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Efficacy of certain botanicals against Mexican bean weevil *Zabrotes subfasciatus* (Coleoptera:Chrysomelidae) in stored red kidney beans (*Phaseolus vulgaris* L.)

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1. ABSTRACT

The effect of leaf powders of four botanicals viz, Neem (*Azadirachta indica*), Eucalyptus (*Eucalyptus saligna*), Goosefoot (*Chenopodium album*) and Carrot grass(*Parthenium hysterophorus*) was studied in stored red kidney beans. The repellency rate and mortality effect were calculated using a completely randomized design with 4 treatments. The data was then projected to statistical analysis and the test significance level was $P<0.05$, the best treatment in terms of the repellency rate was 10 gm, Eucalyptus leaf powder causing 82% repellency within 48 hours of the application and in terms of mortality the treatment with 10 gm *Chenopodium album* leaf powder showed best results causing 96% mortality in 3 days. The results show this trend effort to find alternative options for organic biopesticides that can be used in place of chemical pesticides in a more biodegradable, cost-effective and environmental safe manner.

KEYWORDS: Efficacy, *Zabrotes subfasciatus*, Biopesticides, Leaf powder, repellency, *Chenopodium*

2. INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) is one of the principal food and crash crop legume grown in the tropical world (Abate and Ampofo, 1996; Songa and Rono, 1998; Schmale et al 2002). An extensive range of seed beetles attack the grain of common bean varieties (Mulungu et al. 2007). Although, the predominant damaging pests of stored grain legumes mainly in the tropics are *Callosobruchus macalutus* (Fab.), *Callosobruchus Chinesis* (L.), *Caryedon serratus* (Oliver), *Zabrotes subfasciatus* (Boheman) and *Acenthoselids obtectus* (Say) (Nahdy and Agona, 1995; Nichimei-Msolla and Misangu, 2002; Emana et al , 2003) . The Mexican bean weevil Zabrotes subfasciatus (Boheman) (Coleoptera, Chrysomelidae, Bruchinae) has dispersed worldwide (CABI 2022). Adult females attach their eggs to the seed tegument. Newly hatched larvae enter the seed and spend all developmental time inside it, consuming and destroying seed tissue. Larval feeding behaviour, together with fecal contamination, causes quantitative and qualitative losses (Soares et al. 2015) that can reach 13% (Quintela et al. 2020). The most used control method for seed beetles in stored beans is still by either insecticide spraying onto the grains or fumigation (Upadhyay and Ahmad 2011, Yamane 2013), which is favoured by the size of the seeds and the gaps between them (Hill 2002). However, chemical

insecticides and fumigants can cause some environmental pollution and be unsafe to health (Yamane 2013), among other problems, so that the use of more environmentally safe methods should be always encouraged. Furthermore, from the perspective of integrated pest management (IPM), it is always necessary to develop grain protection methods or systems using lesser chemical insecticides or fumigants (Upadhyay and Ahmad 2011, Yamane 2013). As a result, the current study was developed to examine the interaction effect of various botanicals on the control of *Z. subfasciatus*. It is necessary to seek a different solution that is both environmentally friendly and economically feasible in order to reduce postharvest losses and ensure long term kidney bean productivity. Hence, the objective of this study was to look into effective botanicals against *Z. subfasciatus* in kidney beans under laboratory condition.

3. MATERIALS AND METHODS

3.1 Study area

The study was conducted in the laboratory of Department of Zoology, Isabella Thoburn College, Lucknow at temperature 22±5 °C and Relative humidity 65±10 %. The design of the experiment was completely randomized with four treatments and 6 replications of each . A control was also included without any treatment. It also had its 6 replications. 100 gm of kidney beans with 10 gm of leaf powder was taken for each treatment . This methodology was followed from (Prastowo, 2022) and some changes were also made .

3.2 Insect rearing

The infested kidney beans were bought from the local shop. The food medium (kidney bean seeds) used for insect rearing was first disinfected by keeping the grains in the oven at 40°C for 4 hours and allowed to cool for 2 hrs before use (Jembre B, 2002). Infestation was done by introducing 100 parental adults (1:1 sex ratio) in 1 L volume of glass jar containing 250 g of kidney bean grains. The parental adults were sieved off 13 days after oviposition period and the grains were kept under laboratory condition until the emergence of F1 progeny. New generations of adult bean weevil (*Z. subfasciatus*) obtained from this culture were used in the experiment.

3.3 Plant materials

Plant parts (leaf) used for study were collected from the campus of Isabella Thoburn College and neighbouring areas between November and December, 2023. Fresh plant parts (leaves) of a known weight were kept in a well-ventilated room under shade for 1-2 weeks depending on weather conditions. Dried plant leaves were ground to fine powder using electrical grinder. 10 gm of leaf powder (insecticide) was put in small bundle bag which was made using muslin cloth. The bundle bags were tied using a thread in which the respective name of the leaf were tagged.

Kidney beans used in this experiment were first disinfected . 20 adapted *Zabrotes subfasciatus* were then introduced in the small plastic bowl which was kept in small transparent bowl which was kept into a bigger transparent bowl and in this small bowl 100 gm kidney beans were kept in middle of which the bundle bag was placed. The bowl was then covered with a transparent cap and some very tiny holes were made in the cap to allow aeration.

FIGURE 1- Female and Male *Zabrotes subfasciatus*

Figure 2- Damaged kidney beans grains during insect rearing

Figure 3- Shade dried plant leaves of Neem, Carrot grass, Eucalyptus and Goosefoot

Figure 4- Bundle bags prepared using muslin cloth for dried leaf powder (treatments)

Figure 5- The Experimental Setup

3.4 Repellency Effect

The repellence was observed and calculated after every 6 hours for 2 days. The repellence was observed by the number of insects migrating or escaping the treated small bowl to the outside in the bigger transparent bowl. Repellency was evaluated by the emigration index, calculated as the percentage proportion of the mean number of insects that escaped to the total insect population. The following formula was used for the repellency effect:

$$Repellency\ effect\ = \frac{Mean\ no.\ of\ weevils\ escaped}{No.\ of\ weevils\ treated} \times 100\%$$

3.5 Mortality Effect

Mortality percentage was evaluated by observing the number of insects found dead after every 24 hours until maximum mortality was observed which took total 3 days. Mortality index was calculated as the proportion of mean number of insects dead to the total number of insects dead. The following formula was used for the mortality effect:

$$Mortality\ effect\ = \frac{Mean\ no.\ of\ weevils\ dead}{No.\ of\ weevils\ dead} \times 100\%$$

3.6 Statistical analysis

The data was projected for statistical analysis to find significant differences between control and experimental groups using ANOVA (Analysis of Variance) where the test significance level was $P<0.05$ using IBM SPSS statistical software version 27. The graphs created from the collected data were plotted using MS Excel.

4. RESULTS

Effects of different botanical powder on weevil repellency

The results of the application of leaf powders showed a significant effect on controlling *Z.subfasciatus* in stored kidney beans. Very less to negligible repellence was observed in the controlled treatment. The

maximum repellence was 82% in the treatment of Eucalyptus, the repellency pattern was uniform which increased with time. This was followed by 73% repellency of *Azadirachta indica* followed by 67.5 % repellency of *Chenopodium album*. *Parthenium hysterophorus* showed repellency of 53.5% and was least in the experimental study. (*E. saligna*> *A. indica*>C. *album*> *P. hysterophorus*).

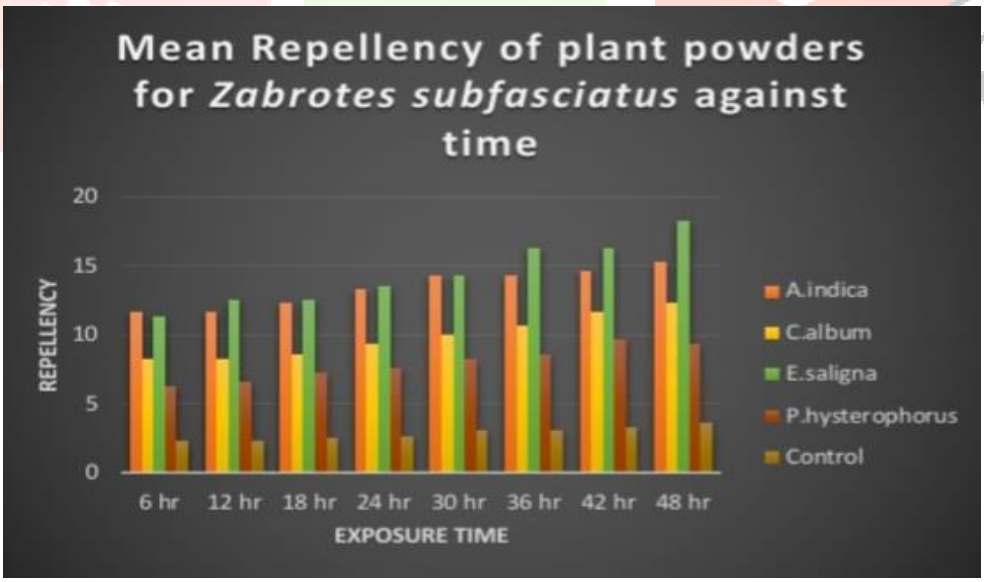
TABLE – 1 Showing repellency data of leaf powders against *Zabrotes subfasciatus*

S. no	Treatment	N	Repellency(Mean ± *SE*)							
			6hr.	12hr.	18hr.	24hr.	30hr.	36hr.	42hr.	48hr.
1	*A. indica*	20	11.33± 0.33	11.66 ±0.33	12.33 ±0.33	13.3± 0.33	14.3± 0.33	14.3± 0.33	14.66 ±0.33	15.3±0 .33
2	*C. album*	20	8.3±0. 33	8.3±0. 33	8.66± 0.33	9.33± 0.33	10.0± 0.33	10.66 ±0.33	11.66 ±0.66	12.3±0 .33
3	*E. saligna*	20	11.3±0. 33	12.6± 0.33	12.6± 0.33	13.6± 0.33	14.3± 0.33	16.3± 0.33	16.3± 0.33	18.3±0 .33
4	*P. hysterophorus*	20	6.33±0 .33	6.66± 0.33	7.33± 0.33	7.66± 0.33	8.33± 0.33	8.66± 0.33	9.66± 0.33	9.66±0 .33
5	Control (Untreated)	20	2.32±0. 33	2.32± 0.33	2.66± 0.33	2.66± 0.33	3±0.0 0	3±0.0 0	3.33± 0.33	3.66±0 .33

*Three out of six replications are considered

*N= No. Of insects

*Test of significance level P<0.05



Effects of different botanical powder on weevil mortality

The mortality effect was observed and the application of plant leaf powder showed a significant effect on insect mortality though the reason of mortality of insect was not included in the experiment only. This data was also project for analysis of variance (ANOVA). Based on observation and results, highest mortality was observed in the treatment of *Chenopodium* powder i.e. 96% and maximum mortality was observed within 3 days of application in replications of *Chenopodium* powder. All other treatments showed relatively low levels of mortality with *A.indica* showing 64.9% mortality followed by *Eucalyptus* and *Parthenium hysterophorus* showing 53.3% and 38.2% mortality respectively. *(C. album>A. indica>E. saligna>P. hysterophorus)*

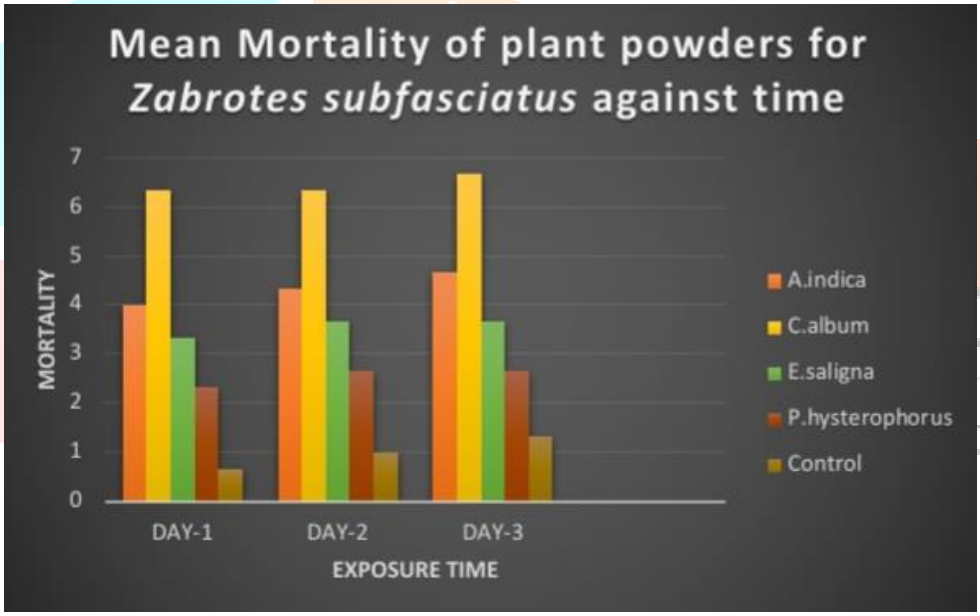
TABLE – 2 Showing mortality data of leaf powders against *Zabrotes subfasciatus*

S.No.	Treatment	N	Mortality (Mean ± *SE*)		
			DAY-1	DAY-2	DAY-3
1	*A.indica*	20	4.0±0.00	4.33±0.33	4.66±0.33
2	*C. album*	20	6.33±0.33	6.33±0.33	6.66±0.33
3	*E. saligna*	20	3.33±0.33	3.66±0.33	3.66±0.33
4	*P. hysterophorus*	20	2.33±0.33	2.66±0.33	2.66±0.33
5	Control(Untreated)	20	0.66±0.33	1.0±0.33	1.33±0.33

*Three out of six replications are considered

*N= No. Of insects

*Test of significance level P<0.05



5. DISCUSSION

The experiment was conducted to evaluate the impact of *Azadirachta indica* ,*Chenopodium album*, *Eucalyptus saligna* and *Parthenium hysterophorus* leaf powders on the repellency and mortality of Mexican bean weevil , *Zabrotes subfasciatus*. The present study suggested that the aforementioned plant leaf powders screened can be uses in the control of bean weevils, especially *Zabrotes subfasciatus* in stored kidney beans.

The results of repellency effect and mortality effect differed from each other . The results of this study shoes highest percentage of repellency of *Eucalyptus saligna* leaf powder against *Zabrotes subfasciatus* in stored kidney beans which was 82% followed by the leaf powder treatment of *Azadirachta indica* (75%) , *Chenopodium album* (67.5%) and *Parthenium hysterophorus(53.5%)* . Khatre et al. in their investigation showed that the treatments with neem, castor and Karanj were highly effective as they registered significant repellent action on the adult fecundity of pulse beetle. The plant derived extracts, powders and essential oils were reported as repellent against stored grain pests like *Callosobruchus maculates* and *T.castaneum*.(Xie et al. 1995)

The highest mortality rate of *Zabrotes subfasciatus* was observed in the treatment of dried *Chenopodium* leaf powder (96%) followed by *Azadirachta indica* . In a similar experiment conducted by (Tamiru et.al, 2016) by using different leaves which included *Chenopodium* and *Azadirachta indica* also showed high mortality rate . *Chenopodium ambrosiodes* mortality was greater than the *Azadirachta indica.* They also reported that the Synergistic effect of leaves is higher than the individual leaves effect. *A.indica, Chenopodium, Eucalyptus, Parthenium* have some active substances that can be used in the biocontrol of *Zabrotes subfasciatus* . Other treatments showed comparatively less mortality effect. Considering the 64.9% mortality effect on *Z.subfasciatus* in the treatment with dried leaf powder of *Azadirachta indica* and 53.3% mortality effect of *Eucalyptus saligna* leaf powder. *Parthenium hysterophorus* showed 38.2% mortality rate which is close to treatment of *Eucalyptus* leaf powder. Thus more research is required to find out the bioactive compounds associated with the activity of aforementioned botanicals that can also be used as binary form to be more effective bioinsecticides to control *Zabrotes subfasciatus* in stored grains.

6. CONCLUSION

This experiment proves that the leaf powder of these plants show insecticidal and repellent activities against *Zabrotes subfasciatus*. These leaf powders can be used as safer alternative to the synthetic insecticides in the pest management. However, further some morestudies are required to elucidate the exact mechanism of action and optimize for maximum Bioefficacy.

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