

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

Ayesha Akter<sup>1</sup>, Sajib Talukder<sup>2</sup>, Tahmina Akter<sup>3</sup>, Mst. Munjuri Akter<sup>4</sup>,  
Mohammad Jasim Uddin<sup>5</sup>

<sup>1</sup>Assistant Professor, <sup>2</sup>MS student, <sup>3</sup>Associate Professor, <sup>4</sup>Lecturer,

Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207;

<sup>5</sup>MS Student, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207.

Corresponding Author: Ayesha Akter

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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<sub>1</sub>: Neem leaves dust 10 gm/kg of stored rice grains; T<sub>2</sub>: Neem seed kernel dusts @ 10 gm/kg of stored rice grains; T<sub>3</sub>: Neem leaves extract @ 10 ml/kg of stored rice grains; T<sub>4</sub>: Neem oil 5 ml/kg of stored rice grains and T<sub>5</sub>: 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<sub>4</sub> treatment, while the lowest 5.25% mortality was recorded in T<sub>5</sub> treatment. For husked rice, the highest mortality (100.00%) was observed in T<sub>4</sub>, while the lowest mortality (9.00%) was recorded in T<sub>5</sub> treatment. At 1<sup>st</sup> generation for unhusked rice, in weight basis, the highest infestation was recorded from T<sub>5</sub> (9.49%) treatment while the lowest in T<sub>4</sub> (1.32) and for husked rice, the highest infestation was recorded from T<sub>5</sub> (10.68%), while the lowest in T<sub>4</sub> (2.79%) treatment. On the other hand, by number basis in unhusked rice, the highest infestation was found from T<sub>5</sub> (11.57%), while the lowest in T<sub>4</sub> (2.47%) treatment and for husked rice, the highest infestation was found from T<sub>5</sub> (14.72%) while the lowest in T<sub>4</sub> (3.86%) treatment. At 1<sup>st</sup> generation, for unhusked rice, the highest weight loss was found in T<sub>5</sub> (18.21%), while the lowest was found in T<sub>4</sub> (3.89%) treatment and for husked rice grain, the highest weight loss was recorded in T<sub>5</sub> (21.45%), whereas the lowest was observed in T<sub>4</sub> (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<sub>4</sub> and T<sub>3</sub> (100.00%), whereas the lowest repellency rate (80.00%) was recorded in T<sub>1</sub> treatment. In case of repellency effect for husked rice, after 5 hours of treatment application the highest repellency rate was found from T<sub>4</sub> and T<sub>3</sub> (100.00%) treatments which was followed by T<sub>1</sub> and T<sub>2</sub> (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. <sup>[1]</sup> 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. <sup>[2]</sup> Bangladesh produces a total of 27.04 million tons of rice from an area of 25.56 million acres. <sup>[3]</sup> 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 parboiled milled rice in earthen pot (motka). <sup>[4]</sup> 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. <sup>[5]</sup> 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. <sup>[6]</sup> 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. <sup>[7]</sup> In Bangladesh, the annual grain losses cost over taka 100 crores. <sup>[8]</sup> 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. <sup>[6,8]</sup> 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. <sup>[6]</sup> 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.* <sup>[4]</sup> 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. <sup>[9]</sup> Indo-Pakistani farmers use neem leaves, biskatali for controlling stored grain pests, while various Nigerian tribes use roots, stems and leaves of plants. <sup>[10,11]</sup> 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. <sup>[12]</sup> 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. <sup>[13]</sup> 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. <sup>[14-16]</sup> 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<sub>1</sub>: Neem leaves dust 10 gm/kg of stored rice grains; T<sub>2</sub>: Neem seed kernel dusts @ 10 gm/kg of stored rice grains; T<sub>3</sub>: Neem leaves extract @ 10 ml/kg of stored rice grains; T<sub>4</sub>: Neem oil 5 ml/kg of stored rice grains and T<sub>5</sub>: 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<sub>4</sub> treatment (Neem oil 5 ml/kg of stored rice grains). On the other hand, no dead insects were found in T<sub>5</sub> (untreated control) treatment which was followed by T<sub>2</sub> (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<sub>4</sub> treatment. On the other hand, no dead insects were found in T<sub>5</sub> treatment which was followed by T<sub>2</sub> (4.25) treatments (Table 1).

**2. Adult emergence:** Adults emerged for 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> 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 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation no adults emerged in T<sub>4</sub> treatment, while the highest number of adults were recorded in T<sub>5</sub> (78.25, 112.25 and 178.50) treatment. In case of total adult emergence for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation no adults emerged in T<sub>4</sub> treatment, while the highest adult was recorded in T<sub>5</sub> (369.00) (Table 2).

**2.2 Husked rice:** In case of husked rice, at 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation no adults emerged in T<sub>4</sub> treatment, while the highest number of adults were recorded in T<sub>5</sub> (84.50, 125.50 and 189.50) treatment. In case of total adult emergence for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation no adults emerged in T<sub>4</sub> treatment, whereas the highest adult was recorded in T<sub>5</sub> (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 <sub>1</sub>	5.25 c	9.50 c	11.75 c	6.25 c	11.25 d	14.00 d
T <sub>2</sub>	3.25 d	8.75 c	10.25 d	4.25 d	10.50 c	11.50 c
T <sub>3</sub>	6.25 b	11.50 b	12.50 b	7.50 b	12.75 b	13.75 b
T <sub>4</sub>	7.50 a	13.25 a	14.25 a	8.75 a	14.00 a	15.50 a
T <sub>5</sub>	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 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> generation & total adult emerged in unhusked and husked rice**

Treatments	Adult emerged at							
	Unhusked rice grain				Husked rice grain			
	1 <sup>st</sup> generation	2 <sup>nd</sup> generation	3 <sup>rd</sup> generation	Total	1 <sup>st</sup> generation	2 <sup>nd</sup> generation	3 <sup>rd</sup> generation	Total
T <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	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 <sub>4</sub>	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 <sub>5</sub>	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

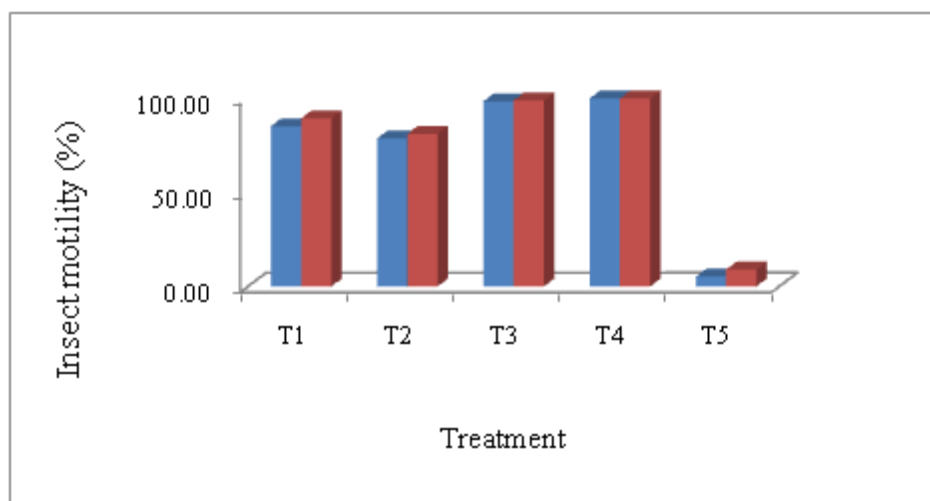


Figure 1: Effect of different neem product for controlling of *S. oryzae* in percentage of insect mortality

**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<sub>4</sub> treatment, whereas, lowest (5.25%) was recorded in T<sub>5</sub> treatment (Figure 1).

**3.2 Husked rice:** For husked rice, the highest mortality (100.00%) was observed in T<sub>4</sub> treatment, whereas lowest (9.00%) was recorded in T<sub>5</sub> treatment (Figure 1).

**4. Status of rice grain in 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation by weight and number basis:** Status of rice grain in terms of healthy, infested seeds and % infestation by weight and number for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> 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 1<sup>st</sup> generation

**4.1.1 Unhusked rice in weight basis:** At 1<sup>st</sup> generation for unhusked rice, in weight basis, the highest healthy seeds was recorded in T<sub>4</sub> (98.70 g) treatment, whereas lowest in T<sub>5</sub> (91.33 g). In case of infested seeds, the lowest infested seeds were

recorded from T<sub>4</sub> (1.30 g) treatment and the highest was observed in T<sub>5</sub> (8.67 g) treatment. In case of % infestation, the highest infestation was recorded from T<sub>5</sub> (9.49%), while the lowest in T<sub>4</sub> (1.32) which was followed by T<sub>3</sub> (2.91%). The highest infestation reduction over control was recorded in T<sub>4</sub> (86.13%) treatment and lowest from T<sub>2</sub> (57.48%) treatment (Table 3).

**4.4.1.2 Husked rice in weight basis:** At 1<sup>st</sup> generation for husked rice, in weight basis, the highest healthy seeds was recorded in T<sub>4</sub> (116.52 g) treatment, whereas lowest in T<sub>5</sub> (107.24 g) treatment. In case of infested seeds, the lowest infested seeds were recorded from T<sub>4</sub> (3.25 g) and the highest was observed in T<sub>5</sub> (11.45 g). In case of % infestation, the highest infestation was recorded from T<sub>5</sub> (10.68%), while the lowest in T<sub>4</sub> (2.79%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (73.88%) and lowest from T<sub>2</sub> (32.058%) treatment (Table 3).

**4.1.3 Unhusked rice in number basis:** At 1<sup>st</sup> generation by number, the highest number of healthy seeds was recorded in T<sub>4</sub> (486) treatment, whereas lowest in T<sub>5</sub> (445) treatment. In case of infested seeds, the lowest infested seeds obtained from T<sub>4</sub>



(12.00) and the highest number was recorded in T<sub>5</sub> (51.50) treatment. In case of % infestation, the highest infestation was found from T<sub>5</sub> (11.57%), while the lowest in T<sub>4</sub> (2.47%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (78.66%) treatment and lowest from T<sub>2</sub> (51.18%) treatment (Table 4).

**4.1.4 Husked rice in number basis:** At 1<sup>st</sup> generation by number, the highest number of healthy seeds was recorded in T<sub>4</sub> (479) treatment, whereas lowest in T<sub>5</sub> (431) treatment. In case of infested seeds, the lowest infested seeds obtained from T<sub>4</sub> (18.50) and the highest number was recorded in T<sub>5</sub> (63.50) treatment. In case of % infestation, the highest infestation was found from T<sub>5</sub> (14.72%), while the lowest in T<sub>4</sub> (3.86%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (73.76%) treatment and lowest from T<sub>2</sub> (43.27%) treatment (Table 4).

#### 4.2 At 2<sup>nd</sup> generation

**4.2.1 Unhusked rice in weight basis:** At 2<sup>nd</sup> generation for unhusked rice, in weight basis, the highest healthy seeds was recorded in T<sub>4</sub> (97.86 g) treatment, whereas lowest in T<sub>5</sub> (88.56 g). In case of infested seeds, the lowest infested seeds were recorded from T<sub>4</sub> (2.11 g) treatment and the highest was observed in T<sub>5</sub> (10.67 g) treatment. In case of % infestation, the highest infestation was recorded from T<sub>5</sub>

(12.05%), while the lowest in T<sub>4</sub> (2.16). The highest infestation reduction over control was recorded in T<sub>4</sub> (82.10%) treatment and lowest from T<sub>2</sub> (42.66%) treatment (Table 5).

**4.2.2 Husked rice in weight basis:** At 2<sup>nd</sup> generation for husked rice, in weight basis, the highest healthy seeds was recorded in T<sub>4</sub> (113.62 g) treatment, whereas lowest in T<sub>5</sub> (97.55 g) treatment. In case of infested seeds, the lowest infested seeds were recorded from T<sub>4</sub> (4.33 g) treatment and the highest was observed in T<sub>5</sub> (17.64 g) treatment. In case of % infestation, the highest infestation was recorded from T<sub>5</sub> (18.08%), while the lowest was recorded in T<sub>4</sub> (3.81%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (78.93%) and lowest from T<sub>2</sub> (40.75%) treatment (Table 5).

**4.2.3 Unhusked rice in number basis:** At 2<sup>nd</sup> generation by number, the highest number of healthy seeds was recorded in T<sub>4</sub> (479) treatment, while the lowest in T<sub>5</sub> (434) treatment. In case of infested seeds, the lowest infested seeds obtained from T<sub>4</sub> (19.00) and highest was recorded in T<sub>5</sub> (62.50) treatment. In case of % infestation, the highest infestation was found from T<sub>5</sub> (14.40%) treatment, while the lowest in T<sub>4</sub> (3.97%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (72.46%) treatment and lowest from T<sub>2</sub> (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 1<sup>st</sup> 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 <sub>1</sub>	96.78 c	3.22 c	3.33 c	64.95	110.87 b	7.67 b	6.92 b	35.21
T <sub>2</sub>	96.12 c	3.88 b	4.04 b	57.48	110.54 b	8.02 b	7.26 b	32.05
T <sub>3</sub>	97.17 b	2.83 d	2.91 d	69.32	115.09 a	4.76 c	4.14 c	61.26
T <sub>4</sub>	98.70 a	1.30 e	1.32 e	86.13	116.52 a	3.25 c	2.79 d	73.88
T <sub>5</sub>	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 1<sup>st</sup> 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 <sub>1</sub>	475 b	23.25 b	4.89 c	57.71	462 c	34.75 b	7.52 b	48.91
T <sub>2</sub>	469 c	26.50 b	5.65 b	51.18	461 c	38.50 b	8.35 b	43.27
T <sub>3</sub>	481 a	19.25 c	4.00 d	65.42	473 b	24.75 c	5.23 c	64.46
T <sub>4</sub>	486 a	12.00 d	2.47 e	78.66	479 a	18.50 d	3.86 c	73.76
T <sub>5</sub>	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 2<sup>nd</sup> 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 <sub>1</sub>	94.56 c	5.24 c	5.54 b	54.01	105.65 b	10.51 b	9.95 b	44.99
T <sub>2</sub>	93.22 c	6.44 b	6.91 b	42.66	104.34 b	11.18 b	10.71 b	40.75
T <sub>3</sub>	95.62 b	3.85 d	4.03 c	66.58	110.15 a	7.69 c	6.98 c	61.39
T <sub>4</sub>	97.86 a	2.11 e	2.16 d	82.10	113.62 a	4.33 d	3.81 d	78.93
T <sub>5</sub>	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 2<sup>nd</sup> 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 <sub>1</sub>	468 b	30.25 c	6.46 c	55.12	445 b	45.75 b	10.28 b	46.50
T <sub>2</sub>	462 c	33.50 b	7.25 b	49.65	448 b	49.50 b	11.05 b	42.50
T <sub>3</sub>	472 b	28.25 d	5.99 d	58.44	467 a	29.75 c	6.37 c	66.85
T <sub>4</sub>	479 a	19.00 e	3.97 e	72.46	471 a	24.25 c	5.15 c	73.21
T <sub>5</sub>	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 3<sup>rd</sup> 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 <sub>1</sub>	93.86 b	5.82 c	6.20 c	59.54	101.57 b	15.22 b	14.98 b	38.28
T <sub>2</sub>	91.54 c	8.35 b	9.12 b	40.49	102.69 b	16.05 b	15.63 b	35.63
T <sub>3</sub>	94.82 b	4.43 c	4.67 d	69.52	107.43 a	8.45 c	7.87 c	67.60
T <sub>4</sub>	97.45 a	2.49 d	2.56 e	83.33	109.45 a	5.27 d	4.81 d	80.17
T <sub>5</sub>	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 3<sup>rd</sup> 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 <sub>1</sub>	461 c	37.25 c	8.08 c	52.74	419 c	64.02 b	15.28 b	39.74
T <sub>2</sub>	450 d	45.50 b	10.11 b	40.87	423 c	69.34 b	16.39 b	35.35
T <sub>3</sub>	467 b	33.25 d	7.12 c	58.36	442 b	39.22 c	8.87 c	65.01
T <sub>4</sub>	473 a	25.00 e	5.29 d	69.09	464 a	25.78 d	5.56 d	78.09
T <sub>5</sub>	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		
	1 <sup>st</sup> generation	2 <sup>nd</sup> generation	3 <sup>rd</sup> generation	1 <sup>st</sup> generation	2 <sup>nd</sup> generation	3 <sup>rd</sup> generation
T <sub>1</sub>	7.96 c	16.45 b	25.49 b	9.21 c	17.95 b	29.56 c
T <sub>2</sub>	11.34 b	18.08 b	27.67 b	12.55 b	19.37 b	32.45 b
T <sub>3</sub>	6.45 d	13.78 c	21.55 c	7.08 d	14.78 c	26.89 d
T <sub>4</sub>	3.89 e	8.78 d	14.34 d	4.38 e	10.12 d	17.55 e
T <sub>5</sub>	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 2<sup>nd</sup> generation by number, the highest number of healthy seeds was recorded in T<sub>4</sub> (471) treatment, whereas lowest was recorded in T<sub>5</sub> (415) treatment. In case of infested seeds, the lowest infested seeds obtained from T<sub>4</sub> (24.25) and the highest number was recorded in T<sub>5</sub> (79.75) treatment. In case of % infestation, the highest infestation was found from T<sub>5</sub> (19.22%) treatment, whereas the lowest in T<sub>4</sub> (5.15%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (73.21%) treatment and lowest from T<sub>2</sub> (42.50%) treatment (Table 6).

#### 4.3 At 3<sup>rd</sup> generation:

**4.3.1 Unhusked rice in weight basis:** At 3<sup>rd</sup> generation for unhusked rice, in weight basis, the highest healthy seeds was recorded in T<sub>4</sub> (97.45 g) treatment, whereas lowest in T<sub>5</sub> (85.34 g). In case of infested seeds, the lowest infested seeds were recorded from T<sub>4</sub> (2.49 g) treatment and the highest was observed in T<sub>5</sub> (13.08 g) treatment. In case of % infestation, the

highest infestation was recorded from T<sub>5</sub> (15.33%), while the lowest in T<sub>4</sub> (2.56). The highest infestation reduction over control was recorded in T<sub>4</sub> (83.33%) treatment and lowest from T<sub>2</sub> (40.33%) treatment (Table 7).

**4.3.2 Husked rice in weight basis:** At 3<sup>rd</sup> generation for husked rice, in weight basis, the highest healthy seeds was recorded in T<sub>4</sub> (109.45 g) treatment, whereas lowest in T<sub>5</sub> (91.89 g) treatment. In case of infested seeds, the lowest infested seeds were recorded from T<sub>4</sub> (5.27 g) treatment and the highest was observed in T<sub>5</sub> (22.31 g) treatment. In case of % infestation, the highest infestation was recorded from T<sub>5</sub> (24.28%), while the lowest was recorded in T<sub>4</sub> (4.81%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (80.17%) and lowest was recorded from T<sub>2</sub> (35.63%) treatment (Table 7).

**4.3.3 Unhusked rice in number basis:** At 3<sup>rd</sup> generation by number, the highest number of healthy seeds was recorded in T<sub>4</sub> (473) treatment, whereas the lowest in T<sub>5</sub>



(424) treatment. In case of infested seeds, the lowest infested seeds obtained from T<sub>4</sub> (25.00) treatment and the highest number was recorded in T<sub>5</sub> (72.50) treatment. In case of % infestation, the highest infestation was found from T<sub>5</sub> (17.10%), while the lowest in T<sub>4</sub> (5.29%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (69.09%) treatment and lowest from T<sub>2</sub> (40.87%) treatment (Table 8).

**4.3.4 Unhusked rice in number basis:** At 3<sup>rd</sup> generation by number, the highest number of healthy seeds was recorded in T<sub>4</sub> (464) treatment, whereas the lowest in T<sub>5</sub> (372) treatment. In case of infested seeds, the lowest infested seeds obtained from T<sub>4</sub> (25.78) and the highest number was recorded in T<sub>5</sub> (94.33) treatment. In case of % infestation, the highest infestation was found from T<sub>5</sub> (25.36%), while the lowest in T<sub>4</sub> (5.56%) treatment. The highest infestation reduction over control was recorded in T<sub>4</sub> (78.09%) treatment and lowest from T<sub>2</sub> (35.35%) treatment (Table 8).

**5. Weight loss:** Weight loss for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> 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 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation, the highest weight loss was recorded in T<sub>5</sub> (18.21, 33.26 and 48.55 %) treatment whereas, the lowest was observed in T<sub>4</sub> (3.89, 8.78 and 14.34 %) treatment (Table 9).

**5.2 Husked rice:** At 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generation, the highest weight loss was recorded in T<sub>5</sub> (21.45, 38.90 and 54.09 %) treatment, while the lowest was observed in T<sub>4</sub> (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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