

Comparative Evaluation of Neem (*Azadirachta Indica*), Turmeric (*Curcuma Longa*), and Other Plant-Based Powders Against Pulse Beetles

Tumma Mounika*, V. Ramalakshmi

Department of Entomology, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati, Odisha 761211, India.

*Corresponding author email ID: tumma.mounika@cutm.ac.in

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ABSTRACT

One of the most harmful post-harvest pests of stored pulses are the pulse beetles (*Callosobruchus* spp.) which cause serious reduction in weight, viability and market value of the seeds. In tropical and subtropical regions, where high temperatures and humidity accelerate the life cycle of the beetles and lead to population growth, infestation is very severe. Pesticide residues in food, contamination of the environment, and damage to the resiliency of beetle populations are all the results of the over-reliance on chemical insecticides for controlling these pests. As a result of this there is a growing need for sustainable and environmentally friendly alternatives, such botanicals. This study is a comparative study of the efficacy of locally available plant powders viz., neem (*Azadirachta indica*) and turmeric (*Curcuma longa*) against *Callosobruchus* spp. associated with the stored pulses, particularly mungbean (*Vigna radiata*) and chickpea (*Cicer arietinum*). Effects of different powder concentrations on adult mortality, oviposition, larval penetration and seed damage were investigated over a storage period of 60 days. According to the results, neem powder was the most effective and there was significant inhibition of egg laying and adult mortality up to 85%. Beetle activity was moderately rejected (65-70%) by turmeric powder, however, the efficiency of other plant powders varied according to their phytochemical composition. The findings underscore the potential of botanicals as safe, inexpensive and biodegradable alternatives to synthetic chemicals. In addition to reducing post harvest losses, their use in the protection of stored pulses promotes ecologically friendly methods of pest control. Smallholder farmers may find useful ways to preserve the quality of seed, reduce financial losses and improve food security by adding these plant-based powders to storing systems.

1. INTRODUCTION

Pulses, also known as grain legumes, are very important for food security worldwide for their high nutritional value such as proteins (20-25%), essential minerals and vitamins and complex carbohydrates. Millions of people are dependent on them as a staple diet, particularly in developing countries, and they fix nitrogen, which enhances soil fertility, livestock feed and human health. Nearly 25% of the global pulse

production and 27% of its consumption is from India alone (FAO, 2022). Despite their importance, pulses are especially susceptible to post-harvest losses induced by insect pests of which the most destructive are the pulse beetles (*Callosobruchus* spp.). These beetles can lead to up to 70% loss of stored grains if not controlled. They infest various pulses, e.g., pigeon pea, mungbean, chickpea and cowpea. By laying their eggs on the surfaces of the seeds, *Callosobruchus* species attack pulses. Both the quantitative (weight

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loss) and qualitative (reduced germination, nutritional deterioration) damage was inflicted by the internal feeding of the emerging larvae on seeds. Control is difficult because of the strong ability of the pest to reproduce, short developmental cycle (24-36 days under ideal circumstances), and tolerance to various storage conditions. Storage losses are compounded by a number of mating habits and host preferences, which accelerate population growth further. Historically, method of control of pulse beetles has been with the use of chemical fumigants and pesticides (Bhutia et al., 2024).

Despite their temporary efficacy, these compounds have serious adverse consequences (contamination of their food, development of resistance in insects, threats to people's and animals' health). Interest in botanicals as a tactic of substitution has increased due to increased knowledge of these hazards. Bioactive substances such as azadirachtin, curcumin and essential oils of botanical powders such as neem (*Azadirachta indica*) and turmeric (*Curcuma longa*) possess ovicidal, insecticidal, repellent and antifeedant properties. These powders are economical, degradable and suitable for an organic storage system. The efficacy of certain botanicals on *Callosobruchus* spp. has been reported in several studies, though there are limited studies on comparative effectiveness under uniform conditions. The most effective and useful solutions for smallholder farmers can be found in combining the evaluation of several plants based powders. Sustainable post-harvest management plans require understanding their mechanism of action, effect on reproductive biology and effect on seed quality (Vardhan et al., 2022).

2. PLANT BASED CONTROL OF PULSE BEETLES

It is not a secret that the use of botanical powders for controlling pulse beetles (*Callosobruchus* spp.) is a safe and efficient method of avoiding synthetic pesticides. Numerous plant species have been tested with regard to their insecticidal, repellent, oviposition-inhibiting, and larvicidal properties such as neem (*Azadirachta indica*), turmeric (*Curcuma longa*), garlic (*Allium sativum*), ginger (*Zingiber officinale*), and eucalyptus (*Eucalyptus globulus*) (Islam et al., 2017; Mounika et al., 2021).

2.1. *Azadirachta indica*, or neem

One of the better-researched plants for the storage grain pests is neem. Azadirachtin, nimbin and salannin contained in its seeds, leaves and kernel powders are ovicidal, growth disrupting, and antifeedant in nature. Neem powder at rate of 5-10%

w/w in stored pulses has been shown in several trials to cause adult death rates of 70-90% in *C. chinensis* and *C. maculatus* (Swella & Mushobozy, 2019). Neem significantly reduces egg laying and larvae penetration into seeds leading to lower seed damage and lower seed weight loss in addition to mortality.

2.2. *Curcuma longa*, or turmeric

When it comes to pulse beetles, turmeric powder with its high curcumin and essential oils has a mitigated effect of insecticidal and also repellent. Turmeric can reduce oviposition by 40-50% and reduce the population of adult beetles by 60-70%, according to studies (Islam et al., 2017). Its effectiveness albeit slightly less than neem is useful in integrated storage pest management strategies because of its safety, availability and biodegradability.

2.3. Other Powders Derived from Plants

The effectiveness of some botanicals in the control of pulse beetles has been evaluated, these include powdered cloves, eucalyptus, ginger and garlic. The efficacy of these powders often differs based on concentration, storage conditions, and species type, even if they are generally associated with a moderate to high level of the mortality of adults (40-75%) and the inhibition of oviposition (30-60%) (Mounika et al., 2021). It has been noted that using a combination of different botanicals can have a synergistic effect to better the overall amount of pests.

3. MECHANISM OF ACTION OF BOTANICAL POWDERS

A diversity of complementary processes are applied by botanical powders to impact on *Callosobruchus* populations. The strong smells of plants such as clove, neem and turmeric deter adult beetles from laying their eggs on treated seeds, one of the major ways they work. Furthermore, due to the interference by bioactive substances such as azadirachtin with the normal eating habits of larvae and adults, these powders exert strong anti-feedant effects, which reduce growth rate and survival. Additionally, botanical powders also have ovicidal activity, which prevents eggs from hatching because it alters the permeability of the eggshell or interferes with the functions of vital enzymes. In addition, some of the substances in these powders have the potential to interfere with development, which would decrease the emergence of adults by interfering with larval molting and pupation (Periginji et al., 2025). Behavioral Modification is another important way. Exposure to plant powders can reduce mating activity resulting in reduced fertility. These systems work in

concert with each other to reduce the levels of infestation, inhibit population growth, and protect stored pulses and provide a safe and environmentally friendly substitute for traditional chemical insecticides. (Vardhan et al., 2021).

4. COMPARATIVE EFFICACY OF BOTANNICALS

Several studies have been done on the efficiency of neem, turmeric and other plant based powder in reducing pulse beetles (*Callosobruchus* spp.) in preserved pulses. Because it contains azadirachtin, a bioactive substance that interferes with insect molting and eating and reproduction, neem (*Azadirachta indica*) regularly turns out the highest efficacy between these botanicals (Mounika et al., 2021). By reducing oviposition and having a feeding deterrent effect, turmeric (*Curcuma longa*), which contains curcumin, provides moderate control. Clove, ginger, and garlic and other botanicals that are less well known have also shown moderate to high efficiency. When combined, these botanicals can provide enhanced pest suppression in a synergistic way which can provide a more thorough approach to management. (Mounika et al., 2021).

The comparative efficiency of various botanicals against *C. chinensis* and *C. maculatus* is shown in Figure 1 and Table 1 summarizes results of several investigations. The most effective ingredient in all these investigations is neem which is followed by turmeric and other plant powders.

1. The concentration of the applied powder: The higher the concentration, the stronger the repellent and insecticidal action of the powder is usually.
2. Storage duration: As the bioactive substances break down or volatilize, their effectiveness may be reduced.
3. Type of host pulse: Due to variation in seed size, texture and nutritional values of different pulses i.e., cowpea, mungbean, and chickpea, these pulses can influence the infestation rates and botanical efficacy.
4. Storage conditions: Both stability of botanical chemicals and the development of the beetles are heavily affected by the temperature and relative humidity.

Table 1. Performance of different botanicals against pulse beetles in stored pulses

Botanical	Pulse Type	Target Species	Observed Effects	Reference
Neem	Chickpea, Cowpea	<i>C. chinensis</i> , <i>C. maculatus</i>	Adult mortality 70–90%, oviposition inhibition 60–80%	Swella & Mushobozy, 2019
Turmeric	Chickpea	<i>C. chinensis</i>	Adult mortality 60–70%, oviposition inhibition 40–50%	Islam et al., 2017
Garlic	Cowpea	<i>C. maculatus</i>	Adult mortality 50–65%, larval inhibition 25–35%	Mounika et al., 2021
Clove	Mungbean	<i>C. chinensis</i>	Adult mortality 55–70%, oviposition inhibition 40–50%	Mounika, 2023

5. BIOCHEMICAL BASIS AND MECHANISTIC INSIGHTS OF BOTANICAL ACTIVITY

The availability of bioactive phytochemicals such as azadirachtin, nimbin, curcumin, eugenol and allicin in botanical powders is largely responsible for their insecticidal and repellants properties. Numerous disruptive effects are caused by the interactions of these chemicals with physiologic and metabolic pathways of *Callosobruchus* species. For instance, the primary active ingredient in neem, azadirachtin, reduces female fertility, impairs feeding and scuttles the hormones responsible for controlled molting and metamorphosis. The major role for turmeric is curcumin as an oviposition deterrent and antifeedant, which reduces the number of eggs laid on the treated seeds. Toxic and repulsive to larval and adult stages, such compounds as the eugenol found in clove and the allicin found in garlic inhibit growth and survival

of these stages. According to mechanistic studies, these phytochemicals make them experience slower growth, less adult emergence and less reproductive production through interference in the activity of the gut enzymes, modifications on hormonal signalling pathways and nervous system functions (Mounika et al., 2021). By understanding these biological processes, scientists and farmers may select and dose botanical powders in the best possible way for specific pulse storage situations, ensuring maximum effectiveness without compromising environmental or consumer safety. (Badavath et al., 2025).

6. INTEGRATION INTO POST-HARVEST PEST MANAGEMENT

Although botanical powders have shown great potential in controlling pulse beetles (*Callosobruchus* spp.) in stored grains, their maximum potential can only be realized when used in an

integrated post-harvest pest management strategy. Pre-storage procedures to reduce vulnerability to beetle infestation such as thorough drying of seeds to ideal moisture levels (usually 8-10%) are the first step towards effective integration. Seed sorting and grading is also of great importance; the removal of broken, damaged or infested grains will minimise the number of initial pest populations that could become a breeding ground for subsequent generations. When it comes to optimizing the effectiveness of botanical powders, storage methods are necessary. Beetle metabolism and reproduction are slowed down by methods of hermetic or airtight storage that restrict oxygen availability, such as metal silos, plastic drums with tight fitting seals or triple layered bags. Where botanical powders are used in conjunction with these storage methods, the rate of survival of *Callosobruchus* beetles is significantly reduced. In addition, the strategic combination of different botanicals may have synergistic effects which enhance insecticidal activity and reduce potential for pest resistance. For example, combining powdered garlic (*Allium sativum*), turmeric (*Curcuma longa*), or neem (*Azadirachta indica*) might all have an effect on beetle nutrition, reproduction behavior and the hormonal balance at the same time. (Mounika et al., 2025). Regular monitoring of stored grains, using simple techniques such as visual inspection, sieving or pheromone traps, ensures early detection of infestation and allows for early intervention before major losses occur. In addition to reducing dependence on synthetic pesticides, a combined post-harvest strategy using botanical powders combined with proper cleanliness of storage and moisture control and monitoring, also meets low-cost pest management, environmental sustainability and food safety criteria (Pulletikurthi et al., 2025). Smallholder farmers in poor nations particularly benefit from such tactics, which offer affordable, environmentally friendly alternatives that maintain quality of seeds and minimize human health risks linked to chemical residues (Vardhan et al., 2022).

7. CONCLUSION

Botanical powders offer feasible, sustainable and environmentally acceptable alternative to synthetic insecticides for control of pulse beetles in stored grains. Numerous biochemical processes are involved in their efficacy: phytochemicals (azadirachtin, nimbin, curcumin, eugenol and allicin) disrupt the ability of *Callosobruchus* species to feed, digest, molt, reproduce and oviposit. Because of these numerous methods, botanicals are particularly effective in controlling beetles in different stages of life from eggs and larvae to adults. Botanical powders can be used to greatly reduce infestation levels, weight loss, and seed

viability deterioration if they are combined with good post-harvest procedures, such as proper drying, sorting of seeds, hermetically storing seeds and monitoring them regularly. Additionally, by promoting food safety and affordability and preserving the environment, their use contributes to sustainable agriculture. This makes them especially relevant to smallholder farmers, who often lack access to expensive synthetic pesticides. To make the best use of the botanical powders more study is required. Their reliability and utility will be further enhanced by research into biochemical pathways, efficient doses, formulations and combination synergies. In the final analysis, the use of botanical powders in comprehensive, post-harvest management schemes offers a sustainable, long-term solution to protect pulses against storage pests and can lead to improved food security and livelihoods in the underdeveloped regions.

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