International Journal of Agriculture and Medicinal Plants
www.isciencepub.com
Volume 2, Number 3, Pages 1-10, 2021

ISSN: 2789-262X (Print)
ISSN: 2789-2638 (Online)

# Effect of plant extracts on rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae)

**Mst. Rozina Akter[1], Mohammad Mosharof Hossain Bhuyain[1]*, Md. Nizam Uddin[1], Md. Adnan Al Bachchu[1], Mukta Dhar[2]**

[1]Department of Entomology, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh, [2]CID, Bangladesh Police, Dhaka

**Research article**

**Article history**
**Received**: 15.5.2021
**Accepted**: 25.6.2021
**Published**:
Online: 30.6.2021

***Corresponding author:**
mosharofhstu77@gmail.com

**ABSTRACT**

Rice weevil, *Sitophilus oryzae* L. is one of the most destructive and notorious insect pests of raw cereal in store. The experiment was conducted to evaluate the toxicity, repellency and residual effects of the plant extracts namely chili, black pepper, ginger, turmeric and cinnamon on rice weevil in the laboratory conditions during March to August 2019. Ethanol was used as solvent to prepare extracts and four different doses (2.5, 2.0, 1.5 and 1.0 mg/mL) along with control were applied for their toxicity, repellency, and residual effects. All treatments were replicated thrice. Results showed that all the extracts had toxic, repellent and residual effects on rice weevil. Mortality at 24,48 and 72 hours after treatments indicated chili extract possessed the highest mortality (29.33%) whereas the lowest (10%) was in turmeric extracts. Mortality percentage was directly proportional to the level of concentrations of extracts and to the exposure time as well. Considering all the concentration and extracts, the order of toxicity was found as chili> black pepper> ginger> turmeric> cinnamon. The chili, black pepper, cinnamon, turmeric and ginger spices extracts had moderate repellent action against rice weevil. The chili extract showed the highest repellency (85.83%) while the turmeric provided the lowest (61.64%). The highest inhibition rate of egg (60.30%) and adult (72.72%), and seed infestation (64.41%) and the lowest rate of egg (58.87%), adult (67.15%), and seed infestation (61.26%) were found in chili and cinnamon, respectively. However, the toxic, repellent and residual effect of chili extract was more effective against rice weevil among the all spices extracts applied.

**Key words:** Repellency, residual effect, *Sitophilus oryzae*, spices extracts, toxicity

## INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal staple food for a large part of the world population in terms of the area cultivated and amount consumed. Globally, more than 90 and 60% of the global rice is grown and consumed in Asia and South East Asia, respectively (FAOSTAT 2005). The rice weevil, *Sitophilus oryzae* L. is a serious pest in warm humid areas of rice and other cereals like sorghum, jowar, maize, etc. and their products (Asmanizar et al. 2008, Prakash et al. 1987). Rice weevil is the most common pest in all types of stores in Bangladesh but loss estimates due to this pest are scanty. Bhuiya et al. (1992) reported 11-16% weight loss of husked rice during 4 months of storage in the laboratory. Both the adult and larvae feed voraciously on a variety of stored cereal grains like rice, wheat, maize and other products causing serious losses. About 40% of world crop losses are attributed to infestation by pests whereas 15% of the total world crop losses caused by insects (Pimental et al. 1997). The uses of chemical

**To cite this article:** Akter, MR, Bhuyain MMH, Uddin MN, Bachchu MAA and Dhar M. 2021. Effect of plant extracts on rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae). Int. J. Agric. Med. Plants. 2(3): 1-10.

insecticides are the most potent technology, but it has ultimately fallen into disrepute both by farmers and traders. The synthetic insecticides are expensive and have in many cases only produced moderate results along with major ecological damage (Franzen 1993). The chemical control of insects in storage has been used with serious draw breaks. Therefore, alternatives of pests control methods, need to be developed. The uses of locally available plants and their products as a bio-degradable component in the control of the storage pests is an ancient technology in many parts of the world. This has created a world-wide interest in the development of alternative strategies including the search for new types of insecticides and use of age-old traditional botanical pest control agents (Heyde et al. 1983). In addition, these products do not leave harmful residue to the environment and have medicinal properties for human, with lower toxicity to mammals (Negahban et al.2006). Different types of plant preparations such as powders, solvent extracts, essential oils and whole plants are being investigated for their insecticidal activity including their action as fumigants, repellents, anti-feedants, anti- ovipositions and insect growth regulators (Isman 2000, Mordue 2004, Rajendran and Sriranjini 2008, Ukeh et al. 2009). Tripathi et al. (2002) reported that the leaf essential oil of turmeric, *Curcuma longa*, exhibited contact and fumigant toxicity against three stored-product beetles. Ukeh et al. (2009) found that *Zingiber officinale* extract was repellent toward adult *S. zeamais* Motschulsky. Higher plants are a rich source of novel natural substances those can be used to develop environmentally safe methods for insect control (Jbilou et al. 2006). Furthermore, the low toxicity of botanical insecticides makes the processing and application of the product inexpensive. In many cases, the materials are locally available and affordable (Childs et al. 2001). These have generated extraordinary interest in recent years as potential sources of natural insect control agents. Many plant powders were evaluated and found effective in the management of *S. zeamais*, attacking maize grains in the stores (Danjuma et al. 2009, Suleiman et al. 2011). The spices are one of the important plant powders tested and found efficacious against insect pests of stored products (Danjuma et al. 2009, Islam et al. 2013, Mary and Durga Devi 2017, Tripathi et al. 2009, Ukeh et al. 2008). The use of locally available common spices to reduce pest damage for stored food is common practice in traditional farm storage. In this regard the current study was conducted to evaluate the toxicity, repellency and residual effect of some spices extracts against *S. oryzae* L. in laboratory condition.

## MATERIALS AND METHODS

The study was conducted in the laboratory of Entomology Department of Hajee Mohammad Danesh Science and Technology University (HSTU), during the period of March to August 2019.

**Collection, processing and preparation of plant extracts:** Dried black pepper, chili and cinnamon, fresh ginger and turmeric were collected from local market of Dinajpur town. Then fresh spices were chopped into small pieces and dried in shade because various compounds may be breakdowns in sunlight. Then the spices were kept in an oven $40^0$C temperature for 6 hours. After that dried spices were grinded by grinding machine (Jaipan Industries Limited, 750 Watts, Made in India). The dusts were passed through a 60-mesh sieve to obtain fine dust and powder. Under laboratory conditions, spices powder was stored in specimen jar with tag. The powder materials were extracted in ethanol solvent. Fifty gram (50g) of each spices powder were weighted and taken separately in 250 mL conical flask and poured 150mL ethanol. The mixture was stirred for 30 minutes and was allowed to shake for 24 hours in the shaker machine and was filtered through a filter paper (Whatman No. 42). The solvent was evaporated in the vacuum rotary evaporator. Finally, greenish and yellowish crude extracts were obtained. The extracts were preserved in the tightly corked bottle. The extracts were preserved in the refrigerator for experimental uses.

**Preparation of doses of plant extracts:** For making different concentrations, the crude extracts were weighted in the electric balance (AR2140, Ohaus Corp. Pine Brook, NJ, USA) and dissolved in ethanol solvent. Different doses were made with spices extracts to treat adult of rice weevil. Prior to conducting study, a pilot experiment was done to obtain appropriate dose for adult.

**Disinfestation of rice grain:** Fresh and sound grains were emption from the local market of Dinajpur. The grains were thoroughly cleaned, sun dried at optimum moisture level, cooled packed and sealed in polythene bag and sealed to avoid future infestation and the rice grains were stored at room temperature for further use.

**Mass rearing of rice weevil:** The insect was reared on clean and un- infested and sterilized rice grains (*Oryza sativum* L.). Two hundred adult insects were released in 1 kg rice seeds in a plastic jar capped with muslin cloth to ensure ventilation. The jar was maintained at $28\pm2^0$C and relative humidity at 70±5%. The jar with rice grains was left undisturbed condition for 7days for oviposition. After oviposition, the adult weevils were separated from the seeds by sieving and seeds along with eggs were left in the jar for adult emergence. After emergence, the newly emerged adults were collected and again released in new seeds allowed for ovipositor in different jar for the continuation during the experimental period. Only 3 days old adults of *S. oryzae* were used in the experiment.

**Insect bioassays:** Insect's bioassay was conducted to determine the direct toxicity, repellency and grain weight loss by rice weevil.

**Toxicity test:** To test the mortality rate or dose response to spices on adult rice weevil residual film method was applied (Busvine, 1971). For bioassay, 60 mm Petri dishes were used. Crude extracts were weighted and dissolved in the respective solvent according to the proportion of the dose concentration of 2.5 mg/mL, 2 mg/mL, 1.5 mg/mL and 1 mg/mL. Then 1.0 mL liquid of each dose was dropped on Petri dishes with the help of pipette, covering the whole area of the Petri dishes. The Petri dishes were air – dried for a few minutes. When solvents were fully evaporated, ten adults (3 days old) of *S. oryzae* were released in each Petri dish. Three replications were made for each dose. Control Petri dishes were treated with solvent only. The Petri dishes were kept in an incubator without food at $25^0$C±$0.5^0$C. The mortality of adult rice weevil was recorded at 12, 24, 36, 48, 60 and 72 hours after treatments. The doses were calculated by measuring the dry weight of the crude extract applied in the Petri dish divided by the surface area of the respective Petri dishes. The mortality percentage was corrected using Abbott's formula (Abbott 1925, Busvine 1971). P = [{(P'- C)/(100 - C)} × 100] Where, P=Percentage of corrected mortality, P`= Observed mortality (%), C = Mortality (%) at control. The observed data then subjected to probit analysis according to Finney (1947) and Busvine (1971) using software development in the development of Agricultural and Environmental Science, University of Newcastle Upon Tyne, United Kingdom.

**Repellency test:** For repellency test, different spices extracts were dissolved in ethanol to proportion to obtain the concentration 2.5 mg/mL, 2 mg/mL, 1.5 mg/mL and 1 mg/mL on adult rice weevil. The repellency test was conducted according to the method of Talukder and Howse (1994a) with some modifications. Filter papers (Whatman No. 40), of cm diameter were cut in 2half and 1 mL of each solution of spices extracts were applied to a half filter paper uniformLy with a pipette. The treated half discs were then air dried and attached with the untreated half with a cello- tape. Precautions were taken so that attachment did not interfere with the free movement of insect from one half to another but the distance between the filter paper segments remained sufficient to prevent seepage of test samples from on half of circle to another. Each filter paper was then placed in a Petri dish. Ten insects were released severally at the center of each filter paper disc and cover with lid. For each spice extracts and each dose, three replications were used. Then the insects present on each strip were counted at 1hours intervals up to the 6 hours. The data were expressed as percentage of repulsion (PR) using the following formula: PR= (Nc-50) ×2; Where, Nc = % of insects present in the control half, Positive (+) value expressed repellency and negative (-) values attractancy. By using analysis of variance (ANOVA) data (PR) were analyzed. The average values were then categorized according to the following scale (McDonald et al. 1970).

| Class | Repellency (%) | Class | Repellency (%) |
|---|---|---|---|
| 0. | >0.01 to 0.1 | III. | 40.1 to 60 |
| I. | 0.1 to 20 | IV. | 60.1 to 80 |
| II. | 20.1 to 40 | V. | 80.1 to 100 |

**Residual effect of the extracts:** To determine the residual activity spices extracts were weighted and dissolved in respective solvent to obtain 2.5 mg/mL, 2 mg/mL, 1.5 mg/mL and 1 mg/mL concentration. 25 gm of rice was mixed with each concentration. Then the mixtures were air dried and taken in plastic pots. Five pair of newly emerged adult insect was released in each pot and cover with clothes. All the treatments and control were replicated three times. The adult insects were removed from each pot after 7 days. Data on adult emergence were counted and recorded after treatment. The Inhibition rate (IR%), were calculated by the following formula: IR (%) = Cn-Tn/Cn×100; Where, Cn = number of insects in control pot, Tn = number of insects in treated pot.

**Statistical analysis:** The collected data were statistically analyzed by ANOVA using MSTAT-C software. The percentage insect mortality was corrected by Abbott's formula before analyzed. The treatment mean values were adjusted by Duncan's Multiple Range Test (DMRT). The insect mortality data were also subjected to probit analysis.

## RESULTS AND DISCUSSION

**Toxic effect:** The probit analysis for the estimation of $LD_{50}$ values, chi-square values and their 95% fiducially limits at 24, 48 and 72 HATs for the mortality of rice weevils are existing in Table 1. The $LD_{50}$ values of chili (3.94, 2.14, 1.38 mg/cm$^2$) black pepper (94.78, 3.052, 1.59 mg/cm$^2$) ginger (11.64, 2.251, 1.869 mg/cm$^2$), turmeric (94.78, 6.87, 3.74 mg/cm$^2$), and cinnamon (94.78, 9.56, 4.83 mg/cm$^2$) indicated that the chili extract was the most toxic than other four spices extracts. The chi- square values were insignificant at 5% level of probability of different spices extracts at different HATs and mortality data did not show any heterogeneity. Comparing the $LD_{50}$ values, it is observed that all the tested spices extracts showed more or less effective controlling rice weevil but chili may be the most effective. Tripathi et al. (2009) evaluated eight spices for their contact and fumigant toxicity, repellency and effects on progeny development against *Callosobruchus maculatus* and *Tribolium castaneum* and found that the powders of large cardamom, turmeric and ginger showed contact toxicity against the two-tested insects.

**Table 1:** $LD_{50}$, 95% confidence limits, regression equations and chi-square values of different plant extracts on *Sitophilus oryzae* L. (n=30)

| Time interval | Spices extracts | $LD_{50}$ (mg/cm$^2$) | 95% confidence limits | | Regression lines | Chi-square with 2 df |
|---|---|---|---|---|---|---|
| | | | Lower | Upper | | |
| 24 HAT | Black pepper | 94.78 | 0.546 | 1.644 | Y =3.017+1.002X | 0.446 |
| | Chili | 3.94 | 2.174 | 7.162 | Y =3.135+3.126X | 0.043 |
| | Cinnamon | 94.78 | 0.546 | 1.644 | Y =3.017+1.003X | 0.446 |
| | Ginger | 11.64 | 0.690 | 196.146 | Y =2.907+1.963X | 1.521 |
| | Turmeric | 94.78 | 0.546 | 1.644 | Y =3.017+1.003X | 0.446 |
| 48 HAT | Black pepper | 3.052 | 2.132 | 4.369 | Y=3.385+3.334X | 0.734 |
| | Chili | 2.14 | 1.897 | 2.429 | Y=3.212+5.386X | 2.628 |
| | Cinnamon | 9.56 | 0.876 | 104.295 | Y=3.483+1.548X | 0.146 |
| | Ginger | 2.92 | 2.251 | 3.789 | Y=2.813+4.698X | 1.484 |
| | Turmeric | 6.87 | 1.405 | 33.598 | Y=3.446+1.857X | 6.869 |
| 72 HAT | Black pepper | 1.59 | 1.257 | 2.023 | Y=4.547+2.233X | 1.217 |
| | Chili | 1.38 | 1.214 | 1.575 | Y=4.322+4.809X | 3.079 |
| | Cinnamon | 4.83 | 1.934 | 12.059 | Y=3.377+2.373X | 1.309 |
| | Ginger | 2.14 | 1.869 | 2.451 | Y=3.394+4.848X | 3.302 |
| | Turmeric | 3.74 | 1.996 | 7.0219 | Y=3.584+2.470X | 1.605 |

HAT = Hours after treatment, Values were based on four concentrations, three replications of 10 insects each. $\chi^2$ = Goodness of fit. The tabulated value of $\chi^2$ is 5.99 (df = 2 at 5% level).

**Direct toxicity effect:** Toxicity effect of five plant extracts, doses and their interaction at different time intervals against adult insects are presented in the Tables 2and 3. The average mortality percentage of rice weevil was significantly differed among all the spices extracts. The average mortality percentage of rice weevil at 24, 48 and 72 hours after treatment indicated that chili extracts performed the highest mortality (29.33%) whereas cinnamon extracts showed the lowest mortality (8.45%) (Table 2). On the basis of mortality data, the order of toxicity was found as chili> black pepper> ginger> turmeric> cinnamon. Mortality of rice weevil was also differed significantly among all concentration levels at different time intervals. The highest average mortality (36.89%) was found at the maximum concentration (2.5 mg/mL). On the other hand, the lowest average mortality (9.56%) was found at the lowest concentration (1.0mg/mL). No mortality was recorded in untreated control at 24, 48 and 72 HATs (Table 2).

In the interaction effects of plant extracts, dose and time, the average value indicated that the highest percent mortality (64.45%) was found in chili extract at the highest dose (2.5 mg/mL) whereas cinnamon extract showed the lowest mortality (5.56%) at the lowest dose (1.0 mg/mL), which was different from all other plant extracts at different concentration levels. No adult mortality was found at control treatment (Table 3). From the above results it is clear that all the plant extracts showed insect mortality at different level but chili plant extracted showed the highest toxicity. The plant study is agreed with the results of Mobolade et al. (2015) observed that insecticidal effects of ethanol extract of *Capsicum frutescens* and *Dennettia tripetala* against *Sitophilus zeamais* on stored maize. The result concluded that capsicum species seeds and fruits powders were significantly toxic to *S. zeamais* and *C. maculatus* in stored maize and cowpea seeds, respectively. As well reported that seed powders of pepper fruits, at 1.5g/25g maize seed achieved 100% *S. zeamais* mortality in 24 hours.

**Repellency effect:** The repellency effect of five spices extracts on rice weevil is presented in the Table 4 and 5. Among the five tested spices extracts, chili showed the highest mean repellent effect (85.83%) followed by turmeric (61.67%), ginger (69.67), black pepper (71.33%) and cinnamon (64.00%). On the basis of repellency rate, it was found that turmeric, ginger, cinnamon and black pepper extracts showed in the same repellency class i.e. class iv and chili extracts was in class v. However, the differences were statistically insignificant (Table 4).Mean repellent effect of different dose levels on rice weevil is presented in Table 6. The highest mean repellency (80.80%) was found with 2.5mg/mL dose whereas the lowest (59.73%) was found with1.0mg/mL dose. There was no significant difference was found among the spices applied.

**Table 2.** Direct effects of different plant extracts and their doses on rice weevil, *Sitophilus oryzae* L. at different HATs

| Spices extracts | % Mortality at different HATs | | | |
|---|---|---|---|---|
| | 24 HAT | 48 HAT | 72 HAT | Average |
| Black pepper | 2.67 b | 17.33 b | 41.33 b | 20.45 b |
| Chili | 11.33 a | 26.67 a | 50.00 a | 29.33 a |
| Cinnamon | 3.33 b | 10.00 c | 12.00 d | 8.45 d |
| Ginger | 4.6 b | 15.33 b | 26.67 c | 15.5 c |
| Turmeric | 3.33 b | 10.00 c | 16.67 d | 10.00 d |
| LSD value | 3.59 | 3.88 | 6.22 | 3.46 |
| CV value (%) | 96.69 | 33.35 | 28.93 | 28.13 |
| P value | 0.00 | 0.00 | 0.00 | 0.00 |
| Doses (mg/mL) | | | | |
| 2.5 | 12.00 a | 38.67 a | 60.00 a | 36.89 a |
| 2.0 | 6.00 b | 22.67 b | 42.67 b | 23.78 b |
| 1.5 | 4.00 b | 11.33 c | 25.33 c | 13.56 c |
| 1.0 | 3.33bc | 6.67 d | 18.67 d | 9.56 e |
| Control | 0.00 c | 0.00 e | 0.00 e | 0.00 e |
| LSD value | 3.59 | 3.81 | 6.22 | 3.46 |
| CV value (%) | 96.69 | 33.35 | 28.93 | 28.13 |
| P value | 0.00 | 0.00 | 0.00 | 0.00 |

HAT = Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5% level of probability.

**Table 3.** Direct toxic effect of different plant extracts and their doses on rice weevil, *Sitophilus oryzae* L. at different HATs

| Spices extracts | Doses (mg/mL) | % Mortality at different time interval | | | |
|---|---|---|---|---|---|
| | | 24HAT | 48HAT | 72HAT | Average |
| Black pepper | 2.5 | 6.67 c-e | 43.33 b | 73.33 b | 41.11 b |
| | 2.0 | 3.33 de | 23.33 c | 53.33 cd | 26.67 c |
| | 1.5 | 0.00 e | 13.33 d-f | 43.33 d-f | 18.89 c-e |
| | 1.0 | 3.33 d | 6.67 e-g | 36.67 ef | 15.56 e-g |
| | Control | 0.00 e | 0.00 g | 0.00 g | 0.00 j |
| Chili | 2.5 | 26.67 a | 70.00 a | 96.67 a | 64.45 ba |
| | 2.0 | 16.67 b | 40.00 b | 73.33 b | 43.33 b |
| | 1.5 | 10.00 b-d | 13.33 d-f | 50.00 de | 24.44 cd |
| | 1.0 | 3.33 de | 10.00 d-g | 30.00 f | 14.45 e-h |
| | Control | 0.00 e | 0.00 g | 0.00 g | 0.00 j |
| Cinnamon | 2.5 | 6.67 c-e | 20.00 cd | 30.00 f | 18.89 c-e |
| | 2.0 | 3.33 de | 13.33 d-f | 13.33 g | 9.99 f-i |
| | 1.5 | 3.33 de | 10.00 d-g | 10.00 g | 7.78 g-j |
| | 1.0 | 3.33 de | 6.667 e-g | 6.67g | 5.56 ij |
| | Control | 0.00 e | 0.00 g | 0.00 g | 0.00 j |
| Ginger | 2.5 | 13.323 bc | 43.33 b | 66.67 bc | 41.11 b |
| | 2.0 | 3.33 de | 20.00 cd | 43.33 d-f | 22.22 c-e |
| | 1.5 | 3.33 de | 10.00 d-g | 13.33 g | 8.89 f-i |
| | 1.0 | 3.33 de | 3.33 fg | 10.00 g | 5.56 ij |
| | Control | 0.00 e | 0.00 g | 0.00 g | 0.00 j |
| Turmeric | 2.5 | 6.67 c-e | 16.67 c-e | 33.33 f | 18.89 c-e |
| | 2.0 | 3.33 de | 16.67 c-e | 30.00 f | 16.67 d-f |
| | 1.5 | 3.33 de | 10.00 d-g | 10.00 g | 7.78 g-j |
| | 1.0 | 3.33 de | 6.67 e-g | 10.00 g | 6.6 h-j |
| | Control | 0.00 e | 0.00 g | 0.00 g | 0.00 j |
| | LSD value | 8.03 | 8.678 | 13.92 | 7.71 |
| | CV (%) | 96.69 | 33.35 | 28.93 | 28.13 |
| | P value | 0.04 | 0.00 | 0.00 | 0.00 |

HAT=Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5% level of probability.

Interaction repellent effect of different spices extracts and their doses on rice weevil at different HATs is presented in Table 5. The highest mean repellency (94.67%) was found on 2.5mg/mL dose of chili extract whereas the lowest mean repellency (45.33%) was obtained on 1.0mg/mL dose of turmeric extract. The repellency class of different extracts at different concentration level varied between iii to v. From the above results it was observed that the tested five spices extracts would be effective to control rice weevil but chili was the most effective. The extracts of black pepper gave moderate repellency and turmeric gave lower levels of repellency. Piperine, a pungent substance in black pepper and cinnamaldehyde, a principal component of cinnamon flavor, are reported to possess insecticidal activities (Huang and Ho 1998, de Paula et al.2000). These findings indicate that such active compounds may play a role in the repellent activity against *S. zeamais* and show their potency at much lower concentrations. Chili and lemongrass are well known to demonstrate insect repellent effects (Oyedele et al. 2002, Chomchalow 2003, Parugrug and Roxas 2008). Nevertheless, repellent activity of chili and lemongrass against *S. zeamais* adults were unconfirmed in our experiment and extracts of lemongrass and dry chili had weak attractant activity. Mobolade et al. (2015) experimented a study to observe insecticidal effects of ethanol extracts of *Capsicum frutescens* and *Dennettia tripetala* against *Sitophilus zeamais* who applied the spices extracts at concentration 10, 20 and 30% v/v against 50 gm of maize grains and observed that *C. frutescens* at 30% v/v possessed the highest repellent action to *S. zeamais.*

**Table 4.** Repellency effect of different plant extracts and their different doses on rice weevil at different HATs

| Spices extracts | % repellency rate | | | | | | Repellency class |
|---|---|---|---|---|---|---|---|
| | 2HAT | 4HAT | 6HAT | 8HAT | 10HAT | Mean | |
| Black pepper | 60.00 b | 58.33 b | 68.33 b | 78.33 ab | 91.67 a | 71.33 b | iv |
| Chili | 80.00 a | 80.00 a | 87.50 a | 89.17 a | 92.50 a | 85.83 a | v |
| Cinnamon | 43.33 c | 53.33 bc | 61.67 b | 70.00 b | 91.67 a | 64.00 bc | iv |
| Ginger | 48.33 bc | 58.33 b | 71.67 b | 76.67 ab | 93.33 a | 69.67 bc | iv |
| Turmeric | 41.67 c | 40.00 c | 65.00 b | 73.33 b | 88.33 a | 61.67 c | iv |
| LSD | 14.13 | 14.29 | 13.52 | 13.35 | 9.82 | 7.63 | |
| CV (%) | 31. 33 | 29.86 | 23.13 | 20.87 | 13.01 | 13.11 | |
| P value | 0.00 | 0.0001 | 0.0043 | 0.0642 | 0.3059 | 0.0000 | |
| Doses (mg/mL) | | | | | | | |
| 2.5 | 72.00 a | 72.00 a | 83.33 a | 80.67 a | 96.00 a | 80.80 a | v |
| 2.0 | 65.33 ab | 62.67 ab | 70.67 b | 78.67 ab | 93.33 a | 74.13 ab | iv |
| 1.5 | 57.33 b | 56.00 b | 65.33 b | 68.00 b | 90.00 a | 67.33 b | iv |
| 1.0 | 24.00 c | 41.33 c | 64.00 b | 82.67 a | 86.67 a | 59.73 c | iii |
| LSD | 12.64 | 12.78 | 12.09 | 11.94 | 8.784 | 6.82 | |
| CV (%) | 31.33 | 29.86 | 23.13 | 20.87 | 13.01 | 13.11 | |
| P value | 0.0000 | 0.0002 | 0.0097 | 0.0773 | 0.1748 | 0.0000 | |

HAT=Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5% level of probability.

**Residual effects:** The residual toxic effects of chili, ginger, black pepper, cinnamon and turmeric extracts on rice weevil are presented in Table 6 and 7. The lowest no. of adult emergence was found in chili (2.00), followed as black pepper (3.33), cinnamon (3.53), ginger (3.06), and turmeric (3.06). The highest % inhibition rate of egg (60.30), % inhibition rate of adult (72.72) and % seed infestation (64.41) were found in chili and the lowest %inhibition rate of egg (58.87), % inhibition rate of adult (67.15), and % seed infestation (61.26) were found in cinnamon (Table 6). The lowest no. of adult emerged (1.40) at the dose level of 2.5 mg/mL and highest (7.533) number of adult emergence was found at the dose level of 1.0 mg/mL (Table 6). The highest % inhibition rate of egg (86.64), % inhibition rate of adult (94.90), and % seed infestation (89.60) was found at the dose of 2.5 mg/mL. The lowest %inhibition rate of egg (62.05), % inhibition rate of adult (73.09) and % seed infestation (64.52) was found at the dose level of 1.0mg/mL (Table 6).The interaction of spices extracts and doses on adult emergence and inhibition rate are presented in Table 7. The lowest number of adult emerged (0.6667) in the highest dose (2.5 mg/mL) of chili spices extracts whereas the highest number of adult emerged similar as black pepper, ginger, turmeric (1.667) in the highest dose (2.5 mg/mL).

**Table 5.** Repellent effect of different plant extracts and their doses on rice weevil at different HATs

| Spices extracts | Doses (mg/mL) | % repellency rate | | | | | | Repellency class |
|---|---|---|---|---|---|---|---|---|
| | | 2 HAT | 4 HAT | 6 HAT | 8 HAT | 10 HAT | Mean | |
| Black pepper | 2.5 | 80.00 a-c | 80.00 ab | 86.67 ab | 80.00 ab | 100.0 a | 85.33 a-c | v |
| | 2.0 | 53.33 c | 46.67 b-e | 60.00 b-d | 80.00 ab | 93.33 a | 66.67 d-f | iv |
| | 1.5 | 60.00 bc | 46.67 b-e | 60.00 b-d | 66.67 ab | 86.67 a | 64.00 d-f | iv |
| | 1.0 | 46.67 c | 60.00 b-d | 66.67 a-d | 86.67 ab | 86.67 a | 69.33 c-f | iv |
| Chili | 2.5 | 86.67 ab | 93.33 a | 96.67 a | 96.67 a | 100.0 a | 94.67 a | v |
| | 2.0 | 93.33 a | 80.00 ab | 93.33 a | 93.33 a | 93.33 a | 90.67 ab | v |
| | 1.5 | 80.00 a-c | 73.33 a-c | 66.67 a-d | 80.00 ab | 96.67 a | 79.33 a-d | iv |
| | 1.0 | 60.00 bc | 73.33 a-c | 93.33 a | 86.67 ab | 80.00 a | 78.67 a-d | iv |
| Cinnamon | 2.5 | 66.67 a-c | 60.00 b-d | 66.67 a-d | 66.67 ab | 93.33 a | 70.67 c-e | iv |
| | 2.0 | 53.33 c | 60.00 b-d | 66.67 a-d | 73.33 ab | 93.33 a | 69.33 c-f | iv |
| | 1.5 | 46.67 c | 66.67 a-c | 6 0.00 b-d | 60.00 b | 86.67 a | 64.00 d-f | iv |
| | 1.0 | 6.67 d | 26.67 de | 53.33 cd | 80.00 ab | 93.33 a | 52.00 fg | iii |
| Ginger | 2.5 | 60.00 bc | 73.33 a-c | 86.67 ab | 86.67 ab | 93.33 aa | 80.00 a-d | iv |
| | 2.0 | 73.33 a-c | 80.00 ab | 73.33 a-d | 73.33 ab | 93.33 a | 78.67 a-d | iv |
| | 1.5 | 53.33 c | 53.33 b-d | 66.67 a-d | 66.67 ab | 93.33 a | 66.67 d-f | iv |
| | 1.0 | 6.67 d | 26.67 de | 60.00 b-d | 80.00 ab | 93.33 a | 53.33 e-g | iii |
| Turmeric | 2.5 | 66.67 a-c | 53.33 b-d | 80.00 a-c | 73.33 ab | 93.33 a | 73.33 b-d | iv |
| | 2.0 | 53.33 c | 46.67b-e | 60.00 b-d | 73.33 ab | 93.33 a | 65.33 d-f | iv |
| | 1.5 | 46.67 c | 40.00 c-e | 73.33 a-d | 66.67 ab | 86.67 a | 62.67 d-f | iv |
| | 1.0 | 0.00 d | 20.00 e | 46.67 d | 80.00 ab | 80.00 a | 45.33 g | iii |
| | LSD | 28.26 | 28.58 | 27.03 | 26.69 | 19.64 | 15.26 | |
| | CV (%) | 31.33 | 29.86 | 23.13 | 20.8 | 13.01 | 13.11 | |
| | P value | 0.2785 | 0.1539 | NS | NS | NS | 0.4658 | |

HAT=Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5% level of probability.

**Table 6.** Residual effects of different plant extracts on rice weevil

| Used spices | Egg after 7 days | % Inhibition rate of egg | No. of adult emergence | % Inhibition rate of adult | No. of holes after 42 days | % Seed infestation |
|---|---|---|---|---|---|---|
| Black pepper | 6.53 a | 59.92 a | 3.33 a | 67.87 b | 5.27 ab | 62.15 ab |
| Chili | 6.33 a | 60.30 a | 2.00 b | 72.72 a | 4.60 b | 64.41 a |
| Cinnamon | 6.87 a | 58.87 a | 3.53 a | 67.15 b | 5.53 a | 61.24 b |
| Ginger | 6.67 a | 59.47 a | 3.07 a | 69.33 b | 5.33 ab | 61.92 ab |
| Turmeric | 6.40 a | 60.50 a | 3.07 a | 68.84 b | 5.20 ab | 62.37 ab |
| LSD | 0.7084 | 2.185 | 0.7382 | 2.613 | 0.7382 | 2.509 |
| CV (%) | 14.73 | 4.98 | 33.55 | 5.15 | 19.41 | 5.48 |
| P value | 0.0000 | 0.0000 | 0.0014 | 0.0010 | 0.1392 | 0.1434 |
| Doses (mg/mL) | | | | | | |
| 2.5 | 4.33 d | 86.64 a | 1.40 d | 94.90 a | 3.07 c | 89.60 a |
| 2.0 | 4.33 d | 77.43 b | 2.60 c | 90.54 b | 5.93 b | 79.90 b |
| 1.5 | 8.80 b | 72.94 c | 3.47 b | 87.39 c | 6.47 b | 78.08 b |
| 1.0 | 12.33 a | 62.05 d | 7.53 a | 73.09 d | 10.47 a | 64.52 c |
| Control | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 0.00 e | 0.00 e |
| LSD | 0.7084 | 2.185 | 0.7382 | 2.613 | 0.7382 | 2.509 |
| CV (%) | 14.73 | 4.98 | 33.55 | 5.15 | 19.41 | 5.48 |
| P value | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Within the column values followed by different letter(s) are significantly different by DMRT at 5% level of probability.

The highest population inhibited in the highest dose of (2.5 mg/mL) of chili and the lowest population inhibited in the lowest dose (1.0 mg/mL) of cinnamon. Tripathi et al. (2009) evaluated eight spices for their contact and fumigant toxicity, repellency and effects on progeny development against *Callosobruchus maculatus* and *Tribolium castaneum* and found that the powders of large cardamom, turmeric and ginger showed residual effect against the two-test insects. Mary and Durga Devi (2017) conducted a study about toxic effect of *Piper nigrum* and *Zingiber officinale* extracts on the mortality of *Tribolium castaneum* on stored wheat and result showed that, *Z. officinale* plant extracts recorded maximum inhibitory effect than *P. nigrum* plant extract against *T. castaneum*.

**Table 7.** Residual effects of different plant extracts on rice weevil

| Spices extracts | Doses (mg/mL) | Egg after 7 days | % Inhibition rate of egg | No. of adult emergence | % Inhibition rate of adult | No. of holes after 42 days | % Seed infestation |
|---|---|---|---|---|---|---|---|
| Black pepper | 2.5 | 4.00 e | 87.69 a | 1.66 ef | 93.93 ab | 3.33 de | 88.70 ab |
| | 2.0 | 8.00 bc | 75.38 bc | 3.00 de | 89.09 bc | 6.33 bc | 78.53 cd |
| | 1.5 | 8.00 bc | 75.48 bc | 3.67 d | 86.66 c | 6.00 bc | 79.66 cd |
| | 1.0 | 12.67 a | 61.04 d | 8.33 ab | 69.69 ef | 10.67 a | 63.84 e |
| Chili | 2.5 | 3.66 e | 88.71a | 0.67 f | 97.57 a | 2.67 e | 90.96 a |
| | 2.0 | 7.00 cd | 78.46 b | 1.33 ef | 95.15 ab | 5.00 cd | 83.05 bc |
| | 1.5 | 9.00 b | 72.30 c | 1.67 ef | 93.93 ab | 5.67 bc | 80.79 cd |
| | 1.0 | 12.33 a | 62.05 d | 6.33 c | 76.96 d | 9.67 a | 67.23 e |
| Cinnamon | 2.5 | 4.67 e | 85.64 a | 1.33 ef | 95.15 ab | 3.00 e | 89.83 a |
| | 2.0 | 7.67 bc | 76.40 bc | 3.00 de | 89.09 bc | 6.67 bc | 77.48 cd |
| | 1.5 | 9.00 b | 72.30 c | 4.00 d | 85.45 c | 7.00 b | 76.27 d |
| | 1.0 | 3.00 a | 60.00 d | 9.33 a | 66.06 f | 11.00 a | 62.71 e |
| Ginger | 2.5 | 5.33 de | 83.53 a | 1.67 ef | 93.93 ab | 3.67 de | 87.57 ab |
| | 2.0 | 7.00 cd | 78.46 b | 3.00 de | 89.09 bc | 6.00 bc | 79.66 cd |
| | 1.5 | 9.00 b | 72.30 c | 4.00 d | 85.45 c | 6.67 bc | 77.40 cd |
| | 1.0 | 12.00 a | 63.07 d | 6.67 bc | 78.18 d | 10.33 a | 64.97 e |
| Turmeric | 2.5 | 4.00 e | 87.64 a | 1.67 ef | 93.93 ab | 2.67 e | 90.96 a |
| | 2.0 | 7.00 cd | 78.46 b | 2.67 de | 90.30 bc | 5.67 bc | 80.79 cd |
| | 1.5 | 9.00 b | 72.30 c | 4.00 d | 85.45 c | 7.00 b | 76.27 d |
| | 1.0 | 11.67 a | 64.10 d | 7.00 bc | 74.54 de | 10.67 a | 63.84 e |
| | LSD | 1.584 | 4.886 | 1.651 | 5.844 | 1.651 | 5.610 |
| | CV (%) | 14.73 | 4.98 | 33.55 | 5.15 | 19.41 | 5.48 |
| | P value | NS | NS | 0.3251 | 0.1261 | NS | NS |

Within the column values followed by different letter(s) are significantly different by DMRT at 5% level of probability.

## CONCLUSION

It is concluded that the spices extracts used in the present study had different level of toxic effect on adults of rice weevil. Among the tested spices, chili extracts showed the highest toxic effect. The insecticidal potential of spices extracts against rice weevil has good prospects. Additional studies have required to developed appropriate formulation and application method of plant based pesticides against stored product pests.

## REFERENCES

Abbott WS. 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology.18: 265-267.

Asmanizar A, Djamin and Idris AB. 2008. Effect of selected plant extraction on mortality of adult *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae), a pest of stored rice grains. Malaysian Applied Biology. 37: 41-46.

Bhuiya MIM, Alam S and Karim ANMR. 1992. Losses to stored rice caused by rice weevil and angoumois grain moth, and their control in Bangladesh. Bangladesh Journal of Agricultural Sciences.19 (1): 13-18.

Busvine JR. 1971. A Critical Review of the Techniques for Testing Insecticides. Commonwealth Agricultural Bureau, London. 345 pp.

Childs FJ, Chamberlain JR and Antwi EA. 2001. Improvement of neem and its potential benefits to poor farmers. Department of International Development. UK. pp. 32.

Chomchalow N. 2003. Protection of stored products with special reference to Thailand. AU Journal of Technology. 7: 31-47.

Danjuma BJ, Majeed Q, Manga SB, Yahaya A, Dike MC and Bamaiyi L. 2009. Effect of some plant powders in the control of *Sitophilus zeamais* Motsch (Coleoptera: Curculionidae) infestation on maize grains. American-Eurasian Journal of Scientific Research. 4(4): 313-316.

de Paula VF, de A Barbosa LC, Demuner AJ, Piló-Veloso D, and Picanço MC. 2000. Synthesis and insecticidal activity of new amide derivatives of piperine. Pest Management Science. 56: 168-174.

Faostat. 2005. Rough rice area (0000ha) by country and geographical region 1961-2004, FAO, Rome, available at: http://: www:irri.org/science/rice stat/index.

Finney DJ. 1947. Probit analysis: a statistical treatment of the sigmoid response curve. Cambridge University Press, London, 333pp.

Franzen H. 1993. Need for development of new strategies for locust control. In: New strategies for locust control. Ed: Rembold, H. ATSAF. Bonn; 89. pp. 9-13.

Heyde JVD, Saxena RC and Schmutterer H. 1983. Neem oil and neem extracts as potential insecticides for control of Hemipterous rice pests. Proceeding of 2$^{nd}$International Neem Conferance. Rauischholzhausen. pp. 377-390.

Huang Y and Ho SH. 1998. Toxicity and antifeedant activities of cinnamaldehyde against the grain storage insects, *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. Journal of Stored Products Research. 34: 11-17.

Islam MS, Haque MA, Ahmed KS, Mondal MF and Dash CK. 2013. Evaluation of some spices powder as grain protectant against pulse beetle, *Callosobruchus chinensis* (L.). Universal Journal of Plant Science. 4: 132-136.

Isman MB. 2000. Plant essential oils for the pest and disease management. Crop Protection. 19(8-10): 603-608.

Jbilou R, Ennabili A and Sayah F. 2006. Insecticidal activity of four medicinal plant extracts against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). African Journal of Biotechnology. 5: 936-940.

Mary R and Durga Devi DV. 2017. Toxic effect of *piper nigrum* and *Zingiber officinale* extracts on the mortality of flour beetle *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) on stored wheat. World Journal of Pharmacy and Pharmaceutical Sciences. 6(5): 1439-1446.

McDonald L, Guy RH and Speirs RD. 1970. Preliminary evaluation of new candidate materials as toxicants, repellents and attractants against stored- product insects. Agricultural Research Service, US Department of Agriculture, Washington DC, marketing Research Report No. 882.

Mobolade DA, Mary TA and Emmanuel OY. 2015. Insecticidal effects of ethanol extracts of *Capsicum frutescens* and *Dennettia tripetala* against *Sitophilus zeamais* Motschulsky on stored maize. International Journal in Agriculture and Forestry. 2:11-17.

Negahban M, Moharramipour S and Sefidkon F. 2006. Chemical composition and insecticidal activity of *Artemisia scoparia* essential oil against three coleopteran stored – product insects. Journal of Asia-Pacific Entomology. 9: 381-388.

Oyedele AO, Gbolade AA, Sosan MB, Adewoyin FB, Soyelu OL and Orafidiya OO. 2002. Formulation of an effective mosquito-repellent topical product from Lemongrass oil. Phytomedicine. 9: 259-262.

Parugrug ML and Roxas AC. 2008. Insecticidal action of five plants against maize weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae). KMITL Science and Technology Journal. 8: 24-38.

Pimental D. 1997. Pest management in agriculture', in D. Pimental (ed.), Techniques for Reducing Pesticide Use: Environmental and Economic Benefits. Chichester, UK, John Wiley and Sons, 1-11 pp.

Prakash A, Rao J, Pasalu IC and Mathur KC. 1987. Rice storage and insect pest management. B.R. Publishing Corporation. Delhi, 15-60.pp.

Rajendran S and Sriranjini V. 2008. Plant products as fumigants for stored-product insect control. Journal of Stored Products Research. 44:

126-135.

Suleiman M, Majeed Q and Abdulkarim B. 2011. Toxicity of three plant powders as biopesticides against *Sitophilus zeamais* Motsch. on stored guinea corn grains.Biology of Environmental Science Journal of Tropics. 8(3): 273- 277.

Talukder FA and Howse PE. 1994a. Laboratory evaluation of toxic and repellent properties of the pithraj tree, *Aphanamixis polystachya* Wall and Parker against *Sitophilus oryzae* L. International Journal of Pest Management. 41(3): 274-279.

Tripathi AK, Prajapati V, Verma N, Bahl JR, Bansal RP and Khanuja SPS. 2002. Bioactivities of the leaf essential oil of *Curcuma longa* (var. Ch-66) on three species of stored- product beetles (Coleoptera). Journal of Economic Entomology. 95:183-189.

Tripathi AK, Upadhyay S, Bhuiyan M and Bhattacharya PR. 2009. A review on prospects of essential oils as biopesticides in insect—pest management. Journal of Pharmacological Phytotheraphy. 1(5): 52-63.

Ukeh DA, Arong GA and Ogban E. 2008. Toxicity and oviposition deterrence of *Piper guineense* (Piperaceae) and *Monodora myristica* (Annonaceae) against *Sitophilus zeamais* (Motsch.) on stored maize. Journal of Entomology. 5 (4): 295-299.

Ukeh DA, Birkett MA, Pickett JA, Bowman AS and Luntz AJM. 2009. Repellent activity of alligator pepper, *Aframomum melegueta*, and ginger, *Zingiber officinale*, against the maize weevil, *Sitophilus zeamais*. Phytochemistry. 70: 751-758.