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Pesticidal effect of naphthalene and different botanicals against anguimous grain moth (*Sitotroga cerealella*)

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ABSTRACT

Anguimous grain moth is a strong seed destroyer causing economic losses to the marginal farmers. Treatments of seeds with different chemicals as remediation of this problem risks environment and creates health hazards. Pesticidal effects of some botanicals and naphthalene on anguimous grain moth inhabiting grains have been tested in this experiment. A total of eight treatments were performed against Anguimous grain moth with one control (T_1). The treatments contained: T_2=5 whole dried neem leaf, T_3=0.25 ml neem oil, T_4=0.25 g ginger powder, T_5=0.25 g neem leaf powder, T_6= 0.25 g mixture of neem leaf powder and ginger powder, T_7=0.25 g naphthalene, T_8= 5 whole tulsi leaf and T_9= 0.25 g neem seed powder. Results indicated that T_7 (100%) showed better performance in case of insect mortality and no F_1 emergence followed by T_3 (53.33%), T_9 (43.66%) and T_6 (40%). Moderate performance was found T_5 and T_2 in case of insect mortality and number of F_1 emergence. But in case of seed germination T_5 (92.00%) showed better performance followed by T_7 (88.00%), T_9 (87.00%), T_6 (85.33%) and T_3 (80.33%). So, naphthalene, neem oil, neem seed powder and neem leaf powder considered as the best treatment among nine treatments for the management of the most destructive Anguimous grain moth.

Keywords: Anguimous grain moth (*Sitotroga cerealella)*; Neem oil; Naphthalene; Neem leaf powder; Neem seed powder; Storage pest.

Introduction

Rice (*Oryza sativa* L., Family: Poaceae) is one the most important cultivated food crops in the world as well as in Bangladesh. In the rice cultivation, insect infestation which may be field or storage borne affects production. During cultivation of rice, insects are always present in the field as well as presence in storage condition. Rice needs a long storage period after harvesting until further use for consumption, seed purpose etc. Under storage, rice is infested by Rice weevil (*Sitophilus oryzae*), Anguimous grain moth (*Sitotroga cerealella*), saw-toothed grain beetle (*Oryzaephilus surinamensis*), Red flour Beetle (*Tribolium castaneum*) and Indian Meal Moth (*Plodiainter punctella*) etc and cause extensive economic loss in the production. Anguimous grain moth (*Sitotroga cerealella*) is a prevalent insect species and often placed at the top of the list as major insect pest of stored rice. Tadesse (2020) reported that in order to ensure that a country has enough food, postharvest storage for proper grain is more crucial than intense and widespread farming. But there are many reasons for rice storage losses. Qu *et al.* (2021) demonstrated that lack of knowledge, inappropriate farming techniques, poor infrastructure and improper harvest management procedures were major causes of rice harvest losses. Reducing postharvest losses of food crops is essential to enhancing agricultural productivity in a sustainable manner (Stathers *et al.* 2020).

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So, management of storage pest is important for reducing postharvest losses. Since 1950s, synthetic insecticides were used to manage storage pests of agricultural crops. However, synthetic chemicals for pest control effects human, wild and aquatic life and the environment at large (Köhler and Triebskorn, 2013; Muñoz-Quezada *et al.* 2013; Baltazar *et al*. 2014; Yuan *et al.* 2014; Meyer-Baron *et al*. 2015; Guyton *et al.* 2015). Besides, the use of adultered and expired ineffective pesticides produces rapid evolution of pesticide resistance pathogens in the ecosystem (Stevenson, 2014). Therefore, alternate methods need for the management of rice storage pest which is non-toxic, environment friendly and also free from human health hazard is an urgent research issue. In Bangladesh, poor and marginal farmers store small quantities of rice for consumption and for use as seed and they cannot practice expensive control measures for storage pest. Botanicals containing bio-pesticidal properties in their bioactive components play vital role for the management of rice storage. Some plants are known to contain bioactive metabolites, which show anti-feedant, repellent and toxic effects on a wide range of insect pests (Stevenson, 2014). Examples of these mostly used important bioactive plants are catnip, pale persicaria, holy basil, artemisia, borage, dahlia, ginger, hyssop, chrysanthemum, lime, black pepper, clove, mahogany, neem and ginger etc. Plant extracts in powder or essential oil form from different bioactive plants are known to be effective repellents against different economic storage pests of grains, even for stored cereals (Khan and Gumbs, 2003). Anguimous grain moth cause economic loss, nutritional damage and reduce germination percentage on rice by breeding on grain and feeding of grain. Therefore our present study was undertaken to assess the effectiveness of neem, tulsi and ginger and naphthalene for the management of Anguimous grain moth (*Sitotroga cerealella*) of rice.

Materials and methods

The present study was conducted at Bangladesh Rice Research Institute (BRRI), Regional Station Rangpur laboratory during the period from June to October 2021. The experiment was carried out following complete randomized design (CRD). A total of eight treatments were performed against one control (T_1) with three replications. The treatments were:

Treatments	Status
T1	Control (Untreated)
T2	Whole neem leaves, 5 in number
T3	0.25 ml neem oil
T4	0.25 g ginger powder
T5	0.25 g neem leaf powder
T6	0.25 g mixture of neem leaf powder
T7	0.25 g naphthalene
T8	Whole tulsi leaf, 5 in number
T9	0.25 g neem seed powder

ginger bulb (*Zingiber officinale*), fresh neem leaves (*Azadirachta indica*), ripe neem kernel and fresh tulsi (*Ocimum tenuiflorum*) leaf were collected and dried in the oven at 50^{o}C to constant weight. Part of the ginger bulb, fresh dried neem leaf and ripe neem kernel were powdered by electric grinder machine then sieved (mesh number 25) to obtain fine and uniform material and the powdered materials were stored in airtight polythene bag until further treatment. Equal amount of neem leaf powder and ginger powder was mixed together to make mixture of neem leaf and ginger powder. Neem oil (pressed organic neem oil) and naphthalene (99% purity) were collected from the market. At the beginning of the experiment *Sitotroga cerealella* population was collected from the BRRI regional station Rangpur store and reared on rice (BRRI dhan87) in laboratory. The female and male moths were distinguished by visual observation of their abdominal tergites and the size of the body with the help of an electron microscope (Olympus Model SZ2-STU2, Tokyo, Japan and scanning objective lens was zoomed at 4×). Fresh and de-infected BRRI dhan87 were collected from BRRI Regional Station seed store house and fully sundried for 3 days. Then seeds were taken in 27 Petri dishes @ 25 g/Petri dishes. A weighing balance (KERN ABJ220-4NM, Balingen, Germany) was used to measure the powder extracts. After the application of treatments, 5 pairs of fresh adults were introduced in each replication and they were kept for 5 days for oviposition at 65% RH and 30^{o}C. Number of dead insect were counted at 24 h after treatment, 48 h after treatment and 72 h after treatment and dead insect were removed. The Petri dishes were kept in regular observation for F_1 adult emergence. Adults were removed and data collection was continued until no F_1 moth was found. Insect mortality data were calculated by using the square root transformation formula. All data were subjected to statistical analysis separately by using analysis of variance technique by R software (versions 4.2.1, 2022). Percent insect mortality

$$\text{Insect mortality (\%)} = \frac{\text{Number of dead insect at treated treatment}}{\text{Total number of insect treated}} \times 100$$

was calculated by using the following formula.

Germination percentage

One hundred rice seeds were taken randomly in a Petri dish from each replication of each treatment. Rice seeds were taken separately for each replication. The seeds were placed on moist filter papers in the Petri dish and maintained at room temperature. The number of germinated seed were counted

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

and recorded after completion of germination. The percentage germination was computed using the following formula.

Results and discussion

Number of dead insects

The number of cumulative dead insects at 24 h after treatment and 48 h after treatment showed statistically significant results. Data presented in Table I showed that after 24 h of treatment the highest number of dead insects was recorded inT_7 (2.97) treatment. The second most dead insect was observed in T_3 (1.95) treatment. Statistically similar results were found in T_6 (1.58) and T_9 (1.58) treatment and T_2 (1.34) and T_5 (1.46) treatments. The lowest dead insect was found in T_1 (0.71) treatment. After 48 h of treatment the highest number of dead insect was found in T_9 (1.46) and T_6 (1.46) treatment followed by T_2 (1.34), T_3 (1.34) and T_5 (1.34) treatment and which were statistically similar. The lowest number of dead insects was found in T_1 treatment. After 72 h of treatment, there were statistically no significant difference among the treatments but numerically different. Numerically highest dead insect were found in T_2, T_3, T_5, T_7 and T_8 treatment and lowest were found in T_1 and T_4 treatment. From the result, it might be concluded that highest number of dead insect was found at T_7 i,e naphthalene followed by T_3 (neem oil), T_9 (neem seed powder) and T_6 (mixture of neem leaf and ginger powder). Highest dead insects were found at naphthalene due to its solid form that turns into toxic gas and due to the exposure of toxic gas it caused huge inhalation and its exposure did cause dermal contact, hemolytic anemia and neurological damage as well. Azadirachtin bioactive ingredients present in neem plant that are responsible to kill insect. Facknath (2006) reported that neem (*Azadirachta indica* A. Juss.) can

Table I. Effect of botanicals and chemicals against anguimous grain moth after different duration of treatments

Treatment	No of dead insects after different duration of treatments		
	24 hours	48 hours	72 hours
T_1 (Control)	0.71 f	0.71 d	0.71
T_2 (5 whole dried neem leaf)	1.34 cd	1.22 ab	1.05
T_3 (0.25 ml neem oil)	1.95 b	1.34 ab	1.05
T_4 (0.25 g ginger powder)	1.05 e	0.88 cd	0.88
T_5 (0.25 g neem leaf powder)	1.46 cd	1.34 ab	1.05
T_6 (0.25 g mixture of neem leaf & ginger powder)	1.58 c	1.46 a	0.88
T_7 (0.25 g naphthalene)	2.97 a	1.22 ab	1.05
T_8 (5 whole dried tulsi leaf)	1.22 de	1.34 ab	1.05
T_9 (0.25 g neem seed powder)	1.58 c	1.46 a	1.22
Level of significance	***	**	Ns
LSD	0.2583719	0.337307	
CV%	9.768086	16.72475	26.49772

*, **, *** indicate significant at 5%, 1% and 0.1% level of probability, respectively and Ns indicates not significant. Values followed by the different letter(s) are significantly different from each other.

reduce insect populations infesting stored products through its toxic effects on the pests by disrupting the insect growth.

Percent insect mortality of anguimous grain moth

Percent insect mortality showed statistically significant variation for commonly used different botanicals and chemical used as experimental treatments for the management of anguimous grain moth in stored rice grain (Figure 1). The highest (%) insect mortality was demonstrated in T_7 (100%) and which was statistically different from others. The second highest (%) insect mortality was observed in T_3 (53.33%) treatments which was also different from other treatments followed by T_9 (43.66%) and T_6 (36.33%) treatment and they were statistically significant. No insect mortality was recorded in T_1 (control) treatment. From the figure I it might be concluded that naphthalene (T_9) was found as 100% mortality in case of anguimous grain moth due to its emission of toxic gas and pungent smell. Naphthalene acts by the activation of cytochrome P450 enzyme in neuronal channel which triggers acute toxicity of neural cells (Li *et al.* 2011). Lin *et al.* (2015) reported that naphthalene-induced respiratory toxicity is related to lipid peroxidation, disruptions of membrane components, and imbalanced energy supply. The study of Obeng-Ofori *et al.* (1998) have shown that, the contact toxicity of naphthalene (concentrations between 100 µg and 100 mg) on stored product insect pest with mortalities above 70% in maize weevil, groundnut weevil, red flour beetle, and large grain borers. On the other hand, neem as a botanical pesticide has many excellent attributes including its broad-spectrum in insect growth regulatory effects, systemic action in some plants, minimal effects on natural enemies and pollinators, rapid degradation in the environment, and no toxicity to vertebrates. It is also reported that the lethality of neem oil is confirmed depending on the concentration applied and can be compared to neurotoxic insecticides and growth inhibitors, as a potent natural insecticide (Isman, 2006; Mourão, 2016). Jibrin and Mohammed (2020) reported that active ingredients in neem tree that make the leaves bitter and azadirachtin bioactive ingredients in neem are useful for insect repellent and mortality role.

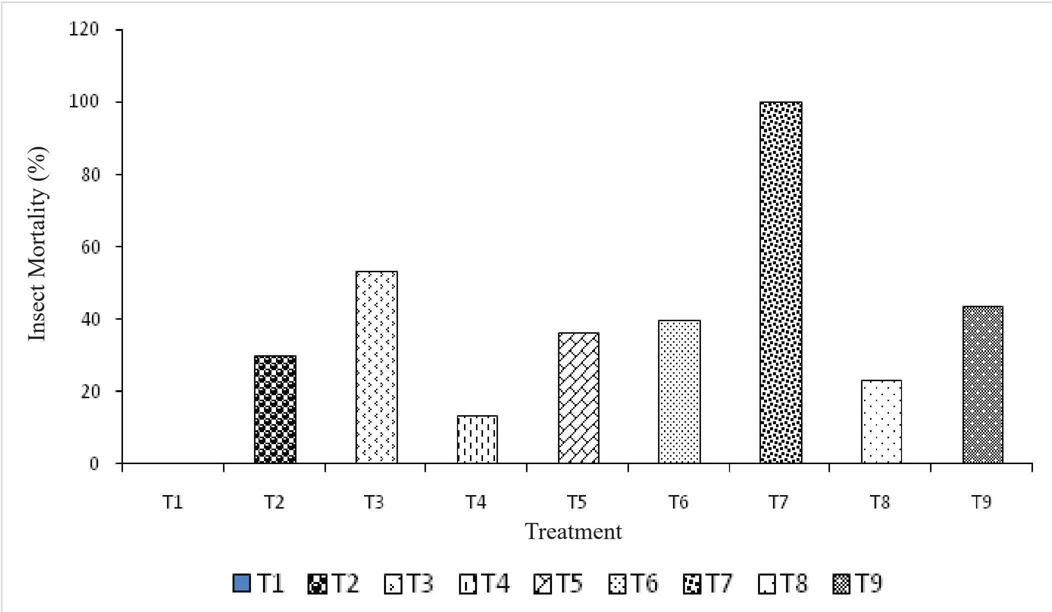

Fig. 1. Insect (Anguimous grain moth) mortality (%)

The treatments were:

T_1=Control, T_2=5 whole dried neem leaf, T_3=0.25 ml neem oil, T_4=0.25 g ginger powder, T_5=0.25 g neem leaf powder, T_6= 0.25 g Mixture of neem leaf powder and ginger powder, T_7=0.25 g Naphthalene, T_8= 5 whole tulsi leaf and T_9= 0.25 g neem seed powder.

Number of F_1 emergence

Number of F_1 emergence showed statistically significant results for the application of experimental treatment for the management of Anguimous grain moth in storage rice grain (Figure 2). Highest number of F_1 emerged in T_1 (80.67) control untreated treatment which was followed by T_8 (71.00), T_5 (68.67), T_4 (67.00), T_2 (62.67), T_6 (59.00), T_9 (54.33) and T_3 (48.67) respectively. No F_1 was emerged in T_7 treatment.Due to the highest mortality and toxic gas emission of naphthalene and thus acted as poison for anguimous grain moth responsible for lowest or no F_1 emergence. Neem oil contain bioactive ingredient azadirachtin that was higher toxic by feeding and thus causes insect mortality, delaying insect growth, curtailing fertility and emergence of F_1 population. Azadirachtin bioactive ingredient found different parts of neem plant. Bruce *et al.* (2004) reported that azadirachtin is the main compound of the neem oil with insecticidal activity and can be found in fruits and leaves. Alexander *et al.* (2023) reported that neem oils contain insecticidal, anti-ovipositant and ovicidal properties that reduce F_1 emergence. Neem oil is a feeding inhibitor, delaying development and growth, reducing fecundity and fertility, changing behavior and causing anomalies in eggs, larvae and adults of insects or mites reported by Masood *et al.* (2006).

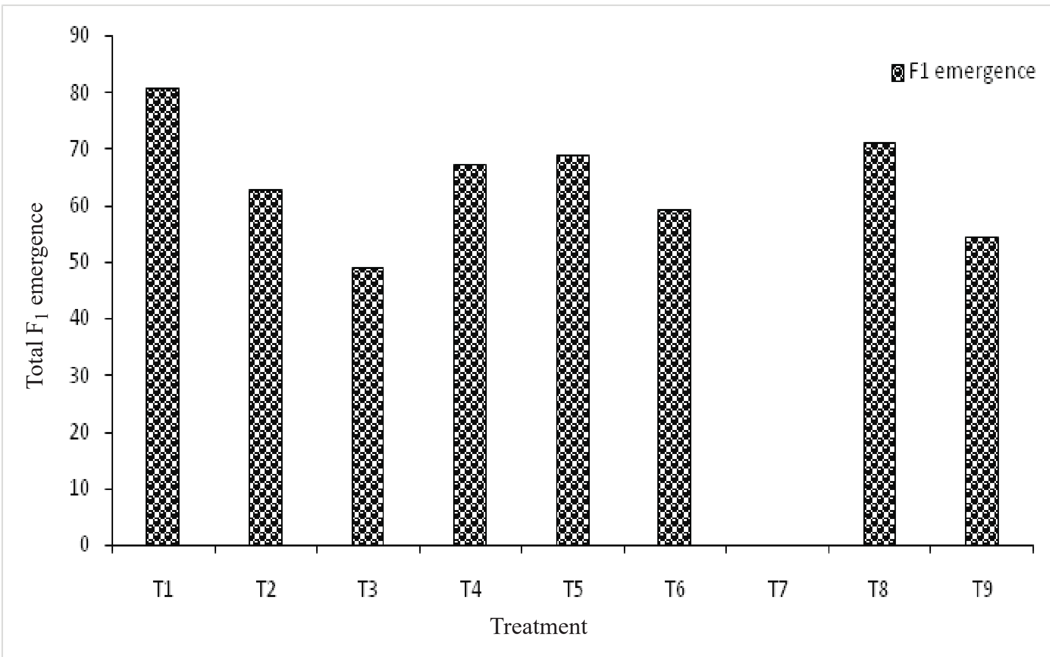

Fig. 2. F_1 emergence of Anguimous grain moth

The treatments were:
T_1=Control, T_2=5 whole dried neem leaf, T_3=0.25 ml neem oil, T_4=0.25 g ginger powder, T_5=0.25 g neem leaf powder, T_6= 0.25 g Mixture of neem leaf powder and ginger powder, T_7=0.25 g Naphthalene, T_8= 5 whole tulsi leaf and T_9= 0.25 g neem seed powder.

Germination of seed

Germination (%) of treated seed showed statistically significant variation for the application of experimental treatments of anguimous grain moth management in storedrice grain (Table II). The highest germination was found in T_5 (92.00%) and which was statistically differ from other treatments. T_7 (88.00%), T_9 (87.00%) and T_6 (85.33%) treatment showed statistically similar result for seed germination. The lowest seed germination was found in T_1 (73.00%) untreated control treatment due to highest F_1 emergence, lowest insect mortality and damage by breed-

Table II. Effect of botanicals and chemicals against Anguimous grain moth on germination (%) of seed

Treatment	Seed germination (%)	% Germination seed over control
T_1 (Control)	73.00 e	--
T_2 (5 whole dried neem leaf)	78.00 cd	6.85
T_3 (0.25 ml neem oil)	80.33 c	10.05
T_4 (0.25 g ginger powder)	78.00 cd	6.85
T_5 (0.25 g neem leaf powder)	92.00 a	26.03
T_6 (0.25 g mixture of neem leaf & ginger powder)	85.33 b	16.90
T_7 (0.25 g naphthalene)	88.00 b	20.55
T_8 (5 whole dried tulsi leaf)	77.00 d	5.48
T_9 (0.25 g neem seed powder)	87.00 b	19.18
Level of significance	***	--
LSD	2.839869	--
CV%	2.017103	--

*, **, *** indicate significant at 5%, 1% and 0.1% level of probability, respectively. Values followed by the different letter(s) are significantly different from each other.

ing and feeding on rice grain. Similarly in case of percent seed germination over control was found highest in neem leaf powder (T_5) followed by naphthalene (T_7), neem seed powder (T_9), T_6 (mixture of neem leaf powder and ginger powder) and T_3 (neem oil). Hossain *et al.* (2018) reported that, dried neem leaf powder showed the highest percent of seed germination over control. From our study, the trend of efficiency among different botanicals and chemical in terms of percent seed germination was T_5 (neem leaf powder) > T_7 (naphthalene) > T_9 (neem seed powder) > T_6 (mixture of neem leaf powder and ginger powder) > T_3 (neem oil) > T_2 (whole dried neem leaf) > T_4 (ginger powder) > T_8 (whole dried tulsi leaf) >T_1 (control).

Conclusion

Findings of the study concluded that among the eight treatments against one control, highest insect mortality was found in T_7 (0.25 g naphthalene) treatment followed by T_3 (0.25 ml neem oil) in case of insect mortality. No F_1 emergence was found in T_7 (0.25 g naphthalene) and lowest F_1 emergence was observed in T_3 (0.25 ml neem oil) followed by T_9 (0.25 g neem seed powder). The highest seed germination was showed in T_5 (0.25 g neem leaf powder) followed by T_7 (0.25 g naphthalene) and T_9 (0.25 g neem seed powder) in case of percent seed germination.

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