Proceedings of the Pakistan Academy of Sciences:
B. Life and Environmental Sciences 58(4): 59-65 (2021)

ISSN (Print): 2518-4261; ISSN (Online): 2518-427X
http://doi.org/10.53560/PPASB(58-4)687

Pakistan Academy of Sciences

Research Article

Efficacy of Indigenous Crude Plant Extracts against Rice Weevil, *Sitophilus oryzae* L. 1763 (Coleoptera: Curculionidae)

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Abstract: Rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae) is a widely distributed and major insect pest of rice that causes considerable losses to both husked and unhusked rice grains. Plant-based pesticides are alternative to synthetic pesticides in managing stored product pests owing to their severe hazardous effects. Thus, locally available plant leaf crude extracts i.e., neem (*Azadirachta indica* A. Juss 1830), turmeric (*Curcuma longa* L. 1753), and mint (*Mentha longifolia* L. Huds. 1762) were investigated at 2 % (w/w) concentration against *S. oryzae* in unhusked and husked rice. Adult mortality was recorded at 24, 48 hours, and seven days after the application whereas, population build-up was recorded at 1-, 2-, and 3-months intervals. Overall and grain weight loss was also recorded at the end of the experiment. In husked and unhusked rice, the highest mortality percentage was observed in turmeric powder (93.30 %) and neem (80.00 %), respectively. In comparison to plant extracts, relatively higher population growth of *S. oryzae* was recorded in control husked and unhusked rice. At the end of the 3rd month, the highest and lowest population in husked rice grains was recorded in control (70.67 ± 3.18) and turmeric treatments (18.00 ± 2.65), respectively, whereas control and neem treatments exhibited the highest (83.67 ± 3.28) and lowest (39.67 ± 2.33) populations in unhusked rice. The lowest grain weight loss in husked and unhusked rice was recorded in turmeric (9.33 %) and neem (16.67 %), respectively. Thus, turmeric and neem extracts should be investigated on large scale under commercial warehouses for the management of *S. oryzae* in husked and unhusked rice.

Keywords: Biopesticides, Phytochemicals, Plant Extracts, Rice Weevil, Mortality

1. INTRODUCTION

Rice grains are the richest source of energy and account for one-fifth of the global calorie supply. It is also a major source of nourishment for about 2.5 billion people around the world [1]. More than 1,200 species of pests have been previously reported to destroy stored products [2]. The post-harvest losses due to the stored grain pests are estimated at 9 and 30 % in developed and developing countries, respectively [3]. Major insect pests of stored rice grains include rice weevil (*Sitophilus oryzae* L.), maize weevil (*Sitophilus zeamais* Motsch.), granary weevil (*Sitophilus granaries* L.), lesser grain borer (*Rhyzopertha dominica* Fabr.), and sawtoothed beetle (*Oryzaephilus surinamensis* L.), which caused heavy grain losses [4]. Among them, *S. oryzae* is the major insect pest of rice and causes a considerable loss to both husked and unhusked rice [5]. Under favourable prolonged storage conditions, it can cause losses up to 80 %, whereas average losses between 10–65 % are reported under moderate storage conditions [6].

Management of stored grain pests is generally based on the use of synthetic chemicals throughout

Received: October 2021; Accepted: December 2021
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the world [7]. These chemicals create severe problems such as resistance in pest species, health hazards, and chemical residues in food products [8]. Accordingly, rice weevil has also developed resistance against many widely used insecticides and fumigants in the stored grains [9, 10].

Thus, there is an urgent need to search for alternate tactics that are readily available, affordable, cost-effective, relatively less toxic, and less harmful to the environment [11]. Plant materials and their derivatives are usually less expensive, easily available, target-specific and safe for the non-targeted species and environment [12, 13]. Accordingly, these naturally occurring plant products and bio-pesticides are potential alternatives to manage agricultural insect pests [14]. Therefore, a broader range of plant derivatives and their products has been studied against several insect pests of stored products as most of them are less toxic, increased food safety, non-pollutant, and biodegradable, improved the production profitability, and reduced pesticide resistance [15]. Among the botanicals evaluated against rice weevil includes neem, eucalyptus, black pepper, Chinese cinnamon, garlic, yellow oleander, mint, basil, black seeds, and lavender in various regions of the world with varying degrees of effectiveness [16-19]. However, in Pakistan, there is little or no studies conducted to exploit locally available crude plant extracts to manage the pest population of stored grains. Therefore, the present study was designed to evaluate the potential of *Azadirachta indica* A. Juss (1830), *Mentha longifolia* L. Huds. (1762) and *Curcuma longa* L. (1753) in managing rice weevil in both husked and unhusked rice grains. The outcome of this research will be useful in the development of bio-rational insecticides.

2. MATERIAL AND METHODS

2.1 Test Insect

Sitophilus oryzae was obtained from the previously maintained culture at the laboratory of the Department of Entomology, Sind Agriculture University Tandojam, Pakistan. Adult weevils were reared on brown rice at 25 ± 2 °C and 65 ± 5 % relative humidity adopted from Mehta *et al.* [20].

2.2 Rice Grains

Husked and unhusked rice variety IRRI-9 used in the study was purchased from the local market. Prior to experiments, the grains were disinfested in the oven at 40 °C for 4 h [21].

2.3 Preparation of Plant Materials

Matured fresh leaves of *A. indica* and *M. longifolia* were obtained from the surroundings of the Sindh Agriculture University, Tandojam, whereas *C. longa* L. powder was purchased from the local market. The plant materials were air-dried for two weeks in a well-ventilated place, ground using an electric blender (GEEPAS China GCG289) and sieved through muslin cloth to obtain a fine powder.

2.4 Experimental Outline

Two experiments (mortality and population build-up) were conducted in the study. In the mortality experiment, the powder of each plant was applied individually at the rate of 2 % into 20 g of both husked and unhusked rice grains in individual petri dishes. The powder and the grains were shacked thoroughly for 3 min to create a homogenous mixture. Thereafter, in each petri dish, five pairs of freshly emerged one-day-old *S. oryzae* were transferred. Moreover, to ascertain the effect of plant powders on the population development of rice weevil in both husked and unhusked rice grains, 2 % concentration of each material was thoroughly mixed with individual grains in plastic jars (Width: 21.855” x Height: 13.875”). Ten pairs of *S. oryzae* adults were introduced into individual jars. A control treatment (husked and unhusked rice grains) without plant powders was included in the experiments. The mouth of the jars was covered with a muslin cloth to ensure aeration and restrict insects inside the jars. Both experiments were arranged in Completely Randomized Design with each treatment replicated thrice.

2.5 Parameters Measured

The mortality of *S. oryzae* was recorded at 24 and 48 hours, and 7 days after the application of treatments, where numbers of live and dead *S. oryzae* were counted. Moreover, monthly observations were done for three months to count live *S. oryzae* to record its population build-up in both husked and unhusked rice. At the end of the third month, weight loss in the individual treatments was also recorded.

2.6 Data Analysis

The collected data was analyzed using ANOVA by STATISTIX 8.1 statistical software, whereas Least Significant Difference (LSD) at 0.05 significant level was used for mean separation [22].

3. RESULTS

Results of the study confirmed a profound impact of plant extracts on the mortality and population development of *S. oryzae* in rice grains. Among plant extracts, neem and turmeric were found more effective against *S. oryzae* in unhusked and husked rice, respectively as comparatively higher mortality of weevils was recorded in husked rice.

3.1 Effect of Crude Plant Extracts on Mortality of *S. oryzae* at Different Intervals

Mortality experiment results (Table 1) revealed that at 24 h after treatment, the highest (2.33 ± 0.33 weevils) mortality was observed in husked rice treated with turmeric powder whereas, in unhusked rice, neem powder caused the highest (1.33 ± 0.33 weevils) mortality. A similar trend was observed at 48 h after exposure as the mortality percentage of weevils showed a gradual rise. After one week, the highest mortality percentage of *S. oryzae* in husked and unhusked rice was recorded in turmeric powder (93.30 %) and neem powder (53.30 %) respectively. Moreover, in husked rice grains, neem and mint powders caused 80.00 % and 63.30 % mortality of *S. oryzae*, respectively at the end of the week. In unhusked rice, 46.70 % and 40.00 % mortality of *S. oryzae* was recorded in mint and turmeric, respectively. No dead weevil was found in the control treatment of both husked and unhusked rice grains at the end of the experiment. Results also indicated that in all the observation intervals (24 h, 48 h, and one week), significantly ($P < 0.05$) higher mortality of *S. oryzae* was recorded in husked rice grains compared to unhusked rice grains.

3.2 Effect of Crude Plant Extracts on the Population Fluctuation of S. oryzae

The application of plant materials also influenced the population build-up of *S. oryzae* in husked and unhusked rice (Figure 1) as relatively higher population build-up was recorded in control husked and unhusked rice treatments. However, significantly less population build-up of *S. oryzae* was observed in both rice grains treated with turmeric and neem powders. After one month, the highest (26.33 ± 1.45 weevils) population was observed in the unhusked rice control treatment, whereas the lowest (7.33±0.33 weevils) population was recorded in husked rice treated with turmeric powder. At two and three months after treatment, steady growth in the *S. oryzae* population was observed in the neem, mint, and turmeric treatments; however, rapid growth was recorded in the control treatment of both rice conditions. At the end of the third month, the highest mean population of *S. oryzae* in husked rice grains was recorded in control (70.67 ± 3.18 weevils), followed by mint treatment (31.33 ± 2.03 weevils). The lowest mean population of *S. oryzae* was recorded in turmeric treatment (18.00 ± 2.65 weevils), followed by neem treatment (28.67 ± 2.03 weevils). Like husked rice, the highest population of weevils was recorded in unhusked control (83.67 ± 3.28 weevils), whereas the population observed in turmeric, mint, and neem treatments was 57.33 ± 2.03 weevils, 47.00 ± 4.16 weevils, and 39.67 ± 2.33 weevils, respectively.

3.3 Weight loss of Unhusked and Husked Rice Grains Mixed with Different Crude Plant Extracts by *S. oryzae*

Similar to the population build-up results, the mean weight loss recorded in husked and unhusked rice grains treated with turmeric and neem powders was significantly lower than the remaining treatments (Table 2). At the end of the experiment, in unhusked rice grains, significantly ($p > 0.05$) highest weight loss was observed in the control treatment (77.33 g or 38.67 %), followed by turmeric treatment (39.67 g or 19.83 %). In husked rice, the highest overall weight loss was recorded in control (65.33 g or 32.67 %), followed by mint (25.33 g or 12.67 %) and neem treatments (18.33 g or 9.17 %).

Table 2. Weight loss of rice grains mixed with plant materials by *S. oryzae* under laboratory conditions

Rice	Plant	Initial weight	Final weight	Grain weight	Overall weight loss	Grain weight loss
Unhusked	Neem	200 g	173.33±2.33c	166.67±2.40b	26.67(13.33 %)	33.33(16.67 %)
	Mint	200 g	168.33±1.76c	162.33±2.03bc	31.67(15.83 %)	37.67(18.83 %)
	Turmeric	200 g	160.33±2.03d	154.33±2.03c	39.67(19.83 %)	45.67(22.83 %)
	Control	200 g	122.67±3.28f	115.67±3.28e	77.33(38.67 %)	84.33(42.17 %)
Husked	Neem	200 g	181.67±1.86ab	175.33±2.19a	18.33(9.17 %)	24.67(12.33 %)
	Mint	200 g	174.67±2.03bc	167.00±2.65b	25.33(12.67 %)	33.00(16.50 %)
	Turmeric	200 g	187.00±0.58a	181.33±0.88a	13.00(6.50 %)	18.67(9.33 %)
	Control	200 g	134.67±4.10e	127.00±4.62d	65.33(32.67 %)	73.00(36.50 %)

*Means followed by the same letters in columns are not significantly different at 0.05 % significance level

Moreover, in unhusked and husked rice grains, the lowest overall weight loss was recorded in neem (26.67 g or 13.33 %) and turmeric (13.00 g or 6.50 %) treatments, respectively.

In continuation to an overall weight loss of grains, the highest grain weight loss of unhusked and husked rice was recorded in their control treatments (84.33 g or 42.17 %) and (73.00 g or 36.50 %), respectively, whereas the lowest grain weight loss was observed in neem treated unhusked rice (33.33 g or 16.67 %) and turmeric treated husked rice (18.67 g or 9.33 %).

4. DISCUSSION

AIt was observed in the study that all the applied plant materials caused significant mortality of *S. oryzae* in both husked and unhusked rice in comparison to control. It has been observed in many previous studies that plant materials have the potential not only to reduce the damage potential of stored grains pests, but many of them have also caused substantial mortality of these pests. The extracts of leaves and seeds of neem, dharek, Melia azedarach, and castor have demonstrated a significant reduction in the feeding and population development of *S. oryzae*, with neem powders exhibiting the lowest weight loss, grain damage, and emergence of adults [23]. Jayakumar *et al.* (2017) also confirmed that variable fumigant and repellent properties of wintergreen, rosemary, lemon, lavender, geranium, eucalyptus, citronella, aniseed, camphor, and vetiver against *S. oryzae* [24]. Another study has also identified that *Annona squamosa* powder has the potential against the populations of *S. oryzae* with 100% death of the targeted individuals. Moreover, leaf powders of *Justicia adhatda*, *A. indica, Carica papaya* and *Ocimum tenuiflorum* also showed potential against *S. oryzae* [25]. Buatone and Indraprichate (2011) also examined the efficacy of the extracts of *Citrus hystrix*, Mentha cordifolia and Hyptis suaveolens against *S. oryzae* in milled rice regarding their insecticidal and repellent properties along with growth prevention and weight loss to grains [26]. Ethanolic extracts of *C. hystrix* showed the highest repellency after 24 h at the concentration of 13.23 mg/ml while, among water extracts, exhibited the highest repellency at 19.04 mg/ml concentration. The suppression of growth ranged from 55 % to 89 %, whereas only 16 % weight loss was recorded after 49 days of the application. The extracts of Myrtus communis, Cymbopogon citrates, *Melia azdarach, Pegnum harmala, Mentha longifolia*, *Diospyros lancifolia,* and *aquilionum* have also shown significant results in reducing the damage of *O. sativa* along with lowering their population development [27, 28].

The results also indicated that *S. oryzae* significantly caused more damage to unhusked rice grains in comparison to husked rice grains, because husk contains a high concentration of silica which may disturb the feeding of *S. oryzae* [29]. Previous studies also reported that plant powders not only affect the feeding of insects but are also capable of blocking the spiracle of insects [30], thus, can lead to suffocation and death of the targeted insects. Rani (2017) also found insecticidal properties of turmeric powder against *S. oryzae* [31] whereas biologically active constituent of Curcuma rhizome was characterized as the sesquiterpene ketone ar-turmerone by spectroscopic analysis that also showed significant insecticidal properties [32]. In a recent study in Indonesia, the application of neem leaf powder at 10 g in rice cause significant mortality of weevils and less weight loss of rice grains [33].

Therefore, in relation to many previous research works, this study also confirmed the potential of turmeric, neem, and mint to protect rice grains either husked or unhusked against *S. oryzae*. However, turmeric was proved more effective against *S. oryzae* in husked rice grains, whereas neem showed the maximum protection of unhusked rice grains. The reasons for such difference in the efficiency of the two tested materials may be that turmeric may have more retention capability in husked rice, thus, providing effective and longer protection in comparison to unhusked rice grains. The feeding behaviour of *S. oryzae* in husked and unhusked rice grains may also have played a significant role in the effectiveness of the various plants. Therefore, turmeric and neem plant powders can be added with rice during storage to lower the population development and losses of *S. oryzae*.

5. CONCLUSION

Although all the tested plant materials showed insecticidal properties against *S. oryzae*, however, turmeric and neem caused relatively higher mortality of weevils in husked and unhusked rice, respectively. The lowest population growth at the end of third month was recorded in turmeric treated husked rice and neem treated unhusked rice grains. Turmeric treated husked rice and neem treated unhusked rice grains exhibited the lowest overall and grain weight loss.

6. CONFLICT OF INTEREST

There is no conflict of interest among authors regarding the publication of this article in this journal.

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