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RESPONSE OF MAIZE TO SILICON APPLICATION

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ABSTRACT

A Field experiment was conducted in *kharif* season 2019-20 at experimental farm of College of Agriculture, Badnapur to study effect of soil and foliar application of silicon on soil nutrient dynamics, yield and quality of maize. The experiment was conducted in Randomized Block Design with five treatments i.e. (T_1): RDF: 150:75:75 kg NPK ha^{-1}, (T_2) : RDF + Potassium Silicate @10 kg ha^{-1} , (T_3) : RDF + Potassium Silicate @ 20kg ha^{-1}, (T_4) : RDF + Two foliar spray of 0.2% of Potassium Silicate @ 30 DAS and 45 DAS, (T_5) : RDF + Two foliar sprays of 0.4% of Potassium Silicate @ 30 DAS and 45 DAS with four replications. It was inferred from the results that application of treatment T_5:(RDF + Two foliar sprays of 0.4% of Potassium Silicate @ 30 DAS and 45 DAS) found superior over T_1: RDF(150:75:75 kg NPK ha^{-1}) in respect of plant height (181.50 cm) ; leaf area plant^{-1} (93.50 dm^2) , grain yield (5717 kg ha^{-1}) stover yield (6627 kg ha^{-1}), test weight (260.50 gm) and starch content (74.40 %). It was also inferred from the result that an application of RDF+ Potassium Silicate @ 20 kg ha^{-1} (T_3) showed synergistic effect on nutrient (N, P and K) uptake in plant after harvest of maize . Similarly available N, P and K content in soil after harvest of maize was also found to be more in the same treatment.

(Key words: Maize, silicon, yield, quality)

INTRODUCTION

Maize is known as 'Queen' of cereals due to its versatile use and having high yield potential. More than 35 products of daily use are derived from Maize *viz*., starch, glucose, high fructose syrup, dextrose etc., (Raut *et al*., 2017). Maize gives good response to nutrient and nutrient application improves growth and yield attributes (Yadav *et al*., 2017).

Silicon plays a significant role in imparting both biotic and a biotic stress resistance and enhance the productivity. For this reason, Si has been recognized as agronomically essential element and silicate fertilizers have been applied to soils (Ma and Takahashi, 1990). Silicon nutrition also manages many abiotic stresses including physical stresses like lodging, drought, radiation, high temperature, freezing and chemical stresses like salt, metal toxicity and nutrient imbalance (Epstein, 1994). It has a role in phosphorus nutrition and there is an interrelationship with phosphorus (Silva, 1971). Epstein and Bloom (2005) suggested that Si enhances disease resistance in plants, imparts turgidity to the cell walls and has been putative role in mitigating the metal toxicities. Silicon fertilization increases the tillers and grains (Liang *et al.,* 1994). In view of this, the present investigation was conducted .

MATERIALS AND METHODS

A field experiment was conducted in *kharif* season 2019-20 at experimental farm of Department of Soil Science and Agricultural Chemistry, College of Agriculture, Badnapur. The experiment was laid out on Vertisols with five treatment combinations, replicated four times in randomized block design. The treatment consists of T_1:RDF (150:75:75 kg NPK ha^{-1}, T_2:(RDF+ Potassium Silicate @ 10kgha^{-1}), T_3: (RDF+ Potassium Silicate @ 20kgha^{-1}), T_4:(RDF+ Two foliar spray of 0.2% of Potassium Silicate @ 30DAS and 45DAS), T_5:(RDF +Two foliar spray of 0.4% of Potassium Silicate @ 30 DAS and 45 DAS).The initial available N, P_2O_5, K_2O content was 117.60, 16.20,498.80 kg ha^{-1} respectively. Nitrogen concentration in plant samples was estimated by the Kjeldhal method as suggested by Piper (1966). Phosphorus was estimated by Vanadomolybdophosphoric acid yellow colour method using spectrophotometer, as described by Jackson (1973). Potassium was determined on flame photometer as suggested by Jackson (1973). 1000 sun dried grains were counted from produce of each net plot for recording of test weight. The starch content in seed was estimated by Anthron method as suggested by Sadasivum and Manickam (1992).The nutrient uptake i.e. uptake of N, P, K, was calculated by using formula. Uptake (kg ha^{-1}) = Nutrient

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concentration % X (dry matter yield (kg ha^{-1}) /100. Available nitrogen in soil was determined by Alkaline Permanganate method as suggested by Subbiah and Asija (1956). The available phosphorus content was estimated by Olsen's method as described by Olsen *et al.* (1954). The available potassium content from soil was established by using ammonium acetate extract as suggested by Jackson (1967).

RESULTS AND DISCUSSION

Growth parameters

Observations recorded under different treatments on plant height are presented in Table 1 . The plant height was significantly highest in treatment RDF + Two foliar sprays of 0.4% of potassium silicate @ 30 DAS and 45 DAS (T_5) (181.50 cm) at harvesting stage over all other treatments followed by treatment RDF + potassium silicate @ 20 kg ha^{-1} (167.50 cm). Significantly lowest plant height (155.00 cm) was recorded in treatment T_1 (RDF: 150:75:75 kg NPK ha^{-1}). These varied responses of plant height to foliar application of potassium silicate may be attributed to variation in native available Si content and response to the additional Si fertilizer. Abro *et al*. (2009) reported that silicon level of 0.25 and 0.50% showed increase in height, however, higher levels above 0.50% was found un-advantageous in wheat crop.

The leaf area plant^{-1}was significantly highest in treatment RDF + two foliar sprays of 0.4% of potassium silicate @ 30 DAS and 45 DAS (T_5) (93.50) at harvesting stage which was at par with treatment T_3 (89.80) RDF + Potassium silicate @ 20 kg ha^{-1}.Faiq *et al.* (2009) noticed that plants supplied with 1 Mm (Millimole) silica produced maximum leaf area and plant height in hydroponics maize.

Yield

The grain yield was significantly highest in treatment RDF + two foliar sprays of 0.4% of potassium silicate @ 30 DAS and 45 DAS (T_5) (5717.50 kg ha^{-1}) which was at par with treatment T_3 (5551.25 kg ha^{-1}) RDF + Potassium silicate @ 20 kg ha^{-1}.This might be due to the effect of silicon during seedling growth, silicon mediated the photosynthetic rate, root activities and nitrate reductase activity. Improvement in maize yield might be due to increased length of cobs and the weight of 1000 seed weight. Singh and Singh (2005) noted maximum grain yield (6588 kg ha^{-1}) with the application of 180 kg silica ha^{-1}.

The straw yield was significantly highest in treatment RDF + Two foliar sprays of 0.4% of potassium silicate @ 30 DAS and 45 DAS (T_5) (6627.50 kg ha^{-1}) over the treatment T_1 (5790.00 kg ha^{-1}) RDF and T_2 (5985.00 kg ha^{-1}) potassium silicate @ 10 kg ha^{-1},(T_4) (6252.50 kg ha^{-1}) , while it was at par with (T_3) RDF + Potassium Silicate @ 20 kg ha^{-1}. Meena (2012) observed that application of silica @ 300 mg kg^{-1} soil recorded dry shoot yield (52.25 g pot^{-1}) of maize.

Quality parameters

The test weight was significantly highest in treatment RDF + two foliar sprays of 0.4% of potassium silicate @ 30 DAS and 45 DAS (T_5) (260.50 g) over the treatment T_1 (233.65 g) RDF, while it was at par with the treatment T_3 (253.45 g) RDF + potassium silicate @ 20 kg ha^{-1}.The increase in thousand grains weight might be attributed due to the beneficial role of silicon in improving photosynthetic activity and plant nutrition.

The starch content was significantly highest in treatment RDF + two foliar sprays of 0.4% of potassium silicate @ 30 DAS and 45 DAS (T_5) (74.40 %) over the treatment T_1 (71.68%) RDF and T_2 (72.63%) RDF+ potassium silicate @ 10 kg ha^{-1}.Treatment T_3 RDF + potassium silicate @ 20 kg ha^{-1} and treatment T_4 were at par with T_5. Ahmad *et al.,* (2013) reported that combine application of silicon at 1.5% and boron at 1% has significantly improved 1000 kernel weight (19.65 g) and starch content (79.71%) in wheat under saline soil conditions.

Nutrient uptake

The highest uptake of N (210 kg ha^{-1}) was recorded in treatment T_3 (RDF + Potassium silicate @ 20 kg ha^{-1})which was at par with treatment T_2 (RDF + Potassium silicate @ 10 kg ha^{-1}) (198.25 kg ha^{-1}). Significantly lowest uptake of N (155.50 kg ha^{-1}) was recorded in treatment T_1 (RDF: 150:75:75 NPK kg ha^{-1}). In presence of silicon, the increase in N uptake could be attributed to enhance vigor of crop growth with increased utilization and translocation of N into plant and synergistic effect between N and silicon in soil system resulting in the enhancement of yield.

Similarly significantly highest uptake of P (38.50 kg ha^{-1}) was recorded in treatment T_3 RDF + potassium silicate @ 20 kg ha^{-1} which was at par with treatment T_2 ((RDF + Potassium silicate @ 10 kg ha^{-1} (34.00 kg ha^{-1}). The increase in total uptake of P due to application of silicon might be attributed to role of silicon in increasing the availability of soil phosphorus which might have increased the biomass and root activity.

The highest uptake of K (174.25 kg ha^{-1}) was also recorded in treatment T_3 (RDF + potassium silicate @ 20 kg ha^{-1}) which was at par with treatment T_2 (RDF + Potassium silicate @ 10 kg ha^{-1}) (164.75 kg ha^{-1}). Significantly lowest uptake of K (142.75 kg ha^{-1}) was recorded in treatment T_1 (RDF: 150:75:75 NPK kg ha^{-1}). Higher application silicon towards uptake of potassium could be linked to silicification process of cell walls. Increase in the potassium uptake might be due to stimulating effect of silicon on activation of H+-ATPase in the membrane. Savant *et al.*(1997) also recorded that an application of silicon @180 kg ha^{-1} increased nutrient concentration and uptake of N, P and K in rice.

Effect of silicon on availability of nutrients

Application of RDF + potassium silicate @ 20 kg ha^{-1} recorded significantly highest available nitrogen content in soil (132.20 kg ha^{-1}),over all the treatments except T_1(RDF) which was recorded significantly lowest available N in soil (121.50 kg ha^{-1}) . While, remaining treatments were found at par with each other. It might be due to synergistic effect of nitrogen and silicon.

Similarly application of RDF + potassium silicate @ 20 kg ha^{-1} had recorded significantly highest available

Table1. Effect of silicon on growth, yield, quality parameters and availability of nutrients in maize

Treatments	Plant height (cm) at harvest	Leaf area plant^{-1}(dm^2) at harvest	Grain Yield kg ha^{-1}	Stover Yield kg ha^{-1}	Test Weight (g)	Starch content (%)	Total N Up take (kg ha^{-1})	Total P Uptake (kg ha^{-1})	Total K Uptake (kg ha^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T1	155.00	70.50	4822	5790	233.65	71.68	155.50	21.50	142.75	121.50	18.50	505.50
T2	161.75	76.25	5015	5985	240.60	72.63	198.25	34.00	164.75	129.72	23.50	521.25
T3	174.00	89.80	5551	6467	253.45	73.18	210.25	38.50	174.25	132.20	24.83	528.00
T4	167.50	82.48	5215	6252	245.90	73.83	162.50	24.00	147.75	124.75	19.75	513.75
T5	181.50	93.50	5717	6627	260.50	74.40	180.50	28.50	152.75	126.00	21.25	515.25
SEm±	4.13	1.85	67.83	82.21	4.56	0.61	4.68	1.58	3.37	2.53	0.94	3.33
CD @5%	11.97	5.18	203.49	238.40	13.68	1.83	13.57	4.42	09.77	7.59	2.72	10.00

phosphorus content in soil (24.83 kg ha^{-1}) which was at par with treatment T_3. Significantly lowest available P was recorded in soil (18.50 kg ha^{-1}) in treatment T_1 (RDF: 150:75:75 NPK kg ha^{-1}). The silicon application decreased the phosphorus retention capacity of soil and thus increases the water soluble phosphorus in soil leading to increase efficiency of phosphatic fertilizers. The silicon in solution renders availability of phosphorus to plant.

Treatment T_3 i.e. RDF + potassium silicate @ 20 kg ha^{-1} recorded significantly highest available potassium content in soil (528.00 kg ha^{-1}),over all the treatments except T_2(RDF + Potassium silicate @ 10 kg ha^{-1}) (521.25 kg ha^{-1}) , which were at par with each other. Significantly lowest available K was recorded in soil (505.50 kg ha^{-1}) in treatment T_1 (RDF: 150:75:75 NPK kg ha^{-1}).The applied Si is responsible for release of native potassium due to secretion of root exudates.

From the results it can be concluded that application of RDF + two foliar sprays of 0.4% of potassium Silicate @ 30DAS and 45DAS (T_5) was effective in growth and yield of maize. Uptake of nutrients increased with the increasing levels of RDF + potassium silicate @ 20 kg ha^{-1} (T_3) . Similarly available N, P and K content in soil after harvest of maize was also found to be more in the same treatment. The quality parameters *viz.,* starch content was also improved with the application of RDF + two foliar sprays of 0.4% of Potassium Silicate @ 30DAS and 45DAS (T_5). Similar results were also noted by Annamwar (2020) in the experiment carried out during 2019-20 at College of Agriculture, Badnapur and asserted that soil application of RDF + calcium silicate @100 kg ha^{-1} showed higher values of NPK (185.2, 19.5 and 633.71 kg ha^{-1}, respectively) at harvest over application of RDF alone (173.86, 16.34 and 575.28 kg ha^{-1}, respectively) .

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