

Project ID-504

Competitive Research Grant

Sub-Project Completion Report

on

Risk assessment and development of
management approach (es) against tomato leaf
miner, *Tuta absoluta* Meyrick

Project Duration

May 2017 to September 2018

Entomology Section
Horticulture Research Centre
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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Acronyms

Abbreviation	Elaboration
IPM	Integrated Pest Management
Bt	<i>Bacillus thuringiensis</i>
<i>T. absoluta</i>	<i>Tuta absoluta</i>
<i>B. bassiana</i>	<i>Beauveria bassiana</i>
<i>M. anisopliae</i>	<i>Metarrhizium anisopliae</i>
DAE	Department of Agriculture Extension
RH	Relative Humidity
MBCR	Marginal Benefit Cost Ratio
WSC	Water Soluble Concentrate

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Executive Summary

The South American tomato leafminer, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), a native of South America, is a serious pest of tomato causing up to 80-100% yield losses if no appropriate control measures are taken. Following its accidental introduction to Spain in 2006, *T. absoluta* was recorded throughout Europe and the Mediterranean by 2010. This invasive pest has since spread to the Middle East and North Africa, East and West Africa, and reached India in 2014, Central Asia in 2015, Bangladesh and Nepal in 2016. This project aims to find out the peak and severity of this invasive pest and its management simultaneously.

Commercial growers have mainly relied on chemical control as a primary management tactic for *T. absoluta*. Because of the heavy use of chemical insecticides, this insect has developed resistance to organophosphates, pyrethroids and others. Pheromone traps are widely used for monitoring and mass trapping. Growers need to implement mass trapping with insecticides or on an area-wide basis to be effective. Several parasitoids and predators of *T. absoluta* have been identified in other *Tuta* affected countries. Biopesticides such as *Bacillus thuringiensis* (*Bt*), *Beauveria bassiana*, and neem products are used in an IPM approach.

Under this project, survey on incidence and pest status of tomato leafminer, *Tuta absoluta* in different region of Bangladesh like Gazipur, Panchagarh, Comilla, Moulvibazar and Jessore and Development of Biorational Management Approach(es) against Tomato leafminer, *Tuta absolutawere* conducted. From the survey results it was found that tomato leaf miner, *Tuta absoluta* damaged up to 27.36% leaves and 25.25% tomato fruits. Among five locations, the highest infestation was observed at Panchagarh and the lowest at Comilla. The peak period of *Tuta* attack was observed in March- April in winter and May-June in summer season and this introduced pest is appearing as a serious challenge to the farmers of Bangladesh especially at Panchagarh regions . The population of this pest was much more higher during summer season than that of winter season. The *Tuta* catch was positively correlated with monthly average temperature, %Relative Humidity (%RH) and rainfall (mm).

Field experiment on “Development of Bio-rational Management Approach(es) Against Tomato leafminer, *Tuta absoluta*” was conducted during two consecutive seasons (winter and summer season) at Gazipur and Panchagarh, respectively. So, considering the result of two consecutive seasons, T₉ treatment package (Application of *Metarrhiziumanisopliae* biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap) may be recommended for controlling tomato leafminer, *Tuta absolutawhich* performed best in reducing *Tuta* infestation, increase of marketable yield highest marginal benefit cost ratio.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project:

Risk assessment and development of management approach(es) against tomato leaf miner, *Tutaabsoluta* Meyrick.

2. Implementing organization: Bangladesh Agricultural Research Institute (BARI)

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator:

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4. Sub-project budget (Tk):

4.1 Total: 1795155.00 (Taka seventeen lac ninety five thousand one hundred fifty five only)

4.2 Revised (if any): 1795155.00 (Taka seventeen lac ninety five thousand one hundred fifty five only)

5. Duration of the sub-project:

5.1 Start date (based on LoA signed): 11May 2017

5.2 End date: 30 September 2018

6 Justification of undertaking the sub-project:

Tomato (*Lycopersicon esculentum* Mill) is one of the most important and popular vegetables in Bangladesh can be grown round the years. It is a good source of vitamin A and C, and it provides antioxidant elements such as lycopene which prevents cancer (Bhutani and Kallo, 1983). It is covered by 6.27% area of the vegetable crops (BBS, 2015). During 2014-15, 414000MT tomato was produced from 30769.23 hectares of land (BBS, 2015). Due to its palatability and vitamin content, its demand in general is increasing day by day throughout the year. But *Tutaabsoluta* is a devastating pest of Tomato originated from South America. In 2006, it was identified in Spain. Since then, it has spread all over Europe, Mediterranean

region, Middle east, Africa and in some countries of central and south Asia. In 2014, it moved in India (Sridhar *et al.*, 2014). Very recently (2016) *Tutaabsoluta* has been detected in Bangladesh (Hossain *et al.*, 2016). It is known to cause 80 to 100% crop loss in tomato (Desneux *et al.*, 2010). The infestation of *Tutaabsoluta* also reported on potato, eggplant and some solanaceous weeds (Urbaneja *et al.*, 2013). It can breed between 10-12 generations in a year. Each female can lay 250-300 eggs in her life time. It attacks on both leaf and fruit. The blotchy mines are the main symptom on leaf. On the other side, zigzag burrows are found on tomato fruits which make the fruit unfit for consumption. As it possesses the capability of rapid expansion and resistant to chemical insecticides, a hue and cry may be occurred among tomato growers and tomato industry as well in Bangladesh. Therefore, it is the right time to assess its pest status, damage severity, critical time of attack and development of effective management approach (es) against this pest. Keeping this view in mind, this project has been designed and proposed.

7 Sub-project goal:

To identify critical time of attack and severity and develop an effective and suitable bio-rational management approach against the invasive species, *Tutaabsoluta* for ensuring quality tomato production in Bangladesh.

8 Sub-project objective (s):

- To find out severity and critical time of attack of the *Tutaabsoluta* on tomato
- to develop an effective management approach(es)
- To demonstrate the impact of best management approach in terms of yield and net income and motivate the farmers to adopt this technology through field day and training/workshop.

9. **Implementing location(s):** Gazipur, Cumilla, Jashore, Moulvibazar, Sylhet and Panchagarh.

10. Methodology in brief:

Tomato is the most popular vegetable in Bangladesh can be grown round the years. But *Tutaabsoluta* is a devastating pest of Tomato. It is a very challenging pest to control. It is originated from South America. Recently *Tutaabsoluta* is considered to be a serious threat to tomato. It is known to cause 80 to 100% crop loss in tomato (Desneux *et al.*, 2010). The infestation of *Tutaabsoluta* also reported on potato, eggplant and some solanaceous weeds (Urbaneja *et al.*, 2013). The newly introduced pest from south America finding at the shores of the Mediterranean a perfect new home where it can breed between 10-12 generations a year. Each female can lay 250-300 eggs in her life time. This pest is crossing borders and

devastating tomato production both protected and open fields. The infestation of *Tuta absoluta* also reported on potato, eggplant and common beans. This moth was first known as a tomato pest in many South American countries. In 2006, it was identified in Spain. The following year it was detected in France, Italy, Greece, Malta, Morocco, Algeria and Libya. In 2009, Turkey In 2010. The advance of *Tuta absoluta* continued to the East to reach Syria, Lebanon, Jordan, Iraq and Iran. Further advances southward reached Saudi Arabia, Yemen, Oman and the rest of the Gulf States. In 2012-2014 *Tuta absoluta* moved from Egypt to reach Sudan, South Sudan and Ethiopia from the East and to reach the Senegal from the west. In 2014 it moved in India and Nepal (Sridhar *et al.*, 2014; Venkatramanan, *et al.* 2017). In 2016 *Tuta absoluta* has introduced in Bangladesh (Hossain *et al.*, 2016). Therefore, it is the right time to assess its pest status, damage severity, critical time of attack and development of effective management approach (es) against this pest. Keeping this view in mind, survey on pest status and incidence of tomato leaf miner, *Tuta absoluta* in different region of Bangladesh development of bio rational management for tomato leafminer, *Tuta absoluta* has been designed and proposed.

The survey was done in Research/ growers' tomato fields in several districts viz. Gazipur (23.5937⁰N and 90.2432⁰E), Jashore (23.1586⁰N and 89.2075⁰E), Cumilla (23.4668⁰N and 91.1631⁰E) Moulvibazar (24.4160⁰N and 91.7611⁰E) and Panchagorh (26.2050⁰N and 88.3741⁰E) separately installing delta traps containing Tuta lures during May to August 2017 for summer season and during November 2017 to April 2018 for winter seasons.

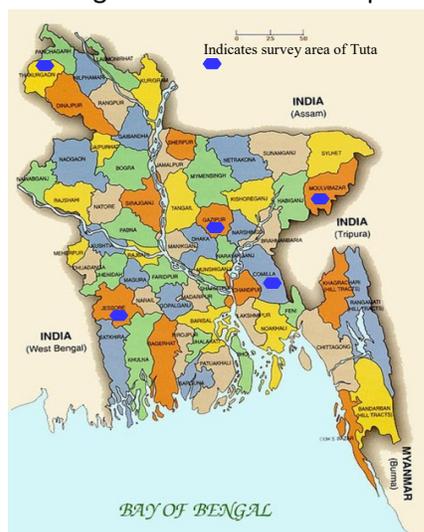


Figure 1: Survey areas in Bangladesh

At Cumilla and Moulvibazar traps were installed at Regional Horticulture/Agriculture Research Station and at Jashore and Panchagarh, traps were installed at farmers' field of Patengali and Bakshipara villages, respectively. In each field, three delta sex pheromone traps collected from Russell IPM were installed. Data were recorded on incidence of leaf miner by using absolute method i.e. counting of infested plant, leaf and fruit from randomly selected 10 plants. Intensity of leaf miner was recorded by using relative method i.e. use of Tuta sex pheromone delta traps where weekly capture of *T. absoluta* male moth was observed and counted. Weather data was collected from Sadar upazila agriculture office, Department of Agriculture Extension (DAE), Panchagarh district.

The Management of *Tuta absoluta* study was carried out at farmers' field (26.2019⁰N and 88.3745⁰E) of Panchagarh and research field of Bangladesh Agricultural Research Institute, Gazipur (23.5937⁰N and 90.2432⁰E) district, Bangladesh. These two sites represent the commercial production areas as well as different climatic zones for tomato production in Bangladesh. Studies were conducted following a Randomized Complete Block design with 10 treatments and 3 replications per location in two consecutive tomato growing seasons from October 2017 to June 2018. BARI tomato -17 and Indian Hybrid tomato variety 501 were used as test crops for winter and summer season, respectively. The treatments were, Treatment₁= Application of *Metarrhiziumanisopliae* biopesticide in soil @ 5g/L of water, Treatment₂=Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water), Treatment₃= Foliar spray of *Bacillus thuringiensis* (Biocure) @ 2g/L of water, Treatment₄= Mass trapping through installation of Delta sex pheromone trap, Treatment₅= Spraying of Spinosad (Tracer 45WSC) @ 0.5ml/L of water, Treatment₆=Spraying with Chlorantraniliprole (Coragen 20SC) @ 0.5ml/L of water, Treatment₇ = Hand picking and destruction of infested leaf and fruit Treatment₈ = Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *M. anisolpiae*biopesticide in soil @ 5g/L of water, Treatment₉= Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap+Application of *M. anisolpiae*biopesticide in soil @ 5g/L of water and Treatment₁₀ = control. Foliar sprays were applied by knap-sack sprayer. Data on number of healthy and infested plants; leaf and fruit infestation by leafminer from the whole plot was recorded weekly. On the other hand, percent plant infestation, leaf infestation per plant and fruit damage (visual estimation)by

leaf miner and marketable yield were recorded. The monetary return from the yield was calculated on the basis of farm gate price during April-June, 2018. Parameters of economic analysis were computed according to following formulas:

Gross return = Yield × Sale price,

Net return for treatment = Adjusted return – Cost of treatment

Marginal Benefit Cost Ratio = $\frac{\text{Adjusted return due to treatment}}{\text{Cost of treatment}}$

The data recorded on different parameters were analyzed statistically by using MSTAT-c software for analysis of variance after transformation. ANOVA was made by F- variance test and the differences between treatment means were compared by LSD test (Gomez and Gomez 1984).

11. Results and discussion

Incidence of Leaf miner, Tutaabsoluta: Incidence of leaf miner in plant, leaf and fruit during summer and winter season 2017-18 are presented in Figure2-4. Among different regions, the highest infestation of leaf miner was recorded at Panchagarh (84.17% plant, 27.36% leaf and 25.25% fruit) followed by Gazipur (38.50% plant, 26.60% leaf and 3.67% fruit) and the lowest infestation (5.0% plant, 6.50% leaf and 2.25% fruit) was observed at Jessore. No infestation was observed at Comilla region during the study period. The reasons of highest incidence of *Tutaabsoluta* at Panchagarh might be the first detection and establishment of Tuta at that region. Another reason could be the intensive cultivation of almost same susceptible tomato cultivars/ varieties all over Panchagarh regions. Between summer and winter season, the highest incidence was recorded in summer season irrespective of locations might be due to prevailing congenial weather condition in summer season , i.e. temperature, %RH and rainfall for their rapid reproduction. It was also observed that the incidence of this pest is comparatively higher in the month of March-April during winter season and May-June during summer season. In November, December and January, the infestation were minimum might be due to low temperature (< 15⁰c).

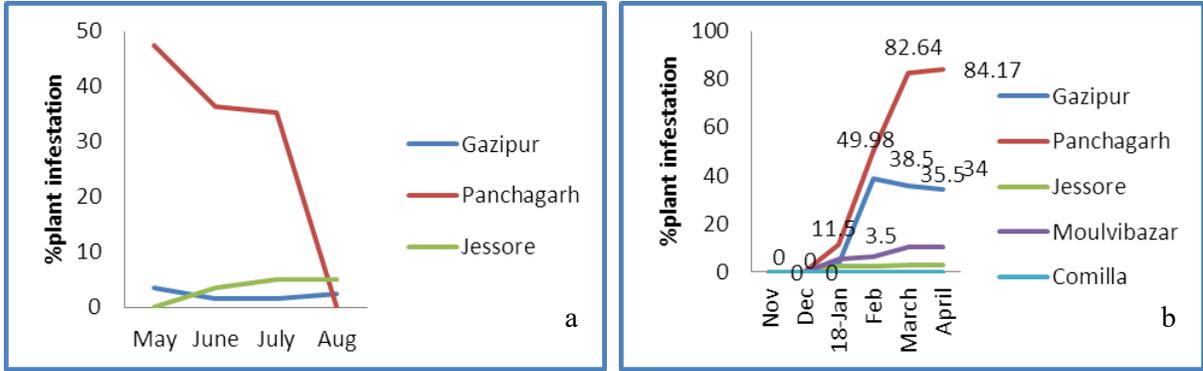


Figure-2: Tuta infested plants during summer (a) and winter seasons (b) 2017-18 at different regions

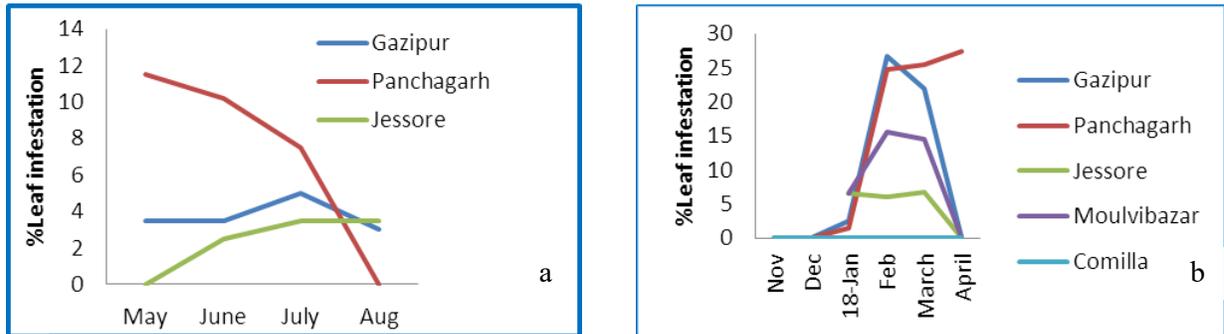


Figure-3: Tuta infested leaves during summer (a) and winter seasons (b) 2017-18 at different regions

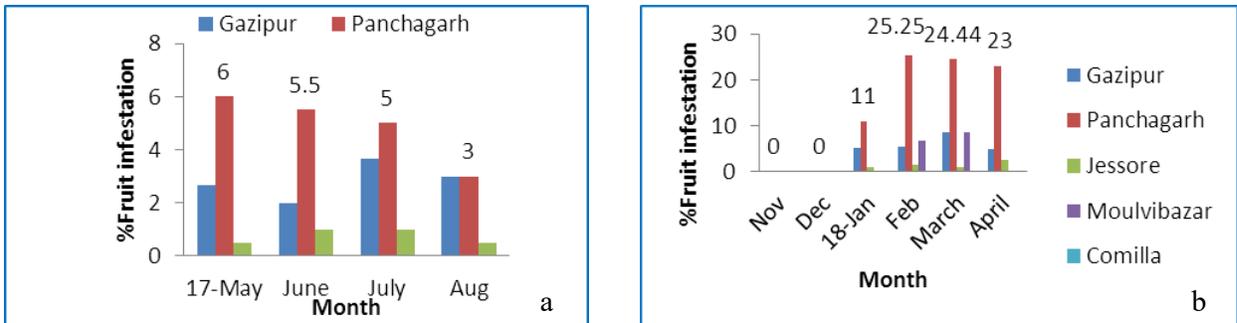


Figure-4: Tuta infested fruits during summer (a) and winter seasons (b) 2017-18 at different regions

Population of *Tuta absoluta* in summer and winter season: Average number of weekly captured *Tuta absoluta* leafminer male moth per trap during May 2017 to April 2018 at different regions are shown in Figure 5 and Figure 6. Results indicated that the highest numbers of *Tuta absoluta* were caught in Panchagarh (275.5/trap/week) during month of May in summer season and March–April (137–142/trap/week) during winter season followed by Gazipur. On the other hand, the lowest population (0.0 to 0.50/trap/week) was recorded in the month of November and December irrespective of locations.

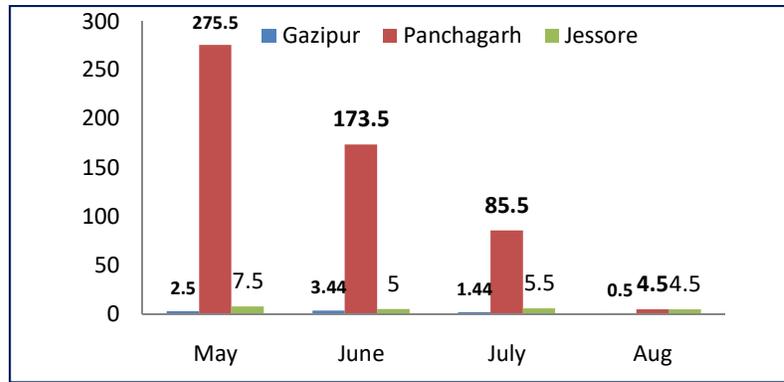


Figure 5: Number of *Tuta absoluta* captured /trap/week during summer season 2017

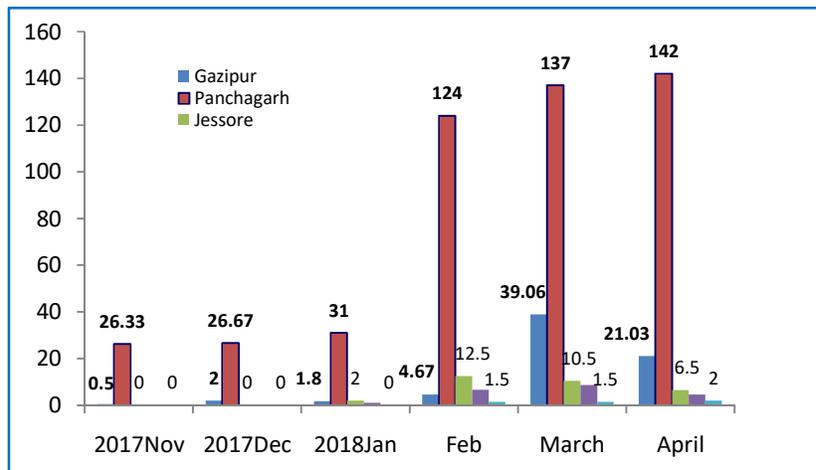


Figure 6: Number of *Tuta absoluta* captured /trap/week during winter season 2017-2018

Relationship between weather parameters and Tuta population

Tuta absoluta population was correlated with weather parameters prevailing during May 2017 to June 2018 cropping period. Tuta catch was positively correlated with monthly average temperature, %Relative Humidity (%RH) and rainfall (mm) (Figure 7-9). Figures indicated that Tuta population increased with the increase of temperature, %RH and rainfall.

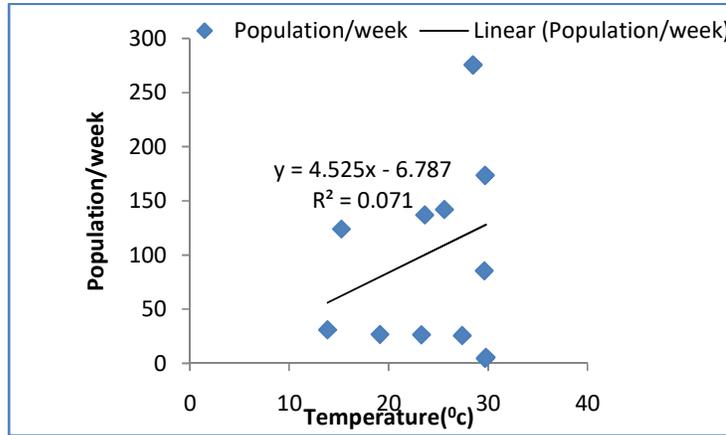


Figure 7: Relationship between monthly average Temperature and *Tutaabsoluta* population during January to June 2018 at Panchagarh

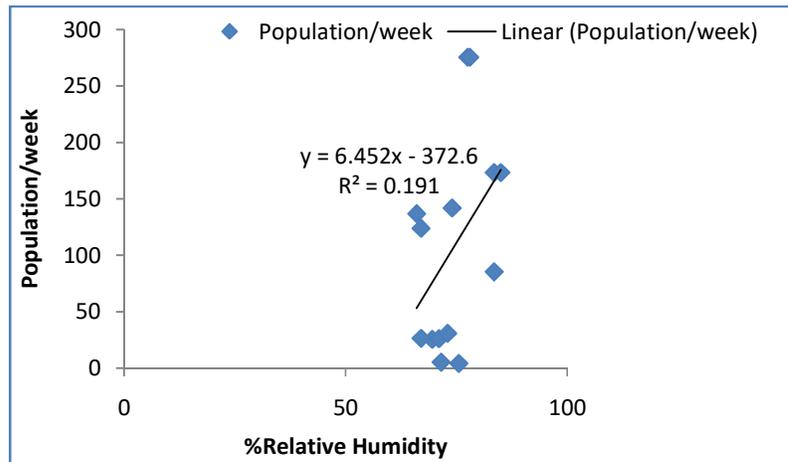


Figure 8: Relationship between monthly average %RH and *Tutaabsoluta* population during January to June 2018 at Panchagarh

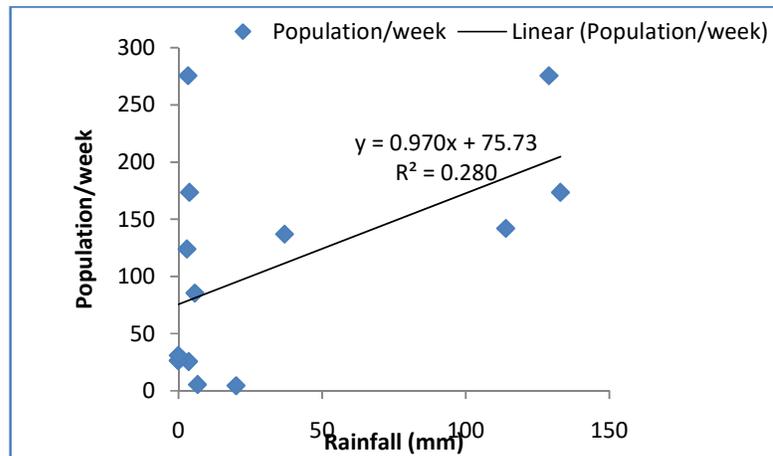


Figure 9: Relationship between monthly average Rainfall and *Tutaabsoluta* population during January to June 2018 at Panchagarh

Conclusion

From the results it could be concluded that tomato leafminer , *Tutaabsoluta* has already appeared and established as a major pest and new threats in tomato production at Panchagarh region though it was detected at that region just two years' back and now spreading rapidly as a serious threats to the tomato farmers of Bangladesh. So, management approach (es) should be developed immediately against this pest.

References

- Desneux, N., M. G. Luna, T. Guillemaud & A. Urbeneja. 2011. The invasive South American tomato pinworm, *Tutaabsoluta*, continues to spread in Afro-Eurasia and beyond: The new threat to tomato world production. *J. Pest Sci.* 84: 403–408.
- Hossain, M. S., M. Y. Mian, and R. Muniappan. 2016. First Record of *Tutaabsoluta* (Lepidoptera: Gelechiidae) from Bangladesh. *Journal of Agricultural and Urban Entomology* Jan 2016 : Vol. 32, Issue 1, pg(s) 101-105 doi
- Sridhar, V., A. K. Chakravarthy, R. Asokan, L. S. Vinesh, K. B. Rebijith & S. Vennila. 2014. New record of the invasive South American tomato leafminer, *Tutaabsoluta* (Meyrick) (Lepidoptera: Gelechiidae) in India. *Pest Manag.Hortic.Ecosyst.* 20: 148–154.
- Urbaneja, A., N. Desneux, R. Gabarra, J. Arnó, J. Gonzalez-Cabrera, A. Mafra-Neto, L. Stoltman, A. D. S. Pinto & J. R. P. Parra. 2013. Biology, ecology and management of the South American tomato pinworm, *Tutaabsoluta*, pp. 98–125. *In* J. Pena [Ed.], *Potential invasive pests of agricultural crops*. CAB International, Oxfordshire, UK, 464 pp.
- Venkatramanan, S, achla Martha, Stephen Eubank, MadavMarathe and AbhijinAdiga. 2017. Hybrid models for Ecological and Anthropogenic drivers of pest invasion: Case Study of *Tutaabsoluta* in Nepal. Published in Proceedings of International Conference on Biodiversity, climate change assessment and impacts on Livelihood during 10-12 january 2017, at Kathmandu, Nepal.

Some pictorial views of *Tutaabsoluta* survey Experiment:



Photograph: Experimental field view during summer season (May-August) at Gazipur



Photograph: Tuta infested leaf and fruits



Photograph: Trapped male adult *Tutaabsoluta* at Panchagarh during Mav 2017



Photograph: Experimental field view during winter season 2017-18 at Gazipur

11.2 DEVELOPMENT OF BIORATIONAL MANAGEMENT FOR TOMATO LEAFMINER, *TUTA ABSOLUTA*

Effect of different treatments on plant, leaf and fruit infestation

Effect of different treatments on percent plant, leaf and fruit infestation by *T. absoluta* at Panchgarh and Gazipur are presented in Table1. The lowest plant (45.23%) and leaf (14.55%) infestation was recorded in T₉ treatment (Application of *M. anisopliae* biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap followed by T₈ treatment (Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *M. anisopliae* biopesticide in soil @ 5g/L of water) at Panchagarh. Per cent reduction of infestation over control were also exhibited the same trend. At Gazipur, the lowest plant (6.78%) and leaf (5.06%) infestation were recorded in T₉ treatment (Application of *M. anisopliae* biopesticide in soil @ @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap) followed by T₈ treatment (Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *M. anisopliae* biopesticide in soil @ 5g/L of water). Both of them were statistically at par.

Accordingly, per cent reduction of infestation over control were also exhibited the same trend. On the contrary maximum infestation was recorded in untreated control plot both at Panchagarh and Gazipur.

Effect of different treatments on Percent fruit infestation by *T. absoluta* at Panchagarh and Gazipur during 2017-18 are presented in Table 2. At Panchagarh, the treatment T₉ had the lowest fruit infestation (10.92%) followed by T₈ treatment (11.00%). Maximum fruit infestation (19.97%) was recorded in control plot. Accordingly, maximum reduction of fruit infestation over control was also found in Treatment T₉ (45.32%) followed by T₈ treatment (44.92%). The similar trend was also found at Gazipur.

Table 1: Effect of different treatments on Percent plant and leaf infestation by *Tutaabsoluta* at Panchagarh and Gazipur during 2017-18

Treatment	Dosage	% plant infestation		% reduction over control		% leaf infestation		% reduction over control	
		Panchagarh	Gazipur	Panchagarh	Gazipur	Panchagarh	Gazipur	Panchagarh	Gazipur
T ₁	5kg/ha	58.64(49.96)b	10.21(18.61)c	30.72	70.36	19.22(4.38)c	7.58(2.75)c	24.33	51.22
T ₂	1.0 ml/L	60.20(50.90)b	8.64(16.97)c	28.88	74.92	17.69(4.20)d	7.26(2.67)c	30.35	53.28
T ₃	2 g/L	58.99(50.17)b	7.23(15.58)c	30.30	79.01	16.97(4.12)de	5.93(2.43)c	33.19	61.84
T ₄	-	80.43(63.74)a	17.30(24.59)b	4.97	49.78	23.35(4.83)b	0.09(3.18)b	8.07	35.07
T ₅	0.5ml/L	46.63(43.04)c	9.86(18.27)c	44.91	71.38	15.07(3.88)fg	7.53(2.74)c	40.67	51.54
T ₆	0.5ml/L	49.14(44.49)c	10.99(19.31)bc	41.94	68.09	16.06(4.00)ef	7.20(2.68)bc	36.77	53.67
T ₇	-	81.28(64.40)a	23.07(28.69)b	3.97	33.03	23.43(4.84)b	4.52(3.81)b	7.76	6.56
T ₈	-	46.40(42.91)c	9.09(17.54)c	45.18	73.61	14.76(3.84)fg	6.41(2.52)c	41.89	58.75
T ₉	-	45.23(42.24)c	6.78(15.09)c	46.56	80.32	14.55(3.81)g	5.06(2.25)c	42.72	67.44
T ₁₀	-	84.64(66.94)a	34.45(35.87)a	-	-	25.40(5.03)a	5.54(3.94)a	-	-
Level of significance		**	**			**	**		
CV%		5.37	8.56			3.05	5.71		

[Treatments: Treatment₁= Application of *Metarrhiziumanisolpia* biopesticide in soil @ 5g/L of water, Treatment₂=Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water), Treatment₃= Foliar spray of *Bacillus thuringiensis* (Biocure) @ 2g/L of water, Treatment₄= Mass trapping through installation of Delta sex pheromone trap, Treatment₅= Spraying of Spinosad (Tracer 45WSC) @ 0.5ml/L of water, Treatment₆=Spraying with Chlorantraniliprole (Coragen 20SC) @ 0.5ml/L of water, Treatment₇= Hand picking and destruction of infested leaf and fruit Treatment₈= Foliar spray of *Bacillus thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *Metarrhiziumanisolpia* biopesticide in soil @ 5g/L of water, Treatment₉= Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap+Application of *Metarrhiziumanisolpia* biopesticide in soil @ 5g/L of water and Treatment₁₀= untreated control]

Table 2: Effect of different treatments on Percent fruit infestation by *Tutaabsoluta* at Panchagarh and Gazipur during 2017-18

Treatment	Dosage	% fruit infestation		% reduction over control	
		Panchagarh	Gazipur	Panchagarh	Gazipur
T ₁	5kg/ha	13.23(3.64)bcd	1.67(1.29)c	33.75	49.24
T ₂	1.0 ml/L	13.37(3.66)bcd	1.66(1.23)c	33.05	49.54
T ₃	2 g/L	12.80(3.58)bcd	1.77(1.33)c	35.90	46.20
T ₄	-	18.29(4.28)ab	2.02(1.41)bc	8.41	38.60
T ₅	0.5ml/L	11.44(3.38)cd	1.44(1.11)c	42.71	56.23
T ₆	0.5ml/L	16.98(4.05)abc	1.32(1.14)c	14.97	59.88
T ₇	-	16.42(4.05)abcd	2.71(1.64)ab	17.78	17.63
T ₈	-	11.00(3.36)cd	1.63(1.27)c	44.92	50.45
T ₉	-	10.92(3.30)d	1.27(1.12)c	45.32	61.39
T ₁₀	-	19.97(4.47)a	3.29(1.81)a	-	-
Level of significance		**	**		
CV%		17.00	9.16		

[Treatments: Same as indicated under table1

Effect of different treatments on marketable yield

The results indicated that T₉ treatment (Application of *M. anisolpia*biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water + Mass trapping through installation of Delta sex pheromone trap) provided the highest marketable yield(51.07ton/ha) followed by T₈treatment (Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *M. anisolpia*biopesticide in soil @ 5g/L of water) (49.41ton/ha) at Panchagarh (Table 3). Accordingly 39.65% and 35.11% marketable yield were increased in T₉ treatment and T₈treatment over untreated control.

But in case of Gazipur, T₈treatment (Application of *M. anisolpia*biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap)provided the highest marketable yield (64.20 ton/ha) followed by T₉(Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *M. anisolpia*biopesticide in soil @ 5g/L of water) treatment (62.21ton/ha). Accordingly, the same trend was found in increased marketable yield over control treatment.

Table 3: Effect of different treatments on marketable yield at Panchagarh and Gazipur during 2017 - 2018

Treatment	Dosage	Marketable yield (ton/ha)		% increase over control	
		Panchagarh	Gazipur	Panchagarh	Gazipur
T ₁	5kg/ha	38.41cd	40.39ef	5.03	7.53
T ₂	1.0 ml/L	39.52cd	46.47c-e	8.07	23.72
T ₃	2 g/L	38.78cd	42.88d-f	6.04	14.16
T ₄	-	37.96cd	42.13ef	3.80	12.17
T ₅	0.5ml/L	39.06bc	43.10d-f	6.80	14.75
T ₆	0.5ml/L	40.85b	51.36bc	11.70	36.74
T ₇	-	37.96cd	40.28ef	3.80	7.24
T ₈	-	49.41 a	64.20a	35.11	70.93
T ₉	-	51.07a	62.21ab	39.65	65.63
T ₁₀	-	36.57d	37.56f	-	-
Level of significance		**	**		
CV%		7.10	5.63		

[Treatments: Same as indicated under table1

Economic analysis

Economic analysis of different treatments for managing *T. absoluta* is presented in Tables 4a and b at Panchagarh and Gazipur, respectively. At Panchagarh, the marginal benefit cost ratio (MBCR) was the highest (10.91) in T₉ treatment (Application of *M. anisopliae* biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap) treated plots followed by that of T₈ treatment (Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap + Application of *M. anisopliae* biopesticide in soil 5g/L of water) (6.95) treated plots.

Table 4a: Economic analysis of different treatments against Tomato leafminer, *Tuta absoluta* at Panchagarh

Treatment	Cost of Treatment (Tk/ha)	M. yield (ton/ha)	Gross return from produce (Tk/ha)	Net return (NR) from Treatment (Tk/ha)	Adjusted net return (Tk/ha)	MBCR
1	2	3	4	5(4-2)	6	7(6/2)
T ₁	5900.00	38.41	960250.00	954350.00	46000.00	7.80
T ₂	12050.00	39.52	988000.00	975950.00	61700.00	5.12
T ₃	22000.00	38.78	969500.00	947500.00	33250.00	1.51
T ₄	12500.00	37.96	949000.00	936500.00	22250.00	1.78
T ₅	9500.00	39.06	976500.00	967000.00	52750.00	5.55
T ₆	26375.00	40.85	1021250.00	994875.00	80625.00	3.06
T ₇	9000.00	37.96	949000.00	940000.00	25750.00	2.86
T ₈	40400.00	49.41	1235250.00	1194850.00	280600.00	6.95
T ₉	30450.00	51.07	1276750.00	1246300.00	332050.00	10.91
T ₁₀	-	36.57	914250.00		-	-

[Treatments: Same as indicated under table1

At Gazipur, the marginal benefit cost ratio (MBCR) was the highest (7.09) in T₉ (Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + Mass trapping through installation of Delta sex pheromone trap+ Application of *M. anisopliae* biopesticide in soil @ 5g/L of water) treated plots followed by that of T₈ treatment (Application of *M. anisopliae* biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap) (5.59) treated plots.

Table 4b: Economic analysis of different treatments against Tomato leafminer, *Tuta absoluta* at Gazipur

Treatment	Cost of Treatment (Tk/ha)	M. yield (ton/ha)	Gross return from produce (Tk/ha)	Net return (NR) from Treatment (Tk/ha)	Adjusted net return (Tk/ha)	MBCR
1	2	3	4	5(4-2)	6	7 (6/2)
T ₁	5900.00	40.39	403900	398000	22400	3.80
T ₂	12050.00	46.47	464700	452650	77050	6.39
T ₃	22000.00	42.88	428800	406800	31200	1.42
T ₄	12500.00	42.13	421300	408800	33200	2.66
T ₅	9500.00	43.10	431000	421500	45900	4.83
T ₆	26375.00	51.36	513600	487225	111625	4.23
T ₇	9000.00	40.28	402800	393800	18200	2.02
T ₈	40400.00	64.20	642000	601600	226000	5.59
T ₉	30450.00	62.21	622100	591650	216050	7.09
T ₁₀	-	37.56	375600	375600	-	-

Cost of Metarrhiziumanisopliae biopesticide : 5000Tk/kg
 Cost of Bioneem plus : @ Tk 2800.00/L
 Cost of *Bacillus thuringiensis* (Biocure) : @ Tk 3500.00/kg
 Cost of *TutaLure* +trap : @300Tk/Lure
 Cost of Spinosad : @4000Tk/L
 Cost of Coragen : @17500Tk/L
 Cost of hand picking :Twolabourers/ha @ Tk 450.00/day
 Cost labourers/spray/ha @ Tk 450.00/day. Spray volume required: 500L /ha
 Farm gate price of Tomato: Tk 25.00/ kg (During May, 2018)

[Treatments: Same as indicated under table1

CONCLUSION

The T₉ (Application of *M. anisopliae* bio pesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap) proved to be effective considering reduction of *T. absoluta* infestation, increase of marketable yield and marginal benefit cost ratio. So, considering the result of two consecutive seasons at two locations, T₉ treatment package (Application of *M. anisopliae* biopesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap) may be recommended for controlling tomato leafminer, *T. absoluta*.

References

- Desneux, N., M. G. Luna, T. Guillemaud and A. Urbeneja. 2011. The invasive South American tomato pinworm, *Tutaabsoluta*, continues to spread in Afro-Eurasia and beyond: The new threat to tomato world production. *J. Pest Sci.* 84: 403–408.
- Hossain, M. S., M. Y. Mian, and R. Muniappan. 2016. First Record of *Tutaabsoluta* (Lepidoptera: Gelechiidae) from Bangladesh. *Journal of Agricultural and Urban Entomology* Jan 2016 : Vol. 32, Issue 1, pg(s) 101-105 doi
- Sridhar, V., A. K. Chakravarthy, R. Asokan, L. S. Vinesh, K. B. Rebijith and S. Vennila. 2014. New record of the invasive South American tomato leafminer, *Tutaabsoluta* (Meyrick) (Lepidoptera: Gelechiidae) in India. *Pest Manag.Hortic.Ecosyst.* 20: 148–154.
- Urbaneja, A., N. Desneux, R. Gabarra, J. Arnó, J. Gonzalez-Cabrera, A. Mafra-Neto, L. Stoltman, A. D. S. Pinto and J. R. P. Parra. 2013. Biology, ecology and management of the South American tomato pinworm, *Tutaabsoluta*, pp. 98–125. *In* J. Pena (Ed.), *Potential invasive pests of agricultural crops*. CAB International, Oxfordshire, UK, 464 pp.
- Venkatramanan, S, A.Marathe, S. Eubank, M. Marathe and A. Adiga. 2017. Hybrid models for Ecological and Anthropogenic drivers of pest invasion: Case Study of *Tutaabsoluta* in Nepal. *Proceedings of International Conference on Biodiversity, climate change assessment and impacts on Livelihood during 10-12 January 2017, Kathmandu, Nepal.*

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

- Among five locations, the highest infestation of Tomato leaf miner *Tutaabsoluta* was observed at Panchagarh and the lowest at Comilla.
- The peak period of Tuta attack was observed in March- April in winter and May-June in summer season
- The population of this pest was higher during summer season than that of winter season.
- The Tuta population was positively correlated with temperature, %Relative Humidity (%RH) and rainfall (mm)
- Tomato leaf miner , *Tutaabsoluta* has already appeared and established as a major pest and new threats for tomato production at Panchagarh region
- Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water)+ Mass trapping through installation of Delta sex pheromone trap + Application of *M. anisopliae* bio pesticide in soil @ 5g/L of water performed best in reducing *T. absoluta* infestation, increase of marketable yield and highest marginal benefit cost ratio.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	115000.00	115000.00	100%	100%	
(b) Lab & field equipment					
(c) Other capital items					

2. Establishment/renovation facilities: N/A

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

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

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(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	504170.1	504170	504170.1	-0.1	100.00	
B. Field research/lab expenses and supplies	699985	629539	688074	-58535	98.30	Delay fund received
C. Operating expenses	106000	104593	91595	12998	86.41	
D. Vehicle hire and fuel, oil & maintenance	156000	145750	116250	29500	74.52	
E. Training/workshop/seminar etc.	89000	86165	0	86165	0.00	
F. Publications and printing	95000	0	25500	-25500	26.84	
G. Miscellaneous	30000	29500	22400	7100	74.67	
H. Capital expenses	115000	115000	115000	0	100.00	

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)
To find out severity and critical time of attack of the Tutaabsoluta on tomato	Data were recorded on incidence of leaf miner by using absolute method i.e. counting of infested plant, leaf and fruit. Intensity of leaf miner was recorded by using relative method i.e. use of Tuta sex pheromone delta traps where weekly capture of <i>T. absoluta</i> male moth was observed and counted. Weather data was collected monthly basis	Severity and critical time of attack of the Tutaabsoluta on tomato was obtained	Severity and critical time of attack of the Tutaabsoluta on tomato was well documented
to develop an effective management approach(es)	Data on numbers of healthy and infested plant, leaf, fruits by leaf miner were recorded weekly. On the other hand, percent plant infestation, leaf infestation and fruit damage (visual estimation) by leaf miner were calculated. The monetary return from the yield was calculated on the basis of farm gate price during April-June, 2018.	Data of the best treatment obtained MBCR obtained	Best management option achieved
To demonstrate the impact of best management approach in terms of yield and net income and motivate the farmers to adopt this technology	-	Input for motivation generated	Most effective and economic technologies well documented

through field day and training/workshop.			
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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.	-	Booklet-1 Factsheet-1	Hossain, MS, A K Das and GMA Halim. 2018. Risk of American Tomato Leaf Miner, <i>Tutaabsoluta</i> in Bangladesh and its management approaches (In Bangla). Entomology Section, Horticulture Research Center, Bangladesh Agricultural research Institute, 9pp. American Tomato leafminer, <i>Tutaabsoluta</i> and its' management.
Journal publication		1 (Accepted)	Hossain, M. S., AK Das, S. Akhter, M. Y. Mian and R. Muniappan. 2018. Management of south American tomato leafminer, <i>Tutaabsoluta</i> in Bangladesh. Journal of biological control. (Accepted)
Information development			-
Other publications, if any	-	-	-

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

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

Application of *Metarrhizium isolpiae* bio pesticide in soil @ 5g/L of water + Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + Mass trapping through installation of Delta sex pheromone trap can be recommended for controlling tomato leafminer, *T. absoluta*.

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

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

iii. Policy Support

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

16 January 2018& 1 time visit by Dr. Md. Abdul Jalil Bhuyan and his associates

ii) Field Monitoring (time& No. of visit, Team visit and output): 02

Visited two times at 16 January and 22 February 2018 by the following personnel;

- Dr. Md. Dr. Md. Abdul Jalil Bhuyan, Research management specialist, NATP-2, BARC
- Dr. Md. Aziz Zillani Chowdhury, Member Director (Crop) BARC, Dhaka
- Dr. Abdus Salam, CSO (Crop), BARC, Dhaka
- Dr. Md. Kabir Uddin, CSO, BARC, Dhaka
- Md. Monirul Islam NATP-2, BARC, Dhaka
- Mr. Abdul Mamun, NATP-2, BARC, Dhaka

Output: Monitoring team gave some valuable advices for the betterment of study those were followed as per their suggestions.

H. Lesson Learned/Challenges (if any):

- i) High rainfall and hail storm caused partial damage of crop at Panchagarch during study period
- ii) Some plants were infected by virus disease which hampered the yield at Panchagarh

I. Challenges (if any):

- i. Could not able to conduct training and workshop due to lack of timely release of fund.

Signature of the Principal Investigator

Date

Seal

Counter signature of the Head of the

organization/authorized representative

Date

Seal