Project ID 729

Competitive Research Grant

Sub-Project Completion Report

on

Integrated Rodent Management in Wheat and Rice through Eco-friendly Control Techniques

Project Duration

May 2016 to September 2018

Vertebrate Pest Division
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Citation
[Integrated Rodent Management in Wheat and Rice through Eco-friendly Control Techniques]
Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

Edited and Published by:

Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
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Acknowledgement

The execution of CRG sub-project has successfully been completed by Vertebrate Pest Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701 using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thank to the World Bank for arranging the grand fund and to BARC for supervising the CRGs. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are also due to the Director PIU-BARC, NATP-2 and his team for given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

Published in: September 2018

Printed by: [Name of press with full address]

Acronyms

RPRW = Rodent problem in rice and wheat

BRRI = Bangladesh Rice Research Institute

BARI = Bangladesh Agricultural Research Institute

PI= Principal Investigator

Co-PI= Co- Principal Investigator

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Executive Summary

The project work was conducted in Rajshahi and Dinajpur districts in 2017-18 to develop an appropriate eco-friendly rodent control technique for wheat and rice crops. The main research activities were done in T-aman and wheat crop seasons. A questionnaire was developed and survey work was completed in the project areas. Survey data revealed that the numbers of small fields were higher than the large fields. Majority of farmers cultivated BRRI's variety of rice and BARI's variety of wheat. Rat damage started at booting stage of rice and wheat. Maximum damage occurred during maturing to ripening stage of rice and wheat crops. Farmers reported that their crop field was mostly affected by large size of rat. Rat caused damage in their crop field by cutting the tiller, making burrow in field and eating grain. Rats hoard a considerable amount of rice and wheat grain in their burrow. Farmers' were known about rodent as a threat for human health. They generally used commonly available acute poison openly in their crop fields for controlling rodents. In rice field higher number of burrow openings were recorded at grain filling stage (14.25/ha) and ripening stage (16.75/ha) but in wheat, the numbers of burrow openings at grain filling and ripening stage were almost similar (16.5 to 19.5/ha). Higher rodent damage was observed in wheat crop (13.25%) while 6.90% damage was observed in rice. Different rodent control options viz. kill trap, live trap, kill trap + acute poison, live trap + acute poison, kill trap + acute poison + chronic poison, Live trap + acute poison + chronic poison were evaluated in the rice and wheat fields of Rajshahi and Dinajpur. Sequential applications of trapping with live or kill trap, acute and chronic poison baiting showed the highest success with more than 90% success in rodent control. Sequential application of trapping with live or kill trap and acute poison baiting showed about 80% success in rodent control. Only 50% success was found in case of using live trap and kill trap that was completely eco-friendly. The major captured animal in rice and wheat field was *Bandicota bengalensis*. A few numbers of *Bandicota indica* and *Rattus rattus* were found in T-aman rice and wheat fields respectively.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Integrated Rodent Management in Wheat and Rice through Eco-friendly Control Techniques.
2. Implementing organization: Bangladesh Agricultural Research Institute
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

   Principal Investigator (Full address with phone and e-mail):

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   Co-Principal Investigator (Full address with phone and e-mail):

   Dr. Md. Shah Alam
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   E-mail: msalam@bari.gov.bd; alamvpd@yahoo.com

   3.1 **Sub-project budget** (Tk): Total: 24,97,400.00

   3.2 Revised (if any):

4. **Duration of the sub-project:**

   4.1 Start date (based on LoA signed): 15 May 2017

   4.2 End date: 30 September 2018

5. **Justification of undertaking the sub-project:** Rice and wheat are the major food crops of Bangladesh. Rat is a major vertebrate pest in Bangladesh agriculture. It causes serious damage to our crops in the field and in storage. It is a serious pest that causes considerable damage to rice and wheat crops. Nature of damage, damage intensity and control techniques may vary based on different species. In Asia, rat damages huge amount of food that is equivalent to the total food of 180 million people for 12 months whereas the damage amount is equivalent to food of 50-55 taka per people in Bangladesh (Prothom alo, 2015). The bandicoot rats (*Bandicota spp*) are found to be the major pests of rice and wheat. The roof rat (*Rattus rattus*), the house mouse (*Mus musculus*) and the lesser bandicoot rat are the pests of storage and fruit crops. It has been reported that rat causes about 5.7% losses in deep water rice which is estimated about 80,000 m. ton national loss, 10% in wheat (about 77,000 m. ton) and about 1% in T. aman rice (88,000 m. ton). Rats are also a major problem in the poultry sector where about Tk. 18,000.00 in cash loss per farm family per year. Buckle and Smith (1994) opined that non-chemical device - such as trapping rodents was an age old method for rodent population management. Unfortunately, trapping alone is an ineffective means of population management. According to the observations of *Ahmed et al.* 1995) trapping can, under some circumstances, be an effective method of rodent management. EPA (1998) reported that Zinc Phosphide (ZP) was used as a rodenticide worldwide since the 1940s to control a variety of animals including rats, mice, squirrels, prairie dogs, voles and gophers. Hood (1972), Tongtavee (1978), and Lund (1988) reported that the acute rodenticide zinc phosphide (Zn3 p2) was used worldwide for controlling urban and field rodent. Brooks & Siddique (1982) reported that 2% Zn3P2 bait cakes was found effective for controlling burrowing rodents in the crop fields. *Parshad et al.* (2007) reported that In India, rodents were estimated to cause 0.44 to 60 percent tiller damage which accounted for

5-10 % of the total grain yield losses in pre harvested rice. Fitzwater and Prakash (1989), *Singleton et al.* (1998), Buckle (1999), Neelanaryanan (2003), *Singleton et al.* (2005), and *Bogle et al.* (2006) practiced IPM applying different methods like trapping rodents in fields and premises, fumigating the live burrows with natural smoke, hunting, physical barriers such as trap barrier system, fumigating the rodent burrows with aluminium phosphide and poison baiting with rodenticides. *Makundi et al.* (2005) reported that among all the available rodent control practices, use of rodenticides was the most common and expedient method. There are some eco-friendly rat-control techniques i.e. trapping, inside burrow baiting; burrow watering with cow dung mixed water etc. One single technique is not so effective for controlling rat successfully. Integration of several techniques can be effective for controlling rat successfully. So by implementing this project, we can save a considerable amount of losses through application of modern eco-friendly rodent management technologies.

6. Sub-project goal: To increase substantial amount of rice and wheat production managing yield loss due to rodent infestation by applying appropriate rodent management techniques.
7. Sub-project objective (s):
    I. To study on rodent species composition and their damage severity in wheat and T-aman rice.
    II. To develop appropriate techniques for controlling rodents in wheat & T-aman rice.
    III. To validate and upscaling of developed rodent control techniques.
8. Implementing location (s): Rajshahi and Dinajpur districts of Bangladesh.
9. Methodology in brief: The research will be conducted in wheat and T-aman growing areas of Bangladesh. Considering this view, two areas i.e Rajshahi and Dinajpur districts were selected where research facilities were available. Rodent species compositions and population were observed in the study areas. Different treatment combination was evaluated and most effective control option was found out. One leaflet was published and training programs were conducted for transferring the technology.
    a) Survey on rat problem in rice and wheat (RPRW): A questionnaire survey on rat damage in rice and wheat was conducted in Rajshahi and Dinajpur districts of Bangladesh. Total 80 farmers, 40 farmers from each district were randomly selected for this study. Scientists of Vertebrate Pest Division took the framers' interview with a prescribed questionnaire sheet. It included different questions, such as size of farm, damage caused by rodent species in rice and wheat including intensity of rat damage, nature of damage, crop growth stage of damage, and different control methods used by the farmers etc. This survey was conducted at the time of T-aman rice and wheat season during 2017-2018.
    b) Observation of rodent population in rice: Rodent population was observed in different growth stages of rice in Rajshahi and Dinajpur districts of Bangladesh to find out the growth stage of rice crop that is seriously damaged by rats. Total number of active burrows was counted and other rodent activities were observed in total growth duration of T-aman rice.
    c) Observation of rodent population in wheat: Rodent population was observed in different growth stages of wheat in Rajshahi and Dinajpur districts of Bangladesh to find out the growth stage of wheat crop that is seriously damaged by rats. Total number of active burrows was counted and other rodent activities were observed in total growth duration of wheat.
    d) Rat damage estimation in wheat and rice field: Ten plots in each crop were randomly selected in Rajshahi and Dinajpur. In each plot ten samples were taken where these ten samples data were used for calculation of the damage in each plot as a percentage. Medium size plots were

selected for sampling data. Ten samples along one of the diagonals were selected in each plot. The distance between samples (between 3 to 5 steps) depends on the length of the diagonal. A sample closer than 3 meters (3 large steps) from any edge of the plot was not chosen. Each sample consists of 50 cm square frame in which all tillers, cut and uncut tillers were counted. These figures were put on a record sheet. The sampling frame is placed without looking, so that taking data would be real. After taking data from one plot next plots were selected randomly and repeated up to ten samples.

Percent damage was calculated with following formula:

$$\text{Percent rat damage} = \frac{\text{Number of cut tillers}}{\text{Total number of tillers}} \times 100$$

e) Evaluation of different control options for controlling rodents in rice: Different control options were evaluated for controlling rodents in T-aman rice fields in Rajshahi and Dinajpur districts of Bangladesh to find out appropriate management techniques against rat in rice field. There were six treatments viz. kill trap, live trap, kill trap + acute poison, live trap + acute poison, kill trap + acute poison + chronic poison, Live trap + acute poison + chronic poison. There was an untreated control. Only active burrows were treated with different treatment combinations. Burrows were treated in the evening and success data were taken in the following morning. Pre and post treatment population indices were taken.

f) Evaluation of different control options for controlling rodents in wheat: Different control options were evaluated for controlling rodents in wheat fields in Rajshahi and Dinajpur districts of Bangladesh to find out appropriate management techniques against rat in wheat field. There were six treatments viz. kill trap, live trap, kill trap + acute poison, live trap + acute poison, kill trap + acute poison + chronic poison, Live trap + acute poison + chronic poison. There was an untreated control. Only active burrows were treated with different treatment combinations. Burrows were treated at the evening and success data were taken in the following morning. Pre and post treatment population indices were taken. At least 20 active burrows were treated for one treatment. Randomized complete design was followed. Burrows were treated for consecutive three days for each treatment. First two days the trap was set and then poison was applied inside the burrow. After treatment, the treated burrows were observed for next two days. If no symptom or sign of rat activity was found then the treatment was considered as successful treatment. All poisons were used with eco-friendly techniques i.e. poison was wrapped with paper then inserted inside the burrow, then burrow was sealed with soil. Data were analyzed with appropriate analyzing software. The newly developed technology was validated in the farmers' field.

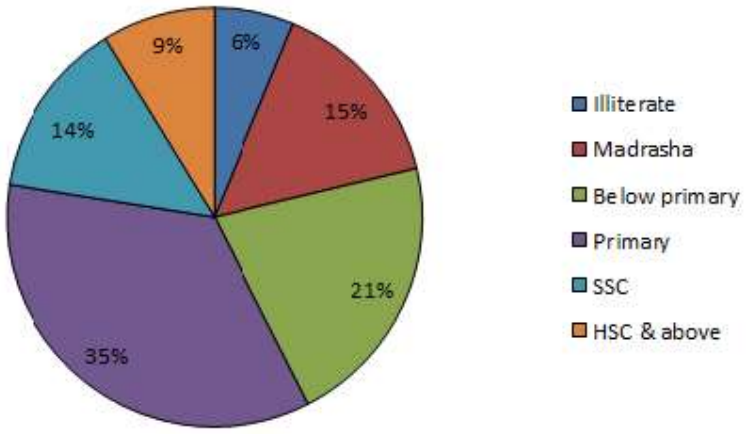
g) Field validation of newly developed technology: Ten farmers were selected at each project site of Rajshahi and Dinajpur. They were trained up about the new technology. They compared the success of this technique with their traditional practice. As traditional practice, they buy acute rodenticide from local market and place near rat burrow opening on a piece of paper openly. But in this new technology farmers firstly used locally available rat traps (either live or kill trap on the basis of availability) in proper way. They selected the active burrow where rat remains inside. Attractive foods were put on the trap and set the trap sensitively and put it near the burrow opening or run ways. After two days, if activity was found, then acute poison bait was used. About 2 g of poison bait wrapped in a paper. Burrow opening was cleaned and wrapped poison bait was inserted into the burrow and then sealed with soil. After operation, rodent

activity was observed up to 2 consecutive days. If no activity was found then it was considered as a successful treatment.

10. Results and discussion:

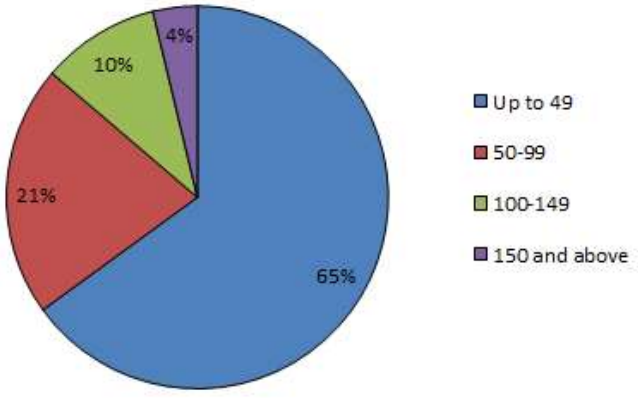
Survey on rat problem in rice and wheat (RPRW): Eighty questionnaires were administered by project scientists during May to October 2017. All interviewed farmers were male in this survey because generally male farmers worked in rice and wheat field and female worked in house as well as kitchen garden. Education levels indicated that majority of farmers (35%) completed their primary education and 21% farmers did not complete primary education but they can read and write in Bangla only (Figure 1). Only 9% farmers passed HSC or above. Moreover, 15% farmers read in Madrasha i.e. religious study in Arabic and illiterate farmers were 6%.

Figure 1. Education level of respondents interviewed in RPRW survey.



The numbers of small farms were higher than the large farm. Maximum farmers (65.00%) reported that they had only up to 49 decimals of land for cultivation of rice and wheat (Figure 2). About 21.00% farmers had 50-99 decimals of land and only 4% farmers had more than 150 decimals of land for rice and wheat cultivation. Majority of farmers cultivated high yielding varieties of rice and wheat developed by BRRI and BARI.

Figure 2. Amount of rice and wheat cultivable land (decimals) of respondents interviewed in RPRW survey.



All the farmers reported that rat was a serious problem in their farms. Rat infestation was started at booting stage of crop. Almost all farmers (78-89%) reported that maximum damage occurred during grain filling to ripening stage of rice and wheat (Tables 1 & 2). Rats generally prefer rice and wheat grain for eating. So, their activity is generally high in grain filling to ripening stage of rice and wheat.

Table 1. RPRW survey respondents' perception about growth stage of T-aman rice highly affected by rat.

Rice growth stage	% of total response
Booting	3.75
Grain filling	8.75
Ripening	8.75
Grain filling to ripening	78.75

Table 2. RPRW survey respondents' perception about growth stage of wheat highly affected by rat.

Rice growth stage	% of total response
Booting	1.25
Grain filling	3.75
Ripening	6.25
Grain filling to ripening	88.75

Farmers were asked about the rat species that affected to their fields. They did not have any idea on rat species. They could mention only the size of rat i.e. small size rat, large size rat etc. Majority of farmers (60-65%) reported that their T-aman rice and wheat crops were affected by large size of rat whereas 33 to 40% farmers saw medium size rat in their field and only 1.25 % farmers noticed small size rat in their crop field (Tables 3 & 4). Generally, crop field of Bangladesh is affected by burrowing field rat i.e. bandicoot rat that is medium to large in size.

Table 3. RPRW survey respondents' perception about rat species that cause damage to T-aman rice field.

Rat species/rat size	% of total response
Small	1.25
Medium	33.75
Large	65.00

Table 4. RPRW survey respondents' perception about rat species that cause damage to wheat field.

Rat species/rat size	% of total response
Small	0
Medium	40
Large	60

Farmers were asked about the nature of rat damage in their wheat and rice crops. According to them, rat damage started at booting stage of crop. Rats cut the rice and wheat tiller. Rat likes to consume sweet food. Rat cut the soft wheat and rice tiller due to its sweetness. They make extensive burrow in crop field. Rats prefer to consume wheat and rice grain. They hoard a considerable amount of rice and wheat grain in their burrows (Tables 5 & 6).

Table 5. RPRW survey respondents' perception about nature of rat damage in T-aman rice field.

Damage pattern	% of total response
Tiller cutting	86.25
Extensive burrowing	88.75
Grain eating	83.75
Hoarding grain into burrow	81.25

Table 6. RPRW survey respondents' perception about nature of rat damage in wheat field.

Damage pattern	% of total response
Tiller cutting	100
Extensive burrowing	100
Grain eating	80
Hoarding grain into burrow	76.25

To guess the economic losses caused by rat in rice and wheat field, farmers were asked about the per cent crop losses caused by rat in their rice and wheat fields. Majority of farmers reported that rat caused about 5% damage in their T-aman rice field (Table 7) and about 15% damage in their wheat crop field (Table 8). About 32 % farmers reported that rat caused 6-10% damage in their T-aman rice and 12% farmers responded that rat caused more than 15% damage in wheat crop.

Table 7. RPRW survey respondents' perception about per cent rat damage in T-aman rice.

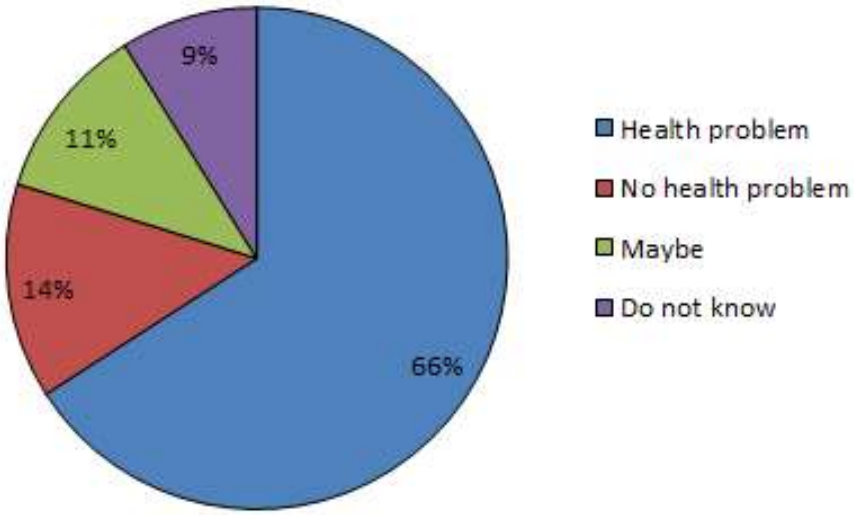
Per cent damage	% of total response
0-5%	58.75
6-10%	32.50
11-15%	8.75
> 15%	0

Table 8. RPRW survey respondents' perception about per cent rat damage in wheat.

Per cent damage	% of total response
0-5%	0
6-10%	11.25
11-15%	76.25
> 15%	12.50

As indicated in Figure 3, the majority of respondents (66%) accepted that rodents cause health problem. Surprisingly, 14% farmers replied that rodent is not a threat for human health and 9% had no idea on it. The scientist discussed this issue with interviewees and determined that farmers understood rodents could spread dirt around and contaminate food and water. Most of the farmers did not know any disease name being spread by rodents and how they could be transmitted.

Figure 3. RPRW survey respondents' perception about rodents causing health problems for human in Rajshahi and Dinajpur.



Rat is the very old enemy of the Bangladesh agriculture. Rats generally prefer uncleaned and dirty places. So, clean cultivation is a good practice to protect crop from rat. Irrigating crop field is an effective way for rat control. Trapping with different kinds of live and kill trap is eco-friendly and effective method for controlling rodent. Farmers generally used commonly available acute poison for rat control. Farmers were asked about the rodent control techniques generally they used in their rice and wheat field. Majority of farmers (78-93%) reported that they used acute poison (Zn_3P_2) in their crop field for rodent control (Tables 9 &10). They take acute rodenticide on a piece of paper and put openly beside rat burrow openings. Farmers are not interested to use traps in their crop field because they think that it will be stealing. They are reluctant to use chronic rodenticide due to its unavailability and high cost.

Table 9. Rodent control methods for rice field cited by respondents interviewed in RPRW survey.

Rat control method	% of total response
Irrigation	20
Trapping	6.25
Using acute poison	93.75
Using chronic poison	0

Table 10. Rodent control methods for wheat field cited by respondents interviewed in RPRW survey.

Rat control method	% of total response
Irrigation	0
Trapping	15
Using acute poison	78.75
Using chronic poison	6.25

Observation of rodent population in rice & wheat: It was observed that rat damage started in rice and wheat field at booting stage and continued up to harvesting stage of crop. In rice field, highest number of burrow opening was recorded at grain filling stage (14.25/ha) and ripening stage (16.75/ha) (Fig. 4). But in wheat crop field, the number of burrow opening was almost similar (16.5 to 19.5/ha) from grain filling to ripening stage. It was also observed that the rat infestation in wheat field of Dinajpur was comparatively higher than the wheat field of Rajshahi (Fig. 5).

Figure 4. Number of active burrow counted in total growth duration of T-aman rice.

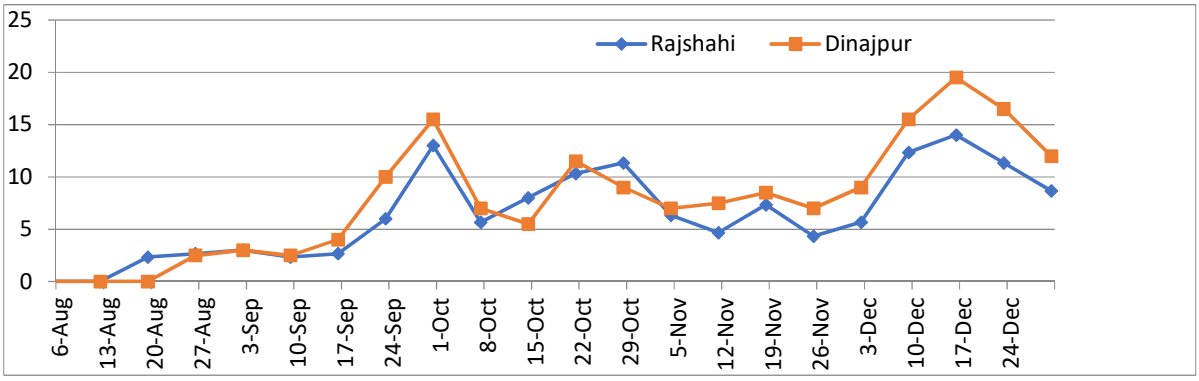
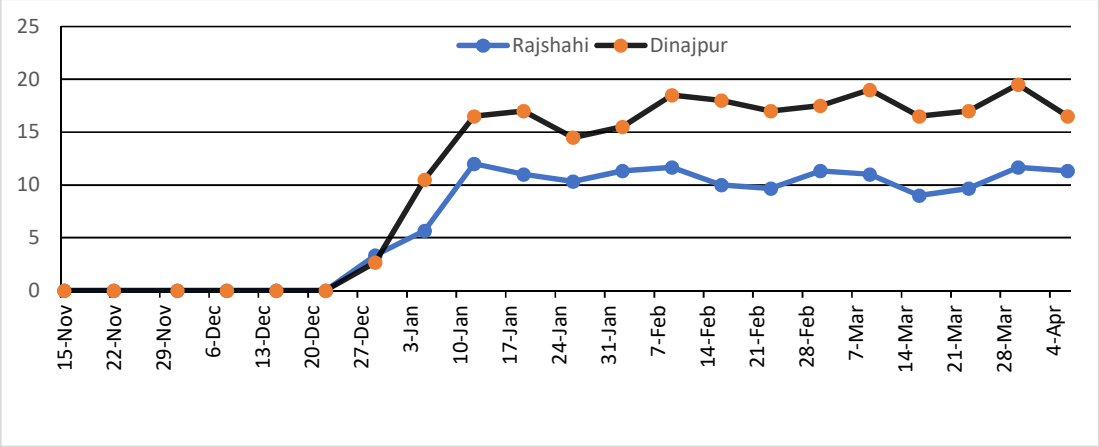
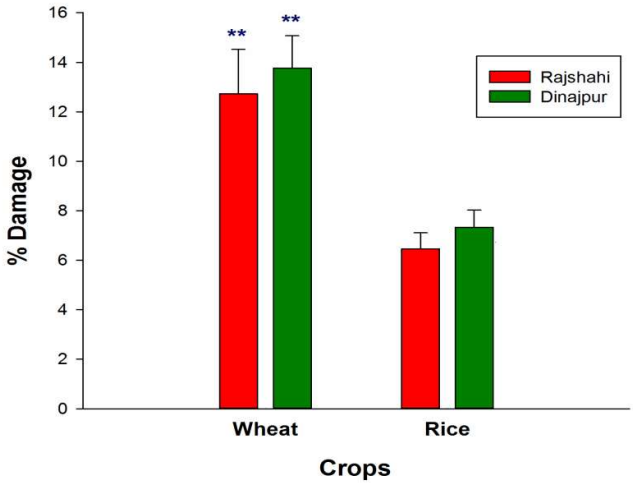


Figure 5. Number of active burrow counted in total growth duration of wheat.



Rat damage estimation in wheat and rice field: Percent rat damage in wheat and rice is presented in Figure 6. Rat damage differed significantly (Rajshahi: t = 3.292, p ≤0.01; Dinajpur: t = 4.342, p ≤0.01) between rice and wheat crops in Rajshahi and Dinajpur. Higher rat damage was observed in wheat crop by 12.73% whereas 6.46% rice was damaged by rat in Rajshahi. Similarly in Dinajpur rat damage in wheat field was 13.76% but it was 7.33% in rice. According to *Ahmed et al*. (1986) rat causes 5.7% losses to deep-water rice in Bangladesh. *Islam et al*. (1993) reported that the damage caused in the rain-fed deep-water rice in Bangladesh which was as high as 6.8% in 1987 and 3.2% in 1988. Sultana & Jaeger (1992) described wheat and rice losses as 2.3 and 1.9 % of the expected yields in two areas of Bangladesh between 1986 and 1988 respectively. *Poche et al.* (1982) reported 12.1 % losses to standing wheat due to rodent infestation in Bangladesh. Bindra and Sagar (1968) reported that in wheat, rat damage ranged from 3.5 to 12%. Srinivasa and Nanda (2010) reported that in paddy cultivation besides pests and diseases attack the rodents also caused significant yield losses in India.

Figure 6. Rat damage in rice and wheat in Rajshahi and Dinajpur.



** indicating significant differences between values where P = 0.01, independent t-test.

Evaluation of different options for controlling rodents in rice & wheat: From this experiment it was found that rat control success differed significantly among the treatments in Rajshahi (Grain filling stage: $F_{6,14}$= 40.296, P<0.001; Ripening stage: $F_{6,14}$= 40.778, P<0.001 and Average: $F_{6,14}$= 69.941, P<0.001) (Table 11). Sequential application of trapping, acute and chronic poison baiting showed the best result (up to 90 % success) for controlling rodent at grain filling stage in rice field which is followed by sequential application of trapping and acute poison baiting that showed up to 73% success whereas along live and kill trap setting showed only 37% and 30% success respectively. Similar result was found in ripening stage of rice where sequential application of trapping, acute and chronic poison baiting showed 97% success. In average 93% rodent population reduction was found in case of sequential application of trapping, acute and chronic poison baiting whereas the sequential application of trapping and acute poison baiting showed 68 to 72 % population reduction. Only 38% and 27% population reduction was found when using live trap and kill trap respectively.

Table 11. Rodent control efficacy of different treatment combinations in T-aman rice field in Rajshahi.

Treatments	Per cent reduction in rodent population (Mean ± SE)		
	Grain filling stage	Ripening stage	Average
Kill trap	30.00 ± 5.77 b	23.33 ± 3.33 bc	26.67 ± 3.33 c
Live trap	36.67 ± 3.33 b	40.00 ± 5.77 b	38.33 ± 3.33 c
Kill trap + Ac	66.67 ± 3.33 a	70.00 ± 5.77 a	68.33 ± 3.33 b
Live trap + Ac	73.33 ± 5.77 a	70.00 ± 11.54 a	71.67 ± 6.01 b
Kill trap + Ac + Ch	90.00 ± 10.00 a	96.67 ± 3.33 a	93.33 ± 6.67 a
Live trap + Ac + Ch	90.00 ± 5.77 a	96.67 ± 3.33 a	93.33 ± 3.33 a
Control	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00 ± 0.00 d

Similar letters show non-significant difference to each other.

Similarly in Dinajpur, rat control success differed significantly among the treatments (Grain filling stage: $F_{6,14}$= 37.30, P<0.001; Ripening stage: $F_{6,14}$= 32.556, P<0.001 and Average: $F_{6,14}$= 65.525, P<0.001) (Table 12). Sequential application of trapping, acute and chronic poison baiting showed the best result reducing 83.33 to 86.67 % in rodent population at grain filling stage in rice field which is followed by sequential application of trapping and acute poison that showed up to 63.33% success whereas along live and kill trap showed only 33.33% and 23.33% success respectively. Similar result was found in ripening stage of rice where by sequential application of trapping, acute and chronic poison baiting showed 90.00% to 100.00% success. In average 86.67 to 93.33% rodent population reduction was found in case of using by the sequential application of trapping, acute and chronic poison baiting whereas by sequential application of trapping and acute poison baiting showed 63.33% to 70.00 % population reduction. Only 33.33% and 21.67% population reduction was found when using live trap and kill trap respectively.

Table 12. Rodent control efficacy of different treatment combination in T-aman rice field in Dinajpur.

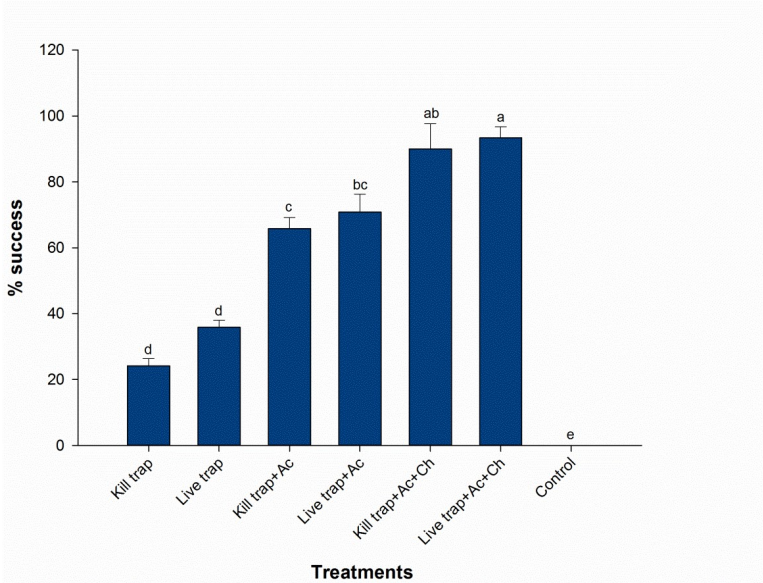
Treatments	Per cent reduction in rodent population (Mean ± SE)		
	Grain filling stage	Ripening stage	Average
Kill trap	23.33 ± 3.33 bc	20.00 ± 5.77 de	21.67 ± 1.67 d
Live trap	33.33 ± 3.33 b	33.33 ± 3.33 cd	33.33 ± 1.67 d
Kill trap + Ac	63.33 ± 3.33 a	63.33 ± 8.82 bc	63.33 ± 3.33 c
Live trap + Ac	66.67 ± 6.67 a	73.33 ± 8.82 ab	70.00 ± 5.00 bc
Kill trap + Ac + Ch	83.33 ± 8.82 a	90.00 ± 10.00 ab	86.67 ± 8.82 ab
Live trap + Ac + Ch	86.67 ± 6.67 a	100.00 ± 0.00 a	93.33 ± 3.33 a
Control	0.00 ± 0.00 c	0.00 ± 0.00 e	0.00 ± 0.00 e

Similar letters show non-significant difference to each other.

Considering two places i.e. Rajshahi and Dinajpur, rodent controlling success differed significantly among the treatments ($F_{6, 14}$= 71.881, P<0.001) (Figure 7) in T-aman rice field. The highest rodent population reduction (93%) was found in sequential application of live trap, acute and chronic

poison baiting which was statistically similar with sequential application of kill trap, acute and chronic poison baiting. Sequential application of live trap and acute poison showed 71% success for rodent control which was statistically similar with sequential application of kill trap and acute poison baiting (66% success in rodent control). On the other hand, only about 35% and 24% success was observed in live trap and kill trap respectively. About 70% captured animals were *Bandicota bengalensis* whereas a few numbers (14%) of *Bandicota indica* were trapped (Table 13). Islam and Karim (1995), Catling and Islam (1999) also reported *Bandicota bengalensis* as a dominant species in deep water rice field in Bangladesh.

Figure 7. Average success of different treatment combinations in T-aman rice field in Rajshahi and Dinajpur.



Similar letters show non-significant difference to each other.

Table 13. Rodent species trapped in the rice field during booting to ripening stage of the 2017 T-aman season in Dinajpur and Rajshahi.

Attributes	Crop growth stage		Total	Percentage
	Grain filling	Ripening		
Trap nights	240	225		
Rat trapped (Total number)				
• *Bandicota bengalensis*	28	23	51	70.83
• *Bandicota indica*	09	12	21	29.17
Total	37	35	72	100

Similar result was found in the experiment in wheat field where rat control success differed significantly among the treatments in Rajshahi (Grain filling stage: $F_{6,14}$= 169.47, P<0.001; Ripening stage: $F_{6,14}$= 210.31, P<0.001 and Average: $F_{6,14}$= 298.94, P<0.001) (Table 14). Sequential application of trapping, acute and chronic poison baiting showed the best result (about 95% success) for controlling rodent at grain filling and ripening stages in wheat field which is followed by the sequential application of trapping and acute poison baiting that showed about 80% success whereas along live and kill trap showed only 45% and 41% success respectively. In average 95.83%

rodent population reduction was found in sequential application of trapping, acute and chronic poison baiting whereas sequential application of trapping and acute poison baiting showed 80 to 83% population reduction. Only 48% and 48% population reduction was found when using live trap and kill trap respectively.

Table 14. Rodent control efficacy of different treatment combination in wheat field in Rajshahi.

Treatments	Per cent reduction in rodent population (Mean ± SE)		
	Grain filling stage	Ripening stage	Average
Kill trap	41.67 ± 4.41 d	55.00 ± 2.89 c	48.33 ± 2.20 c
Live trap	45.00 ± 2.89 d	50.00 ± 2.89 c	47.50 ± 2.50 c
Kill trap + Ac	81.67 ± 3.33 c	80.00 ± 2.89 b	80.83 ± 3.00 b
Live trap + Ac	83.33 ± 1.67 bc	83.33 ± 1.67 b	83.33 ± 0.83 b
Kill trap + Ac + Ch	95.00 ± 2.89 ab	96.67 ± 1.67 a	95.83 ± 1.67 a
Live trap + Ac + Ch	96.67 ± 1.67 a	95.00 ± 2.89 a	95.83 ± 2.20 a
Control	0.00 ± 0.00 e	0.00 ± 0.00 d	0.00 ± 0.00 d

Similar letters show non-significant difference to each other.

Similarly in Dinajpur, rat control success differed significantly among the treatments in wheat field (Grain filling stage: $F_{6,14}$= 96.782, P<0.001; Ripening stage: $F_{6,14}$= 83.59, P<0.001 and Average: $F_{6,14}$= 178.573, P<0.001) (Table 15). Sequential application of trapping, acute and chronic poison baiting showed the best result reducing 90% to 93% in rodent population at grain filling stage in wheat field which was statistically similar with the sequential application of trapping and acute poison that showed about 80% success whereas along live and kill trap showed only 48% and 47% success respectively. Similar result was found in ripening stage of wheat where sequential application of trapping, acute and chronic poison baiting showed 95% success. In average, 93 to 94% rodent population reduction was found by sequential application of trapping, acute and chronic poison whereas the sequential application of trapping and acute poison showed 82% to 83% population reduction. Only 51% and 53% population reduction was found when using live trap and kill trap respectively.

Table 15. Rodent control efficacy of different treatment combination in wheat field in Dinajpur.

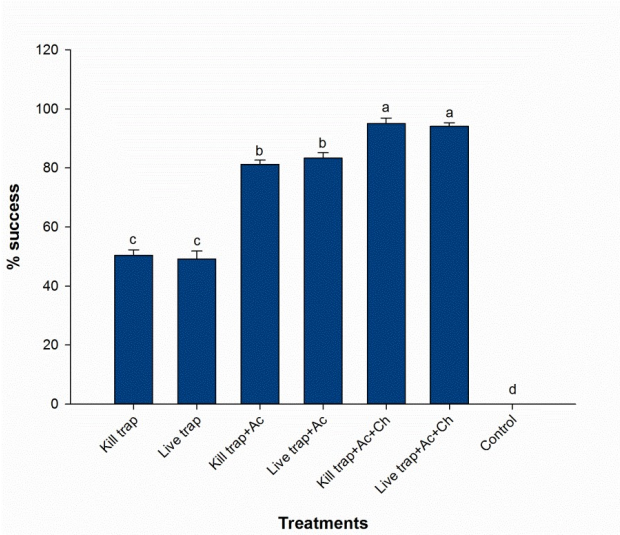
Treatments	Per cent reduction in rodent population (Mean ± SE)		
	Grain filling stage	Ripening stage	Average
Kill trap	46.67 ± 1.67 b	58.33 ± 1.67 b	52.50 ± 1.44 c
Live trap	48.33 ± 4.41 b	53.33 ± 6.01 b	50.83 ± 4.41 c
Kill trap + Ac	78.33 ± 4.41 a	85.00 ± 5.77 a	81.67 ± 0.83 b
Live trap + Ac	81.67 ± 3.33 a	85.00 ± 2.89 a	83.33 ± 3.00 ab
Kill trap + Ac + Ch	93.33 ± 1.67 a	95.00 ± 2.89 a	94.17 ± 2.20 a
Live trap + Ac + Ch	90.00 ± 5.00 a	95.00 ± 2.89 a	92.50 ± 2.89 ab
Control	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00 ± 0.00 d

Similar letters show non-significant difference to each other.

Considering two places i.e. Rajshahi and Dinajpur, rodent controlling success differed significantly ($F_{6,14}$= 390.917, P<0.001) among the treatments in wheat field (Figure 8). The highest rodent population reduction (about 95%) was found by sequential application of trapping, acute and chronic poison which was followed by the sequential application of trapping and acute poison (about 80.00% success). Only about 49% and 50% success was observed in live trap and kill trap

respectively. Majority (86%) of captured animal was *Bandicota bengalensis* whereas a few numbers (14%) of *Rattua rattus* were trapped (Table 16). Hasanuzzaman *et al*., (2009) found *Bandicota bengalensis* as a major vertebrate pest in wheat field of Bangladesh. In another experiment, Roy *et al*., (1987) found *Bandicota bengalensis* as a dominant species in the poultry farm of Monipur, India.

Figure 8. Average success of different treatment combinations in wheat field in Rajshahi and Dinajpur.



Similar letters show non-significant difference to each other.

Table 16. Rodent species trapped in the rice field during booting to ripening stage of the 2017-18 wheat season in Dinajpur and Rajshahi.

Attributes	Crop growth stage		Total	Percentage
	Grain filling	Ripening		
Trap nights	270	255		
Rat trapped (Total number)				
• *Bandicota bengalensis*	46	57	103	85.83
• *Rattus rattus*	11	6	17	14.17
Total	57	53	120	100

In the present study, more than 90% success was found for controlling rodent by sequential application of trapping, acute and chronic poison baiting. This result is compatible with Mian e*t al*. (2007) where integrational of non-chemical and chemical techniques were evaluated in the poultry farm to reduce rodent damage and found 97.5% reduction of rodent population by a sequential application of trapping, acute and chronic poison baiting. More than 80% reduction of rodent population by sequential application of trapping and acute poison baiting was found. In another study, about 85 to 89% reduction of rodent population was observed by a sequential application of trapping and acute poison baiting (Mian *et al*., 2007). About 50 per cent success in case of live and kill trap was observed. In another experiment, Hasanuzzaman *et al*. (2009), found 44.11% success

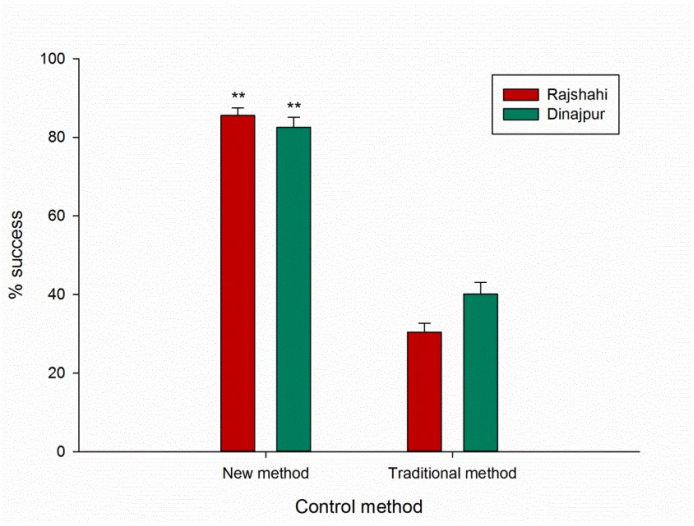
of case type live trap and 30.73% success of tin made kill trap for controlling rodent in wheat field of Bangladesh.

As 80% success in rodent control was achieved in wheat field by applying trapping followed by inside burrow baiting, any kinds of trap i.e. either live or kill trap and any kinds of poison i.e. acute or chronic can be used. So, sequential application of trapping and inside burrow baiting can be a good rodent control technology for controlling rodents in rice and wheat field of Bangladesh. It is obvious that all kinds of poison are harmful for the environment. In this work, small amount of poison bait, is used inside the burrow and the burrow was sealed with soil. So, this poison bait is relatively safe for non-target animals.

In T-aman rice field, trapping followed by poison baiting with acute poison provided comparatively less rat controlling success (about 60-70%) than the success of wheat field. That was early period of this project work where project workers were not skilled for setting trap or placing poison bait. But in wheat season the workers were being skilled and better success was achieved. So, rodent control success mostly depends on proper setting of trap and placement of poison bait.

Field validation of newly developed technology: Comparative rodent control efficacy of new and traditional practice is presented in Figure 9 where rat control success differed significantly among the treatments (Rajshahi: $t = 18.532$, $p \leq 0.01$; Dinajpur: $t = 10.698$, $p \leq 0.01$). When the new rodent control method was used the average success was 85.55 and 82.57 per cent in Rajshahi and Dinajpur respectively whereas in traditional method it was only 30.42 and 40.15 per cent in Rajshahi and Dinajpur respectively. So it was observed that 42 to 55% higher success in rodent control was achieved when new rat control method was used by the farmers.

Figure 9. Rodent control success of new technology compared to traditional practice in wheat field in Rajshahi and Dinajpur.



** indicating significant differences between values where P = 0.01, independent t-test.

Table 17. Benefit cost analysis of different management options against rat damage in wheat field.

Treatments	Pest management cost (Tk/Plot)	Yield (Kg/Acre)	Gross return (Tk/Acre)	Net return (Tk/Acre)	MBCR
T_1=Kill trap	100	1221	19536	19436	1.97
T_2=Live trap	140	1210	19360	19220	1.95
T_3=Kill trap + Ac	160	1255	20080	19920	2.02
T_4=Live trap + Ac	200	1335	21360	21160	2.14
T_5=Kill trap + Ac + Ch	230	1314	21024	20794	2.10
T_6=Live trap + Ac + Ch	270	1295	20720	20450	2.07
T_7=Control	0	617	9872	9872	-

- Market price of wheat per kg = 16 Tk.

Details of economic analysis

T_1= Kill trap
Cost of kill trap = Tk. 40/-
Cost of bait = Tk. 20/-
Cost of labor = Tk. 40/-
Total cost = Tk. 100/-

T_2= Live trap
Cost of live trap = Tk. 80/-
Cost of bait = Tk. 20/-
Cost of labor = Tk. 40/-
Total cost = Tk. 140/-

T_3=Kill trap + Ac
Cost of kill trap = Tk. 40/-
Cost of bait = Tk. 20/-
Cost of acute poison = Tk. 20/-
Cost of labor = Tk. 80/-
Total cost = Tk. 160/-

T_4=Live trap + Ac
Cost of live trap = Tk. 80/-
Cost of bait = Tk. 20/-
Cost of acute poison = Tk. 20/-
Cost of labor = Tk. 80/-
Total cost = Tk. 200/-

T_5=Kill trap + Ac + Ch
Cost of kill trap = Tk. 40/-
Cost of bait = Tk. 20/-
Cost of acute poison = Tk. 20/-
Cost of chronic poison = Tk. 30/-
Cost of labor = Tk. 120/-
Total cost = Tk. 230/-

T_6=Live trap + Ac + Ch
Cost of live trap = Tk. 80/-
Cost of bait = Tk. 20/-

Cost of acute poison = Tk. 20/-
Cost of chronic poison = Tk. 30/-
Cost of labor = Tk. 120/-
Total cost = Tk. 270/-

11. Research highlight/findings (Bullet point – max 10 nos.):

- Rat is the serious threat for wheat and rice cultivation in Dinajpur and Rajshahi. Rat damage started in booting stage of crop and the highest damage occurred at grain filling to ripening stage. Rat hoards a considerable amount of rice (3-5 kg) in their burrow. Rat can damage up to 5% in T-aman rice and 15% in wheat crop. Farmers generally used acute poison bait for controlling rat.
- The highest numbers of burrows were recorded at grain filling stage (14.25/ha) and ripening stage (16.75/ha) of rice.
- In wheat field, the numbers of burrow openings at grain filling and ripening stage were almost similar (16.5 to 19.5/ha). The wheat field of Dinajpur was highly affected than the field of Rajshahi.
- Higher rodent damage was observed in wheat crop (13.25%) whereas 6.90% damage was observed in rice.
- Sequential application of trapping with live or kill trap, acute and chronic poison baiting showed the best result (about 93.33 % success) for controlling rodent in rice field. Sequential application of trapping with live or kill trap and acute poison baiting showed up to 70% success for rodent control. About 35% success was found in case of setting live trap whereas kill trap showed only 24% success in rodent control. About 70% captured animals were *Bandicota bengalensis*.
- Similarly in wheat field, sequential application of trapping with live or kill trap, acute and chronic poison baiting showed the highest success (up to 95.00 %) for controlling rodent. Sequential application of trapping with live or kill trap and acute poison baiting showed up to 80.00% success for rodent control. About 50% success was found in case of setting only live trap and kill trap.
- Majority (85.83%) of captured animal was *Bandicota bengalensis* whereas a few numbers (14.17%) of *Rattua rattus* were trapped.
- About 40 to 50% higher success in rodent control was achieved by sequential application of trapping with live or kill trap and inside burrow baiting compared to traditional practice.
- Rodent control success mostly depends on proper setting of trap and placement of poison bait.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	06	1,85,000.00	06	1,84,950.00	
(b) Lab & field equipment	800	2,30,000.00	800	2,29,932.00	
(c) Other capital items	17	1,26,000.00	17	1,25,928.00	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	58	2	60	1 day	-
(b) Workshop	-	-	-	-	-

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	271400	271400	240895	30505	88.76	
B. Field research/lab expenses and supplies	1085000	952076.5	762596.5	189480	80.10	
C. Operating expenses	300000	297865.5	291552	6313.5	97.88	
D. Vehicle hire and fuel, oil & maintenance	200000	178385	155180	23205	86.99	
E. Training/workshop/seminar etc.	125000	118780	118780	0	100	
F. Publications and printing	130000	110500	34000	76500	30.77	**
G. Miscellaneous	75000	63750	49325	14425	77.37	
H. Capital expenses	311000	310928	310878	50	99.98	

** Fund for PCR has been refunded.

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output (i.e. product obtained, visible, measurable)**	**Outcome (short term effect of the research)**
i) To study on rodent species composition and their damage severity in wheat and T-aman rice.	• Survey on rat problem in rice and wheat • Observation of rodent population in rice & wheat • Rat damage estimation in wheat and rice field	• Farmers' perception on rodent species composition and their damage pattern in rice & wheat was known. • Extents of rat damage in rice and wheat were estimated. • Percent damage caused by rat in rice and wheat was estimated.	• Farmers of project area are aware of rat damage severity in their rice & wheat field. • Farmers are applying control measure immediately after noticed damage symptom in their field.
ii) To develop appropriate techniques for controlling rodents in wheat & T-aman rice.	• Evaluation of different control options for controlling rodents in rice & wheat	• Most suitable and effective control technique has been find out.	• Most suitable and effective control technique has been applied by farmers.
iii)To validate and upscaling of developed rodent control techniques.	• Field validation of newly developed technology	• Effectiveness of newly developed technology was validated by farmers in wheat field.	• Farmers are confident about the effectiveness of new technology.

E. Materials Development/Publication made under the Sub-project:

Publication	**Number of publication**		**Remarks (e.g. paper title, name of journal, conference name, etc.)**
	Under preparation	**Completed and published**	
Technology bulletin/ booklet/leaflet/flyer etc.		**1**	Integrated rodent management in rice and wheat
Journal publication			
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Sequential application of trapping and inside burrow baiting for controlling burrowing rodent

ii. **Generation of new knowledge that help in developing more technology in future**

Only trapping is not so effective for controlling burrowing rodent

iii. Technology transferred that help increased agricultural productivity and farmers' income

Sequential application of trapping and inside burrow baiting for controlling burrowing rodent

iv. Policy Support

G. Information regarding Desk and Field Monitoring

i) **Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):**
PIU-BARC, NATP-2 arranged a monitoring seminar on 14th March, 2018 at BARI, Gazipur. In this seminar, on-going project activities were presented. Respected members discussed as well as evaluated the project activities and put their valuable comments and suggestions. Their comments and suggestions were helpful for the smooth running of the project.
Technical division, BARC organized a monitoring workshop on 15th May, 2018 at BARC, Dhaka. In this workshop, on-going project activities were presented by PI. Respected members discussed as well as evaluated the project activities and put their valuable comments, constructive criticism and suggestions. Project activities were impetuous on the basis of their suggestions.

ii) **Field Monitoring (time& No. of visit, Team visit and output):**
Research Management Specialist had taken information regarding project activities from PI and Co-PI over telephone several times and gave necessary suggestions that were helpful for the smooth running of the project.

I. Lesson Learned/Challenges (if any)

i) Most of the farmers are not aware of the dangers of using poison in open field.
ii) Farmers are not interested to set trap in crop field due to apprehension of stealing the trap.

J. Challenges (if any)

Signature of the Principal Investigator
Date ……
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

References:

Ahmad, N., (1986). Studies on rodent pest management in agro and forest ecosystems. Unpublished PhD thesis, Garhwal University,Srinagar.

Ahmed, E,I. Hussain and J.E. Brooks., (1995). Losses of stored foods due to rats at grain markets in Pakistan. International Biodeterioration and Biodegration. 36, 125-133.

Bindra, O. S. and P. Sagar., (1968). Study on the losses to wheat, groundnut and sugarcane crops by the field rats in Punjab. Proceedings of the International Symposium on Bionomics and Control of Rodents, pp.28-31.Kanpur, India.

Bogle R G, Theron P, Brooks P, Dargan P I, and Redhead J (2006). Aluminium phosphide poisoning. Emergency Medicine Journal 23(1), pp: 3.

Brooks, J. E & Siddique, A. B (1982). A comparative field trail of Two Rodenticides in Bangladesh wheat fields. Technical Report No. 17. Bangladesh Agricultural Research Institute DWRC; 9 pp.

Buckle AP. (1999). Rodenticides- their role in rodent pest management in tropical agriculture. In: Singleton G R, Hinds L A, Krebs C J and Spratt D M. (Eds), Rats, Mice and People: Rodent Biology and Management. Australian Centre for International Agricultural Research (ACIAR), Canberra, pp: 163-177.

Buckle, A.P. and R.H. Smith (1994). Rodent pests and their control. Wallingford, U.K. CAB International. 405 p.

Catling, H.D. and Z. Islam. 1999. Pest of deep water rice and their management. Integrated Pest Management Review. 4, 193-229.

EPA (Environmental Protection Agency) (1998). R.E.D. facts. Washington, DC, United States Environmental Protection Agency.

Fitzwater W D and Prakash I. (1989). Handbook of Vertebrate Pest Control. Indian Council of Agricultural Research, New Delhi, pp :103.

Hasanuzzaman, A.T.M., M.S. Alam and M.M. Bazzaz. (2009). Comparative efficiency of some indigenous traps to capture rats in the wheat field of Bangladesh. J. Agric. Rural. Dev., 7 (1&2), 121-125.

Hood.G.A. (1972) Zinc phosphide a new look at an old rodenticide for field rodents. In : proc. 5the Vertebreat pest conf., Fresno, California, vol.5,pp.85-92.

Islam, Z and Karim, A.N.M.R. 1995. Rat control by trapping in deepwater rice. International Journal of Pest Management, 41, 229-233.

Islam, Z., Morton, R.G. and Jupp, B.P. (1993). The effect of rat damage on deepwater rice yields in Bangladesh. International Journal of Pest Management. 39:250-254.

Lund, M. (1988). Nonanticoagulant rodenticides . In : Rodent pest Management, ed.1. Prakash. CRC Press, Boca Raton, Florida, pp. 331- 40.

Makundi R H, Bekele A, Leirs H, Massawe A W, Rwamugira W, Mulungu L S (2005). Farmer's perceptions on rodents as crop pests: knowledge, attitudes and practices in rodent pest management in Tanzania and Ethiopia. Belgian Journal of Zoology 135 (Suppl.), pp 153–157.

Mian, M.Y., M.S. Alam and A. T. M. Hasanuzzaman. 2007. Integrated approach of rodent management. Int. j. Sustain. Agril. Tech., 3 (1): 16-20.

Neelanaryanan P. (2003). Community traps barrier system for integrated management of rodent pests in low and irrigated rice crops in south East Asia. Rodent Newsletter 27, pp:13-14.

Parshad V R, Neena Singla, Kocher D. K, Rajinder Kaur. (2007). The lesser bandicoot rat Bandicota bengalensis Gray and Hardwicke. Technical Bulletin No. 14, ICAR, New Delhi.

Poche, R, M., Mian, M. Y., Haque, M. E & Sultana , P. (1982). Rodent damage and burrowing charactesisties in Bangladesh wheat fields J. wildlife mgmt., 46 (1) 139-47.

Singleton G R, Jacob S J and Krebs C J. (2005). Integrated management to reduce rodent damage to lowland rice crops in Indonesia. Agriculture Ecosystems and Environment 107, pp: 75-82.

Singleton G R, Sudarmaji and Suriapermana S. (1998). An experimental study to evaluate a trap barrier system and fumigation for controlling the rice field rat, Rattus argentiventer in rice crops in West Java. Crop Protection, 17, pp: 55-64.

Srinivasa Rao N and Nanda Kishore M. (2010). Evaluation of Trap barrier system for the management of Lesser bandicoot rat, Bandicota bengalensis in irrigated rice. Indian Journal of Plant Protection, 38(2), pp:193-196.

Sultana, P & Jaeger, M. M (1992). Control strategies to reduce preharvest rat damage in Bangladesh. In: proc. 15 the Vertebr. pest cont. Newport Beach, california. Vol. 15, pp.261-7.

Tongtavee, K. (1978). Zinc phosphide development. Unpublished ph. D. dissertation, Bowling Green state University ; Bowling Green, Ohio 142 pp.

Figure: Photograph of project site Rajshahi.

Figure: Photograph of active rat burrow in rice field.

Figure: Photograph of rat trapped in kill trap.

Figure: Photograph of rat trapped in live trap.

Figure: Photograph of rat foot print on tracking tile.

Figure: Photograph of rat foot print on field.

Figure: Photograph of cut tiller in rice field.

Figure: Photograph of farmer setting kill trap in wheat field.

Figure: Photograph of farmer setting live trap in wheat field.

Figure: Photograph outside burrow baiting, the common farmers' practice in Bangladesh.

Figure: Photograph of inside burrow baiting, used in this project.

Figure: Photograph of group of farmers, worked in this project.

Figure: Photograph of group of farmers, in practical training class.

Figure: Photograph of scientist, interviewed by TV channel.

Figure: Photograph of farmer, searching rat burrow opening in practical training class.

Figure: Photograph of farmers attended in training class.

Figure: Photograph of trainees attended in training class.