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Proceeding Paper

Sillicon Dioxide (SiO_2) Based Defense Induction in Maize against Fall Armyworm (*Spodoptera frugiperda*) †

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Abstract: Agricultural development is one of the most powerful tools to end extreme poverty but agriculture-driven growth, poverty reduction, and food security are at risk. Plant diseases and insect pests are major limiting factors that reduce crop production worldwide. Fall armyworm (*Spodoptera frugiperda*) is a serious pest of agricultural crops and the use of silicon (Si) has shown promise in various crops due to its capability of changing plant defenses. Present investigations were carried out for the management of FAW on maize and its effects on the biology of fall armyworm under laboratory conditions. In field trials Silicon dioxide (SiO_2) was evaluated at three concentrations i.e. 400, 800, and 1200 ppm against maize FAW. Foliar and drenching application of silicon dioxide at the maximum concentration (1200 ppm) exhibited significant results with minimum FAW population followed by 800 and 400 ppm respectively. In 2nd complement of the research the biological parameters of fall armyworm were assessed under in vitro conditions by feeding larvae with silicon-treated leaves. Results revealed that the larvae survival rate was minimum (36%) at maximum silicon application in comparison to control (95%). The pupal duration was increased to 13.66 days as compared to the control with 7.66 days. Moreover, the adult longevity was also reduced to 7.67 days and fecundity was reduced to 254 eggs in comparison to the control with 512 eggs. Silicon had a significant effect on the biology of fall armyworm and its application can be a potential management technique for fall armyworm.

Keywords: agriculture; *Spodoptera frugiperda*; silicon dioxide; biology

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1. Introduction

The armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae)], is an exceedingly polyphagous, migratory pest that is native to the Americas and has also been observed in Africa (Goergen et al., 2016) and Asia (Sharanabasappa et al., 2018). Moreover, it is also a significant commercial maize pest in South and Central America (Nagoshi et al., 2015). The pest can spread quickly over large areas in a short time (Van et al., 2021). *S. frugiperda* has gained international attention and now poses a serious threat to the nutrition, food security, and way of life of hundreds of millions of agrarian households in Africa and Asia, particularly in maize dependent areas (FAO, 2020).

Different tools and techniques for controlling *S. frugiperda* have been created. Novel synthetic insecticides are still thought to be one of the most effective treatments in Asia for *S. frugiperda* (liu et al., 2022; Nisar et al., 2022). Scientists are working to create biopesticides that incorporate entomopathogenic fungus (Idress et al., 2022), plant-based insecticides (Ahmed et al., 2022), and other ingredients that are less hazardous to humans, the environment, and natural predators. *S. frugiperda* cannot be managed over the long run using a single strategy.

Silicon has the ability to increase a plant's resistance to insect herbivores of the orders Homoptera, Lepidoptera (Haq et al., 2021), Diptera (Parella et al., 2006), Hemiptera (Dias et al., 2014), Coleoptera, and Thysanoptera (Moraes et al., 2009) without having any adverse effects on the effectiveness of the plant's natural enemies. A full-fledged defense response could be triggered when an abiotic danger is recognized since silicon may make it harder for insects to dampen a plant's defenses (Vivancos et al., 2015). Additionally, a plant species' capacity to take in and move silicon throughout its tissues varies substantially. Thus, it is advisable to use exogenous silicon treatments at regular intervals to prevent plants from herbivorous feeding (Badshah et al., 2021). Therefore, present investigations were carried out in light of the aforementioned information to investigate the effects of silicon application at different concentrations against *S. frugiperda* population under field conditions and to determine their impact on *S. frugiperda* biology under controlled conditions.

2. Material and Methods

2.1. Experimental Site

The experiment was carried out at the Entomological research area, University of Agriculture Faisalbad based in Punjab province Pakistan (31.4278° N, 73.0758° E). The climate is features as semi-arid climate. During the experiment in spring growing season the average temperature 27.6 °C | 81.68 °F, Relative humidity 36.25% and 16.25 was recorded (Weather Atlas, 2022). CM-7777 was sown at a defined experimental area using an RCBD layout. The field was divided into 2 blocks for drenching and foliar treatments with different silicon concentrations.

2.2. Silicon Application and Data Collection

Maize plants were treated with Silicon dioxide (SiO_2) using drenching or foliar treatment methods, each with a concentration of 400 ppm, 800 ppm and 1200 ppm. Drenching treatments were sprayed directly to the soil, while foliar applications were performed with the use of a sprayer (1-L spray bottle). Moreover, the water application served as the untreated control. During the process of the analysis, maize plants were exposed to silicon treatment three times after 15 days of seedling emergence and following 10 days interval. Fall armyworm population was recorded in the field after silicon exposure at different concentrations on datasheets.

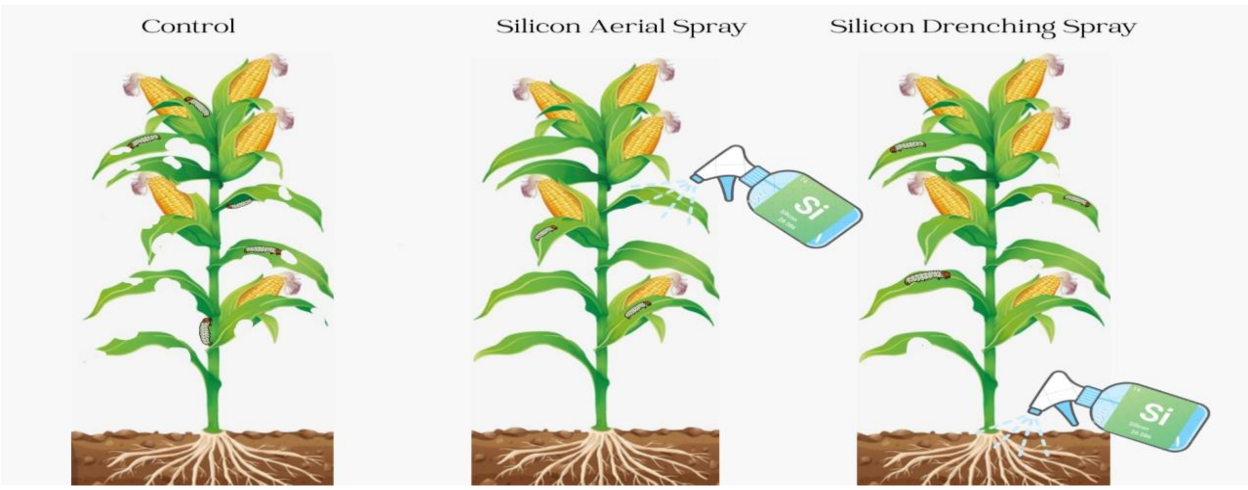

Figure 1. Schematic illustration of the maize plant for Silicon application.

2.3. Insect Culture and Data Collection

Spodoptera frugiperda larvae were obtained from the field and kept in cages to maintain a colony. These larvae were provided with silicon-treated maize leaves. The colony was maintained at 25 ± 5 °C temperature, 65 ± 5 relative humidity, and 16:8 (L:D) hours photoperiod in a growth chamber. The F1 generation was fed until pupation on the silicon-treated maize leaves, and the biological parameters (larval duration, survival, pupal duration, adult longevity, and fecundity) were recorded regularly. For each treatment counted numbers of specimens were used to assess the effect of silicon on biology. In control treatments, silicon-free leaves were offered to larvae on the regular basis.

Figure 2. Collection of the larvae from FAW infested field.

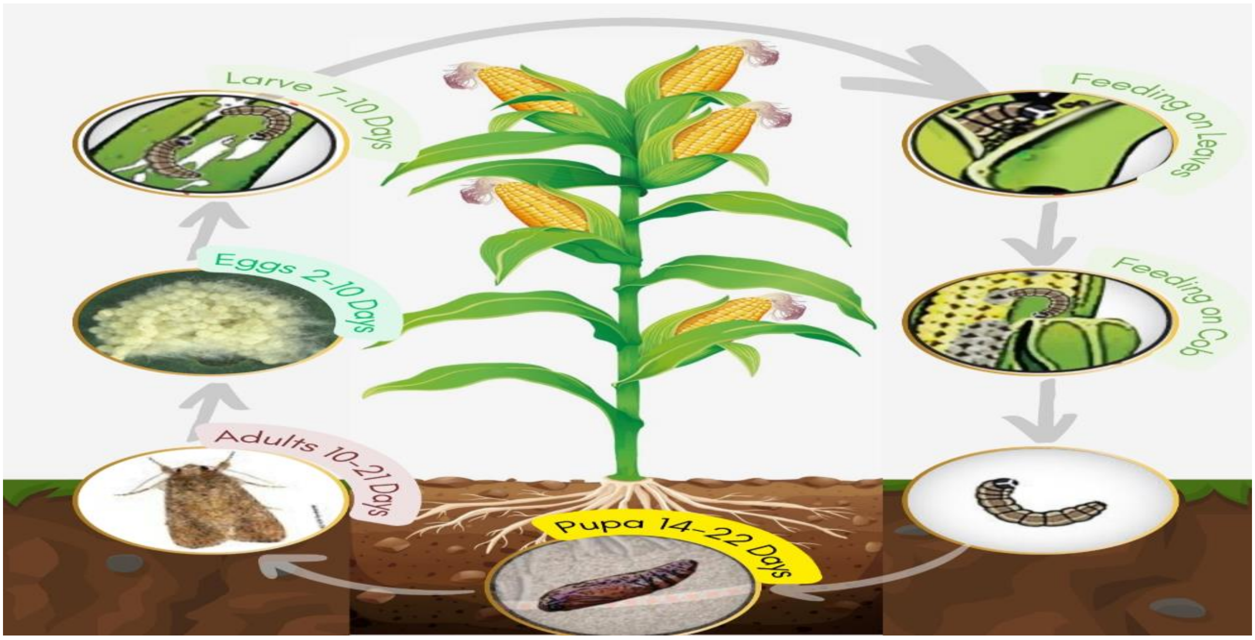

Figure 3. Schematic illustration of Fall Armyworm (FAW) biology.

3. Results and Discussion

3.1. Assessment of Silicon Dioxide on Spodoptera frugiperda Population In Vivo

Application of silicon dioxide at the concentration of (1200 ppm) significantly affected the Fall Armyworm (FAW) population (0.9, 0.7, 0.3) respectively at all observation on comparison to the control. However, the same concentration also produced significant results (0.9, 0.8, 0.6%) during their soil drenching application. Among all concentrations application of silicon dioxide at minimum rate (400 ppm) exhibited minimum FAW population reduction at all observation (2.24, 1.75, 0.85%) during foliar application and during soil drench it showed (1.6, 1.5, 1.85%) population reduction at all observation on comparison to control (Figure 4).

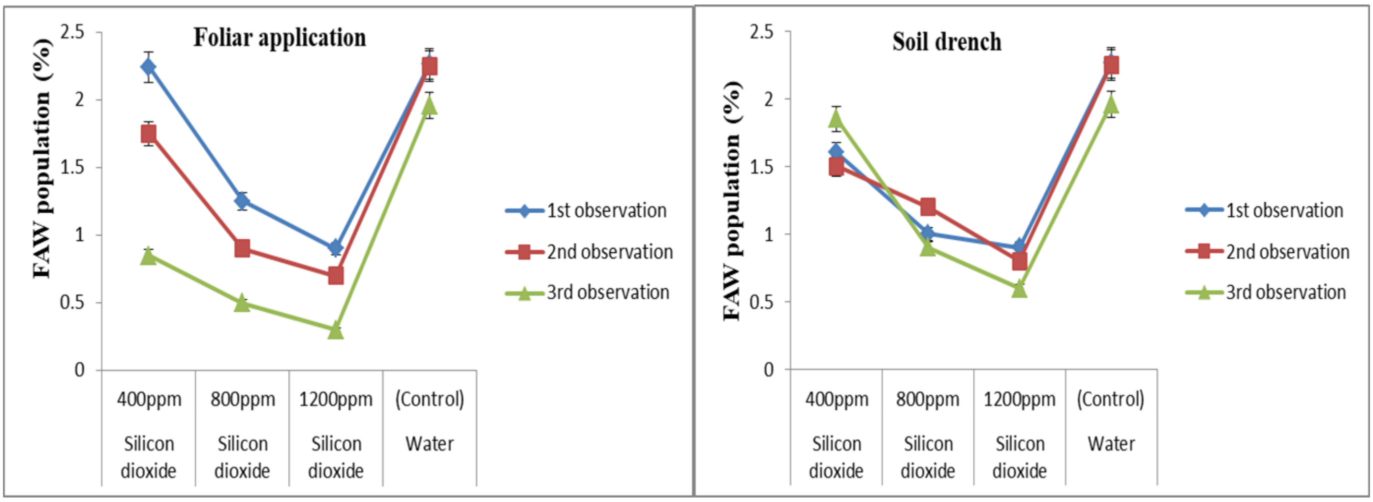

Figure 4. Impact of the foliar and soil drench application of Silicon dioxide at different concentrations against Fall Armyworm (FAW) population in vivo conditions.

3.2. Assessment of Silicon Dioxide on Spodoptera frugiperda Biology In Vitro

Results revealed that the application of Silicon dioxide significantly influenced the *Spodoptera frugiperda* biology at different concentration. Maximum application of Silicon dioxide increased the larval duration (22.3%), Pupal duration (11.5) and decreased the larval survival (36.66%), adult longevity (7.61) and fecundity rate 191. Among all concentrations of silicon dioxide minimum increase in larval duration, pupal duration and decrease in larval survival and adult longevity were recorded at 400 ppm (Figure 5).

Silicon is described as a booster that has been used to counteract several abiotic and biotic stresses (Liang et al., 2015). The results of the contemporary study are same as recorded by (Haq et al., 2022) that the foliar spray of SiO_2 caused the highest larval mortality and decreased fall armyworm infestation on maize plants. Result of the present study in line with the findings of Alyousuf et al., (2022) that Foliar spraying of silicon was more effective in reducing the population density of *B. tabaci* and *T. absoluta* in tomato crop as compared to Si-soil drench application. Results are also supported by the work of Acevedo et al., (2021) that Si addition improves leaf silicon concentration in all parts of plants and decreases the fall armyworm infestation. Results are also in the agreement with the work of Abbasi et al., 2020 that SiO_2 significantly decreased oviposition and prolonged the length of all immature stages as well as the overall cycle.

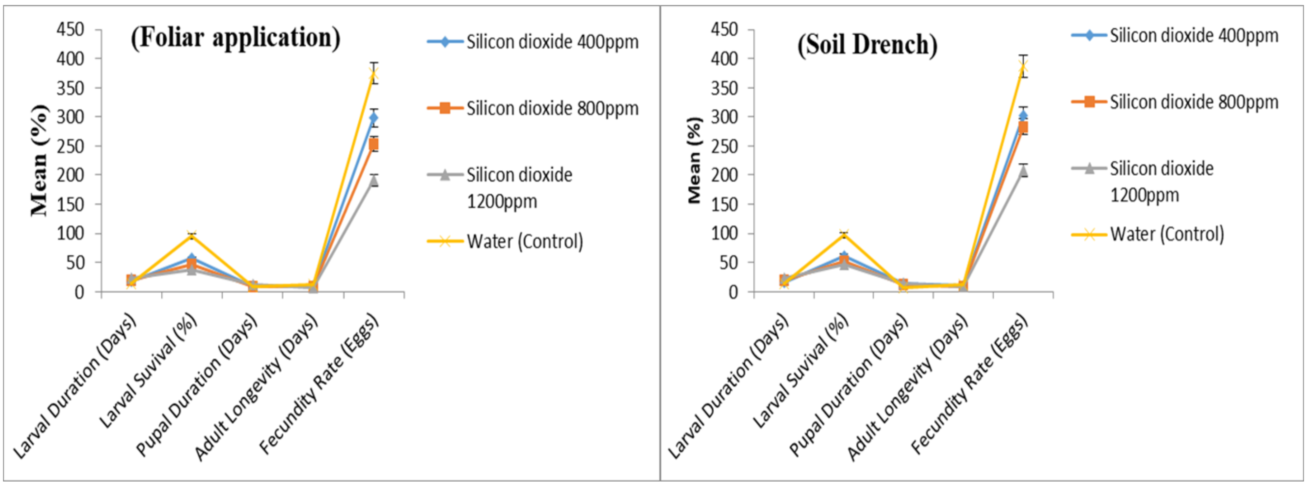

Figure 5. Impact of the foliar and soil drench application of Silicon dioxide at different concentrations against the biology of Fall Armyworm (FAW) in vitro conditions.

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