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Eco-friendly Management of Angoumois grain moth, *Sitotroga cerealella* Olivier using some botanicals on stored paddy

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ABSTRACT

Angoumois grain moth is one of the most damaging pests of rice in storage in tropical and subtropical regions. To combat the infestation of the pest farmer mostly uses the chemical insecticides, which are costly and not environment friendly. Using plant originated botanicals is a good alternative to the chemical pesticides. Hence, the study was conducted to find a suitable botanical to manage the Sitotroga cerealella Olivier, with low cost. The experiment was conducted in the laboratory under the Department of Entomology at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April to September, 2011. Five botanicals viz., dried leaf powder of neem @ 2.5 g/kg paddy, bishkatali @ 2.5 g/kg paddy, marigold @ 2.5 g/kg paddy, mahogany @ 2.5 g/kg paddy, chopped garlic bulb @ 1.0 g/kg paddy along with one untreated control were evaluated. The experiment was laid out in Completely Randomized Design (CRD) with 4 replications. Data were recorded on grain infestation by number and weight, seed germination and economic returns of the management practices in terms of benefit cost ratio (BCR). Among five promising botanicals, dried neem leaf powder reduced the highest grain infestation by number and weight (72.77% & 62.07%, respectively) as well as the highest percentage of germination over control (28.74%) was recorded from this treatment. The highest (11.65) benefit cost ratio (BCR) was also achieved by the dried neem leaf powder than that of other botanicals. So the neem leaf powder considered as the best botanical among the five, for the management of the destructive moth.

Key Words: *Pest Damage, BCR, Botanicals, Neem.*

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I. Introduction

Sitotroga cerealella is often placed at the top of the list as major insect pest of stored rice. *S. cerealella* Olive known as the Angoumois grain moth or paddy moth or rice moth is one of the most dominant pest species in the stored paddy. This insect is not only infests the grains in storage, but also in field

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conditions, which enhances its ability to damage more (Bushra and Aslam, 2014). The pest is so destructive that one gravid female can completely destroy 50 gram of paddy in storage within three subsequent generations (Cogburn, *et al.,* 1975). Chemical control method has got great value for the management of rice moth in storage. Several reports are available on the efficacy of different chemicals (Chandra *et al.,* 1978) to reduce this insect. But the use of chemical insecticides against the attack of paddy moth in storage may cause serious health hazards. The residues of the chemical insecticides remain in the stored grain and also in the environment. Moreover, serious environmental imbalance results due to development of resistance in pest population and subsequent resurgence as well as destruction of beneficial insects. Hence, search for the alternative method of paddy moth control utilizing some non-toxic, environment friendly and human health hazard free methods are being pursued now-a-days. In Bangladesh, most of the farmers are poor and marginal. They store small quantities of seed for edible rice and cannot practice expensive control measures. Therefore, they essentially need some cheap, easy to use, readily available but effective methods for safe storing of rice. Plant products are being liberally available as indigenous source of insecticides and insect repellents have been in use for more than one century. The insecticidal property is not very quick (except natural pyrethrins) as compared to that of synthetic insecticides and fumigants. The plant products certainly possess surface persistence for a long period, have least or no adverse effect on germination ability of seed, cooking quality and milling, easily available with less costing and some of the products like natural pyrethrums have rapid killing action (Prakash and Mathur, 1981). A number of plant products have been reported as being in use against insect pest in stored grains including rice to minimize storage losses due to insects (Ashamo & Akinnawonu, 2012). With a view to the above aspects the experiment was conducted to assess the extent of damage of stored rice grain by rice moth, *S. cerealella* and to evaluate the effectiveness of some promising botanicals against rice moth.

II. Materials and Methods

This experiment was conducted to evaluate the efficiency of five promising botanicals viz., dried neem, bishkatali, marigold, mehogoni leaves, bulb of garlic applied against rice moth, *S. cerealella* infesting stored rice in the laboratory condition. The experiment was laid out in the ambient condition in the laboratory in Completely Randomized Design (CRD) and the treatments were replicated four times. Collected seeds were sun dried on the cemented floor for three consecutive days in the month of April, 2011 and kept the rice grains in 24 plastic pots maintaining one kilogram per pot and the pots were kept in ambient room temperature in the laboratory under the Department of Entomology of Sher-e-Bangla Agricultural University. The moisture content of the grains was 10-12% measured by using a digital moisture meter with the technical help and support from the Seed treatment and preservation center of BADC, Gabtoli, Dhaka. The germination test was also conducted. The treatments and their doses selected for the study have been furnished below:

Treatments	Botanicals	Dose of the botanicals
T1	Dried neem leaf powder	2.5 g /kg paddy grains
T2	Dried bishkatali leaf powder	2.5 g /kg paddy grains
T3	Dried marigold leaf powder	2.5 g /kg paddy grains
T4	Dried mahogoni leaf powder	2.5 g /kg paddy grains
T5	Bulb of garlic	1 g /kg paddy grains
T6	Untreated control	No botanicals were used

Collection, preparation and application of botanicals

The leaves of neem, bishakatali, marigold and mehogani were collected from the Jahangirnagar University and Sher-e-Bangla Agricultural University in February to March, 2011. The leaves were then directly sun dried on metal tray for 5 consecutive days until completely dried up. Each type of dried leaves was then crushed separately with the help of an electric grinder. The bulb of garlic (*Allium sativum* Linn.) was purchased from Agargaon bazaar, Dhaka. The 2.5 gm (0.25% w/w) of the grinded powders of the dried neem leaves were thoroughly mixed with 1 kg of the paddy seeds that were kept in a container of the plastic pot. Similarly, the rest 3 containers of the plastic pot for neem leaf based treatment were thoroughly mixed with 2.5 g of the grinded powders of the dried neem leaves in each container containing one kg of selected paddy grains. Similar procedures were also followed with

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same doses (2.5 g) of grinded powders of the bishkatali, marigold and mehagoni leaves for each container and replicate four times under the experiment for used of four replications. In case of bulb of garlic, chopped one g garlic bulb (0.10% w/w) was thoroughly mixed with each 1 kg of the paddy seeds that were already kept in each container of plastic pot. Similarly the rest 3 plastic pots were thoroughly mixed with same dose of chopped bulb of garlic which contains one kg of rice in each container.

Release of the rice moth, *S. cerealella*

The eggs of rice moth collected from the laboratory under the Department of Entomology of Sher-e-Bangla Agricultural University, Dhaka were released in the rice grains kept in plastic containers assigned for each treatment. About 500 newly laid eggs (10 mg) of rice moth were released on the rice grains kept in each container. Immediately after the release of the rice moth eggs, each container was covered with its lid. The plastic containers with rice grains for each treatment were preserved in ambient temperature in the laboratory up to 6 months that is 180 days after egg release (DAER) for recording data.

Data sampling, collection and calculation

The data on grain infestation by number and weight, grain content loss, and seed germinations were recorded. The data were collected and recorded at 30 days intervals started from 30 DAER and continued up to 180 DAER considering the sampling procedure. For each sample, 100 rice grains from each replicate of each of the treatment were randomly drawn at each data recording time. The sample was taken from the middle of each container (10-15 cm below from the surface) by inserting a spoon. From each of the samples, 100 grains were used to record the data for each time and each parameter. The data on the grain infestation by number and weight, grain content loss, and seed germinations were recorded. The number and weight of infested grains was counted for each sample of 100 grains. The infested grains were identified by recognizing the bore grains caused by the rice moth after emerging adult from the grains. Magnifying lens and simple microscope were also used in that purpose. The percent grain infestation and percent reduction of grain infestation over control were then calculated using the following formulae:

$$\% \text{ grain infestation} = \frac{\text{Number of infested grains}}{\text{Number of total grains observed}} \times 100$$

$$\% \text{ reduction of grain infestation over} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1= Mean value of treated pot; X_2= Mean value of untreated pot

The weight (g) of the 100 grains sample for each treatment were measured and recorded at initial stage of the experiment, i.e., before setting the experiment and the weight of 100 grains were measured and recorded for each treatment at each data recording time from 30 days after egg release (DAER) to 180 DAER. Finally, the percent grain content loss was calculated using the following formula:

$$\% \text{ grain content loss} = \frac{\text{Initial weight of grains} - \text{Weight of grains at data recording time}}{\text{Initial weight of the grains}} \times 100$$

$$\% \text{ increase of grain content loss over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1= Mean value of treated pot; X_2= Mean value of untreated pot

The viability of stored rice grains were assessed through seed germination test. The viability test was done to determine whether or not the rice moth infestation can affect seed germination. The germination rate of the rice seeds was determined at each data recording time from 30 to 180 DAER. The 100 seed sample for each treatment was taken randomly and placed those in water soaked blotting papers in Petridish, and preserved for 5 days at room temperature ranging from 27°C to 34°C for maximum germination of the seeds. After complete germination, the number of germinated seeds was counted and recorded. Finally, the percent seed germination and percent increase of seed germination over control were calculated using the following formulae:

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$$\% \text{ seed germination} = \frac{\text{Number of germinated seeds}}{\text{Number of total seeds tested for germination}} \times 100$$

$$\% \text{ increase of seed germination over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1= Mean value of treated pot, X_2= Mean value of untreated pot

Economic analysis of the botanical based management practices

Economic analysis in terms of Benefit Cost Ratio (BCR) was analyzed on the basis of total expenditure of the respective management treatment along with the total return from that particular treatment using different botanical based treatments against rice moth on rice grains in storage. In this study, BCR was analyzed for the weight (1 kg) of rice grains stored for each treatment considering following parameters given below:

Treatment wise management cost/variable cost: This cost was calculated by adding all costs incurred for labors and inputs for each management treatment along with untreated control during the entire storing period.

Gross Return (GR): The yield in terms of money that was measured by multiplying the total grains saved after the completion of the study by the unit price of rice grains (Taka 18/kg).

Net Return (NR) = The Net Return was calculated by subtracting treatment wise management cost from the gross return.

The Net Return was calculated by subtracting the cost of untreated treatment from treatment wise management cost of gross return.

Adjusted Net Return (ANR): The ANR was determined by subtracting the net return of the control treatment from the net return for a particular management treatment.

Benefit Cost Ratio (BCR): Finally, BCR was calculated for each management treatment using botanicals to justify the economic basis of the management practices using the following formula described by Elias and Karim (1984):

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Adjusted net return}}{\text{Total management cost}} \times 100$$

III. Results and Discussion

Effect of botanicals on grain infestation by number

Significant variations among different botanicals were observed on the grain infestation by number during the management of rice moth, *S. cerealella* in the storage throughout the storing period from 30 to 180 days after egg release (DAER) on paddy (Table 01). In case of 30 DAER, the highest percent grain infestation (1.01%) was recorded in untreated control (T_6), where no botanicals were used followed by T_3(0.74%) comprising dried marigold leaf powder @ 2.5 g/kg paddy, T_4 (0.66%) comprising dried mahogany leaf powder @ 2.5 g/kg paddy. On the other hand, the lowest percent grain infestation by number (0.41%) was recorded in T_1 comprised of dried neem leaf powder @ 2.5 g/kg paddy, which was statistically similar of that g T_5 (0.49%) comprising chopped bulb of garlic @ 1.0 g/kg paddy and T_2 (0.58%) comprising dried bishakatali leaf powder. In case of 60 DAER, the highest percent grain infestation (4.35%) was recorded in untreated control, which was statistically different from all other treatments followed by T_3 (2.58%) and T_2 (2.35%). On the other hand, the lowest percent grain infestation by number (1.60%) was recorded in T_1, which was statistically identical to that of T_5 (1.60%) followed by T_4 (2.10%). More or less similar trends of results were also observed for 90, 120, 150,180 DAER, but the level of infestations were increased with the increase of data recording time. In case of 180 DAER, the highest percent grain infestation (31.81%) was recorded in untreated control (T_6), which was statistically different from all other treatments followed by T_3 (17.84%) and T_2 (16.64%). On the other hand, the lowest percent grain infestation by number (9.39%) was recorded in T_1, which was statistically similar to that of T_5 (11.14%) followed by T_4 (11.89%).Considering the grain infestation reduction over control, the highest reduction (72.77%)

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was recorded in T_1, followed by T_5 (69.13%), T_4 (66.16%). On the other hand, the lowest percent grain infestation reduction over control was recorded in T_3 (48.40%) and T_2 (52.43%). As a result, the trend of efficiency among different botanicals including untreated control in terms of percent grain infestation by number was T_1 (dried neem leaf powder) > T_5 (bulb of garlic) > T_4 (dried mahogany leaf powder) > T_2 (dried bishkatali leaf powder) > T_3 (dried marigold leaf powder) > T_6 (untreated control).

Table 01. Effect of botanicals on the grain infestation by number of stored paddy during the management of rice moth *S. cerealella*in storage

Treatment	Grain infestation (%) by number							% reduction of grain infestation over control
	30 DAER	60 DAER	90 DAER	120 DAER	150 DAER	180 DAER	Mean	
T_1	0.41e	1.60c	2.97d	4.52c	7.91c	9.39c	4.47d	72.77
T_2	0.58cd	2.35b	4.64b	8.44b	14.16b	16.64b	7.80bc	52.43
T_3	0.74b	2.58b	5.01b	9.34b	15.27b	17.84b	8.46bc	48.40
T_4	0.66bc	2.10bc	3.64cd	5.69c	9.32c	11.89c	5.55d	66.16
T_5	0.49de	1.60c	3.80c	5.11c	8.24c	11.14c	5.06d	69.13
T_6	1.01a	4.35a	11.64a	19.61a	29.99a	31.81a	16.40a	-
LSD $_{(0.05)}$	0.13	0.50	0.75	1.51	2.01	2.51	1.24	-
CV (%)	12.6	13.73	9.47	11.38	9.42	10.13	11.1	-

DAER = Days after egg release; In column, means followed by same letters are not significantly different at 5% level of significance by LSD. The values in the column are the means of 4 replications for each treatment.

[T_1= Dried neem leaf powder @ 2.5 g /kg paddy, T_2= Dried bishkatali leaf powder @ 2.5 g /kg paddy, T_3 = Dried marigold leaf powder @ 2.5 g /kg paddy, T_4 = Dried mahogany leaf powder @ 2.5 g /kg paddy, T_5 = Bulb of garlic @ 1.0 gm /kg paddy, T_6 = Untreated control]

Effect of botanicals on the grain infestation by weight

Significant variations among different botanicals were observed on the grain infestation by weight during the management of rice moth, *S. cerealella* in the storage throughout the storing period from 30 to 180 DAER on paddy (Table 02). In case of 30 DAER, the highest percent grain infestation (6.65%) was recorded in untreated control (T_6), which was statistically similar to that of g T_2 (6.44%) and T_3 (6.63%). On the other hand, the lowest percent grain infestation by weight (3.04%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (5.63%) that was statistically similar to that of T_4 (5.73%). In case of 60 DAER, the highest percent grain infestation (4.35%) was recorded in untreated control followed by T_3 (8.14%) and T_2 (7.75%). On the other hand, the lowest percent grain infestation by weight (5.78%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (7.25%) and T_4 (7.47%) (Table 02). More or less similar trends of results were also observed for 90, 120, 150,180 DAER, but the level of infestations were increased with the increase of data recording time. In case of 180 DAER, the highest percent grain infestation (38.82%) was recorded in untreated control, which was statistically different from all other treatments followed by T_3 (24.15%) and T_2 (23.21%). On the other hand, the lowest percent grain infestation by weight (13.06%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (17.14%) and T_4 (18.99%) (Table 02).

Considering the mean infestation of paddy by weight, the highest percent grain infestation (21.65%) was recorded in untreated control, which was statistically different from all other treatments followed by T_3 (13.4%) and T_2 (12.90%). On the other hand, the lowest percent grain infestation by weight (8.21%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (10.92%) and T_4 (11.48%). Similarly, in case of grain infestation reduction by weight over control, the highest reduction (62.07%) was recorded in T_1 followed by T_5 (49.56%), T_4 (46.95%). On the other hand, the lowest percent grain infestation reduction over control was recorded in T_3 (37.73%) and T_2 (40.10%). As a result, the trend of efficiency among different botanicals including untreated control in terms of reducing percent grain infestation by weight was T_1 (dried neem leaf powder) > T_5 (bulb of garlic) > T_4 (dried mahogany leaf powder) > T_2 (dried bishkatali leaf powder) > T_3 (dried marigold leaf powder) > T_6 (untreated control).

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Table 02. Effect of botanicals on the grain infestation by weight of stored paddy during the management of rice moth *S. cerealella*in storage

Botanicals	Grain content loss by weight (%)							% reduction of grain infestation by weight over control
	30 DAER	60 DAER	90 DAER	120 DAER	150 DAER	180 DAER	Mean	
T_1	3.04c	5.78b	7.43d	7.26c	12.71d	13.06e	8.21d	62.07
T_2	6.44a	7.75a	9.87bc	11.73b	18.81b	23.21b	12.9b	40.10
T_3	6.63a	8.14a	11.13b	11.88b	18.97b	24.15b	13.4b	37.73
T_4	5.73b	7.47a	9.54c	11.41b	15.77c	18.99d	11.48c	46.95
T_5	5.63b	7.25a	9.15c	10.60b	15.76c	17.14c	10.92c	49.56
T_6	6.65a	8.71a	16.58a	26.11a	33.03a	38.82a	21.65a	-----
LSD $_{(0.05)}$	0.54	1.40	1.42	1.33	1.331	1.165	1.20	
CV (%)	6.25	12.39	8.88	6.73	4.59	3.44	7.05	

DAER = Days after egg release; In column, means followed by same letters are not significantly different at 5% level of significance by LSD. The values in the column are the means of 4 replications for each treatment.

[T_1= Dried neem leaf powder @ 2.5 g /kg paddy, T_2= Dried bishkatali leaf powder @ 2.5 g /kg paddy, T_3 = Dried marigold leaf powder @ 2.5 g /kg paddy, T_4 = Dried mahogany leaf powder @ 2.5 g /kg paddy, T_5 = Bulb of garlic @ 1.0 gm /kg paddy, T_6 = Untreated control]

From the above findings it was revealed that among five promising botanicals, T_1 (72.77% & 62.07%) comprising dried neem leaf powder @ 2.5 g/kg paddy provided the best results in reducing the grain infestation by number and weight, respectively, followed by T_5 (69.13% & 49.56%, respectively) comprising chopped bulb of garlic @ 1.0 g/kg paddy, T_4 (66.16% & 46.95%, respectively) comprising dried mahogany leaf powder @ 2.5 g/kg paddy, whereas T_3 (48.40% & 37.73%, , respectively) comprising dried marigold leaf powder @ 2.5 g/kg paddy showed the least performance among five botanicals followed by T_2 (52.43% & 40.10%, respectively) comprising dried bishkatali leaf powder @ 2.5 gm/kg paddy. As a result, the order of trend efficiency of five botanicals and untreated control in reducing the grain infestation during the management of rice moth, *S. cerealella*, was T_1 (dried neem leaf powder) > T_5 (bulb of garlic) > T_4 (dried mahogany leaf powder) > T_2 (dried bishkatali leaf powder) > T_3 (dried marigold leaf powder) > T_6 (untreated control) (Table 02). Similar findings were also observed by other researchers. Jilani (1986) reported that the ethanolic extract of neem seed; hexane extract of sweet flag, *Acorns calamus* rhizome and thymel significantly controlled the level of infestation applied against *Sitrotroga cerealella, Tribolium castaneaum, R. dominica* and *Sitophilus oryzae* in wheat grain. Dakshinamurthy (1988) also reported that neem seed kernel oil and eucalyptus powder mixed with rice also gave effective control in reducing the number of adults of *S. cerealella*.

Effect of botanicals on the viability of stored rice seeds

Significant variations among different botanicals were observed on the germination of rice seeds by number during the management of rice moth, *S. cerealella* in the storage throughout the storing period from 30 to 180 DAER (Table 03). In case of 30 DAER, the highest percent seed germination (94.72%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (93.3%), T_4 (92.97%) and T_2 (92.13%). On the other hand, the lowest percent seed germination (90.3%) was recorded in T_3, which was statistically similar (91.22%) to that untreated control. In case of 60 DAER, the highest percent seed germination (93.27%) was recorded in T_1, which was statistically similar to that of T_5 (92.02%), T_4 (91.68%) and T_2 (92.18%). On the other hand, the lowest percent of seed germination (80.35%) was recorded in untreated control, which was statistically similar to T_3 (89.58%). More or less similar trends of results were also observed for 90, 120, 150, and 180 DAER, but the percent seed germinations were decreased with the increase of data recording time. However, in case of 180 DAER, the highest percent seed germination (68.96%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (63.13%), T_4 (62.71%) and T_2 (53.04%). On the other hand, the lowest percent seed germination (41.04%) was recorded in untreated control, which was statistically different from all other treatments followed by T_3 (51.76%).

Considering the mean germination of rice seeds, the highest percent seed germination (85.41%) was recorded in T_1, which was statistically different from all other treatments followed by T_5 (82.37%), and T_4 (81.64%). On the other hand, the lowest percent seed germination (66.34%) was recorded in

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untreated control, which was statistically different from all other treatments followed by T_3 (76.69%) and T_3 (78.06%). Similarly, in case of seed germination reduction over control, the highest reduction (28.74%) was recorded in T_1 followed by T_5 (24.16%) and T_4 (23.07%). On the other hand, the lowest percent seed germination reduction over control was recorded in T_3 (15.60%) and T_2 (17.67%). As a result, the trend of efficiency among different botanicals including untreated control in terms of saving percent seed germination over control was T_1 (dried neem leaf powder) > T_5 (bulb of garlic) > T_4 (dried mahogany leaf powder) > T_2 (dried bishkatali leaf powder) > T_3 (dried marigold leaf powder) > T_6 (untreated control).

Table 03. Effect of botanicals on germination of stored paddy seeds during the management of rice moth, *S. cerealella* in storage

Botanical	Seed germination (%)							% germination saved over control
	30 DAER	60 DAER	90 DAER	120 DAER	150 DAER	180 DAER	Mean	
T_1	94.72a	93.27a	89.95a	85.85a	79.68a	68.96a	85.41a	28.745
T_2	92.13cd	91.18b	86.2b	79.03cd	66.77c	53.04c	78.06de	17.670
T_3	90.3e	89.58c	84.14c	77.76d	66.58c	51.76c	76.69e	15.602
T_4	92.97bc	91.68b	87.53b	81.28b	73.68b	62.71b	81.64c	23.072
T_5	93.3b	92.02ab	87.62b	82.53bc	75.6b	63.13b	82.37bc	24.165
T_6	91.22de	82.35d	72.87d	58.44e	52.1d	41.04d	66.34f	------
LSD $_{(0.05)}$	1.004	1.507	2.01	2.512	2.01	3.014	2.01	
CV (%)	3.27	2.11	1.57	2.15	1.93	3.52	2.50	

DAER = Days after egg release; In column, means followed by same letters are not significantly different at 5% level of significance by LSD. The values in the column are the means of 4 replications for each treatment.

[T_1= Dried neem leaf powder @ 2.5 g /kg paddy, T_2= Dried bishkatali leaf powder @ 2.5 g/kg paddy, T_3 = Dried marigold leaf powder @ 2.5 g /kg paddy, T_4 = Dried mahogany leaf powder @ 2.5 g /kg paddy, T_5 = Bulb of garlic @ 1.0 g /kg paddy, T_6 = Untreated control].

From the above findings it was revealed that among five promising botanicals, T_1 (28.74%) comprising dried neem leaf powder @ 2.5 g/kg paddy performed best results in increasing percent seed germination followed by T_5 (24.16) comprising chopped bulb of garlic @ 1.0 g/kg paddy, T_4 (23.07%) comprising dried mahogany leaf powder @ 2.5 g/kg paddy, whereas T_3 (15.60%) comprising dried marigold leaf powder @ 2.5 g/kg paddy showed the least performance among five botanicals followed by T_2 (17.67%) comprising dried bishkatali leaf powder @ 2.5 g/kg paddy. As a result, the order of trend efficiency of five botanicals and untreated control in saving percent seed germination of rice during the management of rice moth, *S. cerealella*, was T_1 (dried neem leaf powder) > T_5 (bulb of garlic) > T_4 (dried mahogany leaf powder) > T_2 (dried bishkatali leaf powder) > T_3 (dried marigold leaf powder) > T_6 (untreated control). Very little findings were found directly to relate with the effect of botanical on seed germination of rice seeds.

Economic analysis of the botanical based management practices

Economic analysis of botanical based management practices applied against rice moth infesting paddy in storage is represented in Table 04. The untreated control treatment did not incur any pest management cost. The labor costs were involved in neem leaf; bishkatali leaf, marigold and mahogany leaf based treatment for collecting, drying and grinding, and in case of garlic bulb the cost of garlic were only involved. Thus the highest benefit cost ratio (BCR) 11.65 was achieved by T_1 comprising dried neem leaf @ 2.5 g/kg paddy followed by T_4 (8.00) comprising dried mahogany leaf powder @ 2.5 g/kg paddy and T_5 (7.18) comprising chopped bulb of garlic @ 1.0 g/kg paddy and T_2 (5.81) comprising dried bishkatali leaf powder @ 2.5g/kg grains. On the other hand, the lowest BCR (4.35) was achieved in T_3 comprising dried marigold leaf powder @ 2.5 gm/kg paddy. As well as considering the environmental safety and human health hazards free point of view, neem based management practices against insect pests of stored products was also acceptable for the consumers (Table 04).

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Table 04. Economic analysis of botanicals based management practices applied against rice moth on paddy in storage

Treatment	Cost of management (Tk/ton)	Grain saved (kg/pot)	Grain saved (ton)	Gross return (Tk)	Net return (Tk)	Adjusted net return(Tk)	BCR
T_1	370	0.9	900	16200	15830	4310	11.65
T_2	370	0.78	780	14040	13670	2150	5.81
T_3	370	0.75	750	13500	13130	1610	4.35
T_4	360	0.82	820	14760	14400	2880	8.00
T_5	440	0.84	840	15120	14680	3160	7.18
T_6	0	0.64	640	11520	11520	-	-

Market price of paddy 1 kg = 18.00 Tk during the study period

[T_1= Dried neem leaf powder @ 2.5 g /kg paddy, T_2= Dried bishkatali leaf powder @ 2.5 g /kg paddy, T_3 = Dried marigold leaf powder @ 2.5 g /kg paddy, T_4 = Dried mahogany leaf powder @ 2.5 g /kg paddy, T_5 = Bulb of garlic @ 1.0 g /kg paddy, T_6 = Untreated control]

From the economic analysis it may be concluded that the dried neem leaf based management treatment considered as the most economically viable tool for the management of rice moth on paddy in storage, which gave the highest BCR (11.65). As well as considering the environmental safety and human health hazards free, neem based management practices against insect pests of stored products was also acceptable for the consumers. Several worker`s results supported this findings. Plant-derived materials are more readily biodegradable. Some are less toxic to mammals, may be more selective in action, and may retard the development of pesticide resistance to insects. Their main advantage is that they may be easily and cheaply produced by farmers and small-scale industries as crude, or partially purified extracts. In the last two decades, considerable efforts have been directed at screening plants in order to develop new botanical insecticides as alternatives to the existing insecticides. It was reported that when mixed with stored-grains, leaf, neem seed powder, or oil extracts of plants reduced oviposition rate and suppress adult emergence of bruchids, and also reduced seed damage rate (Keita *et al*., 2001).

IV. Conclusion

Findings of the study concluded that among the five promising botanicals, dried neem leaf powder @ 2.5 gm/kg paddy reduced the highest grain infestation by number (72.77%) and weight (62.07%), respectively. The same treatment was showed the highest percent of seed germination over control. But the performance of dried marigold leaf powder @ 2.5 g/kg paddy was the least among the treatment in terms of above aspects. Dried neem leaf @ 2.5 g/kg paddy also considered as the most economic tool and provided the highest (11.65) benefit cost ratio (BCR) than mahogany leaf (8.00), chopped bulb of garlic (7.18), bishkatali (5.81) and marigold leaf powder (4.35).

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V. References

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