DOI: https://dx.doi.org/10.4314/gjpas.v30i3.2

GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 30, 2024: 283-292
COPYRIGHT© BACHUDO SCIENCE CO. LTD PRINTED IN NIGERIA ISSN 1118 – 0579, e-ISSN: 2992 - 4464
www.globaljournalseries.com.ng, Email: globaljournalseries@gmail.com

EFFICACY OF *Azadirachta indica*-TREATED STORAGE MATERIALS AGAINST MAIZE WEEVIL *Sitophilus zeamais* AND RICE WEEVIL *Sitophilus oryzae*

NTA, A. I., BASSEY, D. A., ETIM, I. F., IMALELE, E. E
E-Mail: abonta@unical.edu.ng

(Received 27 May 2024; Revision Accepted 21 June 2024)

ABSTRACT

Weevil infestations cause post-harvest losses and have become important constraints to storage entomology and food security in Nigeria. The present study is aimed at assessing the efficacy of *Azadirachta indica*-treated storage materials against *Sitophilus zeamais* and *Sitophilus oryzae*. Storage materials such as bagco bags, calico bags, and plastic containers were treated with different concentrations (0.5, 1.0, and 1.5mg/ml) of *A. indica* oil. Untreated storage materials served as the control. These treatments were replicated three times following a completely randomized design in the laboratory and monitored for 100 days. The results showed a significant decrease (p<0.05) in weight loss of infested maize and rice grains with different concentrations of the extract and with the different storage materials compared to the control. The highest weight loss among the treatment concentrations across all the storage materials treated with *Azadirachta indica* was recorded for rice grains stored in calico bags at 0.5mg/ml with mean value of 10.61±0.37 and7.12±1.41 for maize grains, while the least value of 1.14±0.09 was recorded for rice grains stored in plastic containers at 1.5mg/ml and 0.75±0.21 was recorded for maize grains stored in plastic containers at 1.5mg/ml. there was a significant increase (p<0.05) in mortality of *S. zeamais* and *S. oryzae* with increased concentrations of the extracts compared to the control. There was no significant increase in mortality of *S. zeamais* and *S. oryzae* compared with the storage materials. The highest mortality for *S. oryzae* 8.00±0.58 was seen in rice grains stored in plastic containers at 0.5mg/ml concentration and least mortality 4.00±0.58 was seen in those stored in bagco bag at 1.0mg/ml concentration. For *S. zeamais*, there was no significant increase on the mortality of *S. oryzae* between 0.5mg/ml and 1.0mg/ml concentrations in *A. indica* treated bagco bags and between 1.0mg/ml and 1.5mg/ml concentrations in *A. indica* treated plastic containers. *S. oryzae* in maize grains stored in plastic containers at 1.0mg/ml had the highest mortality 9.00±1.53 and the least mortality (3.00±0.00) was recorded for *S. zeamais* in maize grains stored in calico bag at 0.5mg/ml of *A. indica* treated materials. Results of the storage materials (Bagco bag, Calico bag, and Plastic container) treated with *Azadirachta indica* leaves extract showed significant decrease (p<0.05) in adult emergence of *S. zeamais* and *S. oryzae* in the different concentrations of extracts compared to the control. There was no significant decrease among the *A. indica* treated storage materials for *S. zeamais* and *S. oryzae* emergence. The highest *S.oryzae* emergence in *A. indica* treated bags was recorded for *S. oryzae* stored in Bagco bag at 1.0mg/ml with mean value of 177.67±9.21 and the least value of 107.33±3.76 was recorded for *S. oryzae* infesting rice grains stored in plastic containers at 1.5mg/ml. There was a significant decrease (p<0.05) in the number of holes bored by *S. zeamais* and *S. oryzae* in maize and rice grains treated with *Azadirachta indica* leaf extract compared to control across various concentrations and storage materials. The highest number of holes bored by *S oryzae* 390.00±28.22 in infested rice grains was recorded in Calico bag at 0.5mg/ml concentration and the least was recorded in plastic containers at 1.5mg/ml concentration (134.67±11.26). Similar trends were observed with Weevil perforative index and percentage damage. The study concludes that bagco bags treated with *A. indica* at 1.5mg/ml are more effective for protection of maize and rice grains in storage.

KEYWORDS: *Azadirachta indica*, *Sitophilus zeamais*, *Sitophilus oryzae*, storage materials, stored grains, pest management.

INTRODUCTION

The preservation of stored grains is of paramount importance to ensure food security and mitigate economic losses caused by insect pest infestations. Insect pests, such as the maize weevil (*Sitophilus zeamais*) and rice weevil (*Sitophilus oryzae*), pose significant challenges to the post-harvest management of grains worldwide (Ojo and Omoloye, 2012).

NTA, A. I., Department of Zoology and Environmental Biology, Faculty of Biological Sciences, University of Calabar, Cross River State, Nigeria
BASSEY, D. A., Department of Zoology and Environmental Biology, Faculty of Biological Sciences, University of Calabar, Cross River State, Nigeria
ETIM, I. F., Department of Zoology and Environmental Biology, Faculty of Biological Sciences, University of Calabar, Cross River State, Nigeria
IMALELE, E. E., Department of Zoology and Environmental Biology, Faculty of Biological Sciences, University of Calabar, Cross River State, Nigeria

Chemical pesticides have been widely used to combat these pests. However, concerns over the environmental impact and the potential health risks associated with pesticide residues have prompted researchers to explore
alternative pest management strategies that are more sustainable and environmentally friendly (Nta, 2019).

In recent years, there has been a growing interest in the use of botanical extracts as a viable and eco-friendly approach to control insect pests in stored grains, with *Azadirachta indica*, commonly known as neem, gaining considerable attention due to its insecticidal properties and long history of use in traditional medicine (Barstow and Deepu, 2018). This tropical evergreen tree, native to the Indian subcontinent, contains bioactive compounds with potent insecticidal and repellent properties (Barstow and Deepu, 2018).

The efficacy of *Azadirachta indica* as a natural insecticide has been extensively studied in the agricultural sector. The active ingredient responsible for its insecticidal properties is *azadirachtin*, a potent compound that affects the development, feeding behavior, and reproduction of insect pests. *Azadirachtin* acts through various mechanisms, including disruption of insect molting, interference with hormone regulation, inhibition of feeding, and interference with the insect's reproductive system (Isman, 2020; Nta *et al.,*).

Azadirachta indica offers several advantages as a pest management tool in stored grains. Firstly, it is derived from a renewable plant source, making it a sustainable and environmentally friendly option compared to chemical pesticides. Additionally, neem-based products have been shown to have a broad spectrum of activity against a wide range of insect pests, including stored grain pests like the maize weevil and rice weevil. Furthermore, *Azadirachta indica* is considered safe for humans, animals, and beneficial insects, minimizing the risk of adverse effects on non-target organisms and preserving biodiversity in the ecosystem (Rahman *et al*., 2017).

In light of the increasing demand for sustainable and environmentally friendly pest management practices, the exploration of *Azadirachta indica*-treated storage materials as an alternative to chemical pesticides has become a topic of considerable interest (Yan, 2017). The findings of this study will contribute to a better understanding of the potential of *Azadirachta indica*-treated storage materials as an effective and sustainable strategy for managing insect pests in stored grains, offering a valuable alternative to conventional chemical-based approaches. Thus the objectives of this paper were to determine the effectiveness of treated bagco bags, calico bags, and plastic containers on weight loss of infested maize and rice grains, to evaluate the effectiveness of treated bagco bags, calico bags, and plastic containers on mortality of *S zeamais* and *S oryzae*, to examine the effectiveness of treated bagco bags, calico bags, and plastic containers on adult emergence of *S zeamais* and *S oryzae* and to determine the effectiveness of treated bagco bags, calico bags, and plastic containers on the extent of damage of *S zeamais* and *S oryzae* on maize and rice grains.

MATERIALS AND METHOD

Study site

The experiment was conducted in the Department of Zoology and Environmental Biology Laboratory, University of Calabar, Calabar which lies within latitude 4.6ºN and longitude 8.2ºE in the South South agro ecological zone of Nigeria. The environmental condition was characterized by ambient temperature of 27±2ºC and 75±20% relative humidity and day light of 12h. The experimental materials were obtained from farms in Calabar South and Ogoja. Calabar South is a local government area of Cross River State, Nigeria. Its headquarters are in the town of Anantigha. It has an area of 264 km2 and a population of 191,630 at the 2006 census. Ogoja is a Local Government Area in Cross River State, Nigeria. Its headquarters is Ogoja town in the northeast of the area near the A4 highway at 6°39′17″N 8°47′51″E.

Collection of maize and rice grains

Clean and un-infested maize grains were collected from maize farm in Calabar South while the rice grains were obtained from Ogoja rice farm.

Collection and preparation of plants extract

Neem leaves (*A. indica*) were collected within the Calabar South, Cross River State. The plant materials obtained were dried at 50ºC using Gallenkamp oven for 72 hours. The dried neem samples were crushed using blender and a simple extraction procedure was used to extract oil from the ground leaves as described by (Ojiako *et al*., 2016). Briefly, the ground leaves were put into a big glass bottle and 1.5 litre of ethanol was added, agitated for proper mixing and allowed to settle. After 2 days, the liquid oil was separated from the chaff by placing a clean muslin cloth at the mouth of a funnel. The filtrate was then poured through the funnel into a 500 ml beaker. The collected neem oil was placed on hot plate at a low temperature (60˚C) for 3hours, to allow for the evaporation of the ethanol solvent. The evaporation process yielded 4.2ml of oil of *A. indica*.

A stock solution of 0.5mg/ml, 1.0mg/ml and 1.5mg/ml concentrations was prepared from *A. indica* and with 1000ml of ethanol for each of the solutions. Therefore, the concentrations of the solution were deduced from the formular below:

$$\text{Concentration} = \frac{\text{Amount}}{\text{Volume}}$$

Where; Amount = the quantity of the solute

Volume = the quantity of the solvent (Molarity (M).

Insect culture

Adult *S. zeamais* and *S. oryzae* were sourced from infested maize and rice grains from Watt market, Calabar South, Cross River State, Nigeria. Culture of *S. zeamais* and *S. oryzae* was performed at the Department of Zoology and Environmental Biology laboratory, University of Calabar. The culture was maintained on dried maize and rice grains in 250cm^3 glass jars covered with muslin cloth at 27±2^{o}C and 80±5% temperature and relative humidity respectively. Several adults of mixed sexes and unknown ages were introduced into the culture media. Frass generated due to feeding activities of the insects were sieved out weekly using sieve of mesh size 0.25mm to rejuvenate the culture stock, prevent excessive grain moisture content and growth of mold (Osipitan *et al.,* 2015). Subsequent insect pest were collected from the stocked culture for further experimental setup.

Preparation of Storage Materials

Three different storage materials were procured for this experiment. These are Bagco crop bags (BCB), Calico bags (CAB) and 100 ml Plastic containers (PLC). Bagco crop bag and calico bag were cut into 12 x 10 cm length and width respectively. Three different concentrations of *A. indica* leaves oil (ALO), 0.50mg/ml, 1.00mg/ml and 1.50mg/ml were used for the study. The cut storage bags were immersed in the solution and were left overnight to ignite the concentration of the active ingredients and for the evaporation of the solvent. For the plastic containers, the extract was aspirated into them, evenly distributed by rolling, covered with muslin cloth, and left overnight for solvent evaporation. Control experiment was set up by soaking the storage materials in the solvent only without the treatment and left overnight (Poopola *et al.,* 2017).

Bioactivity tests

Fifty grams (50g) of maize and rice grains were weighed using an electronic balance [Model: Soehnle Professional 9230 (Max 600g × 0.01)] and added to each storage material (BCB, CAB, and PLC). Ten unsexed teneral adults, *S. zeamais* and *S. oryzae*, were introduced randomly into each material. The bags were tightly folded and firmly tied at the top whilst the plastic containers were covered with untreated muslin cloth and held firmly with rubber band. Control experiment was also set up with insect infestation without extracts in three replicates. All treatments were arranged in a completely randomized designed (CRD). These were kept undisturbed for 100 days.

Determination of weight loss of seeds

This was obtained from the weight of seeds of adult emergence expressed as percentage of seeds provided for the experiment. The percentage weight loss of maize and rice grains was calculated according to Baba-Tierto (1994) formula:

$$\%\ \text{weight loss} = \frac{W_0 - W_1}{W_0} \times \frac{100}{1}$$

Where W_0 is the initial weight of sample before infestation

W_1 is the final weight of sample after infestation

Determination of mortality of adult *S. zeamais* and *S. oryzae* on treated storage materials

Data were collected on the effect of the treatment on the mortality of the adults respectively. This was done by counting, recording and discarding the number of dead insects in each storage materials. Insects were considered dead when they could not move their body parts after being prodded with a brush. The percent mortality was calculated thus:

$$\text{Percent Mortality} = \frac{\text{No.of dead insects}}{\text{Total No.of insects}} \text{ X } \frac{100}{1} \quad (1)$$

Determination of adult emergence on treated storage materials

The total number of adults of *S. zeamais*a nd *S. oryzae* that emerged (dead and alive) was counted after 100 days of exposure and recorded.

Determination of percentage damage of maize and rice grains

Damage was assessed by counting the total number of emergence holes per seed. The percentage damage (PD) of the perforated grains was calculated thus:

$$\text{PD} = \frac{\text{Total number of sampled grains perforated}}{\text{Total number of sampled grains}} \text{ X } \frac{100}{1} \quad (2)$$

The Weevil Perforation Index (WPI) was then calculated:

$$\text{WPI} = \frac{\text{Total number of treated grains perforated}}{\text{Total number of untreated grains seed perforated}} \text{ X } \frac{100}{1} \quad (3)$$

Experimental design and treatment

The experiment was laid out in 4 x 3 factorial arrangements and fitted into a completely randomized design (CRD). Factor A represent three concentrations of *Azadirachta indica* leaves oil (0.50, 1.00 and 1.50mg/ml/100g leaves) and the control while factor C represents the three different storage materials 100ml plastic containers (PLC), 12 x 10cm bagco bags (BCB) and Calico bags (CAB). The experiment was replicated three times. Total treatment combination was 12 (4 x 3).

Data analysis

The data obtained were analyzed statistically using Predictive Analytical Software (PASW) version 20. Results were presented as means ± standard error for respective plant extracts. Analysis of variance was used to test significant differences between the effectiveness of the concentrations (0.5, 1.0, and 1.5mg/ml) of the plant extracts and the storage materials.

The mean differences were separated using Duncan Multiple Range DMR Test of difference at 5% level of significance (P<0.05).

RESULTS

Effect of *Azadirachta indica*- treated storage materials on weight loss of infested maize and rice grains.

Results of the storage materials (bagco bag, calico bag, and plastic container) treated with *Azadirachta indica* leaves extract showed that there was a significant decrease (p<0.05) in weight loss of infested maize and rice grains with different concentrations of the extract and with the different storage materials compared to the control. The highest weight loss among the treatment concentrations across all the storage materials treated with *Azadirachta indica* was recorded for rice grains stored in calico bags at 0.5mg/ml with mean value of 10.61±0.37 and7.12±1.41 for maize grains, while the least value of 1.14±0.09 was recorded for rice grains stored in plastic containers at 1.5mg/ml and 0.75±0.21 was recorded for maize grains stored in plastic containers at 1.5mg/ml (Table 1)

TABLE 1: Effect of *Azadirachta indica* treated storage materials on weight loss of maize and rice grain ($\bar{X}$±SE)

Maize				Rice		
Conc. of extracts (mg/ml)	Bagco bag	Calico bag	Plastic Container	Bagco bag	Calico bag	Plastic Container
0.00	14.96±0.58[c]	14.47±0.14[c]	14.78±0.57[c]	24.66±0.32[c]	25.30±0.74[c]	24.08±0.20[d]
0.5	4.30±0.48[b]	7.12±1.41[b]	2.47±0.25[b]	9.57±0.38[b]	10.61±0.37[b]	7.13±0.90[c]
1.0	2.58±0.36[a]	4.07±0.15[a]	0.97±0.74[a]	4.33±0.95[a]	7.26±0.71[a]	3.41±0.05[b]
1.5	1.19±0.52[a]	1.98±0.22[a]	0.75±0.21[a]	3.21±1.92[a]	7.25±1.32[a]	1.14±0.09[a]
Total	5.75±0.28[b]	6.91±0.28[b]	4.80±0.28[a]	10.44±0.42[b]	12.60±0.42[c]	8.94±0.42[a]

Means followed by different superscripts in each column are significantly different (p < 0.05) according to Duncan's Multiple Range Test (DMRT).

Effect of *Azadirachta indica*- treated storage materials on mortality of *S. zeamais* and *S. oryzae*

Results of the storage materials (bagco bag, calico bag, and plastic container) treated with *Azadirachta indica* leaves extract showed that there was a significant increase (p<0.05) in mortality of *S. zeamais* and *S. oryzae* with increased concentrations of the extracts compared to the control. There was no significant increase in mortality of *S. zeamais* and *S. oryzae* compared with the storage materials. The highest mortality for *S. oryzae* 8.00±0.58 was seen in rice grains stored in plastic containers at 0.5mg/ml concentration and least mortality 4.00±0.58 was seen in those stored in bagco bag at 1.0mg/ml concentration. For *S. zeamais*, there was no significant increase on the mortality of *S. oryzae* between 0.5mg/ml and 1.0mg/ml concentrations in *A. indica* treated bagco bags and between 1.0mg/ml and 1.5mg/ml concentrations in *A. indica* treated plastic containers. *S. oryzae* in maize grains stored in plastic containers at 1.0mg/ml had the highest mortality 9.00±1.53 and the least mortality (3.00±0.00) was recorded for *S. zeamais* in maize grains stored in calico bag at 0.5mg/ml of *A. indica* treated materials (Table 2).

TABLE 2: Effect of *Azadirachta indica* treated storage materials on mortality of *S. zeamais* and *S. oryzae* ($\bar{X}$±SE)

	S. zeamais			*S. oryzae*		
Conc. of extracts (ml)	Bagco bag	Calico bag	Plastic Container	Bagco bag	Calico bag	Plastic Container
0.00	1.33±0.33^{a}	1.67±0.33^{a}	1.67±0.67^{a}	3.33±0.88^{a}	3.00±1.15^{a}	2.33±0.33^{a}
0.5	8.00±1.15^{b}	3.00±0.00^{a}	6.00±1.73^{ab}	6.00±0.58^{a}	5.00±0.58^{ab}	8.00±0.58^{c}
1.0	6.67±2.19^{b}	4.67±1.67^{ab}	9.00±1.53^{b}	4.00±0.58^{a}	7.67±1.76^{b}	6.00±0.58^{b}
1.5	5.33±0.88^{ab}	8.00±1.15^{b}	8.67±1.67^{b}	5.67±1.76^{a}	7.67±1.45^{b}	5.33±0.33^{b}
Total	5.33±0.64^{ab}	4.33±0.64^{a}	6.33±0.64^{b}	4.75±0.50^{a}	5.83±0.50^{a}	5.41±0.50^{a}

Means followed by different superscripts in each column are significantly different ($p < 0.05$) according to Duncan's Multiple Range Test (DMRT).

Effect of *Azadirachta indica* -treated storage materials on adult emergence of *S. zeamais* and *S. oryzae*.

Results of the storage materials (Bagco bag, Calico bag, and Plastic container) treated with *Azadirachta indica* leaves extract showed significant decrease ($p<0.05$) in adult emergence of *S. zeamais* and *S. oryzae* in the different concentrations of extracts compared to the control. There was no significant decrease among the *A. indica* treated storage materials for *S. zeamais* and *S. oryzae* emergence.

The highest *S.oryzae* emergence in *A. indica* treated bags was recorded for *S. oryzae* stored in Bagco bag at 1.0mg/ml with mean value of 177.67±9.21 and the least value of 107.33±3.76 was recorded for *S. oryzae* infesting rice grains stored in plastic containers at 1.5mg/ml. The highest *S. zeamais* emergence was seen in plastic container with the value of 85.33±10.33 at 0.5mg/ml while the least *S. zeamais* emergence was seen in bagco bag with the value of 25.00±2.52at 1.5mg/ml concentration of *A. indica* extract (Table 3).

TABLE 3: Effect of *Azadirachta indica* treated storage materials on adult emergence of *S. zeamais* and *S. oryzae* ($\bar{X}$±SE)

	S. zeamais			*S. oryzae*		
Conc. of extracts (ml)	Bagco bag	Calico bag	Plastic Container	Bagco bag	Calico bag	Plastic Container
0.00	238.33±22.82[b]	222.33±0.88[d]	255.00±5.51[c]	244.67±6.89[d]	274.33±23.67[c]	263.67±7.13[d]
0.5	66.00±4.73[a]	75.33±7.26[c]	85.33±10.33[b]	110.00±4.58[a]	174.67±14.52[b]	163.67±4.48[c]
1.0	47.67±13.28[a]	45.00±4.04[b]	41.67±13.30[a]	177.67±9.21[c]	154.33±10.91[ab]	133.67±5.90[b]
1.5	25.00±2.52[a]	29.33±2.85[a]	32.67±5.90[a]	133.33±4.91[b]	115.00±6.66[a]	107.33±3.76[a]
Total	94.25±4.90[a]	93.00±4.90[a]	103.66±4.90[a]	166.41±5.06 [a]	179.58±5.06 [a]	167.08±5.06 [a]

Means followed by different superscripts in each column are significantly different ($p < 0.05$) according to Duncan's Multiple Range Test (DMRT).

Effect of *Azadirachta indica*-treated storage materials on the extent of damage of infested maize and rice grains.

The results revealed a significant decrease ($p<0.05$) in the number of holes bored by *S. zeamais* and *S. oryzae* in maize and rice grains treated with *Azadirachta indica* leaf extract compared to control across various concentrations and storage materials. The highest number of holes bored by *S oryzae* 390.00±28.22 in infested rice grains was recorded in Calico bag at 0.5mg/ml concentration and the least was recorded in plastic containers at 1.5mg/ml concentration (134.67±11.26). Similarly, the highest number of holes of infested maize grains among the treatment concentrations across all the storage materials was recorded in maize grains 172.00±5.29 stored in calico bags at 0.5mg/ml and the least value of 39.67±12.20 was recorded for maize grains stored in plastic container at 1.5mg/ml (Table 4).

TABLE 4: Effect of *Azadirachta indica* treated storage materials on adult emergence of *S. zeamais* and *S. oryzae* after 100 days ($\bar{X}$±SE)

	S. zeamais			*S. oryzae*		
Conc. of extracts (ml)	Bagco bag	Calico bag	Plastic Container	Bagco bag	Calico bag	Plastic Container
0.00	241.67±23.38[b]	226.67±0.33[c]	260.67±5.93[c]	651.00±15.72[c]	664.67±28.85[c]	636.67±10.93[c]
0.5	165.33±10.37[a]	172.00±5.29[b]	123.67±12.72[b]	323.33±64.89[b]	390.00±28.22[b]	311.33±29.90[b]
1.0	142.67±12.71[a]	159.00±0.58[b]	53.67±18.32[a]	237.67±28.43[ab]	280.67±9.82[a]	162.67±21.45[a]
1.5	127.00±14.73[a]	119.00±8.89[a]	39.67±12.20[a]	143.67±8.57[a]	233.00±35.34[a]	134.67±11.26[a]
Total	169.16±6.16[b]	169.16±6.16[b]	119.41±6.16[a]	338.91±14.37 [a]	392.08±14.37 [b]	311.33±14.37 [a]

Means followed by different superscripts in each column are significantly different ($p < 0.05$) according to Duncan's Multiple Range Test (DMRT).

Weevil's Perforative index

The results indicated a significant decrease ($p<0.05$) in the perforative indexes of maize and rice grains infested by *S. zeamais* and *S. oryzae* when treated with *Azadirachta indica* leaf extracts compared to the control. This decrease occurred across various concentrations of the extracts and different storage materials. The highest perforative index of infested maize and rice grains among the *A.indica* treatment concentrations across all the storage materials was recorded for maize grains stored in calico bags at 0.5mg/ml (75.89±2.42) and the least value (15.29±4.79) was recorded in maize grains stored in plastic container at 1.5mg/ml (Figure 1).

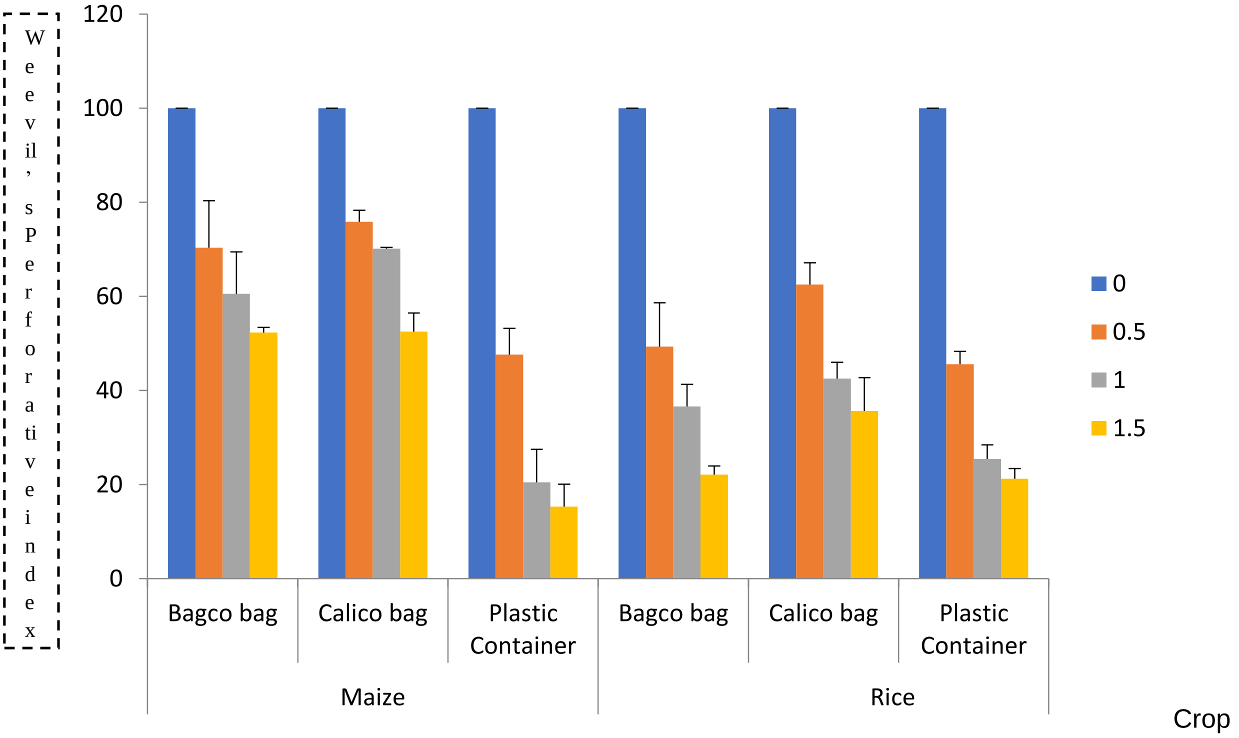

Fig 1: Effect of *A. indica* treated storage materials on perforative indexes of *S. zeamais* and *S. oryzae* infested maize and rice grains ($\bar{X}$±SE).

Percentage damage

Results demonstrated a significant decrease ($p<0.05$) in the percentage damage of maize and rice grains infested by *S. zeamais* and *S. oryzae* when treated with *Azadirachta indica* leaf extract, compared to control, across various extract concentrations and storage materials. The highest percentage damage of infested maize and rice grains among the treatment concentrations across all the storage materials was recorded in maize grains stored in calico bag at 0.5mg/ml (56.39±1.74) and the least value of 5.42±0.45was recorded for rice grains stored in plastic container at 1.5mg/ml (Figure 2).

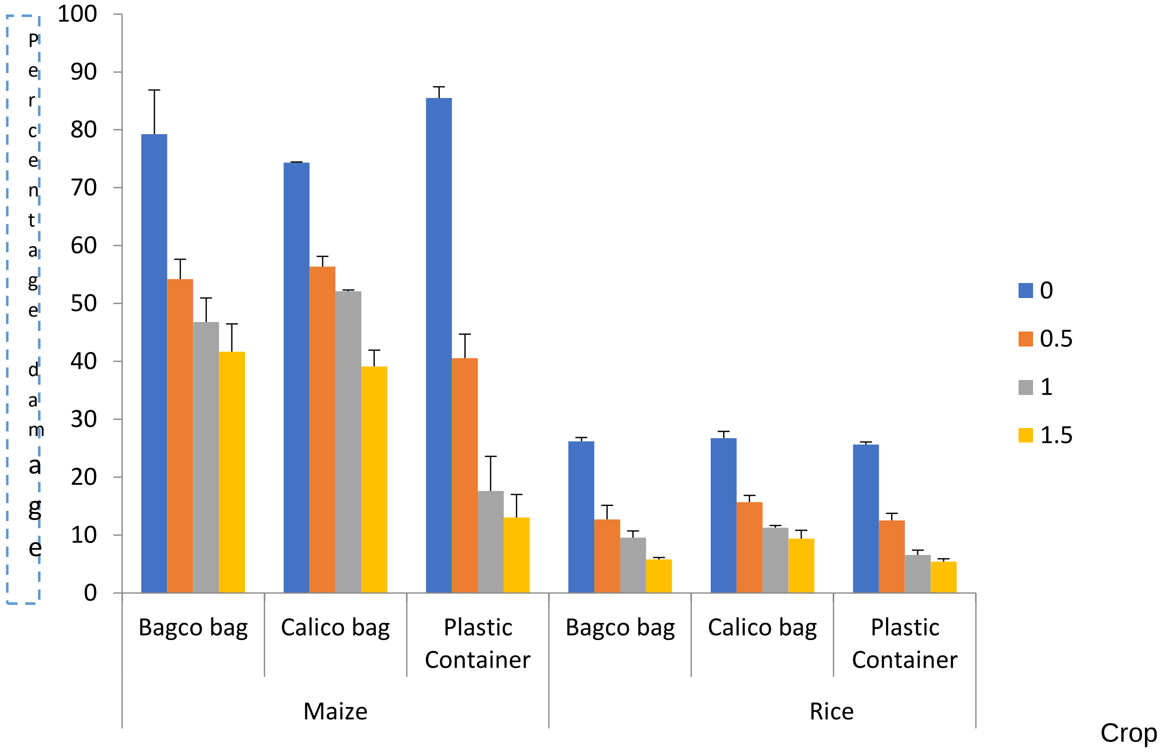

Fig 2: Effect of *Azadirachta indica* treated storage materials on Percentage damage of *S. zeamais* and *S. oryzae* on infested maize and rice grains ($\bar{X}$±SE)

DISCUSSION

The present study investigated the efficacy of *Azadirachta indica* (neem) extract against the maize weevil (*Sitophilus zeamais*) and rice weevil (*Sitophilus oryzae*) infestations in different storage materials. The findings of this study provide valuable insights into the effectiveness of *A. indica* as a natural pest control agent and its potential application in post-harvest grain protection strategies.

Weight loss is a crucial indicator of the extent of damage caused by weevil infestations in stored grains. These findings align with previous studies which reported the insecticidal properties of *Azadirachta indica* extracts against various stored grain pests (Smith *et al*., 2020; Singh *et al*., 2021). The bioactive compounds present in *A. indica* extracts, such as *azadirachtin*, have been attributed to their ability to disrupt the feeding behavior and growth of weevils (Isman, 2020).

Mortality rate is another vital parameter in assessing the effectiveness of pest control measures. This study revealed significant variations in the mortality rate of maize and rice weevils treated with different concentrations of *A. indica* extracts and across different storage materials. These results are consistent with previous research demonstrating the insecticidal activity of *A. indica* extracts against weevils and other stored grain pests (Kapoor *et al*., 2019; Roy *et al*., 2022; Nta *et al.*,).

Adult emergence is an important aspect to consider in evaluating the long-term efficacy of pest control treatments. Our findings indicated significant variations in the levels of adult emergence among the different concentrations of *A. indica* extracts. This suggests that neem extracts may interfere with the reproductive capability and developmental stages of the weevils. Similar results have been reported in studies examining the effects of neem extracts on stored grain pests (Barik *et al*., 2021; Tripathi *et al*., 2022) that revealed that neem oil effectively controlled *Sitophilus oryzae* infestations in stored wheat, which reduced infestation levels.

This study suggested neem oil's potential as a natural alternative for pest control in stored wheat. The disruption of insect development and reproduction by neem compounds contributes to population reduction and ultimately suppresses pest infestations.

The extent of damage caused by weevils, as indicated by the number of holes bored, perforation index, and percentage of damage, is crucial for assessing the quality and market value of stored grains. This study revealed significant variations in the damage inflicted by weevils on maize and rice grains treated with different concentrations of *A. indica* extracts. These findings are consistent with previous research highlighting the protective effects of neem extracts against stored grain pests (Hussain *et al*., 2020; Sharma *et al*., 2023) The study indicated that the application of neem extract led to a decrease in the population of pests infesting stored wheat, indicating its potential as a natural and environmentally friendly method for managing stored grain pests in wheat.

The deterrent and anti-feedant properties of neem compounds contribute to the reduction of grain damage and the preservation of grain quality.

CONCLUSION

The present study demonstrates the efficacy of *Azadirachta indica* (neem) extracts as a natural pest control method against the maize weevil (*Sitophilus zeamais*) and rice weevil (*Sitophilus oryzae*) infestations in various storage materials. The findings support the potential application of *A. indica*-treated storage materials in post-harvest grain protection strategies and highlight their effectiveness in reducing weight loss, mortality rate, adult emergence, and damage caused by weevils.

Further research is recommended to optimize the application methods and concentrations of *A. indica* extracts for different storage materials and environmental conditions. Additionally, studies investigating the residual effects and long-term storage stability of *A. indica* treatments would provide valuable insights into their practical applicability in grain storage facilities.

REFERENCES

Baba-Tierto, N., 1994. Ability of powders and slurries from ten plant species to protect stored grains from attack by Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) and Sitophilus oryzae L. (Coleoptera: Curculionidae). Journal of Stored Product Research, 30: 297 – 301.

Barik, N., Singh, D., and Prajapati, S. K., 2021. Efficacy of neem (Azadirachta indica) oil against Sitophilus oryzae infestation in stored wheat. Journal of Pharmacognosy and Phytochemistry, 10(6), 192-195.

Barstow, M. and Deepu S., 2018. Neem IUCN Red List Threatened Species. Hossain F, Lacroix M, Salmieri S, Vu K., and Follett PA., 2014. Basil oil fumigation increases radiation sensitivity in adult Sitophilus oryzae (Coleoptera: Curculionidae). Journal of Stored Product Research, 59: 108-112.

Hussain, A., Alvi, A. A., Rizwan, M., Ahmed, R., and Ashfaq, M., 2020. Efficacy of neem (Azadirachta indica) extract against stored grain pests in wheat. International Journal of Research in Agricultural Sciences, 7(6), 214-220.

Isman, M. B., 2020. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology, 65, 1-21.

Kapoor, R., Nayak, A., Pandey, R., and Pandey, A., 2019. Efficacy of neem-based insecticides against Sitophilus oryzae (L.) and their influence on grain quality. Journal of Plant Protection and Environment, 16(1), 85-89.

Muhammad, G., Alam, M. A., Mofijur, M., Jahirul, M. I., LV, Y., Xiong, W., 2021. Modern developmental aspects in the field of economical harvesting and biodiesel production from microalgae biomass. Renewable Sustainable Energy. 135, 110-209.

Nta, A. I., 2019. Efficacy of some botanicals against insect pest of crops. Lap Lambert Academic Publishing, USA, 184.

Nta, A. I., Agbo, B. E., Etim, I. F., Bassey, D. A and Imalele, E. E. (). Bioinsecticidal activities of Azadirachta indica and Moringa oleifera against maize weevil (Sitophilus zeamais) and rice weevil (Sitophilus oryzae) – A review, Global Journal of Pure and Applied Sciences,

Ojiako, F. O., Zakka, U., Dialoke, S. A., Ahuchaogu, C. E., Nnebue, O. M. and Izuogu, C. P., 2016. Impregnating Storage Materials with Neem Seed Oil against Callosobruchus maculatus Fabricus (Coleoptera: Chrysomelidae: Bruchinae) in Stored Bambara Seeds (Vigna subterranean L.) Verdcourt", International Letters of Natural Sciences, 52: 28-42.

Ojo, J. A. and Omoloye, A. A., 2012. Rearing the maize weevil, Sitophilus zeamais, on an artificial maize cassava diet, Journal of Insect Science, 12(69): 1 – 8.

Osipitan, A., Omotola, M. and Popoola, K., 2015. Evaluation of infestation and damage by the larger grain borer (Prostephanus truncatus) (Horn) (Coleoptera:Bostrichidae) on selected food grain crops. Journal of Agricultural Science and Environment, 12(1): 15-25.

Popoola, K. O. K., Bassey, D. A. and Braimah, J. A., 2017. Check on larger grain borer (Prostephanus truncatus Horn) using crude neem (Azadirachta indica A. Juss) extract on contaminated dried cassava (Manihot esculenta Crantz) chips. Nigerian Journal of Ecology, 16(1), 94-103.

Rahman, M., El-Aty, A., Kim, S., Shin, S., Shin, H., Shim. J., 2017. A quick, easy, cheap, effective, rugged, and safe sample preparation approach for pesticide residue analysis using gas chromatography with flame photometric detector and electron capture detector. Journal of Chromatographic Science, 55(1): 25-34.

Roy, S., Islam, S., and Saha, R., 2022. Efficacy of neem (Azadirachta indica) against Sitophilus oryzae infestation in stored rice, Journal of Agriculture and Veterinary Science, 15(2), 1-6.

Sharma, S., Singh, B. R., Kumar, V., Sharma, D. K., and Yadav, J. P., 2023. Efficacy of neem, Azadirachta indica extracts against Sitophilus oryzae (L.) infestation in stored rice. International Journal of Current Microbiology and Applied Sciences, 12(3), 230-237.

Smith, A. L., El-Wakeil, N. E., Amer, M. A., and Meyer-Rochow, V. B., 2020. Insecticidal effects of neem (Azadirachta indica) on the maize weevil (Sitophilus zeamais). Frontiers in Environmental Science, 8, 29.

Singh, N. P. and Pratap, A., 2016. Food Legumes for Nutritional Security and Health Benefits. Biofortification of Food Crops, 41-50.

Singh, P., Singh, A. K., and Singh, R. K., 2021. Efficacy of neem, Azadirachta indica oil against Sitophilus oryzae (L.) infestation in stored maize. International Journal of Agriculture, Environment and Biotechnology, 14(3), 693-697.

Tripathi, A. K., 2018. Pests of stored grains. Springer Nature Singapore, 311-359.

Tripathi, S., Prakash, R., and Srivastava, P. C., 2022. Evaluation of neem-based biopesticides against Sitophilus oryzae (L.) in stored maize. Journal of Pharmacognosy and Phytochemistry, 11(3), 700-705.

Yan, Y., S. B. Williams, L. L. Murdock and D. Baributsa., 2017. Hermetic storage of wheat and maize flour protects against red flour beetle, Tribolium castaneum Herbst. Global Journal of Bioscience and Biotechnology, 2 (2): 110-115.