Original Research Article

Correlation and regression studies of organic maize grown under different doses of active silica

ABSTRACT

Chemical fertilization creates the ill effects on soil health and environment especially after green revolution. To mitigate such effects, the adoption of organic farming might be an ecologically viable option. The present experiment was therefore, carried out with aim to study the effects of active silica on growth and yield attributes and their interrelationship with each other during the *Kharif* season of 2018 and 2019 at Organic Unit of Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). The experiment was laid out in split-plot design with three replications consisting of 36 treatment combinations of six soil applications in main plots (0, 50, 75, 100, 125, and 150 kg/ha) and six foliar applications of active silica in subplots (No spray, water spray, 0.25, 0.50, 0.75 and 1.0%). The analysis showed that dry matter accumulation at 60, 75 DAS, and harvest increase with plant height at 60, 75 DAS and harvest, respectively, grains/cob and test weight showed positive correlation with grain yield. Stover yield also increased with increasing plant height and dry matter accumulation. Total N, P and K uptake significantly and positively increased with increasing biological yield; and protein content in grain increased with increasing N content. Si uptake increased significantly and positively with increasing Si content at 60, 75 DAS and harvest.

Keywords: *Active silica; correlation; maize; organic farming; regression.*

1. INTRODUCTION

Maize (*Zea mays* L.) is the world's leading crop and is widely cultivated as cereal grain. It is one of the most versatile emerging crops having wider adaptability. Globally, maize is known as the queen of cereals because of its highest genetic yield potential. It is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. Repetitive growing of cereals, imbalanced fertilization and irrational use of chemical fertilizers causes the various problems *viz*., deficiency of a micronutrient, ground water pollution, poor quality produce, etc. Whereas, organic production on the other hand, is gradually gaining momentum worldwide due to good quality produce, soil health and minimum environmental pollution. Organic growers utilize a wide range of cultural practices and natural inputs to manage crops in a manner they consider safe for the environment and the consumer. In organic production, natural sources of silicon (Si) can be used to increase the growth and yields of crops. Si is the second most abundant element found in the earth's crust, but it is mostly inert and only slightly soluble [1]. Si has a key role in improving crop abilities to withstand biotic and abiotic stresses [2]. Si benefits in maize have been related to its effect on the improving the effective leaf area, photosynthetic efficiency and quality as well as the delay of leaf senescence [3, 4]. Photosynthesis is a determinant factor for crop growth and development as maximum photosynthesis contributes toward more yield and production, and it is the most basic and critical physiological process directly related to maize yield, especially at late developmental stages [5]. In oilseed rape, the improvement of plant resistance to winter conditions and the formation of larger seeds were observed [6]. Dry matter accumulation increases with plant height is also influenced by photosynthesis [7]. Si application increases the growth attributes viz., plant height, stem diameter, number of leaves, cob length in maize [8]. Yield attributes of different crops viz., a number of grains/cob, pods/plant, kernel/spike, seeds/pod and test weight [8, 9, 10], and biological yield [8] significantly increased with Si fertilization. Si fertilization in the form of mono silicic acid in soil and foliar application significantly increased grain yield and improvement of grain quality of maize [11]. The highest positive influence of Si application was observed with the use of Si at 30 DAS and tasseling stages at 1.0% foliar application of active silica, which provided plant height, dry matter accumulation, biological yield and nutrient uptake in maize under organic production system [12]. Keeping the above facts, the present experiment was therefore, carried out with aim to study the effects of active silica on growth and yield attributes and their interrelationship under organic farming.

2. MATERIALS AND METHODS

A field experiment has conducted during the *Kharif* season of 2018 and 2019 at the Organic Unit of Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). The experiment was laid out in split plot design with six soil application in main plots *viz*., 0, 50, 75, 100, 125 (S_5) and 150 kg/ha; and six foliar applications of active silica in sub plots *viz*., No spray, water spray, 0.25, 0.50, 0.75 and 1.0% and replicated thrice. The crop was sown in row 60 cm apart and plant to plant distances of 25 cm by using 20 kg/ha seed rate. Diatomaceous earth was used a source of active silica. It was procured from Seema Minerals and Metal Ltd. at Udaipur. It has 80.69% SiO_2. Soil application of active silica was applied before sowing and foliar spray of active silica was done at 30 DAS and initiation of tasseling stage. Plant height, dry matter accumulation, grain, stover and biological yield were observed by standard method. The protein content was estimated by multiplying N content of seed with a factor 6.25 [13]. Si content was estimated in plant using method suggested by Ma and Takahashi [14]. The N, P and K content of grain and straw were estimated by colorimetric method using spectronic 20 after development of color with Nessler's regent [15], Vandomolybdo phosphoric acid yellow color method [16] and Flame photometer method [16], respectively. The uptake of Si (at 60, 75 DAS and harvest), N, P and K (at harvest) were determined by multiplying nutrient content with their respective dry matter.

To investigate the relationship between fodder yield and various growth, yield, physiological and nutrition factors a correlation matrix was created. Correlation between various parameters viz., growth attributes, yield components, yield, nutrient content and uptake were determined at probability 1 and 5% using the method given by Panse and Sukhatme [17]. Simple linear regression equations for various growth, yield and nutrition characteristics were worked out [17].

3. RESULTS AND DISCUSSION

3.1 Soil application

Soil application of active silica showed the significant and positive relationship among various growth, yield attributes, yield, nutrient content and uptake (Table 1). Dry matter accumulation at 60 (r =0.953**), 75 DAS (r =0.967**) and harvest (r =0.971**) increased with increasing plant height at 60, 75 DAS and harvest, respectively, and were positively correlated with each other. Increased dry matter accumulation resulted in a considerable increase in plant height due to an increase in doses of active silica. This might be owing to Si enhanced cell division and cell elongation, caused erectness of leaves and stem which ultimately lead to enhanced plant height and which enhanced higher dry matter accumulation. These findings are closely associated with

Singh et al. [18] and Mukherjee and Sen [19]. Grains/cob (r =0.993**) and test weight (r =0.997**) shows positive correlation with grain yield. Stover yield also increases with increasing plant height (r =0.940**) and dry matter accumulation (r =0.923**). Indicating that grain and stover yield are dependent on these yield parameters like plant height, dry matter accumulation grains/cob test weight. Since growth is assessed in terms of rate of dry matter production and plant height, and partitioning into distinct plant sections, which ultimately reflects on grain and stover yield, because it is a result of multiple physiological and biological processes. In this manner, the grains serve as a source of dry matter production and the vegetative plant parts as a sink for dry matter accumulation. In maize, vegetative part is the source and sinks in the view of photosynthetic area and assimilation in the grain as it forms the economical part. This might be owing to increasing dose of active silica, which increases biomass of grains owing to accumulation of carbohydrate and ultimately increased the test weight. These findings supported the results of Singh et al. [18], Singh et al. [20], and Jawahar and Vaiyapuri [21]. Correlation studies show that total N uptake (r =0.991**), P uptake (r =0.993**) and K uptake (r =0.996**) were positively correlated with biological yield; and protein content in grain (r =1.000**) positively correlated and increased with increasing N content and also Si uptake increased with increasing Si content in 60 (r =0.986**), 75 DAS (r =0.996**) and harvest (r =0.997**).N, P and K content increase in grain and stover owing to availability of N, P and K increased in soil, because of N has synergetic effect with Si. Si increased retention capacity of soil and increased solubility of P which leading to increased nutrient efficiency of phosphatic fertilizer and positive response of higher silica with K, might be linked to cell well [22]. Increased N, P, and K uptake with the increasing doses of active silica could be attributed to the better availability of N, P, and K and their transport to the plant from the soil. The higher nutrient uptake was mainly due to higher biological yield [23, 24, 25]. Significantly higher dry matter accumulation at different growth stages due to increased photosynthetic activity and minimized biotic and abiotic stress by soil application of active silica at 150kg/ha, which is synchronized supply according to crop needs.

3.2 Foliar application

The relationship between various growth, yield attributes, yield, nutrient content and uptake was found significant, and positive due to foliar application of active silica (Table 2). Dry matter accumulation was significantly and positively correlated with plant height at 60 (r =0.999**), 75 DAS (r =0.996**) and harvest (r =0.993**). Such relation between plant height and dry matter accumulation might be due to foliar application of active silica at 30 DAS and initiation of tasseling stage. It enhances the deposition of Si at the cellular level, which resulted into increased chlorophyll content, leaf area index, photosynthesis capacity and better light interception which ultimately lead to better vegetative growth, plant height as well as dry matter accumulation. These findings are closely associated with [18]. Grains/cob (r =0.983**) and test weight (r =0.974**) showed positive relationship with grain yield. Stover yield also showed significant positive correlation and increased with increasing plant height (r =0.988**) and dry matter accumulation (r =0.986**).This might be owing to active silica applied, particularly during reproductive stage, which enhanced the plant to more exposure to sunlight resulted assimilation of carbohydrates, and growth and development of crop vigorously resulted better nutrients and moisture is taken from the soil which turned into higher grain and stover yield. This might be the reason for increasing the grain and stover yield by foliar application of active silica. Similar results were also observed by Ahmad et al. [26], Patil et al. [27] and Sarma and Shankhdhar [28].Correlation analysis showed that total N (r =0.996**), P (r =0.999**) and K uptake (r =0.999**) were significantly positive correlated and increased with increasing biological yield, and protein content in grain (r =1.000**) increased with increasing N content, and also Si uptake increased with increasing Si content at 60 (r =0.995**), 75 DAS (r =0.999**) and harvest (r =1.000**).Jawahar and Vaiyapuri [21] also reported similar results.

4. CONCLUSION

Based on the present experiment, results indicated that various growth, yield attributes, yield, protein, nutrient content and uptake were significantly and positively correlated with each other under soil application of active silica. Meanwhile, the positive and highly significant relationship between various attributes viz., growth, yield attributes, yield, protein, nutrient content and uptake were also noticed in case of foliar spray of active silica. Overall, it can be concluded that various phonology, nutritional and yield characters of maize in an organic production system were significantly and positively related under both soil and foliar application of active silica.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Table 1.Correlation coefficient and regression equation showing relationship between ‘X’ and ‘Y’ variable of soil application of active silica

S.No.	Dependent variable (Y)	Independent variable (X)	Correlation coefficient (r)	Regression equation (Y=a+bX)
1.	Plant height (cm) at 60 DAS	DMA (g/plant) at 60 DAS	0.953**	Y = 29.588 +1.575X
2.	Plant height (cm) at 75 DAS	DMA (g/plant) at 75 DAS	0.967**	Y =78.266+0.764X
3.	Plant height (cm) at harvest	DMA (g/plant) at harvest	0.971**	Y= 99.796+0.548X
4.	Grain yield (kg/ha)	Grains/cob	0.993**	Y = -583.166+14.328X
5.	Grain yield (kg/ha)	Test weight (g)	0.997**	Y = -6884.738+46.029X
6.	Stover yield (kg/ha)	Plant height (cm) at harvest	0.940**	Y = -5091.239+54.525X
7.	Stover yield (kg/ha)	DMA (g/plant) at harvest	0.923**	Y = 410.481+29.359X
8.	Biological yield (kg/ha)	N uptake (kg/ha) by crop	0.991**	Y = 2201.451+64.174X
9.	Biological yield (kg/ha)	P uptake (kg/ha) by crop	0.993**	Y = 1675.767+365.810X
10.	Biological yield (kg/ha)	K uptake (kg/ha) by crop	0.996**	Y = 2322.805+66.084X
11.	Protein in grain (%)	N content (%) in grain	1.000**	Y = 0.000+6.250X
12.	Si content (%) at 60 DAS	Si uptake (kg/ha) at 60 DAS	0.986**	Y = 0.240+0.017X
13.	Si content (%) at 75 DAS	Si uptake (kg/ha) at 75 DAS	0.996**	Y = 0.615+0.244X
14.	Si content (%) at harvest	Si uptake (kg/ha) at harvest	0.997**	Y = 0.402+0.011X

Table 2.Correlation coefficient and regression equation showing relationship between 'X' and 'Y' variable of foliar application of active silica

S.No.	Dependent variable (Y)	Independent variable (X)	Correlation coefficient (r)	Regression equation (Y=a+bX)
1.	Plant height (cm) at 60 DAS	DMA (g/plant) at 60 DAS	0.999**	Y = 52.684+1.243X
2.	Plant height (cm) at 75 DAS	DMA (g/plant) at 75 DAS	0.996**	Y = -3.781+1.548X
3.	Plant height (cm) at harvest	DMA (g/plant) at harvest	0.993**	Y = 3.942+1.330X
4.	Grain yield (kg/ha)	Grains/cob	0.983**	Y = 4.257+11.688X
5.	Grain yield (kg/ha)	Test weight (g)	0.974**	Y = -4224.148+33.054X
6.	Stover yield (kg/ha)	Plant height (cm) at harvest	0.988**	Y = -8733.919+76.060X
7.	Stover yield (kg/ha)	DMA (g/plant) at harvest	0.986**	Y = -8518.398+101.850X
8.	Biological yield (kg/ha)	N uptake (kg/ha) by crop	0.996**	Y = 1442.706+75.308X
9.	Biological yield (kg/ha)	P uptake (kg/ha) by crop	0.999**	Y = 942.637+420.299X
10.	Biological yield (kg/ha)	K uptake (kg/ha) by crop	0.999**	Y = 892.610+88.270X
11.	Protein in grain (%)	N content (%) in grain	1.000**	Y = 0.000+6.250X
12.	Si content (%) at 60 DAS	Si uptake (kg/ha) at 60 DAS	0.995**	Y = 0.184+0.018X
13.	Si content (%) at 75 DAS	Si uptake (kg/ha) at 75 DAS	0.999**	Y = 0.137+0.014X
14.	Si content (%) at harvest	Si uptake (kg/ha) at harvest	1.000**	Y = 0.059+0.013X