EFFECT OF SILICON FERTILIZERS ON MANAGEMENT OF BROWN SPOT DISEASE OF SUGARCANE UNDER NATURAL FIELD CONDITIONS

ABSTRACT

Brown spot (*Cercospora longipes*), which was a minor fungal foliar disease is now causing serious threat to sugarcane production and had shifted to the major one. To improve the quality of sugarcane and increase its production it is necessary to prevent the crop from negative impacts of diseases. Field bioefficacy experiment was conducted to studied silicon fertilizer treatments for the management of brown spot disease of sugarcane caused by *Cercospora longipes* during 2022-23 at Central Sugarcane Research Station, Padegaon. A field experiment was laid out in randomized block design during *Suru* 2023 with eight treatments and three replications by using susceptible cv. CoM 0265. The results indicated that the brown spot disease intensity ranged from 6.82 to 38.85 per cent during period of experiment. Among the treatments, foliar spray of Potassium silicate @ 0.5% at 120 and 150 DAP was found significantly superior and the most effective for the control of brown spot disease of sugarcane as compared to the rest of the treatments and recorded minimum per cent disease intensity (6.82%) and highest 82.45 per cent disease control , highest number of internode length (23.23cm), cane girth (12.15 cm), No. of internodes (21.92/cane), single cane weight (2.14 kg), NMC (88,890/ha), CCS yield (21.96 t/ha), cane yield (147.50 t/ha), CCS % (14.89 %), Brix (21.87), Purity (95.21%) and sucrose content (21.12 %), respectively as compared to untreated control. The analysis of silicon and potassium concentration showed that the range of mean Si and K concentration observed was 5.97 g/kg to 11.31 g/kg and 1.25% to 2.13% respectively. The observations showed that mean Si and K concentrations were found highest in foliar spray of Potassium silicate @ 0.5% at 120 DAP and 150 DAP.

Keywords: *Cercospora, Brown spot, Silicon fertilizers, Potassium and Calcium silicate*

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a perennial grass of the Poaceae family that is most energetic, life sustaining, highly industrious and widely grown commercial cash crop. The sugarcane industry confronts numerous hurdles for decreasing productivity of sugarcane includes floods, drought, water logging, weed, diseases and pests, etc. Among them, diseases of sugarcane have been found the most devastating and widespread yield reducing factors that tremendously depreciate the crop qualitatively and quantitatively. Sugarcane suffers from a multitude of diseases induced by various microorganism mainly 100 fungus, 10 bacteria, 10 viruses, environmental and physiological abnormalities and nutritional deficiencies. India has observed cases of various foliar diseases, including eye spot (*Bipolaris sacchari*), brown spot (*Cercospora longipes*), ring spot (*Leptosphaeria sacchari*), rusts (*Puccinia melanocephala*), brown stripe (*Cochliobolus stenospilus*), and leaf spots caused by *Curvularia Spp* and *Periconia*. There have been several instances of foliar disease outbreaks recently, according to Rao (2002), Viswanathan and Padmanaban (2008), Viswanathan (2012) and Selvakumar and Viswanathan (2018).

The fungus *Cercospora longipes* E. Butler, which causes brown spot, was once thought to be a minor harm but has recently become a major one. It sporadically becomes a major disease that occurs in a particular season of the year or is limited to areas with high rainfall and humidity, such as Maharashtra's main sugarcane growing areas. Oval, reddish-brown to dark-brown points with a yellow halo encircling them that are orientated parallel to the veins are the typical foliar symptoms of *Cercospora* leaf spot. Eventually, a three-color, concentrically formed halo made of red, yellow and brown was seen around the specks. The marks were evenly spaced over the leaf surface, particularly on older leaves and were readily discernible on both surfaces. The sizes of the brown spots ranged between 0.25 mm and 3.0 mm x 5.0 mm and 15 mm, whilst the surrounding yellow halo lesion varied from 1 mm to 10 mm. The linear shape of the spots in the afflicted leaves sets them apart from other foliar leaf spots in sugarcane (Viswanathan and Ashwin, 2020). Over the past three to four years, the brown spot (*Cercospora longipes*) which was previously negligible in sugarcane, has grown significantly, resulting in a reported loss of 12 to 20% in sugar quality and recovery and significant reduction in sugar yield in areas where the brown spot disease was pervasive (Viswanathan and Ashwin, 2020).

Various methods and chemical inputs are used by farmers and agricultural enthusiasts to improve growth of plants and output. Application of traditional fungicides in the management of diseases has raised major problems regarding fungicide resistance, environmental quality and food safety. Alternative method of managing plant diseases is to use of many nutrients or through use of fertilizer due to which plants able to tolerate diseases or to resist against infections. The silicon fertilization has been found effective in reducing various diseases of different crops. It is thought that silicon forms a physical barrier that can prevent fungal hyphae from penetrating, or it may encourage the formation of antifungal chemicals, as has been shown to control a variety of diseases. Numerous investigations have shown that silicon is useful in managing diseases in several types of plants that are brought on by bacteria and fungus. Research conducted by Ramouthar *et al.,* (2015) on the impact of silicon (Si) on the severity of sugarcane brown rust (*Puccinia melanocephala* H & P. Sydow) revealed that brown rust severity decreased as plant Si content increased due to the application of calcium and potassium silicate. Datnoff and Rodrigues, (2005) observed that silicon, for instance, makes rice more resistant to leaf scald, sheath blight, leaf and neck blast, brown spot and stem rot. Additionally, after applying calcium silicate, a notable decline in the incidence of neck blast and the severity of brown spot (*Cochliobolus miyabeanus*) in rice plants growing in a Histosol in southern Florida. Therefore, it was felt necessary to study the effect of silicon fertilizers in inducing resistance and management of brown spot disease in sugarcane.

2. MATERIAL AND METHODS

2.1 Effect of silicon fertilizers on management of brown spot disease

A field experiment was laid out in randomized block design at the farm of Central Sugarcane Research Station, Padegaon during *Suru* 2023 with eight treatments and three replications by using susceptible cv. CoM 0265. All the recommended agronomical package of practices was adopted for raising the crop. Recommended dose of fertilizer that is 250:115:115 Kg N, P2O5& K2O/ ha was applied. Silicon fertilizers and biofertilizer were purchased from different manufacturers and commercial liquid formulation of silicon solubilizing biofertilizer produced by Krishi Vigyan Kendra, Baramati, was used during the investigation. All said treatments applied as per spray schedule mentioned below in treatments details. *In vitro* experiments were conducted in the laboratory of Department of Plant Pathology and Agriculture Microbiology and laboratory of Department of Soil Science, College of Agriculture, Pune.

Treatment Details:

T_1	:	Foliar sprays of Potassium silicate @ 0.5 % at 120 DAP
T_2	:	Foliar sprays of Potassium silicate @ 0.5 % at 150 DAP
T_3	:	$T_1 + T_2$
T_4	:	Foliar sprays of Calcium silicate @ 1.0 % at 120 DAP
T_5	:	Foliar sprays of Calcium silicate @ 1.0 % at 150 DAP
T_6	:	$T_4 + T_5$
T_7	:	Drenching of silicon solubilizing biofertilizer at 120 DAP
T_8	:	Control

The observation on disease intensity was measured by adopting following 0-9 scale using standard evaluation system (SES) for brown spot disease of paddy developed by International Rice Research Institute (Anonymous, 2002). The data on effect of silicon fertilizer on cane yield and quality contributing parameter of sugarcane was recorded at time of harvest.

List 1 : Disease intensity and respective reactions

Score	Disease Intensity%	Disease reaction
0	No incidence	Immune
1	Less than 1%	Resistant
2	1-3%	
3	4-5%	
4	6-10%	Moderately resistant
5	11-15%	
6	16-25%	
7	26-50%	Moderately susceptible
8	51-75%	Susceptible
9	76-100%	Highly susceptible

2.2 Estimation of Silicon and potassium concentration in leaf samples

After 6 months of application of silicon fertilizers, leaf samples from different treatment of sugarcane were collected for silicon and potassium analysis. Wet digestion of plant samples was carried as per Linder and Harley (1942) method. Silicon and potassium concentration were estimated by atomic absorption spectrophotometer and Flame photometer, respectively.

Calculation

$$\text{Silicon (g/kg)} = \text{O.D.} \times \text{g. f.} \times \frac{\text{diacid volume}}{\text{sample taken}} \times \text{dilution} \times 100 \times \frac{1}{1000} \times \frac{1}{1000}$$

$$\text{Potassium (\%)} = \text{FPR} \times \frac{\text{diacid volume}}{\text{sample taken}} \times \frac{100}{1000 \times 1000}$$

3. RESULTS AND DISCUSSION

3.1. Effect of silicon fertilizers on per cent disease intensity and per cent disease control of brown spot disease of sugarcane

The results of the effect of silicon fertilizers on per cent disease intensity and per cent disease control of brown spot disease of sugarcane is presented in table 1. The results indicated that the brown spot disease intensity ranged from 6.82 to 38.85 per cent during period of experiment. The perusal of the data on per cent disease intensity and per cent disease control indicated that all the treatments were significantly superior in reducing brown spot disease intensity over the untreated control. Among them, T_3-Foliar spray of Potassium silicate @ 0.5 % at 120 and 150 DAP was found significantly superior and the most effective for the control of brown spot disease of sugarcane. It recorded minimum disease intensity (6.82%). The results in terms of per cent disease control of brown spot disease of sugarcane revealed that highest per cent disease control (82.45%) was recorded in T_3 -Foliar spray of Potassium silicate @ 0.5 % at 120 DAP and 150 DAP.

Table 1. Effect of silicon fertilizers on per cent disease intensity and per cent disease control against brown spot disease of sugarcane

Tr. No.	Treatments	Mean per cent disease intensity	Per cent Disease Control
T_1	Foliar spray of Potassium silicate @ 0.5 % at 120 DAP	13.92 (21.91)	64.16
T_2	Foliar spray of Potassium silicate @ 0.5 % at 150 DAP	12.86 (21.01)	66.90
T_3	$T_1 + T_2$ (Foliar spray of Potassium silicate @ 0.5 % at 120 DAP + 150 DAP)	6.82 (15.13)	82.45
T_4	Foliar spray of Calcium silicate @ 1.0 % at 120 DAP	18.59 (25.54)	52.15

T_5	Foliar spray of Calcium silicate @ 1.0 % at 150 DAP	15.70 (23.35)	59.58
T_6	$T_4 + T_5$ (Foliar spray of Calcium silicate @ 1.0 % at 120 DAP + 150 DAP)	9.14 (17.59)	76.48
T_7	Drenching of silicon solubilizing biofertilizer at 120 DAP	12.09 (20.35)	68.88
T_8	Water sprayed control	38.85 (38.56)	---
	S.E. (m) ±	1.00	
	CD (5%)	3.04	
	CV (%)	10.84	

Note: Figures in parenthesis are arcsine transformed values.

Clements (1965) reported that freckles were tiny, rust-coloured or brownish spots on the leaves of sugarcane plants that develop in extremely worn soils. Severe instances might cause impacted lower leaves to die before their time, which might reduce cane output. Not only do freckled plants had fewer leaves, but their freckled leaves also made them less effective at photosynthesis. Applying silicate minerals enabled the correction of this leaf abnormality. This report seemed to be in line with the above results of reduction in PDI of brown spot by application of silicon fertilizers. Similarly, Ayres (1966), Fox *et al.,* (1967), and Wong You Cheong *et al.,* (1972) observed that after Si treatments, the signs of leaf freckling in sugarcane had disappeared. Datnoff *et* al., (1992) found that after calcium silicate slag was applied as fine or standard-grade material or as pellets, the severity of brown spot-on rice (caused by *Bipolaris oryzae (Cochliobolus miyabeanus*) fell by 48–80, 33–60 and 2-23% in both years. Similar results were recorded by Mahmad Toher (2022) in rice in which results showed that in comparison to the control plants, which had a Brown spot disease index of 41.2%, the silicon-treated rice plants had a much lower value of less than 31.6%.

3.2. Effect of silicon fertilizers on cane yield and quality contributing parameter of sugarcane

The result pertaining to the effect of silicon fertilizers treatments of sugarcane on cane yield and quality contributing parameter were significantly influenced by different treatments and are presented in table 2. All the treatments were found significantly superior to the untreated control in respect to cane girth, internode length and number of internodes single cane weight, NMC/ha, cane yield, CCS yield (t/ha), CCS%, brix, purity and sucrose per cent of sugarcane. Among different treatments of sugarcane with silicon fertilizers, T_3 -Foliar sprays of Potassium silicate @ 0.5 % at 120 and 150 DAP was significantly superior over control to the cane yield contributing parameter. This treatment recorded significantly maximum highest number of internode length (23.23cm), cane girth (12.15 cm), No. of internodes (21.92/cane), single cane weight (2.14 kg), NMC (88,890/ha), CCS yield (21.96 t/ha), cane yield (147.50 t/ha), CCS % (14.89 %), Brix (21.87%), Purity (95.21%) and sucrose content (21.12 %), respectively as compared to untreated control. However, it was found statistically at par with treatment foliar spray of Calcium silicate @ 1.0% at 120 DAP and 150 DAP and drenching of silicon solubilizing biofertilizer @ 2.5 lit./ ha at 120 DAP in respect of internode length (22.61cm) (22.41cm), cane girth (11.62cm) (11.13 cm), no. of internodes (21.40/cane) (21.37/cane), single cane weight (1.95 kg) (1.93 kg), NMC (85,110/ha) (83,330/ha), CCS yield (19.91 t/ha) (19.17 t/ha), cane yield (135.48 t/ha) (132.06 t/ha), CCS % (14.65 %) (14.50 %), Brix (21.65) (21.60), Purity (95.10%) (94.65%), sucrose content (20.52 %) (20.36 %), respectively.

The above-mentioned results are in line with the results of several researchers. Raid *et al.* (1992) also observed an increase in sugarcane production of 20% on average when 3 tons/acre of Ca silicate was applied. Ashraf *et al.* (2009) reported that where K and Si were introduced, cane yield and yield characteristics were considerably ($P \leq 0.05$) greater. Bokhtiar *et al*(2012b) observed that, the Ca-silicate treatment significantly affected the plant height, dry matter accumulation, cane yield, and sugar yield. In comparison to the non-amended control, the treatments that received 60 g/pot, or 12 t/ha of Ca-silicate, obtained the largest unit stalk height (341.33 cm) and dry matter accumulation (0.80 kg/pot). These treatments also produced the highest cane yield (2.08 kg/pot). Djajadi *et al.,* (2016) reported that putting organic manure on sugarcane after applying Si liquid fertilizer would yield the maximum amount of crop yield. Dutra *et al.,* (2023) stated that their research unequivocally demonstrates that silicon soil and foliar fertilization changed the C:N:P stoichiometry by improving the rate at which carbon and phosphorus were used, improving sugarcane yield and quality for industrial use.

Table 2. Effect of silicon fertilizers on cane yield and quality contributing parameter of sugarcane

Tr. No.	Treatments	No. of internode	Internode length (cm)	Girth (cm)	Single cane wt (kg)	NMC /ha (1000)	Cane yield (t/ha)	CCS yield (t/ha)	CCS (%)	Brix (%)	Purity (%)	Sucrose (%)
T_1	Foliar spray of Potassium silicate @ 0.5 % at 120 DAP	21.04	21.64	10.46	1.90	77.33	116.60	16.68	14.29	21.16	94.10	20.03
T_2	Foliar spray of Potassium silicate @ 0.5 % at 150 DAP	21.35	21.69	10.48	1.91	80.56	128.42	18.41	14.33	21.23	94.36	20.09
T_3	$T_1 + T_2$ (Foliar spray of Potassium silicate @ 0.5 % at 120 DAP + 150 DAP)	21.92	23.23	12.15	2.14	88.89	147.50	21.96	14.89	21.87	95.21	21.12
T_4	Foliar spray of Calcium silicate @ 1.0 % at 120 DAP	20.60	21.01	10.33	1.79	74.56	103.21	14.61	14.14	21.03	93.73	19.85
T_5	Foliar spray of Calcium silicate @ 1.0 % at 150 DAP	20.73	21.46	10.43	1.85	75.33	108.42	15.40	14.19	21.06	93.76	19.90
T_6	$T_4 + T_5$ (Foliar spray of Calcium silicate @ 1.0 % at 120 DAP + 150 DAP)	21.40	22.61	11.62	1.95	85.11	135.48	19.91	14.65	21.65	95.10	20.52
T_7	Drenching of silicon solubilizing biofertilizer at 120 DAP	21.37	22.41	11.13	1.93	83.33	132.06	19.17	14.49	21.60	94.65	20.36
T_8	Water sprayed control	18.49	19.48	10.11	1.59	72.30	97.62	12.63	12.93	20.03	92.09	18.37
	SE (m) ±	0.62	0.66	0.35	0.07	2.50	5.98	1.14	0.35	0.26	0.56	0.42
	CD (5 %)	1.89	1.99	1.06	0.22	7.60	18.14	3.46	1.07	0.78	1.69	1.29
	CV (%)	5.18	5.25	5.60	6.64	5.45	8.55	11.38	4.27	2.09	1.03	3.66

3.3 Effect of silicon fertilizers on total Si and K concentration of sugarcane leaves

Results on total Si and K concentration in leaves of sugarcane after the treatment with silicon fertilizers was recorded as mentioned in table 3. It was seen that significant difference was observed in Si and K concentration of treated leaves and control. There was increase in total Si and K concentration in the leaves of sugarcane treated with silicon fertilizers. The range of mean Si and K concentration observed was 5.97 g/kg to 11.31 g/kg and 1.25% to 2.13%, respectively. The observations showed that mean Si concentration was found highest in T_3 (Foliar spray of Potassium silicate @ 0.5 % at 120 DAP and 150 DAP) (11.31g/kg) and it was at par with T_7 (Drenching of silicon solubilizing biofertilizer @2.5 lit. / ha. at 120 DAP) (11.16g/kg) respectively. Mean Si concentration observed in control was lowest (5.97 g/kg**).** Mean K concentration was seen highest in T_3 (Foliar spray of Potassium silicate @ 0.5 % at 120 DAP and 150 DAP) (2.13%) and it was lowest in control (1.25%). The higher level of total silica concentration might indicate that the activation of host defensive system or rapid rate of their synthesis induced by the pathogen leading to tissue necrosis and may be responsible for the inhibition of the growth and multiplication of the pathogen.

Table 3. Effect of silicon fertilization on total Si and K concentration of sugarcane leaves

Tr. No.	Treatments	Si conc. (g/kg)	K Conc. (%)
T_1	Foliar spray of Potassium silicate @ 0.5 % at 120 DAP	8.24	1.81
T_2	Foliar spray of Potassium silicate @ 0.5 % at 150 DAP	8.05	1.83
T_3	$T_1 + T_2$ (Foliar spray of Potassium silicate @ 0.5 % at 120 DAP + 150 DAP)	11.31	2.13
T_4	Foliar spray of Calcium silicate @ 1.0 % at 120 DAP	7.85	1.26
T_5	Foliar spray of Calcium silicate @ 1.0 % at 150 DAP	9.25	1.25
T_6	$T_4 + T_5$ (Foliar spray of Calcium silicate @ 1.0 % at 120 DAP + 150 DAP)	9.98	1.68
T_7	Drenching of silicon solubilizing biofertilizer at 120 DAP	11.16	1.61
T_8	Water sprayed control	5.97	1.25
	SE (m) ±	0.2	0.04
	CD (5 %)	0.7	0.11
	CV (%)	4.65	3.88

Above findings are in line with the results of various researchers as mentioned below. Bokhtiar *et al.* (2012a) reported that sugarcane plants treated with calcium silicate have higher levels of silica in their epidermal layers than untreated plants, and they also hold onto more moisture since their cuticle transpiration is reduced. Bokhtiar *et al.* (2012b) observed that when Ca-silicate fertiliser was used, the average silicon deposition in epidermal cells varied from 60.20 to 77.52 (% wt), compared to control 54.24 (% wt). Camargo *et al.* (2014) reported that addition of Si fertilizer increased the Si concentrations in the soil and the leaves of the sugar cane at 8 months in tropical soils of Brazil. According to Teixeira *et al.* (2020) and Silva *et al.* (2023) the use of soluble Si sources in sugarcane crops was relatively new, spurring research in sugarcane with encouraging crop outcomes, due to increases in Si absorption when administered via foliar spraying or fertigation tested in stressed plants. Our above findings are in line with the findings of Silva *et al.* (2023) who reported that compared to the control treatment (6.67 g/kg), silicon supplementation by foliar spraying (Si Foliar) effectively raised Si content in the aerial region of sugarcane plants (9.08 and 9.32 g/kg), respectively.

4. CONCLUSION

As far as disease management is concerned, foliar sprays of Potassium silicate @ 0.5 % at 120 and 150 DAP interval after appearance of disease was found to be most effective in management of brown spot disease as compared to the rest of the treatments which recorded minimum per cent disease severity and highest per cent disease control against brown spot disease. It also recorded highest single cane weight, NMC/ha, CCS yield, cane yield, CCS %, Brix, Purity and sucrose content. However, it was found statistically at par with treatment with foliar spray of Calcium silicate @ 1.0 % at 120 DAP and 150 DAP and drenching of silicon solubilizing biofertilizer @ 2.5 lit./ ha at 120 DAP in case of growth, yield contributing and quality parameters.

The observations showed that mean Si and K concentration was found highest in Foliar spray of Potassium silicate @ 0.5 % at 120 DAP and 150 DAP. The higher level of total silica concentration might indicate that the activation of host defensive system or rapid rate of their synthesis induced by the pathogen leading to tissue necrosis and may be responsible for the inhibition of the growth and multiplication of the pathogen.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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