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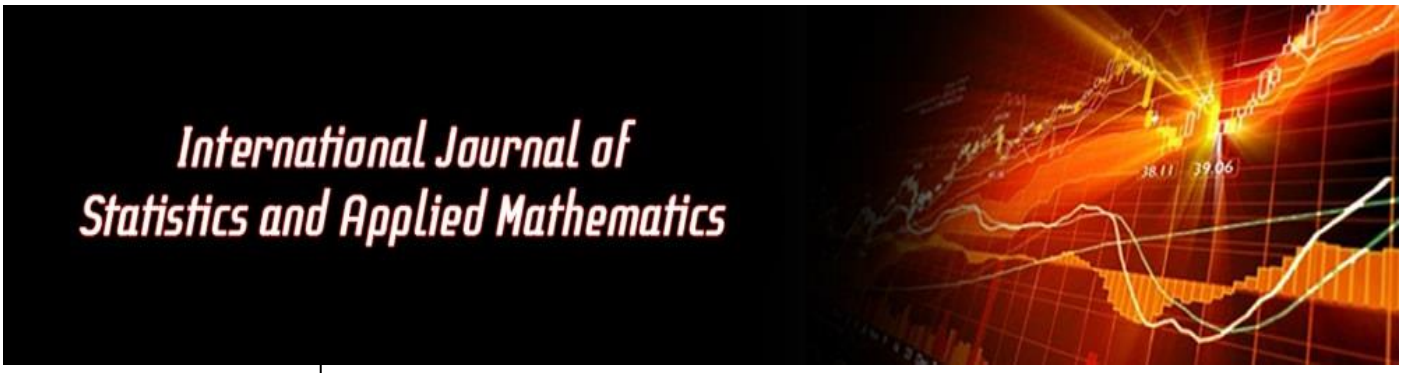

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Effect of silicon application on population of green leaf hopper, *Nephotettix virescens* (Distant) (Hemiptera: Cicadellidae) in Rice

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Abstract
The green leaf hopper, *Nephotettix virescens* (Distant) (Hemiptera: Cicadellidae) is one of the major pests of rice in India. An experiment was conducted at Agricultural Research Station, Anand Agricultural University, Derol, Dist. Panchmahal, Gujarat, India during *kharif* (rainy) season in 2011 and 2012 to know the effect of soil and foliar application of silicon on the population of green leaf hopper, *N. virescens* in rice. Four doses of calcium silicate (500, 1000, 1500 and 2000 kg/ha) applied as soil application and three concentrations of potassium silicate (0.5, 1.0 and 2.0 per cent) applied as foliar sprays were evaluated along with control. All four doses of calcium silicate recorded significantly lower population of green leaf hopper, *N. virescens*, as compared to control, during both the years of study. The highest dose of calcium silicate *i.e.* 2000 kg/ha recorded significantly lowest the population of green leaf hopper, *N. virescens* and it differed significantly from the rest of the treatments.

Keywords: Rice, Green leaf hopper, *Nephotettix virescens*, silicon

Introduction
Rice (*Oryza sativa* Linnaeus) is a staple food for more than half of the world's population. Asia is considered to be a "Rice Bowl" of the world occupying 90 per cent of the world's rice area. China and India are the two largest rice-producing countries. Rice is attacked by more than 100 species of insects, of which about 20 are major pests (Pathak and Saxena, 1980) [6]. Green leaf hoppers (GLH) feed on the leaves or upper parts of the rice plant (Viswanathan and Kalode, 1984) [10]. Frequently they occur in large number causing significant crop losses (Viswanathan and Kalode, 1984) [10]. They also indirectly damage rice plants by acting as the vector for rice tungro virus, a serious disease in the crop causing major yield losses (Cabauatan and Hibino, 1985) [2]. Tungro epidemics were reported from India (Raichaudhuri *et al*., 1970). [7] It was estimated that GLH cause 50 to 80 per cent loss in rice (Alam and Islam 1959) [2].
Insecticides are widely used to manage rice pests, including *N. virescens*. However, the continuous use of a wide range of insecticides has caused many adverse effects. Hence, there is a need to find a suitable alternative to the chemical method of insect control. Insect pest damage may also be reduced through careful management of nutrient requirements of the crop or amendments with mineral nutrients, such as silicon (Si), that reduce crop susceptibility to pests (Meyer and Keeping, 2005) [5]. Silicon application suppressed green leaf hoppers in rice (Maxwell *et al.*, 1972) [4]. Very few workers have studied the effect of silicon application on the incidence of *N. virescens* in rice in India and such studies have not been reported from Gujarat. Hence, it was thought worthwhile to investigate on the impact of soil and foliar application of silicon on the population of *N. virescens* in rice.

Materials and Methods
The present study was conducted at Agricultural Research Station, Anand Agricultural University, Derol, Dist. Panchmahal (Gujarat) during *kharif* (rainy) season for two successive years *i.e.*, 2011 and 2012.

Geographically, Derol is situated on 22^0 36' N latitude and 73^0 27' E longitude and has elevation of 85.36 m above the mean sea level. It falls under middle Gujarat Agro-climatic Zone. The soil of the experimental plot was sandy loam. The experiment was laid out in Randomized Block Design with eight treatments and three replications using rice *cv.* GR-11. Initially, rice seedlings were raised in the nursery for 25 to 30 days. Later on, seedlings were transplanted at a spacing of 20 x 15 cm in the experimental plot. The gross plot and net plot size were 3.90 x 3.20 m and 3.00 and 2.40 m, respectively. Four doses (500, 1000, 1500 and 2000 kg/ha) of soil application (SA) of calcium silicate ($CaSiO_3$) and three concentrations (0.5, 1.0 and 2.0%) of foliar application (FA) of potassium silicate (K_2SiO_3) along with control were evaluated for their impact on the population of green leaf hopper, *N. virescens*. Calcium silicate was applied into soil at the time of transplanting, whereas potassium silicate was applied as a foliar spray at 30, 45 and 60 days after transplanting. Spray application was carried out with knapsack sprayer fitted with a hollow cone nozzle. The volume of the spray solution used was 500 litres per ha. All recommended agronomical practices were followed to raise the rice crop. Calcium silicate ($CaSiO_3$) contains 24 per cent silicon, whereas potassium silicate (K_2SiO_3) contains 18 per cent silicon.

For recording observations on the population of green leaf hopper, *N. Virescens*, ten hills were randomly selected from each net plot area and total number of nymphs as well as adults were counted at weekly interval starting from 30 DAT to harvest.

Statistical analysis of data

Data were statistically analysed as per the procedure given by Steel and Torrie (1980) [8]. Treatments means were compared using Duncan's New Multiple Range Test (DNMRT).

Results and Discussions

The population of green leaf hopper, *N. virescens* was observed only at 30, 37, 45, 52 and 60 DAT during both years of study. Periodical data on population of *N. virescens* were pooled to judge the effectiveness of different treatments.

First year

The data on the population of *N. virescens*, pooled over periods, revealed significant differences among the treatments (Table 1). The lowest (3.30 GLH/hill) population of *N. virescens* was observed in the treatment of SA of calcium silicate @ 2000 kg/ha and it differed significantly from all the treatments except calcium silicate @ 1500 kg/ha (3.72 GLH/hill). Treatments of SA of calcium silicate @ 1000 and 500 kg/ha exhibited 4.11 and 4.35 *N. virescens* per hill, respectively and they were at par with calcium silicate @ 1500 kg/ha. All four doses of calcium silicate were significantly more effective than all three concentrations of potassium silicate. Foliar application of silicon in the form of potassium silicate did not provide protection against *N. virescens* in rice as all three concentrations (0.5, 1.0 and 2.0%) were at par with control plots (5.93 GLH/hill).

Second year

The data on population of *N. virescens*, pooled over periods, indicated that the differences among the treatments were significant (Table 1). SA of calcium silicate @ 2000 kg/ha was found to be most effective with 3.26 *N. virescens* per hill. Furthermore, it differed significantly from the remaining treatments, except calcium silicate @ 1500 kg/ha (3.64 GLH/hill). SA of calcium silicate @ 1500, 1000 and 500 kg/ha recorded 3.64, 3.96, and 4.27 *N. virescens* per hill, respectively and they were at par with one another. FA of potassium silicate (0.5 to 2.0%) supported the population of 4.96 to 5.43 *N. virescens* per hill, but they were at par with control (5.59 GLH/hill).

Table 1: Effect of silicon application on the population of *N. virescens* in rice

Treatments	No. of *N. virescens* / Hill		
	***kharif* 2011**	***kharif* 2012**	**Pooled**
SA of calcium silicate @ 500 kg/ha at TP	2.20b (4.35)	2.18b (4.27)	2.19c (4.31)
SA of calcium silicate @ 1000 kg/ha at TP	2.15b (4.11)	2.11b (3.96)	2.13bc (4.03)
SA of calcium silicate @ 1500 kg/ha at TP	2.05ab (3.72)	2.03ab (3.64)	2.04b (3.68)
SA of calcium silicate @ 2000 kg/ha at TP	1.95a (3.30)	1.94a (3.26)	1.94a (3.28)
FA of potassium silicate 0.5% at 30, 45 and 60 DATP	2.49c (5.71)	2.44c (5.43)	2.46de (5.57)
FA of potassium silicate 1.0% at 30, 45 and 60 DATP	2.47c (5.60)	2.40c (5.25)	2.43de (5.42)
FA of potassium silicate 2.0% at 30, 45 and 60 DATP	2.45c (5.48)	2.34c (4.96)	2.39d (5.22)
Control	2.54c (5.93)	2.47c (5.59)	2.50e (5.76)
S.Em. ± T	0.05	0.05	0.03
P	0.04	0.04	0.03
Y	--	--	0.02
T x P	0.11	0.11	0.08
T x Y	--	--	0.05
P x Y	--	--	0.04
T x P x Y	--	--	0.11
C.V.%	8.38	8.69	8.14

Note: (1) Figures outside parenthesis are $\sqrt{X + 0.5}$ transformed value and those inside parentheses are retransformed values.
(2) Within the column, treatment means followed by same letter within the column do not differ significantly by DNMRT at 5 per cent level of significance.
(3) TP: Transplanting, SA: Soil Application, FA: Foliar Application, DATP: Days After Transplanting

Pooled Results

The data on *N. virescens* population, pooled over 5 periods and 2 years, indicated that all four doses of SA of calcium silicate (500, 1000, 1500 and 2000 kg/ha) were effective against *N. virescens* in rice as they recorded significantly lower population of *N. virescens* as compared to control plots (Table 1). Among four doses of SA of calcium silicate the dose 2000 kg/ha (3.28 GLH/hill) was the most effective treatment and it differed significantly from the rest of the treatments. Calcium silicate @ 1500 kg/ha (3.68 GLH/hill)

and 1000 kg/ha (4.03 GLH/hill) were found to be equally effective in reducing *N. virescens* population in rice. All four doses of SA of calcium silicate were significantly more effective then all three concentrations of FA of potassium silicate in controlling the *N. virescens* in rice. Foliar application of silicon in the form of potassium silicate @ 1.0 and 0.5 per cent recorded 5.42 and 5.57 *N. virescens* per hill, respectively and they were at par with control (5.76 GLH/hill).

Similar result was reported by Maxwell *et al.* (1972) [4], who observed that silicon suppressed green leaf hoppers in rice. Hou *et al.* (2018) [3] also reported reduction in plant hopper population due to soil application of silicon to rice plants. Honeydew excretion by brown plant hopper was reduced due to soil application of silicon in rice, indicating reduced feeding by the pest (Tenguri *et al.*, 2023) [9]. Furthermore, Yang *et al.* (2017) [11] found that silicon application significantly decreased brown plant hopper population growth rates while increased population doubling time and enhanced rice plant resistance to brown plant hopper through impairment of feeding.

Conclusion

Soil application of silicon in the form of calcium silicate at the time of transplanting of rice significantly reduced the population of green leaf hopper, *N. virescens*. All four doses of calcium silicate (500, 1000, 1500 and 2000 kg/ha) were effective against *N. virescens*, but the dose of 2000 kg/ha was significantly the most effective.

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