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Management Strategies of Pulse Beetle through Eco-Friendly Methods in Various Legume Genotypes - A Review

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ABSTRACT

Callosobruchus spp. is a common and major pest of stored legumes. Indiscriminate use of synthetic organic insecticides leads to several health hazards to human being and development of resistance against pesticide is alarming. Therefore, there has been an increased need to explore suitable alternative methods of pest control. A number of Bio pesticide formulations are available which will be eco-friendly and biodegradable. The use of edible oils to protect stored grains, especially pulses against insect pests is an ancient method of pest control in India. In addition to edible oils, extracts and plant parts of certain readily available plants, such as neem have also been utilized in villages where storage facilities are poor. In light of the adverse effects of insecticides on the environment, these methods of pest control are now attracting greater attention and research input. Because of universal compatibility, non-residual and non-toxic nature, it finds a key role in IPM.

Key words: *Botanicals, Biopesticides, pulse beetle.*

INTRODUCTION

Choudhury and Pathak[11] reported that different oils *viz.*, neem, groundnut, soyabean and sesame were highly effective against the pests attacking stored products even at a low concentration of 0.25ml/100g seed.

Treatments with karanj oil (5 and 10 ml/kg) and castor oil (10 ml/kg) effectively reduced bruchid *C. chinensis* oviposition, without impairing the viability of mungbean seed over a period of 18 months[31].

Choudhury[12] worked out the residual effect of eight vegetable oils (groundnut, sesame, linseed, soyabean, neem, castor, safflower and coconut) on chickpea against *C. chinensis* and reported that all oil treatments showed significant reduction in the number of eggs laid, adult emergence and seed damage.

Among twelve vegetable oils tested, the least reduction in grain weight by the bruchid grubs was recorded in seeds treated with the oils of soyabean, castor, taramira, mustard, coconut, groundnut, safflower, rice bran and sunflower @ 1 ml/kg seed, whereas there was no damage in seeds treated with the oil of castor, soyabean, mustard and taramira @ 3 ml/kg seed[36].

Chinwada and Giga[10] reported that commercial vegetable oil and neem oil were very effective against pulse beetles till sixteen weeks to reduce oviposition, per cent eggs hatching, progeny emergence and seed damage when applied at the rate of 2.5 ml/kg seeds. They also reported more than 90% mortality of the pulse beetles.

Khatre *et al.*[17] studied the efficacy of ten vegetable oils viz., sunflower, castor, mustard, safflower, groundnut, palm, sesamum, neem, Karanj and corn each of 5, 7.5 and 10 ml/kg of seeds as seed protectants of Pigeonpea against *C. chinensis* L. and found that neem, castor, Karanj and corn oils retained their toxicity against bruchid adults upto 100 days of storage at 1% level.

Bhadauria and Jakhmola[5] studied the efficacy of groundnut, sesame, soyabean, mustard and neem oils (10 ml/kg of seeds) as repellent, ovipositional deterrent and ovicidal agent against *C. maculatus* on cowpea seeds and reported that the number of eggs laid (8.9) were lowest, while adult emergence, survival rate, grain damage and seed weight loss were not observed, in seeds treated with neem oil.

Bhargava and Meena[6] studied the efficacy of some vegetable oils against pulse beetle, *C. chinensis* on cowpea and found that all the oils caused significant mortality in adults three days after treatment and the mean mortality varied from 60.0 to 80.2 per cent in different oils. They also reported that the oils also inhibited the oviposition in treated seeds as against untreated control. However, there was no adverse effect of test oils on the germination of seeds up to 150 days of treatment.

Yadav *et al.*[39] worked with 9 edible/non-edible oils (10 ml/kg seed) against *Callosobruchus maculatus* in greengram and found that the mortality was significantly higher in oil-treated seeds compared with the control. They also observed a gradual reduction in the efficacy of the oils with delay in time. Castor oil was the most effective treatment, recording no adult emergence, seed damage and seed weight loss.

Biswas and Biswas[7] conducted a laboratory experiment on pre-storage seed treatment of gram (*Cicer arietinum*) with the oils of aripple (*Lantana* sp.), karanj (*Pongamiapinnata*), eucalyptus, neem, palas (*Buteamonosperma*), citronella (*Cymbopogon* sp.) and anona (*Annona* sp.) against *Callosobruchus chinensis* and reported that citronella and neem oil at 2.5 and 5.0 ml/kg of seed effectively controlled *C. chinensis* population by reducing oviposition rate and these treatments also recorded the least seed damage and weight loss due to pulse beetle infestation, as well as the highest percentage of gram seed germination.

Bajya *et al.*[4] worked on the efficacy of some vegetable oils against *C. chinensis* on cowpea seeds and found that neem oil was the most effective in giving the maximum adult mortality (96.0%) 3 days after treatment at 1.2 ml/100 g seeds, whereas, in the control no mortality was observed. The next best treatment was the castor oil at 1.2 ml/100 g seeds, causing 84.0% mortality of the pest.

Khalequzzaman *et al.*[16] evaluated seven vegetable oils *viz.*, sunflower, mustard, groundnut, sesame, soybean, olive and oil palm at the rates of 5, 7.5, and 10 ml/kg of grain as grain protectants of pigeonpea against the pulse beetles and reported that adult emergence was completely prevented and the minimum grain loss was achieved by groundnut oil at 1% up to 66 days after treatment.

Swella and Mushobozy[38] reported that cowpea seeds treated with coconut oil showed greater potential in protecting cowpea against bruchids damage.

Sharanabasappa and Kulkarni[33] studied the efficacy of neem, castor, karanj, mustard, sunflower, oil palm and coconut oils against the fecundity of *C. chinensis* in greengram under laboratory conditions and they reported that among the oils neem oil, castor oil and karanj oil recorded the lowest number of eggs per 50 seeds and similar trend was observed at 60, 90 and 120 days after treatment and they also concluded that there was no adverse effect on germination of seeds at 60 and 120 days after treatment.

Ani[3] investigated the influence of some oil extracts *viz.*, cashew nut oil, coconut oil, udasa nut oil and neem leaf oil in controlling stored black bean weevil (*C. chinensis*). the results showed that the seeds treated with coconut oil extract proved more effective than other oils and was recommended for use by farmers.

Ram *et al.*[30] conducted an experiment to evaluate the effect of some plant materials, sweet flag, goat weed, lantana, Indian privet, mug-wort, chinaberry, rice husk ash, mustard oil and neem oil against pulse beetle. They concluded that the rhizome powder of sweet flag, rice husk ash and mustard oil showed a significant effect in killing the pulse beetle within a week at 0.5, 1 and 2 per cent concentrations. Neem oil was found very effective with 100 per cent mortality of the beetle within two days.

Raja *et al.*[29] conducted the experiment to evaluate the effect of plant volatile oils in protecting stored cowpea *Vigna unguiculata* L. Walpers against *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) infestation. The results revealed that the oils of *Menthaarvensis*, *M. piperata* and *M. spicata* significantly reduced the number of eggs laid for a period of 3 months and *Cymbopogon nardus* for a period of 2 months ($P < 0.05$).

An experiment was conducted for the comparison of the pathogenicity of the entomopathogenic fungi, *Beauveria bassiana, Metarhizium anisopliae* and *Paecilomyces fumosoroseus*to *Callosobruchus maculatus*F. The experiment revealed that the *M. anisopliae* treated adults had the lowest LD50 value

($2.33x10^6$ spores/ml). However, the lowest LD50 value was displayed by adults exposed to *B. bassiana* treated seeds (4.14 days). There was no significant difference (p=0.05) between the LT50 values of *M. anisopliae* and *P. fumosoroseus* treated seeds[19].

Essential oils extracted from five plant materials were tested on oviposition and progeny production of F_1 adult of cowpea bruchid, *Callosobruchus maculatus*F.on cowpea seeds. The results revealed that the *Cymbopogon citratus* and *C. nardus* showed higher effect on oviposition and F_1 adult emergence than the essential oils of *Alpiniacalcarata*, *Cinnamomum zeylanicum* and *Murrayakoeinigii*[25].

Twelve indigenous and exotic isolates of *Beauveria bassiana* and *Metarhizium anisopliae* were evaluated for their virulence and their ability to suppress populations of *Callosobruchus maculatus*F.in stored cowpea by Cherry *et al.*[9]. They concluded that *B. bassiana* 0362 was consistently more virulent than *M. anisopliae* 0351.

Experiments were conducted by Rahman and Talukder[27] to study the bio-efficacies of different plant/weed derivatives that affect the development of the pulse beetle, *Callosobruchus maculatus* fed on blackgram seeds. The results showed that the plant oils were effective in checking insect infestation. The least number of F_1 adults emerged from black gram seeds treated with neem oil.

An experiment was conducted on efficacy of botanicals, bio pesticides and insecticide against pulse beetle, *Callosobruchus chinensis* L. on Bengal gram. They found that neemazal as surface treatment was recorded to be the most effective in reducing egg laying and adult emergence of this bruchid followed by ipomoea, citronella, *Bacillus thuringiensis* var. *kurstaki* and granulosis virus than control[21].

Andre *et al.*[1] evaluated ten *Metarhizium anisopliae* isolates according to their virulence, correlating chitinolytic, proteolytic and α-amylolytic activities, as well proteomic analysis by two dimensional gels of fungal secretions in response to an induced medium containing *Callosobruchus maculatus* F.shells, indicating novel biotechnological tools capable of improving cowpea crop resistance. The results shown that an initial screening revealed the pathogenicity of *M. anisopliae* towards the cowpea weevil *C. maculatus*. Bioassays indicated that three isolates (CG34, CG292 and CG100) demonstrated lethal activity against bruchids, causing considerable mortalities. For isolates CG34 and CG100, CL50 tests were performed, showing no statistical differences between isolates.

Sharda Tripathi *et al.*[34] conducted the experiment to evaluate the effect of neem leaf powder on infestation of the pulse beetle *Callosobruchus chinensis* L.in stored pigeon pea (*Cajanus cajan* L.). General mixing of seeds with neem leaf powder has been the effective control measure of pest infestation and show statistically significant effects over pest infestation.

Andre *et al.*[2] evaluated the insecticidal activity of ten strains of *Beauveria bassiana* and the most lethal fungi strains were analyzed for proteinaceous secretions by two dimensional electrophoresis and for enzyme activities, including chitinolytic, proteolytic and α-amylolytic activities. In which *B. bassiana* screening strains showed that this fungus is more virulent than to *M.* a*nisopliae*. All *B. bassiana* isolates tested caused mortality to *C.maculatus*.

The experiment was conducted by Rahman *et al.*[28] to find out the efficacy of dodder vine extract as seed protectant against pulse beetle, *Callosobruchus chinensis*L. on gram seed. They concluded that the dodder vine extract was found effective in checking oviposition, adult progeny development and severity of seed damage. Seeds treated with 5 per cent concentration of dodder vine extract were less preferred for oviposition, adult emergence and seed weight loss by *Callosobruchus chinensis* L.and this concentration might be useful in protection of pulse seed.

The experiments were conducted by Hossain and Haque[15] to study the efficacy of some indigenous leaf and seed extracts against pulse beetle, *Callosobruchus chinensis* L. on chickpea seeds. The results revealed that all the tested extracts except methi were found effective significantly to check the oviposition, adult emergence, seed infestation and weight loss as compared to control. The extracts of neem seed had no adverse effects on seed germination up to three months of storage.

Sivakumar *et al.*[37] conducted an experiment to evaluate the fumigant toxicity of essential oils against pulse beetle, *Callosobruchus maculatus* F. (Coleoptera: Bruchidae). The results revealed that the lowest LD50 value was observed for eucalyptus oil (11.66 $\mu l l^{-1}$of air) and the LD50 value of geranium was the highest (25.11 $\mu l\ l^{-1}$ of air).

An experiment was conducted to evaluate the suppressive efficacy of entomopathogenic fungi *Beauveria bassiana* against adults of *Callosobruchus maculatus* F. and *Sitophilus granarius* L. on stored grains in darkness. Probit analysis showed that the lowest LT50 values in suspensions with highest concentrations ($2.3x10^7$ conidia per ml) were 6.63 and 10.45 days for *Callosobruchus maculatus* F. and *S. granarius*, respectively[32].

Golnaz Shams *et al.*[14] conducted the experiment to evaluate the suppressive efficacy of entomopathogenic fungi *Beauveria bassiana* against adults of *Callosobruchus maculatus* F. and *Sitophilus granarius* L. on stored grains in darkness (27±2°C and 65±5 per cent relative humidity). Probit analysis showed that the lowest LT50 values in suspensions with highest concentrations (2.3×10^7 conidia per ml) were 6.63 and 10.45 days for*Callosobruchus maculatus* F. and *S. granarius*, respectively.

Shiva Vanmathi*et al.*[35] conducted the laboratory bioassay with five different concentrations of *Beauveria bassiana* ($1x10^4$ to $1x10^8$ ml^{-1}) against the pulse beetle, *Callosobruchus maculatus*F. The results showed that the entomopathogenic fungus, *Beauveria bassiana* caused maximum oviposition reduction and 100 per cent adult mortality was obtained at higher concentrations. Mortality declined with the decrease in concentrations. At higher concentrations, oviposition reduction was 60.58 per cent, and adult mortality was 99.44 per cent at 92 hours respectively.

Zahra Mahdneshin*et al.*[40] conducted the pathogenicity of five Iranian isolates of *Beauveria bassiana* and *Metarhizium anisopliae* was evaluated against adults of *Callosobruchus maculatus*F.adults by immersion bioassay method at 27 ± 1°C and 60 ± 5 per cent relative humidity under laboratory conditions. The results revealed that cumulative mortality of the cowpea weevil at day 11 after treatment with *B. bassiana* isolates IRAN 187C, IRAN 429C, IRAN 441C and *M. anisopliae* isolates IRAN 715C and DEM I001 by conidial suspensions at low and high concentration ranged between 29.4 to 86.2, 9 to 88.3, 21.1 to 96.3, 24.8 to 84.4 and 20.9 to 80.9 per cent, respectively. IRAN 441C of *B. bassiana* had the highest virulence against adult cowpea weevil because it had lower LC50 and LT50 and caused the highest mortality (76 per cent) in treatment by suspensions containing 1×10^8 conidia per ml. *B. bassiana* had higher virulence than *M. anisopliae* against adult of cowpea weevil.

Patel[23] conducted the experiments with extracts of Indian squill *Urginea indica* R., fruit of desert date *Balanites aegyptiaca* L. and seeds of castor *Ricinuscommunis* L. on fecundity, fertility, POP, S.I. and Longevity of pulse beetle *Callosobruchus chinensis* L. were studied. The results revealed that the percent decrease in fecundity has been affected and found to be highest in 2 per cent castor seeds, less in 1.5 per cent desert date and least in 1.5 per cent onion extracts.

Krishnappa*et al.*[18] conducted the experiment with the medicinal plant essential oils such as *Curcuma longa, Zingiberofficinale, Murrayakoenigii* and *Ocimumcaasiym* were investigates for their insecticidal, anti-ovipositional and antifeedant activity against *Callosobruchus maculatus*. They concluded that among four essential oils highest percentage of mortality were showed in (58-81 per cent) *Ocimumcanum* at 500 ppm concentrations. All essential oils showed complete feeding deterrent action at 500ppm concentrations.

Pradyumn and Jakhmola[24] conducted an experiment to evaluate the efficacy of botanical extracts on biological activities of pulse beetle *Callosobruchus maculatus* F. on green gram. The results revealed that the percentage reduction in adult emergence continuously decreased up to 90 days, post treatment under all botanical treatments. At one day after treatment, reduction in adult emergence varied from 25.50 to 65.10 per cent, whereas, it was 6.63 to 25.90 per cent at 90 days after treatment.

Carlos *et al.*[8] conducted the experiments on the susceptibility of the bean beetle *Callosobruchus maculates* F. to *Metarhizium anisopliae* var. *anisopliae* (URM3349) and *Metarhizium anisopliae* var. *acridum* (URM4412) strains was assessed at concentrations of 10^8, 10^7, 10^6, 10^5 and 10^4 conidia per mlunder laboratory conditions. The results revealed that at the concentration of 10^8 conidia per ml, mortality of *Callosobruchus maculatus* F.caused by *M. anisopliae* var. *anisopliae* and *M. anisopliae* var. *acridum*was 74.45 and 58.27 per cent, respectively. The LC50 of *M. anisopliae* var. *anisopliae* was estimated at 9.2×10^3 conidia per ml.

Experiments were conducted to enhance the virulence of two isolates of entomopathogenic fungi, IRAN-187C of *Beauveria bassiana* (Balsamo) Vuillemin, and A-396 isolate of *Metarhizium anisopliae* (Metschnikow) Sorokin, by combination with Insecto-Sec® formulation of diatomaceous earth (DE) against the adults of *Callosobruchus maculatus* F. under laboratory conditions. The results revealed that the combinations between diatomaceous earth and the fungal isolates at lethal and sub-lethal doses achieved high mortality rates in the adult populations; moreover, the treatments improved LT50 values of the fungi[22].

Francisco *et al.*[13] conducted an experiment to evaluate the pathogenicity of different isolates of *Beauveria bassiana* to control *Callosobruchus maculatus* F. in adult phase under laboratory conditions. They found that mortality percentage varied from 12.24 to 100 per cent in the course of nine days experiment. The isolates of *B. bassiana* showed highly pathogenic, characteristic confirmed by mortality superior to 40 per cent in the insects treated until to fourth day in all conidial concentrations tested. Among isolates studied, URM2921, URM2923 and URM4544, presented as the most virulent to the target-insect.

The efficacy of two entomopathogenic fungi *Metarhizium anisopliae* (Deuteromycotina: Hyphomycetes) and *Beauveria bassiana* (Ascomycota: Hypocreales) formulations were assessed against cowpea bruchid, *Callosobruchus maculatus*F. by Radha[26]. The results revealed that in liquid formulation of *Baeuveria bassiana* against *C. maculatus*the percentage of adult mortality was 96 per cent in $5x10^6$ conidialconcentrations at 96 hours interval and LT 50 value was only 1.24 per cent. Comparison of LC50,LT50 values and mortalities indicated that in both assays, *B. bassiana* was consistently morevirulent to bruchids than *M. anisopliae* because it had lower LC50 and LT50 and caused thehighest mortality (96 per cent) in treatment by suspensions containing 5×10^6 conidia per ml.*B. bassiana* had higher virulence than *M. anisopliae* against adult of cowpea weevil.

The efficacy of three entomopathogenic fungi *Paecilomyes fumosoroseus*, *Nomuraea rileyi* and *Verticillium lecanii* alone and with the combination of Natural diatomaceous earth (DE) and silica gel Cab-O-500 and Cab-O-750 evaluated against *Callosobruchus maculates* F. and*Callosobruchus chinensis* L. (Coleoptera: Bruchidae). The results showed that modified diatoms with Calcium hydroxide (Ca-DE) and modified diatoms with Sodium hydroxide (Na-DE) were the highlight treatments against the two tested insects and achieved the highest mortality percentages. The fungus *P. fumosoroseus* was the most effective alone against *C. maculates* LC50, recorded 149 spore/ml.[20].

Further research is required to explore some new botanicals &bio pesticide formulations, which can, more efficiently, be utilized for the food-safety purpose and to overcome the dilemma of health hazards and environmental pollution.

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