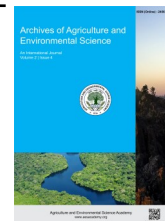




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ORIGINAL RESEARCH ARTICLE



Biology and eco-friendly management of cowpea weevil (*Callosobruchus maculatus*) in pea

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ABSTRACT

A study was conducted in the Entomology laboratory of Gauradaha Agriculture Campus at Jhapa district of Nepal to observe the biology and evaluate the efficacy of botanicals against cowpea weevil (*Callosobruchus maculatus*), which causes serious seed losses of leguminous crops during storage. The cowpea weevil was observed to complete its life cycle with egg-larva-pupal stages lasting 7-18-5 days respectively and the adult lived for 16 days. A completely randomized design was laid with 3 replications of seven treatments; neem (leaf powder) mugwort (leaf powder), sweet flag (rhizome powder), turmeric (rhizome powder), black pepper (seed powder), clove (seed powder), and lemongrass (leaf powder), each 10gm kg⁻¹ pea seeds and compared to an untreated control. Adult mortality and grain damage were recorded for 14 days after treatment at 2 days' interval. Significant ($p \leq 0.001$) differences in the mortality of weevils and grain damage were observed among the treatments. Black pepper showed the highest efficacy with full mortality within 2 days and least grain damage (1.94%) followed by clove (3.33%) and sweet flag (6.67%) reaching full mortality within 4 days, lemongrass (17.50%) and turmeric (14.16%) reached 100% mortality within 12 and 14 days, while neem and mugwort showed very slow effectiveness causing 90% and 86.66% mortality in 14 days and significant grain damage. However, untreated pea seeds suffered severe grain damage (35.83%) and provided conditions for the development of new generation weevils. The results depicted that the use of botanicals provide protection against grain damage, demonstrating their potential as an eco-friendly measure for sustainable storage pest management in legumes.

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INTRODUCTION

The cowpea seed beetle, *Callosobruchus maculatus* Fabricius (Coleoptera: Chrysomelidae), commonly referred to as the bean beetle or southern cowpea weevil, is a well-known and destructive insect pest that affects legume crops, especially during storage (Singh, 1977). Originally native to Africa and Asia, this beetle has now spread across much of the tropical and subtropical world, posing significant challenges to legume producers in

these regions (Beck & Blumer, 2014). The beetle primarily targets members of the legume family (Fabaceae), and its larvae develop exclusively inside legume seeds, a trait that justifies the common name "cowpea weevil". *C. maculatus* undergoes complete metamorphosis (Holometabolous development), progressing through four distinct life stages: egg, larva, pupa, and adult. The eggs and adults are usually found on the seed surface, while the larvae and pupae reside within the grain. Upon hatching, the larvae bore into the seed and consume the endosperm, the nu-

trient-rich part of the grain. This feeding behavior not only destroys the nutritional value of the seed, making it unfit for human consumption, but also compromises its viability for future planting or sprouting. Legumes are one of the most important and affordable sources of plant-based protein for both humans and livestock. They are often referred to as the "poor man's meat" due to their nutritional value and accessibility (Dubey et al., 2024). Thus, protecting legume crops from storage pests like *C. maculatus* is not only essential for economic sustainability but also for maintaining food security and public health (Kodandaraam et al., 2025). *C. maculatus* has been documented to attack more than 21 legume species, but it has a particular preference for crops such as pigeon pea (*Cajanus cajan*), soybean (*Glycine max*), species of *Phaseolus*, and cowpea (*Vigna unguiculata*) (CABI, 2018). These host plants are major components of many smallholder farming systems. The beetle can cause both quantitative and qualitative damage, with recorded losses in stored legumes ranging from 60% to a complete 100% destruction, depending on storage conditions and pest management practices (Pereira, 1983; Bamaiyi et al., 2006; Adebisi & Tedela, 2012).

Female *C. maculatus* lay oval to spindle-shaped, clear, shiny eggs (approximately 0.6–0.75 mm long) glued to the outer surface of legume seeds (Beck & Blumer, 2014; Devi & Devi, 2014). Under warm laboratory conditions, eggs typically hatch within about 4–8 days, though controlled study observed egg durations of 4–5 days (Salunkhe & Gaikwad, 2023). After hatching, the tiny larva chews through the base of the egg and burrows into the seed. The larva is curved, white, and has a small head, which lasts around 8 to 9 days (Raina, 1970). The second instar larva continues burrowing deeper into the seed and feeding on the endosperm and lasts 3 to 4 days. Being more active and voracious feeder, the third instar larva eats aggressively and consumes most of the endosperm. This phase lasts 4 to 5 days (Devi & Devi, 2014). This larva metamorphoses into a whitish exarate pupa, often positioned right under the seed coat that typically lasts 4–7 days under favorable conditions. Devi & Devi (2014) measured pupae lengths of 4.07 mm (male) and 4.57 mm (female), with breadths of ~2.35 mm and 2.60 mm, respectively. The adult beetle stays inside the seed for a few days before chewing a round hole to emerge. Adults are oval-shaped with reddish-brown or chocolate-colored bodies. The wings (elytra) are short, leaving the last abdominal segment exposed. Males are smaller and rounder, while females are slightly larger and have dark stripes on both sides of their abdomen. Adult males live for 9–12 days, and females for 10–14 days (Beck & Blumer, 2014).

To combat this pest, synthetic chemical insecticides have historically been the most widely used method of control. Numerous studies have documented the effectiveness of various commercial insecticides against *C. maculatus* in laboratory and field conditions (Al-Mekhlafi et al., 2012; Mahdavi et al., 2012; Vidyashree et al., 2016; Okonkwo et al., 2017). However, the indiscriminate use of these chemicals has raised serious environmental and health concerns. Over time, pests may develop resistance to these chemicals, reducing their efficacy. Addition-

ally, pesticide residues on grains intended for human and animal consumption can pose significant health risks, including long-term chronic exposure effects. These substances, when improperly handled, can affect the nervous system, causing symptoms such as nausea, vomiting, headaches, dizziness, and in severe cases, seizures, convulsions, or death (Banks et al., 1990). This is a significant concern in regions where regulatory oversight and farmer training on pesticide use may be limited. Due to these challenges, researchers and agricultural extension services are increasingly promoting the use of botanicals and other eco-friendly pest management strategies. Bio-pesticides, often derived from plant extracts or naturally occurring substances, offer numerous advantages over synthetic chemicals. They are generally less toxic, degrade more quickly in the environment, have minimal impact on non-target species, and are effective in small quantities. These qualities make them particularly suitable for small-scale and resource-poor farmers in developing countries (Khan, 2021). Therefore, this research was aimed to study the effectiveness of plant extracts for the management of cowpea weevil after understanding its biological development.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the laboratory of Gauradaha Agriculture Campus, Gauradaha-2, Jhapa district of Nepal. The study area lies 26°33'42" N latitude and 87°43'13.6" E at 70 masl. The site was selected due to accessibility to the researcher and suitable environmental conditions.

Experimental design

The design used was Completely Randomized Design with 8 treatments with 3 replications of each (Table 1).

Preparation of treatments

Neem: Neem leaves were collected from the local areas of Gauradaha, chopped into small pieces and wrapped in newspaper. Then the leaves were subjected to oven dry for 12 hours at 110°C, until the leaves were brittle enough to be grinded into fine powder. After the leaves were ready, they were taken out of the oven and then grinded using grinder and fine powder was made.

Mugwort: Mugwort leaves were collected from the local area, chopped into small pieces and wrapped in newspaper. Then the leaves were subjected to oven dry for 12 hours at 110°C, until the leaves were brittle enough to be grinded into fine powder. After the leaves were ready, they were taken out of the oven and then grinded using grinder and fine powder was made.

Sweet flag: Rhizome of sweet flag was collected from the locality and then subjected to oven dry for 12 hours at 110°C until it was brittle to be grinded into fine powder. The powder was then prepared by grinding the dried rhizome.

Table 1. Details of treatments.

S. No.	Notation	Treatment Details	Dose
1	T1	<i>Azadirachta indica</i> (Neem)	10gm kg ⁻¹
2	T2	<i>Artemisia vulgaris</i> (Mugwort)	10gm kg ⁻¹
3	T3	<i>Acorus calamus</i> (Sweet flag)	10gm kg ⁻¹
4	T4	<i>Curcuma longa</i> (Turmeric)	10gm kg ⁻¹
5	T5	<i>Piper nigrum</i> (Black pepper)	10gm kg ⁻¹
6	T6	<i>Syzygium aromaticum</i> (Clove)	10gm kg ⁻¹
7	T7	<i>Cymbopogon citratus</i> (Lemongrass)	10gm kg ⁻¹
8	T8	Control (Untreated)	-

Turmeric: Locally available turmeric powder was used as treatment.

Black pepper: Dry seeds of black pepper were collected from local market and grinded into fine powder using grinder and used as treatment.

Clove: Dry seeds of clove were collected from the local market and grinded into fine powder using grinder and used as treatment.

Lemongrass: Lemongrass leaves were collected from the local area, chopped into small pieces and wrapped by newspaper. Then the leaves were subjected to oven dry for 12 hours at 110° C, until the leaves were brittle enough to be grinded into fine powder. After the leaves were ready, they were taken out of the oven and then grinded using grinder and fine powder was made and used as treatment.

Procedure

For the efficacy of botanicals

Pea seeds were collected from the local market of Gauradaha, Jhapa. Obtained pea seeds were dried in sun for a day to remove excess moisture and possible insect infestation. The dried pea seeds were placed in 10 jars. After that, the seeds were infested with 3 male and 2 female cowpea weevils to produce next generation for maintaining uniformity during treatment. When the next generation adults were obtained, some healthy pea seeds were separately treated with powdered form of neem, mugwort, sweet flag, turmeric, pepper, clove and lemongrass at the concentration of 10g in 1000 g seed and one control was prepared with no treatment. 70 g of pea seeds were kept in each of the 24 jars and hence, 0.7 g powder of each botanical was used as the treatment. Each plastic jar was infested with 10 adult cowpea weevils obtained by rearing.

For study of biology

To study the life cycle of cowpea weevil, sample of adult weevil was taken from the mother culture. 3 males and 3 females were selected randomly and placed in a jar containing untreated pea seeds. The jar was kept in a suitable place for providing conditions to lay eggs. After eggs were observed on the surface of the pea seeds, few seeds were retained for recording the days the eggs take to transform into larva and then to pupa which was

observed by breaking the seed. Finally, the days for the emergence of adult from the pupa was also noted and the average days were calculated from the various samples observed.

For damage percentage

The number of seeds damaged per the total number of seeds placed in the jar initially was counted for each jar which was treated with different botanicals. The ratio was calculated and expressed in percentage.

Data collection and types

Data was collected every 2 days for the number of dead beetles in each treatment. The data of mortality was collected for 14 Days from the day of treatment. Mortality% of the beetles in each treatment was calculated with each data collected. To study the damage percentage, the number of damaged seeds in each of the treatments was counted and noted. For life cycle, daily observation was done and the days taken for eggs to develop into larva-pupa and adult were noted. The primary data was collected from the experimental setup. Secondary data was collected from various online journals, books and other relevant literature.

RESULTS AND DISCUSSION

Effects of botanical extracts on mortality rate of cow pea weevil

Table 2 shows the effects of different botanical extracts on the mortality rate of cow pea weevil compared to the control after treated at specified intervals in the pea seeds. The mortality of insects varied markedly among treatments with different botanical extracts. Clear differences were observed in both the speed and extent of mortality. Clove and Black pepper were the most effective treatments, recording 96.66% and 100% mortality, respectively, by the second day. Both reached complete mortality (100%) by 4DAT and maintained it until 14DAT, confirming their rapid and consistent insecticidal action. Sweet flag also showed strong efficacy, with 100% mortality achieved by 4DAT, only slightly slower than Clove and Black pepper. In contrast, Turmeric and Lemongrass exhibited a slower mode of action. Lemongrass reached full mortality by 12DAT, while Turmeric required up to 14DAT to achieve 100%. Though eventually effective, these treatments allowed insects to survive longer in the early phase. Neem and Mugwort were the least rapid, with only 3.33% mortality observed in neem and 0% in Mugwort up to 4DAT and a gradual increase thereafter. By 14DAT, mortality

Table 2. Mortality percentage of cowpea weevil.

Treatment	2DAT	4DAT	6DAT	8DAT	10DAT	12DAT	14DAT
Neem	3.33 ^c	3.33 ^c	10.00 ^c	20.00 ^b	30.00 ^{cd}	83.33 ^b	90.00 ^{ab}
Mugwort	0.00 ^c	0.00 ^c	10.00 ^c	16.66 ^b	23.33 ^d	76.66 ^b	86.66 ^b
Sweet flag	46.66 ^b	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a
Turmeric	0.00 ^c	0.00 ^c	40.00 ^b	50.00 ^b	73.33 ^{ab}	96.66 ^a	100.00 ^a
Black pepper	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a
Clove	96.66 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a
Lemongrass	10.00 ^c	13.33 ^b	40.00 ^b	50.00 ^b	60.00 ^{bc}	100.00 ^a	100.00 ^a
Control	0.00 ^c	0.00 ^c	20.00 ^{bc}	23.33 ^b	33.33 ^{cd}	56.66 ^c	66.66 ^c
Grand mean	32.08	39.58	52.5	57.5	65	89.16	92.91
LSD (0.05)	10.59	9.98	27.36	34.43	29.97	12.73	11.71
F-test	***	***	***	***	***	***	***
CV%	19.08	14.57	30.11	34.49	26.64	8.25	7.28
SE _m (±)	1.25	1.17	6.38	4.06	3.53	1.50	1.38

DAT: Days after Treatment, CV: Coefficient of variation, LSD: Least Significant Difference, ***: Significant at 0.1% significance and SE_m(±): Standard error of mean.

in both treatments had risen significantly but had not yet reached 100%. The untreated control group showed no mortality until 4DAT, followed by a gradual increase over time, recording only 66.66% mortality by 14DAT. This mortality was likely due to natural causes or environmental stress rather than treatment effects. Though the mortality percentage in Mugwort was much slower than the control up to 10DAT, it suddenly increased reaching 76.66% in 12DAT while control was limited to 56.66%. Moreover, the development of eggs on the surface of the pea seeds with no treatment added proof to the results that cowpea weevils are uncontrollable without applying any of the botanicals. Statistical analysis indicated that differences among treatments were highly significant ($p \leq 0.001$) throughout the observation period. The coefficient of variation (CV%) ranged from 7.28% to 34.49%, reflecting acceptable variability. The standard error of mean (SE_m±) values ranging from 1.17 to 6.38 confirmed the reliability and consistency of the results.

Grain damage percentage

By the end of the experiment (14DAT), grain damage differed significantly among treatments (Figure 1). The highest damage occurred in the control group (35.83%), reflecting the absence of any protective effect. In contrast, Black pepper caused the least grain damage (1.94%), followed closely by Clove (3.33%) and Sweet flag (6.67%), showing their strong protective ability. Neem, Turmeric, Mugwort, and Lemongrass were comparatively less effective in reducing grain damage, 11.38%, 14.16% and 15% respectively, higher than that of the faster-acting botanical but still much lower than the control. Moreover, the small error bars in black pepper, clove and sweet flag represent consistency of the results across replicates while the control with large error bars indicate lower consistency.

Biology

The cowpea weevil was observed to complete its life cycle with egg-larva-pupal stages lasting 7-18-5 days respectively and the adult lived for 16 days in an average (Table 3). The findings of this study highlight that botanical extracts differ not only in their overall insecticidal effect but also in the speed with which

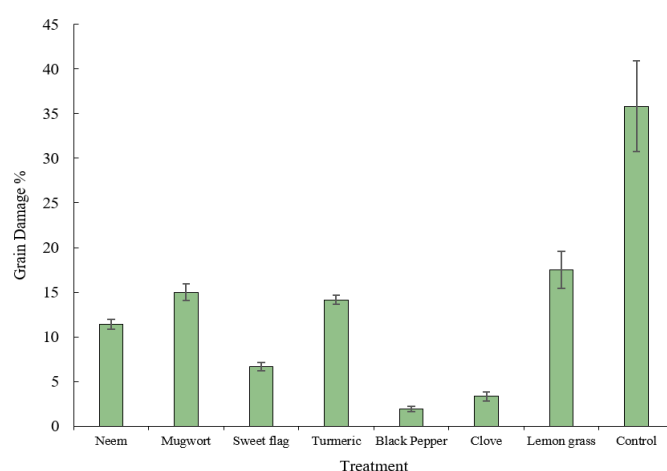


Figure 1. Stat diagram of damage percentage.

they act. Clove and Black pepper were the most promising treatments, inducing nearly complete mortality within the first few days and preventing significant grain damage. Their effectiveness is likely due to the presence of eugenol in Clove and piperine in Black pepper, both of which have been widely reported for their fumigant and repellent action against stored grain pests (Rajendran & Sriranjini, 2008; Isman & Machial, 2006). Sweet flag also performed well, reaching complete mortality by 4DAT and significantly reducing grain damage. This effect may be attributed to asarone, a compound known for its neurotoxic effects on insects (Tripathi et al., 2009). Neem, Turmeric, Mugwort, and Lemongrass acted more slowly, with mortality increasing steadily up to 14DAT. Neem, in particular, is known for azadirachtin, which disrupts feeding and growth rather than causing acute mortality (Isman, 2020). Turmeric contains curcumin, which has been reported to affect insect metabolism but requires longer exposure (Suthisut et al., 2011). As a result, while these botanicals eventually suppressed pest populations, their slower action allowed insects to damage grains before dying. Neem, turmeric, Mugwort, and lemongrass acted more slowly, with mortality increasing steadily up to 14DAT, similar to the results from the research conducted by Paramasivam et al. (2019). The findings also align with the results from the experiment of Niranjana (2022) who found out

Table 3. Biology of Cowpea Weevil.

Stages	Duration (days)
Egg	7±1
Larva	18±1
Pupa	5±1
Adult	16±2

that black pepper killed *Callosobruchus maculatus* completely within 48 hours, while clove achieved near-total mortality within 3-4 days. The control group confirmed the vulnerability of stored grains in the absence of protection, showing the highest grain damage. This finding underlines the importance of botanical treatments in storage pest management, particularly in resource-limited and organic farming systems. Overall, the results align with previous studies that emphasize the potential of plant-derived compounds as eco-friendly alternatives to synthetic insecticides (Isman & Machial, 2006; Dube et al., 2011). Among the tested botanicals, Black pepper, Clove, and Sweet flag stand out as rapid-acting, effective protectants, while Neem, Turmeric, Mugwort, and Lemongrass may serve complementary roles where gradual suppression is acceptable.

Conclusion

The present study evaluated the potential of botanical powders as eco-friendly protectants against the cowpea weevil (*Callosobruchus maculatus*), a major storage pest of leguminous crops. The results confirmed that the botanicals, particularly black pepper, clove and sweet flag powders, have the capacity to effectively suppress infestation within a short duration of time and minimize storage losses, highlighting their suitability as eco-friendly measures to manage cowpea weevil. Besides these, other botanicals like turmeric, neem, mugwort and lemongrass, despite acting slow, can minimize losses to some extent. Based on these findings, it can be concluded that the integration of botanicals into storage practices offers a safe, cost-effective, and sustainable approach to post-harvest pest management for farmers and consumers. To strengthen this practice, farmers are encouraged to adopt botanicals as practical storage protectants, while extension services should promote awareness and training on botanical-based pest control. Further research is recommended to optimize dosage, explore combinations of botanicals, and assess long-term efficacy under varied storage conditions.

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DECLARATIONS

Author contribution statement: Conceptualization: S.D. and N.P.; Methodology: S.D.; Software and validation: S.D., N.P. and D.K.; Formal analysis and investigation: S.D.; Resources: N.P.; Data curation: N.P.; Writing—original draft preparation: S.D.;

Writing—review and editing: L.K.; Visualization: D.K.; Supervision: A.S.; Project administration: N.P.; Funding acquisition: S.D. All authors have read and agreed to the published version of the manuscript.

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Ethics approval: This study was conducted in view of the institutional ethical guidelines and does not harm the human participants.

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