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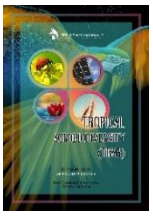

RESEARCH ARTICLE

MANAGEMENT OF ANGOUMOIS GRAIN MOTH (*SITOTROGA CEREALELLA*) OF MAIZE THROUGH ECOFRIENDLY PRACTICES AND SEED HEALTH STATUS IN RANGPUR REGION, BANGLADESH

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ABSTRACT

Maize (*Zea mays* L.), known as "Queen of cereals" is 2nd important cereal crop after rice in the world as well as Bangladesh. It causes damaged by insect pest. Angoumois grain moth (*Sitotroga cerealella*) is one of the important storage pests that caused severe seed damage. The present study evaluated the effectiveness of eco-friendly practices against Angoumois grain moth (*S. cerealella*) and their impact on seed health in stored maize (hybrid variety 9) at farmer house's under PolashBari upazila of Rangpur district, Bangladesh, from the period of 1st April to June 30, 2023. The experiment was laid out in a Completely Randomized Design (CRD) with five replications, testing six botanical extracts (leaf extract of neem, eucalyptus, datura, akondo and garlic clove extract and cow urine), a standard chemical check (Spinosad 2.5 SC), and a control. Results indicated that Spinosad 2.5 SC (1.3 ml/L) was most effective, demonstrating the lowest mean number of insects (3.96/100g seed), infestation (3.56%), grain damage (6.35%), and weight loss (7.89%), alongside the highest mortality (96.59%) and germination (94.56%). Among the botanical treatments, neem leaf extract (3ml/L) showed promising results with relatively lower infestation (7.14%), grain damage (10.03%), and weight loss (12.03%), and higher mortality (85.48%) and germination (90.74%) compared to other botanicals. Garlic clove extract (3ml/L) also exhibited moderate effectiveness. In contrast, the control group exhibited the highest infestation (93.55%), grain damage (96.48%), and weight loss (97.49%), with zero mortality and the lowest germination (39.66%). The findings suggest that Spinosad 2.5 SC offers superior control, while neem leaf extract presents a viable eco-friendly alternative for managing *S. cerealella* and preserving maize seed health under storage conditions. These results underscore the potential for integrating eco-friendly approaches into post-harvest pest management strategies.

KEYWORDS

Maize, Angoumois grain moth (*Sitotroga cerealella*), mortality, weight loss and germination

1. INTRODUCTION

After rice, maize (corn or "Bhutta" in Bengali), from the grass family Poaceae, is Bangladesh's most important cereal crop for both food and animal feed (Alam et al., 2018). In 2020-2021, the country produced a record 2.95 million tons, with 90% going to the growing poultry and fish feed industries (Alam et al., 2014, 2018). This increase in production and yield is largely due to the high-yielding hybrid varieties developed by the Bangladesh Agricultural Research Institution (BARI), Gazipur, Bangladesh. While maize cultivation is expanding across Bangladesh, its potential is limited by seed availability. Unfortunately, these new hybrid varieties are very vulnerable to insect pests, both in the field and during storage (Jena et al., 2023), preventing farmers from fully benefiting from higher yields. Bangladeshi farmers traditionally store maize grain, sometimes for several months, for their own use or to sell later. Storing maize seed safely for the 7-9 months between harvest and the next planting season is a significant challenge in Bangladesh, similar to storing mustard or onion seeds (Alam et al., 2014; Karim and Jabed, 2011).

Maize stored after harvest often suffers from pest infestations, leading to diminished quality and forcing farmers to accept lower prices that may not even cover their production costs. Insects are widely recognized as the primary culprits behind these significant grain losses (Alam et al., 2014, 2019; Perez-Mendoza et al., 2004; Zaidi et al., 2003). Specifically, lepidopterous stalk borers damage maize in the field, while coleopterous weevils are the main threat to stored maize (Alam et al., 2018; Emana, 1993; Fekadu et al., 2013). More than 37 species of lepidopteran pests, in particular, are known to affect stored maize grains (Abraham, 1995). The presence of insect-pests and diseases during storage is a major factor in reducing both overall yield and the germination potential of the grain (Hasan et al., 2025; Javed et al., 2010). In Bangladesh, the maize weevil (*Sitophyllus zeamais*) and the Angoumois grain moth (*Sitotroga cerealla*) pose the most serious threat to stored maize. This is largely because many farmers store their grain on open floors without adhering to proper storage guidelines, resulting in an estimated 60% loss of maize grain during this period (Alam et al., 2014). This problem is exacerbated by farmers' limited understanding of stored grain insect pests and their management. Globally, approximately 10% of harvested grain and pulse crops are lost to insect pests, a situation that is particularly severe in developing countries (Hasan et al., 2025). It estimates that poor storage practices and pests collectively account for losses of about 200 million tons of grain annually worldwide (FAO, 1985). In Bangladesh alone, annual grain losses are reported to be between 20-30% (Alam et al., 2018).

Given the current lack of information regarding the specific storage pests affecting maize in Bangladesh, including the damage they cause and the resulting weight losses, this research aimed to evaluate the effectiveness of six botanical agents and one chemical insecticide in controlling the

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Angoumois grain moth (*Sitotroga cerealella*) in stored maize.

2. Materials and Methods

2.1 Study Site and Period

An investigation was undertaken at farmer's house in PolashBari Upazilla of Rangpur region, Bangladesh, from April 1 to June 30, 2023, to assess the efficacy of six botanical agents (*namely,* leaf powder of neem, eucalyptus, datura, akondo, pithraj and garlic clove powder) and one chemical insecticide, Fipronil 3GR, in controlling the Angoumois grain moth (*Sitotroga cerealella*) under storage conditions. The experimental environment, characterized by an average annual rainfall of 1202mm, maintained temperatures between 25-32°C and relative humidity between 65-75%, with consistent aeration of the mentioned region.

2.2 Collection of Maize Grain

For this study, maize hybrid-9 from Bangladesh Agricultural Research Institute (BARI), Gazipur, was used because it has stable yields in very where under any condition of weather. The maize was cleaned by winnowing and then sieved (1mm) to keep only intact kernels (Masiiwa, 2004). Its moisture content was maintained at 11-12%, and broken kernels and debris were manually removed (Fekadu et al., 2012; Manual of Seed Quality Control, 2006). Before artificial Angoumois grain moth infestation, the seeds were sun-dried for several days to eliminate any exiting insect infestations, a method supported by (Islam et al., 2000). Afterward, the maize was stored in a cool, dry plastic jar to prevent moisture accumulation.

2.3 Botanical Species Tested as Biopesticides

Six botanicals *namely* leaf powder of neem, eucalyptus, datura, akondo, pitraj and garlic clove powder and one chemical insecticide, Fipronil 3GR were used for the experiment. This chemical pesticide was the source of the biopesticides. The details of experimental materials are giving below:

Table 1: The specification of all treatments

Treatments	Local/ Trade Name	Scientific Name	Family/Company name	Parts Used	Doses (g/L)	Method of Application
Neem	Neem	*Azadirachta indica*	Meliaceae	Leaf	3.0	Add mixture
Garlic	Rashon	*Allivum sativum*	Liliaceae	Clove		
Eucalyptus	*Eucalyptus*	*Eucalyptus globulus*	Myrtaceae	Leaf		
Datura	Datura	*Datura stramonium*	Solanaceae	Leaf		
Akondo	Akondo	*Calotropis gigantea*	Apocynaceae	Leaf		
Pithraj	Rohituka tree	*Aphanamixis polystachya*	Meliaceae	leaf		
Bonanza 3GR	Fipronil 3GR	Haychem (Bangladesh) Limited			1.30	

2.4 Test Insect

The present study was conducted with major stored grain pest of maize named Angoumois grain moth under Gelechiidae family of Lepidoptera (*Sitotroga cerealella,* Olivier, 1789).

2.5 Collection and Rearing of Insect

Angoumois grain moths were collected from a farm's storeroom and transported to a storehouse in PolashBari, Rangpur, Bangladesh. They were then kept in a growth chamber at 27-30°C and 70-75% relative humidity. For rearing, 10 pairs of adult moths were placed in 15x12x35cm jars containing fresh maize seeds. The maize had been pre-treated by drying it overnight at 30°C and adjusting its moisture content to 12-13% to prevent prior infestation. Jars were covered with cloth and secured to prevent contamination and insect escape. After 15 days of egg-laying, adult moths were removed, and the jars were returned to the growth chamber to allow the next generation (F_1) to develop for experimental use.

2.6 Collection and Preparation of Tested Botanical Products

Neem, eucalyptus, datura, akondo and pithraj leaves were collected from local forest in PolashBari upazila and the green fresh leaves were washed out by tap water to remove any kind of dirt/debris. Garlic clove and Fibpronil 3GR were collected from local market. To prepare the leaves and clove for grinding, they were dried in an oven at 70°C for 24 hours until crispy. This allowed for fine grinding, and the resulting material was then sieved through a 1mm sieve to obtain fine botanical powders. After that, 3g of Neem, eucalyptus, datura, akondo, pithraj and garlic powder were measured, and they used it as a treatment material for each treatment in this study. Similarly, about 1.3g of Fibpronil 3GR was also taken from main packet that were used as a working material. Besides, while in control treatment there was not any botanicals added.

2.7 Treatment Application

Ten pairs of Angoumois grain moths were introduced into the plastic jar containing 100g grain maize in 0.5-liter plastic jars. Six botanicals with their recommended dosage *i.e.,* 3g for each treatment were measured and added to the maize grain in each jar containing 100g grain maize in 0.5-liter plastic jars. They kept for 3 months. In case mortality test, all botanicals were applied to the respective treatment with their replication according to the mentioned doses and mortality rate were counted daily every 1, 3 and 7 days after application of treatments.

2.8 Insect Infestation (%)

Insect infestation was assessed by the count method after three months of treatments. One hundred seeds were randomly taken from each treatment and the number of insects damaged and un-damaged grains was observed using a hand lens for the presence of hole or burrow. The percentage of insect infested seed was then calculated as follows:

$$\text{Insect infested grain (\%)} = \frac{\text{Number of insect infested grain}}{\text{Total number of grain}} \times 100$$

2.9 Mortality Test of Maize Angoumois Grain Moths

Mortality rate determination periods selected based on an earlier report by and calculated by the following formula (Alam et al., 2018, 2019, 2014):

$$\text{Mortality (\%)} = \frac{\text{Number of dead insects}}{\text{Total number of insects released}} \times 100$$

2.10 Grain Weight Loss (%)

The weight losses were caused by the feeding of larvae inside the seeds. After almost three months of starting the experiment, the final weight was measured from each replication of each treatment. The weight loss was measured by using a digital balance. The percentage weight loss of grain has been calculated by the formula below (Alam et al., 2014, 2018):

$$\text{Grain weight loss (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

2.11 Germination (%)

At the end of the three-month experiment, a germination test was performed. Twenty seeds from each experimental replicate were disinfected with a 1% sodium hypochlorite solution for one minute, followed by a one-minute rinse in distilled water, to prevent fungal contamination during germination. The seeds were then placed on moist filter paper in petri dishes and maintained at room temperature. After ten days, the number of germinated seedlings in each petri dish was counted, and the percentage of germination was calculated using the formula from (Alam et al., 2018).

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

2.12 Data Analysis

Analysis of the experimental data was performed using STATISTIX 10 software. Subsequently, Duncan's multiple range test (DMRT), as described by Duncan in 1951, was employed to differentiate the mean values.

3. Results

3.1 Number of Insects per 100g Grain

After three months in storage, the number of Angoumois grain moths emerging from treated grains varied significantly (Figure 1). Neem leaf powder (3.0g/L) was highly effective, resulting in just 5.76 insects per 100g grain, a result comparable to the Fipronil 3GR standard (1.3g/L, 3.96 insects). Higher insect counts were recorded for garlic clove extract (15.49), Eucalyptus leaf extract (35.66), Datura (42.48), Akondo (49.73), and pithraj (62.86), while the untreated control had the most insects (Figure 1).

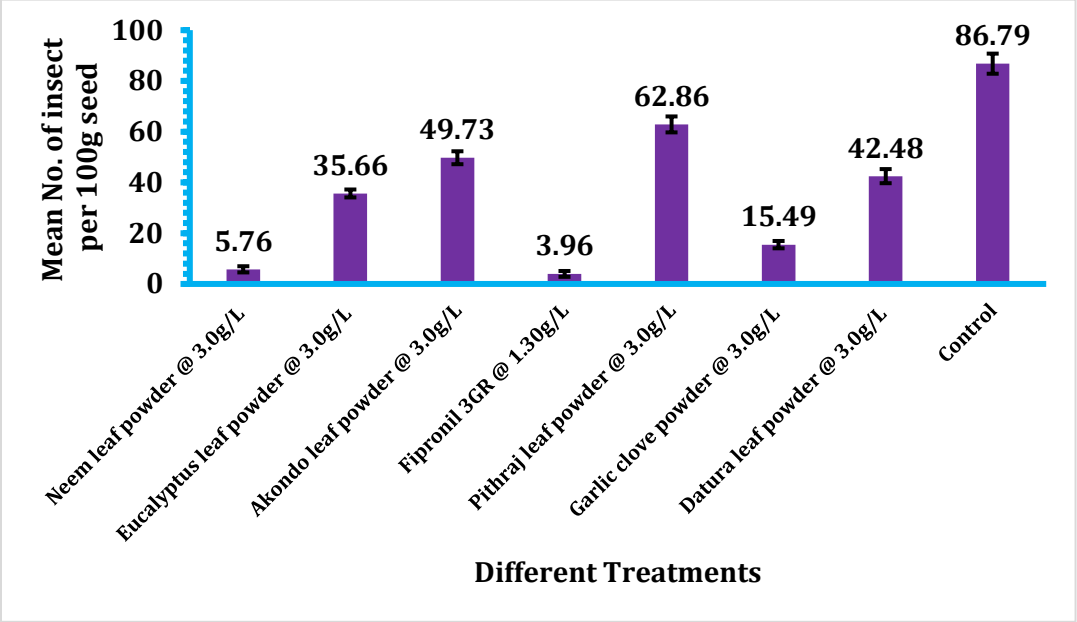

Figure 1: Evaluation of different botanicals and chemical against Angoumois grain moth (*Sitotroga cerealella*) after applied of three months in storage condition.

3.2 Grain Infestation (%) per 100g Seed

As detailed in Table 2, the various botanical treatments had a significant impact ($p<0.05$) on reducing Angoumois grain moth (*Sitotroga cerealella*) infestation after three months of storage. Notably, neem leaf powder at 3.0g/L proved to be the most potent botanical, resulting in only 7.14% grain infestation per 100 grains, a figure that closely mirrors the performance of the Fipronil 3GR standard (1.30g/L, 3.56%). Other botanicals offered less, but still notable, protection against infestation: garlic leaf powder (17.15%), Eucalyptus (39.62%), Datura (43.25%), Akondo (48.63%), and pithraj leaf powder (64.18%). The control treatment had the highest infestation rate, reaching 93.55% per 100g grain.

Table 2: Effects of botanicals on infestation per 100g grain for controlling Angoumois grain moth under storage condition during 1st April to June 30, 2023.

Treatments	Doses (g/L)	Infestation (%)/100g grain
Neem leaf powder	3.0	7.14e±2.45
Eucalyptus leaf powder		39.62cd±3.05
Akondo leaf powder		48.63c±4.52
Datura leaf powder		43.25c±3.26
Garlic clove powder		17.15d±2.66
Pithraj leaf powder		64.18b±3.66
Fipronil 3GR	1.3	3.56ef±1.02
Control		93.55a±4.89
Level of Significant		*
CV (%)		6.48

Means with the different letter are significantly different. * means at 5% level of significant.

3.3 Mortality (%)

As shown in Table 3, the impact of various botanical treatments on adult Angoumois grain moth (*Sitotroga cerealella*) mortality was statistically significant ($p<0.001$) after three months of storage. Neem leaf powder applied at 3.0g/L proved to be the most potent botanical, achieving an 85.48% mortality rate, which nearly matches the 96.59% mortality seen with the Fipronil 3GR standard at 1.30g/L concentration. Following neem, garlic leaf powder caused 69.58% mortality, Eucalyptus 47.33%, Datura 43.96%, Akondo 35.89%, and pithraj leaf powder 30.25%. The untreated control group, as expected, showed no moth mortality.

Table 3: Evaluation the effectiveness of some botanicals on mortality against Angoumois grain moth under storage condition during 1st April to June 30, 2023.

Treatments	Doses (g/L)	Mortality (%)
Neem leaf powder	3.0	85.48ab±0.96
Eucalyptus leaf powder		47.33d±1.75
Akondo leaf powder		35.89ef±2.33
Datura leaf powder		43.96de±2.06
Garlic clove powder		69.58c±1.22
Pithraj leaf powder		30.25f±2.96

Table 3 (cont): Evaluation the effectiveness of some botanicals on mortality against Angoumois grain moth under storage condition during 1st April to June 30, 2023.		
Fipronil 3GR	1.3	96.59a±0.33
Control		0.0g±2.04
Level of Significant		***
CV (%)		9.34

Means with the different letter are significantly different. *** means at 0.01% level of significant.

3.4 Grain Damage (%)

The results of Figure 2 clearly demonstrate that all botanical treatments effectively reduced grain damage caused by the Angoumois grain moth. The untreated control group suffered the highest percentage of damage while pithraj leaf powder (50.63%), Akondo leaf powder (39.05%), Datura leaf powder (33.20%), Eucalyptus leaf powder (25.48%), and garlic clove powder (20.34%) all offered some protection, neem leaf powder at 3.0g/L proved most effective, minimizing grain damage to a level similar to the Fipronil 3GR standard (1.30g/L).

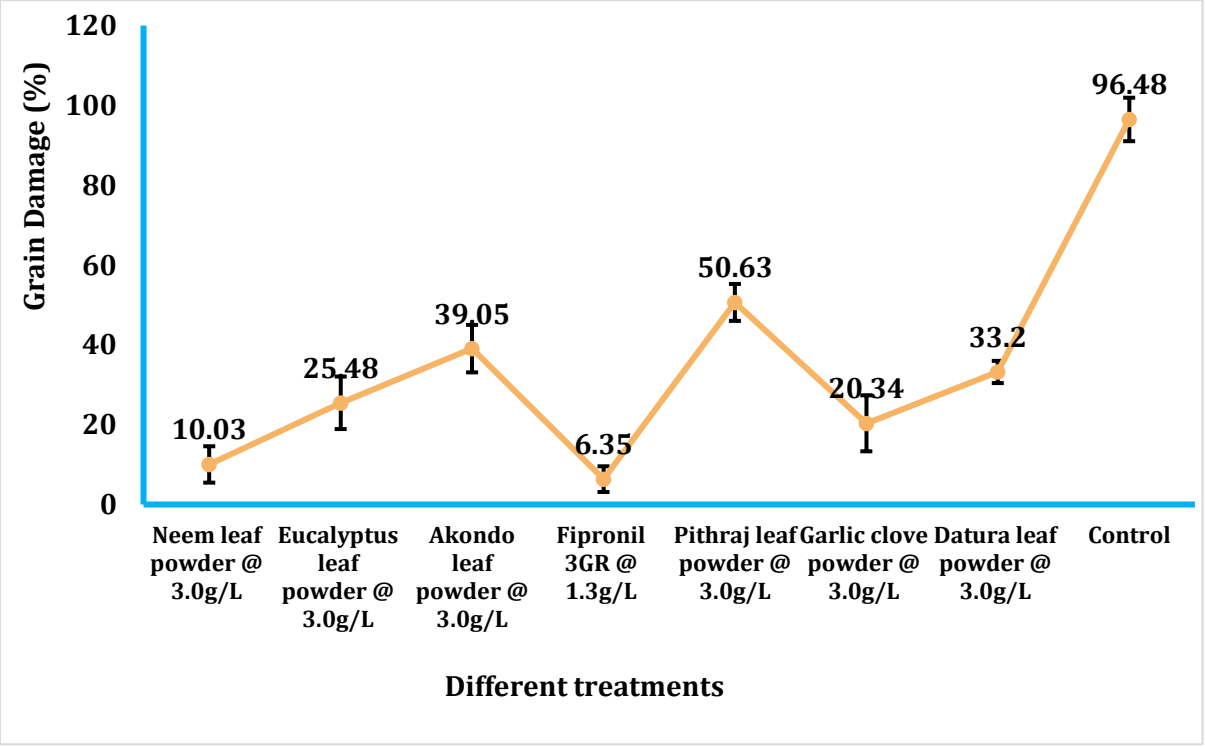

Figure 2: Effect of different botanicals and chemical on percent grain damage of maize for controlling Angoumois grain moth (*Sitotroga cerealella*) after applied of three months in storage condition.

3.5 Weight Loss (%)

Maize seeds treated with botanicals consistently showed significantly ($p<0.05$) less weight loss compared to those left untreated. After three months, the neem leaf powder treatment (3.0g/L per 100g seeds) resulted in the best outcome among the botanicals, demonstrating the least amount of grain weight loss (12.03%). Conversely, pithraj leaf powder (3.0g/L) led to the highest weight loss (56.49%) among the botanical applications. Notably, the effectiveness of neem leaf powder @ 3.0g/L (12.03%) was found to be statistically similar to that of the chemical Fipronil 3GR (1.30g/L) in preventing seed weight loss (7.89%) (Table 4).

Table 4: Evaluation the effectiveness of some botanicals on weight loss against Angoumois grain moth under storage condition during 1st April to June 30, 2023.		
Treatments	**Doses (g/L)**	**Weight loss (%)**
Neem leaf powder	3.0	12.03f±1.05
Eucalyptus leaf powder		29.66de±0.96
Akondo leaf powder		42.19bc±2.23
Datura leaf powder		35.48cd±1.55
Garlic clove powder		23.04ef±2.12
Pithraj leaf powder		56.49b±1.75
Fipronil 3GR	1.3	7.89fg±0.56
Control		97.49a±3.05
Level of Significant		*
CV (%)		4.97

Means with the different letter are significantly different. * means at 0.5% level of significant.

3.6 Germination (%)

All maize seeds treated with either botanical or chemical solutions germinated significantly ($P<0.01$) better than untreated seeds, indicating that none of these treatments harmed germination even after three months (Table 5). The best germination rate (94.56%) was observed with Firpronil 3GR at 1.30g/L Among botanical treatments, neem leaf powder (3.0g/L per 100g seeds) yielded the highest germination (90.74%), a result comparable to Fipronil 3GR. Other botanical treatments, in

descending order of effectiveness, included garlic clove powder (81.03%), eucalyptus leaf powder (64.23%), datura leaf powder (51.08%), and akondo leaf powder (48.63%), with pithraj leaf powder showing the lowest germination (42.05%) among all botanicals tested (Table 5).

Table 5: Evaluation the effectiveness of some botanicals on germination against Angoumois grain moth under storage condition during 1st April to June 30, 2023.

Treatments	Doses (g/L)	Germination (%)
Neem leaf powder	3.0	90.74ab±0.96
Eucalyptus leaf powder		64.23d±1.79
Akondo leaf powder		48.63ef±1.97
Datura leaf powder		51.08e±2.16
Garlic clove powder		81.03c±1.26
Pithraj leaf powder		42.05fg±0.78
Fipronil 3GR	1.3	94.56a±0.76
Control		39.66g±3.25
Level of Significant		**
CV (%)		6.89

Means with the different letter are significantly different. *** means at 0.01% level of significant.

4. Discussions

As regards of number of insects per 100g grain, after three months of storage, all insects were removed from the grain by sieving. The insects from each 100g grain sample per replication were then counted. Significantly different numbers of Angoumois grain moth emerged across the various treatments. Interestingly, neem leaf powder at 3.0g/L resulted in significantly fewer insects (5.76 insects per 100g grain) compared to other treatments. This was statistically similar to the results from pots treated with Fipronil 3GR at 1.30g/L (3.96 insects). Following these, the insect counts were 15.49 for garlic clove powder, 35.66 for Eucalyptus leaf powder, 42.48 for Datura**,** 49.73 for Akondo, and 62.86 for pithraj leaf powder (Figure 1). The highest number of insects was observed in the control treatment. A key characteristic of an effective grain protectant is its ability to reduce insect reproduction in treated grains. In this laboratory study, neem leaf powder at 3.0g/L effectively reduced the number of Angoumois grain moths to 5.76 insects per 100g grain. This finding indicates a significant reduction in insect emergence due to the neem treatment (Abraham, 1997; Akter et al., 2013 and Zote and Shukla, 2023). In case of percent grain infestation per 100g seed, as detailed in Table 2, botanical treatments had a significant impact on reducing angoumois grain moth (*Sitotroga cerealella*) infestation after three months of storage ($p<0.05$). Neem leaf powder at 3.0gl/L emerged as the most successful botanical, limiting grain infestation to just 7.14% per 100 grains, a performance very similar to the Fipronil 3GR standard (1.30g/L, 3.56%). While the untreated control group suffered extensive infestation (93.55% per 100g grain), it's important to note that every botanical tested offered some degree of control. These findings are consistent with existing literature, including work, which supports the use of botanicals for effective pest management by (Alam et al., 2014, 2018, 2019).

As regards of percent mortality, the various treatments had a statistically significant impact on adult Angoumois grain moth mortality ($p<0.001$) (Table 3). Neem leaf powder applied at 3.0g/L achieved the highest mortality among the botanicals (85.48%), nearly matching the effectiveness of the Fipronil 3GR standard (1.30g/L, 96.59%). In contrast, the control group experienced the lowest mortality (0.0%). Importantly, every botanical tested showed some degree of effectiveness in controlling the Angoumois grain moth. These results are consistent with the findings of other researchers, , who have also confirmed the efficacy of botanicals in managing this pest such as (Amin, 2014). Besides, percentage of grain damage, research summarized in Figure 2 indicates that Angoumois grain moth infestations significantly damaged grain, but all botanical treatments tested proved effective in reducing this damage. The untreated control suffered the most damage. Among the botanical applications, pithraj leaf powder @ 3.0g/L (50.63%) was the least effective, while Akondo leaf powder (39.05%), Datura (33.20%), Eucalyptus (25.48%), and garlic (20.34%) provided progressively better protection. Notably, neem leaf powder applied at 3.0g/L offered the best results, minimizing grain damage to a level on par with the standard insecticide, Fipronil 3GR (1.30g/L). The consistently lower damage in jars treated with botanicals over three months of storage confirms their protective efficacy against the Angoumois grain moth. The reduced damage observed is likely due to the botanicals either stopping angoumois grain moth eggs from hatching or discouraging the moths from feeding on the seeds. This outcome supports similar findings regarding the use of plant products for insect control in stored maize and cowpea by (Alam et al., 2014, 2018, 2019; Ashano and Akinnawonu, 2012).

On the other hand, percentage of weight loss, all botanical treatments significantly reduced maize seed weight loss compared to the untreated control. Neem leaf powder (3.0g/L per 100g seeds) proved most effective (12.03%) among the botanicals, resulting in the lowest weight loss (12.03%) after three months (Table 4). Conversely, pithraj lead powder (3.0g/L) led to the highest weight loss (56.49%) among the botanical treatments. Notably, neem leaf powder @ 3.0g/L (12.03%) performed comparably to the chemical Fipronil 3GR @ 1.30g/L (7.89%), showing no significant difference in seed weight loss. Botanical and chemical treatments significantly reduced seed weight loss compared to untreated seeds**.** This effectiveness is attributed to the treatments causing higher mortality and lower survival rates of Angoumois grain moths, leading to less seed damage. These findings align with previous research: synthetic chemicals like Fipronil 3GR effectively protect stored grain (Dobie, 1974 and Emana, 1993)), and neem leaf powder reduces grain damage and weight loss by dehydrating and suffocating the moths and restricting their movement (Fekadu et al., 2013; Ghanashyam et al., 2015 and Hasan et al., 2025). Additionally, leaf powder of Datura, Eucalyptus, Akondo, and garlic likely contributed to lower weight loss by decreasing grain surface humidity, which hinders moth egg laying and larval development (Javed et al., 2010 and Jena et al., 2023).

In case of percentage of germination, all maize seeds treated with botanical or chemical solutions showed significantly improved germination compared to untreated seeds. Among the botanical treatments, neem leaf powder (3.0g/L per 100g seeds) yielded the highest germination rate at 90.74%**,** which was statistically comparable to Fipronil 3GR (94.56%) at 1.30g/L. Conversely, pithraj leaf powder resulted in the lowest germination among all tested botanicals. These findings align with previous research, particularly regarding the efficacy of neem leaf powder and garlic clove powder in reducing insect infestation without harming seed germination by (Karim and Jabed, 2011; Perez-Mendoza et al., 2004; Zaidi et al., 2003).

5. Conclusion

Based on the results of present study, it may be concluded that while the synthetic pesticide Fipronil 3GR proved most effective in controlling the pest and preserving seed health, neem leaf powder emerged as a promising eco-friendly alternative. Its notable efficacy in reducing infestation and damage, along with maintaining seed viability, highlights its potential for integration into sustainable post-harvest pest management strategies for maize. Further research into optimizing the application of neem leaf powder and exploring other botanical options could contribute to more environmentally sound approaches for protecting this vital cereal crop.

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