DOES SOLAR LIGHT TRAP REDUCE THE COST OF PESTICIDES USED IN RICE FIELD?

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ABSTRACT

Pesticide application against insect pest infestation is environmentally unsafe and costly. An attempt was taken to evaluate the solar light trap as ecofriendly and cost-effective approach in Transplanted Aman rice (BRRI dhan32) field at Barhatta Upazila (Sub-district) in Netrokona district of Bangladesh. It was found that rice pest like rice yellow stem borer, rice leaf roller, green leaf hopper, brown plant hopper, rice leaf miner, rice gall midge, white leafhopper, rice bug, rice ear cutting caterpillar, white-backed planthopper, rice caseworm, grasshopper, rice skipper and rice beetle were the major insects that captured under the solar light traps. Some beneficial insects were also attracted by the trap these were ladybird beetle, water scavenger, giant water bug, ground beetle, rove beetle, damsel fly. All the harmful and the beneficial insects were belonging the order of Lepidoptera, Hemiptera, Orthoptera, Coleoptera, Diptera and Odonata. Though the mean yield of rice was statistically insignificant in both fields, the light trap installed fields required the less frequency of pesticides than the control fields which ultimately rendered the low pesticides cost in a great extent. On an average 1,034 BDT was reduced in per hectare.

Keywords: Solar light trap, Ecofriendly, Cost effectiveness, Rice pests

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important crops in the world and grown in 177 countries. In Asia, around 2.7 billion people consume rice as a staple food (Kumar et al., 2009). In Bangladesh rice (*Oryza sativa* L.) dominates the cropping pattern throughout the country as almost 90 percent of populations depend on rice. Bangladesh ranked fourth concerning rice production among the rice-producing countries (FAO, 2019). It is the staple food of about 160 million people in Bangladesh. It provides caloric intake to over 63% of urban consumers and over 71

% for the rural population (Alam, 2013). It generates half of the agricultural GDP and one-sixth of Bangladesh's national revenue. Moreover, the rice sector provides nearly 48% of rural employment. About 11.39 million hectares of land are used for rice cultivation to produce 35.05 million metric tons of rice (BBS, 2018). Around 18% of the national rice production was covered by the *haor* (bowl shaped swallow depression which is flooded during the monsoon) areas (Huq et al., 2012). Netrakona was one of the seven *haor* districts consisted of 52 hoars. As the area was prone to frequent flooding, the farmers preferred to cultivate rice than vegetable crops (BHWDB, 2012). Different rice varieties have been developed by Bangladesh Rice Research Institute (BRRI) over the years including high yielding and modern variety to increase the yield of the crop as well as to reduce the cost of production of rice.

As most of our farmers mainly rely on rice cultivation for their livelihood, from the expectation of higher yields, farmers are now being encouraged to cultivate hybrid variety rather than local variety (Sivagnanam and Murugan, 2020). But the main concern regarding rice cultivation in Bangladesh is the harmful insect pests that cause enormous yield loss (Mackill, 2018). Bangladesh has a tropical monsoon climate characterized by wide seasonal variations in rainfall, temperature and humidity. The infestation of pests in the rice ecosystem is rising day by day due to the climate change (Alam, 2013). Around 800 insect species associated with the rice ecosystem have been reported throughout the world. Out of these, 100 insect species are considered as harmful for the rice ecosystem and the rest of them are considered as friendly species (Pathak, 1970). About 20 species were identified as the most harmful insects that causes around 15-90% yield loss in rice (Pathak and Khan, 1994). Brown plant hopper, yellow stem borer, Rice bug etc. are considered as the major insects in the rice ecosystem (Moses et al., 2019). To reduce insect infestation in the rice field, farmers are practicing different insect management technologies. Different types of methods are used for insect management *viz.* cultural, mechanical, physical, chemical and biological method (Alam, 2013). In Bangladesh, most of the farmer prefers chemical method for insect pest management. This irrational use of chemical pesticides in the rice ecosystem increases the cost of production and has a long-term residual impact on the environment and biodiversity (Yaqub et al., 2017; Sun et al., 2018;). Rice is cultivated around the *haor* area in *Boro* season, using chemical pesticides is so dangerous for the aquatic biodiversity of *haor* areas. There are plenty evidences that represents the harmfulness of chemical insecticides and their residues to fish (Salam et al., 2015; Rahman et al., 2020).

Every year thousand tons of chemical insecticides are being used in Bangladesh. Pesticide use has increased 400% per acre and the cost increased by 600% during the couple of decades. The sales of pesticides were doubled between 1985 and 1990. Currently, 84 pesticides have been registered in Bangladesh which belonging to 242 trade names. In rice fields, over 80% of total pesticides are used (Parveen and Nakagoshi, 2001). In 2017, the farmers of Bangladesh used around 37,258 metric tons of chemical pesticides in their crop fields (DAE, 2018). To fulfill this enormous

demand, the government has to import a huge amount of pesticide from other countries. Moreover, this tremendous and indiscriminate use of pesticides is increasing the cost of production of rice. According to Bangladesh Crop Protection Association (BCPA), the annual import cost stands nearly 200 million USD (Khandker and Hossain, 2017). Considering the economic conditions of the farmers and the alarming effects of chemical pesticides on the environment, alternate pest management tools should be reconsidered. Recently light trap is used for pest control in many agroecosystems (Lee et al., 2017; Yee, 2017; Abd Rahman et al., 2018; Sunitha, 2018; Patidar et al., 2019). The light trap is an ecofriendly management tool that manages the pest by conserving the insect species at a minimum level (Sunitha, 2018). This trap mainly captured the nocturnal harmful insects (Abd Rahman et al., 2018). However, the conventional light trap has some limitations (Kunz, 1988; Gavhande et al., 2019). It cannot be used in some rural areas. This problem is solved by the solar light trap which can be set up in any place (Meshram et al., 2018). This solar light trap is being used in many parts of the world (Kadel et al., 2018; Band et al., 2019). Generally, the solar light trap is used for monitoring and forecasting of pest (Kammar et al., 2020). However, very few researches have been done on the cost reduction of pesticides by using the solar light trap. Therefore, our research was aimed to investigate the cost reduction of pesticides in rice field by using the solar light trap.

MATERIALS AND METHODS

Study site

The study was conducted in Barhatta Upazila (Sub-district) (24º51 to 25º00 North latitude and 90º46 to 91º00 East longitude) of Netrokona district of Bangladesh (Figure 1) Seven blocks (Agricultural unit area mapped by Department of Agriculture Extension, DAE) i.e., Ramvodrapur, Shalpodoshal, Otitpur, Chotokoilati, Roymadov, Singhdha and Fokirer Barzar blocks of seven unions (unit area of Sub-district) in Barhatta Upazila were considered for the experimental site. Insects especially rice yellow stem borer, Rice leaf roller, rice bug, green leaf hopper prone area were selected during the block selection.

Experimental design

Rice field were categorized into control (without light trap) and experimental field (with installation of light trap) Each block has one control field and one experimental field. Transplanted Aman rice variety (BRRI dhan32) was selected to conduct the research.
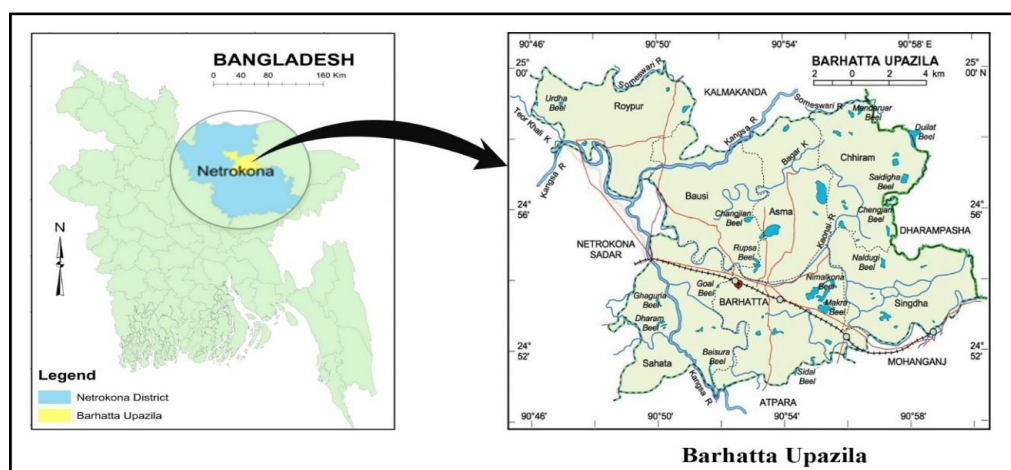
Figure 1. Barhatta Upazila of Netrokona District of Bangladesh

[Source: https://bdmaps.blogspot.com/2011/11/barhatta-upazila.html]

Land preparation

Each control and experimental field size were 1 ha composed of several small plots. Ploughing was done by power tiller. During puddling, manure and chemical fertilizer were used as basal dose. The fertilizers doses were used in the field as Urea 195 kg, TSP 60 kg, MoP 105 kg and Gypsums 68 kg, Zinc Sulphate 12 kg per hectare, respectively. TSP, MoP, Gypsum and Zinc fertilizers were used during land preparation. Urea was used into three splits, first split was in 15 to 20 days after transplanting, second split was in 35 to 40 days and third or final split was done 55 to 60 days after transplanting of the seedlings.

Seedlings raising and transplanting

Seedlings were raised in an ideal seedbed. Around 30 days seedlings were transplanted during mid-August 2019. Seedlings were transplanted by following the line sowing method.

Intercultural operations

Frequent weeding i.e. three times weeding was done. Fertilizer application was done as per need based. Perching was practiced in both categorized of fields. Depending on the requirement, assessed by the presence of insects in the transplanted Aman rice field, different types of insecticides were applied both in control and experimental fields e.g. Sunfuran 5G (Carbofuran), Marshal 20EC (Carbosulfan), Imitaf 20SL (Imidacloprid), Virtako 40WG (Thiamethoxam 20% + Chloraniliprole 20%), Suntap 50SP (Cartap), Diazinon 60EC (Diazinon), Dursban 20EC (Chlorpyrifos), Nitro 505EC (Chlorpyrifos 50% + Cypermathrin 5%), Regent 50 SC (Fipronil). Supplementary irrigation was also provided as per needed.

Solar Light Trap setting and insect collection

Seven solar light traps were set up in 1ˢᵗ week of September 2019 in seven locations of Barhatta Upazila of Netrokona (Figure 2 and Table 1). The bottom portion of the solar light trap was fixed in soil with cementing materials. A bulb with a holder was tightened with the straight frame to prevent it from the collapse. A bowl was set up under the frame to collect the insect samples. The bucket was filled with detergent mixed water to keep the insect samples. A solar panel was set up at the top of the frame which was charged in daytime and used after sunset around 6 pm through the bulb. Data on insect samples were collected on each Wednesday from the solar light trap for nine times during the whole season. Mainly nocturnal insects were trapped in the light traps. Insects were collected from the bowl in the morning at 10 am and the bowl was replaced with fresh detergent water in every Wednesday. The farmers of the consecutive field were involved in the insect collection. The trapped insects were washed after hand picking. After washing, the insects were preserved in a jar containing 70% formaldehyde solution and kept for further identification and analysis.

Figure 2. Experimental setup of solar light trap at T-Aman rice field in Barhatta Upazila of Netrokona district

Data analysis

The preserved collected insect samples were analyzed in the entomology laboratory of Sylhet Agricultural University. We classified the major insects according to their common name and orders. Data on pesticides use frequency were recorded. The yield of transplanted Aman rice (BRRI dhan32) was assessed both in control and in experimental plot. The independent t-test was performed to compare the means of yield by using IBM SPSS 26 software. Finally, we compared the cost of pesticides in both the control and experimental plots to assess the cost-effectiveness of the solar light trap in the transplanted Aman rice fields.

Table 1. Details of the solar light trap used in the T-Aman rice field of Barhatta
Upazila of Netrokona district in 2019

Description of the product	Specification
Solar Panel	20Wp (Approved Brand)
Battery	(Sealed lead Acid Battery)
	Volts = 12.0 (6x2), AH = 4.5, time 4 hours
Controller with box (Micro Controller based)	Load Cable, panel cable, etc.
	Rated Voltage: Input Voltage-20volt Dc
	Output Voltage: 12 Volt Dc
	Rated charging Current:
	HVD :14.2
	LED Display:
	Box Dimension: 7.5x8.5x5.5″ Digital print
	Inside the wooden box for battery
Bulb	Pest attractive bulb, Rated voltage: 12 V
	Rated power: 3W UV LED
Light Trap Frame/ stand with light shade	(As per BRRI specification 50 cm diameter)
Accessories	(Holder, wire for connection and hanging)
Plastic bowl capacity	20 L

RESULTS AND DISCUSSION

Results showed that many insects from different Orders were captured under the
solar light trap (Figure 3). Light trap mainly attracts the nocturnal insects. Nocturnal
insects have the affinity to the light wavelength during night. Park and Lee, (2017);
Sridhar and Kumaran, (2018), reported that insects showed different levels of affinity
to the different wavelength of the light trap.

Figure 3. Insects captured under the solar light trap at T. Aman rice field in Barhatta
Upazila of Netrokona district

After identification of the preserved sample, it was found that insects belonging to the order of Lepidoptera, Hemiptera, Orthoptera, Coleoptera, Diptera and Odonata were mainly captured under the trap. Most common insects trapped in the solar light trap were rice yellow stem borer, rice leaf roller, green leaf hopper, brown plant hopper, rice leaf miner, rice gall midge, white leafhopper, rice bug, rice ear cutting caterpillar, white-backed planthopper, rice caseworm, grasshopper, rice skipper and rice beetle (Table 2). Meena et al., (2018) reported that 40 insect species of the Order Lepidoptera were caught when they had installed a light trap in the rice field. Light trap also showed positive effects on capturing the pest of other crops. Sridhar and Kumaran, (2018) found that light trap can be utilized as an effective component for the management of *Tuta absoluta* (Lepidoptera: Gelechiidae) on Tomato.

Table 2. Insect pest captured under the solar light trap in the Transplanted Aman rice field of Barhatta Upazila of Netrokona district in 2019

Insects	Scientific name	Family	Order
Rice yellow stem borer	*Scirpophaga incertulas* (Walker)	Crambidae	Lepidoptera
Rice leaf roller	*Cnaphalocrocis medinalis* (Guenee)	Pyralidae	Lepidoptera
Green leaf hopper	*Nephotettix virescens* (Distant)	Cicadellidae	Hemiptera
Brown planthopper	*Nilaparvata lugens* (Stal)	Delphacidae	Hemiptera
Rice leaf miner	*Hydrellia philippina*	Ephydridae	Diptera
Rice gall midge	*Orseolia oryzae* (Wood-Mason)	Cecidomyiidae	Diptera
White leafhopper	*Cofana spectra*	Cicadellidae	Hemiptera
Rice bug	*Leptocorisa acuta* (Thunberg)	Alydidae	Hemiptera
Rice ear cutting caterpillar	*Mythimna separate* (Walker)	Noctuidae	Lepidoptera
White-backed planthopper	*Sogatella furcifera*	Delphacidae	Hemiptera
Rice caseworm	*Nymphula depunctalis* (Guenee)	Crambidae	Lepidoptera
Grasshopper	*Oxya* sp.	Acrididae	Orthoptera
Rice skipper	*Pelopidas mathias*	Hesperiidae	Lepidoptera
Rice beetle	*Dyscinetus morator*	Scarabaeidae	Coleoptera

Some of beneficial insects were also attracted by light such as ladybird beetle, water scavenger, giant water bug, ground beetle, rove beetle, damselfly. Our research revealed that solar light trap captured both the beneficial and harmful insect species (Table 3). This refers those nocturnal insects can be beneficial as well as harmful. Singh et al., (2018); Kammar et al*.,* (2020) reported the capture of both beneficial and harmful insects under the light trap.

Table 3. Beneficial Insect captured under the solar light trap in the Transplanted
         Aman rice field of Barhatta upazila of Netrokona district in 2019

Insects	Scientific name	Family	Order
Ladybird beetle	*Coccinella septempunctata*	Coccinellidae	Coleoptera
Water scavenger	*Hydrophilus triangularis* (Say)	Hydrophilidae	Coleoptera
Giant water bug	*Lethocerus americanus*	Belostomatidae	Hemiptera
Ground beetle	*Calleida decora*	Carabidae	Coleoptera
Rove beetle	*Paederus* sp.	Staphylinidae	Coleoptera
Damsel fly	*Nehalennia gracilis*	Coenagrionidae	Odonata

Due to regular light trapping, farmers decided to use pesticide based on insect's
presence. Pesticides application in the rice field is very common practice in
Bangladesh (Islam et al., 2016; Sumon et al., 2016; Rahaman et al., 2018). Farmers
used comparatively less pesticides in experimental plot area than control plot. All of
the control plots required 3 times of pesticide application while experimental plots
required only 1 or 2 times of pesticide application. The average frequency of
pesticide application in control and experimental plots were 3 and 1.6 respectively.
This indicated that almost half of the pesticide usage could be reduced by setting up
the solar light trap in rice field.

Harvesting of rice was done during mid-November 2019. Average yield of BRRI
dhan32 was estimated as 2.92±0.036 MT and 2.9±0.03 MT per hectare in control and
experimental field respectively. It was found that there was no statistical significance
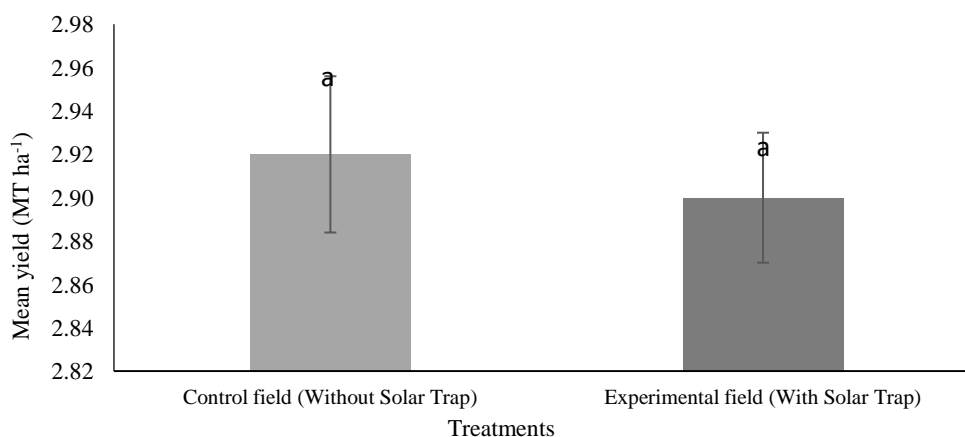(p value=0.501) between the mean yield of rice in control and experimental field
(Figure 4).

Figure 4. Mean yield (MT ha^{-1}) of Transplant-Aman rice (BRRI dhan32) in different
         fields of Barhatta Upazila of Netrokona district in 2019. Similar lettering
         represents statistical similarity between the treatments at 5% level of
         significance

Though the yield of rice was statistically insignificant, the solar light trap contributed to the reduction of pesticide load in the rice field. The solar light trap served here as an eco-friendly management tool against the harmful insect of the experimental fields. Alam, (2013) used light trap as an insect management technology in rice ecosystem at the area of Chittagong, Rajshahi, Gaibandha, Tangail, and Jalukathi district. When we calculated the cost on the use of pesticides, it was found that solar light trap installed fields required less amount of pesticides (Table 4).

Table 4. Pesticide costing in T. Aman rice (BRRI dhan32) in different locations of Barhattaupazila of Netrokona district in 2019

Location	Frequency of pesticide application in control field	Frequency of pesticide application in experimental field	Cost in Control field (BDT ha^{-1})	Cost in Experimental field (BDT ha^{-1})	Reduction of Cost (BDT ha^{-1})	Reduction (%)
Ramvodrapur	03	01	3262	1950	1312	40.2
Sholpadhoshal	03	02	3375	2400	975	28.9
Otitpur	03	01	2775	1875	900	32.4
ChotoKoilati	03	02	3337	2325	1012	30.3
Raimadov	03	02	3225	2250	975	30.2
Fokirer Bazar	03	02	3525	2625	900	25.5
Singhdha	03	01	3262	2100	1162	35.6
Average	03	1.6	3252	2218	1034	31.8

Therefore, it reduced the cost of pesticide per hectare. The maximum reduction percentage of pesticide cost was found in Ramvodrapur which was 40.2% and minimum reduction percentage of pesticide cost was found in Fokirer Bazar which was 25.5%. Finally, it saved around 1034 BDT in an experimental plot area (1 ha) which is equivalent to 31.8% of the cost of pesticides. Siddiquee et al. (2019) reported that the pesticide cost from total cost of production ranges from 12.8-13.6%. Solar light trap reduced the cost of production through the less frequency of application of pesticides against different harmful pest of rice.

CONCLUSION

The solar light trap was found to be effective to capture different insect species in the rice field. This trap was able to reduce the pesticide load to manage harmful insects while sustaining the yield of rice. The reduction of pesticide use resulted in lower

cost of pesticides in rice field. Therefore, the solar light trap can be a sustainable management tool to reduce both the harmful insects and cost of pesticides used in rice fields.

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