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Original Research Article

Assessment of Neem Products for Management of Rice Weevil (*Sitophilus Oryzae* L.) in Stored Rice Grain

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ABSTRACT

The experiment was conducted to study the damage assessment and effect of different neem products for the management of rice weevil (*Sitophilus oryzae* L.) in stored rice grain during the period from July to December 2013. Stored husked and unhusked rice of BR 27 were used as the experimental materials. The experiment consists of the treatments: T_1: Neem leaves dust 10 gm/kg of stored rice grains; T_2: Neem seed kernel dusts @ 10 gm/kg of stored rice grains; T_3: Neem leaves extract @ 10 ml/kg of stored rice grains; T_4: Neem oil 5 ml/kg of stored rice grains and T_5: Untreated control. The experiment was laid out in the ambient condition of the laboratory following in a Completely Randomized Design (CRD). In case of unhusked rice, the highest mortality (100.00%) was observed in T_4 treatment, while the lowest 5.25% mortality was recorded in T_5 treatment. For husked rice, the highest mortality (100.00%) was observed in T_4, while the lowest mortality (9.00%) was recorded in T_5 treatment. At 1st generation for unhusked rice, in weight basis, the highest infestation was recorded from T_5 (9.49%) treatment while the lowest in T_4 (1.32) and for husked rice, the highest infestation was recorded from T_5 (10.68%), while the lowest in T_4 (2.79%) treatment. On the other hand, by number basis in unhusked rice, the highest infestation was found from T_5 (11.57%), while the lowest in T_4 (2.47%) treatment and for husked rice, the highest infestation was found from T_5 (14.72%) while the lowest in T_4 (3.86%) treatment. At 1st generation, for unhusked rice, the highest weight loss was found in T_5 (18.21%), while the lowest was found in T_4 (3.89%) treatment and for husked rice grain, the highest weight loss was recorded in T_5 (21.45%), whereas the lowest was observed in T_4 (4.38%) treatment. In case of repellency effect for unhusked rice, after 5 hours of treatment application the highest repellency rate was found from T_4 and T_3 (100.00%), whereas the lowest repellency rate (80.00%) was recorded in T_1 treatment. In case of repellency effect for husked rice, after 5 hours of treatment application the highest repellency rate was found from T_4 and T_3 (100.00%) treatments which was followed by T_1 and T_2 (90.00%) treatments. Among the neem products neem oil 5 ml/kg of stored rice grains was more effective for controlling rice weevil.

Key words: Rice, rice weevil, storage, neem product and management.

INTRODUCTION

Rice is the most important food for majority of people around the world. It is the staple food for more than two billion people in Asia. [1] In Bangladesh, the geographical, climatic and edaphic conditions are

favorable for year round rice cultivation. About 75% of the total cropped area and more than 80% of the total irrigated area is cultivated for rice. [2] Bangladesh produces a total of 27.04 million tons of rice from an area of 25.56 million acres. [3] Preservation of reserve food grain stocks is necessary to ensure a continuous supply at stable price around the year. The farmers store more than 65% of the total rice produced till the next season for their food, feed and seed purposes. Rice is stored as paddy (unhusked rice) after harvest and also polished milled rice (husked rice).

In Bangladesh, rice is stored as raw parboiled in bamboo made container (dole and golas) or stored as parbolied milled rice in earthen pot (motka). [4] Losses due to insect infestation are the most serious problem in grain storage, particularly in villages and towns of developing countries like Bangladesh. Rice is being damaged by a number of agents, such as insects, rodents, fungi, mites, birds and moisture. [5] Among them, storage insects are the major agents causing considerable losses each year. Nearly seventeen species of insects have been found to infest stored rice. [6] of which rice weevil (*Sitophilus oryzae* Linn.), rice moth (*Sitotroga cerealella*); and beetles (*Tribolium castaneum*) predominate in parboiled rice. In India losses caused by insects accounted for 6.5% of stored grain. [7] In Bangladesh, the annual grain losses cost over taka 100 crores. [8] If these losses could be saved and food grains are properly distributed, famine in most of the countries of Asia and Africa could be averted.

The rice weevil *Sitophilus oryzae* L. is one of the most destructive insect pests of stored grains. It is almost cosmopolitan in distribution being more abundant in warm and humid areas but does not thrive in countries having cold winters. [6,8] Both the adult and larva feed voraciously on a variety of stored cereal grains viz. rice, wheat, maize and other products causing serious losses. In tropical countries, outbreak of this pest may make the stored rice unfit for human consumption within eight months of storage both in unhusked and husked condition. [6] In Bangladesh rice is mostly stored in farm houses for several months or until the harvest of next crop; but stored for longer duration in public sector silos or large storages. Rice weevil is the most common pest in all types of rice stores in Bangladesh but loss estimates due to this pest are scanty. Bhuiya *et al*. [4] reported 11-16% weight loss of husked rice during 4 months of storage in laboratory condition.

In recent years it has been demonstrated that various insect species are affected in their growth activity and metamorphosis by treatment with botanicals like Mahogoni, Bishkatali, Neem products. [9] Indo-Pakistani farmers use neem leaves, biskataili for controlling stored grain pests, while various Nigerian tribes use roots, stems and leaves of plants. [10,11] Our farmers are traditionally protecting their stored products with some herbal substances such as oil, leaves, roots, seeds etc. of different plants instead of chemical control. [12] It is well known that neem extract has proved to be one of the promising plant extract for insect control at the present time. These products do not leave harmful residue with lower toxicity to mammals. [13] The efficacy of neem extracts on various insect pests species were noted earlier such as repellent, antifeedant, growth-retardant, molt disrupting, progeny development disrupting and also oviposition deterrent. [14-16] however the most practical use of these oils is to mix grains or seeds with oil or substances to provide the physical contact of oil with insect cuticle and resulting in behavioral responses. Even the practice of mixing neem materials especially neem oil with store products, food grain and other

commodities showed an effective protection against the insect pests.

Considering the above; the present research work was undertaken with the following objectives to determine the damage assessment of unhusked and husked stored rice grains by rice weevil, to find out the effect of different neem products on adult mortality and development of rice weevil, to evaluate the effect of different neem products on grain weight loss by rice weevil and to evaluate the repellent effect of different neem products against rice weevil.

MATERIALS AND METHODS

The experiment was conducted to study the damage assessment and effect of different neem products for the management of rice weevil (*Sitophilus oryzae* L.) in stored rice grain during the period from July to December 2013. Stored husked and unhusked rice (BR 27) were purchased and collected from the Agricultural Farm of Sher-e-Bangla Agricultural University, Dhaka. Collected stored rice (BR 27) were kept in 20 plastic pots maintaining one kg per pot and then these pots were in ambient room temperature in the laboratory of the Department of Entomology, Sher-e-Bangla Agricultural University. The experiment consists of the treatments: T_1: Neem leaves dust 10 gm/kg of stored rice grains; T_2: Neem seed kernel dusts @ 10 gm/kg of stored rice grains; T_3: Neem leaves extract @ 10 ml/kg of stored rice grains; T_4: Neem oil 5 ml/kg of stored rice grains and T_5: Untreated control. The experiment was laid out in the ambient condition of the laboratory following in a Completely Randomized Design (CRD).

Data were collected on the bellow mentioned parameters: the adult mortality was recorded and converted into percentage. The original data were corrected by the adopting Abbott's (1925) formula.

$$\text{Percentage of mortality} = \frac{\text{No. of dead insects}}{\text{Total no. of insects treated}} \times 100$$

After release of 5 pairs of adult weevils, they were observed daily up to the death. From this mortality data, adult life span was calculated. To determine the percentage of damaged rice seeds, number of seeds having hole and normal seeds were counted per Petri dish or replicate and percentage of damaged seeds were calculated by using the following formula-

$$\text{\% of damaged seeds in No.} = \frac{\text{No .of damaged seeds}}{\text{Total number of seeds}} \times 100$$

$$\text{\% Infestation (by Number)} = \frac{\text{Number of infested seeds}}{\text{Total number of seeds}} \times 100$$

The weight losses were converted into percentage of weight loss of rice seeds. From the above mentioned data, percentage of weight loss, percentage (%) of infested seeds (by weight), percentage reduction in infestation and percent protection of weight loss over control were calculated as follows:

$$\text{\% Weight loss} = \frac{\text{Initial weight of seeds} - \text{Final weight of seeds}}{\text{Initial weight of seeds}} \times 100$$

$$\text{\% Infestation (by weight)} = \frac{\text{Weight of infested seeds}}{\text{Total weight of seeds}} \times 100$$

$$\text{\% Infestation reduction} = \frac{\text{(\% Infestation in control} - \text{\% Infestation in treatment)}}{\text{\% Infestation in control}} \times 100$$

The data obtained from the experiments were statistically analyzed on one factor CRD with help of computer based programme MSTAT-C software. The means was separated to determine the level of significance following Duncan's Multiple Range Test (DMRT) and Least Significance Difference (LSD) wherever necessary at 5% level of probability.

RESULTS AND DISCUSSION

1. Number of dead insects: Number of cumulative dead insects after 24, 48 and 72 hours showed statistically significant variation due to different neem products for management of rice weevil in unhusked and husked stored rice grain (Table 1).

1.1 Adult mortality in unhusked rice: After 24, 48 and 72 hours of treatment application the highest number of dead insects (7.50, 13.25 and 14.25) were recorded in T_4 treatment (Neem oil 5 ml/kg of stored rice grains). On the other hand, no dead insects were found in T_5 (untreated control) treatment which was followed by T_2 (Neem seed kernel dusts @ 10 gm/kg of stored rice grains) treatments (Table 1).

1.2 Adult mortality in husked rice: After 24, 48 and 72 hours of treatment application the highest number of dead insects (8.75, 14.00 and 15.50) were recorded in T_4 treatment. On the other hand, no dead insects were found in T_5 treatment which was followed by T_2 (4.25) treatments (Table 1).

2. Adult emergence: Adults emerged for 1st, 2nd, 3rd generations and also total varied significantly for the application of different neem products for the management of rice weevil in stored rice grain for unhusked and husked condition (Table 2).

2.1 Unhusked rice: For unhusked rice, at 1st, 2nd and 3rd generation no adults emerged in T_4 treatment, while the highest number of adults were recorded in T_5 (78.25, 112.25 and 178.50) treatment. In case of total adult emergence for 1st, 2nd and 3rd generation no adults emerged in T_4 treatment, while the highest adult was recorded in T_5 (369.00) (Table 2).

2.2 Husked rice: In case of husked rice, at 1st, 2nd and 3rd generation no adults emerged in T_4 treatment, while the highest number of adults were recorded in T_5 (84.50, 125.50 and 189.50) treatment. In case of total adult emergence for 1st, 2nd and 3rd generation no adults emerged in T_4 treatment, whereas the highest adult was recorded in T_5 (399.50) (Table 2).

Table 1: Effect of different neem products on the number of dead insects after different times in unhusked and husked rice

Treatments	No. of dead insects for					
	Unhusked rice grain after			Husked rice grain after		
	24 hours	48 Hours	72 Hours	24 hours	48 Hours	72 Hours
T_1	5.25 c	9.50 c	11.75 c	6.25 c	11.25 d	14.00 d
T_2	3.25 d	8.75 c	10.25 d	4.25 d	10.50 c	11.50 c
T_3	6.25 b	11.50 b	12.50 b	7.50 b	12.75 b	13.75 b
T_4	7.50 a	13.25 a	14.25 a	8.75 a	14.00 a	15.50 a
T_5	0.00 e	0.00 d	0.00 e	0.00 e	0.00 e	0.00 e
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	5.66	4.11	6.89	4.48	7.23	5.44

Table 2: Effect of different neem products on adult emergence at 1st, 2nd, 3rd generation & total adult emerged in unhusked and husked rice

Treatments	Adult emerged at							
	Unhusked rice grain				Husked rice grain			
	1st generation	2nd generation	3rd generation	Total	1st generation	2nd generation	3rd generation	Total
T_1	6.25 b	9.25 c	14.00 c	29.25 c	7.75 b	11.75 b	15.50 b	35.00 c
T_2	8.50 b	12.50 b	19.00 b	40.00 b	9.25 b	14.25 b	21.50 b	45.00 b
T_3	2.50 c	4.25 d	5.00 d	11.75 d	3.50 c	7.50 c	8.25 c	19.25 d
T_4	0.00 d	0.00 e	0.50 e	0.00 e	0.00 d	0.00 e	0.00 d	0.00 e
T_5	78.25 a	112.25 a	178.50 a	369.00 a	84.50 a	125.50 a	189.00 a	399.50 a
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	3.98	6.78	5.45	7.33	5.95	6.34	4.55	7.02

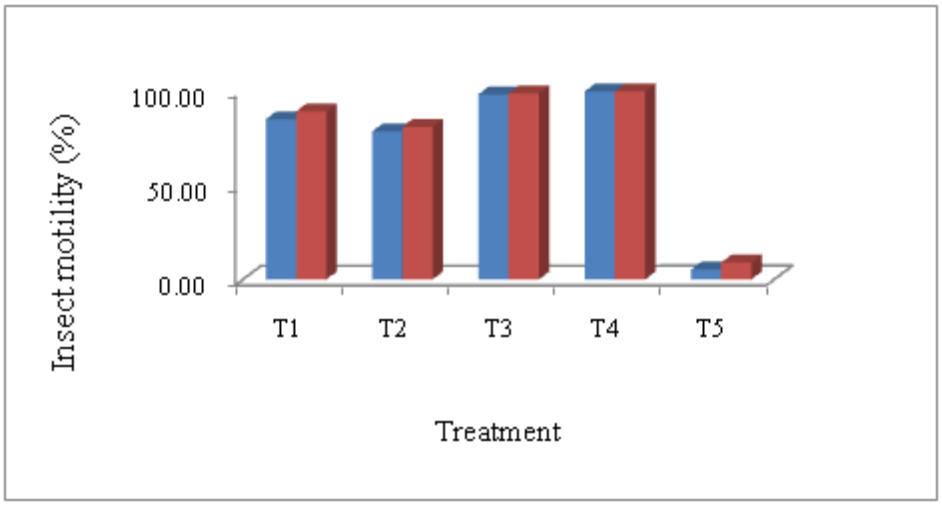

Figure 1: Effect of different neem product for controlling of *S. oryzae* in percentage of insect mortality

3. Insect mortality: Insect mortality showed statistically significant variation for different neem products for the management of rice weevil in unhusked and husked stored rice grain (Figure 1).

3.1 Unhusked rice: In case of unhusked rice, the highest mortality (100.00%) was observed in T_4 treatment, whereas, lowest (5.25%) was recorded in T_5 treatment (Figure 1).

3.2 Husked rice: For husked rice, the highest mortality (100.00%) was observed in T_4 treatment, whereas lowest (9.00%) was recorded in T_5 treatment (Figure 1).

4. Status of rice grain in 1st, 2nd and 3rd generation by weight and number basis: Status of rice grain in terms of healthy, infested seeds and % infestation by weight and number for 1st, 2nd and 3rd generation showed statistically significant variation under the present trial for different neem products for the management of rice weevil in unhusked and husked stored rice grain.

4.1 At 1st generation

4.1.1 Unhusked rice in weight basis: At 1st generation for unhusked rice, in weight basis, the highest healthy seeds was recorded in T_4 (98.70 g) treatment, whereas lowest in T_5 (91.33 g). In case of infested seeds, the lowest infested seeds were recorded from T_4 (1.30 g) treatment and the highest was observed in T_5 (8.67 g) treatment. In case of % infestation, the highest infestation was recorded from T_5 (9.49%), while the lowest in T_4 (1.32) which was followed by T_3 (2.91%). The highest infestation reduction over control was recorded in T_4 (86.13%) treatment and lowest from T_2 (57.48%) treatment (Table 3).

4.4.1.2 Husked rice in weight basis: At 1st generation for husked rice, in weight basis, the highest healthy seeds was recorded in T_4 (116.52 g) treatment, whereas lowest in T_5 (107.24 g) treatment. In case of infested seeds, the lowest infested seeds were recorded from T_4 (3.25 g) and the highest was observed in T_5 (11.45 g). In case of % infestation, the highest infestation was recorded from T_5 (10.68%), while the lowest in T_4 (2.79%) treatment. The highest infestation reduction over control was recorded in T_4 (73.88%) and lowest from T_2 (32.058%) treatment (Table 3).

4.1.3 Unhusked rice in number basis: At 1st generation by number, the highest number of healthy seeds was recorded in T_4 (486) treatment, whereas lowest in T_5 (445) treatment. In case of infested seeds, the lowest infested seeds obtained from T_4

(12.00) and the highest number was recorded in T_5 (51.50) treatment. In case of % infestation, the highest infestation was found from T_5 (11.57%), while the lowest in T_4 (2.47%) treatment. The highest infestation reduction over control was recorded in T_4 (78.66%) treatment and lowest from T_2 (51.18%) treatment (Table 4).

4.1.4 Husked rice in number basis: At 1st generation by number, the highest number of healthy seeds was recorded in T_4 (479) treatment, whereas lowest in T_5 (431) treatment. In case of infested seeds, the lowest infested seeds obtained from T_4 (18.50) and the highest number was recorded in T_5 (63.50) treatment. In case of % infestation, the highest infestation was found from T_5 (14.72%), while the lowest in T_4 (3.86%) treatment. The highest infestation reduction over control was recorded in T_4 (73.76%) treatment and lowest from T_2 (43.27%) treatment (Table 4).

4.2 At 2nd generation

4.2.1 Unhusked rice in weight basis: At 2nd generation for unhusked rice, in weight basis, the highest healthy seeds was recorded in T_4 (97.86 g) treatment, whereas lowest in T_5 (88.56 g). In case of infested seeds, the lowest infested seeds were recorded from T_4 (2.11 g) treatment and the highest was observed in T_5 (10.67 g) treatment. In case of % infestation, the highest infestation was recorded from T_5 (12.05%), while the lowest in T_4 (2.16). The highest infestation reduction over control was recorded in T_4 (82.10%) treatment and lowest from T_2 (42.66%) treatment (Table 5).

4.2.2 Husked rice in weight basis: At 2nd generation for husked rice, in weight basis, the highest healthy seeds was recorded in T_4 (113.62 g) treatment, whereas lowest in T_5 (97.55 g) treatment. In case of infested seeds, the lowest infested seeds were recorded from T_4 (4.33 g) treatment and the highest was observed in T_5 (17.64 g) treatment. In case of % infestation, the highest infestation was recorded from T_5 (18.08%), while the lowest was recorded in T_4 (3.81%) treatment. The highest infestation reduction over control was recorded in T_4 (78.93%) and lowest from T_2 (40.75%) treatment (Table 5).

4.2.3 Unhusked rice in number basis: At 2nd generation by number, the highest number of healthy seeds was recorded in T_4 (479) treatment, while the lowest in T_5 (434) treatment. In case of infested seeds, the lowest infested seeds obtained from T_4 (19.00) and highest was recorded in T_5 (62.50) treatment. In case of % infestation, the highest infestation was found from T_5 (14.40%) treatment, while the lowest in T_4 (3.97%) treatment. The highest infestation reduction over control was recorded in T_4 (72.46%) treatment and lowest from T_2 (49.65%) treatment (Table 6).

Table 3: Effect of different neem products for the management of rice weevil in stored unhusked and husked rice grain at 1st generation by weight basis

Treatments	Total weight of seeds for							
	Unhusked rice grain				Husked rice grain			
	Healthy (g)	Infested (g)	Infestation (%)	Infestation reduction over control (%)	Healthy (g)	Infested (g)	Infestation (%)	Infestation reduction over control (%)
T_1	96.78 c	3.22 c	3.33 c	64.95	110.87 b	7.67 b	6.92 b	35.21
T_2	96.12 c	3.88 b	4.04 b	57.48	110.54 b	8.02 b	7.26 b	32.05
T_3	97.17 b	2.83 d	2.91 d	69.32	115.09 a	4.76 c	4.14 c	61.26
T_4	98.70 a	1.30 e	1.32 e	86.13	116.52 a	3.25 c	2.79 d	73.88
T_5	91.33 d	8.67 a	9.49 a	--	107.24 c	11.45 a	10.68 a	--
Level of significant	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	10.44	5.66	8.99	--	4.56	6.57	8.99	--

Table 4: Effect of different neem products for the management of rice weevil in stored unhusked and husked rice grain at 1st generation by number basis

Treatments	Total number of seeds for							
	Unhusked rice grain				Husked rice grain			
	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)
T_1	475 b	23.25 b	4.89 c	57.71	462 c	34.75 b	7.52 b	48.91
T_2	469 c	26.50 b	5.65 b	51.18	461 c	38.50 b	8.35 b	43.27
T_3	481 a	19.25 c	4.00 d	65.42	473 b	24.75 c	5.23 c	64.46
T_4	486 a	12.00 d	2.47 e	78.66	479 a	18.50 d	3.86 c	73.76
T_5	445 d	51.50 a	11.57 a	--	431 d	63.50 a	14.72 a	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	5.66	7.09	4.33	--	6.78	5.45	6.33	--

Table 5: Effect of different neem products for the management of rice weevil in stored unhusked and husked rice grain at 2nd generation by weight basis

Treatments	Total weight of seeds for							
	Unhusked rice grain				Husked rice grain			
	Healthy (g)	Infested (g)	Infestation (%)	Infestation reduction over control (%)	Healthy (g)	Infested (g)	Infestation (%)	Infestation reduction over control (%)
T_1	94.56 c	5.24 c	5.54 b	54.01	105.65 b	10.51 b	9.95 b	44.99
T_2	93.22 c	6.44 b	6.91 b	42.66	104.34 b	11.18 b	10.71 b	40.75
T_3	95.62 b	3.85 d	4.03 c	66.58	110.15 a	7.69 c	6.98 c	61.39
T_4	97.86 a	2.11 e	2.16 d	82.10	113.62 a	4.33 d	3.81 d	78.93
T_5	88.56 d	10.67 a	12.05 a	--	97.55 c	17.64 a	18.08 a	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	5.89	7.77	4.35	--	5.56	7.99	4.55	--

Table 6: Effect of different neem products for the management of rice weevil in stored unhusked and husked rice grain at 2nd generation by number basis

Treatments	Total number of seeds for							
	Unhusked rice grain				Husked rice grain			
	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)
T_1	468 b	30.25 c	6.46 c	55.12	445 b	45.75 b	10.28 b	46.50
T_2	462 c	33.50 b	7.25 b	49.65	448 b	49.50 b	11.05 b	42.50
T_3	472 b	28.25 d	5.99 d	58.44	467 a	29.75 c	6.37 c	66.85
T_4	479 a	19.00 e	3.97 e	72.46	471 a	24.25 c	5.15 c	73.21
T_5	434 d	62.50 a	14.40 a	--	415 c	79.75 a	19.22 a	--
Level Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	6.09	4.55	7.93	--	5.88	6.09	5.22	--

Table 7: Effect of different neem products for the management of rice weevil in stored unhusked and husked rice grain at 3rd generation by weight basis

Treatments	Total weight of seeds for							
	Unhusked rice grain				Husked rice grain			
	Healthy (g)	Infested (g)	Infestation (%)	Infestation reduction over control (%)	Healthy (g)	Infested (g)	Infestation (%)	Infestation reduction over control (%)
T_1	93.86 b	5.82 c	6.20 c	59.54	101.57 b	15.22 b	14.98 b	38.28
T_2	91.54 c	8.35 b	9.12 b	40.49	102.69 b	16.05 b	15.63 b	35.63
T_3	94.82 b	4.43 c	4.67 d	69.52	107.43 a	8.45 c	7.87 c	67.60
T_4	97.45 a	2.49 d	2.56 e	83.33	109.45 a	5.27 d	4.81 d	80.17
T_5	85.34 d	13.08 a	15.33 a	--	91.89 c	22.31 a	24.28 a	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	7.33	4.18	6.67	--	9.02	3.55	6.66	--

Table 8: Effect of different neem products for the management of rice weevil in stored unhusked and husked rice grain at 3rd generation by number basis

Treatments	Total number of seeds for							
	Unhusked rice grain				Husked rice grain			
	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)
T_1	461 c	37.25 c	8.08 c	52.74	419 c	64.02 b	15.28 b	39.74
T_2	450 d	45.50 b	10.11 b	40.87	423 c	69.34 b	16.39 b	35.35
T_3	467 b	33.25 d	7.12 c	58.36	442 b	39.22 c	8.87 c	65.01
T_4	473 a	25.00 e	5.29 d	69.09	464 a	25.78 d	5.56 d	78.09
T_5	424 e	72.50 a	17.10 a	--	372 d	94.33 a	25.36 a	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	5.66	8.99	3.57	--	5.90	4.04	5.55	--

Table 9: Effect of different neem products on weight loss of stored unhusked and husked rice grain at different generation

Treatments	Weight loss (%) for					
	Unhusked rice grain			Husked rice grain		
	1st generation	2nd generation	3rd generation	1st generation	2nd generation	3rd generation
T_1	7.96 c	16.45 b	25.49 b	9.21 c	17.95 b	29.56 c
T_2	11.34 b	18.08 b	27.67 b	12.55 b	19.37 b	32.45 b
T_3	6.45 d	13.78 c	21.55 c	7.08 d	14.78 c	26.89 d
T_4	3.89 e	8.78 d	14.34 d	4.38 e	10.12 d	17.55 e
T_5	18.21 a	33.26 a	48.55 a	21.45 a	38.90 a	54.09 a
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.88	4.67	5.78	6.89	5.55	8.99

4.2.4 Unhusked rice in number basis: At 2nd generation by number, the highest number of healthy seeds was recorded in T_4 (471) treatment, whereas lowest was recorded in T_5 (415) treatment. In case of infested seeds, the lowest infested seeds obtained from T_4 (24.25) and the highest number was recorded in T_5 (79.75) treatment. In case of % infestation, the highest infestation was found from T_5 (19.22%) treatment, whereas the lowest in T_4 (5.15%) treatment. The highest infestation reduction over control was recorded in T_4 (73.21%) treatment and lowest from T_2 (42.50%) treatment (Table 6).

4.3 At 3rd generation:

4.3.1 Unhusked rice in weight basis: At 3rd generation for unhusked rice, in weight basis, the highest healthy seeds was recorded in T_4 (97.45 g) treatment, whereas lowest in T_5 (85.34 g). In case of infested seeds, the lowest infested seeds were recorded from T_4 (2.49 g) treatment and the highest was observed in T_5 (13.08 g) treatment. In case of % infestation, the highest infestation was recorded from T_5 (15.33%), while the lowest in T_4 (2.56). The highest infestation reduction over control was recorded in T_4 (83.33%) treatment and lowest from T_2 (40.33%) treatment (Table 7).

4.3.2 Husked rice in weight basis: At 3rd generation for husked rice, in weight basis, the highest healthy seeds was recorded in T_4 (109.45 g) treatment, whereas lowest in T_5 (91.89 g) treatment. In case of infested seeds, the lowest infested seeds were recorded from T_4 (5.27 g) treatment and the highest was observed in T_5 (22.31 g) treatment. In case of % infestation, the highest infestation was recorded from T_5 (24.28%), while the lowest was recorded in T_4 (4.81%) treatment. The highest infestation reduction over control was recorded in T_4 (80.17%) and lowest was recorded from T_2 (35.63%) treatment (Table 7).

4.3.3 Unhusked rice in number basis: At 3rd generation by number, the highest number of healthy seeds was recorded in T_4 (473) treatment, whereas the lowest in T_5

(424) treatment. In case of infested seeds, the lowest infested seeds obtained from T_4 (25.00) treatment and the highest number was recorded in T_5 (72.50) treatment. In case of % infestation, the highest infestation was found from T_5 (17.10%), while the lowest in T_4 (5.29%) treatment. The highest infestation reduction over control was recorded in T_4 (69.09%) treatment and lowest from T_2 (40.87%) treatment (Table 8).

4.3.4 Unhusked rice in number basis: At 3rd generation by number, the highest number of healthy seeds was recorded in T_4 (464) treatment, whereas the lowest in T_5 (372) treatment. In case of infested seeds, the lowest infested seeds obtained from T_4 (25.78) and the highest number was recorded in T_5 (94.33) treatment. In case of % infestation, the highest infestation was found from T_5 (25.36%), while the lowest in T_4 (5.56%) treatment. The highest infestation reduction over control was recorded in T_4 (78.09%) treatment and lowest from T_2 (35.35%) treatment (Table 8).

5. Weight loss: Weight loss for 1st, 2nd and 3rd generation showed statistically significant variation under the present trial for different neem products for the management of rice weevil in unhusked and husked stored rice grain (Table 9).

5.1 Unhusked rice: At 1st, 2nd and 3rd generation, the highest weight loss was recorded in T_5 (18.21, 33.26 and 48.55 %) treatment whereas, the lowest was observed in T_4 (3.89, 8.78 and 14.34 %) treatment (Table 9).

5.2 Husked rice: At 1st, 2nd and 3rd generation, the highest weight loss was recorded in T_5 (21.45, 38.90 and 54.09 %) treatment, while the lowest was observed in T_4 (4.38, 10.12 and 17.55 %) treatment (Table 9).

SUMMARY AND CONCLUSION

Considering the results of the study, it could be concluded that in most cases, the infestation of rice weevil, *S. oryzae* could be minimized by use of neem products. Among the neem products neem oil 5 ml/kg of stored rice grains was more effective followed by neem leaves extract @ 10 ml/kg of stored rice grains (90 ml alcohol + 10 gm leaves dusts) for controlling rice weevil.

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