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EFFECT OF SILICON ON DRY MATTER YIELD AND NUTRIENT UPTAKE OF HYBRID MAIZE

S. Jawahar*, K. Suseendran, C. Kalaiyarasan, S. Ramesh, S.R. Vinodkumar and K. Arivukkarasu

Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar– 608 002 (Tamilnadu), India

Abstract

Field experiments were conducted at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamilnadu (Location-I) and at Farmers Field, Mallamapuram Village, Dharmapuri district, Tamil Nadu (Location-II) during 2015 – 2017 to study the effect of silicon on dry matter yield and nutrient uptake of hybrid maize. The experiment consisted of sixteen treatments *viz.,* each three levels of silixol granules (25, 50 and 100 kg ha^{-1}) and Silixol plus spray (1, 2 and 3 ml litre^{-1} on 20, 40 and 60 DAS) and their interactions along with recommended dose of fertilizers (RDF) and as control. The experiments were laid out in Randomized Block Design with three replications. The results of the experiments revealed that, among the different levels of silicon, the combination of soil and foliar application recorded highest values compared to individual application of soil and foliar. Among the treatments tried, combination of soil and foliar application of RDF + silixol granules @ 100 kg ha^{-1} + silixol plus @3 ml l^{-1} recorded higher values for dry matter yield of hybrid maize during 30,60 DAS and at harvest in Location-I and Location-II. In respect of nutrient uptake of maize, RDF + silixol granules @25 kg ha^{-1} + silixol plus@ 1 ml l^{-1} recorded highest NPK&Si uptake in both the locations. Thus it can be concluded that conjoint application of RDF + silixol granules@ 25 kg ha^{-1} + silixol plus @1 ml l^{-1} on 20, 40 and 60 DAS holds immense potentiality to enhance the dry matter yield and nutrient uptake of hybrid maize.

Key words: silicon, hybrid maize, dry matter yield, nutrient uptake

Introduction

Silicon is the second most abundant element in the earth's surface and plays a significant role in imparting biotic, abiotic stress resistance and enhancing crop productivity (Epstein, 1999). It is also considered as an environmentally-friendly element in relation to soils, fertilizers and plant nutrition. Silicon is accumulated at levels equal to or greater than essential nutrients in plant species belonging to the families Poaceae and Cyperaceae (Savant *et al.,* 1997). Silicon is the only element known that does not damage plants with excess accumulation. It has been demonstrated to be necessary for healthy growth and stable production. Long term system of intensive crop cultivation depletes the available soil silicon (Si). Depletion of available Si in the soil could be one of the possible limiting factors amongst others contributing to declining yield of maize. The lower values of Si in the soil could be due to severe and frequent soil erosion and sediment transportation. Due to the desilication process, Si in the soil is continuously lost as the result of leaching process. The silicon content in some regions might be limited to sustainable crop production. Hence, improved Si management to increase yield and sustain crop productivity appears to be necessary in tropical as well as in sub-tropical countries (Meena *et al.,* 2014).

The growth and yield of maize was enhanced by silicon fertilization (Pei *et al.,* 2010) and application of silicon increased the growth attributes (leaf area, chlorophyll content, root length, fresh shoot weight, dry shoot weight), yield attributes (cob length, cob diameter, number of grains and test weight) and yield of maize (Jigar Sharma *et al.,* 2013). Although silicon is the second largest element present in the soil but due to its presence in the amorphous form, it is not available for plants. Plants absorb silicon from the soil solution in the form of monosilicic acid, also called orthosilicic acid (Lewin and Reimann, 1969). The beneficial effect of orthosilicic acid was earlier reported by Jawahar *et al.,* (2015a&b) in

***Author for correspondence :** E-mail : jawa_au@yahoo.com

rice. As far as maize is concerned a very few work's have been done with silicon nutrition. Keeping the aforesaid facts in consideration, the present investigation was carried out to study the effect of silicon through ortho silicic acid formulations *viz.,* silixol granules and silixol plus on dry matter yield and nutrient uptake of hybrid maize.

Materials and Methods

Field experiments were conducted at two different locations *viz.,* Location I at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar and Location I at farmer's field at Mallamapuram in Dharmapuri district. The soils of the experimental fields were clay loam and sandy loam respectively. The maize crop was raised during February – June 2016 (Location-I) and December- April 2017 (Location-II). The maize cultivar DKC 9133 (Hybrid) was chosen for the study. Maize crop was fertilized with 250:75:75kg N, P_2O_5 and K_2O ha^{-1} and were applied in the form of Urea (46% N), Single Super Phosphate (16% P_2O_5) and Muriate of Potash (60% K_2O). Fifty percent of the recommended N and full dose of P_2O_5 and K_2O were applied basally. Remaining half of N was top dressed in two equal splits at 25 and 45 DAS. The experiment consisted of sixteen treatments *viz.,* each three levels of silixol granules (25, 50 and 100 kg ha^{-1}) and Silixol plus spray (1, 2 and 3 ml litre^{-1} on 20, 40 and 60 DAS) and their interactions along with recommended dose of fertilizers and as control. The experiments were laid out in Randomized Block Design with three replications. Silixol granules and Silixol plus were obtained as gift sample from Privi Life Sciences Pvt. Ltd. Navi Mumbai, India-400709 and were applied as per the treatments. The plants selected at random in two border rows were cut close to the cotyledonary node at 30, 60 DAS and at harvest for estimating dry matter yield (DMY). The collected samples were chopped, air dried and then oven dried at 80°C till concordant values were obtained. The dry weight of samples were recorded and expressed in kg ha^{-1}. The crop samples collected at the time of harvesting from outside the net plot was used for analysis of N, P, K and Si uptake by crops. The values recorded were expressed in kg ha^{-1}.

Results and Discussion

Dry matter yield

Dry matter yield (DMY) was greatly influenced by silicon levels at all stages in both the locations (Table 1 and 2). In general higher dry matter yield was noticed with higher level of silicon. The dry matter yield ranged from 4913 to 6270, 8138 to 10242 and 13104 to 15673 kg ha^{-1} in Location-I and 4937 to 6342, 8218 to 10826 and 14040 to 15609 kg ha^{-1} in Location-II on 30, 60 DAS and at harvest stage respectively. Among the different levels of silicon, the combination of soil and foliar application recorded highest dry matter yield compared to individual application of soil and foliar. Foliar application of silicon was found to be lesser effect compared to soil application. With respect of soil application T_4 (T_1+Silixol granules @100 kg ha^{-1}) recorded highest dry matter yield of 5545, 9135 and 14506 kg ha^{-1} in Location-I and 5788, 9723 and 14953 kg ha^{-1} in Location-II on 30, 60 DAS and at harvest stage over other levels respectively. With respect to foliar application, T_7 (T_1+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS) recorded highest dry matter yield of 5216, 8613 and 13809 kg ha^{-1} in Location-I and 5354, 8985 and 14547 kg ha^{-1} in Location-II on 30, 60 DAS and at harvest stage over other levels respectively. From this, the combination of soil and foliar application of RDF + silixol granules 100 kg ha^{-1} + silixol plus 3 ml L^{-1} (T_{16}) recorded higher dry matter yield of 6270, 10242 and 15673 kg ha^{-1} in Location-I and 6342, 10826 and 15609 kg ha^{-1} in Location-II at 30, 60 DAS and at harvest respectively. The higher DMY under T_{16} (RDF + silixol granules 100 kg ha^{-1} + silixol plus 3 ml L^{-1}on 20, 40 and 60 DAS) could be due to the maintenance of high photosynthetic activity and efficient utilization of light and translocation of assimilated products to sink (Kaya *et al.,* 2015). Increased plant height, larger leaf area and increased dry matter of shoot might have accumulated more photosynthates and produce higher biological yield (DMY). This is in conformity with the reports of Jawahar and Vaiyapuri (2010) and Ali Rohanipoor *et al.,* (2013). Similar reports were earlier outlined by Jawahar *et al.,* (2009) who reported that application of silicon at 100 kg ha^{-1} through fly ash significantly increased plant height, LAI and DMY of maize. This was on par with T_{15} (RDF + silixol granules 100 kg ha^{-1} + silixol plus 2 ml L^{-1}) and T_{14} (RDF + silixol granules 100 kg ha^{-1} + silixol plus 1 ml L^{-1}) in Location-I and Location-II. The lesser dry matter yield was recorded under treatment T_1 (RDF), which registered a dry matter of 4913, 8138 and 13104 kg ha^{-1} and 4937, 8218 and 14040 kg ha^{-1} on 30, 60 DAS and at harvest respectively in Location-I and Location-II.

Nutrient uptake

Application of Si significantly increased the NPK and Si uptake of maize. Among the different levels of silicon, the combination of soil and foliar application recorded highest NPK&Si uptake compared to individual application of soil and foliar (Table 3 and 4). Foliar application of silicon was found to be lesser effect compared to soil application. With respect of soil application T_4 (T_1+Silixol granules @ 100 kg ha^{-1}) recorded highest nutrient uptake in both locations over other levels. With respect to foliar application, T_7 (T_1+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS) recorded highest nutrient uptake in Location-I and Location-II. From this, the combination of soil and foliar application of RDF + silixol granules 100 kg ha^{-1} + silixol plus 3 ml L^{-1} (T_{16}) recorded highest NPK&Si uptake over others in both locations. This was on par with T_{15} (RDF + silixol granules 100 kg ha^{-1} + silixol plus 2 ml L^{-1}) and T_{14} (RDF + silixol granules 100 kg ha^{-1} + silixol plus 1 ml L^{-1}). The lesser NPK&Si uptake was recorded under treatment T_1 (RDF) in Location-I and Location-II. The N uptake was higher with T_{16} when compared to other levels due to its potential to raise the soil available nitrogen (Ho *et al.*, 1980). Silicon fertilized plant gained maximum benefits of sample nitrogen availability. Increasing silicon levels increased phosphorus content due to decreased retention capacity of soil and increased solubility of

Table 1: Effect of silicon on DMY (kg ha^{-1}) of hybrid maize on 30, 60 DAS and at Harvest (Location-I).

Treatments	30 DAS	60 DAS	Harvest
T_1- RDF(250:75:75 kg N, P_2O_5 & K_2O ha^{-1})	4913	8138	13104
T_2- T_1+Silixol granules @ 25 kg ha^{-1}	5386	8881	14146
T_3 - T_1+Silixol granules @ 50 kg ha^{-1}	5510	9105	14485
T_4 - T_1+Silixol granules @ 100 kg ha^{-1}	5545	9135	14506
T_5- T_1+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	5060	8290	13455
T_6 - T_1+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	5194	8587	13783
T_7- T_1+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	5216	8613	13809
T_8- T_2+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	5665	9385	14841
T_9- T_2+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	5690	9410	14884
T_{10}- T_2+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	5705	9456	14923
T_{11} -T_3+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	5905	9684	15247
T_{12}-T_3+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	5941	9715	15288
T_{13} -T_3+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	5970	9745	15314
T_{14} -T_4+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	6192	10189	15624
T_{15} -T_4+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	6236	10210	15641
T_{16} -T_4+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	6270	10242	15673
S.Ed	44.40	72.99	89.88
CD(p=0.05)	90.68	149.07	192.36

Table 2: Effect of silicon on DMY (kg ha^{-1}) of hybrid maize on 30, 60 DAS and at Harvest in (Location-II).

Treatments	30 DAS	60 DAS	Harvest
T_1- RDF(250:75:75 kg N, P_2O_5 & K_2O ha^{-1})	4937	8218	14040
T_2- T_1+Silixol granules @ 25 kg ha^{-1}	5541	9299	14744
T_3 - T_1+Silixol granules @ 50 kg ha^{-1}	5721	9601	14926
T_4 - T_1+Silixol granules @ 100 kg ha^{-1}	5788	9723	14953
T_5- T_1+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	5110	8513	14256
T_6 - T_1+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	5297	8872	14519
T_7- T_1+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	5354	8985	14547
T_8- T_2+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	5955	9992	15130
T_9- T_2+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	5982	10073	15156
T_{10}- T_2+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	6024	10118	15173
T_{11} -T_3+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	6138	10361	15351
T_{12}-T_3+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	6165	10423	15371
T_{13} -T_3+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	6199	10494	15388
T_{14} -T_4+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	6298	10698	15557
T_{15} -T_4+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	6324	10765	15576
T_{16} -T_4+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	6342	10826	15609
S.Ed	41.28	71.10	90.41
CD(p=0.05)	88.34	152.16	193.48

Table 3: Effect of silicon on N, P, K and Si uptake (kg ha^{-1}) of hybrid maize (Location-I).

Treatments	N	P	K	Si
T_1- RDF(250:75:75 kg N, P_2O_5 & K_2O ha^{-1})	128.16	40.84	43.98	60.21
T_2- T_1+Silixol granules @ 25 kg ha^{-1}	141.12	57.23	61.64	71.59
T_3 - T_1+Silixol granules @ 50 kg ha^{-1}	145.33	62.16	66.94	76.03
T_4 - T_1+Silixol granules @ 100 kg ha^{-1}	146.02	62.41	67.21	76.72
T_5- T_1+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	132.25	45.07	48.53	63.25
T_6 - T_1+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	136.38	51.01	54.93	67.91
T_7- T_1+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	136.94	51.33	55.28	68.28
T_8 - T_2+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	150.25	67.13	72.29	81.97
T_9- T_2+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	150.96	67.57	72.77	82.46
T_{10}- T_2+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	151.13	67.93	73.16	82.93
T_{11} -T_3+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	155.38	72.72	78.31	87.83
T_{12}-T_3+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	155.98	72.89	78.49	88.01
T_{13} -T_3+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	156.21	73.26	78.90	88.35
T_{14} -T_4+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	160.52	76.96	82.67	92.98
T_{15} -T_4+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	161.03	77.14	82.94	93.46
T_{16} -T_4+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	161.59	77.81	83.12	93.88
S.Ed	1.16	0.51	0.81	1.40
CD(p=0.05)	2.38	1.05	1.66	2.87

Table 4: Effect of silicon on N, P, K and Si uptake (kg ha^{-1}) of hybrid maize (Location-II).

Treatments	N	P	K	Si
T_1- RDF(250:75:75 kg N, P_2O_5 & K_2O ha^{-1})	130.29	41.89	45.34	61.68
T_2- T_1+Silixol granules @ 25 kg ha^{-1}	143.25	58.28	63.01	73.06
T_3 - T_1+Silixol granules @ 50 kg ha^{-1}	147.46	63.21	68.60	77.50
T_4 - T_1+Silixol granules @ 100 kg ha^{-1}	148.15	63.46	68.57	78.19
T_5- T_1+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	134.38	46.12	49.89	64.72
T_6 - T_1+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	138.51	52.06	56.29	69.38
T_7- T_1+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	139.07	52.38	56.24	69.75
T_8 - T_2+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	152.38	68.18	73.65	83.44
T_9- T_2+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	153.09	68.62	74.13	83.93
T_{10}- T_2+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	153.26	68.98	74.52	84.40
T_{11} -T_3+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	157.51	73.77	79.67	89.30
T_{12}-T_3+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	158.11	73.94	79.85	89.48
T_{13} -T_3+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	158.34	74.31	80.26	89.82
T_{14} -T_4+Spraying of Silixol plus @ 1ml litre^{-1} on 20, 40 & 60 DAS	162.65	78.01	84.03	94.45
T_{15} -T_4+Spraying of Silixol plus @ 2ml litre^{-1} on 20, 40 & 60 DAS	163.16	78.99	85.30	94.93
T_{16} -T_4+Spraying of Silixol plus @ 3ml litre^{-1} on 20, 40 & 60 DAS	163.72	79.60	85.96	95.35
S.Ed	1.12	0.51	0.83	1.36
CD(p=0.05)	2.41	1.09	1.79	2.92

phosphorus leading to increased efficiency of phosphatic fertilizer (Subramanian and Gopalasamy, 1991). Positive response of higher silicon application towards potassium can be linked to silicification of cell wall. This finding is in the line with Chanchareonsook Jongruk *et al.,* (2002) and Ahmed *et al.,* (2008) who reported that application of NPK fertilizer in combination with Si significantly increased total N, P and K uptake of maize. Silicon also favourably influenced the uptake of silicon and the higher silicon content was associated with the higher rate of silicon application. This might be due to increase in root growth and enhanced soil silicon availability with silicon application. These findings are in agreement with reports of Jawahar *et al.,* (2015b) and Campos *et al.,* (2015).

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