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Potential of resistance inducers for controlling *Agrotis segetum* Denis & Schiffermüller (Lepidoptera, Noctuidae) in sugar beet in Khuzestan, Iran

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ABSTRACT: Efficacy of some resistance inducers for reduction of *Agrotis segetum* (Lepidoptera, Noctuidae) in sugar beet was evaluated under field conditions. The inducers include salicylic acid, calcium silicate and sodium silicate which applied in two dosages, 100 and 50 per cent of recommended field dosages (RFD). The larval density in calcium silicate treatment was significantly lower than control (H"19.5%). However, other inducers, salicylic acid and sodium silicate, did not significantly affect the larval density. Reduction of the application dosage to 50 per cent RFD did not have significant effect on the inducer efficacy. © 2022 Association for Advancement of Entomology

KEYWORDS: Salicylic acid, calcium silicate; sodium silicate, cutworm

Sugar beet, *Beta vulgaris L.,* is attacked by many insect pests (Heibatian *et al.*, 2018). The black cutworm, *Agrotis segetum* Denis & Schiffermüller (Lepidoptera, Noctuidae) is a serious pest of sugar beet in many regions of Europe, Africa and Asia (Bowden *et al.*, 1987) including Iran (Darabian and Yarahmadi, 2017). The larvae of *A. segetum* consume the leaf epidermis, cuts seedling stems, and sometimes eats up the entire seedling through the stem at ground level (Heibatian *et al.*, 2018). There are many restrictions for chemical control of the pests in sugar beet fields (Darabian and Yarahmadi, 2017). Host plant resistance (HPR) considers as an appropriate alternative of chemical control in integrated pest management (IPM) programs (Mohammadi *et al.*, 2015a, b; Ongaratto *et al.*, 2021). Secondary metabolites (Zandi-Sohani *et al.*, 2018; Su *et al.*, 2018; Azadi *et al.*, 2018; Rajabpour *et al.*, 2019) and physical properties (Shahbi and Rajabpour, 2017; Kafeshani *et al.*, 2018) of the host plants can significantly affect the population density of pests. Fertilizers and plant hormone analogs play important role in the HPR enhancement (Abdollahi *et al.*, 2021). In this study, effects of silicon-based fertilizers and salicylic acid (as a plant hormone) in induction of HPR to *A. segetum* were investigated in sugar beet fields.

The commercial sugar beet cultivar, Antec® (Strube company, Germany), was cultivated (@900000 plants per ha) in a sugar beet field, 7000 m^2, in Amale seif country, Susa district, north Khuzestan province, southwest Iran (32°14'02"N; 48°14'15"E) during 2019-2020. The field divided was in 28 plots (each plot 200 m^2). The experiment was performed in a randomized complete block design with four replications (plots). In the sugar beet field, no insecticide was applied during the study. The

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Table 1. ANOVA parameters for main effects and interactions for *Agrotis segetum* density on sugar beet plants (data were $(X+1)^{0.5}$ transformed prior to analysis; error df=168)

Source	df	F value	P-value
Date	7	5.32	<0.0001
Resistance inducers*	3	1.86	0.0430
Application dosage	1	0.81	0.3690
Date × Resistance inducers	21	1.92	0.0125
Date × Application dosage	7	0.95	0.4676
Resistance inducers × Application dosage	2	2.01	0.1367
Date × Resistance inducers × Application dosage	14	1.44	0.1394

**(silicate potassium, silicate calcium and salicylic acid)*

experimental treatments include the different potential resistance inducers at 100 and 50 per cent recommended field dosage (RFD). The treatments were: silicate potassium at 100 per cent RFD (2 L ha^{-1}), silicate potassium at 50 percent RFD (2 L ha^{-1}), silicate calcium at 100 percent RFD (2 L ha^{-1}), silicate calcium at 50 percent RFD (1 L ha^{-1}), salicylic acid at 100 percent RFD (2.5 Mol L^{-1} ha^{-1}), salicylic acid at 50 percent RFD (1.25 Mol L^{-1} ha^{-1}). In control plots, the plants were sprayed with water. The plants were treated, single time, with a hand operated knapsack sprayer with hollow cone nozzle. The spraying was done at four leaf phenological stage of sugar beet plant, when the noctuid pests have occurred on sugar beet fields of Khuzestan province.

Sampling was weekly done from September 2019 to May 2020. At each sampling date, ten plants were randomly chosen by traveling in an X-shaped pattern through each plot and soil under each selected plant was removed, about 10 cm deep and wide, and the numbers of larva, 2^{nd}- 5^{th} instars, were counted. The factorial analysis (8 sampling dates × resistant inducer treatments × 2 application dosages) based on a completely randomized block design was carried out using the GLM procedure. The least significant difference (LSD) test, as a post hoc test of analyses of variance (ANOVA), was used for mean comparisons. The analyses were performed using SAS 9.2 (SAS Institute, Inc., Cary, NC).

The densities of the larvae in different sampling weeks were significantly different. There were treatment effects and their interactions on *A. segetum* density. The pest density in weeks 1-5 were significantly more than weeks 6-8 (Table 1, Fig. 1). Moreover, significant differences were observed in the larval infestations between different resistance inducer. Among the treatments, calcium silicate showed significant decrease in larval density of *A. segetum* in comparing with control (about 19.5% less than control). The results revealed that dosages (100 and 50% RFD) and its interactions have no significant effect on the larval density in sugar beet, indicating the lower dose is enough to lower the larval population (Table 1, Fig. 2).

Silicon depositions in host plant tissues provides a mechanical barrier against pest feeding. Furthermore, silicon is important element and elicitor for producing defensive metabolites, eg. tannins and phenolic compounds (Reynolds *et al.*, 2009). Induction of resistance using silicon-based fertilizers in corn to *Spodoptera frugiperda* Smith (Alvarenga *et al.*, 2017), sugarcane to *Sesamia* spp. (Nikpay *et al.*, 2015), and soybean to *Helicoverpa punctigera* Wallengren (Johnson *et al.,* 2020) were previously reported. The present study showed that salicylic acid has no significant effect in sugar beet

Fig. 1 Population density of *Agrotis segetum* larvae in different sampling weeks (Different letters indicate significant statistical difference at 5%)

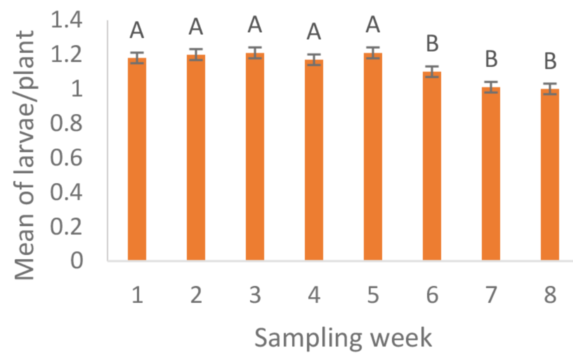
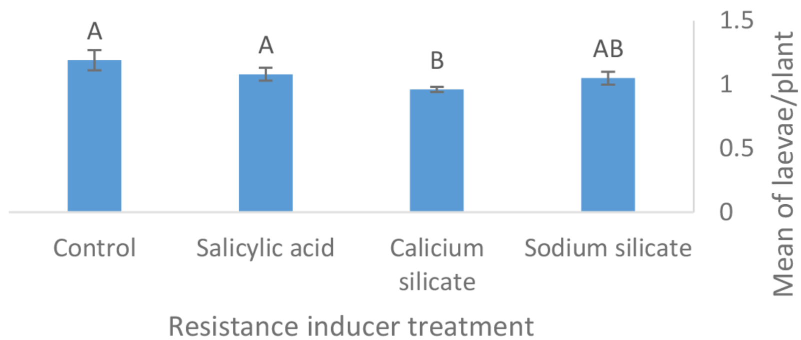


Fig 2. Population density of *Agrotis segetum* larvae in resistance inducer treatments (Different letters indicate significant statistical difference at 5%)



resistance to *A. segetum*. Salicylic acid as a phytohormone, mediates some multiple signaling pathways that involve in the plant defensive biochemistry. The significant effect of salicylic acid in HPR of many some noctuid pests including *H. agmigera* Hubner (War *et al.*, 2013) and *S. frugiperda* (Gordy *et al.*, 2015) were documented. Different feeding behavior of *A. segetum* may be the main reason of the conflict results. The noctuid pests, *H. agmigera* and *S. frugiperda* feed on leaf tissues. It is demonstrated that salicylic acid causes induction of defensive chemicals, especially poly phenols, and enzymes, including jasmonic acid and polyphenol oxidase, in host plant leaves (Abdollahi *et al.*, 2021). In conclusion, calcium silicate (1 L ha^{-1}) can be used for resistance induction of sugar beet to *A. segetum*. The resistance can be integrated in IPM programs of sugar beet fields for sustainable control of the pest.

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