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RESEARCH ARTICLE

Entomocidal activity of *Azadirachta indica*, *Pongamia pinnata* and *Tridax procumbens* leaf powder against the rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae)

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ABSTRACT

Pests of stored grains cause significant quantitative and qualitative damage mainly in tropical regions. The rice weevil, *Sitophilus oryzae* L. is one of the most destructive species infesting stored rice and other cereal grains. In the present study entomocidal activity of *Azadirachta indica* (neem), *Pongamia pinnata* (karanj) and *Tridax procumbens* (coat buttons) leaf powder against adult *S. oryzae* under controlled laboratory conditions have been evaluated. Leaf powder obtained from different plant having concentration of 5, 10, 15, 20, 25, and 30 mg were used to treat 50g rice grain for each concentration while 50g untreated grains used controls. Insect mortality recorded after 7, 14, 21, and 28 days after treatment. The results of *A. indica* exhibited the highest and fastest mortality achieving 100% with the concentrations of 25 mg and above within 14 days whereas *P. pinnata* resulted delay but 100% mortality with 25 and 30 mg by 28 days and *T. procumbens* showed mortality at 25 mg & 30 mg concentrations after 28 days. The overall efficacy ranking was *A. indica* > *P. pinnata* > *T. procumbens*. The findings highlight the strong potential of these botanicals, particularly neem, as safe, sustainable, and cost-effective alternatives to synthetic protectants for stored-grain pest.

KEY WORDS: Stored grain, pests, neem, karanj, *Tridax procumbens*, botanicals, *Sitophilus oryzae*

INTRODUCTION

Insect pests of stored grain and their products are among the most persistent and economically significant threats to food security worldwide, especially in tropical and subtropical regions where warm and humid conditions favor rapid pest multiplication. Losses in stored grains are not limited to quantitative but also extend to deterioration in quality, nutritional value, and marketability due to contamination by insect fragments, excreta, and microbial growth. In India, post-harvest losses caused by insect pests are estimated to be 20-25% of total production (Rajashekar *et al*., 2010), posing a serious challenge to the nation's grain reserve and livelihood of farmers.

Among the insect pests, rice weevil, *Sitophilus oryzae* (Linnaeus) (Coleoptera: Curculionidae), is one of the most destructive cosmopolitan species infesting stored cereals such as rice, wheat, maize, and barley. Both adults and larvae feed inside the grains, causing hollowing leading to qualitative and quantitative reduction. The infestation often begins unnoticed within a short period after storage and can spread rapidly under favorable temperature and humidity, leading to significant post-harvest damage (Talukder, 2006). The pest's ability to develop within the grains, with its high reproductive potential, makes their management highly difficult in household as well as at commercial storage facilities.

To mitigate these losses, synthetic fumigants and chemical proteetants such as phosphine, malathion, and permethrin have been widely used for decades. However, extensive and often indiscriminate use of such chemicals has resulted in the development of resistant strains of storage pests (Benhalima *et al*., 2004). Moreover, chemical residues in food products, environmental contamination, and adverse effects on non-target organisms, including humans have raised serious concerns regarding their long-term sustainability. Consequently, there is an increasing

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global emphasis on identifying natural, biodegradable, and safer alternatives for grain protection.

In this context, botanical insecticides derived from plants with inherent pest-deterrent properties have gained considerable attention. These plant products are generally inexpensive, readily available, and environmentally compatible. They act through diverse mechanisms such as repellency, feeding deterrence, growth inhibition, and oviposition suppression (Adeyemi, 2010). The neem tree, *Azadirachta indica* A. Juss., for instance, is well known for its bioactive compound azadirachtin, which disrupts growth, reproduction, and feeding behavior in a wide range of insect pests (Isman *et al*., 1990). Similarly, *Pongamia pinnata* (karanj) contains flavonoids such as karanjin and pongamol, known for their insecticidal, anti-feedant, and growth-regulatory activities (Kesari *et al*., 2010). *Tridax procumbens* (coat buttons), although primarily recognized for its medicinal and antimicrobial properties, has recently been reported to possess entomocidal potential through its rich profile of terpenoids, aldehydes, and phenolic

Table 1. Effect of *A. indica* leaf powder on mortality of *S. oryzae*

Plant powder	Concentration (mg/50g)	% mortality at day 7	% mortality at day 14	% mortality at day 21	% mortality at day 28
A. indica	5 mg	22	35	48	60
	10 mg	38	52	70	85
	15 mg	55	68	82	95
	20 mg	70	85	96	100
	25 mg	78	92	100	100
	30 mg	85	100	100	100

Table 2. Effect of a *P. pinnata* leaf powder on mortality of *S. oryzae*

Plant powder	Concentration (mg/50g)	% mortality at day 7	% mortality at day 14	% mortality at day 21	% mortality at day 28
P. pinnata	5 mg	15	25	38	45
	10 mg	30	45	60	72
	15 mg	45	62	75	88
	20 mg	60	78	90	100
	25 mg	72	88	98	100
	30 mg	85	95	100	100

Table 3: Effect of *T. procumbens* leaf powder on mortality of *S. oryzae*

Plant powder	Concentration (mg/50g)	% mortality at day 7	% mortality at day 14	% mortality at day 21	% mortality at day 28
T. procumbens	5 mg	10	18	28	35
	10 mg	25	40	50	60
	15 mg	40	55	68	80
	20 mg	55	70	85	93
	25 mg	65	82	95	100
	30 mg	75	90	100	100

Table 4:

Treatment	LC_{50} for the leaf powders				Mortality (Average) on different days			
	7	14	21	28	7	14	21	28
Neem	14.03	9.39	5.53	3.48	58.0 ± 10.0	72.0 ± 10.2	82.7 ± 8.5	90.0 ± 6.5
Karanj	16.97	11.72	7.88	5.92	51.2 ± 10.7	65.5 ± 11.0	76.8 ± 9.9	84.2 ± 9.0
Tridax	19.36	13.86	10.27	8.05	45.0 ± 10.1	59.2 ± 11.1	71.0 ± 11.4	78.0 ± 10.6

compounds (Sharma & Kumar, 2009). Protection of different wheat grain varieties in the storage using extracts of various parts of neem have already been reported earlier (Juneja, 2024).

Unlike solvent-based extracts, powdered plant materials offer a simple, cost-effective, and residue-free approach that can be readily adopted by rural farming communities. The physical properties of powders, such as fine particle size and adsorption capability, may also contribute to desiccation and suffocation of insect pests, thereby enhancing their efficacy under storage conditions. Considering the limitations of synthetic protectants and the growing interest in eco-friendly alternatives, the present study was undertaken to evaluate the entomocidal efficacy of leaf powders of *A. indica*, *P. pinnata*, and *T. procumbens* against the rice weevil *S. oryzae* under controlled laboratory conditions. The findings of this investigation are expected to contribute toward developing sustainable and plant-based strategies for stored-grain protection.

MATERIALS AND METHODS

Insect collection and culture

Adults of *S. oryzae* were collected from infested stored rice in Kalmeshwar, Nagpur district, Maharashtra, and reared on clean rice grains (*Oryza sativa*) at 32-36°C (Figs. 1-2).

Plant material

Leaves of *A. indica*, *P. pinnata*, and *T. procumbens* were collected locally, washed, shade-dried for 15 days, powdered using an electric grinder, sieved, and stored in airtight containers (Fig. 3 & 4).

Bioassay

The entomocidal efficacy of leaf powders was conducted under laboratory conditions having 27 ± 2^{oC} temperature and 65 ± 5% relative humidity. The entomocidal efficacy bioassay of leaf powders against *S. oryzae,* have been studied. Clean and uninfested rice grains 50g placed in glass jars and thoroughly mixed with leaf powders of *A. indica*, *P. pinnata*, and *T. procumbens* using following concentrations of 5, 10, 15, 20, 25, and 30 mg for every 50g of grain. Similarly 50g rice untreated rice grains were used as controls. Twenty individuals of about 3-5 days old, of mixed sex adult weevils introduced into each jar. The jars were covered with muslin cloth and secured with rubber bands to allow aeration. Each treatment was replicated three times. The setup was maintained undisturbed and adult mortality was recorded after 7, 14, 21, and 28 days of exposure. Insects were considered dead if they did not respond to gentle probing with a fine brush. Number of damage and undamaged grains were counted from each test sets and mortality was calculated and analyzed using Abbott's formula (Abbott, 1925).

RESULTS

Leaf powder of all three plants exhibited significant mortality in adult *S. oryzae* over a 28-day exposure period, with efficacy increasing with both dose and duration. The highest mortality was recorded with *A. indica*, followed by karanj, *P. pinnata* and tridax, *T. procumbens*.

Azadirachta indica (Neem)

A dose of 30 mg neem leaf powder for every 50 g of rice, caused 85% mortality within 7 days, which reached to 100% within 14 days. Both 20 & 25 mg neem powder produced 100% mortality by day 28. The result indicates clearly that mortality rates due to neem powder increased over time and the trend of mortality increase was gradual depend on concentration and exposure duration. This demonstrates rapid and strong insecticidal action, suggesting the presence of highly active compounds e.g., azadirachtin that act quickly through contact and ingestion (Table 1).

Pongamia pinnata (Karanj)

Karanj leaf powder exhibited late onset of mortality compared to neem leaf powder, but final mortality reached 100% at the concentrations 20 mg, 25 mg and 30 mg in 28 days. At lower concentrations 5, 10, 15 mg, increase in were slow but gradual resulting 15-45% (on day 7) and 45-88% (on day 28). The progressive trend indicates delayed toxicity, consistent with compounds such as karanjin and which act as feeding deterrents which resulted death due to starvation (Table 2).

Tridax procumbens (Tridax)

Tridax leaf powder also resulted slower mortality very similar to Karanj in which initial mortality, 10-25% reached in 7 days. The, mortality increased steadily over time, reaching 100% by day 28 with only 25 & 30 mg concentrations. The results show that 25 mg concentration is sufficient to kill the insects within 28 days. The cumulative toxicity was possibly due to secondary metabolites such as flavonoids, terpenoids that require prolonged exposure. We may conclude that *Tridax* is less potent initially, but demonstrates effective residual activity over longer exposure periods and can be considered as potential variable for insecticidal effect for certain stored grain pests (Table 3).

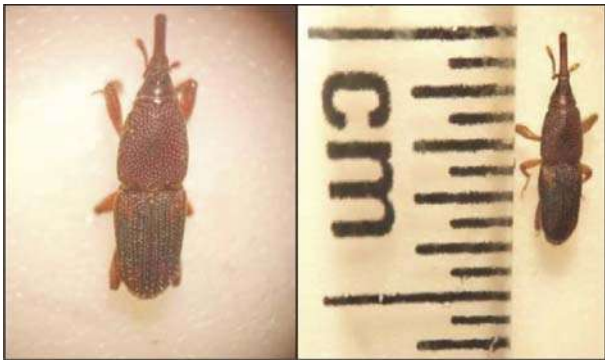

Fig. 1. Adult of *Sitophilus oryzae* found in collected rice

Fig. 2. Rice infested with *Sitophilus oryzae*

Fig. 3. Leaves of a) *Pongamia pinnata,* b) *Azadirachta indica,* c) *Tridax procumbens*

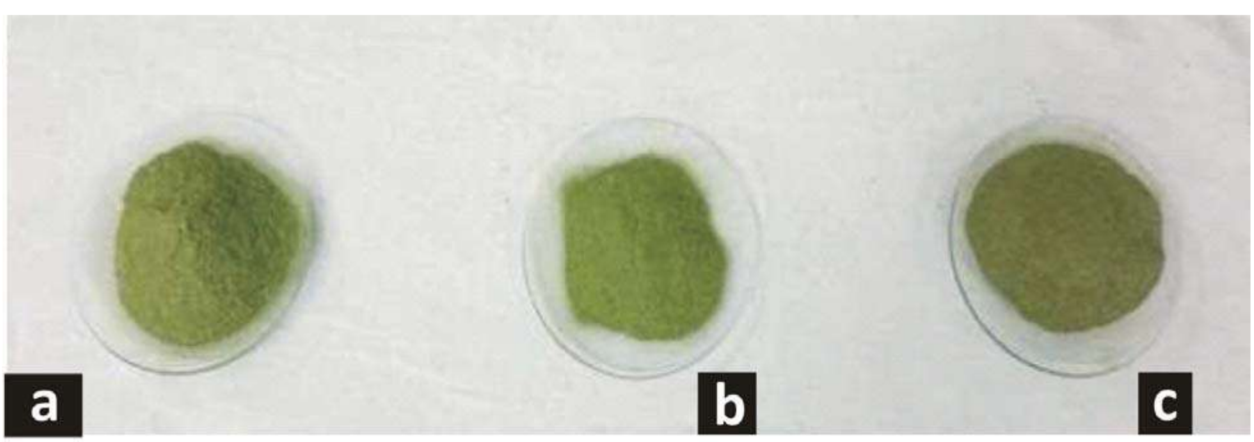

Fig. 4. Powders of a) *Pongamia pinnata,* b) *Azadirachta indica,* c) *Tridax procumbens*

Mortality followed a consistent dose- and time-dependent pattern have been evaluated and correlated among all the treatments. The average mortality and the LC50 was evaluated (Table 4, Fig. 5). The result suggests that mortality occurred in 7 days has high LC50 using all the three powders however the LC 50 of Neem powder was lowest and followed by Karanj and the highest with *Tirdax*. The similar trend was recorded for 14, 21 and 21 days. The result further suggests that, with lowest concentration the mortality although occuring at 100% but take more time to kill the insect. The efficacy rank remained as *A. indica followed by P. pinnata and lowest with T. procumbens*. Neem caused high and quick mortality, where as karanj and tridax exhibited gradual and sustained effects, ideal for long-term protection in grain storage.

DISCUSSION

The extended 28-day exposure period revealed cumulative and sustained mortality effects in all three botanical treatments. Neem exhibited the fastest knockdown and complete mortality within two weeks, indicating the rapid action of azadirachtin and other limonoids. Karanj showed progressive mortality with longer exposure, consistent with the delayed but potent effects of karanjin and pongamol. *Tridax* required higher doses and longer exposure but ultimately achieved full mortality at 25-30 mg, confirming its slow-acting entomocidal potential. These results demonstrate that prolonged exposure enhances contact toxicity and residual efficacy of plant powders under storage conditions.

Leaves of many tropical plants harbor secondary metabolites such as alkaloids, flavonoids, terpenoids, and phenolic compounds that act as natural defense agents against herbivorous insects. Leaf powders in particular provide both physical and chemical protection, as their fine particles can abrade insect cuticles and interfere with respiration, while bioactive compounds exert toxic, repellent, or antifeedant effects. For example, leaf powders of *Ocimum gratissimum*, *Lantana camara*, and *Eucalyptus globulus* have shown oviposition deterrence, growth inhibition, and mortality against *Callosobruchus* and *Sitophilus* species. Thus, entomocidal activities of leaves extend beyond azadirachtin in neem, encompassing a wide spectrum of bioactive metabolites that can be exploited in grain protection.

All the botanicals tested in the present investigation caused mortality in weevil. Among these, *A. indica* powder produced the better result followed by *P. pinnata* and *T. procumbens*. This results is in accordance with similar studies reported earlier on the effectiveness of these plant products against insects of stored grain (Ileke & Ogungbite, 2014).

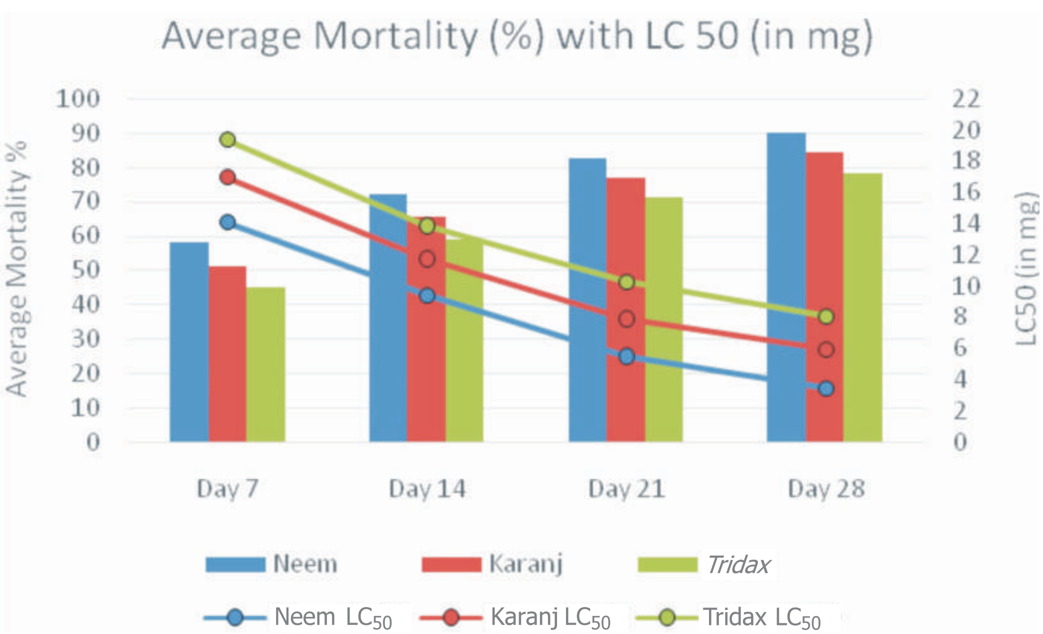

Fig. 5. Correlation between insect mortality and LC_{50} due to different concentration of leaf powders

Seeds and leaves of neem have been traditionally used for centuries to control pest (Koul *et al*., 1990). In addition, neem contains Azadirachtin which is a potent anti-feedant for many insects while salannun and sodium nimbinate are repellent and spermicide, respectively (Isman, 1990). Azadirachtin induces sterility in insects by preventing oviposition and interrupting sperm production in male (Chaudhary *et al*., 2017). It is effective against nearly 550 insect species (Anuradha & Annadurai, 2008) and it inhibits feeding and growth in a wide variety of insects taxa including Lepidoptera (moths and butterflies), Coleoptera (beetles and weevils), Diptera (flies), Hymenoptera (ants and wasps), Hemiptera (aphids, leafhoppers, whiteflies, bugs), Orthoptera (grasshoppers and katytids), Dictyoptera (cockroaches and mantids), Isoptera (termites), Siphonoptera (fleas) and Thysanoptera (Debashri & Tamal, 2012).

The significantly high 87.08% mortality was reported with neem leaf powder (Rojasara *et al*., 2019). According to Singh *et al*. (2017), neem kernel 2 per cent was effective against *S. oryzae* as of wheat added with neem kernel powder recorded minimum grain damage (3.84%), weight loss (1.15%), adult emergence (16.17) and highest inhibition rate (92.58%). The leaves powder of *A. indica* was found highly effective in prohibiting the adult emergence and reduction in grain damage with mortality 70.74% (Devi *et al*., 2014). Also at 1.0g concentration achieved 100% mortality of *S. oryzae* (Ileke & Oni, 2011). The neem leaf powder mixed with wheat grain in lokwan and sharbati varieties resulted 90% and 96.6% mortality respectively with the dose of 0.3g/50g grains and 100% with 1.2g as well as in 1.8g in both the varieties (Juneja, 2024). Mortality seen in rice weevil due to neem in present study also resulted due to action of Azadirachtin inhibiting feeding and growth in rice weevil.

Pongamia pinnata contains active metabolites such as Karanjin, pongamol, glabrin and pinnatin etc. Karanjin is effective against large number of insects (Mathur *et al*., 1990). *P. pinnata* show insecticidal, nematicidal, antifungal, antibacterial and antiviral activities (Simin *et al*., 2002; Kesari *et al*., 2010). Several recent studies have demonstrated that pongamol contains pesticidal properties against pests such as aphids, mites (Kumar *et al*., 2007), hopper (Hiremath *et al.,* 1997) houseflies, louse, termites (Ahmed *et al.,* 2022), mosquito, and beetles. Toxicity and deterrence of pongamol to pests were confirmed in the laboratory for the human head louse *Pediculus humanus capitis* (Samuel *et al*., 2009). Red flour beetle *Tribolium castaneum* (Mamun *et al*., 2008), pulse beetle *Callosobruchus chinensis* (Yankanchi & Lendi, 2009), mosquitos (Lale & Kulkarni, 2010) and the termite *Odototermes obesus* (Verma *et al*., 2011), *Coptotermes heimi* (Ahmed *et al*., 2022). Thus, it is revealed that pongam also contains chemicals that should be useful for pest management. Dry leaf powder of *P. pinnata* caused 73.1% mortality on pulse beetle, *Callosobruchus chinensis* L. (Yankanchi & Lendi, 2009). Red floor beetle, *Tribolium castaneum* showed 55.13% mean repellent effect (Mamun *et al*., 2008). Methanolic extracts of crude seed oil of *Pongamia pinnata* (Karanj) showed the maximum growth reduction and anti-feedancy against the larvae of *S. litura* (Kumar *et al*., 2006). The dosages at 1 and 2% of karanja oil give better control of stored grain pest compared with lower concentration (Kumar *et al*., 2014).

Tridax procumbens L. (Asteraceae) is a common weed and pest plant found in tropical and subtropical environments. It is known for its antimicrobial (Jindal *et al*., 2012), antiviral, antibiotic, anti- inflammatory, and insecticidal activities (Sharma & Kumarr, 2009). The Extract from members of Asteraceae plant family is reports effective against various stored grain pests. Essential oils of *Ageratum conyzoides* (L.), *Wedelia trilobata* (L.), *Lantana camara* (L.), *Tridax procumbens*, *Chromolaena odorata* (L)., *Achillea millefolium* L. have been effective against *Sitophilus spp*., maize weevil (*S. zeamais*), rice weevil (*S. oryzae*) and wheat weevil (*S. granaries*) through inhibition of oviposition and progeny emergence (Alkan 2020; Bouda *et al*., 2001; Ruchuon 2021). *T. procumbens* essential oil contains 25 compounds with five principle components as 1,2-cyclooctanediol, hexanal, 4-heptenal, 2,4-nonadienal, and 1,6-dimethylhepta-1,3,5- triene. It has significant application on stored products to control progeny of *S. zeamais* that cause seed damage (Wanna & Kaewduangta, 2022). Dried powder of *T. procumbens* (5mg/g seed) was found to be more effective causing 100% mortality against pulse beetle *Callosobruchus chinensis* L. (Yankanchi & Lendi, 2009). *T. procumbens* are not much effective as compared with *A. indica* in present study.

Thus it can be suggested that use aof high concentration of any neem product for the management of store grains may be effective but not advisable due to it growth regulator activity may be harmful to the human consumption in long term, hence the other two plant varieties could be used under controlled condition having lower concentration in correlation to disrupt the life cycle of the *S. oryzae* and disrupt the cycle of development during storage. The entomocidal potential of botanical powders as eco-friendly alternatives to synthetic insecticides.

CONCLUSION

The rice weevil is one of the severe damaging pests of rice that causes grain losses in the storage condition. The study was conducted to evaluate the toxicity of plant powder of *A. indica*, *P. pinnata, T. procumbens* against *S. oryzae*. All the plant powders were significantly effective against weevil, compared with untreated control. *A. indica* was found to be the best plant powder formulation, as a grain protectant against rice weevil. The mortality rate did not affect with increasing concentration in case of *A. indica* but in *P. pinnata* and *T. procumbens*, the mortality increased with increasing concentration and exposure time. Plant products did not deteriorate the grain quality and quantity. However, further investigations are needed to determine the actual mode of action and exact insecticidal component. The selected plants being medicinal having no harmful effects on the non-target organisms. Therefore, they could be integrated with other insect pest management system.

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