of leaves up to 3.5% as compared with control treatment (Table 3). One of the impartment reasons of increase in number of leaf in term of silicon application is reduction in leaves senescence affected by this treatment which its reason can be augmentation in strength of leaf tissue [11]. Mean comparisons for number of compound leaf affected by time of foliar spray displayed that the highest number of leaves was obtained in condition of foliar spray at stage of stem elongation and the least amount of this trait was related to foliar spray at stage of pod emergence (Table 5). Probably, effect augmentation of silicon at stage of stem elongation is associated with duration of silicon impressment. Because at stage of stem elongation; there is more time for silicon impressment on plant.

Leaf area

In this study, no significant difference was observed among studied varieties from the view point of leaf area, but silicon application had significant effect on leaves area of bean (Table 1). Mean comparisons for leaf area affected by different concentrations of silicon and time of silicon application demonstrated that concentration of 2% silicon had no impact on leaf area, nonetheless; concentration of 4% silicon at stages of stem elongation and before flowering caused significant increase in leaf area. Based on results, in concentration of 4% silicon at stages of stem elongation and before flowering, leaf area were 262cm and 278cm, respectively; which were higher up to 18.5% and 25.7% as compared with control treatment (Table 7). There are reports which represented silicon application delays leaves senescence [19]. Savas et al [19] stated that in roses leaves which treated with silicon; leaves were darker and less prone to senescence. Silicon leads to production of more stable plants and thus shading of top leaves on bottom leaves reduces [20] which declines process of senescence in bottom leaves. On the other hand, growth of each leaf increases as a result of various factors. Studies have shown that use of silicon improves plant canopy structure and thus increases amount of light absorption and photosynthesis [11] Undoubtedly, augmentation of photosynthesis and preparation of asmilat will increase growth in different parts of plant such as leaves.

Chlorophyll content index

In this investigation, in Talash cultivar; silicon application had no impact on index of chlorophyll content. In Mahali variety, silicon foliar spray with concentration of 4 per thousand at stage of stem elongation; amount of leaf chlorophyll content increases up to 27% as compared with control treatment. Other treatments had no significant effect on this trait (Table 8). Assessments have shown that silicon increases production amount of Jasmonic acid and Saliscan acid in plants [21] Several studies have been represented that use of exogenous augments both hormones of Jasmonic acid and Saliscan acid in leaves chlorophyll index of plants [22]

Total dry weight of plant

With consideration to the mean comparisons for total dry weight of plant affected by silicon concentrations in two cultivars of Mahali and Talash, at control condition total dry weight of Mahali variety was more as compared with Talash cultivar. In Mahali variety, total dry weight was not affected by silicon application. In Talash cultivar, concentration of 2 per thousand had no effect on total dry weight; but, concentration of 4 per thousand caused to significant increase in total dry weight of plant. In Talash cultivar, by foliar spraying of silicon with concentration of 4 per thousand; total dry weight of plant was obtained about 46.3 g which was 12.1% higher as compared with non-application of silicon (Table 6). Abubakr et al [7] also conducted a study that showed usage of silicon under normal and low water conditions increased shoots dry weight. So that, in normal condition; silicon application increases shoots dry weight up to 52%.

Number of total pods per plant

Number of total pods per plant was affected by concentration of 4 per thousand. Silicon concentration of 2 per thousand caused significant decrease in number of total pods per plant. In silicon application with concentration of 2 per thousand, number of total pods per plant was 14 which was lower about 6% as compared with non-foliar spray of silicon (Table 3). The results showed that number of pods in main stem had significant decrease affected by both concentration of 2 and 4 per thousand, nonetheless; number of pods per subsidiary stem declined. It seems that silicon has negative impact on number of pods. Possibly, direct spraying of silicon on flower buds leads to infertility and thus had negative effect on flower buds of main stem because flower buds appears soon on main stem, but had no influence on buds of subsidiary stem. Nonetheless, there is no report of negative effect of silicon on fertilization of flowers. On the other hand, silicon foliar spray with concentration of 4 per thousand increased number of subsidiary stem, therefore, number of pods per subsidiary stem augmented indirectly and in concentration of 4 per thousand decreased, number of pods caused by reduction in number of pods per main stem has been offset.

Pod length

In this study, significant differences were obtained among cultivars from the view point of pod length. In Talash cultivar, pod length was 9.9 cm, while in Mahali variety pod length was 8.8 cm which was lower about 11.1% as compared with Talash cultivar (Table 2). Mean comparisons for pod length influenced by concentrations and application time of silicon showed that concentration of 4 per thousands had no effect on pod length but concentration of 4 per thousands affected significantly on pod length based on application time of silicon. Use of silicon with concentration of 4 per thousands at stage of pod emergence had no effect on pods length but spraying at stages of stem elongation and flowering increased pods length. Foliar spray of silicon at stage of stem elongation was more effective in augmentation of pods length. Foliar spray of silicon with concentrations of 2 and 4 per thousands increased pods length up to 49.3% and 15.6%, respectively (Table 7). Pods growth is largely dependent on amount of asymilat which is transferred from leaves to pods. As regards, silicon application increases bean leaf area; hence more asymilat produces and will transfer to pods, which will augments more growth in pods.

Number of seeds per pod

According to the results obtained from mean comparisons for number of seeds per pod affected by different concentrations of silicon at different times in two studied varieties, at control condition there was no significant difference among cultivars from the view point of seeds number per pod. In Talash cultivar, concentration of 2 per thousand had no impact on number of seeds per pod but with concentration of 4 per thousand in two stages of stem elongation and pods emergence, number of seeds per pod increased up to 26% and 30.4%, respectively. No significant difference was observed between two treatments of foliar spray with concentration of 4 per thousand at stages of stem elongation and flowering from the view point of seeds number per pod. In Mahali variety, foliar spray only at stage of stem elongation caused significant

increase in number of seeds per pod. By increasing concentration of silicon in this cultivar, greater augmentation was obtained in number of seeds per pod. With use of silicon at concentrations of 2 and 4 per thousand in stage of stem elongation, seeds number per pod increases up to 22.7% and 54.5%, respectively as compared with control (Table 8). It was observed that, response of studied cultivars to silicon application is different. Several studies have shown that silicon can have different effects on different characteristics of different cultivars [23].

Number of seeds per plant

According to the results; in Talash cultivar with foliar spray at stages of stem elongation and before flowering more number of pods was obtained as compared with foliar spray at stage of pod emergence but significant difference was observed between both treatments of foliar spray at stages of stem elongation and before flowering from the view point of seeds number per plant. In Mahali variety with foliar spray at stage of stem elongation, number of seeds per plant was higher as compared with foliar spray at stages of before flowering and pod emergence. No significant difference was found between two treatments of foliar spray at stages of before flowering and pod emergence from the view point of seeds number per plant (Table 6). According to the results obtained from mean comparisons for number of seeds per plant affected by different concentrations of silicon at different times, silicon application with concentration of 2 per thousand had no impact on number of seeds per plant but with concentration of 4 per thousand at stage of stem elongation, number of seeds per plant increased as compared with control treatment. In treatment of 4 per thousand at stage of stem elongation, number of seeds per plant was 45 which was higher about 41% as compared with control treatment (Table 7). In addition to pod augmentation, usage of silicon caused to increase in number of seeds per plant through considerable increment in number of seeds per pod.

100- Seeds weight

Mean comparisons for 100- seeds weight affected by different concentrations of silicon at different stages of bean growth demonstrated that in none of studied cultivars, concentration of 2 per thousand had no effect on 100- seeds weight. But concentration of 4 per thousand caused to significant increase in 100- seeds weight. According to the results in Talash cultivar, foliar spray with concentrations of 4 per thousand at three stages of stem elongation, flowering and pod emergence caused similar increases in 100-seeds weight as compared with control treatment. In Talash variety with concentrations of 4 per thousand at three stages of stem elongation, flowering and pod emergence; 100-seeds weight augmented up to 7.8 % as compared with control treatment. In Mahali cultivar, concentrations of 4 per thousand at stage of pod emergence had no effect on 100-seeds weight but in foliar spray with concentration of 4 per thousand at stages of stem elongation and before flowering, 100-seeds weight increased up to 5.2% and 11.7%, respectively as compared with control treatment. Therefore in Mahali variety, amount of augmentation in 100-seeds weight influenced by concentration of 4 per thousand at stage of flowering was further (Table 8). This reaction could be for the reasons that with foliar spray of silicon at flowering stage, power of seeds sink increases due to hormonal alterations [24] and hence amount of transition Asmylath to seeds increases and 100-seeds weight can be augmented.

Seed yield per area unit

At this probe, in Talash cultivar foliar spray at stages of stem elongation and before flowering further amount of seed yield was observed as compared with pod emergence stage. No significant difference was found between stages of stem elongation and flowering from the view point of seed yield per area unit. In Mahali variety with foliar spray of silicon at stage of stem elongation, higher seed yield was obtained as compared with stages of flowering and pod emergence. No significant difference was observed between stages of flowering and pod emergence from the view point of seed yield (Table 6). Concentration of 2 per thousand had no effect on seed yield per area unit but concentration of 4 per thousand at stages of stem

elongation and before flowering caused to increase in seed yield per area unit. With concentration of 4 per thousand at stages of stem elongation and before flowering, seed yield per area unit augmented up to 38% and 21%, respectively. Based on the results of this investigation, concentration of 4 per thousand at stage of stem elongation had further increase in comparison with stage of pre-flowering (Table 7). Also, Parande et al [23] observed significant increase in seed yield per area unit with silicon application.

Harvest index

Mean comparisons for harvest index affected by silicon application at different growth stages in studied cultivars showed that in Talash cultivar more amount of harvest index was obtained at stages of stem elongation and before flowering as compared with stage of pod emergence. No significant difference was observed between stages of stem elongation and pre-flowering from the view point of harvest index. In Mahali variety with foliar spray of silicon at stage of stem elongation, higher harvest index was obtained as compared with stages of per-flowering and. No significant difference was observed between stages of pre-flowering and pod emergence from the view point of harvest index (Table 7). Concentration of 2 per thousand had no effect on harvest index but concentration of 4 per thousand at stages of stem elongation and before flowering caused to augmentation in harvest index with amounts of 34.7% and 14.8%, respectively as compared with control treatment. Increase rate in stage of stem elongation was more (Table 6). Mina et al [24]reported that silicon increases transmission amount of Asmylath from source to sink and also augments proportion of sink to source in plants.

Silicon concentration

In this study, significant difference was observed among studied cultivars from view point of silicon concentration. In Mahali variety silicon concentration was higher than in Talash cultivar (Table2). The results obtained from mean comparisons for silicon concentration affected by different concentrations of silicon showed that silicon application caused significant increase in silicon concentrations. Therefore, the highest silicon concentration of bean leaves was obtained in foliar spray with concentration of 4 per thousand (Table 3). Mercy and Mohamad [25] reported similar results in wheat and stated that with usage of silicon, amount of silicon absorption in plant increases.

Conclusion

Augmentation in seed yield was much higher than biological yield, which investigation of harvest index represents significant increase of seed yield as compared with biological yield. Therefore, it seems silicon causes at least part of increase in seed yield of bean by transferring more produced Asmylath. In general, it seems that foliar spray of silicon will have positive role on seed yield of bean.

Table 2: Mean comparisons for the traits in the different varieties of bean

	Number of leaf	Plant height	Number of subsidiary stem	Pod length	Silicon concentration
talash	8.69017	48.54984	3.34294	9.927967	3.978424
mahali	9.198647	52.35608	2.791495	8.874538	4.356761

Table 3: Mean comparisons for the studied traits affected by the concentration of silicon

	Number of leaf	Number of total pods per plant	Silicon concentration
0	8.444 c	14.94 a	2.998 c
2	8.780 b	14.09 b	4.517 b
4	9.609 a	14.36 ab	4.988 a

Table 4: Mean comparisons for the studied traits affected by the concentration of silicon in bean cultivars

		Total dry weight of plant
talash	0	41.21 b
talash	2	42.46 b
talash	4	46.37 a
mahali	0	48.45 a
mahali	2	48.73 a
mahali	4	47.19 a

Table 5: Mean comparisons for the studied traits affected by the application time of silicon

	Number of leaf	Plant height
Stem elongation	9.147 a	48.07 b
Pre-flowering	8.970 ab	52.76 a
Pod emergence	8.717 b	50.53 ab

Table 6: Mean comparisons for the studied traits affected by the application time of silicon in bean cultivars

		Harvest index	Number of seeds per plant	Seed yield per area unit
Talash	Stem elongation	33.03 a	36.18 a	541.3 a
Talash	Pre-flowering	32.30 ab	36.25 a	541.0 a
Talash	Pod emergence	29.86 c	31.82 b	473.9 b
Mahali	Stem elongation	30.65 bc	37.11 a	551.6 a
Mahali	Pre-flowering	25.38 d	30.89 b	460.3 b
Mahali	Pod emergence	25.02 d	30.73 b	449.4 b

Table 7: Mean comparisons for the studied traits affected by the different time of application in silicon concentration

		Number of subsidiary stem	Leaf area	Harvest index	Pod length	Number of seeds per plant	Seed yield per area unit
0	Stem elongation	2.892 b	219.5 d	26.48 c	8.500 c	30.61 c	444.8 c
0	Pre-flowering	2.776 b	220.0 d	27.59 c	8.442 c	32.48 bc	472.3 c
0	Pod emergence	2.788 b	223.4 cd	27.63 c	8.241 c	31.50 bc	456.4 c
2	Stem elongation	3.052 b	247.9 b	29.24 bc	9.805 b	34.06 bc	504.2 bc
2	Pre-flowering	2.908 b	220.9 d	27.46 c	9.783 b	32.56 bc	476.4 c
2	Pod emergence	2.961 b	219.5 d	28.01 c	8.304 c	31.68 bc	463.9 c
4	Stem elongation	4.527 a	262.8 ab	34.79 a	12.43 a	44 a	631.4 a
4	Pre-flowering	2.812 b	278.0 a	31.47 b	9.660 b	35.68 b	553.3 b
4	Pod emergence	2.888 b	243.1 bc	26.68 c	9.445 bc	30.64 c	464.7 c

Table 8: Mean comparisons for the studied traits affected by the concentration and application time of silicon in bean cultivars

			Chlorophyll content index	100- seeds weight	Number of seeds per pod
talash	0	Stem elongation	26.49 bc	38.44 de	2.317 de
talash	0	Pre-flowering	24.36 cdef	38.77 de	2.348 de
talash	0	Pod emergence	23.30 ef	38.25 e	2.295 de
talash	2	Stem elongation	24.84 cdef	39.00 cde	2.561 cde
talash	2	Pre-flowering	24.86 cdef	38.96 cde	2.584 cde
talash	2	Pod emergence	26.79 bc	39.10 cde	2.509 de
talash	4	Stem elongation	27.66 ab	41.55 a	2.962 bc
talash	4	Pre-flowering	25.45 bcdef	41.22 ab	3.036 b
talash	4	Pod emergence	24.54 cdef	41.68 a	2.418 de
mahali	0	Stem elongation	23.59 def	38.43 de	2.185 e
mahali	0	Pre-flowering	23.27 f	38.20 e	2.165 e
mahali	0	Pod emergence	23.41 def	38.35 de	2.236 e
mahali	2	Stem elongation	26.06 bcde	39.70 cd	2.724 bcd
mahali	2	Pre-flowering	26.15 bcd	38.60 de	2.240 e
mahali	2	Pod emergence	23.25 f	38.56 de	2.171 e
mahali	4	Stem elongation	29.63 a	40.21 bc	3.471 a
mahali	4	Pre-flowering	25.52 bcdef	42.43 a	2.244 e
mahali	4	Pod emergence	23.73 def	39.40 cde	2.155 e

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