Efficacy of plant essential oils against rice weevil, *Sitophilus oryzae* L.

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ABSTRACT

The rice weevil, *Sitophilus oryzae* is a major stored grain insect pest that causes both quantitative and qualitative damage to cereals. Hence, the study was conducted to evaluate the insecticidal efficacy of *Clerodendrum multiflorum, Clerodendrum viscosum, Vitex negundo, Argemone mexicana* and *Withania somnifera* leaves essential oil against *S. oryzae* in laboratory conditions. The essential oil isolated from *V. negundo* and *A. mexicana* at 2.0 µL/gm of wheat was found to be toxic, causing 100% mortality as compared to other plant essential oils. The percentage of oviposition deterrence increased from 20% to 90% by increasing the concentrations of essential oils. Interestingly, all plant essential oils were inhibited F1 adult emergence at lower dose. Essential oils of *V. negundo* and *A. mexicana* revealed significant toxicity, oviposition deterrence and inhibition of F1 adult emergence of *S. oryzae* at lower concentrations. Thus, these plant essential oils may be suggested as admixtures in the integrated management of rice weevil during the storage of grains.

Keywords: Bio-pesticides, Essential oils, Oviposition deterrence *S. oryzae*

MS History: 07.03.2021(Received)-29.05.2021(Revised)- 30.05.2021(Accepted).

Citation: Rekha R. Tangadi, Ganesh S. Jadhav, Ashwini A. Devarshi and S. R. Yankanchi. 2021. Efficacy of plant essential oils against rice weevil, *Sitophilus oryzae* L. *Journal of Biopesticides,* **14**(1):22-26.

INTRODUCTION

The rice weevil, *Sitophilus oryzae* is a serious pest of stored products in India that cause severe damage in both quantity and quality of stored cereals so grains are non-viable as well as not suitable for human consumption (Chauhan*et al.*, 2005; Sahaf *et al.,* 2008). Effective management of *S. oryzae* is mainly depending upon the use of conventional liquid and gaseous insecticides (White and Leesch, 1995). Although these insecticides are effective, at the same time insects developed resistance, increasing application cost, produced undesirable effects on environment and direct toxicity to consumers (Benhalima *et al.,* 2004; Collins *et al.,* 2005; Rajendran and Sriranjini, 2008; Pimentel *et al.,* 2009).

The growing awareness of environmental hazards caused by synthetic insecticides has led to search for safe and environment friendly alternatives. In this regard, a number of studies are being carried to find out the plant origin chemicals for their insecticidal properties against wide-range of insect pest including stored grain insect pests (Naumann and Isman, 1995; Patil *et al.,* 2006; Isman, 2006; Yankanchi *et al.,* 2014; Pazhanisamy and Archunan, 2019). Plant leaf powders, extracts and essential oils were evaluated to determine the insecticidal properties against insect pests, because phytochemicals are ecofriendly and safe to human (Patil *et al.,* 2006; Isman and Seffrin, 2014; Jadhav *et al.,* 2016). Plant essential oils are 20-80 complex mixtures of secondary metabolites that produce odor and flavors to leaves, flowers, fruits, barks, and seeds. So, many plants essential oil are used to the control of stored grain insect pests (Rajendran and Sriranjini, 2008; Isman, 2020). Hence, the experiments were designed to evaluate the insecticidal efficacy of *Clerodendrum multiflorum, Clerodendrum viscosum, Vitex negundo, Argemone mexicana* and *Withania somnifera* leaves essential oil against rice weevil, *S. oryzae* in laboratory conditions.

MATERIALS AND METHODS

Insect culture

Insect culture of rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae) was raised by

adults collected from grain traders in Kolhapur. The collected adults were reared on clean and insecticides free whole wheat grains (verity: AKW 1071) of 5-liter capacity plastic containers. The containers were covered with muslin cloth for proper aeration. Weevil culture was maintained in laboratory conditions of 28 ± 2°C temperature, 70 ± 5% relative humidity and natural photoperiod as described by Narayana Swamy *et al.* (2014). Weevil cultures were repeated for more than two generations to get laboratory cultured adults and they were used for all experiments.

Extraction of essential oils

The plant leaves of *Clerodendrum multiflorum, Clerodendrum viscosum, Vitex negundo, Argemone mexicana* and *Withania somnifera* were collected in the morning hours in and around of Kolhapur city. Plants were authenticated by experts with help of herbariums deposited in the Department of Botany, Shivaji University, Kolhapur. Collected materials were cleaned, dried at room temperature and powdered by using a domestic grinder. The ground powders were individually subjected to hydro-distillation for extraction of essential oils by using modified Clevenger type apparatus. Essential oils were extracted with *n*-hexane and then anhydrous sodium sulfate was used to remove water content. Oils were stored in airtight scintillation vials and then kept in the refrigerator at 4°C for further use.

Insecticidal bioassay

Five concentrations (20-100 µL/mL) of essential oils were prepared in *n*-hexane and were tested to determine insecticidal efficacy as described by Thomas *et al.* (2002). Each concentration of essential oil was mixed with wheat grains (1 mL/50 gm) for a minute and control group wheat grains were treated with *n*-hexane only in bottles. Ten pairs of 2-3 days adult weevils were released in to each bottle, covered with muslin cloth and kept under laboratory conditions with three replicates. Toxicity results of weevils were recorded every day for up to 7 days. And then all live and dead insects were removed from the bottles and observed for 45 days to determine oil effect on emergence of F1 generation weevils. Percentage of F1 generation was calculated according to Aldryhim (1995) formula.

Oviposition deterrence bioassay

The oviposition deterrence efficacy of essential oils was evaluated against *S. oryzae* as described by Holloway (1985). The wheat grains were treated with essential oils as mentioned above procedure and released 10 pairs of adult insects include the control group. After 48 hours wheat grains were treated with acid-fuchsin stain in order to count egg plugs. Percentage of oviposition deterrent was calculated according to the Elhag (2000) formula. All results were corrected and statistically analyzed the one-way ANNOVA by using SPSS software (version 20) and means were separated by Least Significant Difference (LSD) admitting significant at $P < 0.05$ level.

RESULTS AND DISCUSSION

Insecticidal activities of five plant essential oils showed different levels of grain protection by killing the weevils. However, the *V. negundo* and *A. mexicana* essential oils demonstrated highest (100%) toxicity at 2 µL/gm after a week of exposure (Table 1).

Table 1. Insecticidal activity of plant essential oils against rice weevil, *S. oryzae*

Conc. of EOs (µL/gm)	Percent mortality*				
	C. multiflorum	***C. viscosum***	***V. negundo***	***A. mexicana***	***W. somnifera***
0.4	16 ± 3.3^{d}	10 ± 3.3^{c}	20 ± 3.3^{d}	26 ± 3.3^{e}	21 ± 2.31^{c}
0.8	33 ± 6.7^{c}	26 ± 3.3^{b}	43 ± 3.3^{c}	46 ± 6.7^{d}	34 ± 4.18^{c}
1.2	46 ± 6.6^{c}	36 ± 6.2^{b}	56 ± 4.7^{c}	63 ± 6.6^{c}	56 ± 4.73^{b}
1.6	63 ± 3.3^{ab}	53 ± 6.7^{a}	80 ± 7.4^{ab}	86 ± 6.6^{ab}	83 ± 7.36^{a}
2.0	76 ± 6.6^{a}	63 ± 6.6^{a}	100 ± 0.0^{a}	100 ± 0.0^{a}	87 ± 10.8^{a}

Means ± SE followed by the same letter in column are not significantly different at $P < 0.05$.

At the same essential oil concentration and exposure time, the *C. viscosum* and *C. multiflorum* showed 63% and 76% mortality respectively. Toxicity on insects increased with increasing concentration of oils and exposure time with all plant essential oils. The *V. negundo* and *A. mexicana* oil treated seeds were free from insect damage, it indicates that all insects were dead before feeding and toxicity on insects were too early as compare to other plant

oils. Interestingly all plant essential oils were completely inhibited progeny production (F1 generation) of the rice weevil even at lower concentrations. Oviposition deterrent efficacy results were given in Fig. 1 and revealed that the *V. negundo* and *A. mexicana* essential oils were found to be more effective than the other plant oils.

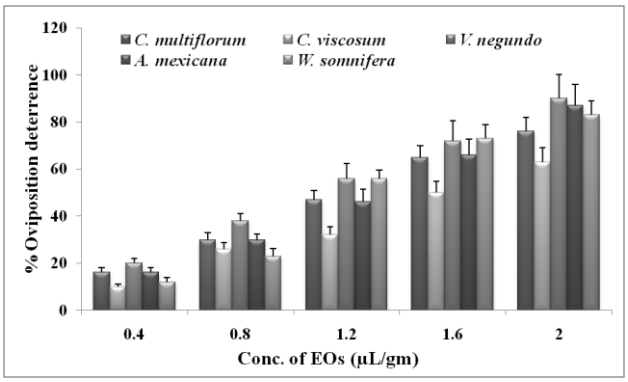

Fig. 1. Oviposition deterrence activity of plant essential oils against rice weevil, *S. oryzae.*

In the present report, the five plants leaf essential oil demonstrated the insecticidal, inhibition of progeny production and oviposition deterrence activities against *S. oryzae* but toxicity levels varied with each plant essential oil. Plant essentials oils mainly contain monoterpenes, diterpenes and sesquiterpenes which are highly volatile compounds that cause toxicity by inhibiting the respiration and enzyme activities to stored grain insect pests (Obeng-Ofori and Reichmuth, 1999; Sahayaraj, 2008; Isman and Seffrin, 2014; Kedia *et al.*, 2015). Previous reports shown that essential oils have insecticidal activities against stored products, agricultural and vector insect pests (Rajendran and Sriranjini, 2008; Sivakumar *et al.*, 2010; Trivedi *et al.*, 2017; Pavela *et al.*, 2019). Rajendran and Sriranjini (2008) reported the essential oils and their components isolated from Lamiaceae, Myrtaceae, Lauraceae and Apiaceae family plants showed toxic effects on stored product beetles of *S. oryzae*, *S. zeamais*, *T. castaneum*, and *R. dominica* and moths of *S. erealella* and *C. cephalonica* but essential oils are more effective to control the beetles than the moths. We observed that the *V. negundo* and *A. mexicana* oils demonstrated highest insecticidal activities on rice weevil, *S. oryzae*. Ovicidal and toxic effect of plant extracts on castor semilooper, *A. janata* results showed that *V. negundo* and *A. mexicana* extracts produced maximum insecticidal activities (Devarshi *et al.*, 2017). *A. mexicana* leaf extract showed strong insecticidal activity to tobacco caterpillar, *Spodoptera litura* and American bollworm, *Helicoverpa armigera* (Malavannana *et al.*, 2008a and 2008b) and *V. negundo* extract revealed toxic action to *S. litura* (Deepthy *et al.*, 2010). Among all plant essential oils *V. negundo* and *A. mexicana* essential oils showed 90% and 87% oviposition deterrence respectively (Fig. 1). The inhibition of F1 adult emergence of *S. oryzae* at lower concentrations in all plant oils and these results are confirmed with findings of Yankanchi and Gadache, (2010) against rice weevil, *S. oryzae*.

Based on the present study results, *V. negundo* and *A. mexicana* essential oils could be used as alternative agents for control of stored grain insect pests. However, large scale experiments to be necessary to prove the efficacy of these oils under the commercial storage conditions to confirm the required concentrations and economic values for use of these essential oils as grain protectants. At the same time, study should be extended to confirm the oil toxicity to non-target organisms including mammals.

Acknowledgement

The authors are thankful to the Shivaji University, Kolhapur for the financial assistance (Ref. No. SU /C & U. D. Section /71 /1374).

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