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Influence of Inert Minerals and Botanicals on Adult Emergence of Pulse Beetle, *Callosobruchus maculatus* (Fabricius), in Stored Blackgram

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ABSTRACT

Background: Pulses hold significant global importance as a food source, with the pulse beetle, *Callosobruchus maculatus*, being a major pest affecting them. As consumer preferences shift towards insecticide residue-free food, pest management strategies are adapting. Inert minerals and botanicals offer a promising solution to address concerns about insecticide safety, resistance development, and regulatory standards. Hence, this study seeks to assess how these substances impact the emergence of *C. maculatus* adults.

Methods: One kilogram of blackgram was taken in three replications and treated with inert minerals and botanicals. In each container, ten pairs of newly emerged adult beetles were introduced. A subsample of 50 g was taken in small plastic jars to record, the day when the first adult beetle emerged, the daily count of adult beetles and the overall count of emerged adult beetles.

Result: The research showed no significant difference between treatments and untreated control *w.r.t* day of first adult emergence of *C. maculatus*. The percentage of adult emergence of *C. maculatus* in blackgram seeds treated with diatomaceous earth was 21.06% which was significantly the lowest value when compared to untreated control (86.03%). The total count of emerged adult beetles from the main sample was less in diatomaceous earth (135.33 adults) against untreated control (751.67 adults). Among all the treatments tested, diatomaceous earth performed better in controlling the adult emergence of *C. maculatus.*

Key words: Adult emergence, Blackgram, *Callosobruchus maculatus,* Diatomaceous earth, Inert minerals, Spinosad.

INTRODUCTION

Pulses are one of the most significant food products in the world, because of their greater protein level. It contains 20-30 per cent protein, is rich in lysine and tryptophan and is a good supplement to cereals and root crops. The per capita availability of pulses has declined compared to the FAO/ WHO recommendation of 51.30 g per day (2019) to 47.90 g per day (2020). The position of Indian production of most pulses is 23.01 MT and processes the most pulses at around 22.0 MT, but it also imports about 3.0 MT (2020) annually on average to satisfy its rising consumption requirements (MoA and FW).

The most significant insect pest infesting pulses is the pulse beetle, *Callosobruchus maculatus*. The grubs are accountable for the damage, because they consume the complete grain's composition, leaving only the shell. The infestation spreads to stores after the beetles attack in the field.

Mixing of inert materials such as ashes and botanical powders to grains or seeds against insect pest attacks has been practiced by farmers of Indian origin for a long back. Four categories of inert dust are used to safeguard stored products. Clay, sand, paddy husk ash and other materials in the first category have been demonstrated to have insecticidal qualities (Edwards and Schwartz, 1981). Minerals like magnesite, dolomite, copper oxychloride and limestone form the second category. The third category comprises silica-containing manufactured dust (silicon dioxide). Dust with naturally occurring silica, like Diatomaceous Earth (DE), composed of fossilized skeletons of diatoms, belongs to the fourth category. Nowadays, DE dusts are widely accessible and used in both developed and emerging nations to manage insects in stored products (Korunic, 1998). The action of inactive dusts is most commonly understood to harm arthropods by removing the outer lipid layers which leads to an increased loss of water from the epidermis (Ebeling and Wager, 1961).

Biodegradable botanicals like neem (*Azadirachta indica*), sweet flag (*Acorus calamus*), phoolakri (*Lantana*

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camara), draik (*Melia azedarach*), kali mirch (*Piper nigrum*), and Basuti (*Adhatoda zeylanica*) are effective and easily accessible options for managing storage insect pests and are eco-friendly. Spinosad is a commercially available insecticide with low environmental risk and is organically derived. It is a neurotoxin made up of tetracyclic macrolide compounds spinosyns A and D (hence, spinosAD), which operate on the GABA receptors and post-synaptic nicotinic acetylcholine receptor. This mode of action is different from that of other known insecticides (Thompson *et al*., 2000). It has been authorized for use in over 250 products across 50 countries. (Mertz and Yao, 1990; Thompson *et al.,* 2000). Insect pests that affect pulses result in significant global quantitative and qualitative losses. The use of inert minerals and botanicals will be a key part of the management of pests in stored products, even though Pest management strategies are evolving to align with consumer preferences for insecticide residue-free food. Inert minerals and botanicals provide a solution to address concerns regarding insecticide safety for humans, hinder the development of insecticide resistance in pests and adhere to stringent insecticide regulations. Therefore, this study aims to evaluate the influence of inert minerals and botanical powders on the adult emergence of *C. maculatus*.

MATERIALS AND METHODS

Materials used in the experiment

Diatomaceous earth, China clay, Paddy husk ash, Cow dung ash, Sweet flag powder, Neem kernel powder and Spinosad.

Methodology

The dosages of inert minerals and botanicals are given in Table 1. One kilogram of black gram was taken in three replications and treated with inert minerals and botanicals. Ten pairs of newly emerged adult beetles were introduced into individual jars. These beetles exhibited sexual dimorphism, with easily distinguishable male and female characteristics. The females were notably larger than the males, possessing an overall darker appearance, while the males had a brown hue. Specifically, the plate covering the end of the abdomen exhibited distinct differences: it was larger and displayed dark areas along the sides in females, while in males, it was smaller and lacked the darkened regions (Christopher and Lawrence, 2014). Any live adult beetles, if present in the treated jars, were removed after ten days of egg-laying. Later the eggs were permitted to hatch and were kept in an incubation until they developed into adult beetles. A small portion of 50 grams was taken in small plastic jars from these treatments, replication-wise.

Table 1: Dosages of inert minerals and botanicals by mixing with seed method.

Treatments	mg per Kg of seed
Diatomaceous earth	420
China clay	1620
Paddy husk ash	1020
Cow dung ash	3300
Sweet flag powder	480
Neem kernel powder	520
Spinosad	23

mg = milligram Kg= kilogram.

The small plastic jars were kept at room temperature of 32±20°C and 75±2% relative humidity. From this subsample, the day of the first adult emergence, day-wise number of adults and the total number of adults emerged were recorded to calculate per cent adult emergence. The count of adult *C. maculatus* beetles that emerged from the seven different treatments and the control group was carried out daily, starting from the first day and they were removed from their respective containers. This counting process was continued until no more beetles emerged. The total number of adults emerged was recorded as per the standard procedures at 40 DAT from the main sample. From the sub-sample, the per cent adult emergence was calculated as mentioned below:

Percent adult emergence

The percentage of adult emergence for the test insect was computed by using the following formula:

Per cent adult emergence =

$$\frac{\text{Total number of emerged adults}}{\text{No. of eggs retained in the sample}} \times 100$$

The data obtained on per cent adult emergence, day of first adult emergence and the total number of adults emerged from the main sample were subjected to suitable transformations and subjected to ANOVA (CRD) (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Day of first adult emergence

No significant difference was observed among the treatments concerning the first day of adult emergence of *C. maculatus* on treated black gram seeds and untreated control. The initial emergence of adult *C. maculatus* was noted on the 30th day which was the earliest/ minimum in untreated control. The initial emergence of adult *C. maculatus* was noted at 38.36 days which was the maximum in spinosad treated seeds. Diatomaceous earth, sweet flag powder, neem kernel powder, paddy husk ash, china clay and cow dung ash have shown first adult emergence on 37.02, 36.20, 35.60, 33.60, 32.20, and 31.62, mean days respectively where there was no notable difference in significance observed between the treatments as mentioned in Table 2.

Adult emergence

The highest adult emergence of 86.03 per cent was noticed in untreated control and differed significantly from all other treatments except cow dung ash which was on par with the untreated control with an adult emergence per cent of 76.23.

Table 2: Effect of inert minerals and botanicals on the adult emergence of *C. maculatus*.

Treatments (mg/Kg)	Day of first adult emergence (days)	% Adult emergence*	Total number of adults emerged from each sample***
Diatomaceous earth (420 mg/kg)	37.02	21.06 (22.65)^{ab}	135.33 (2.09)^{b}
China clay (1620 mg/kg)	32.20	65.20 (45.35)^{ef}	530.07 (2.71)^{ef}
Paddy husk ash (1020 mg/kg)	33.60	54.16 (41.17)^{de}	422.33 (2.61)^{e}
Cow dung ash (3300 mg/kg)	31.62	76.23 (49.16)^{fg}	626.67 (2.78)^{fg}
Sweet flag powder (480 mg/kg)	36.20	32.10 (30.86)^{bc}	249.07 (2.39)^{c}
Neem kernel powder (520 mg/kg)	35.60	43.13 (36.46)^{cd}	310.12 (2.47)^{cd}
Spinosad (Check) (23 mg/kg)	38.36	10.36 (16.31)^{a}	80.33 (1.89)^{a}
Control	30.00	86.03 (52.44)^{gh}	751.67 (2.87)^{gh}
SEm(±)	3.33	3.13	0.04
CD (P=0.05)	NS	9.40	0.13
CV%	1.23	1.06	1.22

*Values in parentheses are angular transformed values, **square root transformed values, Where? ***log transformed values. In a column means followed by same letter do not differ significantly by LSD (P=0.05).

The lowest adult emergence of 10.36% was observed with spinosad which was on par with diatomaceous earth with an adult emergence percent of 21.06, but the spinosad treatment significantly differed from all the treatments including untreated control as indicated in Table 2. These were followed by 32.10 per cent adult emergence in sweet flag powder which was on par with diatomaceous earth. These were followed by neem kernel powder and paddy husk ash with adult emergence of 43.13 and 54.16 per cent, respectively which were on par with each other. These were followed by china clay and cow dung ash with adult emergence of 65.20 and 76.23 per cent, respectively which were on par with each other. Among the inert minerals, the lowest adult emergence (21.06%) was found in diatomaceous earth which was on par with the spinosad (insecticide check) but showed a significant difference with the other inert minerals. Among botanicals, both sweet flag powder (32.10%) and neem kernel powder (43.13%) were found to be effective.

The results obtained in this experiment can be corroborated by the findings of Mondal *et al.* (2018) who noticed that the mean number of *C. chinensis* adults that emerged from the 250 chickpea seeds ranged from 0.0 to 87.00 when treated with the concentrations of spinosad ranged from 50 to 1000 ppm with significant difference with the control (87.00). Similarly, Wakil *et al*. (2010) found that the highest number of offspring emerged in the untreated control jars (94.3 adults per jar), which was significantly different from the treatments involving diatomaceous earth at concentrations of 200, 400, 600 and 800 ppm when mixed with gram seeds. The maximum dose (800 ppm) of DE demonstrated the lowest number of *C. maculatus* adults (5.3 adults per jar). The current findings align with the research by Kaur *et al.* (2019), where they observed the lowest adult emergence of *C. chinensis* (0.44 beetles) with sweet flag powder. This result was statistically distinct from the other plant powders, except for neem leaf powder-treated pea seeds, which yielded 1.66 beetles compared to 78 beetles in the untreated control. The current results corroborate with the results of Adebayo and Ibikunle (2014) who stated that the emergence of *C. maculatus* adults from untreated control (3.13) was not significantly different from those that emerged from seeds treated with powered clay (2.97) but both were significantly higher than the number of adults that emerged from cow dung ash (2.31) and rice husk ash (2.53) treated cowpea seeds.

Total number of adults emerged from main sample

The data on the total number of adults emerged from the main sample (Table 2) was less in spinosad-treated seeds (80.33 adults) and diatomaceous earth (135.33 adults) followed by sweet flag powder (249.07 adults) which significantly differed from all treatments. A greater number of adults emerged from untreated control (751.67) which was on par with cow dung ash-treated seeds (626.67).

CONCLUSION

In the current study, Diatomaceous earth proved as the most effective treatment, showing the lowest adult emergence of *C. maculatus* in stored black gram, followed by sweet flag powder. This suggests that resource-constrained farmers could benefit from using inert minerals like Diatomaceous earth for controlling pulse beetles in stored black gram, especially considering the potentially prohibitive costs of chemical pesticides. Additionally, employing inert minerals and botanical pesticides presents a viable strategy for mitigating environmental pollution and other associated hazards. Moreover, with the widespread use of chemical pesticides in farming and agro-industries, transitioning to these alternative methods could be prudent and beneficial.

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Conflict of interest

All the authors, certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria, educational grants, participation in speakers' bureaus, membership, employment, consultancies, stock ownership, or other equity interest and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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