ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 211-226, June 2021

IMPACT OF BROWN PLANT HOPPER (BPH) MANAGEMENT TRAINING ON BORO RICE CULTIVATION IN SERAJGANJ DISTRICT

M. A. QUAYUM[1], M. M. HOSSAIN[2] AND T. SHARMIN[3]

Abstract

A study was conducted under the project areas of Tarash Upazila at Sirajganj district. The objectives were to assess the improvement of farmers' knowledge and perception on different factors of BPH incidence and its management to examine the economic impact on rice and to determine the profitability of Boro rice cultivation among the different groups of farms. Out of 850 samples listed, 170 representative farmers among which 16 target, 54 trained and 100 non-trained farmers were selected respectively by stratified random sampling technique. Rice plants are affected by 20-33 major insect pests. Among them, BPH is considered as most damaging one. Eighty eight, 83 and 93% target, trained and non trained farmers reported that the project needs to continue while 100% farmers of each group reported that the project is beneficial to control BPH to increase rice production. Eighty seven, 56 and 51 % farmers of the target, trained and non-trained group used double nozzle for spraying insecticides to control BPH in their field. In boro season, 2073 kg/ha and 1209 kg/ha yield loss of BRRI dhan29 were found before and after the project, respectively. The lower yield loss was due to proper management taken by the farmers who got training and acquired sufficient knowledge for controlling BPH. The study revealed that 37% higher cost and 47% higher time is required by single nozzle sprayer than double nozzle sprayer. Therefore, farmers of all categories prefer double nozzle sprayer as it is good for health and saves money and time. They also reported that use of double nozzle sprayer is more profitable than single nozzle sprayer. Benefit cost analysis indicated that the gross return, net return and BCR were found higher in case of the target farmers and these were Tk.171107/ha, Tk.73735/ha and 1.76 respectively, but the cost of production per kg was lower (Tk.10.27) than those of the other two groups due to more knowledge gathered by the target farmers on management practices for rice production. Partial budgeting analysis indicated that the double nozzle users were more benefited by Tk 7287/ha than the single nozzle users for boro rice cultivation. Thus, after the project the farmers of all categories of the project area were socio-economically benefited learning how to use double nozzle for controlling BPH.

Keywords: Rice, Brown plant hopper management, Bangladesh.

Introduction

Pest problem in Bangladesh is becoming severe because of intensive rice cultivation. Every year 15% and 18% yield losses occurred due to disease

[1]Ex Principal Scientific Officer, Agril. Economics Division, [2]Chief Scientific Officer, Entomology Division, Bangladesh Rice Research Institute (BRRI), Gazipur -1701, [3]MS Student, Department of Zoology, Dhaka University, Bangladesh.

infection and insect pests infestation respectively (Haq *et al.*, 2006). Therefore, it is essential to save the crops from this huge loss by using BRRI developed different pest management technologies. Studies (Haq *et al.*, 2006) revealed that 13% rice yield could be increased by adopting these technologies. For environmental safety it is necessary to reduce the use of pesticides. It is quite possible to protect the crop from the damage of insects and diseases by using eco-friendly management practices such as use of resistant to moderately resistant rice varieties, different cultural, mechanical and biological, cultivation methods, fertilizer management, water management, rice based cropping systems, use of botanicals etc (Haq *et al.*, 2006). It is revealed that trained farmers could easily differentiate between harmful and beneficial insects through integrated pest management practice which is long lasting, inexpensive and environmentally safe (Pathak and Khan, 1994). The use of pesticides has been reduced remarkably after training at Farmer Field School (FFS) in different areas of the country. Farmers obtained 12% more yield than before as result of training in Bangladesh (Islam *et al.*, 2004; Haq *et al.*, 2006). Thus, farmers of the country should practice this method to increase the rice production reducing the damage by insects. Insect control is an important constraint limiting yields of modern rice in all rice growing seasons. Research has firmly established that insects cause considerable yield losses on rice crops in the tropics. It is also established that those losses can often be prevented through the application of appropriate insecticides. However, most insecticides are more expensive especially at the high rate used for complete protection. There is also evidence that yield losses can be reduced considerably through one or two applications of insecticides (Islam *et al.*, 2004). Also insects do not always appear in sufficient numbers to warrant the use of high levels of application. On the contrary, sometimes there are some types of insects appeared in the field and damage rice crops in a large scale. Thus, there is a real economic problem of determining the optimal method of controlling insect pests to get the maximum net return from their rice crops.

Benefit cost analysis by Gomez *et al.* (1979) indicated that the findings helped emphasize the importance of IRRI's objective to develop cheaper and cost-effective methods of insect management in rice (IRRI 1979). Litsinger *et al.* (1978) and Carbonell (1980) have examined farmers' insect management practices in Central Luzon, Philippines, in some detail to report on the design of superior, farmer-applicable methods of pest management in rice in Laguna.

A number of sets of data have been examined showing yield losses due to insects and the economics of insect control in fairly intensive rice growing areas in the Philippines and found that if farmers cultivate modern insect resistant varieties and apply no insecticides, they may lose between 0 and 2 t/ha to insects averaging 1 t/ha. If they apply one treatment, costing less than peso 200/ha in 1979, the yield loss due to insects will be cut to about 0.5 t/ha (Herdt and Jayasuriya, 1981). The implementation of pest control methods require a

substantial increase in farmers' technical knowledge about insects and identification of insects as well as insecticides to be used to control them. Rice is subject to attack from dozens of insects, and the damage to the plant can be severe. Some of the more common and widely distributed rice insects in Asia are rice stem borers, brown planthopper (BPH), green leafhoppers, white-backed planthopper, the gall midge and whorl maggot. The use of insecticides was sometimes uneconomical because of the high cost of the chemicals. As a result, it needs the insecticide industry as well as to devise ways of reducing the amounts needed for effective insect control (Chandler, 1979).

Entomologists and agricultural economists are testing numerous methods of increasing the efficiency and reducing the cost of insecticide use. Integrated pest management- the combination of resistant varieties, different management practices and insecticides are becoming most widely recognized as the most effective and efficient way of keeping insect populations at low levels. For instance, BPH outbreaks are common only where two or more rice crops are grown consecutively in a single year. Thus, planting some other crops between rice crops significantly reduces the BPH populations, because the insect has an extremely narrow host range. BPH damage to the rice crop undoubtedly can be kept at low levels and yields and profits can be increased by using resistant varieties and by employing such practices as multiple cropping and insecticide placement (Chandler,. 1979). The BPH was first officially recorded in Bangladesh in 1969, but there are earlier records using synonyms of *N. lugens* in 1957 and in 1917. Catches in light traps near Dhaka showed that the insect population has gradually increased since 1970. The first confirmed case of hopper-burn, due to the BPH in Bangladesh was in 1976 found near Dhaka (Alam and Karim, 1977). The BPH has become a serious threat to rice production throughout Asia. The increase in severity of the insect appears to be associated with the technology used in modern rice culture. The BPH recently increased in abundance and caused severe yield losses in several tropical countries of Asia. It damages the rice plant by directly feeding on it and by transmitting the grassy stunt and ragget stunt disease. Losses from the insect alone are more than one million tons of rice valuing US $100 million in Japan and US$ 50 million in Taiwan. (Dyck and Thomus, 1979). The ecology of the BPH involves the relationship between the insect and its biotic and abiotic environments. The most important factors of the biotic environment are host plants, and natural enemy fauna, those of the abiotic environment are climate (temperature, relative humidity, solar radiation, rainfall, wind) and agricultural chemicals such as fertilizers, insecticides etc.(Dyck *et al.*, 1979).

Boro rice contributes the lion's share in the rice production in Bangladesh. Bangladesh needs 2.7% increase of rice production per year (Alam et al, 2004). It is clear from the table A that the area and yield as well as production of boro rice gradually increase which indicates the importance of growing this crop to feed

the increased population. On the other hand, BPH is a major pest which affects tremendously in this season. This is why this study was undertaken.

Table A. Area (000 ha), yield (ton/ha) and production (000 tons) of boro rice from 1971-76 to 2011-16 in Bangladesh.

Year	Area (000 ha)	Yield (t/ha)	Production (000 tons)
1971-76	1080.16	1.97	2113.00
1976-81	1065.62	2.03	2175.00
1981-86	1448.66	2.43	3526.00
1986-91	2206.82	2.42	5392.40
1991-96	2646.34	2.56	6784.80
1996-01	3322.31	2.94	9819.00
2001-06	3937.86	3.28	12927.40
2006-11	4681.68	3.80	17952.00
2011-16	4777.20	3.78	18947.60

Source: BBS,different issues from 1974 to 2014., DAE, 2014 and DAE, 2016

Rown planthopper causes severe damage in rice production in Bangladesh. The insect passes a considerable time (about 2.5 months) in the respective field unnoticed-before causing any visible damage required to cause hopper burn. Unfortunately, the rice farmers fail to identify the pest at that time mostly due to ignorance and unawareness which in turn allow the insects to develop a huge population required to cause hopper burn. To combat the situation it is necessary to make farmers aware through training about BPH management. Therefore, this study has been undertaken with the following objectives to solve this serious problem in BPH endemic areas of Sirajganj district.

Specific Objectives:

1. To assess the improvement of farmers' knowledge and perception on different factors of BPH incidence and its management;
2. To determine the farmers' perceptions on the merits and demerits of the BPH management technology (nozzle) selected through the project activities;
3. To examine the economic impact of harmful insects infestation on rice cultivation; and
4. To determine and compare the profitability of Boro rice cultivation among different groups of farms.

Methodology

Sampling Procedure and sample size:

Five villages named Humkuria, Dobila, Ghargram, Washin and Kanchenswar under the project areas of Tarash upazila at Sirajganj district were selected for the study. Three types of farmers were recognized in those villages such as target, trained and non-trained farmers. Target farmers were also called participating farmers. Participating farmers/target farmers were those farmers who were trained and plots of those farmers were selected for the project. Trained farmers were those who got only training and they did not give land for the project, while non-trained farmers were those who neither got training nor gave land for the project. Farmers were listed first and found 850 farmers. Then, the representative farmers were selected by stratified random sampling technique. Total number of sample farmers was 170 for the study taking proportionate number, 20% from each of the above category. Among the selected samples, 16, 54 and 100 were target, trained and non- trained farmers, respectively.

Data Collection and Analysis:

Survey was conducted during October 2016 to January, 2017. Data were collected by trained enumerators interviewing the sample farmers through structured questionnaire and finalized after pre-testing. Descriptive statistics as well as profitability analysis were done for analyzing the collected data based on target farmer, trained farmer and non trained farmers. In addition, partial budgeting analysis was done to find out the economic benefits of using double nozzle compared to single nozzle in spraying insecticides.

Results and Discussion

Farmers knowledge and perception on BPH:

Eighty eight, 83 and 93 % of target, trained and non trained farmers reported that the project needs to continue while 100% farmers of each group reported that the project is beneficial to control BPH to increase rice production (Table 1). Ninety four, 74 and 96% farmers of target, trained and non trained farmers reported that the BPH attack was comparatively higher in the boro season, while on an average of all samples 89% farmers reported it. But only 6, 4 and 3% farmers of target, trained and non- trained farmers reported that the BPH attack was higher in the aman season. On an average of all groups of farmers 29 and 69 % farmers respectively reported that the BPH attack was found in the nymph and adult stages.

Table 1. BPH related information given by the different categories of farmers (% respondents) in the study area

Items	Group			Average
	Target farmers	Trained farmers	Non trained farmers	
Project needs to continue	88	83	93	89
Project is beneficial	100	100	100	100
Plant damage due to more attack	94	96	67	79
BPH attack shown	94	93	70	79
Badly affected season: Boro season	94	74	96	89
Aman season	6	4	3	4
Know about the BRRI Project	100	100	90	94
Know about resistant variety	13	6	13	11
Control measure taken	94	83	53	66
BPH attacks in Nymph stage	6	83	3	29
BPH attacks in adult stage	88	24	90	69
Use same insecticides as before	25	83	40	52
Methods of insecticides application:				
Apply after drying field	75	65	47	55
Apply making furrow	75	50	30	41
Apply mixing kerosene and water	13	24	13	16
Transplant in Line for easy application	31	24	10	16
Apply mixing with fertilizer	60	11	8	14
Apply after removing water	6	17	7	10
Type of nozzle used:				
Single nozzle	13	44	49	44
Double nozzle	87	56	51	56

Farmers in the project area adopted different methods of insecticides application for controlling BPH such as apply after drying field, apply making furrow, mixing kerosene and water, transplant in line for easy application, mixing with fertilizer and apply after removing water from the crop field (Table 1). On an average, 55, 41, 16, 16 and 14% farmers respectively applied insecticides in their field after drying field, making furrow, mixing kerosene and water, transplant in line for easy application and apply mixing with fertilizer. Eighty seven, 56 and 51 % farmers of the target, trained and non- trained group used double nozzle for spraying insecticides to control BPH in their rice crop field.

Impact on BPH management options:

Farmers in the project area adopt different types of BPH management practices of which use of resistant variety, use of balanced fertilizer, regularly insect monitoring, use of high organic fertilizer, use of light trap, insecticide use at economic threshold level and draining out of water from the field are the most important ones (Table 2) . Before the project, the control measure taken by the different categories of farmers was poor, but after the project farmers of all categories were more careful about the management practices for controlling BPH. On an average, before the project, 14, 18, 68 and 6 % farmers used balanced fertilizers, used high organic fertilizers, insecticide used insecticides at economic threshold level, and drained out of water from the field to control insects/BPH respectively, while after the project the corresponding figures were 81, 32, 89 and 85%.

Table 2. Brown plant hopper management options of different categories of farmers (% of respondents) before and after the project

Management option	Before the project (2016)				After the project (2017)			
	Target farmers	Trained farmers	Non-trained farmers	Average	Target farmers	Trained farmers	Non-trained farmers	Average
Use of resistant variety	6	-	-	1	19	19	27	24
Use of balanced fertilizers	6	9	17	14	14	93	74	81
Regular insect monitoring	6	7	2	4	44	74	23	41
Use of high organic fertilizer	13	28	13	18	50	48	20	32
Use of light trap	6	4	4	4	31	11	6	10
Use of Neem extract	6	9	2	5	13	6	7	7
Use of beneficial insects	-	4	3	3	44	48	17	29
Insecticide use at economic threshold level	75	65	69	68	100	91	87	89
Draining out of water from the field	6	6	6	**6**	88	76	90	**85**

Farmers' perceptions on BPH:

Table 3 shows the general perceptions of farmers about BPH before and after the project. It can be assumed from the table that the maximum farmers in the study area did not know much about BPH before the project. But after the project most of the farmers' response on different aspects of BPH was correct. This indicates that after the project farmers gathered sufficient knowledge regarding BPH.

Table 3. Farmers perceptions on different aspects of BPH control before and after the project

Aspects	Respondent farmers (%)					
	Before the project (2015)			After the project (2017)		
	Yes	No	Don't know	Yes	No	Don't know
BPH eats other insects	2	-	98	4	26	70
BPH eats eggs of other insects	1	-	99	2	27	71
BPH sucks sap of leaves	29	-	71	50	29	21
BPH sucks stem	49	1	50	77	8	15
BPH eats spider	1	11	88	4	39	57
Spider eats BPH	19	16	65	80	3	17
BPH increased due to insecticide use	2	70	28	4	93	3
BPH decreased due to insecticide use	82	2	16	93	7	-

Table 4. Farmers' response about the impact of harmful insects on rice in different seasons before and after the project in the study areas

Insects	% respondents			
	Before the project		After the project	
	Boro season	Aman season	Boro season	Aman season
Brown plant hopper(BPH)	99	14	80	11
White backed planthopper (WBPH)	87	10	82	13
Stem borer (SB)	92	14	70	8
Leaf roller (LR)	40	3	54	8
Rice hispa (RH)	2	1	2	3
Rice bug (RB)	64	9	61	6
Green leafhopper (GLH)	65	1	42	2
Ear cutting caterpillar (ECC)	23	2	11	3
Mealy bug (MB)	2	-	1	-
Thrips	56	-	35	7

Impact on infestation of harmful insects:

Ninety nine percent and 87 % farmers reported that BPH and WBPH respectively attacked boro rice before the project while 80 and 82% farmers reported that these insects attacked in this season after the project (Table 4). Similar findings were obtained in case of stem borer, rice bug, GLH, ECC and thrips. This indicates that the infestation of different harmful insects reduced to a great extent during post-adoption period. After the project in the Aman season the findings were quite opposite except BPH due lack of knowledge of farmers about the insects.

Impact on rice yield loss:

Before the project in the boro season 2073kg/ha yield loss of variety BRRI dhan 29 affecting about 20% area while after the project only 1209 kg/ha yield loss of this variety was found affecting only 6.5% area (Table 5). Similar results were found in case of other varieties both in the boro season and aman season before and after the project. Therefore, the benefit in case of yield loss in the Boro season was found 42, 91, 15 and 37% for BRRI dhan 29, hybrid, miniket and pajam respectively, The yield loss was found less after the project due to proper management taken by the farmers after training and acquiring knowledge for controlling BPH.

Table 5. Yield loss (kg/ha) and BPH affected area (%) in different seasons before and after the project

Season	Variety	Before the project (2015)		After the project (2017)		% benefit in case of yield
		Yield loss (kg/ha)	Affected area (% of total)	Yield loss (kg/ha)	Affected area (% of total)	
Boro	BRRI dhan 29	2073	20.00	1209	6.50	42
	Hybrid	676	7.10	61	0.12	91
	Miniket	59	4.00	50	4.20	15
	Pajam	63	5.20	40	3.5	37
Aman	BR11	143	2.76	122	0.22	15
	BRRI dhan 32	40	2.00	32	2.40	20
	Ranjit	93	14.00	60	1.00	35
	Bina-7	52	3.00	43	2.20	17

Farmers perception on spraying nozzle:

The most important advantage of double nozzle sprayer is that it covers more land in less time reported by 100% farmers of target, trained and non- trained farmers (Table 6). Ninety percent and 72% of target farmers respectively reported that less labour cost and physically and environmentally helpful in case

of double nozzle. The disadvantages of double nozzle machine are needs furrow and needs more money reported by 50 and 75% target farmers respectively, while 37 and 54% trained farmers reported these disadvantages. However, on an average, 41, 60 and 67 % farmers reported that double nozzle spraying needs furrow, needs more money and line planting respectively. On an average of all farmers, 18 and 32 % farmers respectively reported that easy walking and spraying, and needs less money are the advantages of single nozzle sprayer. On the other hand, 54 and 31 % farmers respectively reported that single nozzle sprayer needs more time and high labour cost which are the most important disadvantages of this sprayer. The other most important disadvantage of single nozzle sprayer is that it sprays only one way reported by 84% farmers.

Table 6. Advantages and disadvantages of double and single nozzle sprayer as opined by the different categories of farmers in the project area

Advantages of double nozzle:	Categories of farmers (% of farmers)			
	Target farmers	Trained farmers	Non trained farmers	Average
Covers more land in less time	100	100	100	100
Spray covers in the base of the plant	9	10	8	9
Uniformity in coverage	60	20	10	18
Good yield	64	45	16	30
Easy walking and spraying	70	30	28	33
Less labour cost	90	65	46	56
Physically and environmentally helpful	72	25	26	30
Disadvantages of double nozzle:				
Needs furrow	50	37	42	41
Needs more money	75	54	61	60
Furrowing dries water	25	22	14	18
Needs line planting	75	78	60	67
Advantages of single nozzle:				
Needs less money	31	37	30	32
Spraying covers base of the plant	63	30	20	27
Uniformity in coverage	13	7	14	12
Good yield	-	4	5	4
Easy walking and spraying	-	19	20	18
Physically and environmentally sound	-	4	4	4
Disadvantages of single nozzle:				
Needs furrow	27	30	33	31
Needs more time	88	65	43	54
Furrowing dries water	36	4	7	9
Needs line planting	18	12	40	29
Needs frequent tank loading	18	6	4	6
High labour cost	40	35	27	31
Sprays only one way	90	80	86	84

The average cost per hectare for applying insecticides by single nozzle sprayer was Tk 1542 and time required is 21.12 hr/ha, but the average cost and time required by double nozzle sprayer were Tk 964 and 11.12 hr/ha respectively (Table 7). This indicates that 37% higher cost and 47% higher time is required by single nozzle sprayer than double nozzle sprayer. Therefore, farmers of all categories prefer double nozzle sprayer as it is good for health and saves both money and valuable time.

Table 7. Comparative cost (Tk./ha) of spraying by single and double nozzle sprayer

Items	Single nozzle	Double nozzle	Difference over double nozzle
Cost (Tk./ha)	1542	964	578 (37)
Time required (hr/ha)	21.12	11.12	10.00 (47)
Times/season	1.70	1.22	0.48 (28)

Note: Cost: Cost of pesticides and labour. Figures in the parentheses indicate percentages

Table 8 showed that 100% farmers reported that they prefer double nozzle sprayer to single nozzle sprayer. Eighty eight, 93 and 60% farmers of target, trained and non- trained group respectively reported that double nozzle sprayer is hygienic to use. On an average, 62% farmers in the survey area informed others about double nozzle sprayer.

Table 8. Preference of type of nozzle by the different categories of farmers

Items	Categories of farmers (%)			
	Target farmers	Trained farmers	Non- trained farmers	Average
Prefers single nozzle	-	-	-	-
Prefers double nozzle	100	100	100	100
Double nozzle-healthy	88	93	60	73
Double nozzle not healthy	-	9	20	25
Inform others about double nozzle	100	93	40	62
Farmers informed about double nozzle (no.)	25	37	8	19

Farmers perceptions on the use of Double Nozzle:

Table 9 shows the opinions of different categories of farmers about double nozzle sprayer for controlling BPH. On an average, hundred percent farmers of the three categories of farmers reported that less time is required by double nozzle sprayer to spray and improved technology. They also reported that use of double nozzle sprayer is more profitable than single nozzle sprayer. On an average, 96, 98 and 97 % farmers respectively reported that double nozzle sprayer are good for small and poor farmers, more yield giving and very satisfactory solution.

Table 9. Farmers' opinion on double nozzle sprayer for controlling BPH

Opinion	Categories of farmers (%)			
	Target farmers	Trained farmers	Non trained farmers	Average
Right solution in case of insecticide use	100	100	93	96
Good for small and poor farmers	100	100	93	96
Environment-friendly technology	100	93	57	72
Difficult and needs knowledge acquiring for application	88	83	83	84
Less time needed	100	100	100	100
More time needed	31	22	46	37
Need more capital	50	74	50	58
More yield	100	100	97	98
Very suitable for this locality	100	96	93	95
Very satisfactory solution	100	96	97	97
Technically very easy	94	56	57	60
Improved and profitable	100	100	100	100

Impact of using Double Nozzle on Boro rice production:

Table 10 showed the comparative cost of Boro rice cultivation by single nozzle users and double nozzle users in the study area. The land preparation cost for single nozzle users and double nozzle users were Tk.15782/ha and Tk.17341/ha respectively. The fertilizer cost and irrigation cost were more or less same for both the groups. However, the human labour cost was found higher for the single nozzle users (Tk.55580/ha) compared to double nozzle users (Tk.48985/ha) due to higher seedbed preparation cost and insecticide cost as well as difference in management practices. The cost for insecticides was 19.12 % higher for the single nozzle users compared to the double nozzle users due to less amount of insecticide use by the double nozzle users. The total cost was found higher (4.23%) for the single nozzle users than the double nozzle users. The yield, gross return, net return and BCR were higher for the double nozzle users compared to the single nozzle users. Therefore, the cost of cultivation was found higher for the single nozzle users (Tk 13.37/kg) compared to the double nozzle users (Tk.12.40/kg) indicating 7.22% higher cost of cultivation for the single nozzle users for Boro rice cultivation

Table 10. Comparative cost and returns (Tk/ha) of MV Boro rice cultivation for double nozzle and single nozzle users

Cost items	Double nozzle users	Single nozzle users	Difference
Land preparation	17341	15782	1559 (9.88)
Seedbed cost	2266	2970	-704 (23.70)
Seeds	1418	1287	131 (10.17)
Fertilizer	8256	8221	35 (0.43)
Irrigation	13225	12644	581(4.60)
Insecticides	440	544	-104 (19.12)
Human labour	48985	55580	-6595 (11.87)
Land rent	22264	22214	50 (0.2)
Total Cost	114195	119242	-5047(4.23)
Yield (kg/ha)	9206	8920	286 (3.21)
Gross returns	168150	165910	2240 (1.35)
Net returns	53955	46668	7287(15.61)
BCR	1.47	1.39	0.08 (5.93)
Cost of cultivation (Tk./kg)	12.40	13.37	-0.97 (7.22)

Note: Figures in the parentheses indicate percentages. Plus sign means higher and minus sign means lower cost and returns of the double nozzle users than those of the single nozzle users.

Partial budgeting analysis indicates that the double nozzle users are benefited by Tk 7287/ha than the single nozzle users for using double nozzle sprayer for Boro rice cultivation in the study area (Table 11). Therefore, double nozzle is more economically advantageous than single nozzle.

Table 11. Partial budgeting, single nozzle versus double nozzle users

Debit (Tk/ha)		Credit (Tk/ha)	
Single Nozzle users		Double nozzle users	
1. Cost of single nozzle users plot	119242	1. Returns from single nozzle users plot	165910
2. Revenue forgone for not practicing double nozzle	168150	2. Cost saved for not practicing double nozzle	114195
3. Profit/loss	- 7287	3. -------	-------
	280105		280105

Impact on profitability of Boro rice cultivation:

Most of the cost items were found higher for the non- trained farmers as shown in the table 12. The cost for land preparation, fertilizer, irrigation and human labour were Tk.18631/ha, Tk.8913/ha, Tk.14062/ha and Tk.57599/ha respectively in case of non-trained farmers, while the corresponding figures for the trained farmers were Tk.15514/ha, Tk.7504/ha, Tk11853/ha and Tk.44634/ha. The total cost for Boro rice cultivation in case of the target, trained and non-trained farmers were Tk. 97372/ha, Tk.103901/ha and Tk.126226/ha respectively. The yield was found higher for the target farmers (9480 kg/ha) compared to the trained (9200 kg/ha) and non-trained farmers (8973 kg/ha) due to better management practices. The gross return, net return and BCR were found higher in case of the target farmers and these were Tk.171107/ha, Tk.73735/ha and 1.76 respectively, but the cost of production per kg was lower (Tk.10.27) than those of the other two groups. This is due to more knowledge gathered by the target farmers on management practices for crop production.

Table 12. Cost and returns (Tk/ha) of MV Boro rice cultivation of different farmers group in relation to training status

Cost item	Farmers group according to Training obtained		
	Target Farmer	Trained Farmer	Non-Trained Farmer
Land preparation	15565	13314	18631
Seedbed cost	1310	2553	2792
Seeds	857	1322	1460
Fertilizer	6516	7504	8913
Irrigation	9906	11853	14062
Insecticides	469	415	526
Human labour	40744	44634	57599
Land rent/season	22007	22308	22239
Total Cost	97372	103901	126226
Yield (kg/ha)	9480	9200	8973
Gross returns	171107	169590	164740
Net returns	73735	65689	38514
BCR	1.76	1.63	1.31
Cost of cultivation (Tk./kg)	10.27	11.29	14.07

Conclusions and Recommendations

After the project the farmers of all categories of the project area were financially benefited by using improved BPH management techniques. They had gathered sufficient knowledge regarding BPH control, use of balanced fertilizer dose and

insecticides application. Farmers became aware of harmful insects which were a threat to increase crop production because they got training on different aspects of pest management. They could increase higher yield and income from rice production using right management practices and applying proper inputs. They learned how to use double nozzle for controlling BPH and reported that use of double nozzle is better than single nozzle use because it has more advantages than that of single nozzle. Double nozzle sprayer can be disseminated among the farmers through the personnel of department of agricultural extension and research institutes. Thus rice growing farmers need necessary training on improved insecticides application and its proper management to gain adequate knowledge to increase rice production. Therefore, sufficient credit should be provided to the farmers in time to purchase high cost inputs. At the same time policy should be made to subsidize on agricultural implements like double nozzle sprayers so that farmers can use these with minimum cost to grow rice profitably. So the more the training of farmers on improved BPH management techniques for rice cultivation the more benefit they obtain.

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