Eco friendly management of Pulse beetle [*Callosobruchus maculatus* (Fabricius)] on stored Black gram [*Vigna mungo* (Linnaeus)] at Prayagraj, India

ABSTRACT

The study was conducted in Completely Randomized Design (CRD) with 7 treatments and 1 untreated control each replicated thrice in Laboratory conditions. The treatments are T1 (clove powder), T2 (black pepper powder), T3 (asafoetida latex powder), T4 (castor oil), T5 (cinnamon oil), T6 (citronella oil), T7 (Spinosad 45 SC) and T8 (untreated control). From the above treatments Spinosad gave 100% mortality at 3, 7 and 10 DAR of pulse beetle, 1.20% grain damage and 2.81% weight loss of seeds after 30, 60, 90 and 120 DAR of pulse beetle. Black pepper gave 87.77% mortality, 3.30% grain damage and 8.58% weight loss which resulted with little difference from Spinosad. Black pepper even gave 73.33% germination after 6 months of storage. Castor oil ranked next by recording 57.77% mortality, 7.48% grain damage and 13.91% weight loss. When compared with the result of biological insecticide the botanicals namely black pepper was found to be as effective as the biological insecticide. It also showed higher percentage of germination. Since majority of the pulses are damaged at storage by bruchids and managing them with the use of insecticides leads negative impact on the environment, an alternative strategy using botanicals which can be easily attained by farmers that are budget friendly with promising results and low health hazards was experimented. Present findings concluded that the locally available treatments gave good protection to the damage caused by bruchids on black gram seeds during storage. Effectiveness of the treatments in decreasing order is Spinosad > black pepper > castor oil > clove powder > cinnamon oil > citronella oil > asafoetida latex powder.

Keywords: Black gram (*Vigna mungo* L.), Botanicals, Bruchids, Pulse beetle (*Callosobruchus maculatus* F.), Storage pest management.

1. INTRODUCTION

Pulses are the ancient food crops with evidence of their cultivation for over 8000 years. They are important source of protein in many developing countries and are considered as the second most important group of crops worldwide. They are biologically rich source of protein and essential minerals that complement well with cereal based diet because of high

amount of lysine. Indian Council of Medical Research has recommended an average daily consumption of 40 grams of pulses. Hence there is an urgent need for increasing the pulses production to meet the growing demand for consumption (Ramazeame *et al*., 2014). India is the largest producer and consumer of pulses in the world contributing around 25-28% of the total global production. Pulses are well suited in rainfed conditions and require less farm resources, hence farmers prefer to grow them from economic point of view throughout the country (Sushmita *et al*., 2019). The total pulse production In India in the year 2021-22 is 26.96 million tonnes with an area more than 28 million ha for pulses cultivation which leads to the largest pulse producing country in the world. It ranks first in area and production with 31% and 21% respectively (Annual report, Government of India: 2021-22).

In stored grains, damage caused by insects are very common and are of great concern. *Callosobruchus maculatus* F. is one of the most serious pests that can cause total loss of the stored grain in a few months (Soe *et al*., 2020). The initial infestation occurs in the field itself. It causes decreased germination potential, weight loss and reduction in commercial value of the seeds (Okunola 2003). Due to attack of *C. maculatus*, 55-60% loss in seed weight, 45.50-66.30% loss in protein content and pulse seeds have been reported and they became unfit for human consumption as well as for planting (Gujar and Yadav 1978). At present, pest control measures on storage crops depend on the use of synthetic chemicals, but it is not advisable to mix insecticide with food grains due to the environmental health hazard and development of genetically resistant pest. Moreover, synthetic chemicals are costly and most of the farmers prefer locally available, cheap, and effective method to control the notorious pest. Since most of the farmers store their crops in homes, there is a need to develop safer and cheaper alternatives for insect pest control (Islam *et al*., 2013).

Recently, the use of different plants and their derivatives has appeared as an effective alternative to the poisonous chemical insecticides or the traditional methods for the control of various insect pests of crops and storage. The plant product like Black pepper (*Piper nigrum*), Asafoetida (*Ferula asafoetida*) and Clove powder (*Syzygium aromaticum*) (Swamy and Wesley, 2017) and botanical oils with insecticidal properties like Cinnamon (*Cinnamomum verum*), Citronella (*Cymbo pogonnardus*), Kaffir Lime (*Citrus hystrix*) (Soe *et al*., 2020), Vetiver oil (*Chrysopogon zizanioides*), Citrodora oil (*Eucalyptus citriodora*) (Raja and William, 2008), Castor (*Ricinus communis*) (Ratnasekera and Rajapakse, 2009) are becoming an attractive alternative to the synthetic, dangerous and more expensive insecticide used in developing countries. With the objective of providing quality food for general public the

interest of researchers has been directed towards finding alternative to pesticide like use of essential oils, powdered spices and herbs, botanicals that are environment friendly and pose less dangers to the ecosystem. At the same time plant-derived materials are more readily biodegradable, relatively specific in the mode of action and easy to use. Therefore, a study was undertaken to screen some botanicals powders like herbs, spice powders *viz*., Clove powder, Black pepper powder, Asafoetida latex powder and essential oils *viz*., Castor oil, Cinnamon oil, and Citronella oil comparing their effectiveness with Spinosad a biopesticide and an untreated control with a view to explore the insecticidal properties against Pulse beetle (*Callosobruchus maculatus* F.) on stored Black gram (*Vigna mungo* L.) in laboratory condition with the objective to evaluate the efficacy of certain botanicals like powdered herbs, spices and oils against Pulse beetle (*Callosobruchus maculatus* F.) on stored Black gram (*Vigna mungo* L.). and to observe impact of germination on the treated Black gram (*Vigna mungo* L.).

2. MATERIALS AND METHODS

The present study was carried out at Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P from October to April 2022 – 2023 to know the efficacy of botanical oils and essential oils against Pulse beetle (*Callosobruchus maculatus* F.) on black gram (*Vigna mungo* L.) by comparing their results with biological insecticide on Per cent mortality of the pest, Per cent weight loss and Per cent grain damage of the seeds along with germination impact on treated pulse seeds under laboratory conditions.

2.1 Seed of Black gram:

Five Kg seeds of black gram was obtained from Malwa organics a certified organic farm at the rate of 180 rupees per Kg. They were completely free from insects and microorganisms. The grains were cleaned from straw, dust, light grains, and other impurities before testing.

2.2 Plant materials:

Botanicals *viz*., black pepper was harvested from Nongdam (T) Village Kamjong district, Manipur, India. clove and asafoetida latex were collected from the local markets sun dried and grinded into powder. Essential oils *viz*., cinnamon oil, castor oil and citronella oil were purchased from Vaadi herbals which is 100% pure essential oils.

Table 1: Botanicals and their plant parts.

Botanicals	Plant parts
Clove	Buds
Black pepper	Seeds
Asafoetida	Latex
Castor	Seeds
Cinnamon	Bark
Citronella	leaves

2.3 Other materials:

Petri plates, dropper, plastic container, muslin cloth, weighing machine, germination paper etc. were obtained from Department of Entomology, SHUATS, Prayagraj.

2.4 Pest description:

Table 2: Pest description.

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Family	Chrysomelidae
Genus	*Callosobruchus*
Species	*maculatus*

2.5 Insect culture: Rearing of *Callosobruchus maculatus* F.

To initiate the culture, healthy grains of Black gram were kept in two cylindrical jars of 500g capacity and 20 pairs of bruchid adults were isolated and released into each jar. The mouth of the container was covered with a muslin cloth secured firmly by rubber band.

After the emergence of new adults, the bruchids were introduced into healthy Black gram seeds kept in series of cylindrical jars for research purpose. These studies were conducted at 30 to 35^0C temperature and 70-80% relative humidity in laboratory.

3. RESULTS AND DISCUSSION

3.1 Efficacy of botanicals against pulse beetle on stored black gram (*Vigna mungo* L.).

The experiment was conducted on the effect of botanicals powders *viz*., clove, black pepper, asafoetida latex and essential oils like cinnamon oil, citronella oil and castor oil as surface protectants and contact toxicants against *C. maculatus*. Pulse beetle (*Callosobruchus maculatus* F.) of 5 pairs were released in the 24 jars of which 18 treated jars are with botanical powders and essential oils, 3 jars treated with bio pesticide and 3 untreated jars containing 100g of Black gram each. The efficacy of the botanicals against pulse beetle was evaluated considering Per cent adult mortality at 3,7 and 10 Days after release, Per cent grain damage at 30,60,90, and 120 days after release of Pulse beetle, Per cent seed weight loss at 30, 60, 90, and 120 days after release of Pulse beetle from the treated seeds**.**

Per cent adult mortality

$$= \frac{\text{Total number of dead pulse beetle}}{\text{Total number of pulse beetle released}} \times 100$$

Per cent grain damage

$$= \frac{\text{Number of bored seeds}}{\text{Total number of seeds}} \times 100$$

Per cent weight loss

$$= \frac{\text{Initial weight} - \text{Final weight}}{\text{Final weight}} \times 100$$

3.1.1 Efficacy based on Per cent mortality:

The results after treating the seeds for 3 DAR, 7DAR and 10 DAR revealed that maximum mortality of *Callosobruchus maculatus* F. on Black gram was observed on seeds treated with 4ppm of Spinosad 45 SC at 100% mortality and 87.77% mortality on 3g of black pepper treated seeds **(Table 3)**. This was followed by treatments with 5% castor oil, 3g clove powder, 1% cinnamon oil, 5% citronella oil and 400mg of asafoetida powder at 57.77%, 44.44%, 34.44%, 27.77%, and 7.77% respectively where, citronella oil and castor oil were on

par with each other. The least effective among the treatments is asafoetida latex powder at 7.77% which is significantly different from the untreated control at 0.00%.

The data depicted the effect of different treatments on overall mean of adult mortality of pulse beetle, *C. maculatus* F. in Black gram under different exposure periods. After 3, 7, and 10 Days of Release of five pairs of pulse beetle on all the experimenting units, adult mortality observed on the treated seeds was recorded highest at spinosad treated seeds and lowest at asafoetida treated seeds. 2nd highest mortality record was observed in 3g of black pepper treated seeds which were on par with 4ppm of spinosad treated seeds.

Per cent mortality was observed comparing the research works from Islam *et al*., 2013 on black pepper powder, Soe *et al*., 2020 on cinnamon oil and citronella oil and Ahmed *et al*., 2016 on clove powder.

3.1.2 Efficacy based on Per cent Grain damage:

The results after treating the seeds with botanicals for 30 DAR, 60 DAR, 90 DAR and 120 DAR were evaluated and the means were recorded and analyzed. According to the recorded data the minimum grain damage of black gram was observed on seeds treated with 4ppm of Spinosad 45% SC at 1.20%. Comparing with the results of the botanicals, black pepper was found to be as effective with grain damage of 3.30% which were at par with spinosad. Castor oil was the next effective treatment with Per cent grain damage of 7.48% which were at par with black pepper powder. Castor oil, clove powder, and cinnamon oil were at par with each other at 7.48%, 14.20% and 19.47% respectively followed by citronella oil (24.22%) which were at par with cinnamon oil. The least effective treatment causing the most grain damage is by 400 mg of Asafoetida latex powder at 34.04% which is significantly different from the untreated control at 54.94%.

Data collected after 30 Days of Release revealed that grain damage observed on the treated black gram seeds was with a range of 0.00% to 19.10%. The most effective treatment that resulted in minimum Per cent grain damage is spinosad treated black gram seeds at Per cent grain damage of 0.00% and the least effective botanical treatment that have maximum Per cent grain damage at 30 DAR is asafoetida powder at 19.10% grain damage. The untreated control had 31.50% grain damage at 30 DAR. Similarly, after 60, 90, and 120 DAR Per cent grain damage observed on the treated seeds was maximum at asafoetida treated seeds and minimum at spinosad treated seeds at a range of 0.00% to 26.43% and the untreated control had 41.74% grain damage at 60 DAR, 1.38% to 37.65% and the untreated control had

62.45% Per cent grain damage at 90 DAR, 3.41% to 52.99% and the untreated control had 84.06% grain damage at 120 DAR respectively.

Per cent grain damage was observed comparing the research works from Miah *et al*., 2013 on castor oil, Soe *et al*., 2020 on cinnamon oil and citronella oil and Swamy and Wesley 2017 on black pepper, clove powder and asafoetida powder.

3.1.3 Efficacy based on Per cent weight loss:

The results after treating the seeds with botanicals for 30DAR, 60DAR, 90DAR and 120DAR were recorded and evaluated. The means of the time period were compared and one overall mean was observed. The results revealed that minimum weight loss is observed on seeds treated with spinosad at 2.81%. Black pepper treated seeds also gave overall weight loss of 8.58% which were at par with spinosad treated seeds. Seeds treated with 5% castor oil and 3g of clove powder also gave Per cent weight loss of 13.91% and 16.29% which were at par with each other followed by 1% of cinnamon oil at 20.16% which were at par with clove powder. Seed treatment at 1% cinnamon oil (20.16%) and 5% citronella oil (20.76%) were also at par with each other. 5% Citronella oil treated seeds also gave weight loss of 20.76% which were at par with asafoetida treated seeds at 25.14%. The least effective among the treatments which have maximum weight loss is 400 mg of asafoetida treated seeds at 25.14%, which is significantly different from the untreated control at 40.62% **(Table 3).**

Data collected after 30, 60, 90, and 120 Days of Release revealed that weight loss observed on the treated black gram seeds was with a range of 0.00% to 13.04% and the untreated control at 22.49% weight loss at 30 DAR, 0.00% to 21.09% and the untreated control at 33.95% weight loss at 60 DAR, 3.76% to 29.63% and the untreated control at 45.02% weight loss% at 90 DAR, 7.48% to 36.80% and the untreated control at 61.02% weight loss at 120 DAR respectively.

Per cent mortality was observed comparing the research works from Islam *et al*., 2013 on black pepper powder, Soe *et al*., 2020 on cinnamon oil and citronella oil and Ahmed *et al*., 2016 on clove powder.

Table 3: Efficacy of botanicals against pulse beetle on stored black gram (*Vigna mungo* L.).

Treatment symbols	Treatments	Per cent adult mortality				Per cent grain damage					Per cent weight loss				
		3 DAR	7 DAR	10 DAR	mean	30 DAR	60 DAR	90 DAR	120 DAR	mean	30 DAR	60 DAR	90 DAR	120 DAR	mean
T1	Clove powder	33.33	46.67	53.33	44.44	8.98	12.38	15.36	20.07	14.20	6.92	10.59	17.60	30.03	16.29
T2	Black pepper powder	83.33	86.67	93.33	87.77	2.17	1.77	3.96	5.28	3.30	2.05	4.55	9.96	17.76	8.58
T3	Asafoetida powder	3.33	6.67	13.33	7.77	19.10	26.43	37.65	52.99	34.04	13.04	21.09	29.63	36.80	25.14
T4	Castor oil	53.33	56.67	63.33	57.77	3.50	6.41	8.15	11.86	7.48	5.84	10.18	16.07	23.56	13.91
T5	Cinnamon oil	30.00	33.33	40.00	34.44	10.53	16.55	21.24	29.55	19.47	11.35	16.04	21.56	31.67	20.16
T6	Citronella oil	23.33	26.67	33.33	27.77	14.71	20.60	27.84	33.74	24.22	12.70	17.25	22.68	30.40	20.76
T7	Spinosad 45 SC	100.00	100.00	100.00	100.00	0.00	0.00	1.38	3.41	1.20	0.00	0.00	3.76	7.48	2.81
T8	Untreated control	0.00	0.00	0.00	0.00	31.50	41.74	62.45	84.06	54.94	22.49	33.95	45.02	61.02	40.62
C.D. at 5%		7.901	8.655	7.901	6.473	3.535	2.895	2.095	1.624	15.860	2.453	3.645	5.821	6.537	13.978
SE(m)		2.635	2.887	2.635	2.205	1.169	0.957	0.693	0.537	5.402	0.811	1.205	1.925	2.162	4.789
SE(d)		3.727	4.082	3.727	3.118	1.653	1.354	0.980	0.760	7.639	1.147	1.705	2.723	3.057	6.773
C.V. %		11.170	11.215	9.205	9.799	17.904	10.540	5.393	3.088	54.412	15.096	14.695	16.041	12.602	51.682

3.2 Germination impact on the treated black gram (*Vigna mungo* L.).

Black gram seeds after storing for 6 months were subjected to germination test. 50 seeds from each container were subjected to germination test by rolled paper towel test according to International Rules of Seed Testing at initial month. Here the germination paper was first labelled and soaked in water. The seeds were alligned in the manner of 5 X 10 seeds per germination paper. After placing the seeds, the germination paper was rolled and were secured with two rubber bands at the ends after proper labelling. The rolled papers were wet or watered after every alternate day. The germinated seeds were counted after 7 days and recorded for further study to find out impact of germination on the treated black gram (*Vigna mungo* L.).

Germination response on the treated black gram (*Vigna mungo* L.) was calculated by the formula:

$$\text{Germination \%} = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ seeds} \times 100$$

3.2.1 Germination impact on stored black gram with treatment after 6 months of storage:

The germination test was recorded after 6 months of storage with treatment. The recorded germination count was converted into percentage *i.e.*, 54% to 73.33% and data were subjected to ANOVA. From the recorded data, it can be stated that 3 g of black pepper powder treated seeds gave the best result for germination at 73.33%, followed by 3g of clove powder treated seeds (70.06%) which were at par with each other. The next effective treatment on germination would be by 4ppm of Spinosad treated seeds (68.66), 5% of cinnamon treated seeds (68%) which were on par with clove powder. 5% of castor oil treated seeds (64.00%), 400 mg of asafoetida treated seeds (63.33%) and 1% of citronella treated seeds (63.33) were also on par with each other with citronella oil. The least effective among the treatments which have minimum per cent germination is citronella treated seeds and asafoetida treated seeds at 63.33%, which is significantly different from the untreated control at 54.00% **(Table 4).**

The germination % after 6 months of storage ranged from 54.00% to 73.33%. The maximum germination % after 6 months of storage was observed in Black pepper treated seeds at 73.33% and the treatment with the least germination% was observed in asafoetida powder and citronella oil treated seeds at 63.33% which is significantly different from the untreated

control at 54.00 %. The data of current experiment revealed that the germination per cent of black gram seeds stored upto 6 months under controlled condition was higher than the germination of untreated seeds.

Germination % was observed comparing the research works from Rathod *et al*., 2019 on clove powder and black pepper powder.

Table 4: Germination impact on stored black gram with treatment after 6 months of storage.

Treatment symbols	Treatments	Germination %
T1	Clove powder	70.66
T2	Black pepper powder	73.33
T3	Asafoetida powder	63.33
T4	Castor oil	64.00
T5	Cinnamon oil	68.00
T6	Citronella oil	63.33
T7	Spinosad 45 SC	68.66
T8	Untreated control	54.00
C.D. at 5%		9.210
SE(m)		3.046
SE(d)		4.308
C.V. %		8.034

4. CONCLUSION

From the present study, among all the six botanicals comparing their efficacy with Spinosad on the basis of adult mortality, grain damage and weight loss, black pepper treated seeds gave the best results which was at par with spinosad treated seeds. Castor oil treated seeds ranked next most effective botanical treatment after black pepper treated seeds. Among the three powders, black pepper powder was found to be most effective in terms of adult mortality and among the three botanical oils, castor oil was found to be the most effective in terms of both mortality, seed weight loss and grain damage against management of *Callosobruchus maculatus* Fabricius. Effectiveness of the treatments in decreasing order is Spinosad > black pepper > castor oil > clove powder > cinnamon oil > citronella oil > asafoetida latex powder. When compared with the result of biological insecticide the botanicals namely black pepper

was found to be as effective as the marketed bio-pesticide and also showed higher percentage of germination. The findings of the current investigation indicate that the botanical treatment namely black pepper powder is highly effective against pulse beetle on stored black gram and can be used as a sustainable pest management strategy which can be easily attained by farmers that are budget friendly with promising results, low health hazards and less environmental pollution. Based on the current study, botanicals like herbs and spice powders along with essential oils has potential to protect black gram seeds against pulse beetle (*C. maculatus* F.). Thus, the result of this study showed that the locally available treatments gave good protection to the damage caused by bruchids on black gram seeds during storage.

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