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INFLUENCE OF SILICIC ACID FOLIAR SPRAY ON THE INCIDENCE OF SUCKING INSECT PESTS AND THEIR NATURAL ENEMIES IN RAPESEED

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ABSTRACT

Silicon induces resistance in various crops against insect pests of diverse feeding guilds, including hemipterans, through upregulation of plant defense mechanisms along with maintenance of plant physiological processes. The present investigation to study the effect of silicon in the form of silicic acid (SA) against major sucking insect pests (*Lipaphis erysimi* and *Bagrada hilaris*) and natural enemies (*Coccinella transversalis* and *Episyrphus balteatus*) in rapeseed revealed that the foliar application of SA @ 0.4% thrice at 30, 40 and 50 days after sowing significantly reduced the colonization of *L. erysimi* as against non-significant effect on the population of *B. hilaris.* Three sprays of SA @ 0.4% significantly increased the population of *C. transversalis* without any significant effect on *E. balteatus* population. The silicon content of the rapeseed grains was also found to be significantly enhanced (0.32%) with 3 sprays of SA @ 0.4%.

Key words: *Lipaphis erysimi, Bagrada hilaris*, incidence, predators, silicon, silicic acid, rapeseed, aphid, painted bug, natural enemy

Rapeseed (*Brassica napus* L., Family: Brassicaceae) is the most important oilseed crop, contributing more that 13% of the world's total vegetable oil production (Amar et al., 2008) and known for its multiple component ecosystem. Insect pests are an inevitable component in rapeseed ecosystem, and are considered as a major biotic stress causing around 19.9 % yield loss in India (Ghosh et al., 2019; Liu et al., 2022; Rialch et al., 2022). The sucking insect pests of rapeseed are the major threats and aphid species such as cabbage aphid (*Brevicoryne brassicae*), mustard aphid (*Lipaphis erysimi*) and peach aphid (*Myzus persicae*) are the important ones, causing major yield loss in India (Yadav and Rathee, 2020). Among these aphid species, *Lipaphis erysimi* alone causes 29.4% yield loss and 2.84% oil loss in rapeseed (Kumar et al., 2017). The painted bug (*Bagrada hilaris*) is another important sucking pest in rapeseed which causes 30.0% weight loss of rapeseed (Singh and Malik, 1993).

The element silicon (Si) is considered as the quasi-essential for various crops (Guntzer et al., 2012) and Si fertilization has been proven to provide physical resistance against various sucking insect pests such as *Nephotettix virescens, Bemisia tabaci, Nilaparvata lugens, Tetranychus urticae* and *Sogatella furcifera* (Correa et al., 2005; Islam et al., 2020). Silicic acid (SA) is an important source of silicon (Shwethakumari et al., 2021) and the foliar application of SA acts as a bio-stimulant playing a major role in inducing structural defense through deposition of amorphous silica on the cell wall, cell lumen, intracellular spaces and trichomes and thereby reduces the population buildup of sucking pests (Alyousuf et al., 2022). The application of Si also acts in a tritrophic system i.e., its application creates a change in emission of herbivore induced plant volatiles that indirectly helps to attract natural enemies of insect pests (Leroy et al., 2019). Moreover, researches on possible role of silicic acid in inducing resistance in rapeseed against major sucking insect pests viz., rapeseed aphid (*L. erysimi*) and painted bug (*B. hilaris*) along with natural enemy complex including transverse lady bird beetle (*Coccinella transversalis*) and marmalade hover fly (*Episyrphus balteatus*) is very much scanty. Therefore, our present investigation aimed at studying the effect of foliar spray of SA on population buildup of sucking insect pests and natural enemies of rapeseed and to find out the dosage and time of spraying to include in integrated pest management strategy.

MATERIALS AND METHODS

A field experiment was carried out in the Instructional Cum Research (ICR) farm, Assam Agricultural University (AAU), Jorhat (26º 45' N, 94º 12' E) during 2021-22. The recommended package of practices for the rabi crops of Assam, 2021 was followed to raise the crop. The quality planting materials of rapeseed (Var. TS 38) were obtained from ICR Farm, AAU, Jorhat selected and sown at a spacing of 30 x 10 cm. Five treatments viz., foliar spray of silicic acid (SA) @ 2 ml/ ℓ at 30 and 40 DAS, foliar spray of SA @ 4 ml/ ℓ at 30 and 40 DAS, foliar spray of SA @ 2 ml/ ℓ at 30, 40 and 50 DAS and foliar spray of SA @ 4 ml/ ℓ at 30, 40 and 50 DAS along with a control with milliQ water spray was done. The time of spraying of SA was fixed at 30, 40 and 50 days after sowing to maximize the chances of active translocation of Si vegetative stages and initial flowering stages of rapeseed. All the sprays were done with milliQ water in the late evening hours.

Data on the incidence of insect pests and natural enemies was recorded from 7 days after final foliar application of SA i.e., from 50th day after sowing (DAS) in all the treatments at weekly interval for a month. In the case of *L. erysimi,* ten plants were randomly chosen in each plot, tagged and the number of aphids were counted in the top 10 cm of the inflorescence (Choudhury and Pal, 2009). The population of *B. hilaris* was counted from five quadrates in each replication by selecting five plants randomly in each quadrate (Divya et al., 2015). To record the occurence of *C. transversalis*, ten plants were randomly selected in each plot and the number of grubs and beetle(s)/ plant was recorded (Sarwar, 2013). In the case of syrphid (*E. balteatus*), ten plants were randomly selected in each plot and the number of larva/ plant was recorded (Varshney et al., 2017). After 80 DAS, five plants were randomly collected from each replication and analyzed the Si content at the Department of Environmental Sciences, Tezpur University, Tezpur. The rapeseed plants were dried in the hot air oven at 70ºC and then microwave digestion of samples was performed. Prior to microwave digestion, the samples were subjected for pre digestion by adding 7 ml of 70% nitric acid, 2 ml of 30% hydrogen peroxide and 1 ml of 40% hydrofluoric acid (Laxmanarayanan et al., 2022). The Si content was estimated using the molybdenum blue colorimetric method at 600 nm (Ma et al., 2001). The data on the population dynamics of *L. erysimi*, *B. hilaris*, *C. transversalis* and *E. balteatus* along with Si content of the plant samples was analyzed with two- way ANOVA. The correlation analysis between Si content of rapeseed and the incidence of insect pests and natural enemies was also done using R software (R core team, 2022).

RESULTS AND DISCUSSION

The results of foliar sprays of SA on the of *L. erysimi* revealed that three sprays of 0.4% SA at different growth stages significantly reduces the population of *L. erysimi* (Table 1). At 57 DAS, the lowest aphid population was recorded in treatment with three sprays of SA @ 0.4% (56.95 aphids/ plant) followed by the treatment with three sprays of SA @ 0.2% (65.45 aphids/ plant) as compared to the highest aphid count (86.85 aphids/ plant) in the control. Similar trend was observed for 64, 71 and 78 DAS suggesting possible reduction in colonization of aphids due to the application of SA. The Si application significantly reduced growth of aphids in maize (Moraes et al., 2005; Oliveira et al., 2020), wheat (Costa and Moraes 2006) and in groundnut

Table 1. Effect of silicic acid on the incidence of *L.erysimi* and *B. hilaris* in rapeseed

Treatment	Mean population of *L. erysimi*				Mean population of *B. hilaris*			
	57 DAS	64 DAS	71 DAS	78 DAS	57 DAS	64 DAS	71 DAS	78 DAS
2 sprays of 0.2% SA	70.80^{b}	130.75^{b}	56.35^{b}	2.00^{b}	0.65	0.67	0.70	0.27
2 sprays of 0.4% SA	66.30^{bc}	123.10^{c}	47.55^{c}	1.70^{b}	0.62	0.62	0.67	0.30
3 sprays of 0.2% SA	65.45^{c}	124.20^{c}	46.25^{c}	1.20^{c}	0.65	0.65	0.67	0.27
3 sprays of 0.4% SA	56.95^{d}	108.95^{d}	38.50^{d}	1.05^{c}	0.65	0.60	0.67	0.30
Control	86.85^{a}	153.05^{a}	72.75^{a}	3.70^{a}	0.65	0.67	0.62	0.30
SEm±	1.58	1.44	1.98	0.11	0.03	0.02	0.02	0.01
CD	4.86***	4.43***	6.11***	0.38***	NS	NS	NS	NS
CV (%)	4.56	2.45	7.59	12.95	9.17	7.88	8.62	12.19

Data are mean of 4 replications; Treatments receiving same letter do not significantly differ; *** Significant at 0.1% LOS ($p \leq 0.001$); NS- Nonsignificant; DAS- Days after sowing

(Parthiban et al., 2019), which supports our findings. In the present study, it is evident that both concentration and number of sprays of SA is crucial to reduce the colonization of aphids. Among the various molecular and biochemical mechanisms that are involved in the reduction of colonization of *L. erysimi* (Islam et al., 2020), deposition of Si on the leaf tissues helps in reducing the multiplication of sucking pests (Sogawa, 1982). Huber et al. (2012) also stated that the reduction in aphid population in Si amended plots was due to soluble Si deposition in plant tissues, which might be true in our case. Besides these supportive findings, the importance of Si in controlling the population of aphids was also reported by Abdollahi et al. 2021, suggested that application of potassium silicate significantly reduced the population of *B. brassicae.* Parthiban et al. (2019) also proved the reduction of colonization of *Aphis craccivora* in groundnut by the application of calcium silicate, which is also an important source of silicon.

It is also interesting to note that the application of SA did not significantly affect the population buildup of *B. hilaris* (Table 1). Hence the role of Si is minuscule in controlling the population of painted bug. The count of *B. hilaris* ranged from 0.27 to 0.70/ plant. Silva et al. (2010) also reported that the Si alters the plant nutrients and makes the plant tissues harder, because of which the insect pests find difficulty to feed upon them. Reed et al. (2013) reported that *B. hilaris* inserts its stylet by repetitive insertion between epidermal layers to lacerate and flush the fluid, which might help in breaking the resistance developed in rapeseed induced due to the spraying SA spray.

It is also interesting to note that *C. transversalis* clearly indicated that the SA spray significantly attracted *C. transversalis* whereas it did not affect *E. balteatus* (Table 2). In the case of *C. transversalis,* the maximum count was recorded in three sprays of SA @ 0.4% in all the sampling periods except 78 DAS. Other SA treatments also significantly increased *C. transversalis* counts when compared to control. At 57 DAS, it was 0.88/ plant in three sprays of 0.4% SA whereas, 0.30/plant in control. At 64 DAS, the maximum was recorded in three sprays of SA @ 0.4% (1.08 Nos./ plant). Liu et al. (2017) and Leroy et al. (2019) also reported that the Si amendment significantly induced the herbivore induced plant volatiles, which creates more attractiveness towards natural enemies. In contrast, the application of SA had not affected the population of *E. balteatus* (Table 2). At 57 DAS, the population of *E. balteatus* was between 0.75 to 0.82 larva/ plant, which got increased to 1.12 to 1.20 larva/ plant at 64 DAS; this further got reduced from 0.20 to 0.27 larva/ plant at 78 DAS. Nikpay and Nejadian (2014) reported that the population of predatory insect, *Stethorus* sp. in sugarcane was not affected significantly by Si application, Nikpay and Laane (2020) also support present findings, wherein the application of SA for four times did not affect the population of natural enemy, *Stethorus gilvifrons.*

The effect of SA with an emphasis on concentration and number of sprays on Si content of rapeseed revealed that the foliar application of SA significantly increased the silicon content in rapeseed as the concentration and number of sprays increased (Fig. 1). The highest Si content was observed in three sprays of SA @ 0.4% (0.32%), whereas the lowest was recorded in control (0.16%). A SA concentration dependent increase in Si content was observed in plant samples of rapeseed by

Table 2. Effect of silicic acid on the occurance of *C. transversalis* and *E. balteatus* in rapeseed

Treatment	Mean counts of *C. transversalis*				Mean counts of *E. balteatus*			
	57 DAS	64 DAS	71 DAS	78 DAS	57 DAS	64 DAS	71 DAS	78 DAS
2 sprays of 0.2% SA	0.58[c]	0.90[ab]	0.87[ab]	0.17	0.77	1.15	0.70	0.25
2 sprays of 0.4% SA	0.67[bc]	0.90[ab]	0.92[ab]	0.22	0.80	1.12	0.65	0.27
3 sprays of 0.2% SA	0.77[ab]	0.90[ab]	0.95[a]	0.20	0.82	1.15	0.67	0.20
3 sprays of 0.4% SA	0.88[a]	1.07[a]	1.05[a]	0.22	0.80	1.17	0.67	0.22
Control	0.30[d]	0.60[c]	0.70[b]	0.10	0.75	1.20	0.62	0.27
SEm±	0.04	0.07	0.07	0.03	0.03	0.06	0.03	0.02
CD	0.12***	0.23**	0.32**	NS	NS	NS	NS	NS
CV (%)	12.59	17.11	16.69	18.23	6.84	9.67	8.57	21.24

Data mean of four replications; Treatments receiving same letter do not significantly differ; ***Significant at $p \leq 0.001$; ** Significant at $p \leq 0.01$; NS- Non-Significant

Kuai et al. (2017). Application of SA @ 0.4% thrice significantly enhanced the Si content when compared to other treatments, which was supported by the results of Shwethakumari and Prakash (2018) in soybean.

The correlation analysis shows that there was a significant negative correlation between Si content of rapeseed and population of *L. erysimi* (Fig. 2). It was also observed that 83.71% reduction in aphid population was observed with the application of Si content. Present results also showed that each unit of increase in the Si content influences the reduction of aphid population by 154. 01 units. A non-significant negative correlation was also recorded between the painted bug population, recording only 4.18% population reduction as influenced by Si application with 0.07-unit population reduction of painted bug for each unit of added Si content. In contrast, the population of *C. transversalis* was found to have a positive significant correlation with Si content of rapeseed and 28% of increase in population with 0.16 unit increase in population for each unit of Si content. Though the syrphid population had a non-significant negative correlation with Si content, its population was not significantly affected by Si content. The reduction in population of *Rhophalosiphum maidis* by Si fertilization was reported by Moraes et al. (2005), which also supports our findings. The present findings are in corroboration with the studies carried out by Oliveira et

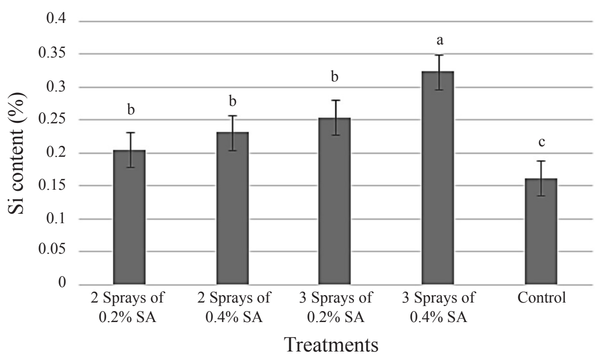
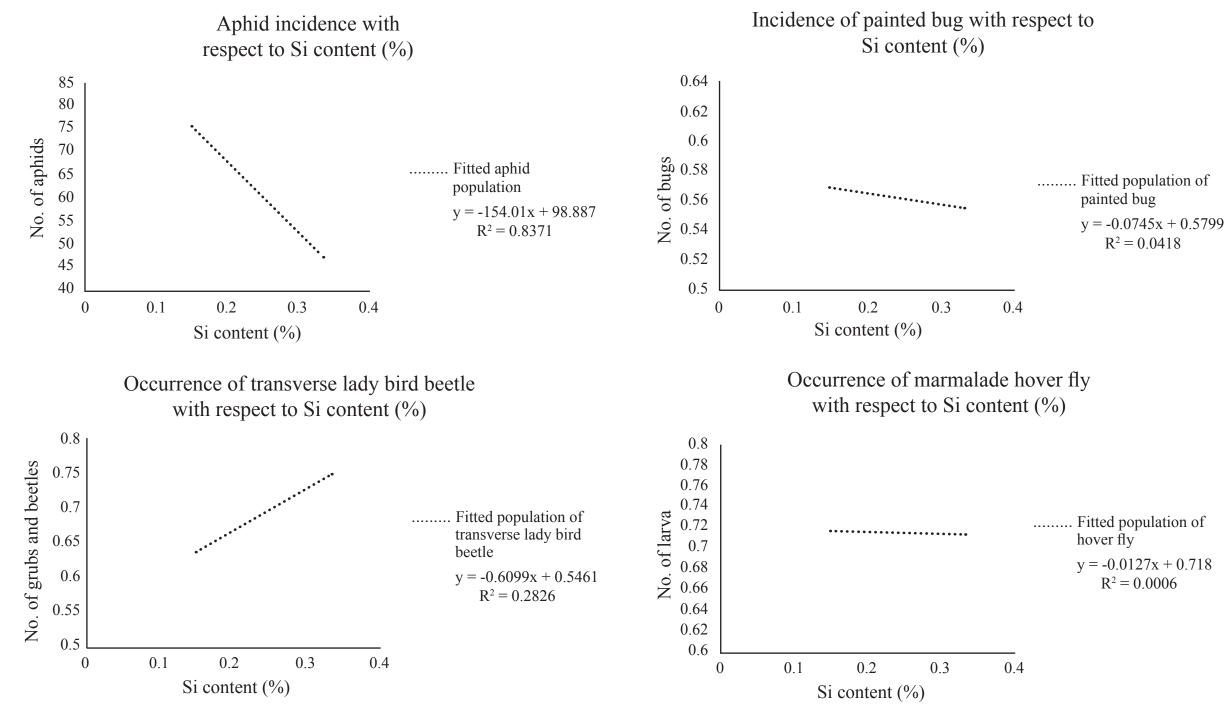


Fig. 1. Effect of silicic foliar spray on Si content (%) in rapeseed



Component	Correlation coefficient (r)
Si content vs. *L. erysimi*	-0.91**
Si content vs. *B. hilaris*	-0.20 (NS)
Si content vs. *C. transversalis*	0.48**
Si content vs. *E. balteatus*	-0.03 (NS)

** Significant at $p \leq 0.05$; NS- Non-significant

Fig. 2. Influence of Si content on population of sucking pests and natural enemies in rapeseed

al. (2020), who reported the Si application attracted the natural enemy of aphids i.e., the parasitoid, *Lysiphlebus testaceipes* against maize aphids. The present study also shows that the population of *E. balteatus* was not affected by SA fertilization. These results are supported by the studies conducted by Cividanes et al. (2022), who reported the application of Si did not significantly affect the population and parasitism of *Cotesia flavipes* against sugarcane borer (*Diatraea saccharalis*).

Incipient for possible inclusion of Si spray as a part of an integrated pest management strategy. For better understanding of the effect SA spray on the population dynamics of sucking insect pests and natural enemies of rapeseed, a detailed study revealing the physiological processes could be useful to arrive at a logical conclusion.

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AUTHOR CONTRIBUTION STATEMENT

Karthik R, Deka M K and Prakash N B planned the experiment, Karthik R and Deka MK Conducted experiments, Prakash NB provided silicic acid for experiments, Ajith S performed Statistical Analysis, Karthik R and Kalita S manuscript editing and reviewing.

CONFLICT OF INTEREST

No conflict of interest.

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