TRENDS IN CURRENT BIOLOGY
ISSN 2584-2080 (online)
Vol 2(3): 23–33
https://doi.org/10.14719/tcb.3686

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RESEARCH ARTICLE

Bioefficacy of *Mucana pruriens* extracts against Rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae)

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OPEN ACCESS

ARTICLE HISTORY

Received: 10 April 2024
Accepted: 16 July 2024

Available online
Version 1.0 : 30 July 2024

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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CITE THIS ARTICLE

Chowdhury SK, Roy S, Banerjee M, Basnett D, Mazumdar T. Bioefficacy of *Mucana pruriens* extracts against Rice weevil, Sitophilus oryzae (Coleoptera: Curculionidae). Trends in Current Biology. 2024; 2(3): 23-33. https://doi.org/10.14719/tcb.3686

Abstract

In the agricultural sector, the rice weevil, *Sitophilous oryzae* L. is one of the most damaging pests, causing significant economic losses worldwide. It is an internal feeder of grains. The female rice weevil causes damage to the grain by creating a hole in it and laying her eggs inside. The main purpose of our study was to investigate the biological effect of an aqueous extract of *Mucana pruriens*on rice weevil under laboratory conditions. To assess the biological activities, data like number of the days to adult emergence, total adult emergence, percent infestation, weight loss, adult longevity, and adult sex ratio were recorded. The findings showed that, in the case of a 100 mg/ml plant extract, the maximum number of days needed for the adult emergence of rice was 66 and 72 days for wheat weevil, and the minimum number of days required was 20 and 25 in case control of both rice and wheat grains. When rice grains were treated with 0 mg/ml aqueous extracts, the maximum number of adult emergences observed was 72 on rice grains, while 66.00 occurred on wheat grains. The highest percentage of infestation (40.00%) was found in rice grains, while the highest percentage (39.78%) was found in wheat grains treated with 0 mg/ml aqueous extracts. The lowest weight loss (7.99%) was observed in rice grains and the highest weight loss (16.66%) in wheat grains treated with 100 mg/ml extracts; on the other hand, the lowest weight loss (13.33%) was observed in rice grains and the highest in wheat grains treated with 0 mg/ml aqueous extracts. When weevils were raised on untreated rice and wheat grains, the longest recorded adult lifespan was achieved overall. For rice weevil control that is safer, plant aqueous extracts with concentrations of 100 mg/ml and 75 mg/ml ought to be utilized. The present studies were carried out to examine the environmentally friendly aqueous extracts of *Mucana pruriens* and their pesticidal efficacy in controlling rice weevil. The study anticipates that *Mucana pruriens* extracts will exhibit significant insecticidal properties, potentially providing a natural alternative to synthetic insecticides. This study contributes to sustainable pest management strategies for stored grains.

Keywords

Rice weevil; plant extracts; stored grains; efficacy; biological effects

Introduction

One-fifth of the calories in the world are found in rice grains, which are the richest source of energy. Additionally, it provides a significant amount of food for roughly 2.5 billion people worldwide (1). It has been documented in the past that over 1,200 pest species ruin products that are kept in storage (2). According to estimates, post-

harvest losses in developed and developing nations, respectively, are caused by stored grain pests at 9% and 30% (3). The primary insect pests that cause significant damage to stored rice grains are the sawtoothed beetle (*Oryzaephilus surinamensis* L.), lesser grain borer (*Rhyzopertha dominica* Fabr.), granary weevil (*Sitophilus granaries* L.), maize weevil (*Sitophilus zeamais* Motsch.), and rice weevil (*Sitophilus oryzae* L.) (4). S. oryzae is the most common insect pest among them, causing significant damage to both husked and unhusked rice (5). It can result in losses of up to 80% under favorable extended storage conditions, while moderate storage conditions are known to cause losses of on average between 10% and 65% (6). Worldwide, the use of synthetic chemicals is typically the basis for managing stored grain pests (7). Serious issues are brought about by these chemicals, including pest species resistance, health risks, and chemical residues in food products (8). As a result, in the stored grains, rice weevil has also developed resistance against numerous commonly used fumigants and insecticides (9, 10). Therefore, it is imperative to look for alternatives that are easily accessible, reasonably priced, economical, less hazardous, and less detrimental to the environment (11). Generally speaking, plant materials and their derivatives are less expensive, more readily available, target-specific, and safe for the environment and non-targeted species (12, 13). As a result, biopesticides and these naturally occurring plant products offer viable substitutes for controlling agricultural insect pests (14). Since most plant derivatives and their products are less toxic, increase food safety, are non-polluting, biodegradable, improve production profitability, and reduce pesticide resistance, a wider range of plant derivatives and their products have been studied against various insect pests of stored products (15). Neem, eucalyptus, black pepper, Chinese cinnamon, garlic, yellow oleander, mint, basil, black seeds, and lavender are among the botanicals that have been studied against rice weevil in different parts of the world with differing degrees of success (16-19).

Unfortunately, there have been few or no studies carried out in the Dakshin Dinajpur district of West Bengal to manage the pest population of stored grains by using locally accessible crude plant extracts. Therefore, the present study was designed to evaluate the bio-efficacy of aqueous extracts of *Mucana pruriens* against rice weevil. This study aims to evaluate the insecticidal properties of *Mucanapruriens* extracts against *S. oryzae* Specifically, it seeks to determine the efficacy of the extracts in controlling *S.oryzae* infestations in stored rice and wheat grains and to assess the potential for developing a natural, eco-friendly alternative to chemical insecticides.

Materials and Methods

The investigations were carried out to the effect of crude aqueous plant extracts on different biological parameters of *Sitophilous oryzae* L. during storage conditions.

2.1. Plant selection and identification

The experimental plant was collected for from the Medicinal plants garden of Botany Departmental, Balurghat college, Balurghat, Dakshin Dinajpur. The plant was identified and authenticated as *Mucuna pruriens* by Dr. Monoranjan Chowdhury, Professor of Botany, North Bengal University.

2.2. Collection and Preparation of extract

The fresh leaves of *Mucuna pruriens* were collected and carefully washed with distilled water to remove dust and dirt particles. The collected materials were sun dried until complete dryness. Then the dry leaves were crushed with the help of an electric blender to get fine powders. The resultant powders were sieved through a mesh sieve of 0.2 mm. The fine powder was weighted 100gm. 500ml capacity of four conical flasks were taken and 250 ml distilled water poured into each conical flask. The weighted 100 gm powder was divided four parts i.e. 25 gm and mixed with water by hand shaking of each conical flask and kept sunlight for heat and mouth of conical tight cotton plugs. The sun heating and hand shaking process were maintained up to seven days. The aqueous extracts were prepared by this process filtered using Whatman No.1 (9 cm) blotting paper. The resultant aqueous extracts of leaves with the concentration of 100 mg mL-1 were obtained. Aqueous extracts of 75, 50 and 25 mg mL-1 concentrations were obtained by diluting the original extract (100 mg mL-1) with distilled water. The manufactured solutions of aqueous extracts were placed in the refrigerator at 4 °C for pest control.

2.3. Collection and Culture of *Sitophilus oryzae* (L.)

The adult's rice weevils were collected from the infested stored Rice grains from the rental house of Dr. Swapan Kumar Chowdhury, Assistant professor of Botany, Balurghat College and were brought to laboratory of Botany Department for experiment. Rice weevils were identified by Dr. Manish Kanti Biswas, Associate Professor, Department of Zoology, Surendra Nath College, Kolkata.

For culturing of these rice weevils, the weevils were shifted to transparent plastic jars along with Rice and Wheat grains. In each plastic jar, 10 pairs of Adults Rice weevil along with 50-gram Rice and Wheat grains were shifted to an incubator for maintained at constant conditions of 27 ± 2 °C. After ten days of the introduction of adult Rice weevil, the adult weevils were removed from the plastic jars via sieving and were shifted to new jars having un-infested Rice and Wheat grains for the multiplication of the culture. After 20 days of the introduction of the weevils, new progeny started to emerge. The adult weevils were collected on daily basis from the mother culture and the weevils which emerged on the same day were used for the investigations.

2.4. Experimental Protocol

2.2.1. Direct spraying on grains

The experiment was conducted in the laboratory of the Department of Botany to investigate the effect of plant aqueous extracts on the biology of Rice weevil. The studies were carried out under controlled conditions of 27 ± 2°C. The Rice and Wheat grains were sterilized in a hot air oven for three hours at 45°C in order to eliminate the chances of

prior invasion. The 90 gm disinfected seeds were treated with plant aqueous extracts and then kept in transparent plastic jars of 200 ml capacity and level as control, treated-1, treated-2, treated-3 and treated-4. The plant aqueous extracts were used at five different concentrations of 0, 25, 50, 75 and 100 mg mL-1 respectively. After 48 an hour of the treatment of grains, 10 pairs of freshly emerged (24 hour starved) adult Rice weevil inoculated in grains containing plastic jars. The adult weevils were sexed on the basis of their dimorphic rostrum characteristics and distinguishing shapes and lengths of their abdomens (20). After introduction of weevils, the jars were enclosed with fine mesh cloth to minimize the chances of escape of weevils and to facilitate the ventilation. The jars were fastened with rubber band. The weevils remained in the treated jars for ten days to ensure copulating and oviposition. After 10 days of the introduction, the weevils were removed from the tested arena. After 20 days of the introduction of adult weevils, the jars were carefully observed to record data on the duration of adult emergence. The data on the number of adult weevils emerged from each treatment were noted on daily basis. At 45 days after the start of investigations, the data was recorded on the total number of adult progenies emerged and percent infestation by calculating the total and infested grains. The percent grains weight loss caused by weevil was calculated with the help of formula (21):

Percent weight loss = Initial weight - final weight × 100 / Initial weight

For recording data on the life span of adult weevils, the newly formed adult weevils were shifted to adult jars with fresh rice and wheat grains for feeding purpose. For this purpose, 20 pairs of weevils were selected from each treatment. The food of the weevils was changed after every 15 days, to inhibit the emergence of F2 generation of weevils. The weevils were carefully observed on daily basis to record data on the mortality of adult weevils and was continued up to the mortality of last weevil. The data on the sex ratio of adult weevils was recorded, by calculating the number of male weevils emerged per 50 females.

Percentage of infestation (%) = Total number of bored grains/ Total number of grains taken × 100

Weight loss of grains was calculated by weighting the treated grains after 45 days and compare the initial and final weight.

2.2.1. Direct spraying on Rice weevils

To perform this experiment, 10 pairs of adult fresh weevil put into the petridishes marked by 0, 25, 50, 75 and 100 mg mL-1 concentration. The different concentration of plant aqueous extract solutions was spraying directly by the sprayer and allow to observation at room temperature.

Results

3.1. Life cycle studies of Rice and wheat weevil

The life cycle of *Rice weevils* takes around 28 to 32 days (Figure-1). The adult female rice weevil lays an average of 4 eggs per day and may live four to five months, producing 250-400 eggs. The eggs hatch after three days, and the larva feeds on the grain kernel for around 18 days, making it hollow. A single generation can be complete in around 28 days. The table below presents our test results. Here we see that a total of fifteen live *Rice weevils* were released into rice and wheat seeds to test their life cycle. The results in the table-1 show that the first four weeks there was no increase in number of Rice weevils and in the fifth week there was a total increase of 12 *Rice weevils* in rice seeds and 16 in wheat seeds (Figure-2).

Figure-1: Life cycle study of weevil

Table-1: Life cycle studies of weevil before start the experiments

No. of week	Total no. of pest inoculated	No of weevil emergence (Rice)	No of weevil emergence (wheat)
Week-1	10	0	0
Week-2	10	0	0
Week-3	10	6	8
Week-4	10	12	13
Week-5	10	20	22
Week-6	10	24	28

Table-2:- Percentage of infestation of Rice and Wheat grains

Sl.No.	Concentration (mg/ml)	Total no. of Rice grains	Total No. of bored rice grains	Percentage of infestation	Total no. of Wheat grains	Total No. of bored wheat grains	Percentage of infestation
1	0	6890	2756	40%	2438	926	37.98%
2	25mg/ml	6890	2342	33.99%	2438	780	31.99%
3	50mg/ml	6890	1998	28.99%	2438	682	27.97%
4	75mg/ml	6890	1171	16.99%	2438	365	14.97%
5	100mg/ml	6890	551	7.99%	2438	170	6.97%

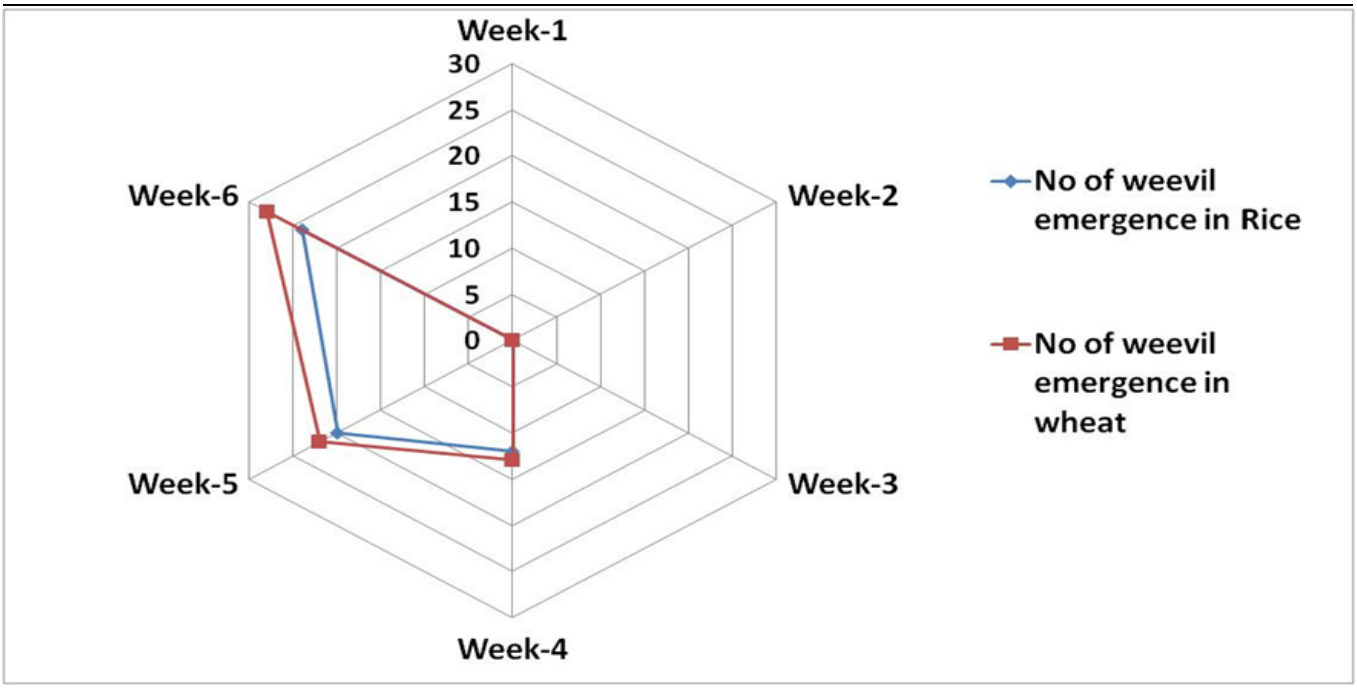

Figure-2:- Emergence of rice and wheat weevil

3.2. Days to Adult Emergence

The treatments regarding emergence of new progeny (Figure-3). In control jar, maximum 20 day required for rice and 25 days required emergence of new progeny. The application of 25 mg/ml concentration, the maximum 34 days and 37 days required to emergence of adults were noted when the tested insects were cultured on *Mucuna pruriens* aqueous extracts applied rice and wheat grains. Among the treatments by 50mg/ml concentration, 43 days and 47 days required to emergence of new progeny were recorded on *Mucuna pruriens* extracts. At 75mg/ml concentration, the maximum 52days and 55 days required to emergence of new progeny were documented when weevils were cultured on rice and wheat grains treated with *Mucuna pruriens* aqueous extracts. The maximum 66days and 72 days required to emergence of new progeny were noted on rice and wheat grains having *Mucuna pruriens* aqueous extracts at 100 mg/ml concentration.

3. 3. Total Adult Emergence

Significant variations were observed among the treatments regarding total adult emergence of rice weevil from treated rice and wheat grains (Figure-4). At control concentration, the maximum number of 75 and 66 total adult emergence was documented when weevils were cultured on Rice and wheat grains without aqueous extracts. At 25 mg/ml concentration, the maximum number of 58 and 48 total adult emergence were recorded when weevils were cultured on grains having application of *Mucuna pruriens* aqueous extracts. At 50 mg/ml concentration, the maximum number of 44 and 35 total adult emergence were documented on seeds having application of *Mucuna pruriens* aqueous extracts. At 75 mg/ml concentration, the maximum number of 23 and 19 total adult emergences were documented on seeds having application of *Mucuna pruriens* aqueous extracts. At 100mg/ml concentration, the maximum number of 05 and 03 total adult emergence were documented on seeds having application of *Mucuna pruriens* aqueous extracts.

3.4. Percent Infestation

The treatments of grains with selected botanical extracts show significance differences among the treatments regarding percent infestation by rice and wheat weevil. At control, the maximum rice grains infested 40%, at 25 mg/ml total rice grains infested 33.99%, at 50 mg/ml total rice grain infested 28.99%, at 75mg/ml total rice grains infested 16.99% and at 100mg/ml total rice grains infested 7.99%. At control, the maximum wheat grain infested 37.98%, at 25gm/ml total wheat grains infested 31.99%, at 50mg/ml total wheat grains infested 27.97%, at 75mg/ml total wheat grains infested 14.97% and at 100mg/ml total wheat grains infested 6.97%.

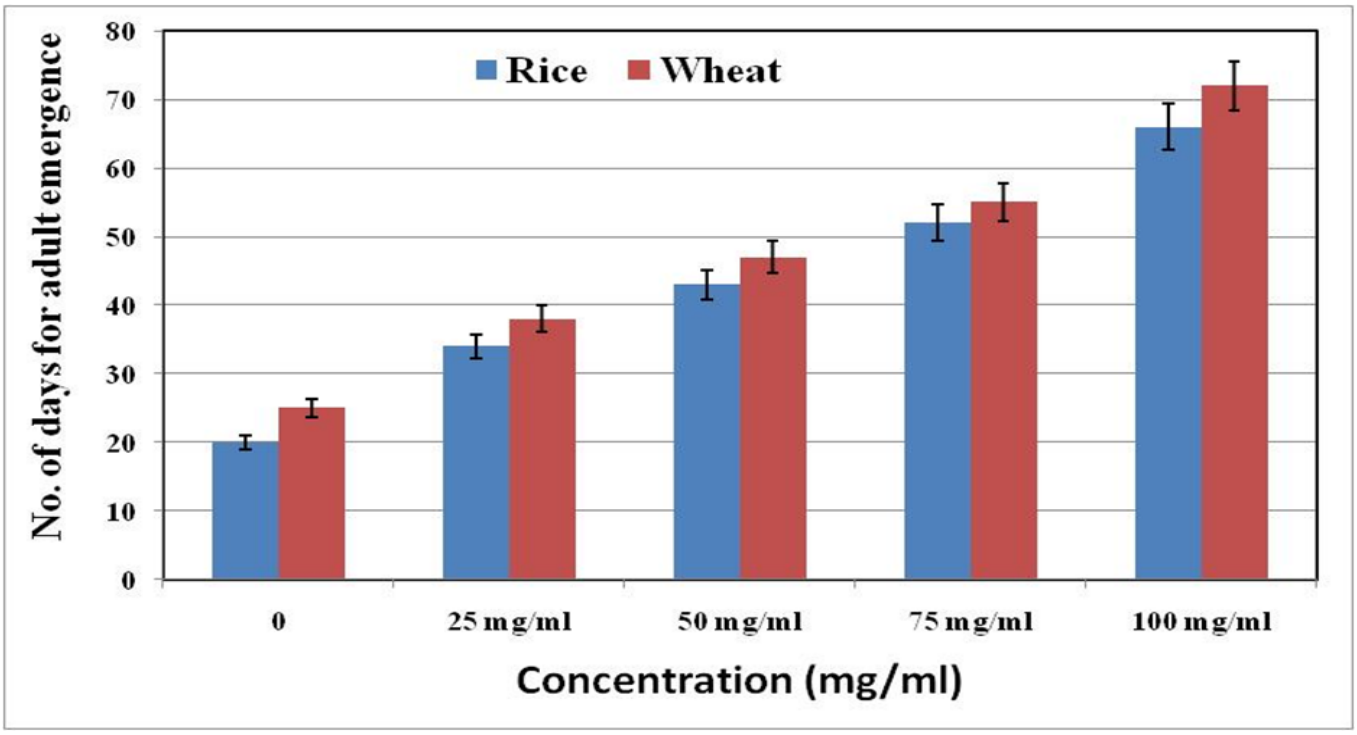

Figure-3:- Graphical representation of number days for adult emergence

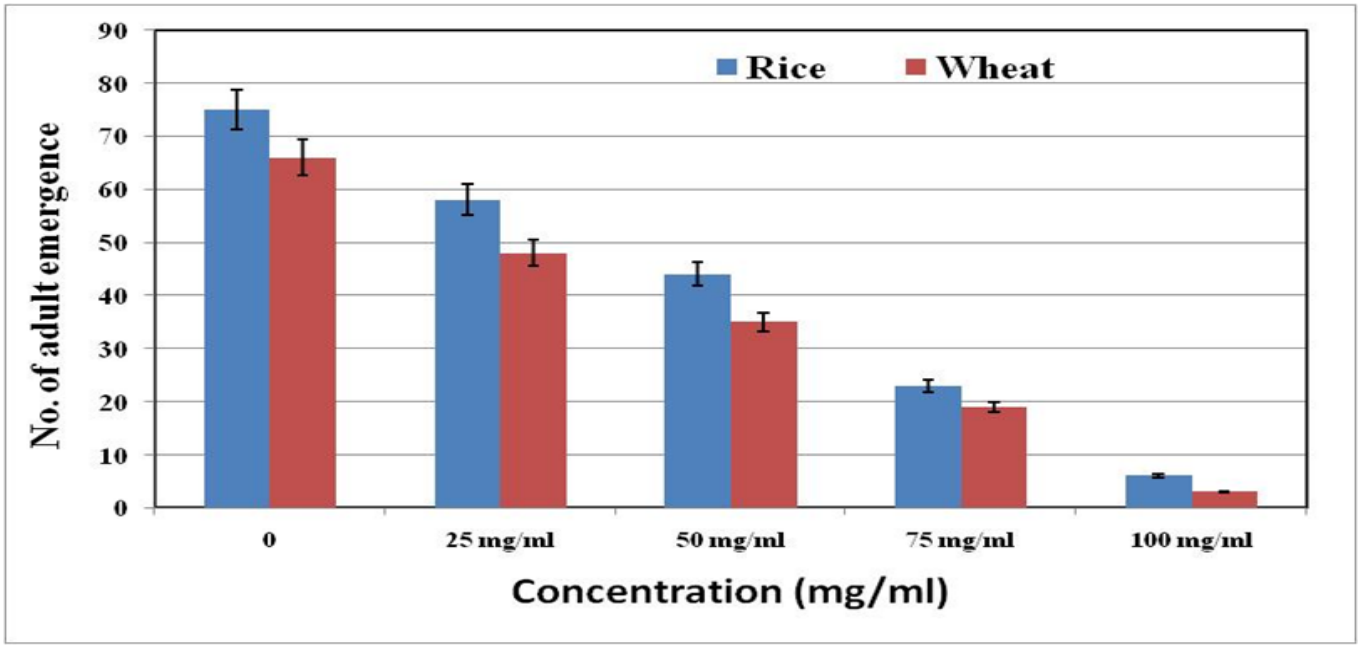

Figure-4:- Graphical representation of adult emergence

3.5. Adult Longevity

At 0 mg/ml concentration, maximum 60 days life span of adults was documented on Rice grains and 63 days on wheat grains when application of plant extracts (Figure-6). At 25 mg/ml concentration, the maximum 51 days adult life span was documented on Rice grains and 54 days having application of plant extracts. At 50 mg/ml concentration, the maximum 41-day life span of adults was observed on rice grains and 42 on wheat grains when application of aqueous extracts. At 75 mg/ml concentration, the maximum 35 days life span of adults was documented on rice grains and 36 days on wheat grains when application of aqueous extract whereas; lowest life span of adults 27 days was documented on rice grains and 29 days on wheat grains treated with 100 mg/ml aqueous extract.

3.6. Weight Loss of grains

3.6.1. In Rice grains

After 45 days collected the test results of each concentration (figure-9). In case of control test, we got final weight of 78 grams in this case total weight of rice decreased by 12 grams. Then in case of 10-gram concentration we got final weight of 84 grams in this case total weight of rice decreased by 6 grams. In case of 20 grams concentration, we got final weight of 86 grams in this case total weight of rice decreased by 4 grams. In case of 30 gm concentration, we got the final weight of 87 gm in this case complete weight of rice decreased by 3 gm. In case of last concentration 50 grams, we got final weight of 89 grams in this case total weight of rice decreased by 1 gram.

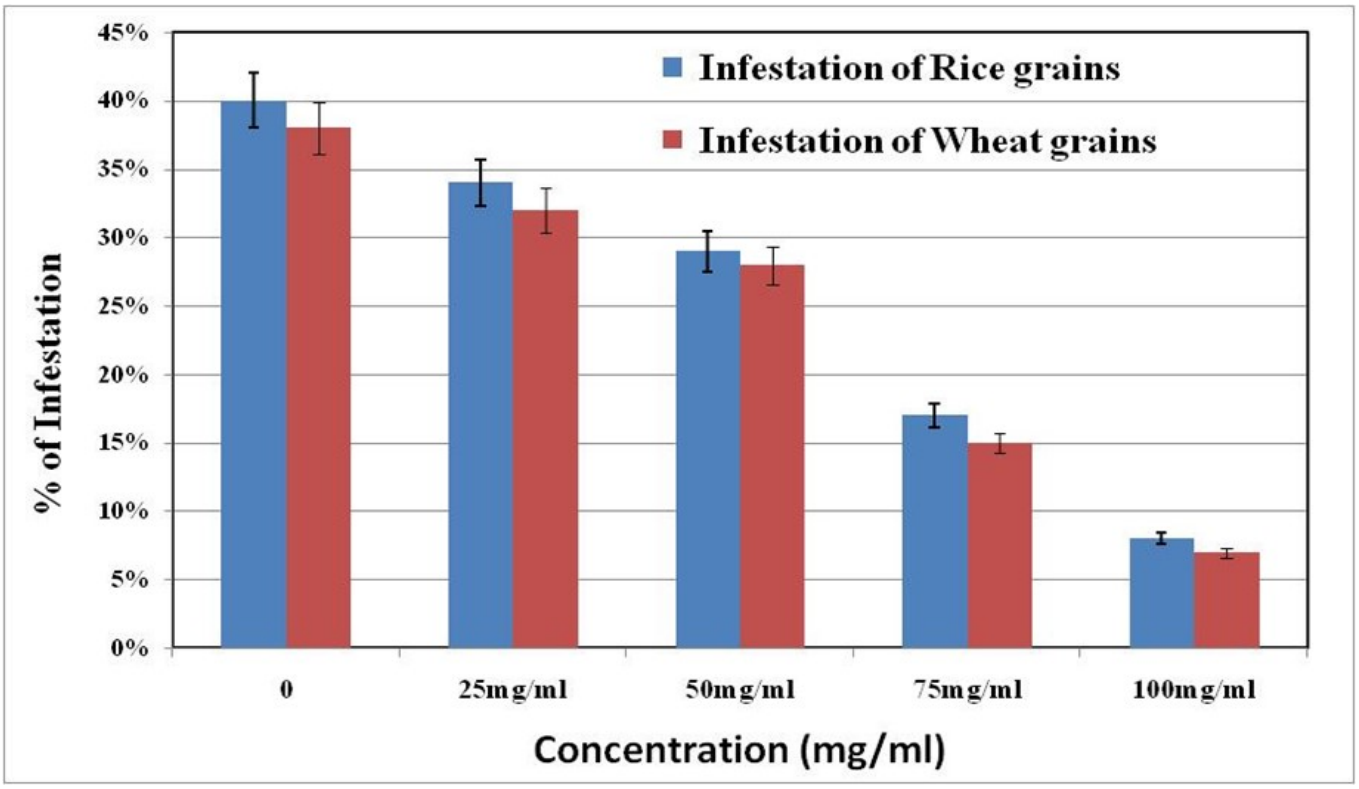

Figure-5:- Graphical representation of % of infestation

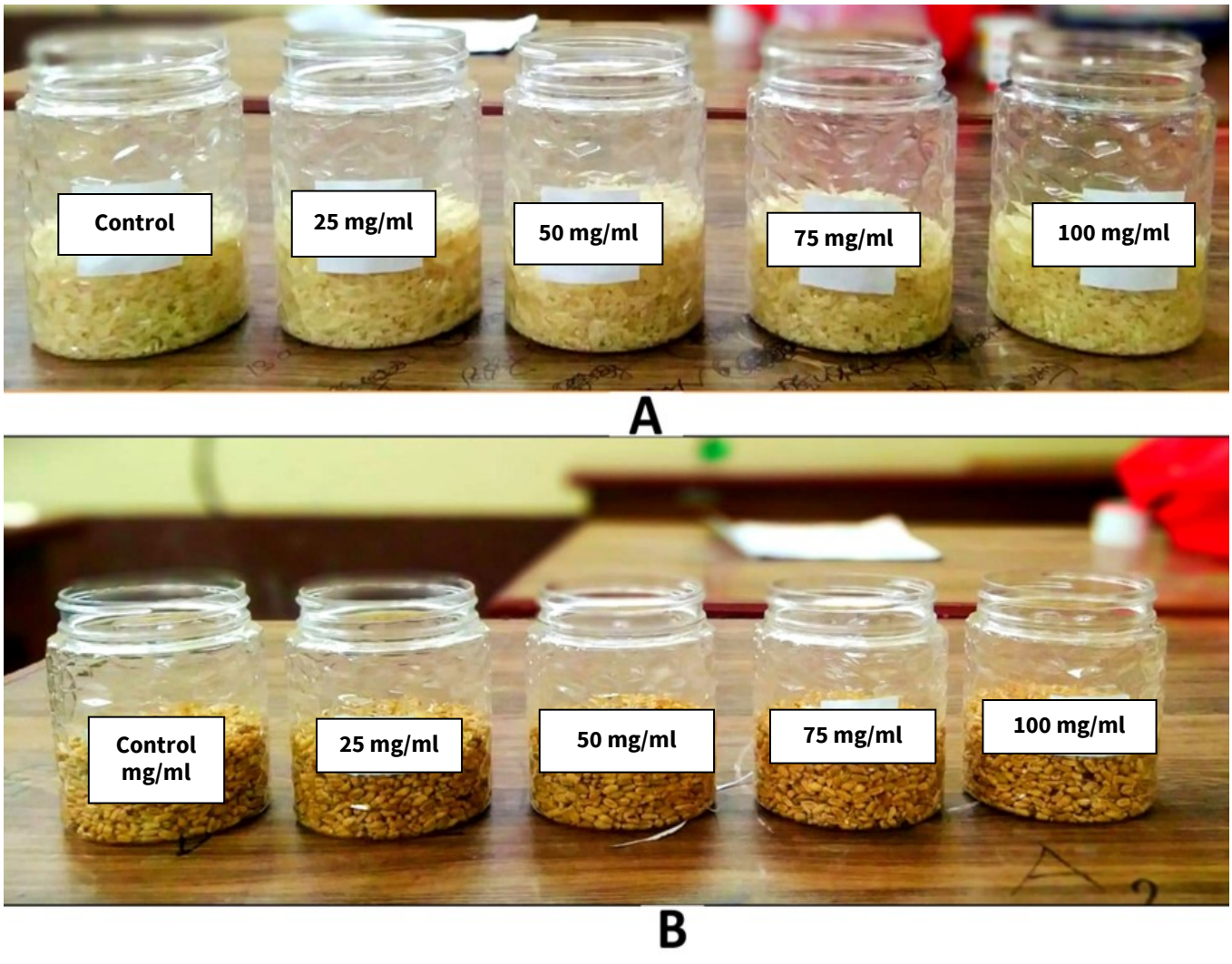

Figure-6: - Pesticidal activity tested against Rice and Wheat weevil of four different concentrations of plant extract.

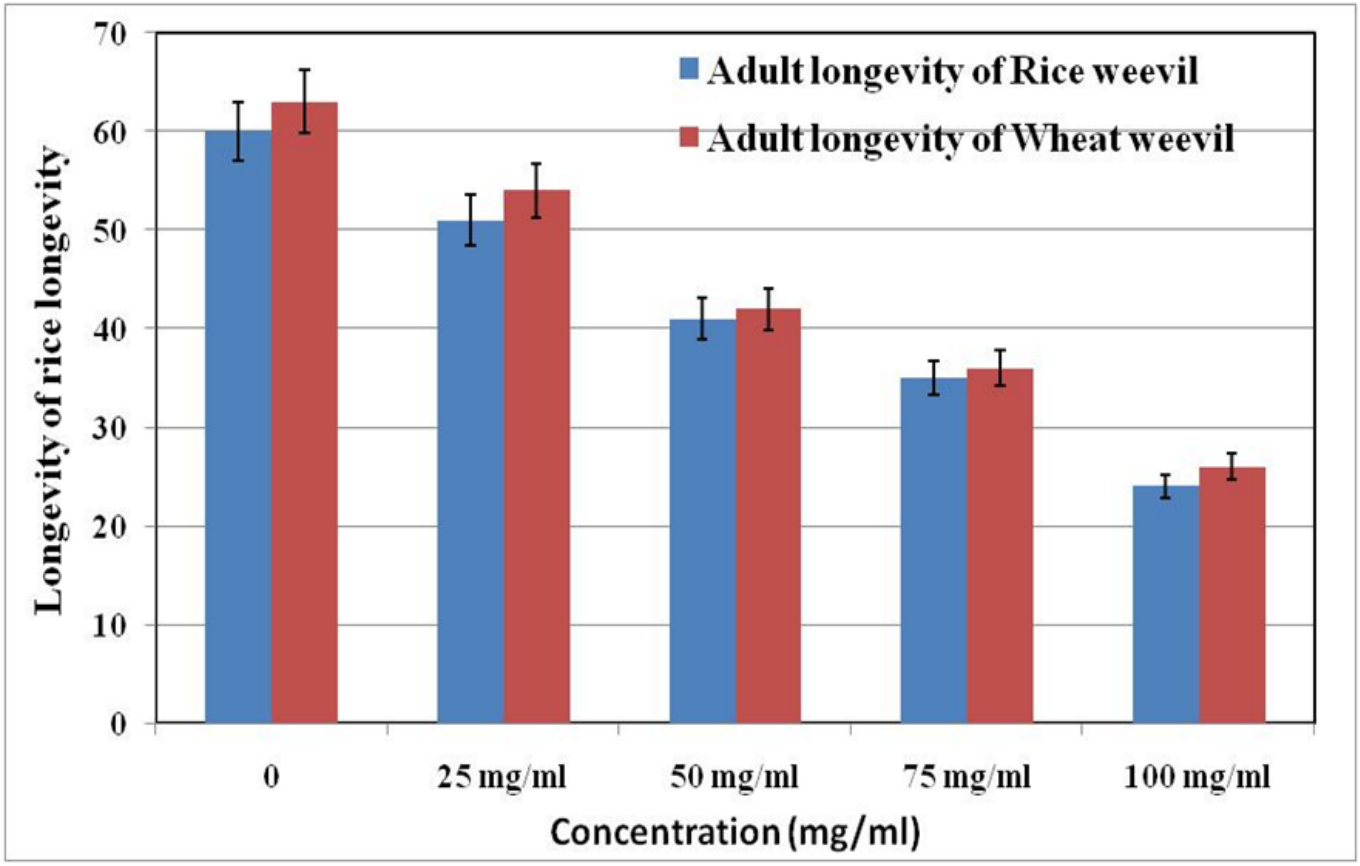

Figure-7:- Graphical representation of adult longevity of rice weevil

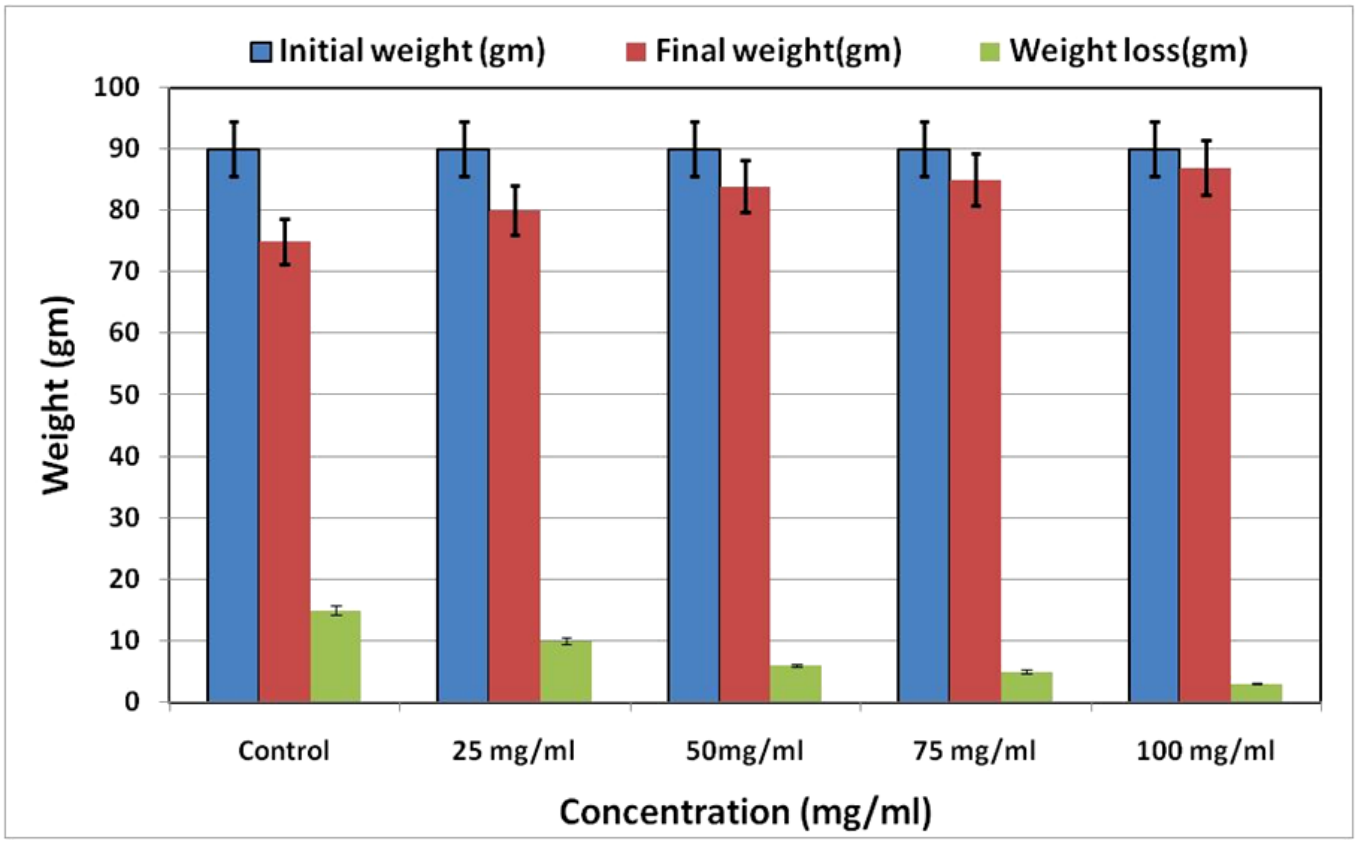

Figure-8: -Graphical representation of weight loss of Rice by weevil

3.6.2. In Wheat grains

After 45 days we collected the test results of each concentration (figure-9). In case of control test, we got final weight of 75 grams in this case total weight of rice decreased by 15 grams. Then in case of 10-gram concentration we got final weight of 80 grams in this case total weight of wheat seeds decreased by 10 grams. In case of 20 grams concentration, we got final weight of 83 grams in this case total weight of wheat seeds decreased by 6 grams. In case of 30 gm concentration, we got the final weight of 85 gm in this case complete weight of wheat seeds decreased by 5 gm. In case of last concentration 50 grams, we got final weight of 87 grams in this case total weight of wheat seeds decreased by 3 grams.

3.7. Direct spraying test

After direct spraying of the plant extract on Rice weevil and data of death weevil collected which is shown in figure-10.

Discussion

The study found that when compared to the control, all of the applied plant materials significantly increased the mortality of *S. oryzae* in both husked and unhusked rice. Numerous prior studies have noted that plant materials not only lessen the potential for damage caused by pests that prey on stored grains, but many of them have also significantly increased the pests' mortality. The feeding and population development of *S. oryzae*has been

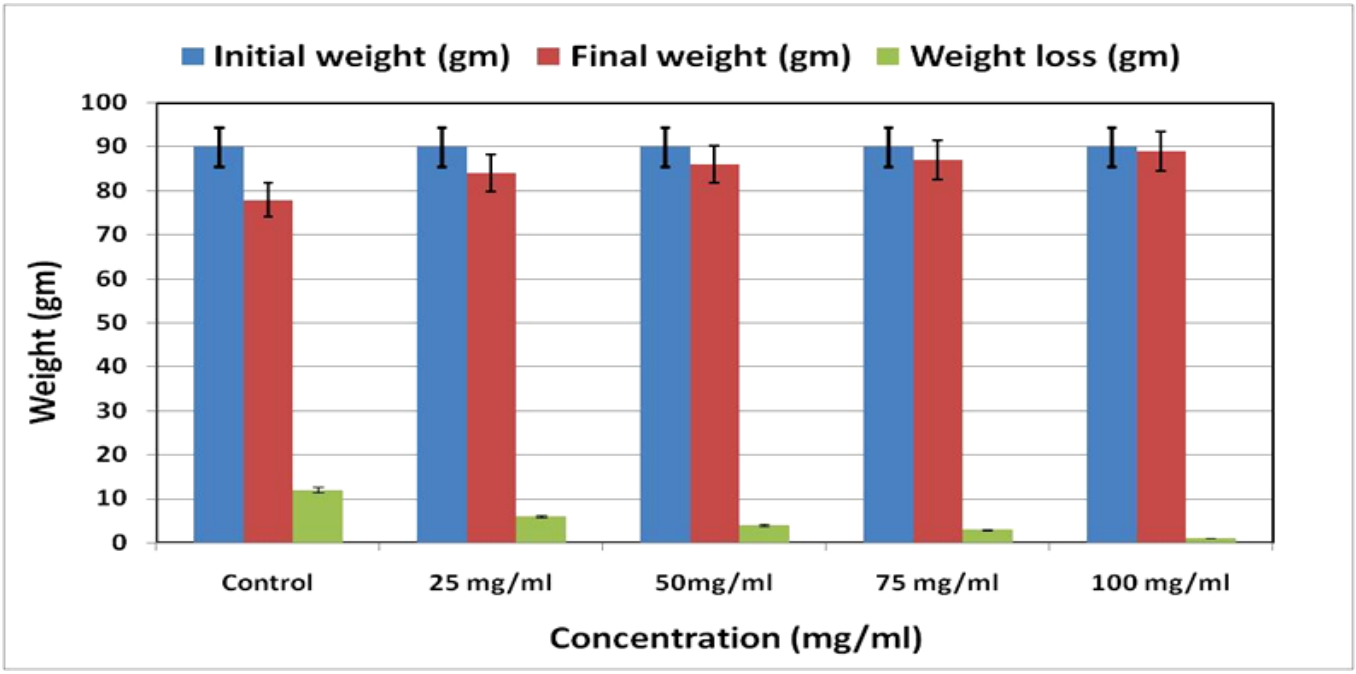

Figure-9:-Graphical representation of weight loss of Wheat by weevil

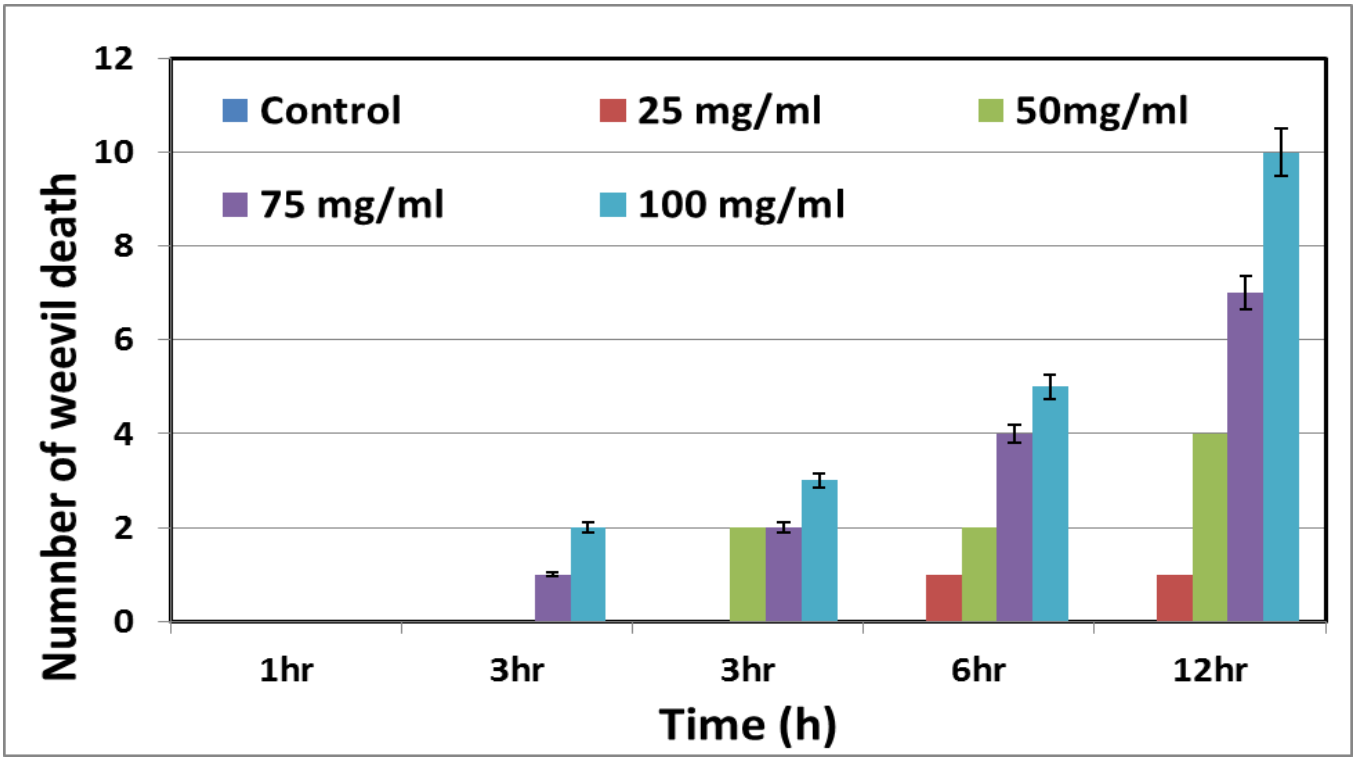

Figure-10: - Graphical represent of number of weevil death

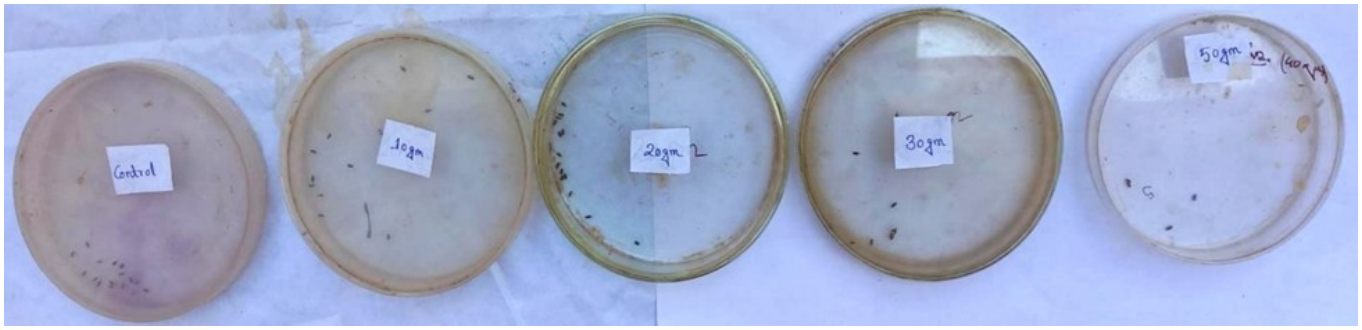

Figure-11: Plate showing weevil morality by direct spraying of crude extract

significantly reduced by extracts of neem leaves and seeds, dharek, Melia azedarach, and castor, with neem powders showing the least amount of weight loss, grain damage, and adult emergence (23) Jayakumar et al. (2017), studied varying fumigant and repellent qualities of wintergreen, rosemary, lemon, lavender, and geranium eucalyptus, citronella, aniseed, camphor, and vetiver against *S. oryzae* (24).

According to a different study, *Annona squamosa* powder can destroy the targeted individuals in S. oryzae populations. Additionally, leaf powders from *A. indica, Ocimum tenuiflorum, Carica papaya*, and *Justicia adhatda* demonstrated potential against *S. oryzae* (25). In addition, Buatone and Indraprichate (2011) investigated the insecticidal and repellent qualities, as well as the ability of *Citrus hystrix*, *Mentha cordifolia*, and *Hyptis suaveolens* extracts to prevent growth and reduce weight loss in grains, in relation to *S. oryzae* in milled rice (26). After 24 hours, *C. hystrix* ethanolic extracts demonstrated the highest repellency at a concentration of 13.23 mg/ml, while water extracts demonstrated the highest repellency at a concentration of 19.04 mg/ml. The suppression of growth ranges from 55 % to 89 %, whereas only 16 % weight loss was observed after 49 days of the application. The extracts of *Mentha longifolia*, *Pegnum harmala, Myrtus communis, Cymbopogon citrates, Melia azdarach, Diospyros lancifolia*, and *aquilionum* have all demonstrated noteworthy effects in reducing *O. sativa* damage and population development (27, 28). Because husk has a high concentration of silica, which may interfere with *S. oryzae's* feeding, the results also showed that *S. oryzae* significantly more damaged unhusked rice grains than husked rice grains (29). According to earlier research, plant powders can prevent insects from breathing (30), which can cause the insects to suffocate and perish. They can also have an impact on how insects feed.

In addition, Rani (2017) discovered that turmeric powder exhibited insecticidal properties against *S. oryzae* (31). Meanwhile, spectroscopic analysis identified the sesquiterpene ketone arturmerone as the biologically active component of Curcuma rhizome, which also demonstrated noteworthy insecticidal properties (32). According to a recent Indonesian study, adding 10 g of neem leaf powder to rice caused significant weevil mortality and reduced rice grain weight loss (33). Thus, this study also confirmed the ability of turmeric, neem, and mint to protect rice grains—husked or unhusked—against *S. oryzae*, which is consistent with many other research studies. Neem offered the best protection for unhusked rice grains, while turmeric was found to be more effective against *S. oryzae* in husked rice grains.

The observed disparity in the efficacy of the two materials under test could potentially be attributed to the greater retention capacity of turmeric in husked rice, which offers more durable and effective protection when compared to unhusked rice grains. The way that *S. oryzae* feeds on both husked and unhusked rice grains may have contributed significantly to the different plants' abilities. Thus, to reduce *S. oryzae* population growth and losses during storage, plant powders such as turmeric and neem can be mixed with rice. The minimum emergence of new progeny and weight losses documented in the maximum concentration proves the validity of this phenomenon. All the tested plant doses did not show any significant effect on the sex ratio of rice weevil. The future studies concentrating on the effects of refined extracts of *Mucuna pruriens* against rice weevil are needed.

Conclusion

The present results confirmed that the aqueous extracts of *Mucuna pruriens* at four different concentrations possess strong growth-regulating properties and should be used for the safer management of Rice weevil. The research on the bioefficacy of *Mucuna pruriens* extracts against *Stiophilus oryzae* holds the promise of providing a sustainable and environmentally friendly solution to the problem of rice weevil infestations. By harnessing the natural insecticidal properties of this tropical leguminous plant, this study aims to contribute to the development of effective and eco-friendly pest management strategies for stored rice and potentially other grain crops.

Acknowledgements

I am gratefully acknowledged to Plant Physiology and Biochemistry Laboratory, Department of Zoology, Balurghat College for their help.

Author's contributions

SKC designed and wrote the paper, MB wrote the paper. and improved the manuscript and Dewa Basnett wrote and corrected, TM check and edited the language. Sandip Roy worked and collected data.

Compliance with ethical standards

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical issues: None.

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