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Role of silica in induction of resistance in rice to yellow stem borer, *Scirpophaga incertulas* (Walker) (Lepidoptera : Pyralidae)

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ABSTRACT

A field experiment on the influence of silicon applied in forms of fertilizer formulations on yellow stem borer,(YSB) Scirpophaga incertulas (Walker) infesting rice was conducted at Central Research Farm, Orissa University of Agriculture and Technology, Bhubaneswar during wet season, 2014. The results of the experiment on various parameters revealed that foliar application of orthosilicic acid @ 4 ml/l (T_2) at 20, 35, 50 and 65 days after transplanting (DAT) was the best treatment in reducing dead heart and white ear head incidence followed by the application of orthosilicic acid @ 2 ml/l. Both the treatments significantly reduced the feeding tunnel by YSB as compared to the other treatments. Silicon uptake by rice plants was found to be higher in orthosilicic acid @ 4ml/l followed by calcium silicate @ 1 t/ha, orthosilicic acid @ 2ml/I and calcium silicate @ 0.5 t/ha. The grain yield was highest in orthosilicic acid @ 4 ml/l (45.08 q/ha) followed by orthosilicic acid @ 2 ml/l and calcium silicate @ 1 t/ha. Foliar application of silicon in form of orthosilicic acid was found to be highly effective against yellow stem borer followed by basal application of calcium silicate, steel slag and fly ash in rice.

Key words: *silicon, dead heart, white ear head, yellow stem borer*

Among the various bottlenecks in rice cultivation, insect pest problem is one of the major constraints that deplete production and productivity substantially. The rice plant is attacked by more than 100 insect species globally and around 20 species cause economic damage (Pathak and Khan 1994). Being monophagous in nature and non-availability of commercial resistant varieties, yellow stem borer is still regarded as the most destructive insect pest of rice in Odisha. Added to this, wilful application of insecticides, as a cocktail mixture by the farmers do not produce any satisfactory result and has compounded the pest problem. Under such circumstances, exploitation of induced resistance could be helpful. Silicon, though not an essential element has tremendous influence in monocots, particularly in rice to reduce stem borer infestation. Panda *et al.* (1977) have reported that the larvae of yellow stem borer were unable to attack a resistant rice accession due to higher uptake of silica in their stems.Ranganathan *et al.* (2006) also reported that addition of silica in rice led to substantial reduction in stem borer damage. Keeping this in view, an experiment was conducted to find out the field efficacy of silicon based fertilizer against yellow stem borer.

MATERIALS AND METHODS

Thirty days old seedlings of a rice variety Swarna (135 days) was transplanted in a randomized block design, in the field at Central Research Farm, Department of Entomology, OUAT during wet season, 2014, with all recommended agronomic practices.Different formulation of silicon fertilizers were applied both as basal and foliar sprays on rice on different dates. A total of nine treatments including a control were imposed

Table 1. Effect of silicon on the incidence of yellow stem borer and feeding tunnel length in rice

Treatments	Incidence of dead heart (%) at							Mean dead heart(%)	Meanwhite ear head (%)	Tunnel length (cm) at	
	15 DAT	22 DAT	29 DAT	36 DAT	43 DAT	50 DAT	57 DAT			Maximum Dead heart	Maximum white ear head
Orthosilicic acid @ 2ml/l	0.00(0.71)	0.33(0.88)	0.41(0.91)	1.92(1.54)	4.07(2.13)	3.61(2.03)	2.31(1.68)	1.81(1.41)	4.05(2.13)	5.11(2.36)	4.39(2.21)
Orthosilicic acid @ 4ml/l	0.00(0.71)	0.75(1.09)	0.83(1.12)	1.47(1.39)	3.05(1.87)	2.88(1.84)	1.60(1.44)	1.51(1.35)	3.33(1.95)	4.87(2.30)	4.33(2.20)
Calcium silicate @ 0.5t/ha	0.00(0.71)	0.38(0.90)	0.37(0.90)	2.11(1.62)	4.58(2.25)	3.26(1.93)	2.41(1.70)	1.87(1.43)	4.52(2.24)	5.92(2.52)	4.83(2.31)
Calcium silicate @ 1t/ha	0.00(0.71)	0.78(1.10)	1.10(1.27)	1.91(1.54)	4.43(2.21)	2.83(1.82)	2.12(1.61)	1.88(1.46)	4.21(2.15)	6.03(2.55)	4.67(2.27)
Fly ash @ 250kg/ha	0.00(0.71)	1.05(1.24)	1.12(1.27)	2.70(1.78)	3.95(2.10)	3.06(1.88)	2.39(1.70)	2.04(1.52)	5.82(2.49)	7.42(2.81)	7.10(2.75)
Fly ash @ 500kg/ha	0.00(0.71)	1.03(1.23)	0.75(1.09)	2.55(1.74)	3.69(2.04)	3.33(1.92)	2.00(1.57)	1.91(1.47)	4.82(2.28)	6.92(2.72)	6.57(2.66)
Steel slag @ 250kg/ha	0.00(0.71)	0.33(0.88)	0.74(1.08)	3.15(1.91)	4.43(2.22)	3.79(2.07)	3.32(1.95)	2.25(1.54)	7.46(2.81)	7.23(2.77)	5.37(2.42)
Steel slag @ 500kg/ha	0.00(0.71)	0.86(1.13)	1.13(1.28)	2.61(1.76)	4.37(2.21)	3.38(1.96)	2.50(1.73)	2.12(1.55)	5.28(2.39)	6.87(2.70)	5.03(2.35)
Control	0.00(0.71)	1.81(1.52)	2.79(1.76)	7.69(2.89)	10.48(3.3)	7.56(2.83)	4.71(2.27)	5.00(2.18)	11.44(3.45)	12.60(3.61)	18.70(4.38)
SE_m(±)	0.00	0.16	0.17	0.10	0.10	0.13	0.09	-	0.18	0.17	0.09
C.D.(0.05)	NS	NS	NS	0.30	0.29	0.39	0.28	-	0.54	0.50	0.28
CV(%)	-	-	-	9.80	7.48	11.11	9.31	-	6.44	10.63	6.08

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

of silicon on yellow stem borer and grain yield. Silicon in form of orthosilicic acid was applied as foliar spray four times at 20, 35, 50 and 65 DAT and calcium silicate, fly ash and steel slag each were applied as soil application (basal).

Observation on yellow stem borer in terms of dead heart was carried out at weekly interval starting from 15 DAT and white ear head at 7 days before harvesting. Feeding tunnel produced by feeding of yellow stem borer larvae at maximum dead heart (43 DAT) and maximum white ear head stage (113 DAT) were recorded from 10 random hills/sub-plot treatment-wise. The plant sample at maximum dead heart period and maximum white ear head stage were collected and analysis of silica uptake by the plant was determined in the laboratory of ICAR-NRRI, Cuttack as per the method suggested by Wei-min et al. (2005). All the data recorded from various observations were subjected to statistical analysis as per the method suggested by Gomez and Gomez (1984) with necessary transformation wherever required.

RESULTS AND DISSUSSION

A. Effect of silicon on yellow stem borer and feeding tunnel

(i) Incidence of dead heart

The data revealed that there is no significant difference between the treatments upto 29 DAT, so far the incidence of dead heart was concerned (Table 1). However, significant difference between the treatments in relation to dead heart was observed from 36 DAT onwards. At 36 DAT, the control treatment registered 7.69% dead heart while orthosilicic acid @ 4 ml/l produced only 1.47 % dead heart, remaining at par with orthosilicic acid @ 2 ml/l, calcium silicate @ 1 t/ha and calcium silicate @ 0.5 t/ha and the trend more or less existed for rest of the period of observation. As regards to mean performance, it was observed that treatment T_2 (orthosilicic acid @ 4 ml/l) was the best treatment in recording 1.15% dead heart as against 5% dead heart in control.

(ii) Incidence of white ear head

The data on white ear head (Table 1) revealed that the treatment orthosilicic acid @ 4 ml/l was the best treatment that produced lowest white ear head (3.3%) which remained at par with most of the other silicon treatments excluding T_7 (7.46% white ear head) whereas, control treatment supported 11.44% white ear head.

(iii) Effect of silicon on larval feeding potential

It has been observed that larval feeding was minimum in orthosilicic acid @ 4 ml/l (4.87 cm) which was at par with many other treatments excluding T_5 (fly ash @ 250 kg/ha) (7.42 cm) which indicated that uptake of silicon has definitely interfered in feeding potential by yellow stem borer larvae, whereas, in control treatment feeding tunnel length was found to be 12.60 cm which was significantly different from all the treatments (Table 1). Similarly, at 113 DAT (maximum white ear head stage), it was observed that tunnel length was minimum in T_2 (4.33 cm) which was at par with T_1, T_3, T_4, T_7 and T_8 treatments (4.39-5.37 cm). At this stage the control treatment recorded a tunnel length of 18.70 cm which is significantly different from other treatments.

It was visualized that irrespective of the treatments, the mean DH and WEH incidence was even less than half the value of these parameters in control treatment. Production of less DH and WEH in various silicon treatments may be attributable to failure of neonate larvae to penetrate the leaf sheath and stem due to higher deposition of silica. Bandong and Litsinger (2005) have also studied excessive stem hardening in rice due to silica mediated lignin and cellulose deposition on leaf sheath cell, which caused less penetration and reduced feeding tunnel length. Chandramani *et al.* (2010) also suggested that reduction in stem borer incidence in rice was caused due to wearing of mandibles of early larval instars which might have prevented further penetration to cause dead heart and white ear head. The present finding is well supported by the finding of the above authors.

B. Uptake of silicon by rice plants

It was observed that the plants in T_2 (orthosilicic acid @ 4 ml/l) contained 15.30 % silica followed by T_4 (calcium silicate @ 1 t/ha) (15.10%) , T_1 (orthosilicic acid @ 2 ml/l) and T_3 (calcium silicate @ 0.5 t/ha), each with 15% silicon content (Table 2). At this stage a corresponding value for control was also 11.20%. Silicon content at white ear head stage (113 DAT) was found to be maximum in T_2 (15.50 %) which was significantly different from rest of the treatments. The treatment T_1 and T_4 retained each of 13.50% silica, whereas, control treatment had least amount of silicon (10.20%). This indicates when silica is applied to the rice plants, the plants uptake silicon. Orthosillicic acid being a source of well available silicon to rice plants caused higher mobility into plant system as compared to other form of fertilizers. Ma and Takahashi (2002) stated that rice is a good silicon accumulator and respond to available form of silicon and when silica level in paddy straw comes below 11% the plants can accumulate more silica. Thus, treated rice plants accumulated more silica than the untreated plants in the present finding.

Table 2. Silica uptake in rice at maximum dead heart (43 DAT) and maximum white ear head stage (113 DAT) and grain yield

Treatments	Silica uptake (%)		Grain yield (q/ha)
	Maximum dead heart	Maximum White ear head	
Orthosilicic acid @ 2ml/l	15.00(3.94)	13.50(3.74)	39.37
Orthosilicic acid @ 4ml/l	15.30(3.97)	15.50(4.00)	45.08
Calcium silicate @ 0.5t/ha	15.00(3.94)	12.20(3.56)	32.54
Calcium silicate @ 1t/ha	15.10(3.95)	13.50(3.74)	37.78
Fly ash @ 250kg/ha	12.30(3.58)	10.50(3.32)	28.89
Fly ash @ 500kg/ha	13.60(3.75)	10.60(3.33)	31.43
Steel slag @ 250kg/ha	14.00(3.81)	10.70(3.35)	31.43
Steel slag @ 500kg/ha	14.00(3.81)	11.90(3.52)	32.06
Control	11.20(3.42)	10.20(3.27)	23.97
SEm(±)	0.05	0.04	3.21
CD(0.05)	0.16	0.12	9.61
CV(%)	2.46	1.92	16.53

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values.

C. Effect of silica on rice grain yield

The data on grain yield of rice (Table 2) revealed that highest grain yield of 45.08 q/ha was received from treatment T_2 (orthosilicic acid @ 4 ml/l) which was statistically at par with T_1 (orthosilicic acid @ 2 ml/l) (39.37 q/ha) and T_4 (calcium silicate @ 1 t/ha) (37.78 q/ha). The treatment T_3 (32.54 q/ha) was at par with T_8 (32.06 q/ha) and T_6 (31.43 q/ha) and rest of the treatments. However, the control treatment (T_9) registered the lowest grain yield of 23.97 q/ha.

Kornodorfer and Lepsch (2001) have also observed higher grain yield in rice due to silicon application. Higher grain yield in rice due to silica fertilization also has been observed by Fallah *et al.* (2014) and Kasturi Thilagam *et al.* (2014). Hence, the present finding is in line of conformity with the observations of the above authors.

Thus, it can be concluded that the treatment orthosilicic acid @ 4 ml/l was instrumental for production of higher grain yield through enhanced photosynthesis and reduced yellow stem borer incidence.

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