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Competitive Research Grant

Sub-Project Completion Report

on

UPSCALING OF LAC PRODUCTION TECHNOLOGIES FOR POVERTY REDUCTION OF THE ULTRA POOR AND MARGINAL FARMERS

Project Duration

May 2017 to September 2018

Entomology Division, Bangladesh Agricultural Research Institute
Joydebpur, Gazipur



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



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UPSCALING OF LAC PRODUCTION TECHNOLOGIES FOR POVERTY REDUCTION OF THE ULTRA POOR AND MARGINAL FARMERS

Project Implementation Unit

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Bangladesh Agricultural Research Council (BARC)

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National Agricultural Technology Program-Phase II Project (NATP-2)

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Bangladesh

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Table of Contents

Sl. no.	Contents	Page No.
	List of tables	i
	Executive Summary	iv
1.	Title of the Sub-Project	1
2.	Implementing organization	1
3	Principal Investigator and Co- Principal Investigators	1
4.	Sub-project Budget	1
5.	Duration of the sub-project	1
6.	Justification of undertaking the sub-project	1
7	Sub-project goal	1
8.	Sub-project objectives	1
9	Implementing location	1
10.	Methodology in brief	1
11.	Results and discussion	7
12	Research highlight/findings	24
B.	Implementation position	24
C.	Financial and physical progress	25
D.	Achievement of Sub-project by objectives: (Tangible form)	26
E	Materials Development/Publication	26
F	Technology/Knowledge generation/Policy Support (as applied)	26
G	Lesson Learned/Challenges (if any)	27
H	Challenges	27
i.	Suggestion for future (if any)	27

List of Tables

Table	Contents	Page No.
1	Length and breadth of new ber shoots in kartiki and baisakhi lac crop at 4-different regions of Bangladesh	7
2	Lac production efficacy of ber at four different regions of Bangladesh during July-October 2017 kartiki crop season	8
3	Lac production efficacy of ber at four different regions of Bangladesh during November 2017-June 2018 baishakhi crop season	9
4	Lac production efficacy of rain tree at 2-different locations of Chapainawabganj during July-October 2017 kartiki crop season	9
5	Lac production efficacy of rain tree at 2-different locations of Chapainawabganj during November 2017-June 2018 baishakhi crop season	10
6	Lac production efficacy of babla at 2-different locations of Chapainawabganj during June-October 2017 kartiki crop season	10
7	Lac production efficacy of babla at 2-different locations of Chapainawabganj during November 2017-June 2018 baishakhi crop season	11
8	Nymphs/10 cm ² shoot area of different ber cultivars during July-October 2017 kartiki and November 2017-June 2018 baishakhi crop season (pooled data)	12
9	Lac production efficacy of ber cultivars at 4-different regions of Bangladesh during July-October 2017 kartiki crop season	13
10	Lac production efficacy of ber cultivars at 4-different regions of Bangladesh during November 2017-June 2018 baishakhi crop season	13
11	Mean number of lac predators during July-October 2017 kartiki lac crop season at different locations of Bangladesh	14
12	Effect of different treatments in reducing <i>Eublemma amabilis</i> populations over untreated control at different regions of Bangladesh during July– October, 2017 kartiki crop season	15
13	Effect of different treatments in reducing <i>Pseudohypatopa pulveria</i> populations over untreated control at different regions of Bangladesh during July– October, 2017 kartiki crop season	15
14	Effect of treatments on lac insect population at different regions of Bangladesh during July– October, 2017 kartiki crop season	16
15	Effect of treatments on the yield of lac at different regions of Bangladesh during July–October, 2017 kartiki crop season	16
16	Benefit cost analysis after application of treatments for controlling lac predators during July–October, 2017 kartiki crop season	17
17	Mean number of lac predators at different locations of Bangladesh	17

	during November 2017-June 2018 baishakhi crop season	
18	Effect of different treatments in reducing <i>Eublemma amabilis</i> populations over untreated control at different regions of Bangladesh during November 2017-June 2018 baishakhi crop season	18
19	Effect of different treatments in reducing <i>Pseudohypatopa pulveria</i> populations over untreated control at different regions of Bangladesh during November 2017-June 2018 baishakhi crop season	19
20	Effect of treatments on lac insect populations over untreated control in November 2017-June 2018 baishakhi crop season at different regions of Bangladesh	20
21	Effect of treatments on the yield of lac n at different regions of Bangladesh during November 2017-June 2018 baishakhi crop season	20
22	Benefit cost analysis after application of treatments for controlling lac predators during November 2017-June 2018 baishakhi crop season	21
23	Effect of treatments on lac insect population and yield of lac during November 2017-June 2018 baishakhi lac crop season Nachole, Chapainawabganj	22

Executive Summary

Lac is a natural resin secreted by an insect *Kerria lacca* (Kerr), which thrives on the tender twigs of specific host trees viz, ber (*Zizyphus mauritiana*). It has a versatile use in our country like furniture burnishing, tannery industry, jewellery industry, post office, machine tools factory etc. Lac can be considered as the promising cash crop in Bangladesh. Lac cultivation is very simple; no extra land is required, need small investment and requires only part-time attention. Since lac insects are cultured on host trees (e.g. ber, rain tree, babla, khair, palash, etc.) grown primarily in wasteland areas, on different fallow lands, homestead areas, besides ponds, ails, ditches, roads, railways etc. Promotion and expansion of lac cultivation in promising areas could bring reasonable income and employment for the ultra poor and marginal farmers.

The overall weather and soil condition of most of the areas of Bangladesh are suitable for lac cultivation. Long time lac cultivation was confined in the north-west corner of the country, especially at Rajshahi and Chapainawabgonj regions. Through a sub-project funded by NATP: Phase-I, lac research was strengthened and expanded in some areas of Rangpur, Nilphamari and Joydebpur, Gazipur. Through this project, the modern lac cultivation technologies have been validated and introduced to lac growers both in existing lac producing and new promising areas of the country viz. Nachole of Chapainawabgonj; RARS, Jamalpur and BARI, Joydebpur, Gazipur.

There are many lac host plants in different areas of Bangladesh remain unutilized. Under this project, lac cultivation was expanded utilizing those host plants and thus not only a large amount of raw lac (stick lac) was produced but also a large number of un-employed, ultra poor and marginal farmers earned some money from it.

There are some constraints in lac cultivation like lac enemies (predators, parasites etc.), extreme hot weather condition and in some extent tradition, superstition and ignorance of lac growers. Modern lac cultivation technologies like predator management techniques, water application at extreme hot weather condition during March-May and improved lac production techniques have been demonstrated and expanded to lac farmers at three different areas of Bangladesh that increased lac production and income generation for ultra poor and marginal farmers. Thus the project complies with the National Agricultural Policy (NAP), Sustainable Development Goal (SDG) and objectives of NATP through income generation, employment opportunities and uplifting livelihood of ultra poor and marginal farmers.

For the expansion of lac cultivation, host plants have been planted in different project areas. So, planting of huge number of host plants surely create positive impact on environment. With increasing universal environment awareness, the importance of lac has assumed special relevance in the present age, being eco-friendly, bio-degradable and self-sustaining natural materials. Through this project, lac production and socio-economic condition of the lac farmers have been increased to a considerable extent.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: UPSCALING OF LAC PRODUCTION TECHNOLOGIES FOR POVERTY REDUCTION OF THE ULTRA POOR AND MARGINAL FARMERS

2. Implementing organization: Bangladesh Agricultural Research Institute

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

a. Principal Investigator: Dr. Debasish Sarker, Chief Scientific Officer & Head, Entomology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Tel: 02-49270124, Cell: 01712274933 e-mail: dpsarker@gmail.com

b. Co- principal investigators:

1. Dr. Md. Mokhlesur Rahman, Principal Scientific Officer, Lac Research Station, BARI, Chapainawabganj. Tel : 0781-52263 Cell:01712652089 e-mail: mmrahman1234@yahoo.com

2. Dr. Jagadish Chandra Barman, Senior Scientific Officer, Lac Research Station, BARI, Chapainawabganj. Tel : 0781-52263 (on request) Cell: 01737220042 e-mail: barrmansso@yahoo.com

4. Sub-project budget (Tk):

4.1 Total : 17,99,120/-

4.2 Revised : 17,99,120/-

5. Duration of the sub-project:

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

5.2 End date : 30 September 2018

6. Justification of undertaking the sub-project:

Lac can be considered as the promising cash crop in Bangladesh. Lac cultivation is very simple; no extra land is required, need small investment and requires only part-time attention. Lac has a great importance for its versatile use throughout the world. It is widely used in paint and varnishing, ornaments, cosmetics, electric insulation, pharmaceutical industries, jewelry industry, chocolate and fruit coating, urea coating, tannery industries, automobile industries, machine tool factories, textile industries etc. The major world demand of lac is being fulfilled by India. Bangladesh has a great opportunity to take part in sharing the world lac market. Since lac insects are cultured on host trees (e.g. ber, rain tree, babla, khair, palash, etc.) grown primarily in wasteland

areas, on different fellow lands, homestead areas, besides ponds, ails, ditches, roads, railways etc., promotion and expansion of lac cultivation in promising areas could bring reasonable income and employment for the ultra poor and marginal farmers.

The overall weather and soil condition of most of the areas of Bangladesh are suitable for lac cultivation. For long time lac cultivation was confined in the north-west corner of the country. Through a sub-project funded by NATP: Phase-2, lac research has been strengthened and expanded in some areas of Chapainawabganj, Jamalpur and Gazipur regions. Upscaling of the modern lac cultivation technologies in new promising areas of the country undoubtedly increased lac production, uplifted income generation and created employment opportunities for ultra poor and marginal farmers. Thus the present sub-project complies with the National Agricultural Policy (NAP), Sustainable Development Goal (SDG) and objectives of NATP through income generation, employment opportunities and uplifting livelihood of ultra poor and marginal farmers.

7. Sub-project goal: Improve livelihood condition of the ultra poor and marginal farmers.

8. Sub-project objective (s):

1. Development of management packages of biotic and abiotic stresses of lac cultivation at the targeted AEZ.
2. Field validation of the developed technologies and expansion of lac cultivation in promising areas of the country involving ultra poor and marginal farmers for poverty reduction.
3. Awareness development of lac growers, extension personnel and related consumers on the developed technologies as well as different aspects of lac cultivation for the improvement of lac industry.

9. Implementing location (s): Chapainawabganj, Jamalpur and Gazipur.

10. Methodology in brief:

Under the sub-project, Different activities have been done at 03 (three) different Agro-ecological Zones (AEZ) of the country, covering Chapainawabganj, Jamalpur and Gazipur regions. Within first three months, the project areas and farmers were selected. Lac insects require plant hosts for its development, survival and reproduction. The important host plants available in Bangladesh are jujube (*Zizyphus jujuba*), babla (*Acacia arabica*) and rain tree (*Samania saman*). Therefore, Farmers were selected on the basis of: (i) those who have at least 3 (three) medium sized jujube/babla/rain tree plants and (ii) interest on lac cultivation utilizing modern technologies. In each location, 50 farmers were selected for kartiki crop and another 50 for baishakhi crop. Three villages from Chapainawabganj region, two villages from Jamalpur region and one village from Gazipur region have been selected for the project activities. A total of 2,000 existing host plants have been brought under lac cultivation.

The first criterion for lac cultivation is the availability of tender shoots on the host plants as tiny red-coloured nymphs of lac insects settle on the young, succulent shoots of the host plants and suck the plant sap till the completion of their life cycle. So, pruning of host plants was an essential operation here. This operation has been done in two different times for two different crops, viz., kartiki and baishakhi crop in each year. Thinning/removal of off-shoots, application of fertilizers and irrigation (as and when needed) have been done under this program. Farmers of this program have got monetary benefits for field preparation, purchasing of fertilizers, labour cost for preparation of host plants, application of fertilizer, irrigation and intercultural operations.

Lac is a non-conventional but promising cash crop in Bangladesh. Farmers are growing lac crops following traditional cultivation procedures. Modern lac cultivation techniques are essential for increased lac production and more monetary benefits. Expansion of modern lac cultivation techniques requires the promotional activities like awareness building through seeing and believing methods and motivational visits on its improved production technology demonstration crop field. All these activities were done under this sub-project.

Collection of lac seed, distribution and inoculation on the host plants have been done at different sub-project locations under this program. Farmers has get monetary benefits for the purchasing of lac seeds, labourers cost during lac seed inoculation, intercultural operation and processing cost from this sub-project. The farmers has also get yield of lac from the host plants.

Continuous monitoring on the growth and development of lac insects in different sub-project locations has been done during the whole cropping period. The number of lac nymphs/cell during initial settlement and at harvest, growth and development of lac nymphs and crops has been monitored and recorded during both the cropping seasons. The yield data were recorded for economic analysis.

Collected data has been summarized and analyzed through tabular method using descriptive statistics. Spreadsheet tool like MS Excel has been used for data entry and analysis in computer. Computer based statistical package MSTAT has also been used for data analysis. Monthly statement of expenditure (SoE) has been submitted monthly, periodical financial report has been submitted quarterly and technical report at half-yearly. Annual technical and financial reports have been submitted at each year ending and the final technical and financial reports have been submitted during the end of the sub-project.

To fulfill the objectives of the sub-project, the following experiments have been conducted with referred methodologies:

PRODUCTION OF LAC CROP ON EXISTING HOST PLANTS AT DIFFERENT REGIONS OF BANGLADESH

The study was conducted to compare the development of lac insect and yield of lac on different host plants at Lac Research Station and Nachole of Chapainawabganj; RARS, Jamalpur and BARI, Gazipur regions during July-October 2017 kartiki crop and November 2017-June 2018 baishakhi crop seasons. Three different existing host plants (treatments) viz. jujube (*Zizyphus jujuba*), babla (*Acacia arabica*) and rain tree (*Albizia lebbek*), depending upon the availability at targeted areas, were selected to study lac production efficacy following Randomized Complete Block and replicated design. One tree of each host was considered as a replicate and 5 replications were considered for each treatment. The average age of jujube plants was 20 years in all locations except Gazipur (average age was 15 years), the age of babla was 20 years and the age of rain tree was 15 years. In order to grow new tender shoots, pruning was done in the last week of February and at the end of April 2017 for kartiki and baishakhi lac crop, respectively. Comparatively light pruning was done for rain tree plants. Fertilizers and irrigation were applied to the host plants to enhance new shoot growth. Lac seeds were collected from the previous crop (host: jujube) for the inoculation to new host trees. The host plants were inoculated by broodlac in the last week of June 2017 for kartiki crop and in the first week of November 2017 for baishakhi crop with 50 sticks of 30 cm length in each plant except rain tree. One hundred broodlac sticks of same size were used for each rain tree inoculation. During inoculation, the broodlac sticks were tied onto the host branches both vertically and horizontally for the reason that the young shoots get full inoculation. After 7 days, when the inoculation was completed the broodlac sticks were collected from the host and brought to the store for collection of sticklac.

After settlement of the tiny lac nymphs on young shoots, 5 samples, each of 10 cm² area, were selected from different shoots in each replication and the number of nymphs was recorded (in-situ) separately at 15 days intervals up to crop harvest. After cell formation by the nymphs, the population was enumerated on the estimated basis of the number of the cells on 10 cm² area of 5 shoots selected from each replication. The individual cells were recorded with the help of a fine needle and forceps separately at 15 days interval up to crop harvest. Regular observations were made on the growth and development of lac crop. The yield of sticklac was recorded separately during harvest. Per cent mortality of lac insects was calculated on the basis of initial and final population data.

PRODUCTION OF LAC ON DIFFERENT BER CULTIVARS AT DIFFERENT REGIONS OF BANGLADESH

The study was conducted to compare the development of lac insect and yield of lac on different ber cultivars at Lac Research Station and Nachole of Chapainawabganj; RARS, Jamalpur and BARI, Gazipur areas during July-October 2017 kartiki crop season and November 2017-June 2018 baishakhi crop season. Three different ber cultivars (treatments) viz. local kul, appel kul and BAU kul were selected to study lac production

efficacy at different regions of Bangladesh following RCB and replicated design. One tree of each host was considered as a replicate and 5 replications were considered for each treatment. The average age of ber plants was 20 years in all locations except Gazipur (average age was 15 years). Lac seeds were collected from the previous crop (host: ber) for the inoculation to new host trees. In order to grow new tender shoots, pruning was done in the last week of February 2017 and in the end of April 2017 for kartiki and baishakhi crop, respectively. Fertilizing and irrigation were applied to the host plants to enhance new shoot growth. The host plants were inoculated by broodlac in the last week of June 2017 and in the first week of November 2017 for kartiki and baishakhi crop, respectively. Fifty sticks of 30 cm length were inoculated in each plant. During inoculation, the broodlac sticks were tied onto the host branches both vertically and horizontally for the reason that the young shoots get full inoculation. After 7 days, when the inoculation was completed the broodlac sticks were collected from the host and brought to the store for collection of sticklac.

After settlement of the tiny lac nymphs on young shoots, 5 samples, each of 10 cm² area, were selected from different shoots in each replication and the number of nymphs was recorded (in-situ) separately at 15 days intervals up to crop harvest. After cell formation by the nymphs, the population was enumerated on the estimated basis of the number of the cells on 10 cm² area of 5 shoots selected from each replication. The individual cells were recorded with the help of a fine needle and forceps separately at 15 days interval up to crop harvest. Regular observations were made on the growth and development of lac crop. The yield of sticklac was recorded separately during harvest. Per cent mortality of lac insects was calculated on the basis of initial and final population data.

UPSCALING AND FIELD VALIDATION OF BIO-RATIONAL BASED MANAGEMENT APPROACHES AGAINST LAC PREDATORS AND THEIR SAFETY TO LAC INSECT

The experiment was carried out at Lac Research Station and Nachole of Chapainawabganj; RARS, Jamalpur and BARI, Gazipur areas during July-October 2017 kartiki crop season and November 2017-June 2018 baishakhi crop season. Twenty years old jujube plants were used for the study in all locations except Gazipur (15 years old jujube plants). Four treatments were studied and each treatment was replicated thrice following RCB design. The treatments were as follows: T₁= Spraying of Neem seed extract @ 10g crushed seed/litre of water, T₂= Spraying of Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water, T₃= Spraying of Spinosad (Success 2.5 SC) @ 1.2 ml/litre of water, and T₄ = Control with water spray only. One jujube plant was considered as one replication of a treatment. In order to grow new tender shoots, pruning was done in the last week of February and at the end of April 2017 for kartiki and baishakhi lac crop, respectively. Fertilizers and irrigation were applied to the host plants to enhance new shoot growth. Lac seeds were collected from the previous crop (host: jujube) for the inoculation to new host trees. The host plants were inoculated by broodlac in the last week of June 2017 for kartiki crop and in the first week of November 2017 for baishakhi

crop with 50 sticks of 30 cm length in each plant. During inoculation, the broodlac sticks were tied onto the host branches both vertically and horizontally for the reason that the young shoots get full inoculation. After 7 days, when the inoculation was completed the broodlac sticks were collected from the host and brought to the store for collection of sticklac.

After settlement of the tiny lac nymphs on young shoots, 5 samples, each of 10 cm² area, were selected from different shoots in each replication and the number of nymphs was recorded (in-situ) separately at 10 days intervals up to crop harvest. After cell formation by the nymphs, the population was enumerated on the estimated basis of the number of the cells on 10 cm² area of 5 shoots selected from each replication. The individual cells were recorded with the help of a fine needle and forceps separately at 10 days interval up to crop harvest. Regular observations were made on the incidence of lac predators. The treatments were applied twice: First immediately after the pest infestation noticed while the second in one month after the first application. The appearance of lac predators, *E. amabilis* and *P. pulverea* were observed at 10 days interval up to crop harvest. This observation was made at the same time of counting lac nymphs at the same place. The stages of the predator were examined and its number was recorded. The yield of sticklac was recorded separately during harvest. Per cent mortality of lac insects was calculated on the basis of initial and final population data. Per cent reduction of predator population was calculated over untreated control treatment. Benefit cost ratios of different treatments were determined following Ali *et al.* (1996).

EFFECT OF WATER APPLICATION ON LAC YIELD UNDER EXTREME HOT WEATHER CONDITION

The main abiotic constrain of lac cultivation during baishakhi crop season is extremely higher temperature with hot wind that causes death of lac insect. Therefore, the experiment was undertaken at two different locations of Nachole under Chapainawabganj district during November 2017-June 2018 baishakhi crop season. Twenty years old jujube plants were used for the study. Three treatments were studied and each treatment was replicated five times following RCB design. The treatments were as follows: T₁= Basal application of water at 7 days intervals, T₂= Basal application of water at 15 days intervals and T₃= Control (without water application). Water was applied to the surrounding soil of the host plants during March-May as there was no rain in that period and temperature was very high. One ber plant was considered as one replication of a treatment. The host plants were inoculated by broodlac in the first week of November 2017 with 50 sticks of 30 cm length in each plant. During inoculation, the broodlac sticks were tied onto the host branches both vertically and horizontally for the reason that the young shoots get full inoculation. After 7 days, when the inoculation was completed the broodlac sticks were collected from the host and brought to the store for collection of sticklac.

After settlement of the tiny lac nymphs on young shoots, 5 samples, each of 10 cm² area, were selected from different shoots in each replication and the number of nymphs was recorded (in-situ) separately at 15 days intervals up to crop harvest. After cell formation by the nymphs, the population was enumerated on the estimated basis of the number of the cells on 10 cm² area of 5 shoots selected from each replication. The individual cells were recorded with the help of a fine needle and forceps separately at 15 days interval up to crop harvest. Regular observations were made on the incidence of lac predators. The treatments were applied twice: First immediately after the pest infestation noticed while the second in one month after the first application. The appearance of lac predators, *E. amabilis* and *P. pulverea* were observed at 15 days interval up to crop harvest. This observation was made at the same time of counting lac nymphs at the same place. The stages of the predator were examined and its number was recorded. The yield of sticklac was recorded separately during harvest. Per cent mortality of lac insects was calculated on the basis of initial and final population data. Per cent reduction of predator population was calculated over untreated control treatment. Benefit cost ratios of different treatments were determined following Ali *et al.* (1996).

11. Results and discussion:

PRODUCTION OF LAC ON EXISTING HOST PLANTS AT DIFFERENT REGIONS OF BANGLADESH

Length and breadth of shoots

Table 1. Length and breadth of new ber shoots in kartiki and baisakhi lac crop at 4-different regions of Bangladesh

Locations	Kartiki Crop		Baishakhi crop	
	Shoot		Shoot	
	Length (m)	Breadth (cm)	Length (m)	Breadth (cm)
LRS, Chapainawabgonj	2.20	1.52	2.33	1.57
Nachole Chapainawabgonj	2.12	1.43	2.23	1.50
RARS, Jamalpur	2.32	1.67	2.47	1.77
BARI, Gazipur	2.10	1.40	2.17	1.43
Level of Significance	NS	NS	NS	NS
LSD	0.331	0.035	0.044	0.470

Length and breadth of new shoots of the host plants played an important role for the settlement of lac nymphs and lac production. In kartiki and baishakhi crop seasons, statistically non-significant differences in shoot length of BER plant was obtained in different areas with the highest at RARS, Jamalpur (2.32m and 2.47m, respectively). The highest shoot breadth (1.67cm and 1.77cm in kartiki and baishakhi crop season, respectively) was also found at RARS, Jamalpur (Table 1). All the study locations showed statistically identical length and breadth of new shoots in kartiki and baishakhi crop seasons.

Table 2. Lac production efficacy of ber at four different regions of Bangladesh during July-October 2017 kartiki crop season

Locations	Lac population/10 cm ² area of shoot			Yield of Stick lac (Kg/plant)
	Initial Population	Final Population	% Mortality	
LRS, Chapainawabgonj	989.70	247.40 a	75.0 c	5.80 a
Nachole Chapainawabgonj	961.90	201.90 c	79.1 a	4.98 ab
RARS, Jamalpur	967.50	222.50 b	77.0 b	5.75 a
BARI, Gazipur	975.60	195.10 c	80.0 a	4.35 b
Level of Significance	NS	*	*	*
LSD	29.71	17.35	1.033	0.470

Means having same letter(s) in a column did not differ significantly by LSD test. * = Significant at 5% level.

Lac insect populations

The number of lac insect population per unit area of ber host branches varied significantly in different locations of the study at their final stage of life span, though it was insignificant at initial stages. Initial population of lac nymphs in different areas were counted by 961.90-989.70 and 857.80-898.50 where final population was 195.10-247.40 and 145.80-197.70 in kartiki and baishakhi lac crop seasons, respectively (Table 2 and 3).

It is revealed from Table 2 and 3 that significant differences in lac insect mortality at different locations were also found in the study. Mortality of lac insect ranges from 75.0-80.0% and 78.0-81.9% in kartiki and baishakhi crop seasons, respectively. The highest insect mortality was found at Joydebpur, Gazipur (80.0% and 81.9%) identically followed by Nachole, Chapainawabgonj (79.10% and 81.30%) in kartiki and baishakhi crop seasons, respectively. The lowest mortality of lac insects was noticed at Lac Research Station, Chapainawabgonj (75.0% and 78.0%, in kartiki and baishakhi lac crop seasons,

respectively). The mortality at RARS, Jamalpur was 77.0% in kartiki crop and 79.6% in baishakhi crop seasons. According to Mishra *et al.* (1996) *Kerria lacca* thrives on a number of host plants but its mortality varies from 75-90% up to crop harvest. Bhagat found 41.2-60.2% mortality on polash and 30.49-48.84 on ber after one month of inoculation. Their findings comply to the present findings.

Table 3. Lac production efficacy of ber at four different regions of Bangladesh during November 2017-June 2018 baishakhi crop season

Locations	Lac population/10 cm ² area of shoot			Yield of Stick lac (Kg/plant)
	Initial Population	Final Population	% Mortality	
LRS, Chapainawabgonj	898.50	197.70 a	78.0 c	4.75 a
Nachole Chapainawabgonj	885.40	165.50 bc	81.3 a	4.35 b
RARS, Jamalpur	876.10	178.40 b	79.6 b	4.95 a
BARI, Gazipur	877.80	159.23 c	81.9 a	3.85 C
Level of Significance	NS	*	*	*
LSD	23.13	15.69	1.013	0.310

Means having same letter(s) in a column did not differ significantly by LSD test. * = Significant at 5% level.

Table 4. Lac production efficacy of rain tree at 2-different locations of Chapainawabganj during July-October 2017 kartiki crop season

Locations	Lac population/10 cm ² area of shoot			Yield of stick lac (Kg/plant)
	Initial Population	Final Population	% Mortality	
LRS Chapainawabganj	337.67	70.33	79.2	15.50
Nachole Chapainawabganj	346.33	85.67	75.3	17.75

The host plants rain tree and babla were used at LRS and Nachole of Chapainawabganj region only. The initial number of lac insect per unit area of rain tree branches was 337.67-346.33 in kartiki crop and 307.2-316.7 in baishakhi crop seasons (Table 4 and 5). Mortality of lac insect was lower at Nachole (75.3 and 79.7% in kartiki and baishakhi crops, respectively) than Chapainawabganj (79.2 and 82.1% in kartiki and baishakhi crops, respectively). Similar trend in lac insect population settlement on babla host

branches was noticed at both locations resulting in the same trend in mortality of lac insect (Table 6 and 7).

Table 5. Lac production efficacy of rain tree at 2-different locations of Chapainawabganj during November 2017-June 2018 baishakhi crop season

Locations	Lac population/10 cm ² area of shoot			Yield of stick lac (Kg/plant)
	Initial Population	Final Population	% Mortality	
LRS Chapainawabganj	307.2	55.2	82.1	11.50
Nachole Chapainawabganj	316.7	64.8	79.7	14.50

The number of lac insects per unit area of different host branches varied from host to host as the diameter of the branches was different. The number of lac nymph per unit area of jujube is higher than rain tree and babla because its diameter is higher. The number of lac nymph in rain tree and babla was very close as their diameter was very close with each other.

Yield of sticklac

Significantly the highest yield of sticklac (5.80 kg/plant and 4.75 kg/plant in kartiki and baishakhi crop seasons, respectively) was obtained from LRS, Chapainawabganj area identically followed by RARS, Jamalpur (5.75 kg/plant and 4.90 kg/plant in kartiki and baishakhi crop seasons, respectively) (Table 1 and 2). The lowest yield of sticklac (4.35 kg/plant and 3.85 kg/plant) was found at Joydebpur, Gazipur area in both kartiki and baishakhi lac crop seasons. The yield at Nachole was obtained 4.98 kg/plant and 4.35 kg/plant in kartiki and baishakhi crop seasons, respectively. Both of the host plants rain tree and Babla produced better lac yield at Nachole than LRS (Table 4-5 and 6-7).

Table 6. Lac production efficacy of babla at 2-different locations of Chapainawabganj during June-October 2017 kartiki crop season

Locations	Lac population/10 cm ² area of shoot			Yield of Stick lac (Kg/plant)
	Initial Population	Final Population	% Mortality	
LRS Chapainawabganj	318.00	68.33	78.5	4.25
Nachole Chapainawabganj	336.00	78.67	76.6	4.80

Table 7. Lac production efficacy of babla at 2-different locations of Chapainawabgonj during November 2017-June 2018 baishakhi crop season

Locations	Lac population/10 cm ² area of shoot			Yield of Stick lac (Kg/plant)
	Initial Population	Final Population	% Mortality	
LRS Chapainawabgonj	299.0	57.7	80.7	3.75
Nachole Chapainawabgonj	316.0	67.3	78.7	4.35

The yield of lac per plant was high in rain tree as its canopy was higher than other host plants. On the other hand, the lac yield was lowest in babla because its branches were lower. The jujube plants at Joydebpur, Gazipur produced comparatively lower lac yield as these plants were smaller (15 years old) than other 3 locations (20 years old). Rao and Singh (1990) cited that, average yields of stick lac per tree are 10 kg for kusum, 6 kg for jujube and 4 kg for palash. These yields can be increased to 15, 7 and 5 kg, respectively, by various cultural methods which include inoculation using synthetic nets, timely pruning, insecticide use for pest control and the use of quality broodlac.

PRODUCTION OF LAC ON DIFFERENT BER CULTIVARS AT DIFFERENT REGIONS OF BANGLADESH

Lac insect populations

The number of lac nymph at initial stage did not vary significantly at different regions of Bangladesh on the same jujube cultivar, but significant difference in nymph population was found at the final stage of their life span on different jujube cultivars (Table 8). Nymph populations were counted as 833-861 (initial populations) and 175-190 (final populations) with a mortality range of 77.6-79.0% on local cultivar, 803-877 (initial populations) and 171-190 (final populations) with a mortality range of 78.3-79.2% on appel kul and 818-869 (initial populations) and 168-217 (final populations) with a mortality range of 75.0-79.1% on BAU kul during July-October 2017 kartiki and November 2017-June 2018 baishakhi crop seasons, respectively, at different locations of Bangladesh. The lowest mortality was found 75% on BAU kul at Jamalpur region followed by 77.3% on apple kul at the same region where the highest mortality was recorded 80.9% on apple kul at Gazipur region.

Table 8. Nymphs/10 cm² shoot area of different ber cultivars during July-October 2017 kartiki and November 2017-June 2018 baishakhi crop season (pooled data)

Location	Local kul			Appel kul			BAU kul		
	Initial population	Final population	Mortality (%)	Initial population	Final population	Mortality (%)	Initial population	Final population	Mortality (%)
LRS, Chapainawabgonj	835.8	187.3 a	77.6 c	833.2	175.0 b	79.0 b	861.2	190.1 b	77.9 ab
Nachole Chapainawabgonj	803.6	171.0 b	78.7 b	849.4	177.2 b	79.2 b	877.4	190.3 b	78.3 ab
RARS, Jamalpur	829.4	168.5 b	79.1 b	838.2	189.4 a	77.3 c	869.2	207.3 a	75.0 b
BARI, Gazipur	806.6	158.0 c	80.3 a	856.6	187.2 a	80.9 a	868.6	182.3 c	79.0 a
LS	NS	*	*	NS	*	*	NS	*	*
LSD	33.10	9.370	0.809	24.72	3.031	1.073	17.03	5.780	1.033

Yield of sticklac

Different ber cultivars produced sticklac ranging from 4.35-5.75 kg/plant by local kul, 4.65-6.70 kg/plant by appel kul and 4.50-6.80 kg/plant by BAU kul in kartiki lac crop season at different regions of Bangladesh (Table 2). In baishakhi crop season, different cultivars produced sticklac ranging from 4.00-4.95 kg/plant by local kul, 4.05-5.55 kg/plant by appel kul and 4.20-5.75 kg/plant by BAU kul at different regions of Bangladesh (Table 3). The highest yield of sticklac (6.80 kg/plant and 5.75 kg/plant in kartiki and baishakhi crop seasons, respectively) was obtained from BAU kul at Jamalpur region. Local kul produced the highest yield (5.75 kg/plant) at LRS, Chapainawabgonj followed by Nachole (5.65 kg/plant), RARS, Jamalpur (5.25 kg/plant) and Gazipur (4.35 kg/plant) region in kartiki crop season (Table 2). But in baishakhi crop season, local kul produced highest yield (4.95 kg/plant) at Jamalpur region (Table 3). The highest yield of sticklac by appel kul (6.70 kg/plant and 5.55 kg/plant in kartiki and baishakhi crop seasons, respectively) was obtained at Jamalpur region (Table 2 and 3). The lowest yield of sticklac ranging from 4.35-4.65 kg/plant and 4.00-4.20 kg/plant was found at Joydebpur, Gazipur region in both kartiki and baishakhi lac crop seasons, respectively. All of three jujube cultivars at Joydebpur, Gazipur produced comparatively lower lac yield as these plants were smaller (15 years old) than other 3 locations (20 years old).

Table 9. Lac production efficacy of ber cultivars at 4-different regions of Bangladesh during July-October 2017 kartiki crop season

Treatments/Host plants	Yield of Stick lac (Kg/plant)			
	LRS Chapainawabgonj	Nachole Chapainawabgonj	RARS Jamalpur	BARI Gazipur
Local ber cultivar	5.75	5.65	5.25	4.35
Appel kul	5.50	4.75	6.70	4.65
BAU kul	5.00	4.80	6.80	4.50

Local kul produced better at LRS and Nachole where BAU kul and appel kul produced better at Jamalpur region.

Table 10. Lac production efficacy of ber cultivars at 4-different regions of Bangladesh during November 2017-June 2018 baishakhi crop season

Treatments/Host plants	Yield of Stick lac (Kg/plant)			
	LRS Chapainawabgonj	Nachole Chapainawabgonj	RARS Jamalpur	BARI Gazipur
Local ber cultivar	4.80	4.45	4.95	4.00
Appel kul	4.60	4.00	5.55	4.05
BAU kul	4.10	4.25	5.75	4.20

Local kul produced better yield of sticklac at RARS, Jamalpur where BAU kul and appel kul produced better at Jamalpur region.

UPSCALING AND FIELD VALIDATION OF BIO-RATIONAL BASED MANAGEMENT APPROACHES AGAINST LAC PREDATORS AND THEIR SAFETY TO LAC INSECT IN KARTIKI CROP SEASON

Lac predator population status at different regions

The incidence of lac predators *Eublemma amabilis* and *Pseudohypatopa pulverea* varied significantly at different study locations of Bangladesh. Incidence of *E. amabilis* was higher than *P. pulverea* in both crop seasons at all locations. The highest number (2.93) of *E. amabilis* was recorded at Nachole, Chapainawabganj; followed by LRS, Chapainawabgonj (2.57) and the lowest (1.90) was at RARS, Jamalpur in kartiki lac crop

season (Table 11). On the contrary, the highest number (1.97) of *P. pulvereae* was noticed at LRS, Chapainawabgonj identically followed by Nachole (1.93) and it was lowest (1.50) at Gazipur region.

Table 11. Mean number of lac predators during July-October 2017 kartiki lac crop season at different locations of Bangladesh

Locations	Mean no./10 cm ² area of shoot	
	<i>Eublemma amabilis</i>	<i>Pseudohypatopa pulveria</i>
LRS, Chapainawabgonj	2.57 b	1.97 a
Nachole, Chapainawabgonj	2.93 a	1.93 a
RARS, Jamalpur	1.90 c	1.53 b
BARI, Gazipur	2.43 b	1.50 b
Level of Significance	*	*
LSD	0.279	0.054

Both of *E. amabilis* and *P. pulveria* population was highest at Chapainawabganj region and lowest at Jamalpur and Gazipur regions, respectively.

Reduction of *Eublemma amabilis* population: It is clearly revealed form Table 12 that Neem seed extract @ 10g crushed seed/litre of water reduced 70.5-79.1% at LRS and 70.4-80.6% at Nachole, Chapainawabganj; 72.2-75.0% at Jamalpur and 70.2-76.4% at Gazipur region. Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water reduced 64.5-72.9% at LRS and 64.0-75.5% at Nachole, Chapainawabganj; 62-70.4% at Jamalpur and 65.2-71.8% at Gazipur region. Spinosad (Success 2.5 SC) @ 1.2ml /litre of water reduced 57.1-67.3% at LRS and 57.6-73.3% at Nachole, Chapainawabganj; 52.7-61.1% at Jamalpur and 62.4-69.8% at Gazipur region.

Reduction of *Pseudohypatopa pulvereae* population: It is clearly revealed form Table 13 that Neem seed extract @ 10g crushed seed/litre of water reduced 64.6-75.0% at LRS, Chapainawabganj; 71.9-74.8% at Nachole, Chapainawabganj; 72.8-74.2% at Jamalpur and 66.5-73.1% at Gazipur region. Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water reduced 58.4-70.2% at LRS, Chapainawabganj; 64.1-68.5% at Nachole, Chapainawabganj; 60.7-69.7% at Jamalpur and 63.5-67.1% at Gazipur region. Spinosad (Success 2.5 SC) @ 1.2ml /litre of water reduced 53.1-64.1% at LRS, Chapainawabgonj; 60.0-65.3% at Nachole, Chapainawabganj; 51.1-62.5% at Jamalpur and 53.5-61.6% at Gazipur region.

Table 12. Effect of different treatments in reducing *Eublemma amabilis* populations over untreated control at different regions of Bangladesh during July– October, 2017 kartiki crop season

Treatments	% Reduction of <i>E. amabilis</i>			
	LRS, Chapai.	Nachole, Chapai.	RARS Jamalpur	BARI Gazipur
Neem seed extract @ 10g crushed seed/L	70.5-79.1	70.4-80.6	72.2-75.0	70.2-76.4
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	64.5-72.9	64.0-75.5	62-70.4	65.2-71.8
Spinosad (Success) 2.5 SC @ 1.2ml/L	57.1-67.3	57.6-73.3	52.7-61.1	62.4-69.8
Untreated control	-	-	-	-

The table shows that at all locations, the highest reduction of *E. amabilis* was found when sprayed with Neem seed extract followed by Azadirachtin and the lowest was found with Spinosad. The per cent reduction was calculated over control. The range of reduction indicates the reduction up to 30 days after spraying.

Table 13. Effect of different treatments in reducing *Pseudohyptopa pulveria* populations over untreated control at different regions of Bangladesh during July– October, 2017 kartiki crop season

Treatments	% Reduction of <i>P. pulveria</i>			
	LRS, Chapai.	Nachole, Chapai.	RARS Jamalpur	BARI Gazipur
Neem seed extract @ 10g crushed seed/L	64.6-75.0	71.9-74.8	72.8-74.2	66.5-73.1
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	58.4-70.2	64.1-68.5	60.7-69.7	63.5-67.1
Spinosad (Success) 2.5 SC @ 1.2ml/L	53.1-64.1	60.0-65.3	51.1-62.5	53.5-61.6
Untreated control	-	-	-	-

Lac insect population: Statistically insignificant population of lac insect was observed in all treatments at initial stage (Table 14). After that the population gradually decreased in time and at the end of its life cycle the population was statistically significant in different treatments. The highest mortality (85.99%) of lac insect was observed in control treatment followed by 82.55% in Neem seed extract @ 10g seed/litre of water treated plants. The lowest mortality (82%) was found in Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water treated plants it was statistically insignificant with Neem seed extract

treated plants. The reduction in lac insect mortality in different treatments was due to the control of its predators.

Table 14. Effect of treatments on lac insect population at different regions of Bangladesh during July– October, 2017 kartiki crop season

Treatment	Mortality of lac insect (%)				
	LRS	Nachole	Jamalpur	Gazipur	Average
Neem seed extract @ 10g crushed seed/L	71.6	70.4	69.9	70.4	70.6
Azadirachtin (Bio-neem +) 1 EC @ 1ml/L	74.2	74.2	71.2	73.8	73.3
Spinosad (Success) 2.5 SC @ 1.2ml/L	77.5	76.7	74.4	74.9	75.9
Untreated control	81.0	80.6	78.6	79.7	79.7

The table shows that at all locations, the highest reduction of *E. amabilis* was found when sprayed with Neem seed extract followed by Azadirachtin and the lowest was found with Spinosad. The per cent reduction was calculated over control. The range of reduction indicates the reduction up to 30 days after spraying.

Yield of scrapped lac: A significant difference of lac yield was observed in different treatments (Table 15). The highest yield (1.95 kg/plant) was found in Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water treated plants identically followed by Neem seed extract treated plants (1.73 kg/plant) and the lowest yield (1.13 kg/plant) was recorded from untreated control plants.

Table 15. Effect of treatments on the yield of lac at different regions of Bangladesh during July–October, 2017 kartiki crop season

Treatment	Yield of Scrapped lac (kg/tree)				
	LRS	Nachole	Jamalpur	Gazipur	Average
Neem seed extract @ 10g crushed seed/L	6.7 a	6.2 a	7.0 a	5.5 a	6.3 a
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	6.1 a	5.6 a	6.5 a	4.9 a	5.8 a
Spinosad (Success) 2.5 SC @ 1.2ml/L	5.6 b	5.4 b	5.9 b	4.4 b	5.3 b
Untreated control	4.7 c	4.4 c	4.8 c	3.6 c	4.4 c
Level of Significance	*	*	*	*	*
LSD value	0.2871	0.1746	0.2471	0.1682	0.2421

Means having same letter(s) in a column did not differ significantly by DMRT. * = Significant at 5% level.

Table 16. Benefit cost analysis after application of treatments for controlling lac predators during July–October, 2017 kartiki crop season

Treatments	Yield of lac (kg/tree)	¹ Gross return (Tk/tree)	² Cost of treatment (Tk/tree)	Net return (Tk/tree)	Adjusted net return (Tk/tree)	MBCR
Neem seed extract @ 10g seed/L	6.3 a	1890	84	1806	486	5.79
Azadirachtin (Bio-neem plus) 1 EC @ 1.0ml/L	5.8 a	1740	105	1635	315	3.00
Spinosad (Success) 2.5 SC @ 1.2ml/L	5.3 b	1590	117	1473	153	1.31
Untreated control	4.4 c	1320	0	1320	0	-

¹Market price of scrapped lac = Tk 300/kg,

²[Cost of Neem seed: @ Tk 40/kg; Cost of Bio-neem plus: @ Tk 250/100ml; Success 2.5 SC: @ Tk 375/100ml, Cost of labour: Tk 300/working day; Spray volume required: 10L/tree]

Benefit/ cost analysis: The marginal benefit cost ratio (MBCR) of different treatments applied against lac predators as calculated based on the expenses incurred and value of stick lac is presented in Table 6. The highest MBCR (5.79) was obtained from the tree sprayed with Neem seed extract @ 10g seed/litre of water, very closely followed by Azadirachtin (3.00) (Bio-neem plus 1 EC) @ 1.0 ml/litre of water sprayed plants. The lowest MBCR (1.31) was obtained from the tree sprayed with Spinosad (Success 2.5 SC) @ 1.2 ml/litre of water treated plants.

UPSCALING AND FIELD VALIDATION OF BIO-RATIONAL BASED MANAGEMENT APPROACHES AGAINST LAC PREDATORS AND THEIR SAFETY TO LAC INSECT IN BAISHAKHI CROP SEASON

Lac predator population status at different regions

The incidence of lac predators *Eublemma amabilis* and *Pseudohypatopa pulverea* did not vary significantly at different study locations of Bangladesh. Incidence of *E. amabilis* was higher than *P. pulverea* in both crop seasons at all locations. The highest number (1.40) of *E. amabilis* was recorded at LRS, Chapainawabganj; followed by RARS, Jamalpur (1.37) and the lowest (1.27) was at BARI, Gazipur in kartiki lac crop season (Table 17). On the

contrary, the highest number (1.20) of *P. pulvereae* was noticed at LRS, Chapainawabganj identically followed by Nachole (1.13) and it was lowest (0.93) at Jamalpur region.

Table 17. Mean number of lac predators at different locations of Bangladesh during November 2017-June 2018 baishakhi crop season

Locations	Mean no./10 cm ² area of shoot	
	<i>Eublemma amabilis</i>	<i>Pseudohypatopa pulveria</i>
LRS, Chapainawabgonj	1.40	1.20
Nachole, Chapainawabgonj	1.33	1.13
RARS, Jamalpur	1.37	0.93
BARI, Gazipur	1.27	1.00

Both of *E. amabilis* and *P. pulveria* population was highest at Chapainawabgonj region and lowest at Jamalpur and Gazipur regions, respectively.

Table 18. Effect of different treatments in reducing *Eublemma amabilis* populations over untreated control at different regions of Bangladesh during November 2017-June 2018 baishakhi crop season

Treatments	% Reduction of <i>E. amabilis</i>			
	LRS, Chapai.	Nachole, Chapai.	RARS Jamalpur	BARI Gazipur
Neem seed extract @ 10g crushed seed/L	73.5-77.9	71.0-76.6	72.5-75.67	70.9-74.2
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	67.5-71.9	65.7-70.5	63.9-72.4	66.4-73.0
Spinosad (Success) 2.5 SC @ 1.2ml/L	57.1-63.0	59.6-64.3	60.7-68.1	62.4-67.8
Untreated control	-	-	-	-

The table-18 shows that at all locations, the highest reduction of *E. amabilis* was found when sprayed with Neem seed extract followed by Azadirachtin and the lowest was found with Spinosad. The per cent reduction was calculated over control. The range of reduction indicates the reduction up to 30 days after spraying.

Table 19. Effect of different treatments in reducing *Pseudohypatopa pulveria* populations over untreated control at different regions of Bangladesh during November 2017-June 2018 baishakhi crop season

Treatments	% Mortality of <i>Pseudohypatopa pulveria</i>			
	LRS	Nachole	Jamal	Gazipur
Neem seed extract @ 10g crushed seed/L	68.6-76.3	70.1-77.0	69.8-74.8	71.5-77.1
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	61.4-71.2	64.1-69.9	63.7-69.7	63.5-70.8
Spinosad (Success) 2.5 SC @ 1.2ml/L	57.3-63.8	59.1-65.0	55.1-64.3	54.4-63.6
Untreated control	-	-	-	-

The table-19 shows that at all locations, the highest reduction of *E. amabilis* was found when sprayed with Neem seed extract followed by Azadirachtin and the lowest was found with Spinosad. The per cent reduction was calculated over control. The range of reduction indicates the reduction up to 30 days after spraying.

Reduction of *Eublemma amabilis* population: It is clearly revealed from Table 2 that Neem seed extract @ 10g crushed seed/litre of water reduced 70.5-79.1% at LRS, Chapainawabgonj; 70.4-80.6% at Nachole, Chapainawabgonj; 72.2-75.0% at Jamalpur and 70.2-76.4% at Gazipur region. Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water reduced 64.5-72.9% at LRS, Chapainawabgonj; 64.0-75.5% at Nachole, Chapainawabgonj; 62-70.4% at Jamalpur and 65.2-71.8% at Gazipur region. Spinosad (Success 2.5 SC) @ 1.2ml /litre of water reduced 57.1-67.3% at LRS, Chapainawabgonj; 57.6-73.3% at Nachole, Chapainawabgonj; 52.7-61.1% at Jamalpur and 62.4-69.8% at Gazipur region.

Reduction of *Pseudohypatopa pulvere*a population: It is clearly revealed from Table 3 that Neem seed extract @ 10g crushed seed/litre of water reduced 64.6-75.0% at LRS, Chapainawabgonj; 71.9-74.8% at Nachole, Chapainawabgonj; 72.8-74.2% at Jamalpur and 66.5-73.1% at Gazipur region. Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water reduced 58.4-70.2% at LRS, Chapainawabgonj; 64.1-68.5% at Nachole, Chapainawabgonj; 60.7-69.7% at Jamalpur and 63.5-67.1% at Gazipur region. Spinosad (Success 2.5 SC) @ 1.2ml /litre of water reduced 53.1-64.1% at LRS, Chapainawabgonj; 60.0-65.3% at Nachole, Chapainawabgonj; 51.1-62.5% at Jamalpur and 53.5-61.6% at Gazipur region.

Lac insect population: Statistically insignificant population of lac insect was observed in all treatments at initial stage (Table 20). After that the population gradually decreased in time and at the end of its life cycle the population was statistically significant in different treatments. The highest mortality (85.99%) of lac insect was observed in control treatment followed by 82.55% in Neem seed extract @ 10g seed/litre of water treated

plants. The lowest mortality (82%) was found in Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water treated plants it was statistically insignificant with Neem seed extract treated plants. The reduction in lac insect mortality in different treatments was due to the control of its predators.

Table 20. Effect of treatments on lac insect populations over untreated control in November 2017-June 2018 baishakhi crop season at different regions of Bangladesh

Treatment	Mortality of lac insect (%)				
	LRS	Nachole	Jamalpur	Gazipur	Average
Neem seed extract @ 10g crushed seed/L	74.4	75.7	70.4	73.0	73.4
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	75.0	77.4	72.3	74.4	74.8
Spinosad (Success) 2.5 SC @ 1.2ml/L	78.2	79.7	74.4	74.9	76.8
Untreated control	83.1	84.0	81.8	82.7	82.9

At all locations, spraying with Neem seed extract produced the lowest mortality of lac insect followed by Azadirachtin and Spinosad. The highest mortality was obtained from untreated control treatment.

Table 21. Effect of treatments on the yield of lac n at different regions of Bangladesh during November 2017-June 2018 baishakhi crop season

Treatment	Yield of Stick lac (kg/plant)				
	LRS	Nachole	Jamalpur	Gazipur	Average
Neem seed extract @ 10g crushed seed/L	5.52 a	5.20 a	5.65 a	4.39 a	5.19 a
Azadirachtin (Bio-neem plus) 1 EC @ 1ml/L	5.35 a	5.08 a	5.38 a	4.25 a	5.02 a
Spinosad (Success) 2.5 SC @ 1.2ml/L	4.52 b	4.25 b	4.90 b	3.48 b	4.29 b
Untreated control	3.67 c	3.75 c	3.80 c	3.00 c	3.56 c
Level of Significance	*	*	*	*	*
LSD value	0.2781	0.1604	0.2841	0.1740	0.2241

Means having same letter(s) in a column did not differ significantly by DMRT. * = Significant at 5% level.

At all locations, spraying with Neem seed extract produced the highest yield of stick lac followed by Azadirachtin and Spinosad. The highest lac yield was obtained from untreated control treatment.

Yield of scrapped lac: A significant difference of lac yield was observed in different treatments (Table 19). The highest yield (1.95 kg/plant) was found in Azadirachtin (Bio-neem plus 1 EC) @ 1.0 ml/litre of water treated plants identically followed by Neem seed extract treated plants (1.73 kg/plant) and the lowest yield (1.13 kg/plant) was recorded from untreated control plants.

Benefit/ cost analysis: The marginal benefit cost ratio (MBCR) of different treatments applied against lac predators as calculated based on the expenses incurred and value of stick lac is presented in Table 6. The highest MBCR (4.83) was obtained from the tree sprayed with Neem seed extract @ 10g seed/litre of water, very closely followed by Azadirachtin (3.18) (Bio-neem plus 1 EC) @ 1.0 ml/litre of water sprayed plants. Negative MBCR (0.80) was obtained from the tree sprayed with Spinosad (Success 2.5 SC) @ 1.2 ml/litre of water treated plants.

Table 22. Benefit cost analysis after application of treatments for controlling lac predators during November 2017-June 2018 baishakhi crop season

Treatments	Yield of lac (kg/tree)	¹ Gross return (Tk/tree)	² Cost of treatment (Tk/tree)	Net return (Tk/tree)	Adjusted net return (Tk/tree)	MBCR
Neem seed extract @ 10g seed/L	5.19	1557	84	1473	405	4.83
Azadirachtin (Bio-neem plus) 1 EC @ 1.0ml/L	5.02	1506	105	1401	333	3.18
Spinosad (Success) 2.5 SC @ 1.2ml/L	4.29	1287	117	1170	102	0.80
Untreated control	3.56	1068	0	1068	0	-

¹Market price of scrapped lac = Tk 300/kg,

²[Cost of Neem seed: @ Tk 40/kg; Cost of Bio-neem plus: @ Tk 250/100ml; Success 2.5 SC: @ Tk 375/100ml, Cost of labour: Tk 300/working day; Spray volume required: 10L/tree]

EFFECT OF WATER APPLICATION ON LAC CULTIVATION UNDER EXTREMELY HOT WEATHER CONDITION

Lac insect population: Statistically insignificant population of lac insect was observed in all treatments at initial stage (Table 1). After that the population gradually decreased in time and at the end of its life cycle the population was statistically significant in different treatments. Application of water reduced the mortality of lac insect resulting in higher lac yield. The lowest mortality (72.3%) was found when basal application of water was done at 7 days intervals identically followed by water application at 15 days intervals (73.9%). The highest mortality (83.0%) of lac insect was observed in control treatment where no water was applied to the host plants. Application of water to the host plants might change the microclimate that reduced lac insect mortality.

Yield of scrapped lac: A significant difference of lac yield was observed in different treatments (Table 23). The highest yield of stick lac (5.55 kg/plant) was obtained when basal application of water was done at 7 days intervals identically followed by water application at 15 days intervals (5.05 kg/plant). The lowest yield of stick lac (4.22 kg/plant) was obtained in control treatment where no water was applied to the host plants. Application of water to the host plants reduced lac insect mortality that increased lac yield.

Table 23. Effect of treatments on lac insect population and yield of lac during November 2017–June 2018 baishakhi lac crop season Nachole, Chapainawabganj

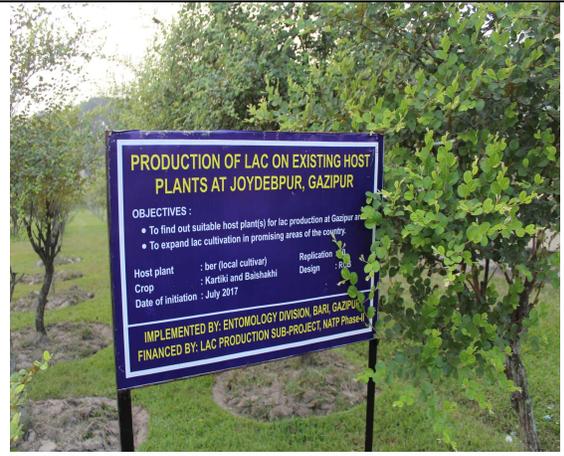
Treatments	Lac nymph per 10 cm ² area of shoot			Yield of stick lac (kg/tree)
	Initial population	Final population	Mortality (%)	
Basal application of water at 7 days intervals	983.33	272.73 a	72.3 b	5.55 a
Basal application of water at 15 days intervals	977.53	255.20 ab	73.9 b	5.05 a
Control (without water application)	985.60	167.53 c	83.00 a	4.22 b
LS	NS	*	*	*
CV (%)	0.60	2.87	0.85	3.49

Means having same letter(s) in a column did not differ significantly by DMRT. LS= Level of significance; * = Significant at 5% level; NS = Non significant.

Some experimental views are given below through photographs:



Lac Research Field at BARI, Gazipur



Experimental Field at BARI, Gazipur (1)



Experimental Field at BARI, Gazipur (2)



Experimental Field at RARS, Jamalpur



Farmers of Nachole, Chapainawabgonj are going back in their home with Broodlac from Lac Research Station



Lac development on ber plant at RARS, Jamalpur

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

- 📌 Apple kul (6.7 kg/tree) and BAU kul(6.8 kg/tree) have been found as good hosts of lac at Jamalpur region.
- 📌 Lac production efficacy of ber was better at Jamalpur region (5.75 kg/tree), next to LRS (5.80 kg/tree), Chapainawabganj.
- 📌 Rain tree & Babla produced good yield of lac in both Nachole (17.75 and 4.80 kg/tree, respectively) & LRS (15.50 and 4.25 kg/tree, respectively), Chapainawabganj.
- 📌 Both of *Eublemma amabilis* and *Pseudohypatopa pulvereana* were found major pest of lac at all of four locations. Predator population was 1.8 times higher in kartiki crop season.
- 📌 Twice the application of neem seed extract @ 10g crushed seed/litre of water reduced 70.4-80.6% lac predators and increased lac yield.
- 📌 Farmers are highly impressed with modern lac production technologies.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment I. Laptop Computer II. Digital Camera	01 01	55,000/- 25,000/-	01 01	55,000/- 25,000/-	100% Achievement
(b) Lab & field equipment	x	x	x	x	
(c) Other capital items	x	x	x	x	

2. Establishment/renovation facilities:

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

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

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	x	x	x	x	-
(b) Workshop	x	x	x	x	-

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance at Bank	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	334341	334341	334341	0	100	Balance in Bank Tk.1070/- for closing charge of Bank account.
B. Field research	826484	809255	807053	(+) 2202	100	
C. Operating expenses	208295	206010	204475	(+) 1535	100	
D. Vehicle hire and fuel, oil	133000	120433	123100	(-) 2667	100	
E. Training/ workshop /seminar etc.	90000	0	0	0	100	
F. Publications and printing	87000	73037	20825	(+)52212 (Refunded)	100	
G. Miscellaneous	40000	38553	38553	0	100	
H. Capital expenses	80000	80000	80000	0	100	
Grand Total=	1799120	1661629	1608347	1070	-	

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)
1. Field validation of the developed technologies and expansion of lac cultivation in promising areas of the country involving ultra poor and marginal farmers for poverty reduction.	* Production of lac on existing host plants viz. ber, rain tree & babla. * Production of lac on different ber cultivars.	* Ber was the best host compared to rain tree and babla. * BAU kul & appel kul produced better lac yield at Jamalpur region.	Unutilized ber, rain tree and babla plants could be taken under lac cultivation in new expanded areas.
2. Development of management packages of biotic and abiotic stresses of lac cultivation at the targeted AEZ.	* Determination of pest status on lac crop. * Bio-rational based management approaches against lac predators. * Management against extreme hot weather condition.	* Predator popn. was higher (1.8 times) in kartiki crop. * Twice application of Neem seed extract @ 10g crushed seed/litre of water reduced 70.4-80.6% lac predators.	* Farmers will take initiatives in time to manage lac predators. * Yield loss will be minimized due to predator attack.
3. Awareness development of lac growers, extension personnel and related consumers on the developed technologies as well as different aspects of lac cultivation for the improvement of lac industry.	* Demonstration of improved lac cultivation technologies in farmers' field. * Farmers' field visit. * Production of fact sheet.	* Four demonstrations were done in 3-study locations * Two fact sheets were produced.	* Farmers will practice modern lac cultivation technologies. * Lac production will be increased.

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	
Fact sheet	none	02	attached 10(ten) copies of each

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

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

- Production of lac on existing host plants viz. ber, rain tree and babla.
- Production of lac on BAU and Appel kul is more profitable at Jamalpur region.

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

- Twice application of neem seed extract @ 10g crushed seed/litre of water reduced 70.4-80.6% lac predators and increased lac yield.
- Basal application of water to the lac host during March-May increased lac production.

G. Lesson Learned/Challenges (if any)

- Easy access of Indian lac products in the local market makes the farmers worried with low price of their product.
- Women are involved in lac cultivation, but they don't have proper training on modern lac cultivation techniques.
- Almost all farmers involved in lac cultivation want us to ensure market price of their product.
- Farmers are highly impressed with modern lac production technologies.

H. Challenges (if any)

- Lac growers face some administrative complexity in licensing both in new and renewal. Licensing procedure should be easier.
- Farmers are getting low price of their product. Therefore, lac marketing channel should be developed providing reasonable price for their product.
- Higher temperature during April-May is becoming a great threat to lac production since last several years. It might be an effect of global warming.

I. Suggestion for future (if any):

The following research agenda has been identified for future action:

- Development of biological control tactics to manage lac predators.
- Development of smart lac production technologies addressing the effect of global warming.
- Development of marketing channel to ensure reasonable price for farmer's products.
- Development of mechanical processing techniques for lac.

Signature of the Principal Investigator
Date
Seal

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