

Competitive Research Grant
Sub-Project Completion Report

on

**Development Of Ginger Production Technology
Under Soilless Culture Using Fertigation
Technique In Bangladesh**

Project Duration

May 2017 to September 2018

Submitted By
Spices Research Centre
Bangladesh Agricultural Research Institute
Shibganj, Bogra

Submitted to

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



September 2018

Competitive Research Grant

Sub-Project Completion Report

on

**Development Of Ginger Production Technology
Under Soilless Culture Using Fertigation
Technique In Bangladesh**

Project Duration

May 2017 to September 2018

**Submitted By
Spices Research Centre
Bangladesh Agricultural Research Institute
Shibganj, Bogra**



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



September 2018

Citation

M. A. Islam and M. S. Islam. 2018. Development of ginger production technology under soilless culture using fertigation technique in Bangladesh. A report of Competitive Research Grant Sub-Project under National Agricultural Technology Program-Phase II Project (NATP-2), Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka, Bangladesh.

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

Edited and Published by:

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

Acknowledgement

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

Published in: September 2018

Printed by: {Name of press with full address}

Acronyms

BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
SRC	:	Spices Research Center
SRSC		Spices Research Sub-Center
BCR	:	Benefit cost ratio
DAP	:	Days After Planting
CRG	:	Competitive Research Grant
EDTA	:	Ethylene Diamine Tetra Acetic Acid
DMRT	:	Duncan Multiple Range Test
RCBD	:	Randomize complete block design
NARIs	:	National Agricultural Research Institutions
NATP	:	National Agricultural Technology Program

Table of Contents

Sl. No.	Subject	Page No.
	Cover Page	i
	Citation	ii
	Acronyms	iii
	Table of Contents	iv
	Executive summary	v
A.	Sub-project Description	1
1	Title of the CRG sub-project	1
2	Implementing organization	
3	Name and full address of PI/Co-PI (s)	
4	Sub-project budget	
5	Duration of the sub-project	
6	Justification of undertaking the sub-project	
7	Sub-project goal	
8	Sub-project objective	
9	Implementing location	
10	Methodology	
11	Results and discussion	
12	Research highlight/findings	
B.	Implementation Position	
	Procurement	
	Establishment/renovation facilities	
	Training/study tour/ seminar/workshop/conference organized	
C.	Financial and physical progress	
D	Achievement of Sub-project by objectives	
	Materials Development/Publication made under the Sub-project	
F	Technology/Knowledge generation/Policy Support	
	Generation of technology	
	Generation of new knowledge that help in developing more technology in future	
	Technology transferred that help increased agricultural productivity and farmers' income	
	Policy Support	
G.	Information regarding Desk Monitoring	
H.	Information regarding Field Monitoring	
I.	Lesson Learned/Challenges	
J.	Challenges	
	Annexure	
	Plate	
	References	

Executive Summary

Two experiments were conducted at Spices Research Center, Bogra and Spices Research Sub-Center Lalmonirhat during April 2017 to March 2018. The effect of soilless substrates and conventional method on growth and yield of ginger were studied. The main objective of the study was to determine the most suitable growth substrate for cultivation of ginger using fertigation technique and to produce disease free seed rhizome for higher yield. Seven combinations of growth substrates: {1) Coco-dust, 2) Sawdust 3) Rice bran, 4) 50% Coco-dust + 50% sawdust 5) 50% Sawdust+ 50% rice bran, 6) 50% Coco-dust+ 50% rice bran and 7) Sandy loam soil (control), and three ginger varieties (BARI Ada-1, BARI Ada-2 and BARI Ada-3 were compared in two locations 1) SRC, Bogra and 2) SRSC, Lalmonirhat. On the other hand two conventional methods (P_1 =SRC recommended production practice, and P_2 = Farmer practice and three ginger varieties (BARI Ada-1, BARI Ada-2 and BARI Ada-3) were compared in two location (SRC, Bogura and SRSC, Lalmonirhat).

Experiment I:

In case of fertigation experiment, combined effect of different growth substrate, varieties and locations significantly influenced the growth and yield of ginger under soil less cultivation. The highest rhizome yield (45.2 t ha^{-1}) was obtained from plants grown in $M_1V_1L_1$ (Coco dust \times BARI Ada-1 \times Bogra location) while the lowest yield (8.5 t ha^{-1}) were found from $M_7V_3L_2$ (Control \times BARI Ada-3 \times Lalmonirhat location) treatment combination. Benefit-cost ratio: Among the treatments, it was found that the highest benefit-cost ratio of 2.40 was recorded from $M_1V_1L_1$ (Coco dust \times BARI Ada-1 \times Bogra location). The lowest benefit-cost ratio of 0.47 was observed in the $M_3V_3L_2$ (Rice bran \times BARI Ada-3 \times Lalmonirhat location). In conclusion, ginger variety BARI Ada-1 can profitably be cultivated on Coco -dust substrate along with the fertigation.

Experiment II:

In case of conventional methods, different practices, varieties and locations significantly influenced the growth and yield contributing characters of ginger production. The highest (14.34 t ha^{-1}) rhizome yield was obtained from plants grown in $P_1V_1L_1$ (SRC practices \times BARI Ada-1 + Bogra location) followed by $P_1V_2L_1$ (SRC practices \times BARI Ada-2 \times Bogra location, 13.12 t ha^{-1}) treatment combination. The lowest yield (6.66 t ha^{-1}) were found from $P_2V_3L_2$ (Farmers practices \times BARI Ada-3 \times Lalmonirhat location) treatment combination. It might be due to highest (56.33%) disease infestation in $P_2V_3L_2$ (Farmers practices \times BARI Ada-3 \times Lalmonirhat location) treatment combination that ultimately reduced rhizome yield. Benefit-cost ratio: Among the treatments, it was found that the highest benefit-cost ratio of 1.97 was recorded with the $P_1V_1L_1$ (SRC practices \times BARI Ada-1 \times Bogra location) treatment combination. The lowest benefit-cost ratio of 0.72 was observed in $P_2V_3L_2$ (Farmers practices \times BARI Ada-3 \times Lalmonirhat location) treatment combination.

Comparison of ginger yield per hectare was between fertigation system and conventional method for one season of ginger production. The average yield of ginger using fertigation system was (45.2 t ha^{-1}) in the best treatment combination ($M_1V_1L_1$: Coco dust \times BARI Ada-1 \times Bogra location). The development cost of fertigation system was TK. 1878466 ha^{-1} . Meanwhile, the average farm price for mature harvested was ginger TK. 100 kg^{-1} . Farmers who used this fertigation system were able to earn average higher net income of TK. 2621534 ha . The average highest yield for the conventional method was (14.24 t ha^{-1}) in the best treatment combination ($P_1V_1L_1$: Spices Research Center practices \times BARI Ada-1 \times Bogra location). However, the cost of production per kilogram of ginger was higher for conventional method than that of fertigation system. By considering the different average farm price, it was found that the average net income for the cultivation of ginger using fertigation system was higher than the conventional method. The average net income is affected by the level of production and its market price. Fertigation system: Yield: 45.2 t ha^{-1} i.e. 45200 kg , Price: TK. 100.00 kg^{-1} , Gross benefit: $4520000 \text{ TK. ha}^{-1}$, Cost of fertigation: $1878466 \text{ TK. ha}^{-1}$, Gross margin: $26,41,534 \text{ TK. ha}^{-1}$.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Development of ginger production technology under soilless culture using fertigation technique in Bangladesh
2. Implementing organization: Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Shibganj
3. Name and full address with phone, cell and E-mail of PrI/Co-PI (s): PI-

Principal Investigator: **Dr. Md. Ashikul Islam**
Senior Scientific Officer
Spices Research Centre
Shibganj, Bogra
Mobile: 01711119287,
Email: nirusrc@yahoo.com.

Co- Principal Investigator: **Dr. Md. Shafikul Islam**
Chief Scientific Officer
Spices Research Centre
Shibganj, Bogra
Mobile: 01712101439
Email: srcinchargeshibganj@gmail.com

4. Sub-project budget (Tk): 28,00,000
 - 4.1 Total: (TK.)28,00,000
 - 4.2 Revised (if any): (TK.) 26,46,540
5. Duration of the sub-project: May 2017- September 2018
 - 5.1 Start date (based on LoA signed): 09 May 2017
 - 5.2 End date: 30 September 2018

6. Justification of undertaking the sub-project:

Ginger is one of the important major spices crop grown in Bangladesh. Bangladesh possesses favorable agro-ecological condition for the production of ginger. Area under ginger crop is about 11,000 hectare. The production of ginger is about 2.19 lakh metric ton against the annual demand of 1.77 lakh metric ton (Anon., 2015).The yield of ginger in Bangladesh is very low compared to other countries (India, China, Thailand Malaysia, Indonesia and Jamaica) of the world. The lowest production of ginger is due to lack of suitable land for cultivating high quality and severe attack of rhizome rot causing lack of interest among the farmers to cultivate ginger. Rhizome rot is complex disease caused by bacteria, fungus and nematode. Among several factors affecting ginger production, the

rhizome rot caused by *Pythium aphanidermatum* is responsible for drastic yield reduction. The disease may reduce 50-80% rhizome production. Rhizome rot is difficult to control through single approach. Earlier it was assumed that *Pythium aphanidermatum* is the only causal agent for rhizome rot of ginger. But from last few years it was observed that some other fungi and bacteria might be responsible for rhizome rot of ginger.

Commercial ginger cultivation method is carried out nomadically on highland slopes. This nomadic cultivation system is applied because gingers cannot be grown continuously in the same area as the area has been infected with soil-borne diseases such as bacterial wilt and fusarium wilt that cause declination of yield up to 80%. The former ginger crop area should be left idle for 6 years before the new phase of ginger cultivation can be carried out.

By using fertigation technology, ginger cultivation can be done in the same area continuously. Fertigation technology is a cultivation system without soil. In this system, the crop media such as coco dust, coco peat, sawdust, rice bran, perlite and burnt paddy husk are used in poly bag as a replacement of soil. The growing media are filled into the polybags according to appropriate size. Besides, in fertigation system, irrigation and fertilization are done simultaneously and directly to the root zones at a required amount. This fertigation system is able to increase crop yield and reduce the use of fertilizer by supplying fertilizer solution based on crop based formulation to the root zone based on their growth levels and needs. Fertigation technology is able to save the cost of production as it does not involve the cost of land preparation, weeding and fertilizer spreading, unlike the conventional method. The technology can be automated using a timer; therefore it can reduce the labour force.

The pathogen causing rot is soil borne and as well as seed borne. No effective control measure is developed yet now in our country. Uses of disease free seed rhizome as planting materials have a chance to reduce the disease infection. Soilless culture system produce disease free seed rhizome as well as reduced the infection. In this system seed rhizomes are planted in soilless substrate (such as coco - dust, saw dust, paddy husk) placed in black poly bag using fertigation technique. Plant with poly bag if infected can easily be isolated and destroyed. The substrate used in poly bag may be considered as disease free materials. So, there is less chance to expand the disease to other neighboring plant. So plant obtained from the remaining poly bag can be considered to produce disease free seed. As the causal organism seed borne was noticed, so there is no alternative to use disease free healthy seed rhizome for ginger cultivation. Planting of rhizome in natural media without soil may be helpful in producing disease free seeds of ginger.

Fertigation technology is normally applied in soil less culture. Yield of chilli, rock melon and tomato cultivated in soilless system increased 3-5 times compared to those using conventional method (Rijck and Sehrevens 1998). In Malaysia and Thailand, ginger is produced in a large scale with fertigation system in poly bag. In soilless production system, many types of growing media or substrates such as rockwool, perlite, vermiculite and coco peat have been used to grow many kinds of crop (Raja Harun *et al.* 1991; Jarvis 1992; Bohme 1995; Komada *et. at.* 1996). Media like rock wool, perlite and vermiculte are expensive because these are not easily available. Hence, alternative substrates that are cheaper and locally available such as coconut fibers and burnt paddy husks should be used as alternative media (Ortege *et al.* 1996).

Ginger can be harvested as young ginger (3-4 months) or mature ginger (8-9 months). In Malaysia, ginger is also cultivated using shifting cultivation technique. This is done to avoid infertile soil problems and soil - borne diseases caused by *Fusariumoxysporum* and *Pseudomonas solanacearum* that can infect plant roots and also to avoid leaf spot disease (Burrage 1992; Whipps 1992).The fertigation method using coco peat in black plastic bag is an alternative technique in ginger cultivation to overcome the problem for ginger cultivation. Besides, the cost of embroidery works, which are the main task of the conventional method, is also reduced.

Fertigation technology is proved (Malaysia, Thailand and many other countries) to be effective and efficient in the cultivation of leafy vegetables, spices crop and fruits. The yield of ginger has increased by three to five folds per unit area compared to the conventional cultivation method. Ginger cultivation in lowland areas using fertigation method is also capable to increase the average yield of ginger rhizome (5.4 kg per clump) up to two or three fold compared to the conventional method, 900g/clump).

From the above discussion it may be concluded that cultivation of ginger in soilless substrate in poly bag using fertigation technique can overcome the disease problem to some extent and increase the productivity of the crop. Ginger seeds produced by this system are not contaminated with bacteria and fungi. Disease free ginger seeds free from bacteria and fungi are difficult to find in the market. Further, the price of disease free ginger seeds can reach up to TK.100-150 Kg⁻¹ and this price provides a lucrative business opportunity for the entrepreneurs. Hence, a new business opportunity is created by them. Moreover, this

technology is also environment friendly to some extent than the conventional methods. Therefore, this study have been conducted to determine the effect of soilless substrates (such as coco peat, sawdust and rice bran) using fertigation technique.

7. Sub-project goal:
Mass production of disease free seed rhizome, soilless cultivation of ginger and dissemination of generated technologies to the ginger growers of the country.

8. Sub-project objective (s):

- a) To study the suitability of ginger cultivation under fertigation system
- b) To determine the effect of soilless substrates (such as coco - dust, sawdust and rice bran) on growth and yield of ginger
- c) To determine the optimum growth substrate for ginger cultivation using fertigation technique
- d) To produce disease free healthy seed rhizome for higher yield and economic return

9. Implementing location (s): Spices Research Centre, BARI, Shibganj, Bogra and Spices Research Sub-Centre, BARI, Lalmonirhat

10. Methodology in brief:

For the development of soilless culture of ginger using fertigation technique, following methodology and activities was undertaken to achieve the output of the project. Experiment under the project was carried out in the research field of Spices Research Centre, Bogra and Spices Research Centre Sub -Centre, Lalmonirhat.

Details of the methodology are enumerated below:

Materials and methods

Planting materials

BARI Ada-1, BARI Ada-2 and BARI Ada-3 were used in this study. 10-month-old ginger rhizomes were used as seed. The rhizomes were cut into smaller pieces of about 4 cm long and 40 g in weight containing 2 – 3 buds. The seed rhizomes were treated with Autostein prior to planting. Ginger rhizome was harvested at 10 months after planting as mature ginger.

Rain shelter structure

A side-netted rain shelter of 30 m long x 10 m wide x 4.5 m high located in Spices Research Centre, Bogra and Spices Research Sub-Centre Lalmonirhat was used for the study. All structures were made of GI iron frame with transparent polyethylene film (180 µm thick) roofing and insect repellent net (0.1 x 0.1 mm²) side cladding. Entrance into the shelter was through double doors to reduce the chance of insect entry.

Water tank structure

Three Plastic water tank (1500 liter) was used for each location in the study. The plastic tanks were placed on a concrete structure. The structure was made with brick, sand and cement (7 m long x 3 m wide x 1.5 m high). The plastic tank was used for keeping nutrient solution and irrigation water.

Experimental design and growth media

The treatments were arranged in randomized complete block design (RCBD) with seven levels of treatment and six replications. Two polybags (plant) were used per treatment in each replication. The treatments were as follows: 1) Coco-dust, 2) Sawdust 3) Rice bran, 4) 50% Coco-dust + 50% Sawdust 5) 50% Sawdust+ 50% Rice bran, 6) 50% Coco-dust+ 50% Rice bran, and 7) Sandy loam soil (control). The size of polybag was 40 cm x 30 cm x 30 cm. The polybags (40 cm x 30 cm x 30 cm) filled with the substrate were kept in shady place for 15 days before planting. Spacing of polybag was 12-15 cm. The seed rhizome was planted into the media according to the treatments. One nutrient solution channel made of rubber pipe was provided for each replication. Each polybag was individually irrigated with nutrient solution via a dripper on the surface of the growth media placed in polybag. Planting was done 5th April, 2017 and harvesting was done 24th February 2018. Intercultural operation not needed.

Irrigation system

The irrigation system, which was built in the side-netted rain shelter, consisted of a 1,500litre tank, 1.5 Hp water pump, water filter, pressure meter and six lateral lines (40 m each), which looped to each other. Each of the lateral lines was equipped with 42 drippers that placed into 42 polyethylene bags, side by side. The distance between each line was 1.0 m and the distance between each dripper point in the lateral line was 0.3 m. A valve was attached to an inlet to control the amount of the irrigated solution to be pumped in. A small valve was also attached to each lateral line to maintain the flow

through the drip line. The nutrient solutions were supplied through 0.3 m micro tubes and arrow drippers.

Nutrient concentration and irrigation frequency

The fertilizer was formulated based on the needs of the plant rhizomes. All the fertilizer components were water soluble. The macro and micro nutrients was prepared separately as A and B stock solutions, respectively, at 100 x dilution. Solution A contained calcium nitrate and EDTA iron, while solution B contained all other components (potassium dihydrogen phosphate, potassium nitrate, manganese sulfate, magnesium sulfate, boric acid, copper sulfate, ammonium molybdate and zinc sulfate). All components were added one by one to ensure that they dissolved completely in the water. In preparing stock A solution, calcium nitrate were added into the container containing tap water (pH 5.5 - 6.5) and stirred until it dissolved, then the solution was poured into a 100-litre vessel. Iron powder was added into another container that contained tap water, stirred until it dissolved completely, and then added into the vessel. The same procedure was applied in preparing stock B solution.

The irrigation solution was prepared in a 1,500-litre tank. Stock A and stock B was added into the tank at 1:1 ratio until the needed electrical conductivity (EC) was achieved. The EC of the nutrient solution were between 1.8 μS and 2.3 μS . The stock solution A was put first in to the plastic tank followed by stock solution B. The irrigation scheduling was automatically implemented by a digital timer, three times per day in the first 3 months (0800 h, 1200 h and 1600 h), six times per day in the 4th - 7th months (0700 h, 0800 h, 1000 h, 1200 h, 1400 h and 1600 h), and once per day in the last 2 months (1000 h). The duration of irrigation was 1-2 min and an identical amount of fertilizer solution was applied to all polyethylene bags. The daily irrigation volume per plant was 675 ml in the first 3 months, 1,350 ml in the 4th - 7th months, and 75 ml in the last 2 months. Routine practices for pest, disease and weed control was followed. Insecticide and fungicide was applied once every 2 weeks.

Parameter measurements

The growth of the ginger plants was measured monthly by measuring the plant height and weight of leaves/shoot⁻¹. The ginger plants were randomly selected and the rhizomes were harvested after 10 months of planting to determine the yield and growth

of rhizomes. The weight was measured immediately after harvest to prevent desiccation and water loss from the rhizomes.

Statistical analysis

Data on different morphological and yield contributing characters were collected and analyzed using by R program and mean values were separated by DMRT.

1st year experiment (2017)

Experiment No. 1 Effect of growing media on rhizome yield of ginger

- Objective**
- ❖ To identify suitable growing media for seed rhizome production of ginger
 - ❖ To produce disease free healthy seed rhizome.

Materials and Methods:

Variety/Materials BARI Ada-1, BARI Ada-2 and BARI Ada-3

Design CRD

Treatments 1) Coco-dust , 2) Sawdust 3) Rice bran , 4) 50% Coco-dust + 50% Sawdust 5) 50% Sawdust+ 50% Rice bran , 6) 50% Coco-dust+ 50% Rice bran and 7) Sandy loam soil (control)

Replication 6 (Six)

Plot size 30 m long x 10 m wide x 4.5 m high

Poly bag size 40 cm x 30 cm x 30 cm (16"x12" x12")

Plant system Paired row (Distance between paired rows was 50cm). The growth media of about 2.0 kg for T1 to T6 was placed in perforated (6-8 hole at the side of the base 2.5 cm from the bottom) black polyethylene bag. Required quantity of clean water and nutrient solution was applied to the media for proper germination and growth of the plant. Shade was provided over the nursery where Poly bag was placed

Fertilizer dose and methods of application Nutrient solution were made (KH₂PO₄ (270g), KNO₃ 580g, Ca(NO₃)₂.4 H₂O (1000 g), MgSO₄.7H₂O (510g), EDTA Iron 80 g, MnSO₄.4 H₂O (6.10g), H₃BO₃ (1.80 g), CuSO₄.5 H₂O (0.40 g), (NH₄)₆Mo₇O₂₄.4 H₂O (0.38 g), and ZnSO₄.7 H₂O 0.44 g) per 1000L

Irrigated/rainfed Irrigated

Data recording	<p>I. Days to 80% sprouting,</p> <p>II. Plant height at 7 month,</p> <p>III. No. of leaves plant⁻¹ at 7 month,</p> <p>IV. No. of tillers plant⁻¹ at 7 month,</p> <p>V. Wt. of primary, secondary and mother rhizome plant⁻¹,</p> <p>VI. Shoot weight and root weight</p> <p>VII. No. of plant at harvesting time polybag⁻¹,</p> <p>VIII. Yield polybag⁻¹ (kg)</p> <p>IX. Yield (t ha⁻¹)</p>
Experiment No. 02	Effect of r production methods on yield of ginger
Objective(s)	<ul style="list-style-type: none"> ❖ To study the performance of conventional ginger production compared to fertigation technology ❖ To study the benefit cost ratio of conventional method and fertigation technique for ginger production
Materials and Method:	
Variety/Materials	BARI Ada-1
Treatment	<p>T₁= SRC Recommended production practice of ginger</p> <p>T₂= Farmer practice (1st week of April planting + 50g seed rhizome size + spacing 50 × 25cm + irrigation in dry period + no mulch + ridge method + fertilizer dose: cow dung @ 5.0 + urea, TSP, MOP, gypsum @ 304, 267, 233, 111kg ha⁻¹ (Anon., 2007). The rhizomes were planted as per the experimental treatments. The unit plot size was 4.0 × 1.5m).</p>
Design	RCB
Replication	8 (Eight)
Plot size	3.0 m x 1.5 m
Plant spacing	50 cm x 25 cm
Fertilizer dose and methods of application	<p>Cow dung 5 t ha⁻¹ applied during land preparation. The crop was fertilized with N₁₀₀ P₅₄ K₁₆₆ S₂₀ kg ha⁻¹. The entire quantity of cow dung, P, K, S and ½ of N were applied during land preparation. The rest of N was applied in two equal splits at 25 and 50 DAP.</p>
Irrigated/rainfed	Irrigated

Data to be recorded	I. Days to 80% sprouting,
	II. Plant height at 7 month,
	II. No. of leaves plant ⁻¹ at 7 month,
	V. No. of tillers plant ⁻¹ at 7 month,
	V. Wt. of primary, secondary and mother rhizome plant ⁻¹ ,
	VI. Shoot weight and root weight
	VII. No. of plant at harvesting time polybag ⁻¹ ,
	VIII. Reaction to common pests and diseases
	IX. Yield t ha ⁻¹

11. Results and discussion:

The sub-project was consisted of two experiments, which were carried out to investigate various aspects of ginger production under soil less cultivation and conventional method in two locations. The results and discussion of the two experiments are presented below:

Experiment-1

Effect of locations

Different parameter viz., 80% emergence, plant height, number of tillers poly bag⁻¹, number of leaves polybag⁻¹, root weight, root length, yield polybag⁻¹ and yield (t ha⁻¹) were significantly varied between the locations but weight of primary and secondary rhizome polybag⁻¹ and disease severity did not vary significantly (Table 1). The highest yield (22.76 t ha⁻¹) was obtained from L₁: (Bogra location) and the lowest (22.21 t ha⁻¹) was found from L₂: (Lalmonirhat location).

Effect of varieties

Different ginger variety showed significant effect on 80% emergence, plant height, number of tillers polybag⁻¹, number of leaves polybag⁻¹, weight of primary and secondary rhizome polybag⁻¹, root weight, root length, yield polybag⁻¹ and yield (t ha⁻¹) (Table 2). The highest yield (25.80 t ha⁻¹) was found in V₁ (BARI Ada-1) and the lowest (19.62 t ha⁻¹) was found in V₃ (BARI Ada-3). It might be due to the fact that the plants produced from BARI Ada-1 showed vigorous growth and maximum number of leaves per polybag than the other variety, which might have helped in higher rate of photosynthesis, and this ultimately resulted in highest rhizome yield.

Effect of growth substrates

Different growth had significant effect on 80% emergence, plant height, number of tillers polybag⁻¹, number of leaves poly⁻¹, weight of primary & secondary rhizome poly bag⁻¹, root weight, root length, yield polybag⁻¹, yield (t ha⁻¹) and disease severity (%) (Table 3). The highest yield (37.42 t⁻¹) was obtained from M₁ (Coco- dust) and the lowest yield (10.35 t ha⁻¹) was found from M₇ (soil). This could be due to the higher porosity of M₁ (Coco dust substrate) treatment compared the other treatments.

Combined effect of varieties and locations

Combined effect of varieties × locations on plant height, 80% emergence, number of leaves polybag⁻¹, weigh of secondary rhizome polybag⁻¹, yield polybag⁻¹ and yield (t ha⁻¹) was found significant while number of tillers polybag⁻¹, weight of primary rhizome polybag⁻¹, root weight, root length and disease severity (%) was not found significant, (Table 4). The highest yield (26.22 t ha⁻¹) was obtained from V₁L₁ treatment combination (BARI Ada-1 × Bogra location) and the lowest yield (19.42 t ha⁻¹) was found from V₃L₂ treatment combination (BARI Ada-3 × Lalmonirhat location).

Combined effect of growth substrates and locations

Significant influence of growth substrates and locations was found on the yield and yield components of ginger under soil less cultivation. Growth substrates × locations had significant effect on 80% emergence. The M₁L₁ treatment combination (Coco- dust × Bogra location) required less time (28.11 days) to 80% emergence while the highest (51.55 days) was required for M₇L₂ combination (Control + Lalmonirha location) which was statistically different from all other treatments. The highest rhizome yield (39.06 t ha⁻¹) was obtained from M₁L₁ treatment combination (Coco- dust substrate and Bogra location). Yield contributing characters like plant height, number of leaves polybag⁻¹, tillers polybag⁻¹, weight of primary rhizomes polybag⁻¹ and weigh of secondary rhizomes polybag⁻¹ were higher in the above treatment combination (M₁L₁). The lowest (10.06 t ha⁻¹) was found on M₇L₂ treatment combination (Control treatment × Lalmonirhat location) (Table 5).

Combined effect of growth substrate and variety

Yield and yield contributing characters were varied due to the combined effect of growth substrate × variety. The highest rhizome yield (44.32 t ha⁻¹) was recorded from M₁V₁ treatment combination (Coco- dust × BARI Ada-1) which was significantly differed from others treatments combinations. The second and third highest yield was obtained from M₁V₂ (Coco- dust × BARI Ada-2) treatment combination (35.77 t ha⁻¹) and M₁V₃ (Coco- dust × BARI Ada-3) treatment combination (32.10 t ha⁻¹), respectively. Yield contributing characters like maximum number of leaves poly bag⁻¹, maximum number of tillers polybag⁻¹, highest weight of primary rhizomes polybag⁻¹ and secondary rhizomes polybag⁻¹ were higher in the above treatment combination, while the lowest yield (8.77 t ha⁻¹) was found from M₇V₃ (Control × BARI Ada-3) treatment combination (Table 6). Among the treatments, the lowest rhizome rot damage (3.54%) was found in the M₁V₁ treatment combination (Coco dust × BARI Ada-1) followed by M₁V₂ (Coco- dust × BARI Ada-2) (3.69 %) and (Coco- dust × BARI Ada-3) treatment (5.24 %). Inversely, the highest incidence of rhizome rot was found in the M₇V₃ (Control + BARI Ada-3) treatment combination (36.75%) followed by M₇V₂ (Control × BARI Ada-2) treatment combination (29.75%) and M₇V₁ (Coco dust × BARI Ada-1) treatment combination (27.87%).

Combined effect of growth substrates, varieties and locations

Combined effect of growth substrates × varieties × locations significantly influenced the growth and yield contributing characters of ginger produced under soil less cultivation. The treatment combination $M_7V_3L_2$ (Control × BARI Ada-3 and Lalmonirhat location) took the highest days (52.50) to complete 80% emergence while it was minimum (20.66 days) required in $M_1V_1L_1$ (Coco dust × BARI Ada-1 × Bogra location) combination. There was a non significant effect on plant height between treatments (Table. 7). However, the tallest plant (93.67 cm) was produced by ginger cultivated in $M_1V_1L_1$ (Coco- dust × BARI Ada-1 × Bogra location) treatment followed by (91.17 cm) $M_1V_1L_2$ (Coco- dust × BARI Ada-1 × Lalmonirhat location) treatment combination and the lowest (53.00cm) was found in $M_7V_3L_2$ (Control × BARI Ada-3 × Lalmonirhat location) treatment combination. Treatment containing $M_1V_1L_1$ (Coco- dust × BARI Ada-1 × Bogra location) produced the tallest plants might be due to the higher porosity of coco-dust that facilitate better aeration for growth and development. Plant grown in $M_3V_1L_1$, $M_3V_2L_1$, $M_3V_3L_1$, $M_3V_1L_2$, $M_3V_2L_2$, and $M_3V_3L_2$ gave lower plant height.

The higher content of rice bran in the medium (M_3) added more moisture content that lowered oxygen in the media, which consequently reduced height of the ginger plant compared to other treatments. Similar studies also showed that high water holding capacity reduces the growth and yield of tomato and cucumber (De Rijcket *al.*, 1998).

Number of leaves/hill and number of tillers polybag⁻¹ varied significantly due to growth substrates × varieties × locations. The maximum number of leaves polybag⁻¹ and number of tillers polybag⁻¹ (661.1 and 39.66 respectively) were found from $M_1V_1L_1$ (Coco- dust × BARI Ada-1 × Bogra location) followed by (555.2 and 35.66 respectively) from $M_1V_1L_2$ (Coco dust × BARI Ada-1 × Lalmonirhat location). On the other hand the minimum number of leaves/poly bag and number of tillers polybag⁻¹ (163.0 and 8.5 respectively) were found from $M_7V_3L_2$ (Control × BARI Ada-3 × Lalmonirhat location) treatment combination followed by (165 and 10.17 respectively) from $M_7V_3L_1$ (Coco- dust × BARI Ada-3 × Bogra location) treatment combination.

The weight of primary rhizome and secondary rhizome were also significantly influenced by the combined effect of substrates × varieties × locations.. The highest weight of primary rhizome polybag⁻¹ and secondary rhizome polybag⁻¹ (703.67g and 1063.7g respectively) were found in $M_1V_1L_1$ (Coco- dust × BARI Ada-1 × Bogra location) followed by (696.83g and 1058.8g respectively) in $M_1V_1L_2$ (Coco- dust × BARI Ada-1 × Lalmonirhat location) treatment combination while the lowest (105.83g and 183g respectively) were found in $M_7V_3L_2$ (Soil × BARI Ada-3 × Lalmonirhat location) treatment, respectively.

Significant difference in rhizome yield between treatment combinations was observed. The highest rhizome yield (45.2 t ha⁻¹) was obtained from plants grown in $M_1V_1L_1$ (Coco dust × BARI Ada-1 × Bogra location) followed by $M_1V_1L_2$ (Coco dust × BARI Ada-1 × Lalmonirhat

location, 43.4 t ha⁻¹), M₁V₂L₁ (Coco dust × BARI Ada-2 × Bogra location) treatment combination. These results showed that ginger cultivated in Coco dust × BARI Ada-1 × Bogra location increased the rhizome yield. This might be due to high oxygen availability in the coco dust media supported requirement for high oxygen for growth as the underground rhizomes. The second highest rhizome yield (33.5 t ha⁻¹) was found from M₆V₁L₁ (Coco dust × BARI Ada-1 × Bogra location) treatment combination followed by (32.8 t ha⁻¹ and 29.8 t ha⁻¹ respectively) from M₆V₁L₂ (50% coco dust × 50% rice barn × BARI Ada-1 × Lalmonirhat location) and M₆V₂L₁ (50% coco dust × 50% rice barn × BARI Ada-2 × Bogra location). The lowest yield (8.5 t ha⁻¹) was found from M₇V₃L₂ (Soil × BARI Ada-3 × Lalmonirhat location) treatment combination followed by (9.1 t ha⁻¹ and 9.7 t ha⁻¹ respectively) from M₇V₃L₁ (Soil × BARI Ada-3 × Bogra location) and M₇V₂L₂ (Soil × BARI Ada-2 × Lalmonirhat location) treatment combination.

Economic analysis

Total variable cost

An attempt was made to as the cost and return analysis in ginger production. The total variable cost of ginger production was the highest (Tk.3186441 ha⁻¹) in the M₃V₁L₁, M₃V₁L₂, M₃V₂L₁, M₃V₂L₂ and M₃V₃L₁, M₃V₃L₂. The lowest cost of production (Tk.1288041 ha⁻¹) was recorded from the M₇V₁L₁ (Control × BARI Ada-1 × Bogra location), M₇V₁L₂ (Control × BARI Ada-1 × Lalmonirhat location), M₇V₂L₁ (Control × BARI Ada-2 × Bogra location), M₇V₂L₂ (Control × BARI Ada-2 × Lalmonirhat location), M₇V₃L₁ (Control × BARI Ada-3 × Bogra location), M₇V₃L₂ (Control × BARI Ada-3 × Lalmonirhat location) treatment combinations. The higher production cost in M₃V₁L₁, M₃V₁L₂, M₃V₂L₁, M₃V₂L₂, M₃V₃L₁ and M₃V₃L₂ might be due to higher prices of rice bran (Table 8).

Gross return

The highest gross return (Tk.4500000 ha⁻¹) was recorded from M₁V₁L₁ (Coco dust × BARI Ada-1 × Bogra location) followed by Tk.4300040 ha⁻¹ in M₁V₁L₂ (Coco dust × BARI Ada-1 × Lalmonirhat location), Tk.3800040 ha⁻¹ in M₁V₂L₁ (Coco dust × BARI Ada-2 × Bogra location) and Tk.3300020 ha⁻¹ in M₁V₂L₂ (Coco dust × BARI Ada-2 × Lalmonirhat location) treatment combination while the lowest value of gross return (Tk.800050 ha⁻¹) was obtained from M₇V₃L₂ (Control × BARI Ada-3 × Lalmonirhat location) (Table 8). The highest gross return obtained in M₁V₁L₁ probably due to the low cost of coco dust growth substrate and higher rhizome yield.

Gross margin

The results presented in the (Table 8) showed that the gross margin was comparatively higher (Tk. 2621534 ha⁻¹) with M₁V₁L₁ (Coco dust × BARI Ada-1 × Bogra location) which was followed by Tk. 2421574 ha⁻¹ in M₁V₁L₂ (Coco dust × BARI Ada-1 × Lalmonirhat location) treatment combination while the lowest net return (Tk. 1686411 ha⁻¹) was received with M₃V₃L₁ (Rice bran × BARI Ada-3 × Bogra location) treatment combination.

Benefit-cost ratio

Among the treatments, it was found that the highest benefit-cost ratio of 2.40 was recorded with the $M_1V_1L_1$ (Coco- dust \times BARI Ada-1 \times Bogra location) followed by 2.29 in $M_1V_1L_2$ (Coco- dust \times BARI Ada-1 \times Lalmonirhat location) treatment combination. The lowest benefit-cost ratio of 0.47 was observed in the $M_3V_3L_2$ (Rice barn \times BARI Ada-3 \times Lalmonirhat location). In conclusion, ginger can profitably be cultivated Coco- dust substrate with BARI Ada-1 (Table 8).

Table 1 . Effect of locations on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Locations	Emergence (%)	Plant height (cm)	Number of tillers bag ⁻¹	Number of leaves bag ⁻¹	Weight of primary rhizome (g) bag ⁻¹	Weight of secondary rhizome (g) bag ⁻¹	Root length (cm)	Root weight (g)	Yield poly bag ⁻¹ (g)	Yield (t ha ⁻¹)	Disease severity (%)
L ₁	34.87b	74.21a	23.47a	309.70a	305.38	455.47	29.55b	40.14b	754.39a	22.76a	14.44
L ₂	37.59a	70.16b	21.21b	300.28b	302.69	451.89	30.59a	40.86a	745.63b	22.21b	18.22
L. S.	**	**	**	**	NS	NS	**	*	*	*	NS
CV%	6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115

L.S. = Level of significance, L₁: Bogra Location, L₂: Lalmonirhat Location, * Significant at 0.05% level of probability, ** Significant at 0.01% level of probability, NS: Not Significant

Table 2 . Effect of varieties on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers/bag	Number of leaves/bag	Weight of primary rhizome (g)/bag	Weight of secondary rhizome (g)/bag	Root length (cm)	Root weight (g)	Yield/poly bag (g)	Yield (t ha ⁻¹)	Disease severity (%)
V ₁	27.77c	75.70a	24.82a	325.12a	368.32a	545.98a	28.13c	38.62c	862.49a	25.80a	14.28
V ₂	38.57b	72.04b	22.19b	300.73b	289.59b	433.77b	29.96b	40.54b	738.06b	22.03b	16.36
V ₃	42.35a	68.82c	19.10c	289.12c	254.19c	381.29c	32.13a	42.34a	649.48c	19.62c	18.34
L. S.	**	**	**	**	**	**	**	**	**	**	NS
CV%	6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115

L.S. = Level of significance, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, ** Significant at 0.01% level of probability, NS: Not Significant

Table 3. Effect of growth media on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers/bag	Number of leaves/bag	Weight of primary rhizome (g)/bag	Weight of secondary rhizome (g)/bag	Root length (cm)	Root weight (g)	Yield/poly bag (g)	Yield (t ha ⁻¹)	Disease severity (%)
M ₁	28.75e	87.31a	33.94a	532.75a	559.86a	788.03a	23.14d	31.72f	1239.39a	37.42a	11.83b
M ₂	33.27cd	76.60b	24.88c	464.56b	308.25c	447.69c	30.69c	39.47d	786.72c	23.67c	13.34b
M ₃	43.94b	60.72e	16.93f	292.69c	212.64f	368.25e	35.81a	51.33a	597.94f	17.91e	18.67ab
M ₄	32.38d	73.94c	21.89d	246.42d	279.86d	388.19d	34.00b	43.61c	687.67d	20.26d	15.54b
M ₅	34.47c	69.11d	19.97e	223.05e	233.33e	377.06de	35.05ab	45.67b	629.74e	18.86e	16.39b
M ₆	33.88cd	8.00b	26.92b	202.67f	380.75b	583.67b	29.71c	38.03d	965.56b	28.92b	17.08b
T ₇	46.88a	59.63e	11.83g	172.78g	153.55g	788.03a	22.11d	33.67e	343.06g	10.35f	31.46a
L. S.	**	**	**	**	**	**	**	**	**	**	**

CV%	6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115
-----	------	------	------	------	------	------	------	------	------	------	-----

L. S. : Level of significance. M₁: Coco dust M₂: Sawdust, M₃: Rice bran, M₄: 50% Coco dust + 50% Sawdust, M₅: 50% Sawdust + 50% Rice bran, M₆: 50% Coco dust + 50% Rice bran M₇ Control (Soil), ** Significant at 0.01% level of probability, NS: Not Significant

Table 4 . Combined effect of varieties and locations on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers/bag	Number of leaves/bag	Weight of primary rhizome (g)/bag	Weight of secondary rhizome (g)/bag	Root length (cm)	Root weight (g)	Yield/poly bag (g)	Yield (t ha ⁻¹)	Disease severity (%)
V ₁ L ₁	25.28e	77.83a	26.13	335.17a	370.02	548.00a	27.58	42.73	872.62a	26.22a	13.53
V ₁ L ₂	30.26d	73.95b	23.50	315.07b	366.62	543.95a	28.67	41.95	852.37b	25.38a	14.22
V ₂ L ₁	38.24c	73.57b	23.25	303.62c	290.07	435.33b	29.50	40.88	748.41c	22.64b	15.03
V ₂ L ₂	38.90c	70.86c	21.14	297.83cd	289.12	432.21b	30.40	40.19	727.71d	21.42c	15.58
V ₃ L ₁	43.59a	70.12c	21.02	290.31de	256.05	383.10c	32.71	38.95	656.80e	19.82d	17.15
V ₃ L ₂	41.09b	66.78d	18.97	287.93e	252.33	379.50c	31.55	38.28	642.14e	19.42d	22.46
L. S.	**	**	NS	**	NS	**	NS	NS	**	**	NS
CV%	6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115

L. S. :Level of significant, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, L₁: Bogra Location, L₂: Lalmonirhat Location, ** Significant at 0.01% level of probability, NS : Not Significant

Table 5. Combined effect of growth media and locations on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers/bag	Number of leaves/bag	Weight of primary rhizome (g)/bag	Weight of secondary rhizome (g)/bag	Root length (cm)	Root weight (g)	Yield/poly bag (g)	Yield (t ha ⁻¹)	Disease severity (%)
M ₁ L ₁	28.11f	88.50a	35.83	552.72a	561.50a	789.50a	21.56	31.66	1291.00a	39.06a	32.02
M ₁ L ₂	29.39ef	86.11a	32.05	512.78b	558.22a	786.55a	22.67	31.7	1187.77b	35.75b	30.89
M ₂ L ₁	32.05de	77.53b	26.08	294.67d	309.50c	449.39c	22.89	38.94	756.00f	23.08e	20.15
M ₂ L ₂	34.50cd	75.66bc	23.67	290.72d	307.00c	446.00c	23.38	40.00	817.44e	24.24e	20.05
M ₃ L ₁	44.00b	65.17e	17.86	204.39g	213.72f	371.17de	28.92	51.05	595.00i	17.97g	17.94
M ₃ L ₂	43.89b	56.28f	16.00	200.94g	211.56f	365.33e	30.00	51.61	600.88i	17.83g	17.28
M ₄ L ₁	29.61ef	75.17bcd	22.89	248.67e	281.78d	390.06d	30.50	43.27	679.11g	20.21f	16.53
M ₄ L ₂	35.17c	72.72cd	20.89	244.17e	277.94d	386.33d	31.39	43.94	696.22g	20.38f	14.83
M ₅ L ₁	33.50cd	71.61d	20.94	223.00f	234.61e	378.89e	33.11	45.16	612.33i	18.39g	14.56
M ₅ L ₂	35.44c	66.61e	19.00	223.11f	232.06e	375.22de	34.56	46.16	647.14h	19.33fg	13.81
M ₅ L ₁	34.61cd	78.39b	28.05	470.39c	383.22b	586.28b	34.89	37.5	995.44c	29.95c	12.87

M ₆	L ₂	33.16cd	77.61b	25.77	458.72c	378.27b	581.06b	35.33	38.50	935.67d	27.89d	7.17
	L ₁	42.22b	63.14e	12.61	174.06h	153.33g	223.06f	35.56	33.33	351.83j	10.63h	6.99
M ₇	L ₂	51.55a	56.11f	11.05	171.50h	153.78g	222.72f	36.28	34.00	334.28j	10.06h	3.50
L. S.		**	**	**	**	**	**	NS	NS	**	**	NS
CV%		6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115

L. S.=Level of significant, M₁: Coco dust M₂: Sawdust, M₃: Rice bran, M₄: 50% Coco dust + 50% Sawdust, M₅: 50% Sawdust + 50% Rice bran, M₆: 50% Coco dust + 50% Rice bran M₇ Control (Soil), L₁: Bogra Location, L₂: Lalmonirhat Location, ** Significant at 0.01% level of probability, NS : Not Significant

Table 6. Combined effect of growth media and varieties on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Treatment	Emergenc e (%)	Plant height (cm)	Number of tillers/bag	Number of leaves/bag	Weight of primary rhizome (g)/bag	Weight of secondary rhizome (g)/bag	Root length (cm)	Root weight (g)	Yield/poly bag (g)	Yield (t ha ⁻¹)	Disease severity (%)	
M ₁	V ₁	21.17i	92.42a	37.16a	608.12a	700.25a	1061.25a	20.50	30.17	1492.50a	44.32a	3.54
	V ₂	24.83h	86.33b	33.58b	508.92b	492.00b	705.92b	23.00	31.25	1172.75b	35.77b	3.69
	V ₃	25.25h	83.17bc	31.08bc	481.16c	487.33b	596.92c	25.92	33.75	1052.92d	32.1c	5.24
M ₂	V ₁	26.75h	82.08bc	26.79def	298.33e	345.92d	538.25d	29.41	36.92	870.50f	26.22de	12.42
	V ₂	27.33h	80.21cd	24.33fg	291.16e	300.83e	453.50e	30.50	39.50	799.58g	23.99fg	13.37
	V ₃	31.08g	78.67cd	23.49gh	288.58e	278.00f	51.33i	32.16	42.00	690.08i	20.78h	14.23
M ₃	V ₁	32.33fg	76.83de	19.25jk	216.58ij	285.50ef	405.75fg	34.08	49.50	696.50i	20.94h	18.17
	V ₂	32.75fg	76.33def	17.04kl	204.17jk	203.08gh	360.92hi	35.75	51.33	588.25j	17.26jkl	18.42
	V ₃	33.42fg	73.25efg	14.50lm	187.25kl	149.33i	338.08i	37.58	53.16	509.08k	15.53l	19.42
M ₄	V ₁	34.42efg	73.25efg	24.58efg	252.08f	340.67d	415.83f	32.08	41.83	758.16h	22.16gh	14.50
	V ₂	35.00def	73.25efg	21.58hij	246.33fg	279.25f	401.58fg	34.25	43.91	696.33i	20.34hi	15.46
	V ₃	35.33def	71.92fg	19.50jk	240.83fgh	219.67g	347.16i	35.66	45.08	608.50j	18.29jk	16.67
M ₅	V ₁	38.00cde	71.75fg	22.41ghi	229.42ghi	289.50ef	412.92f	32.92	43.66	717.55i	21.54h	16.08
	V ₂	38.50cd	68.92gh	19.75ijk	224.00hi	221.83g	382.00gh	35.00	46.00	626.42j	18.69ij	16.33
	V ₃	39.92c	66.50hi	17.75k	215.75ij	188.66h	336.25i	37.25	47.33	545.25k	16.36kl	16.75
M ₆	V ₁	40.58c	64.25hij	29.25cd	487.42c	398.33c	705.33b	27.88	36.58	1099.75c	33.15c	7.23
	V ₂	40.75c	62.21ij	27.16de	460.25d	394.83c	530.75d	29.58	38.00	951.17e	28.17d	6.82
	V ₃	47.83b	61.08jk	24.33fg	446.00d	349.08d	514.91d	31.67	39.50	845.70f	25.45ef	7.20
M ₇	V ₁	51.00ab	59.67jk	14.25m	183.83l	218.08g	282.50j	20.00	31.66	402.50l	12.30m	27.87
	V ₂	51.67a	57.00k	11.91mn	170.25lm	135.33i	201.75k	21.67	33.75	331.92m	9.98n	29.75
	V ₃	52.92a	56.83k	9.33n	164.25m	107.25j	184.42k	20.50	35.58	294.75m	8.77n	36.75
L. S.	**	**	**	**	**	**	**	NS	NS	**	**	NS
CV%	6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115	

L. S.=Level of significant, M₁: Coco dust M₂: Sawdust, M₃: Rice bran, M₄: 50% Coco dust + 50% Sawdust, M₅: 50% Sawdust + 50% Rice bran, M₆: 50% Coco dust + 50% Rice bran M₇ Control (Soil), V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, ** Significant at 0.01% level of probability, NS : Not Significant

Table 7. Combined effect of growth media, varieties and locations on soil less ginger production using fertigation technique (Expt. 1, 2017- 18)

Treatment		Emergence (%)	Plant height (cm)	Number of tillers/bag	Number of leaves/bag	Weight of primary rhizome (g)/bag	Weight of secondary rhizome (g)/bag	Root length (cm)	Root weight (g)	Yield/poly bag (g)	Yield (t ha ⁻¹)	Disease severity (%)	
M ₁	V ₁	L1	20.66o	93.67	39.66	661.1a	703.67a	1063.7a	21.00	30.33	1524.0a	45.2a	3.67
		L2	21.67no	91.17	35.66	555.2b	696.83a	1058.8a	20.00	30.00	1461.0b	43.4a	3.71
	V ₂	L1	31.66g-k	87.67	34.67	519.7c	492.17b	707.2b	23.50	31.33	1244.5c	38.4b	3.35
		L2	33.00ghi	85.00	32.17	498.2cd	491.83b	704.7b	22.50	31.17	1101.0d	33.2c	53.13
	V ₃	L1	32.00g-j	84.17	31.50	477.3d-g	488.66b	597.6c	25.66	33.33	1104.5d	33.6c	3.48
		L2	33.50gh	82.17	30.33	485.0de	486.00b	596.2c	26.16	34.16	1001.3e	30.7cd	3.60
M ₂	V ₁	L1	22.83mno	81.08	30.00	300.6i	346.83d	540.7d	28.33	36.50	890.2fg	26.9ef	11.83
		L2	26.83j-n	79.33	28.16	296.0i	345.00d	535.8d	30.50	37.33	850.8fgh	25.4f-h	13.00
	V ₂	L1	34.00fg	77.17	28.08	293.0i	301.83e	454.8e	30.00	38.67	768.5jk	23.7g-k	12.91
		L2	34.83fg	75.50	28.00	289.3i	299.83e	452.2ef	31.00	40.33	830.7ghi	24.3f-j	13.83
	V ₃	L1	39.33def	74.33	26.33	290.3i	279.83e	352.6ijk	31.66	41.66	609.3pq	18.6n-s	13.86
		L2	41.83cd	72.17	25.83	286.8i	276.16e	350.0ijk	32.67	42.33	770.8ijk	23.0h-l	14.60
M ₃	V ₁	L1	30.50g-l	68.17	25.66	219.0m-p	287.17e	406.8g	33.50	49.17	701.2l-o	21.2j-o	16.50
		L2	31.67g-k	60.33	25.50	214.1n-q	283.83e	404.7g	34.67	49.83	691.8no	20.7k-p	19.83
	V ₂	L1	49.00ab	65.00	25.33	205.0o-r	204.16fg	363.2h-k	35.17	51.16	580.8pq	17.5q-t	17.00
		L2	46.67bc	57.16	24.83	203.3pqr	202.00fg	358.7ijk	36.33	51.50	595.7pq	17.0r-t	19.83
	V ₃	L1	52.50a	62.33	23.83	189.2qrs	149.83 h	343.5jk	37.33	52.83	503.0r	15.3tu	18.33
		L2	53.33a	51.33	23.50	185.3rs	148.83h	332.7k	37.83	53.50	515.2r	15.8st	20.50
M ₄	V ₁	L1	23.33mno	78.33	23.33	253.8j	342.00d	417.5efg	31.33	41.50	755.3j-m	22.5h-l	13.50
		L2	27.16j-n	75.32	22.83	250.3jk	339.33d	414.2fg	32.84	42.16	761.0j-l	21.8i-m	15.50
	V ₂	L1	31.16g-l	74.66	22.67	248.6jkl	280.83e	403.6g	33.50	43.50	696.0m-o	20.4l-q	15.00
		L2	35.66efg	71.83	22.16	244.0j-m	277.67e	399.50gh	35.00	44.33	696.7m-o	20.2l-q	15.91
	V ₃	L1	34.33fg	72.50	21.00	243.5j-m	222.50f	349.0ijk	34.50	44.83	586.0pq	17.7p-t	15.16
		L2	42.66cd	71.00	20.50	238.2j-n	216.83fg	345.3ijk	36.83	45.32	631.0pq	18.9m-s	18.17
V ₁	L1	26.33k-n	74.66	20.50	232.6j-o	290.67e	414.8fg	32.17	43.17	715.1k-n	21.5i-o	14.50	

M ₅	V ₂	L ₂	28.33h-m	69.17	20.33	226.2j-p	288.33e	411.0g	33.67	44.16	719.9k-n	21.6i-n	17.67	
		L ₁	34.66fg	71.16	20.17	222.5l-p	223.83f	383.5ghi	34.50	45.50	611.8pq	18.3o-t	14.66	
	V ₃	L ₂	36.00efg	66.66	19.00	225.5k-p	219.83f	380.5g-j	35.50	46.50	641.0op	19.0m-r	18.00	
		L ₁	39.50def	69.00	18.67	213.8n-q	189.33g	338.3k	37.00	46.83	510.0r	15.3tu	15.32	
	M ₆	V ₁	L ₂	42.00cd	64.00	18.50	217.6m-p	188.00g	334.2k	37.50	47.83	580.5q	17.4q-t	18.17
			L ₁	27.50i-m	83.16	18.33	493.7cd	399.83c	709.0b	27.60	36.16	1108.3d	33.5c	7.20
V ₂		L ₂	26.00l-o	81.00	18.08	481.2def	396.83c	701.7b	28.16	37.00	1091.2d	32.8cd	7.27	
		L ₁	35.83efg	79.33	17.00	465.0e-h	396.33c	532.8d	28.83	37.66	997.0e	29.8de	7.11	
V ₃		L ₂	34.16fg	78.00	16.00	455.5fgh	393.33c	528.6d	30.33	38.33	905.3f	26.5fg	6.50	
		L ₁	40.50de	72.66	15.33	452.5gh	353.50d	517.0d	30.32	38.83	881.0fg	26.5fg	7.18	
M ₇	V ₁	L ₂	39.33def	73.83	15.16	439.5h	344.66d	512.8d	33.00	40.16	810.5h-j	24.4f-i	7.21	
		L ₁	25.83l-o	65.75	13.66	185.2rs	220.00f	283.5l	20.82	31.17	414.1s	12.6uv	27.50	
	V ₂	L ₂	50.16ab	58.66	13.33	182.5rs	216.16fg	281.5l	21.16	32.16	390.8st	11.9vw	28.25	
		L ₁	51.33ab	62.66	12.50	171.5s	131.33hi	202.2m	22.17	33.50	340.2tu	10.2v-x	29.50	
	V ₃	L ₂	52.00ab	56.66	11.33	169.0s	139.33h	201.3m	24.33	34.00	323.7u	9.7v-x	30.00	
		L ₁	49.50ab	61.00	10.17	165.5s	108.67i	185.3m	25.00	35.33	301.1u	9.1wx	35.66	
		L ₂	52.50a	53.00	8.50	163.0s	105.83i	183.5m	21.00	35.833	288.3u	8.5x	37.83	
Level of signi.			**	NS	**	**	*	*	NS	NS	**	**	NS	
CV%			6.58	4.31	8.04	3.85	4.16	3.56	6.67	5.21	3.40	5.90	115	

M₁: Coco dust M₂: Sawdust, M₃: Rice bran, M₄: 50% Coco dust + 50% Sawdust, M₅: 50% Sawdust + 50% Rice bran, M₆: 50% Coco dust + 50% Rice bran M₇ Control (Soil), V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, L₁: Bogra Location, L₂: Lalmonirhat Location, * Significant at 0.05% level of probability ** Significant at 0.01% level of probability, NS : Not Significant

Table 8: Economic analysis of ginger production per hectare as influenced by using fertigation technique (Expt. 1, 2017-18)

Treatment		Yield (t ha ⁻¹)	Gross return (Tk./ha)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Benefit cost ratio (BCR)	
M ₁	V ₁	L ₁	45.2	4500000	1878466	2621534	2.40
		L ₂	43.4	4300040	1878466	2421574	2.29
	V ₂	L ₁	38.4	3800040	1878466	1921574	2.02
		L ₂	33.2	3300020	1878466	1421554	1.76
	V ₃	L ₁	33.6	3300060	1878466	1421594	1.76
		L ₂	30.7	3000070	1878466	1121604	1.60
M ₂	V ₁	L ₁	26.9	2600090	1660941	939149	1.57
		L ₂	25.4	2500040	1660941	839099	1.51
	V ₂	L ₁	23.7	2300070	1660941	639129	1.38
		L ₂	24.3	2400030	1660941	739089	1.44
	V ₃	L ₁	18.6	1800060	1660941	139119	1.08
		L ₂	23.0	2300000	1660941	639059	1.38
M ₃	V ₁	L ₁	21.2	2100020	3186441	(-)1086421	0.66
		L ₂	20.7	2000070	3186441	(-)1186371	0.63
	V ₂	L ₁	17.5	1700050	3186441	(-)1486391	0.53
		L ₂	17.0	1700000	3186441	(-)1486441	0.53
	V ₃	L ₁	15.3	1500030	3186441	(-)1686411	0.53
		L ₂	15.8	1500080	3186441	(-)1686316	0.47
M ₄	V ₁	L ₁	22.5	2200050	1711791	488259	1.29
		L ₂	21.8	2100080	1711791	388289	1.23
	V ₂	L ₁	20.41	2000041	1711791	388289	1.23
		L ₂	20.21	2000021	1711791	288230	1.17
	V ₃	L ₁	17.7	1700070	1711791	(-)11721	1.17
		L ₂	18.9	1800090	1711791	88299	1.05
M ₅	V ₁	L ₁	21.5	2100050	2423691	(-)323641	0.87
		L ₂	21.6	2100060	2423691	(-)323631	0.87
	V ₂	L ₁	18.3	1800030	2423691	(-)623661	0.74
		L ₂	19.0	1900000	2423691	(-)523691	0.78
	V ₃	L ₁	15.3	1500030	2423691	(-)923661	0.62
		L ₂	17.4	1700040	2423691	(-)723651	0.70
M ₆	V ₁	L ₁	33.5	3300050	2474541	825509	1.33
		L ₂	32.8	3200080	2474541	725539	1.29
	V ₂	L ₁	29.8	2900080	2474541	425539	1.17
		L ₂	26.5	2600050	2474541	125509	1.05
	V ₃	L ₁	26.5	2600050	2474541	125509	1.05
		L ₂	24.4	2400040	2474541	(-)74501	0.97
M ₇	V ₁	L ₁	12.6	1200060	1288041	(-)87981	0.93
		L ₂	11.9	1100090	1288041	(-)187951	0.85
	V ₂	L ₁	10.2	1000020	1288041	(-)28802	0.78
		L ₂	9.7	900070	1288041	(-)387971	0.70
	V ₃	L ₁	9.7	900070	1288041	(-)387971	0.70
		L ₂	8.5	800050	1288041	(-)48799	0.62

M₁: Coco dust @ 3TK. 3/kg, M₂: Sawdust@ 2.5 TK. 3/kg, M₃: Rice bran@ 10 TK. 3/kg, M₄: 50% Coco dust + 50% Sawdust, M₅: 50% Sawdust + 50% Rice bran, M₆: 50% Coco dust + 50% Rice bran M₇: Control (Soil)@ 5TK. kg⁻¹, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, L₁: Bogra Location, L₂:

Lalmonirhat Location, Polyethylene @ 120 TK. kg⁻¹, Seed rhizome @ 100 TK.kg⁻¹, Rhizome sell price @100 TK.kg⁻¹, Ca(NO₃)₂@ 2640 TK. kg⁻¹, EDTA Iron@ 7480 TK. kg⁻¹, KH₂PO₄@ 4000 TK. kg⁻¹, KNO₃@ 4180 TK. kg⁻¹, Mg SO₄@ 1430 TK. kg⁻¹, MnSo₄@ 2040 Tk. kg⁻¹, H₃BO₃@ 2860 Tk. kg⁻¹,CuSo₄ @ 3080 Tk. kg⁻¹,,Mo₇O₂₄@ 30

Experiment-2

Effect of production practices

Different production practice had significant effect on 80% emergence, plant height, number of tillers plant⁻¹, number of leaves plant⁻¹, weight of primary and secondary rhizomes plant⁻¹, yield plant⁻¹, yield plot⁻¹, yield (t ha⁻¹), dry matter %, and disease severity (Table 1). The highest yield (11.01 t ha⁻¹) was obtained from P₁: {Spices Research Center practices (SRC)} and the lowest yield (7.64 t ha⁻¹) was found from P₂: {Farmer practices (FP)}

Effect of locations

The different location showed significant effect on 80% emergence, plant height, number of tillers plant⁻¹, number of leaves plant⁻¹, weight of primary rhizomes plant⁻¹, secondary rhizomes plant⁻¹, yield plant⁻¹, yield plot⁻¹, yield (t ha⁻¹) but had no significant effect on dry matter (%) and disease severity (Table 2). The highest yield (10.46 t ha⁻¹) was found in L₁ (Bogra location) and the lowest yield (8.18 t ha⁻¹) was found from L₂ (Lalmonirhat location). Plants grown in Bogra location showed vigorous growth and gave maximum number of leaves per plant than the Lalmonirhat location which might have helped in higher rate of photosynthesis and this ultimately resulted in maximum rhizome yield in Bogra location.

Effect of varieties

The different variety showed significant effect on 80% emergence, plant height, number of tillers plant⁻¹, number of leaves plant⁻¹, weight of primary and secondary rhizomes plant⁻¹, yield plant⁻¹, yield plot⁻¹, yield (t ha⁻¹), dry matter (%), and disease severity (Table 3) The highest yield (10.65 t ha⁻¹) was found in V₁ (BARI Ada-1) followed by (8.99 t ha⁻¹) in V₂ (BARI Ada-2) and the lowest yield (8.34 t ha⁻¹) was found in V₃ (BARI Ada-3). It might be due to the fact that the plants produced from the BARI Ada-1 showed vigorous growth and gave maximum number of leaves per plant than the other variety which might have helped in higher rate of photosynthesis and this ultimately resulted in maximum rhizome yield.

Combined effect of production practices and varieties

Combined effect of production practice × variety had significant effect on plant height, number of tillers plant, number of leaves plant⁻¹, yield plant⁻¹, yield plot⁻¹, yield (t ha⁻¹) and dry matter (%) and non-significant 80% emergence, weight of primary rhizomes/plant, weight of secondary rhizomes plant⁻¹ and disease severity (%), (Table 4). The highest rhizome yield (12.62 t ha⁻¹) was obtained from P₁V₁ (SRC practices × BARI Ada-1) treatment

combination followed by 10.62 t ha⁻¹ in P₁V₂ (SRC practices × BARI Ada-2) and 9.79 t ha⁻¹ in P₁V₃ (SRC practices × BARI Ada-3). The lowest rhizome yield (6.89 t ha⁻¹) was found in P₂V₃ (Farmers practices × BARI Ada-3) treatment combination. The highest dry matter (24.00%) was obtained from P₁V₁ (SRC practices × BARI Ada-1) treatment combination followed by 23.67 % in P₁V₂ (SRC practices × BARI Ada-2) while the lowest dry matter (17.83%) was obtained from P₂V₂ (Farmers practices × BARI Ada-2) treatment combination. Among the treatments, the lowest rhizome rot damage (23.67 %) was found from the treatment combination of P₁V₂ (SRC practices × BARI Ada-2) followed by 24.66 % in P₁V₁ (SRC practices × BARI Ada-1) treatment combination. Inversely, the highest incidence (56.32 %) of rhizome rot was found in the P₂V₃ (Farmers practices × BARI Ada-3) treatment combination.

Combined effect of production practices and locations

Combined effect of production practice × location had significant effect on plant height, number of tillers/plant, weight of primary rhizome plant⁻¹, yield plant⁻¹, yield plot⁻¹ and yield (t ha⁻¹) and non-significant effect on 80% emergence, number of leaves plant⁻¹, weight of secondary rhizomes plant⁻¹, dry matter (%) and disease severity (%) (Table 5). The treatment combination P₂L₂ (Farmers practices × Lalmonirhat location) took the maximum days (44.78) to complete 80% emergence while it was minimum (38.22 days) in P₁L₁ (SRC practices × Bogra location). The highest yield (12.93 t ha⁻¹) was obtained from P₁L₁ (SRC practices × Bogra) treatment combination followed by 9.09 t ha⁻¹ in P₁L₂ (SRC practices × Lalmonirhat) and the lowest (7.28 t ha⁻¹) was found from P₂L₂ (Farmers practices × Lalmonirhat) treatment combination. The highest dry matter (22.78 %) was obtained from P₁L₁ (SRC practices + Bogra) treatment combination followed by (22.67 %) P₁L₂ (SRC practices × Lalmonirhat) while the lowest dry matter (18.67%) was obtained from P₂L₂ (Farmers practices × Lalmonirhat) treatment combination. Among the treatments, the lowest rhizome rot damage (25.33 %) was found from the treatment combination of P₁L₁ (SRC practices × Bogra) followed by P₁V₂ (SRC practices × Lalmonirhat), 25.78 %, treatment combination. Inversely, the highest incidence (48 %) of rhizome rot was found in the P₂L₂ (Farmers practices × Lalmonirhat) treatment combination

Combined effect of varieties and locations

Combined effect of varieties × location had significant effect on yield and yield contributing characters and non significant effect on 80% emergence, dry matter (%) and disease severities (%) (Table 6). The highest plant height, maximum number of tillers and leaves plant⁻¹, weight of primary and secondary rhizomes plant⁻¹ were found from V₁L₁ (BARI Ada-1 × Bogra location) and the lowest of these parameters were found from V₂L₂ (BARI Ada-2 × Lalmonirhat location). The highest yield (11.68 t ha⁻¹) was recorded in V₁L₁ treatment combination (BARI Ada-1 × Bogra location) that was significantly differed from others treatments. Yield contributing characters like plant height, maximum number of leaves/plant, maximum number of tillers/plant, highest weight of primary and secondary rhizomes/ plant were higher in the above treatment (V₁L₁) combination, while the lowest yield (7.39 t ha⁻¹) was found from V₂L₂ (BARI Ada-2 × Lalmonirhat location) treatment combination (Table 6). Among the treatments, the lowest rhizome rot damage (32.50 %)

was found from V_1L_1 (BARI Ada-1 × Bogra location) treatment combination followed by V_2L_1 (BARI Ada-2 × Bogra location 32.83 %). Inversely, the highest incidence (42.50 %) of rhizome rot was found from V_2L_2 (BARI Ada-2 × Lalmonirhat location) treatment combination.

Combined effect of production practices, varieties and locations

Combined effect of different practices, varieties and locations significantly influenced the growth and yield contributing characters of ginger. The treatment combination $P_2V_3L_2$ (Farmers practices × BARI Ada-3 × Lalmonirhat location) took the maximum (46.66) days to complete 80% emergence while it was minimum (35.00 days) in $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location). There was a significant difference in plant height between treatments. The tallest plants (87.60 cm) were produced by ginger cultivated in $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) treatment combination and the lowest (64.33cm) were found in $P_2V_3L_2$ (Farmers practices × BARI Ada-3 × Lalmonirhat location) treatment combination (Table 7). Treatment containing $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) produced the tallest plants compared to other treatments. It might be due to use of mulching which had reduced the evaporation of soil moisture, suppressed weed growth and conserved moisture coming from the rainfall during the early stage of plant growth.

Number of leaves plant⁻¹ and number of tillers plant⁻¹ varied significantly due to different practices × varieties × locations. The maximum number of leaves plant⁻¹ and number of tillers plant⁻¹ (451.66 and 23.47, respectively) were found from $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) followed by (388.20 and 20.20, respectively) from $P_2V_1L_1$ (Farmers practices × BARI Ada-1 × Bogra location). It might be due to mulch condition conserved sufficient moisture in the soil which was utilized by the leaves to promote better growth than the non mulch treatment. On the other hand the minimum number of leaves plant⁻¹ and number of tillers plant⁻¹ (211.0 and 10.5, respectively) were found from $P_1V_2L_2$ (SRC practices × BARI Ada-2 × Lalmonirhat location) treatment combination.

The weight of primary and secondary rhizome was also significantly influenced by different practices × varieties × locations. The highest weight of primary and secondary rhizomes/plant (37.46g and 349.46g respectively) were found from $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) followed by 32.13g and 305.20g, respectively from $P_1V_3L_1$ (SRC practices × BARI Ada-3 × Bogra location) treatment while the lowest, respectively were found from $P_2V_2L_2$ (Farmers practices × BARI Ada-2 × Lalmonirhat location 22.33g and 189.0g) treatment respectively. The highest primary and secondary rhizome in $P_1V_1L_1$ might be due to rice mulching in SRC practice. That enhances producing vigorous plant growth in compared to farmers practices (non mulch), which helped in deposition of greater amount of assimilates to the primary rhizomes and secondary rhizomes.

Significant differences in rhizome yield between treatments combination was observed. The highest (14.34 t ha⁻¹) rhizome yield was obtained from plants grown in $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) followed by $P_1V_2L_1$ (SRC practices × BARI Ada-2 × Bogra location (13.12 t ha⁻¹) treatment combination. The highest yield in $P_1V_1L_1$ might be due to rice straw mulch conserved more soil moisture and markedly suppressed early weed

growth, increased crop emergence, and conserved more soil moisture leading to maximum growth and yield per plot over farmers practices which helped to produce more number of leaves per plant, vigorous plant growth, deposition of more food material and finally gave more yield. These results showed that ginger cultivated in SRC practices × BARI Ada-1 × Bogra location increased the rhizome yield. The lowest yield (6.66 t ha^{-1}) was found from $P_2V_3L_2$ (Farmers practices × BARI Ada-3 × Lalmonirhat location) treatment combination. The highest yield in $P_1V_1L_1$ might be due to less disease infestation and highest (56.33%) disease infestation in $P_2V_3L_2$ (Farmers practices × BARI Ada-3 × Lalmonirhat location) treatment combination that ultimately reduced the rhizome yield.

Economic analysis

Total variable cost

An attempt was made to do the cost and return analysis in ginger production. The total cost of production was the higher ($\text{Tk.}768396.00 \text{ ha}^{-1}$) $P_2V_1L_1$, $P_2V_1L_2$, $P_2V_2L_1$, $P_2V_2L_2$, $P_2V_3L_1$ and $P_2V_3L_2$ treatment combinations have same (Farmers practices × varieties × Lalmonirhat location) While the lowest cost of production ($\text{Tk.}649996 \text{ ha}^{-1}$) was recorded from the the SRC practices × three varieties (BARI Ada-1, BARI Ada-2 and BARI Ada-3) and two locations (Bogra and Lalmonirhat location) treatment combination have same cost of production (Table 8).

Gross return

The highest gross return ($\text{Tk.}1282890 \text{ ha}^{-1}$) was recorded from the $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) followed by $P_1V_2L_1$ (SRC practices × BARI Ada-2 × Bogra location, $\text{Tk.}1166020 \text{ ha}^{-1}$) treatment combination while the lowest value of gross return ($\text{Tk.}557940 \text{ ha}^{-1}$) was obtained from $P_2V_3L_2$ (Farmers practices × BARI Ada-3 × Lalmonirhat location) treatment combination (Table 8). The highest gross return was obtained probably due to the low cost of ginger production under SRC practices and higher rhizome yield.

Gross margin

The results presented in the (Table 8) showed that the net return was comparatively higher ($\text{Tk.}632894 \text{ ha}^{-1}$) with the $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) followed by $P_1V_2L_1$ (SRC practices + BARI Ada-2 + Bogra location, $\text{Tk.} 516024 \text{ ha}^{-1}$) treatment combination while the lowest negative net return ($\text{Tk.} -25591 \text{ ha}^{-1}$) was received with $P_2V_1L_2$ (Farmers practices × BARI Ada-1 × Lalmonirhat location) treatment combination (Table 8).

Benefit-cost ratio

Among the treatments, it was found that the highest benefit-cost ratio of 1.97 was recorded with the $P_1V_1L_1$ (SRC practices × BARI Ada-1 × Bogra location) followed by 1.79 in $P_1V_2L_1$ (SRC practices × BARI Ada-2 + Bogra location) treatment combination. The lowest benefit-cost ratio of 0.72 was observed in the $P_2V_3L_2$ (Farmers practices × BARI Ada-3 × Lalmonirhat location) treatment combination (Table 8).

Table 1 . Effects of different production practices using conventional method on ginger production (Expt. 2, 2017- 18)

Practice's	Emergence (%)	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield Plot ⁻¹ (kg)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)
P ₁	38.78b	77.29a	16.76a	307.39a	30.03a	265.87a	293.19a	5.28a	11.01a	22.72a	25.56b
P ₂	44.11a	73.95b	15.23b	278.28b	28.44b	225.96b	266.58b	3.67b	7.64b	18.78b	47.17a
L. S.	**	**	**	**	**	**	**	**	**	**	**
CV%	3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32

L. S.= Level of significant, P₁: SRC practices, P₂:Farmer practices, ** Significant at 0.01% level of probability

Table 2 . Effects of locations using conventional method on ginger production (Expt. 2, 2017- 18)

Locations	Emergence (%)	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield plot ⁻¹ (kg)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)
L ₁	40.83b	79.43a	17.82a	323.84a	33.94a	278.15a	306.69a	5.00a	10.46a	20.83	35.83
L ₂	42.05a	71.81b	14.17b	261.78b	24.53b	213.67b	253.08b	3.94b	8.18b	20.67	36.88
L. S.	**	**	**	**	**	**	**	**	**	NS	NS
CV%	3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32

L. S.= Level of significant, L₁: Bogra location , L₂: Lalmonirhat location, ** Significant at 0.01% level of probability, NS = Not Significant

Table 3. Effect of varieties using conventional method on ginger production (Expt. 2, 2017- 18)

Variety	Emergence (%)	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield plot ⁻¹ (kg)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)
V ₁	38.42b	81.27a	20.01a	374.72a	32.22a	277.75a	306.22a	5.11a	10.65a	21.92a	32.75b
V ₂	42.67a	70.78c	12.27c	216.38c	27.89b	215.47b	261.77b	4.32b	8.99b	19.58b	34.00b
V ₃	43.25a	74.82b	15.71b	287.33b	27.60b	244.52b	271.67b	3.99c	8.34c	20.75ab	42.33a
L. S.	**	**	**	**	**	**	**	**	**	**	**
CV%	3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32

L. S.= Level of significant, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, ** Significant at 0.01% level of probability

Table 4 . Combined effect of practices and varieties using on conventional method on ginger production (Expt. 2, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers plant	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield plot ⁻¹ (kg)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)	
P ₁	V ₁	35.83	82.83a	21.57a	411.33a	32.23a	313.07	330.46a	6.04a	12.62a	24.00a	24.66
	V ₂	40.00	71.96d	12.95d	223.56d	29.30b	223.93	272.77b	5.10b	10.62b	23.67a	23.67
	V ₃	40.50	77.07bc	15.77c	287.26c	28.57bc	260.60	276.3b	4.70b	9.79b	19.83b	28.33
P ₂	V ₁	41.00	79.70ab	18.45b	338.10b	32.20a	242.43	281.97b	4.18c	8.67c	18.67b	40.83
	V ₂	45.33	69.60d	11.58d	209.20d	26.49c	207.00	250.78c	3.53d	7.36d	17.83b	44.33
	V ₃	46.00	72.57cd	15.65c	287.38c	26.63c	228.43	267.00c	3.28d	6.89d	20.50b	56.32
L. S.	NS	*	*	**	NS	NS	*	*	**	*	NS	
CV%	3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32	

L. S.: Level of significant, P₁: SRC practices, P₂: Farmer practices, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, * Significant at 0.05% level of probability, ** Significant at 0.01% level of probability, NS : Not Significant

Table 5 . Combined effect of practices and locations on conventional method using ginger production (Expt. 2, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield Plot ⁻¹ (kg)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)	
P ₁	L ₁	38.22	80.00a	18.11a	332.67	35.29a	303.96	339.27a	6.19a	12.93a	22.78	25.33
	L ₂	39.33	74.58b	15.41b	282.11	24.78c	252.36	274.11b	4.37b	9.09b	22.67	25.78
P ₂	L ₁	43.44	78.87a	17.53a	315.01	32.59b	227.78	259.06b	3.81c	8.00c	18.89	46.33
	L ₂	44.78	69.04c	12.92c	241.44	24.29c	199.55	247.11b	3.52c	7.28c	18.67	48.00
L. S.	NS	*	*	NS	*	NS	**	**	**	NS	NS	
CV%	3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32	

L. S.= Level of significant, P₁: SRC practices, P₂: Farmer practices, L₁: Bogra location , L₂: Lalmonirhat location, * Significant at 0.05% level of probability, ** Significant at 0.01% level of probability, NS = Not Significant

6 . Combined effect of varieties and locations on conventional method using ginger production (Expt. 2, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield Plot ⁻¹ (kg)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)	
V ₁	L ₁	37.67	85.77a	21.83a	419.93a	37.99a	313.16a	320.02a	5.59a	11.68a	21.83	32.50
	L ₂	39.17	76.77bc	18.18b	329.50b	26.43c	242.33bc	292.42a	5.08b	9.62bc	19.83	33.00
V ₂	L ₁	42.16	72.73cd	13.33c	227.43cd	33.12b	241.10bc	294.22a	4.63c	10.59b	20.83	32.83
	L ₂	43.16	68.83d	11.20c	205.33d	22.67d	189.83c	229.33c	4.33c	7.39d	20.67	35.17
V ₂	L ₁	42.66	79.80b	18.30b	324.15b	30.70b	280.20ab	305.83ab	3.65d	9.13c	19.33	42.17
	L ₂	43.83	69.83d	13.12c	250.50c	24.50cd	208.83c	237.50	3.55d	7.55d	22.00	42.50
L. S.	NS	*	*	**	**	**	**	**	**	**	NS	NS
CV%	3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32	

L. S.= Level of significant, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, L₁: Bogra location, L₂: Lalmonirhat location, * Significant at 0.05% level of probability, ** Significant at 0.01% level of probability, NS = Not Significant

Table 7. Combined effect of production practices, varieties and locations on conventional method using ginger production (Expt. 2, 2017- 18)

Treatment	Emergence (%)	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Weight of primary rhizome plant ⁻¹ (g)	Weight of secondary rhizome plant ⁻¹ (g)	Yield plant ⁻¹ (g)	Yield plot ⁻¹ (g)	Yield (t ha ⁻¹)	Dry matter (%)	Disease severity (%)	
V ₁	L ₁	35.00	87.60a	23.47a	451.66a	37.46a	349.46a	353.93a	6.85a	14.34a	24.00	24.66
	L ₂	36.67	78.06b-d	19.66b	371.00bc	27.00d-f	276.66abc	307.00a-c	5.23b	10.90b	24.00	24.66
V ₂	L ₁	39.66	73.60c-f	14.00c-e	236.13fg	36.26ab	257.20abc	332.20ab	6.30a	13.12a	20.66	23.33
	L ₂	40.33	70.33e-g	10.50e	211.00g	23.00fg	190.66c	213.33d	3.90c-e	8.12cd	20.33	24.00
P ₁	L ₁	40.00	78.80b-d	16.87bc	310.20c-e	32.13bc	305.20ab	331.67ab	5.43b	11.32b	23.67	28.00
	L ₂	41.00	75.33c-e	14.67cd	264.33e-g	25.00e-g	216.00bc	221.00d	3.97cd	8.26cd	23.66	28.66
V ₁	L ₁	40.33	83.93ab	20.20ab	388.20ab	38.53a	276.86abc	286.10a-d	4.33c	9.02c	19.66	40.33
	L ₂	41.67	75.47c-	16.70bc	288.00d-f	25.87d-g	208.00c	277.83b-	4.03c	8.33cd	20.00	41.33

P ₂	V ₂	L ₁	44.66	e 71.86d- g	12.66de	218.73fg	29.98cd	225.00bc	d 256.23cd	3.86c- f	8.05cd	19.00	42.33
		L ₂	46.00	67.33fg	11.90de	199.66g	22.33g	189.00c	245.33cd	3.33d- f	6.84d	18.33	46.33
	V ₃	L ₁	45.33	80.80a- c	19.73b	338.10b-d	29.27c-e	255.20bc	280.00b- d	3.23ef	6.93d	18.00	56.33
		L ₂	46.66	64.33g	11.56de	236.66fg	24.00fg	201.67c	254.00cd	3.20f	6.66d	17.66	56.33
L. S.		NS	**	**	**	**	**	*	*	*	NS	NS	
CV%		3.30	3.20	7.03	7.78	4.80	11.86	8.26	4.77	5.74	7.63	16.32	

L. S.= Level of significant, P₁: SRC practices, P₂:Farmer practices, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, L₁: Bogra location , L₂: Lalmonirhat location, * Significant at 0.05% level of probability, ** Significant at 0.01% level of probability, NS = Not Significant

Table 8. Economic analysis of ginger production per hectare as influenced production practice × varieties × locations (Expt. 2, 2017-18)

Treatment combination		Yield of old mother rhizomes (t ha ⁻¹)	Fresh rhizome yield (t ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Benefit-cost ratio (BCR)
P ₁	V ₁ L ₁	1.5	14.24	1282890	649996	632894	1.97
	L ₂	1.10	10.90	923650	649996	273654	1.42
	V ₂ L ₁	1.0	13.12	1166020	649996	516024	1.79
	L ₂	0.89	8.12	734420	649996	84428	1.13
	V ₃ L ₁	0.92	11.32	992920	649996	342924	1.53
	L ₂	0.75	8.26	727210	649996	77214	1.12
P ₂	V ₁ L ₁	1.4	9.02	849170	768396	80774	1.11
	L ₂	1.0	8.33	742805	768396	(-)25591	0.97
	V ₂ L ₁	0.94	8.05	736825	768396	(-)31571	0.96
	L ₂	0.80	6.66	563610	768396	(-)204786	0.73
	V ₃ L ₁	0.85	6.93	568905	768396	(-)199491	0.74
	L ₂	0.68	6.84	557940	768396	(-)210456	0.72

P₁: Spices Research practices, P₂: Farmers practices, V₁: BARI Ada-1, V₂: BARI Ada-2, V₃: BARI Ada-3, L₁: Bogra location, L₂: Lalmonirhat location, Cost of the seed rhizome @ Tk. 100/kg, Urea @ TK. 16/kg, TSP @ TK. 22/kg, MP @ TK. 15/kg, Gypsum @ TK. 14/kg, Zinc@ TK. 220/kg, Cow dung @ TK. 1.5/k, Old mother rhizomes sales @ Tk60/kg, fresh harvested rhizomes sales @ Tk. 85/kg.

Comparative performance of ginger under fertigation and conventional method

Table 9 showed comparison of ginger yield per hectare between fertigation system and conventional method for one season of ginger production. The average yield of ginger using fertigation system was (45.2 t/ha) in the best treatment combination (M₁V₁L₁: Coco dust × BARI Ada-1 × Bogra location). The development cost of fertigation system was TK. 1878466 t/ha. Mean while, the average farm price for mature ginger TK. 100/kg. Entrepreneurs who used this fertigation system were able to earn average higher gross margin of TK. 2621534 t/ ha. The average highest yield for the conventional method was (14.24 t/ha) in the best treatment combination (P₁V₁L₁: Spices Research Center practices × BARI Ada-1 × Bogra location). However, the cost of production per kilogram of ginger was higher for conventional method than that of fertigation system. By considering the different average farm price, it was found that the average net income for the cultivation of ginger using fertigation system was higher than the conventional method. The average net income is affected by the level of production and its market price.

Table 9. Comparison of ginger yield per hectare between fertigation system and conventional method for one season of ginger production

Parameter	Fertigation system (Best treatment)	Conventional method (Best treatment)
Average yield (t/ha)	45.2 (M ₁ V ₁ L ₁ treatment)	14.34 (P ₁ V ₁ L ₁ treatment)
Average gross income TK. 100/kg for fertigation system produced ginger and TK. 85/kg for conventional method produced ginger	4500000 (M ₁ V ₁ L ₁ treatment)	1282890 (P ₁ V ₁ L ₁ treatment)
Production cost (TK. /kg)	39.16 (M ₁ V ₁ L ₁ treatment)	46.42 (P ₁ V ₁ L ₁ treatment)
Average net income (TK./ha)	2621534 (M ₁ V ₁ L ₁ treatment)	632894 (P ₁ V ₁ L ₁ treatment)

12. Research highlight/findings:

- (Ex. no. 1) The highest rhizome yield (45.2 t ha⁻¹) was obtained from plants grown in (Coco dust media × BARI Ada-1). The lowest yield (8.5 t ha⁻¹) was found from (Control treatment × BARI Ada-3).
- The variety BARI Ada-1 with coco- dust substrate performed better with regard to improved growth, quality, and higher yield and less disease incidence.
- The highest benefit-cost ratio of 2.40 was recorded with the (Coco- dust media × BARI Ada-1) and the lowest benefit-cost ratio of 0.47 was observed in (Rice bran × BARI Ada-3). In conclusion, ginger can profitably be cultivated in Coco dust substrate with BARI Ada-1.
- Ex. no. 2) The highest rhizome yield (14.34 t ha⁻¹) was obtained from plants grown in (SRC practices × BARI Ada-1) and the lowest yield (6.66 t ha⁻¹) was found from (Farmers practices × BARI Ada-3) might be due to highest (56.33%) disease infestation in (Farmers practices × BARI Ada-3) treatment combination that ultimately reduced the rhizome yield.
- The variety BARI Ada-1 with SRC recommendation production practices best performance among the treatment and less disease incidence
- The highest benefit-cost ratio of 1.97 was recorded with the (SRC practices × BARI Ada-1). The lowest benefit-cost ratio of 0.72 was observed in the (Farmers practices × BARI Ada-3)
- Ginger cultivation using fertigation method has been proven to increase the yield and income compared to conventional method. The high cost or initial capital will be offset by higher production. Significant increase in yield up to two or threefold than the conventional method was able to provide high gross margin.
- However, yield and income analysis showed that this technology has a strong competitive edge and is suitable to be adopted by farmers as it can provide higher return than conventional method.

13. References

Anonymous, 2017. Annual Research Report, Spices Research Centre, BARI, Bogra, pp 39.

Bohme, M. 1995. Evaluation of organic, synthetic and mineral substrates for hydroponically grown cucumber. Acta Hort. 401: 209-217.

De Rijck, G. and Schrevens, E. 1998. Distribution of nutrient and water in rockwool slabs. Scientia Horticulturae 72: 277-285.

Jarvis, W. R. 1992. Managing disease in green house crops. St Paul, MN, USA: American Psychopathological Society Press.

Komada, H., Yokoyama, H., Yamamoto, M., Terada, T. and Matsui, Y. 1996. Sugi bark, a potential growth substrate for soilless culture with bioactivity against some soil borne disease. J. Hort. Sci. 72: 989-996.

Ortega, M.C., Monero, M.T., Ordovas, J. and aguado, M.T. 1996. Behaviour of different horticultural species in phytotoxicity bioassay of bank substrate. Sci. Hort. 66: 125-132.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	-	-	-	-	
(b) Lab &field equipment					
Seed, fertilizer, pesticide, etc. inputs	LS	880934	LS	869907	Tk. 934/- added from Capital item Tk. 40000/- added from miscellaneous item
pH meter	1		1		
EC meter	1		1		
Labour	517		517		
Water pump	1		1		
GI iron frame	96 nos		96 nos		
Chemical					
KH ₂ PO ₄	7kg		7kg		
KNO ₃	15kg		15kg		
Ca(NO ₃) ₂ .	30kg		30kg		
MgSO ₄ .	10.25kg		10.25kg		
EDTA Iron	5kg		5kg		
MnSO ₄	10kg		10kg		
H ₃ BO ₃	4kg		4kg		
CuSO ₄	4kg		4kg		
(NH ₄) ₆ Mo ₇ O ₂₄	700gm		700gm		
ZnSO ₄	7.31kg		7.31kg		
(c) Other capital items					

Furniture	LS	66226	LS	66226	Tk. 274/- transferred from research item
Equipment, tools, etc.		724760		724760	Tk. 660/- transferred from research item

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
water tank structure	2	100%	-	-	

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

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	27	3	30	1 Day	-
(b) Workshop	29	1	30	1 Day	-

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	192989.6	159930	159930	0	82.869	Lack of fund
B. Field research/lab expenses and supplies	880934	869907	869907	0	98.748	-
C. Operating expenses	359230	353656	353656	0	98.448	-
D. Vehicle hire and fuel, oil & maintenance	220000	208585	208585	0	94.811	-
E. Training/workshop/seminar etc.	139900	125765	125765	0	89.896	-
F. Publications and printing	140000	68000	68000	0	48.571	Fund not released
G. Miscellaneous	75960	69711	69711	0	91.773	-
H. Capital expenses	790986	790986	790986	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 study the suitability of ginger cultivation under fertigation system	<ul style="list-style-type: none"> - Site selection -Making shed structure -Making water tank structure -Collection of seed rhizome -Field visit 	<ul style="list-style-type: none"> - Developed techniques for sustainable yield and quality potentials -Transferable technologies have been identified for ginger production. 	<ul style="list-style-type: none"> -Fertigation technology of ginger may help farmers to reduce the production cost. -Environmental pollution due to indiscriminate use of chemicals has been minimized. The research findings of the project can ensure the farmers to produce ginger in a large scale cultivation
To determine the effect of soilless substrates (such as coco- dust, sawdust and rice bran) on growth and yield of ginger	<ul style="list-style-type: none"> -Soilless substrates collection. - Polybag preparation and placement at selected site - Seed rhizome planting -Placement of plastic rubber pipe and dripper for each polybag 	<ul style="list-style-type: none"> - Developed ginger production technology using fertigation system with soilless substrate -Further increase of ginger production area outside the project area 	<ul style="list-style-type: none"> -Entire nation of Bangladesh, especially farmers would be benefited using soilless culture to produce disease free healthy rhizome strategies which have been proved from this research works.
To produce disease free healthy seed rhizome for higher yield and economic return	<ul style="list-style-type: none"> -Disease free healthy seed rhizome production - Rhizome harvesting - Monitoring, data collection and analysis - Cost analysis 	<ul style="list-style-type: none"> -Substantial increase of farm family income - Reduce import of ginger 	<ul style="list-style-type: none"> -Fertigation technology coupled with soilless culture technique can ensure repeated cultivation of ginger from the same piece of land. This opportunity could provide a lucrative return to the capital that has been issued because of extremely local demand and high export price. In addition, the farmers have been benefited economically and their livelihood has improved by using this technology.

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

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet /leaflet/flyer etc.	1	-	dvwU@#Mkb c×wZ‡Z gvwU Qvov Av`v Pvl
Journal publication	-	-	
Information development	-	-	Ginger production technology under soilless culture using Fertigation technique
Other publications, if any (Officers Training Manual)	-	1	Development Of Ginger Production Technology Under Soilless Culture Using Fertigation Technique In Bangladesh

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

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

Developed of soilless ginger production technique:

- a) Coco- dust media with BARI Ada-1 was the best for ginger production media under soilless culture
- b) Ginger cultivation using fertigation method has been proven to increase the yield and income compared to conventional method. The high cost or initial capital will be offset by higher production. Significant increase in yield up to two or threefold than the conventional method was able to provide high net income.
- c) Cost and return analysis showed that this technology has a strong competitive edge and is suitable to be adopted by farmers as it can provide higher return than conventional method.

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

Soilless ginger production was found suitable for the ginger growing region. Continuation of this study is needed for more awareness of ginger growing farmers.

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

Developed soilless ginger production technology may help to increase agricultural productivity and farmers' income in the ginger growing area, which was broadcasted on TV media "Dipto TV, BTV" and in print media "Daily Janakantha". Dissemination of the developed technologies is needed for ginger production area.

iv. Policy Support

- All farmers need to bring under soilless ginger production technology program with the involvement of GO and NGOs.

- Banking facility and easy access to agricultural loan from bank are needed to improve.
- Ginger production technique in the previous growers of northern and hilly area of Bangladesh was found, which needs to replace this new technology.

G. Information regarding Desk Monitoring

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

- Duration of monitoring workshop: 15 May 2018
- Output: To arrange officers training and workshop at Spices Research Center, BARI, Bogura. Different officers know how to produce disease free seed rhizome by using fertigation technique. Continuation of this study is needed for those areas.

H. Information regarding Field Monitoring

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

- Duration of Field Visit: 19 March 2018
- Coverage of Monitoring Report: From May 2017 to March 2018
- Location(s) of the Program: Bogra and Lalmonirhat.
- Field Monitoring Members: 1. Md. Abdur Rahman and 2. Dipok Kumar, Monitoring Associate, PIU, BARC, Dhaka
- Output: Continuing the sub-project as per planned following standard methodology.

I. Lesson Learned/Challenges (if any)

- i) Fertigation technique should be increased and quality seed rhizome must be made available to farmers. In this aspect, active participation of BARI, DAE, BADC and private entrepreneurs are needed.
- ii) Disease free seed rhizome production technology should be made available at farmer's level so that they can produce their own seeds.
- iii) Due to lack of institutional facility and support, the rapid development of agricultural sector is slower.
- iv) Farmers skill should be increased through rigorous training and field demonstration
- v) Special program should be initiated to increase "ginger production area" in the country and NATP should encourage a project aimed to start organizing farmers in ginger growing region to established ginger production shade house.

J. Challenges (if any)

Natural calamities especially heavy rainfall slightly affected for ginger growing season. Banking facility and Agricultural loan system are very limited in the ginger growing area.

Signature of the Principal Investigator
Date
Seal

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

Annexure 1: Weather Data (April 2017 to April 2018.) of different locations

	Temperature			Rainfall	Average Relative Humidity
	Month	Max.	Min.	(mm)	(%)
Bogra	April, 2017	32.06	23.01	121.00	83.40
	May,2017	34.72	25.61	230.00	93.13
	June,2017	33.15	26.39	214.00	92.23
	July,2017	33.02	27.67	511.00	96.97
	Aug,2017	33.99	28.21	190.00	96.43
	Sept,2017	33.03	26.98	245.00	94.00
	Oct,2017	32.82	25.55	304.00	97.47
	Nov,2017	30.27	18.75	002	91.90
	Dec,2017	27.66	16.28	015	97.30
	Jan,2018	22.84	10.25	0.00	98.43
	Feb,2018	26.42	14.47	0.035	83.80
	March,2018	32.11	21.01	0.010	88.37
	April,2018	32.27	22.72	115.00	86.17
Lalmonirhat	April, 2017	30.36	21.72	171.6	91.77
	May,2017	32.34	23.47	357.9	92.58
	June,2017	32.42	25.82	98.8	92.9
	July,2017	32.36	26.45	347.9	94.65
	Aug,2017	32.77	26.67	545.9	94.77
	Sept,2017	32.88	26.28	101.88	95.67
	Oct,2017	31.33	24.01	148.65	95.32
	Nov,2017	29.01	17.64	0.20	94.10
	Dec,2017	26.70	14.94	0.00	97.74
	Jan,2018	21.41	9.41	0.00	80.13
	Feb,2018	26.77	14.16	0.00	69.00
	March,2018	30.99	18.98	13.4	67.30
	April,2018	30.60	21.67	152.2	83.80

Annexure 2: Elemental composition of Saw dust, Coco-dust and Rice bran media (Analysis from soil science lab, BARI, Gazipur)

Sl. No.	Specification	Tested result		
		Saw dust	Coco-dust	Rice bran
01.	Physical condition	Dust	Dust	Dust
02.	Colour	Black	Black	Off-white
03.	Moisture (%)	20.22	18.42	12.98
04.	OM (%)	55.90	69.70	65.70
05.	Ca (%)	3.648	4.176	3.024
06.	Mg (%)	1.566	1.792	1.298
07.	K (%)	0.538	1.075	0.770
08.	N (%)	0.84	1.28	1.20
09.	P (%)	0.148	0.952	0.161
10.	S (%)	0.35	0.36	0.35
11.	B (ppm)	0.003	0.018	0.007
12.	Cu (ppm)	0.011	0.018	0.002
13.	Fe (ppm)	0.341	0.722	0.066
14.	Mn (ppm)	0.182	0.384	0.035
15.	Zn (ppm)	0.0020	0.0059	0.0066

Preparation of different growth substrates



Covered with polyethylene



Coco- dust



Rice bran



Sawdust



50% Coco- dust + 50% Rice bran



50% Sawdust+ 50% Rice bran

Bead preparation and polybag placement



Bead preparation



Polyb

Pipe and dripper placement of polybag



Bogra location



Lalmohatir location



Overview of the experiments on ginger production under fertigation technique- 2017-2018



Conventional method with BARI Ada-1, 2 & 3 + Farmers practices at Lalmonirhat location



Conventional method with BARI Ada-1, 2 & 3 + SRC practices at Bogra location





Conventional method with BARI Ada-1, 2 & 3 + Farmers practices at Bogra location



Farmers motivation of soilless ginger cultivation technique at SRC, Bogra



Soilless ginger production field visit by different visitors



Dr. Abul Kalam Azad, DG, BARI and Dr. Md. Abdus Satter,CSO, BARC visited experiment field at SRC, Bogra



Sanat Kumar Saha, Additional secretary ministry of Agriculture visited experiment field at SRC, Bogra project



NATP Monitoring team Dipok Kumar and AbdurRahman visited experiment field at Bogra



MP Mannan and A. S. F Feroz, Chief Whip visited soilless ginger cultivation experiment field at SRC, Bogra





Dipto TV and BTV recording soilless ginger cultivation experiment at SRC, Bogra



Harvested ginger rhizome under soilless culture using fertigation technique



Harvested ginger rhizome under conventional method (SRC practices and farmers practice)





Workshop at SRC, Bogra under CRG project

14. References

- Anonymous, 2017. Annual Research Report, Spices Research Centre, BARI, Bogra, pp 39.
- Bohme, M. 1995. Evaluation of organic, synthetic and mineral substrates for hydroponically grown cucumber. *Acta Hort.* 401: 209-217.
- De Rijck, G. and Schrevens, E. 1998. Distribution of nutrient and water in rockwool slabs. *Scientia Horticulturae* 72: 277-285.
- Jarvis, W. R. 1992. *Managing disease in green house crops.* St Paul, MN, USA: American Psychopathological Society Press.
- Komada, H., Yokoyama, H., Yamamoto, M., Terada, T. and Matsui, Y. 1996. Sugi bark, a potential growth substrate for soilless culture with bioactivity against some soil borne disease. *J. Hort. Sci.* 72: 989-996.
- Ortega, M.C., Monero, M.T., Ordovas, J. and aguado, M.T. 1996. Behaviour of different horticultural species in phytotoxicity bioassay of bank substrate. *Sci. Hort.* 66: 125-132.