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Eco-friendly Techniques Against Pulse Beetle in Seeds Under Storage: An Insight

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Abstract: Pulse beetle *Callosobruchus* sp. (Coleoptera: Bruchidae), a cosmopolitan insect, is commonly spread in the subtropical and tropical regions and presents a significant danger to stored legumes. So many of the pulse bugs inhabit the field seeds, and no concealed infestation is found before storage. *Callosobruchus* sp. helps field infestation of pulse crops. It tends to become very widespread and serves as a possible cause of population construct-up in post-harvest stores causing significant losses. Post-harvest losses can be reduced by detecting the hidden infestation. Insecticide fumigation is commonly used to inhibit the infestation, but their application has many adverse effects on the ecosystem. Injudicious use of chemical insecticides under storage is not safe for consumption, and insects may develop resistance towards these insecticides. So there is an increased need to explore alternative and eco-friendly methods for the management of this pest while retaining the grain quality.

Keywords: Pulse beetle, Field infestation, Pest management, Insecticide, *Callosobruchus*

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Introduction

Callosobruchus maculatus (F.) (Coleoptera: Bruchidae), Pulse beetle, is generally referred to as cowpea weevil or bean insect. This is the primary pest of the preserved cowpea, green gram, black gram, and other pulse grains (Onyido *et al.*, 2011). This is a cosmopolitan pest generally spread in subtropical and tropical regions (Giga and Smith, 1983). *Callosobruchus* sp. induces possible legume losses by consuming grain protein, and their risk varies from 12-30% in developing countries (FAO, 1994). Females produce eggs on seed coating, and larvae grow

predominantly inside seeds, at the cost of embryo and endosperm grain, which are responsible for damage to cowpea. Infested seeds are becoming rapidly porous, resulting in perforation and weight loss, with adult insects forming flaws at the end of larval development. The *C. maculatus* is one of the cowpea's most crucial storage pests throughout the tropics (Park *et al.*, 2003). Among preserved seed pests of the pulse, pulse bug, *Callosobruchus chinensis* L. is known to become the most common and most cost-effective pest (Ahmed *et al.*, 2003). Around 20-25% post-harvest

losses occur due to the use of traditional methods in the developing countries (Maneepun, 2003).

Field infestation of pulse crops by *Callosobruchus* sp. seems to exist very common (Mohan and Subbarao, 2000). The *C. maculatus* infestation begins in the field and proceeds to storage (Messina, 1984). While this field infestation happens at a very low rate, it serves as a possible cause of population develop-up in stores throughout the post-harvest season, causing significant losses (Khavilkar and Dalvi, 1984). Many pulse bugs infest field crops, and concealed infestations are not observed before storage.

Adverse effects of synthetic insecticides used to protect grain:

Synthetically derived insecticides have performed a significant function in the growth of agriculture in particular and primarily in storing post-harvest grains (Ogendo and Hagstrum, 2004; Mbata and Fadamiro, 2005). Although, their use by farmers is criticized throughout the world. While the significance of insecticides in the management of pests have been identified, the misapplication of chemicals exposes human populations to potential health risks and adversely affects the environment (Fields and White, 2002; Pazou *et al.*, 2006). The consequences of pesticide use include the growth of multiple cancers and the possibility of immunotoxic, neurotoxic, genotoxic, reproductive disturbances, and a high occurrence of psychological and dermatological disorders (Alavanja *et al.*, 2004).

Storage and use of insecticides in unsafe areas and disposing of empty packages after use can increase environmental risks. One of the significant issues caused by the misuse of synthetic insecticides and inappropriate usage of insecticides is the emergence of resistant strains among the communities of controlled pests, which leads to the challenges of managing these insects. Resistance to different insecticides has also been confirmed in many preserved-product insects globally (Leontieva *et al.*, 2006; Opit *et al.*, 2012).

Eco-friendly techniques against pulse beetle:

The utilization of dust and fumigants is successful in managing bruchids but is inefficient at the farm level due to non-sealed rural storage systems. The application of pesticides in food grains stored for consumption purposes is harmful (Bekele *et al.*, 1995). Inappropriate application of chemicals impacts the ecosystem and disturbs the food chain contributing to biomagnifications (Rajendran, 2003). A further limiting factor under consideration is the establishment of resistance by preserved grain pests against certain insecticides. A few strains of *Tribolium castaneum* (Sinha and Watters, 1985) and pulse beetle (Singh and Srivastava, 1983) had already developed resistance against malathion.

Reproduction and development of storage pests are affected due to secondary metabolites, which are produced from some plant sources. In this regard, several researches have been performed on the impacts of plants with the insecticidal potential to regulate cowpea beetle. (Keita *et al.*, 2001; Sanon *et al.*, 2006; Dabiré *et al.*, 2008; Ilboudo *et al.*, 2010; Ileke and Olotuah, 2012; Ekeh *et al.*, 2013; Asawalam and Anaeto, 2014; Ilboudo *et al.*, 2015).

The non-chemical eco-friendly techniques including seed coating by plant extracts/oils (Schoonhoven, 1978), seed drying by the bio-electrical thermal device (Monica and Natarajan, 2016), integrating host plant resistance (Pedigo, 1996), controlled atmosphere, the release of natural enemies (Doumma *et al.*, 2010), dielectric heating [microwave (MW), radio frequency (RF)] (Fu, 2004), irradiation techniques leading to male sterility (Faruki *et al.*, 2007), insect growth regulators (IGR) and usage of pheromone traps (Ukeh *et al.*, 2013), etc. can be used for the management of the pest while maintaining the quality of the grains (Fig. 1). The farmers utilize the locally available and affordable plant oils as grain protectants.

Fig. 1: Eco-friendly techniques for the control of pulse beetle.

Use of plant parts and extract:

Researchers have revealed various effects of phytochemicals and plant extracts on pests such as antifeedant action, oviposition deterrent, inhibition of juvenile hormone synthesis, repellent action, and lessening of the life span of intermediates and adults (Khan *et al.*, 2015; Singh and Pandey, 2016; Kausar *et al.*, 2017; Singha and Rajkumari, 2021). The mechanism of action of the oils is partly due to activity on natural respiration, which results in suffocation (Schoonhoven, 1978, Campolo *et al.*, 2018).

For many decades, the utility of plant substances for preserving grain, especially cowpea, has been seen as a potential alternative to synthetic insecticides (Govindan *et al.*, 2020). Plant substances can produce volatile chemicals that neutralize or mislead adult beetles and eventually prevent emigration and invasion or treated stocks (Boeke *et al.*, 2004).

Use of edible and non-edible oils:

Mishra and Faruqui (2019) reported the optimal and effective dose of neem and karanj oil having pesticide value against the cowpea beetle, *C. maculatus* on stored cowpea. The non-edible oils (karanj oil and neem oil) were evaluated for their efficacy in managing the cowpea beetle. Treatments with different doses of neem oil

(0.10%, 0.25%, 0.5% and 1.0%) and karanj oil (0.25%, 0.5%, 0.75% and 1.0%) have been suggested. The data was recorded for % seeds with eggs laid, the number of eggs per seed, perforations per seed, % damaged seeds, and Weevil Perforation Index (WPI). The efficacy of the treatment has been worked out based on adult emergence holes and WPI. The neem oil (0.5 and 1.0%) and karanj oil (1.0%) provided absolute protection of stored seeds as these treatments did not show a single damaged seed. The % germination in all treated seeds was also worked out. The results of this study suggested that the non-edible oils (neem oil and karanj oil) were found to protect from seed weevil. Mishra and Faruqui (2019) have suggested that non-edible oils can be explored as an alternative to chemical insecticides against pulse beetle, *C. maculatus* in cowpea seed under storage.

The use of non-edible oils and edible oils could provide surface protection for pigeon pea against *Callosobruchus chinensis*. The seeds could effectively be protected up to 9 months of storage by using an 8 ml/kg quantity of seeds (Singh, 2003). Maximum reduction such as 97.9% in the emergence of F1 adult and 89.1% of fecundity can enhance developmental period up to 14.4% (Namdev *et al.*, 2014). After the use of neem oil as a grain protectant, the parental mortality was

found to be 91.70% (Meghwal *et al.*, 2007). Hossain *et al.* (2014) observed that the seed oils of sesame, castor, neem, and karanj (4 to 8 ml/kg) showed a substantial reduction in weight loss of chickpea seeds and seed infestation. The use of edible oils against pulse beetles is safe and effective without any harmful effect to the human beings (Nair *et al.*, 2020).

Use of plant insect-resistant cultivars:

Harvesting insect-resistant cultivars are the most promising, eco-friendly, cost-effective, and feasible way to reduce the dependency on pesticides in agriculture (Pedigo, 1996). The resistant varieties of various legume crops have been developed.

Use of parasitoids as biological control:

Biological control against *Callosobruchus* sp. has not been commonly utilized, although many parasitoid species are reported. The parasitoids in combination with resistant cowpea cultivar IT 81D-994 have drastically suppressed the appearance of *C. maculatus* at storage (Doumma *et al.*, 2010).

Natural prevalence of *Dinarmus* sp, bruchid parasitoid (Pteromalidae: Hymenoptera) has been identified in the stored black grams seeds and field level. In 5 separate sets (A to E), 500 black gram seeds were distributed with 2 sets of fresh bruchid adults with 3 replicates. After bruchid inoculation, two pairs of freshly formed adult parasitoids were released at 5, 10, 15, and 20 days (A to D). A set of control (E) was maintained with no parasitoid release. In the treatments, first-generation parasitoids produced on the 5th and 10th day had more adult parasitoids (9.0 and 11.0), and bruchid adult appearance was less (3.0 and 2.0) in the treatments. The bruchids and parasitoids were permitted in the same collection of seeds for up to four generations. The adult appearance of parasitoids was the strongest in the second generation, and the least was the occurrence of bruchid and parasitoid in the subsequent period. During the second generation, the seeds in control were completely damaged. Mass culture methods

of the parasitoid and the possibility of large-scale release to manage bruchids should be researched in the future (Soundararajan *et al.*, 2012).

Use of controlled atmosphere packing:

In controlled atmosphere packing (CAP), the grains are kept in a modified atmosphere like a high concentration of carbon dioxide (CO₂) with a low oxygen level. The bag must be airtight. The atmospheric conditions within the bag control the fungi and breeding insects, which eliminates any need for fumigation. Modified atmosphere (MA) provides another alternative where pressurized cylinders produce additional desired gases (N₂ or CO₂), and after the treatment, there are no harmful residues (Sujeetha *et al.*, 2014).

Mechanical control and Physical control:

A treatment method was developed to achieve 100% cowpea weevil mortality coupled with RF forced hot air to heat a substance at 60 C for 10 min, accompanied by forced air cooling for 20 min (Jiao *et al.*, 2012).

In a recent study (Mishra and Faruqui, 2017), uninfected cowpea seeds of susceptible variety EC-4216 (250 g) were provided with 8 treatments viz., mixed with fine sand (20 and 40% w/w), coarse sand (20 and 40% w/w), and sand layer (fine and coarse) of 1 cm and 2 cm, respectively to find out suitable alternative against the cowpea beetle, *C. maculatus*, on stored cowpea. The fine sand layer of 2 cm provided absolute protection of stored seeds as these treatments did not show a single damaged seed. The maximum % germination was 100% in the treatment with the 2 cm layer of fine sand. The results of this study suggested that the fine sand was found to protect from seed weevil. So fine sand can be explored as an alternative to chemical insecticides against pulse beetle, *C. maculatus* in cowpea seed under storage (Mishra and Faruqui, 2017).

Use of ionizing radiation:

The ionizing ultraviolet light having photon energies of 3 to 124 eV and wavelengths of 10-400

nm have sterilized, prevented emergence or damaging effect on stored grain pests by destroying their DNAs (Faruki *et al.*, 2007). Different ionizing radiations used on grains are X-rays, high-energy electrons, gamma rays from radioactive cobalt-60 and cesium-137. At lower doses, these radiations can sterilize the insects (Shadia and Abd El-Aziz, 2011).

Conclusion

In the current scenario, there is an utmost need to search for a natural compound, which can serve as an alternative to chemical pesticides due to their untoward environmental and health issues. The detection of hidden infestation can reduce the post-harvest losses. Different eco-friendly non-chemical methods have been suggested for the management of the pulse beetles. For the inhibition of the infestation, the fumigation with insecticides is widely used method. However, it shows various harmful effects on consumers and environment. The indigenous materials of botanical origin have been found to possess toxic, deterrent and/or repellent properties against insects when mixed with grain. Hence, many naturally occurring substances and plant products having insecticidal properties can serve as an alternative to chemical pesticides in agriculture.

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