RESEARCH ARTICLE

EFFICACY OF PLANT DERIVED ESSENTIAL OILS AGAINST *SITOPHILUS ORYZAE* (L.) IN STORED WHEAT GRAINS

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Abstract: Certain plant derived essential oils are known as a source of secondary metabolites and used as insecticides to repel insects. As part of an effort aimed at the development of reduced-risk pesticides based on plant essential oils, the toxicity of essential oils was investigated against rice weevil *Sitophilus oryzae* L. under laboratory conditions i.e. 28±2^{0}C temperature, 60±5% relative humidity and a 16:8 light:dark photoperiod in BOD. The treatments were the essential oil from various botanicals i.e. Eucalyptus (*Eucalyptus globules*), Lemongrass (*Cymbopogon citrates*), Citrus *(Citrus maxima*) and their different combinations. Data was recorded for various parameters *viz.* per cent adult mortality, grain damage, weight loss and progeny emergence. Study revealed that the combination of essential oils of Eucalyptus (0.5 %) + Lemon grass (0.5 %) was found to be significantly superior among all the treatments and recorded consistently increased rate of adult mortality 61.67, 78.33 and 96.67 % after 7, 14 and 21 days and progeny emergence 60.28, 56.17 and 54.78, respectively. This treatment also recorded with minimum loss in weight and minimum grain damage after 75 days of insect release. The minimum adult mortality, maximum grain damage and maximum weight loss were recorded in control. The validated information provides ample scope for the use of essential oils against store grain pests.

Keywords: Wheat, *Sitophilus oryzae,* Management, Essential oils

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important cereal crop of India next to rice. Wheat is the major source of protein in human foods, having higher protein content than maize, rice and other major cereal grains. Stored products are subjected to sustain considerable quantitative and qualitative losses by more than 600 species of beetle pest and 70 species of moths (Rajendran and Sriranjini 2008). In stored grain, insect damage may account for 10- 40 % of loss worldwide (Matthews 1993) whereas in India it was estimated as 6.5 % of the total storage, Raju (1984). Wheat is infested by various insect pests during storage condition. Among all insects *Sitophilus oryzae* is a major insect of cereal crops in storage Baloch (1992). Grub and adults of *S. oryzae* are internal feeders and cause severe qualitative and quantitative losses to wheat grains, Nalini *et al*., (2007). Plant synthesized natural products are well known to have a range of useful insecticidal properties against insect pests' Arthur (1996). In this regard, the toxicity of different essential oils has been evaluated for their insecticidal properties against different stored grain pests (Shaaya, *et al*., 1991; Sarac *et al.,* 1995; Tunc, *et al*., 2000; and Negahban, *et al*., 2006). The control of rice weevil and other pests of stored products by the use of essential oils is the most widely adopted method, while chemical insecticides have serious drawbacks, such as environmental pollution, insect's resistance, high mammalian toxicity and increasing cost of application. This leads to search for more safe and less expensive alternative chemicals such as plant extracts as alternatives to synthetic insecticides. Over 2000 species of plants are known to possess some insecticidal activities (Klocke 1989). Therefore, the aim of present investigation was to evaluate the toxicity of various botanical essential oil alone or in combinations on biological performance of *S. oryzae*.

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MATERIALS AND METHODS

Preparation of essential oil extraction

The fresh leaves of plants *i.e.* eucalyptus, lemongrass and citrus were collected from the H.R.C., Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. Collected samples were shadow dried under good ventilation for 48 Hrs and woody stems were separated. Shadow dried leaves were used for oil extraction. The leaves of Eucalyptus, Lemongrass and Citrus were cut into small pieces separately and small pieces of leaves were hydro-distilled in Clevenger apparatus continuously for 6 to 7 Hrs at 60 to 70^{0}C temperature to yield essential oils. The oils were collected in eppendorf tubes separately and stored at 4^{0}C temperature in refrigerator.

Insect culture

Adults of test insects *i.e. S. oryzae* were collected locally from naturally infested stored wheat grains. The culture of *S. oryzae* was maintained at 28±2^{0}C temperature, 60±5% relative humidity and a 16:8 light:dark photoperiod in BOD. The culture was raised by 50 pairs of newly emerged *S. oryzae* adults into 500g of wheat grains in 1 Kg capacity plastic container. After 45 days newly emerged (F_1) adults were collected and used for the experimental purpose. Ten pairs of adult *S. oryzae* were released in

each 50g of experimental and control grains kept in 300g plastic container which was covered with a lid. The containers were maintained at 28±2^{0}C temperature, 60±5% relative humidity and a 16:8 light:dark photoperiod in BOD.

Observation and calculation

The assessment parameters comprised of adult mortality number of F_1 progeny produced and progeny reduction in both treatment and control conditions, % grain damage, and % weight loss were investigated during experimentation.

Adult mortality

To collect the adult mortality data the Whatman filter papers no. 1 treated with different testing doses were fixed at bottom of containers and filled with 50g of wheat grains. In control the ethanol treated filter papers were fixed at bottom of containers. Ten pairs freshly emerged adults were released in each container and kept in BOD at 28±2^{0}C temperature, 60±5% relative humidity and a 16:8 light:dark photoperiod in BOD. Each treatment was replicated thrice. The adult mortality was recorded at 7, 14 and 21 days after released. The following formula was used to calculate the % mortality:

$$\text{Adult mortality (\%)} = \frac{\text{Total number of dead adult insects}}{\text{Total number of release adult insects}} \text{ X } 100$$

Progeny emergence of *S. oryzae*

The plant essential oil at concentration levels of 1.0 % and in combination of 0.5 % was used to evaluate its efficacy against *S. oryzae*. Each concentration was applied in three replicates, and each replicate was contained 25 g of wheat grains. The plant essential oil of required concentration levels was socked in cotton swap and kept with wheat grains. In control treatment only water was used. Then, 10 adults of *S. oryzae* was transferred in wheat grains and plastic container were kept at 28±2^{0}C temperature, 60±5% relative humidity and a 16:8 light:dark photoperiod in BOD. The emerged progeny after hatching of eggs was recorded after 6 weeks of treatment. The reduction percentages in *S. oryzae* progeny was calculated with following equation as described by El-Lakwah *et al.* (1992).

$$\text{Reduction (\%)} = \frac{\text{MNEC} - \text{MNET}}{\text{MNEC}} \text{ X } 100$$

MNEC = Mean number of insects which emerged in the control

MNET = Number of insects which emerged in the treatment

Grain damage

After 75 days, the sample of 100 grains was taken from each treatment and control. The total number of grains was counted and % grain damage was calculated by following formula:

$$\text{Grain damage (\%)} = \frac{\text{Total number of damaged grains}}{\text{Total number of grains}} \text{ X } 100$$

Grain weight Loss

After 75 days of insect confinement, the % weight loss was calculated by following formula:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \text{ X } 100$$

Statistical Analysis

The data recorded during the course of investigation were subjected to statistical analysis by using ANOVA for Complete Randomized Design. The data were transformed as and when required. Standard error of mean in each case and the critical difference only for significant cases were computed at 5 % level of probability.

RESULTS AND DISCUSSION

The insecticidal activities of lemongrass, eucalyptus and citrus essential oils were evaluated against *S. oryzae* adults by direct contact application method (Tables 1 & 2).

The essential oil (Eucalyptus 0.5 % + Lemon grass 0.5 %), after 21 days of the infestation of wheat grains, resulted in largest number of dead insects (96.67 %) and this treatment proved best among all the treatments. The next best essential oil (Citrus 0.5% + Eucalyptus 0.5 %) recorded adult mortality of 90.00 %, 21 days after treatment. Lemongrass 0.5 % + Citrus 0.5 %, Lemongrass essential oil (1.0 %), Eucalyptus essential oil (1.0 %) and Citrus essential oil (1.0 %) resulted in 83.33 %, 81.67 %, 73.33 % and 65.00 % adult mortality of *S. oryzae* respectively after 21 days of treatment. Results are in support with the finding of using essential oils of *Eucalyptus globules* on *S. oryzae* in the adult phase in stored wheat resulted 100 % of mortality (Rupp *et al.* 2005) and also higher adult mortality of *S. oryzae* has been reported with eucalyptus leaf powders (Deb *et al.* 2016). Similar results on-effectiveness of lemon grass essential oil (Saljoqi *et al.* 2006) and *Citrus sinensis* (Akunne *et al.*2015) extracts have been reported against *S. oryzae*.

Plant derived essential oils were found to be very effective in reduction of progeny emergence and its ranged from 54.78 to 78.06 % (Table 2). Maximum % reduction in progeny emergence 78.06 was recorded with essential oil (Lemongrass 0.5 % + Citrus 0.5 %) and 68.50 % with treatment lemongrass essential oil 75 days after treatment. Present results on progeny emergence of *S. oryzae* corroborates with the findings of Nalini *et al.* (2007) who has reported the reduction in adult progeny build up.

After 75 days of treatment used all the treatments were found significantly superior over control in decreasing the grain damage. The maximum grain damage of 25.33 % was recorded in control. Among the all treatments minimum grain damage (6.00 %) was recorded with T4 treatment and maximum grain damage (11.00 %) was found with T3 treatment. The

treatments T6, T5, T2 and T1 were recorded with 7.33, 8.00, 9.33 and 10.67 % grain damage, respectively. The treatments T4 and T6 were found statistically at par to each other. The treatments T5 and T2 were found statistically at par. Patil *et al.* (2014) reported lowest infestation of seed treated with plant leaves. Sharma *et al.* (2016) obtained minimum number of damaged seeds in essential leaf oil treated seeds.

With regard to loss in weight of wheat grains after 75 days of treatment used, the data showed (Table-1) a significant difference between treatments and control. The maximum weight loss (25.50 %) of grains was found in control. The treatment T4 was found best with minimum weight loss (2.67 %). The treatments T6, T5, T2 and T1 were observed with 4.37, 6.32, 6.79 and 8.63 % weight loss, respectively. The treatment T3 recorded poor responce with weight loss (10.67 %) among all the treatments. The treatments T5 and T1 were found statistically at par to each other. Zayed (2012) evaluated mustard seeds, turmeric rhizomes, anise seeds, black pepper seeds and malathion 1% dust against rice weevil and reported the all treatments had significant desired effects on the percentages of wheat weight loss. Nalini *et al.* (2007) reported minimum loss in grain weight in botanical treated grains. Sharma *et al.* (2016) obtained minimum reduction in seed weight loss fumigated seed by essential leaf oil.

Traditional significance of study to farmers

Fumigants are being used since long to control stored grain pests but today, storage grain pest control has to face up to the economic and ecological consequences of the use of pest control measures. On other hand traditional knowledge in management of stored grain pest developed by ancient people through generations of their interaction with nature and natural resources is far better. Ancient people used plant leaves and plant parts in the past to control stored grain pests**.** keping in mind we used essential oils, the high activity of these compounds could make it a potential substitute for fumigants in various uses in stored-product control. Plant-derived essential oils, in general, are considered minimum-risk pesticides and may be used by farmers against stored grain pest.

Table 1. Efficacy of essential oils of plants on Per cent mortality of *Sitophilus oryzae*

Treatments	Per cent Mortality		
	7 Days after treatment	14 Days after treatment	21 Days after treatment
T_1 Eucalyptus oils @1.0%	36.67 (37.24*)^{c}	61.67 (51.73)^{c}	73.33 (58.91)^{c}
T_2 Lemongrass oils @ 1.0%	51.67 (45.94)^{d}	66.67 (54.73)^{d}	81.67 (64.67)^{d}
T_3 Citrus oils @ 1.0%	31.67 (34.22)^{b}	58.33 (49.78)^{b}	65.00 (53.71)^{b}
T_4 Eucalyptus oils @ 0.5% + Lemongrass oils @ 0.5%	61.67 (51.73)^{f}	78.33 (62.27)^{f}	96.67 (81.37)^{f}
T_5 Lemongrass oils @ 0.5% + Citrus oils @ 0.5%	53.33 (46.89)^{d}	71.67 (57.84)^{e}	83.33 (65.93)^{d}
T_6 Citrus oils @ 0.5% + Eucalyptus oils @ 0.5%	56.67 (48.82)^{e}	73.33 (58.91)^{e}	90.00 (71.54)^{e}
T_7 Control	0.00 (0.00)^{a}	0.00 (0.00)^{a}	0.00 (0.00)^{a}
C.D. (P=0.05)	**2.77**	**2.96**	**5.55**

*Figures in parenthesis are angular transform value

Table 2. Efficacy of essential oils of plants on progeny emergence, grain damage and weight loss against *Sitophilus oryzae*

Treatments	% Reduction in Progeny Emergence			Grain Damage %	Weight loss %
	After 50 days	After 65 Days	After 75 Days		
T_1 Eucalyptus oils @1.0%	72.22 ± 2.63^{c}	60.04 ± 1.07^{c}	56.17 ±1.13^{b}	10.67 ± 0.93^{c}	8.63 ± 0.18 ^{d}
T_2 Lemongrass oils @ 1.0%	77.78 ± 2.77^{c}	63.64 ± 1.62^{d}	60.28 ± 1.21^{c}	9.33 ± 0.88 ^{bc}	6.97 ± 0.03 ^{c}
T_3 Citrus oils @ 1.0%	61.11 ± 2.85^{b}	52.73 ± 1.53^{b}	54.78 ± 0.61^{b}	11.00 ± 0.57 ^{c}	10.67 ± 0.67 ^{e}
T_4 Eucalyptus oils @ 0.5% + Lemongrass oils @ 0.5%	94.44 ± 2.46^{e}	78.17 ± 0.39^{g}	78.06 ± 1.54 ^{e}	6.00 ± 0.61 ^{a}	2.67 ± 0.16 ^{a}
T_5 Lemongrass oils @ 0.5% + Citrus oils @ 0.5%	86.11 ± 2.93^{d}	70.95 ± 2.93^{e}	67.11 ± 0.44^{d}	8.00 ± 0.01 ^{b}	6.32 ± 0.21^{c}

T_6 Citrus oils @ 0.5% + Eucalyptus oils @ 0.5%	88.89 ± 2.89[d]	74.56 ± 2.89[f]	68.5 ± 1.31[d]	7.33 ± 0.33[ab]	4.37 ± 0.18 [b]
T_7 Control	0.00[a]	0.00[a]	0.00[a]	25.33 ± 1.2 [d]	25.50 ± 0.28[f]
C.D. (P=0.05)	**8.42**	**2.35**	**1.97**	**1.99**	**0.93**

CONCLUSION

Different plant product like essential oils of leaf extract having considerable potential as insecticide compound are gaining tremendous importance for the management of insect of store products. The combination of extracted essential oils was highely toxic than using separately. The combination of essential oils (Eucalyptus + Lemon grass) proved best among the treatments and showed highest toxicity against *S. oryzae*. The progeny emergence of *S. oryzae* was significantly reduced in wheat grains treated at different doses of essential oils extracted from eucalyptus, lemongrass and citrus leaf. All the essential oils alone and in combination found significantly superior over control.

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