

Project ID --730

## Competitive Research Grant

# Sub-Project Completion Report

on

## DEVELOPMENT OF PROPAGATION AND PROCESSING TECHNOLOGIES FOR BAY LEAF AND CINNAMON

Project Duration

May 2017 to September 2018

Regional Spices Research Centre  
Bangladesh Agricultural Research Institute  
Joydebpur, Gazipur



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



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Project Implementation Unit  
National Agricultural Technology Program-Phase II Project (NATP-2)  
Bangladesh Agricultural Research Council (BARC)  
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### *Acknowledgement*

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## Acronyms

mL	Millilitre	TLC	Thin Layer Chromatography
mg	Milligram	AI	Active Ingredient
min	Minute	DAS	Day After Spraying
wt	Weight	SPE	Solid Phase Extraction
kg	Kilogram	FID	Flame Ionization Detector
rpm	Revolution Par Minute	ECD	Electron Capture Detector
BARC	Bangladesh Agricultural Research Council	ID	Internal Diameter
NATP	National Agricultural Technology Program	MgSO <sub>4</sub>	Magnesium Sulfate
CRG	Competitive Research Grant	NaCl	Sodium Chloride
PIU	Project Implementation Unit	LOD	Limit of Detection
USAID	United States Agency for International Development	LOQ	Limit of Quantification
GoB	Government of Bangladesh	LSD	Least Significant Difference
HPLC	High Performance/Pressure Liquid Chromatography	LC	Liquid Chromatography
GC	Gas Chromatography	me	Milli-equivalent
MRL	Maximum Residue Level	ADI	
PCR	Project Completion Report	FAO	Food and Agriculture Organization
PI	Principal Investigator	WHO	World Health Organization
Co-PI	Co-Principal Investigator	v/v	
TK.	Taka	uv	Ultra violet
LoA	Letter of Agreement	ND	Not Detected
PSI	Pressure Square Inch	BAURES	Bangladesh Agricultural University Research Systems
FTD	Flame Thermionic Detector	RSD	Relative Standard Deviations
Fig.	Figure	PSA	Primary Secondary Amine

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## Executive Summary

Bay leaf and cinnamon are two high valued spices having valuable aroma, higher nutritive and medicinal value, widely used in Bangladesh for preparation of many kinds of foods, beverage, cosmetics and medicines. Production of cinnamon and bay leaf can be increased using BARI Cinnamon-1 and BARI Bay leaf-1 having high yield and stress tolerant habit. Two experiments were conducted at the Regional Spices Research Center, BARI, Gazipur and Citrus Research Station, Jaintapur, Sylhet during May 2017 to September 2018 to evaluate the effect of IBA concentration and time of air layering in Cinnamon and Grafting of bay leaf and cinnamon on Cassia root stock. Air layering and cutting was done in five times (Mid-April, Mid-May, Mid-June, Mid-July and Mid-August) with six levels of IBA concentration viz. 1000, 2000, 3000, 4000, 5000 ppm and control (no IBA). Three types of grafting (cleft, side and contact) were performed in five times viz. March, April, May, June and July on *C. cassia* rootstock. Other two experiments were included for post-harvest processing of cinnamon and bay leaf. Different levels of fermentation and drying temperature have been exposed for processing of bay leaf. Cinnamon bark is exposed to different pre-treatment followed by various temperatures for drying. No root was emerged in cuttings and all cuttings of cinnamon and bay leaf died after 30-40 days. Layering time and IBA concentration showed significant effect on rooting, success and survival rate of cinnamon layers. Layering time and IBA concentration in bay leaf showed significant effect on rooting, success and survival rate of layers. The number of successful layers and percentage of rooting were significantly higher in July (7.67,76.67%) followed by May(7.33,73.33%) and August (7.33,73.33%) layering with 4000 ppm IBA application and layering was not successful in April(0.33,3.33%) layering without IBA treatment. The highest establishment rate was found in May layering (6.33, 86.31%) with 4000 ppm IBA but no layers survived in April, July and August layering without IBA application in bay leaf. The Success of air layers and percentage of rooting in cinnamon layers was significantly higher in July (8.0,80%) followed by May (7.67,76.67%) and June (7.67,76.67%) layering with 5000 ppm IBA application. The final survival number and establishment rate of cinnamon plant was maximum in April layering (4.67, 62.50%) with 4000 ppm IBA but no layers was survived in April, May, June, July and August layering in control (without IBA application). Further more two experiments were conducted on processing of Cinnamon and Bay leaf in experiment set B. Drying of Cinnamon at 40<sup>0</sup>C temperature in the oven without any pre-treatment found better compared to other treatments. Fresh bay leaf dried at 40<sup>0</sup>C temperature or shade drying without pre-treatment seems better having good color and aroma. Continuations of these experiments are essential to confirm the results.

## CRG Sub-Project Completion Report (PCR)

### A. Sub-project Description

1. **Title of the CRG sub-project:** Development of propagation and processing technologies for Bay leaf and Cinnamon
2. **Implementing organization:** Bangladesh Agricultural Research Institute (BARI)
3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

Principal Investigator : **Dr. Shailendra Nath Mozumder**, Principal Scientific Officer  
Regional Spices Research Centre, BARI, Gazipur-1701.  
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Co-Principal Investigator : **Md. Mostafa Kamal**, Scientific Officer  
Regional Spices Research Center, BARI, Gazipur-1701.  
Email: [mamun\\_src@yahoo.com](mailto:mamun_src@yahoo.com), Mobile: 01968250539
4. **Sub-project budget (Tk):**
  - 4.1 Total : Taka 1800000.00 (Eighteen lakh).
  - 4.2 Revised (if any) : Taka 1735000.00 (Seventeen lakh thirty five thousand).
5. **Duration of the sub-project** : 17 Months (May 2017 to September 2018)
  - 5.1 Start date (based on LoA signed): 01 May 2017
  - 5.2 End date : 30 September 2018
6. **Justification of undertaking the sub-project**

Bay leaf and cinnamon are two high valued spices having valuable aroma, higher nutritive and medicinal value widely used in Bangladesh for preparation of many kinds of foods, beverage, cosmetics and medicines. The demands are usually met up by importing from other countries which required a huge expenditure. Production of cinnamon and bay leaf can be increased using BARI released Cinnamon (BARI Cinnamon-1) and Bay leaf (BARI Bay leaf-1) variety having high yield and stress tolerant habit. Homesteads, hilly and highlands are suitable for their cultivation. Lack of quality saplings are the major constraints for expanding their growing areas. No standard technology yet been developed for their propagation in Bangladesh. The quality of imported cinnamon and bay leaf is poor due to admixture, sub-standard processing and long storage duration. The quality (Sweetness, Pungency, Aroma/Eugenol, Color, Texture) of cinnamon is greatly affected by processing (bark cleaning, quill production and drying), packaging and storing. Similarly, Bay leaf quality also depends on its post-harvest handling and processing. Research information regarding these things are scanty in our country and less thrust has so far been given on it in the past. To increase cinnamon and bay leaf production, intensive research on their propagation and processing are very much essential in our country.
7. **Sub-project goal:** Development of appropriate propagation and standard processing techniques of Bay leaf and Cinnamon for rapid dissemination of high yielding varieties (BARI

Cinnamon-1 and BARI Bay leaf-1) to increase bay leaf and cinnamon production as well as ensure quality leaf and quill production, respectively.

8. **Sub-project objective (s):**

a) To develop standard propagation techniques for rapid multiplication of bay leaf and cinnamon to ensure quality sapling production.

b) To develop processing techniques for bay leaf and cinnamon for quality leaf and quill production.

9. **Implementing location (s):** Regional Spices Research Centre, BARI, Gazipur and Citrus Research Station, Jaintapur, Sylhet

10. **Methodology in brief:**

Spices Research Centre, BARI has developed one Cinnamon variety BARI Cinnamon-1 and BARI Bayleaf-1. Major component technologies propagation and processing are very much essential for successful cultivation and dissemination of these varieties. Vegetative propagation is better for bay leaf and Cinnamon for rapid result and quality assurance. Three approaches viz. cutting, air layering and grafting on *Cinnamomum cassia* rootstock were included in the “Experiment set - A” which included four experiments. IBA solutions have been used for root initiation in cutting and layering. Grafting on *Cassia* rootstock would be another approach which needs to be standardized through experimentation. “Experiment Set B” which included two experiments for post-harvest processing of Cinnamon and Bay leaf.

**Experiment set – A: Propagation**

**Experiment-1 and 2: Effect of time and IBA concentration on cutting and layering in cinnamon and bay leaf**

The experiment was conducted in a factorial Complete Randomized Design (CRD) with six levels of IBA viz. 1000, 2000, 3000, 4000, 5000 ppm and control (without IBA) with five times of layering in the middle (15<sup>th</sup>) of each April, May, June, July and August at the Regional Spices Research Centre, BARI, Gazipur and Citrus Research Station, Jaintapur, Sylhet during May 2017 to September 2018. Proximal slanting cut end of 30 cuttings for each treatment were placed in the hormone solutions for five minutes then kept 15 minutes to discard extra solution. After treating with hormone, the cuttings were planted in the 15 cm raised beds of soil, sand and compost mixture at a spacing of 15x10 cm. For better water holding capacity and root development in layering, soil mixture was prepared with 50% loamy soil and 50% well decomposed cow dung and kept open for 2 weeks. Treatment wise hormone solution was taken with a small glass dropper pot applied on the cut surface (from where bark was removed) of the shoot. No hormone was applied for control treatment. Each replication of a single treatment consisting 10 layering shoots and a total of 30 for 3 replications was used and tagged properly. The stool or gooti was made by covering the cut portion with 160-180g of moist soil mixture, covered by polythene and tied tightly with jute rope. When a number of roots are established and visible through polythene, the air layering seems suitable to separate from the mother plant. A half cut was given at 2-3 cm below the stool of air layering. After one week, the layering was separated by gentle full cut from the previously cut place and extra

branches and leaves were trimmed out. The trimmed layering shoot was planted in previously prepared polybag after removing the ploythene and kept one week under shade then 3 weeks in partial shade for establishment. Air layering seems suitable to plant in the field when a number of roots and shoots were established in polybag. Data on length and number of roots per layering was count breaking the stool just after detachment of layering. The samples of three livestock of layer were broken and the numbers of roots were counted and lengths of roots were measured with a digital slide calipers at 60 days after separation. After separation from the mother plants, success of detached layers and number of leaves were counted at 60 days of planting in the polybag. Data is taken on success rate, days to budbreak, leaf and shoot growth, vigour of the saplings, establishment rate, disease and insect pest reaction. Besides these, seedlings of Cinnamon, Bayleaf and *C. cassia* has been produced for using as rootstock.

#### **Experiment 3-4: Grafting of cinnamon and bay leaf scion on cassia rootstocks**

Design : CRD with 2 Factors Treatments: 15 Replication : 3

Factor A: Three (3) Types of grafting: i) Contact ii) Cleft and iii) Vineer

Factor B: 5 Times i) April ii) May iii) June iv) July and v) August

Duration: April 2017 to June 2018.

Location: RSRC, BARI, Gazipur and Jaintapur, Sylhet

The experiment was conducted using a Complete Randomized Design (factorial) using two factors comprising six time of grafting (Mid-March, Mid-April, Mid-May, Mid-June, Mid-July and Mid-August), three types of grafting (cleft, vineer and contact). Ten (10) grafts were considered as single treatment and a total of 90 grafting were done for each month. 10-12 cm long 4-7 months old scion having 0.5 -0.7 cm diameter were used to graft on to rootstock which is matched with the scion. Scion was covered with transparent polythene bag so that bud-break and leaf initiation become visible. Similarly same age and diameter was considered for contact grafting. When new shoots/leaves of the scion are visible, it seems contacted with rootstock, the upper portion of the rootstock and cover of scion was removed. After full contact union a half cut was given at 2-3 cm below the cut portion of contact grafting. After one week the graft was separated by final cut from the previous cut place and excess branches and leaves were trimmed out. The trimmed grafts are kept one week under shade followed by 2 weeks in partial shade for establishment. When a number of roots and shoots were established, the grafts seem suitable to plant in the field. Data on number of established grafts, dead grafts, length and number of shoots and leaves per graft was counted from all the grafts. The number of leaves per established were counted manually and lengths of shoots were measured with a digital slide calipers. The success of detached grafts and number of leaves were counted at 30 and 60 days after grafting. The data were compiled properly and analyzed statistically by 'R' and MS-Excel Program.

#### **Experiment Set -B: Processing of Bayleaf and Cinnamon**

##### **Experiment-5: Effect of fermentation and drying temperature on the quality of Bay leaf.**

Design: CRD with 2 factors, Treatments: 15

Factor A: Three (3) Fermentation duration; i) 24 hours ii) 48 hours and ii) Control (no fermentation)

Factor B: Five (5) Temperature: i) 40°C ii) 50°C iii) 60°C iv) Shade drying and v) Sun drying (Conventional)

Duration : May, 2017 to September, 2018

Location : RSRC, BARI, Gazipur.

The experiment was conducted using a Complete Randomized Design (factorial) using two factors comprising three types of pretreatment and five drying methods (40°C, 50°C, 60°C in oven, shade drying and sun drying). Bay leaf harvested from the field and allowed for pretreatment according to the schedule of the experiment. 100 g sample was considered as single treatment and a total of 4500 g of fresh bay leaf was used for 15 treatment combinations with 3 replications. After pre-treatment, leaves are allowed to dry at various temperatures in oven, shade and sun under ambient natural condition. Data was taken on aroma, quality and quantity basis using laboratory equipment and organolaptic means.

#### **Experiment-6: Effect of pre-treatment and drying temperature on the quality of cinnamon quills.**

Design: CRD with 2 Factors Treatments: 20

Factor A: Four (4) pre-drying treatments: i) Deeping in boiling hot water for 20 seconds ii) 40 seconds, iii) Vaportreatment for 2 minutes and iv) Direct drying (No pre-treatment).

Factor B: Five (5) Temperature; i) 40°C ii) 50°C, iii) 60°C and iv) Sun drying and v) shade drying (Control)

Duration: April 2017 to June 2018

Location: RSRC, BARI, Gazipur

The experiment was conducted using a Complete Randomized Design (factorial) using two factors comprising three types of pretreatment and five drying (40°C, 50°C, 60°C in oven, shade drying and sun drying). Cinnamon bark were collected with a sharp knife and blunt bended kotah. Barks were treated with deeping in boiling water for 20, 40 second, vapor for 2 minutes and untreated control. Treated bark were kept under shade for one hour before drying to remove water or vapor from the bark and to avoid attachment with rapper due to sticky nature of Cinnamon bark. The cinnamon barks were then allowed to drying after different pretreatment viz. 20 and 40 seconds in boiling water, 2 minute in Vapor and control (no pre-treatment) followed by one hour stay under shade to remove extra water. After one hour, samples were allowed to drying in shade and at 40, 50 and 60 degree centigrade temperature in electric oven for 48, 36 and 24 hours, 96 hours in shade and 72 hours in sunlight to get desirable weight. Pungency and taste were observed under organolaptic means. Data was taken on aroma and quality also. Data calculation and analysis was done using MS-Excel, and “R” programs and report was prepared after analysis.

## 11. Results and discussion:

### Experiment-1 of set A

#### Effect of time and IBA concentration on the performance of bay leaf layering

##### Effect of time on success of air layering

The time of layering had significantly affected the success of layering (Table 1.1). Early rooting was observed in May layering (51.8 days) which was statistically similar with April, June and July while August layering took more (68.1 days) for root visibility. Similar result was observed in separation of layers from the mother plant. Rooting success was similar in all five months but establishment rate was declined after June (Table 1.1 and Fig.1.1).

Table 1.1. Effect of layering time on the performance of bay leaf

Layering Time	Days to root visible	Days to cut	% rooting	Establish (% 60 DAS)	% Dead at 60 DAS	Roots /Layer	Length of root (cm)	No branch	Leaves /layer
April	54.2b	72.6b	42.78	81.82a	17.09e	3.37b	7.27b	3.06a	4.41b
May	51.8b	71.4bc	52.22	76.60a	30.44c	4.31a	8.48a	2.18b	5.18a
June	53.0b	71.9bc	51.11	77.17a	26.22d	4.41a	8.49a	2.25b	5.44a
July	53.0b	68.5c	55.56	68.00b	42.79b	3.63ab	6.74a	1.81c	4.65ab
August	68.1a	87.7a	53.33	51.04c	47.94a	3.59ab	6.21c	1.86c	4.61ab
Significance	*	*	NS	*	**	*	*	*	*
CV%	4.15	3.95	6.80	6.68	8.61	6.09	6.07	10.64	6.41

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.

Successful layer was slightly higher (5.56) in July layering (Fig 1.1) where higher percentage of rooting (55.56%) also initiated in July layering (Table1.1) but establishment rate was higher (81.82%) in April as well as lower establishment rate was recorded (51.04%) in August layering. (Table 1.1). Successful layer was lower (2.72) in August layering (Fig 1.1)

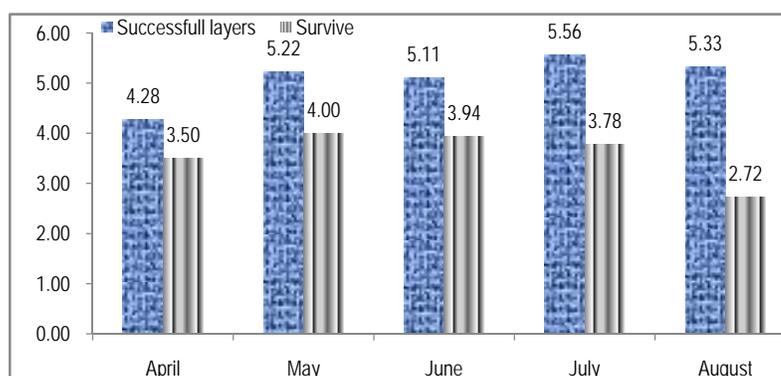


Fig.1.1. Success and establishment rate of bay leaf layering at different time of layering

Death rate of detached layer was higher (47.94%) in August layering and it was minimum in April (17.09%). The lower success in August layering might be due to fall of temperature and lower humidity in October delayed and hampered rooting as well as shoot initiation.

The effect of time of layering was significantly affected on the death of detached layers, number and length of roots, and leaves per layers (Table 1.1). May and June layering gave more number ( $\geq 4$ ) of longer ( $\geq 8$  cm) roots, and leaves ( $\geq 5$ ) compared to May, July and August layering. Hot humid weather favors rooting and leaf initiation that caused more rooting and leaves in May and June than April and August layering.

### Effect of IBA concentration on Bay leaf layering

IBA concentration had significant effect on rooting and success of air layering in bay leaf (Table 1.2 and Fig. 1.2). Control treatment and lower dose of IBA took more times to initiate roots compared to higher doses of IBA concentrations. Days to separation of layers from the mother plant was not significantly affected by IBA concentration. The number of successful layer was significantly higher (7.13) and highest rooting (71.33%) found in 4000ppm IBA concentration followed by 5000ppm where number of successful layer was 6.87 and the highest (75.91%) establishment at 60 days was recorded and it was lower (10%) in control. (Table 1.2 and Fig. 1.2)

The number of established layer was significantly higher (78.69%) in 4000ppm of IBA application followed by 5000 ppm IBA (75.91%) and it was lower in control (16.67%). These findings are resembled with the findings of Sharma *et. al.* (1989) the highest rooting percentage in plum was obtained with IBA treatment of cuttings with 2000 mg I<sup>-1</sup> during summer.

Table 1.2 Effect of IBA concentrations on the performance of Bay leaf layering

IBA Conc.ppm	Days to root visible	Days to cut	Rooting (%)	Establish (%) 60 DAS	% Dead at 60 DAS	Roots /Layer	Length of root (cm)	No branch	Leaves /layer
1000	58.6b	74.7b	36.67b	56.22c	43.78b	4.20a	8.31a	2.14ab	5.12a
2000	56.5b	73.4b	54.00ab	71.78ab	28.22c	4.05a	8.25a	2.09ab	5.70a
3000	51.7c	69.5c	65.33a	70.02ab	29.98c	4.52a	8.43a	3.83a	5.72a
4000	49.7c	69.3c	71.33a	78.69a	21.31d	4.57a	8.39a	2.27ab	5.82a
5000	49.7c	69.9c	68.67a	75.91a	24.09d	4.50a	8.33a	2.31ab	5.72a
Control	69.9a	89.8a	10.00c	16.67d	50.00a	1.33b	2.93b	0.75b	1.07b
Significance	NS	NS	*	*	*	*	*	*	*
CV%	4.15	3.95	6.80	6.68	8.61	6.09	6.07	10.64	6.41

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.

Andrea *et al.*, (1996) obtained the maximum success (87.5%) of plum cuttings from 1500 ppm K-IBA solution. Neto *et al.* (2006) and Canli and Safer (2009) obtained the highest success using 1000 ppm IBA in cherry cutting and layering. Indole-butyric-acid (IBA) enhanced root development and root growth by enhancing cell division resulted the maximum success of layering compared to control and lower level of IBA concentration (Mozumder *et al.*, 2014).

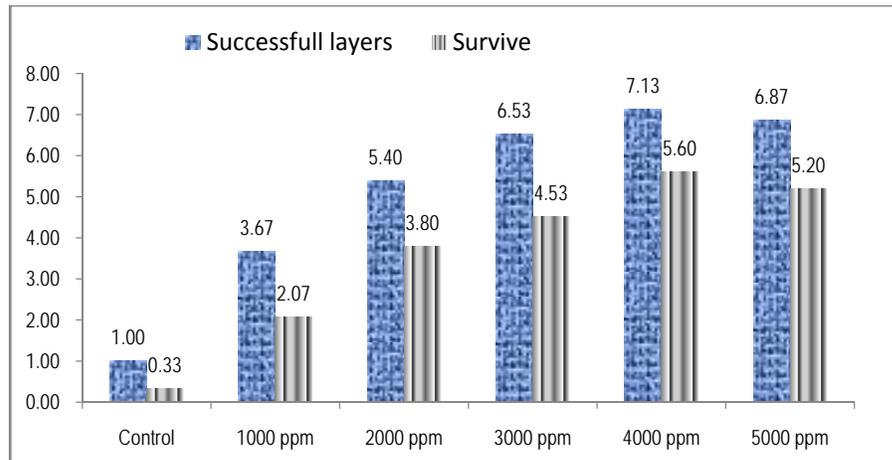


Fig.1.2. Success and establishment rate of bay leaf layering at different IBA concentration

There was significant variation of death of layers after detaching from the mother plant, rooting and leaf production with various levels of IBA treatment (Table1.2). A number of air layering shoots were died in the poly bag after separation from the mother plant. Application of IBA resulted more number ( $\geq 4$ ) of longer ( $\geq 8$  cm) roots compared to control. Numbers of leaves were increased with increasing IBA concentration. The highest number of leaves (5.82/layer) was recorded from the application of 4000ppm IBA which was statically similar in all IBA levels and it was the lowest (1.07/layer) in control. IBA helps to accelerate cell division and root initiation in upper parts of the cut portion of the plant resulted more rooting and leaves with higher doses of IBA.

### Combined effect of time and IBA concentration in bay leaf layering

Layering time and IBA concentration showed significant effect on rooting and success rate of layers (Table 1.3a and 1.3b) in bay leaf. August layering with lower concentration of IBA or control treatment took more 2-3 days compared to April, May, June and July month's layering for root initiation and separation of layers from the mother plant. Early rooting (45.3 days) was found in May layering with 4000ppm while it was significantly delayed (83.7 days) in August layering

without IBA treatment. Bay leaf layers took about 8 weeks to separation that was slightly affected due to layering time but greatly for hormone application.

Table 1.3 a. Combined effect of layering time and IBA on success of bay leaf propagation

Time	IBA Conc.	Days to root visible	Days to Separation	Successful layers (nos)	Rooting (%)	Survive (60 DAS)
April	1000	58.0	75.7	3.00d	30.00d	1.67ef
	2000	54.3	73.0	4.33cd	43.33cd	3.67cd
	3000	50.0	68.0	5.33bc	53.33bc	4.33bc
	4000	48.3	67.0	6.67ab	66.67a	5.67ab
	5000	48.3	67.0	6.33b	63.33ab	5.67ab
	Control	66.0	84.7	0.33f	3.33	0.00g
May	1000	54.7	73.7	4.00c	40.00c	2.67de
	2000	51.3	70.7	5.00bc	50.00bc	4.00c
	3000	47.7	66.0	6.67ab	66.67a	5.00bc
	4000	45.3	66.0	7.33a	73.33a	<b>6.33a</b>
	5000	45.7	66.0	6.67ab	66.67a	5.33b
	Control	66.0	86.3	1.67e	16.67e	0.67fg
June	1000	56.3	71.7	3.67cd	36.67cd	2.67de
	2000	54.3	71.7	5.00bc	50.00bc	4.00c
	3000	47.7	67.3	6.33ab	63.33ab	5.00bc
	4000	46.7	67.3	7.00ab	70.00a	5.67ab
	5000	46.7	67.3	6.67ab	66.67a	5.33b
	Control	66.3	86.3	2.00e	20.00e	1.00f
July	1000	56.3	70.0	3.67cd	36.67cd	2.00e
	2000	53.7	68.7	6.67ab	66.67a	4.67bc
	3000	48.0	65.0	7.00ab	70.00a	4.67bc
	4000	46.3	65.0	<b>7.67a</b>	<b>76.67a</b>	5.67ab
	5000	46.3	65.0	7.33a	73.33a	5.67ab
	Control	67.3	77.3	1.00ef	10.00ef	0.00g
August	1000	67.7	82.7	4.00cd	40.00cd	1.33ef
	2000	68.7	83.0	6.00bc	60.00bc	2.67de
	3000	65.0	81.0	7.33a	73.33a	3.67cd
	4000	62.0	81.0	7.00a	70.00a	4.67bc
	5000	61.3	84.3	7.33a	73.33a	4.00c
	Control	<b>83.7</b>	114.3	0.33f	3.33f	0.00g
Level of Significance		NS	NS	*	*	*
CV%		4.15	3.95	6.80	6.80	7.59

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns', '\*', and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.

The number of successful layer was significantly higher in July layering (7.67, 76.67%) with 4000ppm IBA closely followed by May and August (7.33, 73.33%) with same level IBA application and the success was almost nil (0.33, 3.33%) in April and August layering without IBA. The lower

success in August layering with low IBA is due to fall of temperature and lower hormonal activity hampered rooting. No layer was survived finally from April, July and August layering without IBA application.

Table 1.3b. Combined effect of layering time and IBA on success of bay leaf propagation

Time	IBA Conc.	Establish (% 60 DAS)	% Dead at 60 DAS	Roots Layer	Length of root (cm)	No of branch	Leaves /layer
April	1000	55.56c	44.44	3.83	8.50	2.33b	4.50
	2000	85.00a	15.00	2.53	8.77	1.43c	5.59
	3000	81.11a	18.89	4.42	8.87	2.67a	5.57
	4000	86.11a	13.89	4.70	8.93	2.30b	5.44
	5000	<b>89.68a</b>	10.32	4.73	8.53	2.27b	5.38
	Control	0.00	100.0	-	-	-	-
May	1000	64.44bc	35.56	4.33	8.63	2.33b	5.10
	2000	80.56ab	19.44	4.61	8.57	2.17b	5.56
	3000	73.57b	26.43	4.82	9.03	2.50a	5.82
	4000	<b>86.31a</b>	13.69	4.78	9.10	2.27b	6.31
	5000	79.17ab	20.83	4.67	9.33	2.40a	6.29
	Control	33.33d	66.67	2.67	6.20	1.40c	2.00
June	1000	72.22b	27.78	4.32	8.80	2.20b	5.33
	2000	80.00ab	20.00	4.52	8.20	2.27b	6.00
	3000	79.37ab	20.63	4.63	8.27	2.17b	6.07
	4000	80.95ab	19.05	4.56	8.27	2.28b	6.02
	5000	80.16ab	19.84	4.43	9.00	2.23b	5.91
	Control	50.00c	50.00	4.00	8.43	2.33b	3.33
July	1000	55.56bc	44.44	4.33	8.20	2.00bc	5.50
	2000	69.84bc	30.16	4.36	8.20	2.17b	5.53
	3000	66.67bc	33.33	4.37	8.30	2.30b	5.63
	4000	73.81b	26.19	4.37	8.17	2.20b	5.65
	5000	77.38b	22.62	4.35	7.60	2.21b	5.59
	Control	0.00	100.0	-	-	-	-
August	1000	33.33f	66.67	4.17	7.40	1.83bc	5.17
	2000	43.49e	56.51	4.25	7.53	2.42ab	5.83
	3000	49.40de	50.60	4.35	7.70	2.18b	5.52
	4000	66.27d	33.73	4.44	7.47	2.31b	5.70
	5000	53.17cd	46.83	4.33	7.17	2.44ab	5.45
	Control	0.00	100.0	-	-	-	-
Significance level		*	*	NS	*	*	*
CV%		6.68	8.61	6.09	6.07	10.64	6.41

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.

Significant variations on survivability of layers after detaching from mother plant, rooting and leaf production due to layering time with various IBA concentrations (Table 1.3.a and 1.3.b). The maximum number and rate of survive layers (6.33, 83.31%) was found in May layering with 4000 ppm IBA treatment and it was statistically similar with April Layering (5.67, 89.61%) with 5000 ppm IBA while it was nil (0%) in April, July and August layering without IBA application. Higher concentration IBA results more number of roots in early June-July layering compared to control and lower concentration of IBA treatment in later layering might be the cause of such variation. The number and length of root did not differ significantly with the range of 2.53 to 4.67 and 7.17-9.33 cm per layers at 60 days with the combination of different IBA concentration with time of layering (Table 1.3b).

Number of branches and leaves were increased with increasing IBA concentration in all months of layering. Kakon et al., 2008 showed that among different varieties BARI guava-1 showed the best performance with different concentrations of growth regulators had significant effect on almost all parameters. IBA at 1200 ppm showed the best performance among the treatments.

The maximum number of leaves (6.31/layer) per layer was recorded from the application of 4000ppm IBA in May layering and lowest (2.0/layer) was found from control in the same time of layering. There was no successful layering in April, July and August without IBA that had no roots or leaves. IBA accelerate cell division and root initiation high temperature and humidity resulted more rooting and leaves with higher doses of IBA in May and June layering. Sing (2001) found that use of IBA was beneficial in enhancing the callus formation, number, length and diameter of both primary and secondary roots and survival of air-layered twigs. This findings are almost similar with the report of Rymbai et al. (2010) that air layers of guava have been successfully achieved by exogenous application of IBA at 4000 ppm. The result from these observations were partially resembled with some findings such as Sharma *et. al.* (1989) get maximum success with 2000 ppm IBA, Andrea *et. al.* (1996) obtained from 1500 ppm IBA while Canli and safer (2009) and Neto *et. al.* (2006) get the maximum success with 1000 ppm IBA concentration in plum. Yadav (1989) found that highest concentration of IBA (5,000 ppm) proved significantly better for rooting and survival of air layers of kagzilime. All the findings were varied because those experiments were conducted in different plants species, environment, soils, climates and times.

## Conclusion

Bayleaf layering was found very much unsuccessful with or without IBA treatment. Layering time and IBA concentration significantly influence on the success and rooting of layers under Bangladesh condition. May to July layering with 4000 ppm IBA treatment found better for successful air layering for vegetative propagation of bayleaf in Bangladesh.

## Experiment 2 of set A

### Effect of time and IBA concentration on the performance of cinnamon layering

Most of the tropical fruit plants showed good shoot and root growth in cuttings and air layering during the hot humid weather condition in rainy season of Bangladesh. In present work on cinnamon, no shoot growth was observed and no root was emerged in cuttings even treated with all doses of IBA. All cuttings were died after 30-40 days. The success of cutting in all treatments was nil. Sándor (2011) found that the autumn propagation period gives the best and most reliable results from the point of view of the rooting of hardwood cuttings at under 15°C and IBA stimulant should be left of completely. The weather condition of Bangladesh might be unfavorable for rooting in BARI cinnamon-1 cuttings might be due to shy rooting habit of this variety.

### Effect of layering time on success of air layering

The time of layering was significantly affected on the success of layering (Table 2.1). Early rooting was observed in May layering (72.8 days) which was statistically similar with April, June and July while August layering took more days (84.4) for root visibility. Similar result was observed in separation of layers from the mother plant. Rooting success was similar in all five months but establishment rate was declined after June (Table 2.1 and Fig. 2.1)

Table 2.1. Performance of Cinnamon leaf layering at different time

Layering time	Days to root visible	Days to Separation	Rooting (%)	Establish (% 60 DAS)	% Dead at 60 DAS	Roots Layer	Length of root (cm)	No. of branch	Leaves /layer
April	78.8	94.9	48.89ab	39.74ab	60.26b	2.15a	6.21a	1.89a	4.04a
May	72.8	93.2	50.00a	45.20a	54.80c	2.02a	7.21a	2.00a	3.99a
June	76.3	92.2	50.00a	42.14a	57.86bc	2.16a	6.93a	2.04a	4.01a
July	72.9	90.8	51.67a	38.54b	61.46b	2.13a	6.29a	1.98a	4.04a
August	84.4	101.7	40.00b	22.09c	77.91a	1.44b	4.44b	1.56b	2.79b
Significance	NS	NS	*	*	*	NS	*	*	*
CV%	16.66	18.10	10.93	11.89	12.28	18.08	5.38	10.08	18.96

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns', '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively

Successful layer was slightly higher in July layering (51.67%) where the highest number of successful layers was 5.17 (Fig 2.1) but establishment number (2.67) and rate (45.2%) was highest in May layering. Lower establishment number and rate was recorded in August (1.33, 22.09%,

respectively) layering (Table 2.1 and Fig.2.1). This result seems that cinnamon is shy and slow rooting habit that caused longer time for rooting. The effect of time of layering was significantly affected on the death of detached layers, number and length of roots, and leaves per layers (Table 2.1).

Death rate of detached layer was higher (77.91%) in August layering and it was minimum in May (54.8%). The lower success in August layering might be due to fall of temperature and lower humidity in October delayed and hampered rooting as well as shoot initiation. Wamananand (2018) mentioned that first week of July is the most suitable time for air layering in cinnamon as it supported better rooting percentage (87.5%) in cinnamon (*Cinnamomum verum* L.) under wet humid tropical conditions.

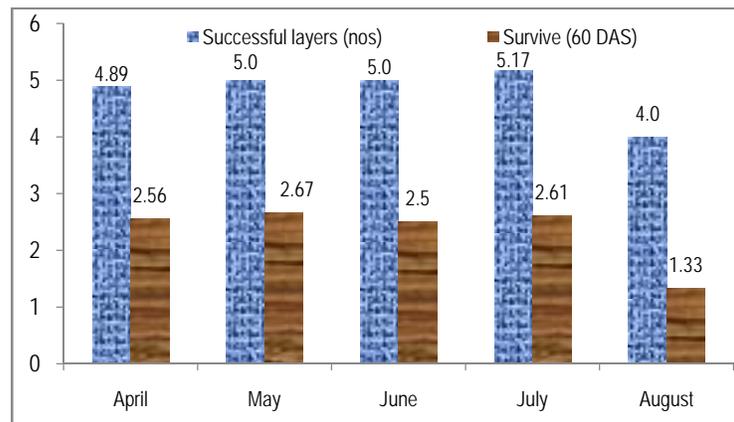


Fig.2.1. Success and establishment rate of bay leaf layering at different time

April, May, June and July layering gave more number ( $\geq 2$ ) of longer ( $\geq 6$  cm) roots, and leaves ( $\geq 4$ ) compared to August layering. Hot humid weather favors rooting and leaf initiation that cause more rooting and leaves in April to July than August layering. As the growth rate of cinnamon is slow, the number of root, shoot and leaves are less compared to other plants.

### Effect of IBA concentration on Cinnamon layering

IBA concentration had significant effect on rooting and success of air layering in cinnamon (Table 2.2 and Figure 2.2). Control treatment and lower dose of IBA took more times to initiate roots compared to higher doses of IBA concentration. Days to separation of layers from the mother plant was not significantly affected by different IBA concentrations. The number of successful layers (7.73) and percentage of rooting was significantly higher (73.33%) in 4000 and 5000ppm IBA concentration applied followed by 3000ppm (6.53, 65.33%) and it was lower in control (0.93,

9.33%) that described in the table 2.2 and fig.2.2. The number of established layer (4.2) and rate of layers establishment (56.48%) was significantly higher in 5000ppm of IBA followed by 4000 ppm (4.0, 53.62%) and it was nil in control (0%). These findings are resembled with the findings of Sharma *et al.* (1989) who obtained highest rooting percentage in plum with higher concentration of IBA treatment during summer. Andrea *et al.*, (1996) obtained the maximum success (87.5%) of plum cuttings from 1500 ppm K-IBA solution.



Pic 1. Different steps of air layering in Cinnamon

Table 2.2. Performane ofCinnamon layering at different IBA concentrations

IBA Conc.ppm	Days to root visible	Days to Separation	Rooting (%)	Establish (% 60 DAS)	% death at 60 DAS	Roots Layer	Length of root (cm)	No of branch	Leaves /layer
1000	81.1b	95.0bc	24.67c	24.44	75.56	1.53b	5.43b	1.53b	3.41b
2000	74.5bc	94.0bc	42.67b	42.65	57.35	2.42a	7.59a	2.23a	4.39a
3000	69.7c	87.5c	65.33ab	48.05	51.95	2.65a	8.24a	2.52a	4.90a
4000	69.0c	87.5c	73.33a	53.62	46.38	2.63a	7.90a	2.55a	4.97a
5000	68.7c	87.5c	73.33a	56.48	43.52	2.64a	8.13a	2.54a	4.98a
Control	99.3a	116.0a	9.33d	0.00	100.00	0.00c	0.00c	0.00c	0.00c
Significance	*	*	*	NS	*	NS	*	*	*
CV%	16.66	18.10	10.93	11.89	12.28	18.08	5.38	10.08	18.96

Means having same letter(s) or without letter are not significantly different by DMRT. ‘ns’ ’\*’ and ‘\*\*’ means not significant, significant at 5% and 1% probability level, respectively.

Netoet. al. (2006) and Canli and Safer (2009) obtained the highest success using 1000 ppm IBA in cherry cutting and layering. Indole-butyric-acid (IBA) enhanced root development and root growth by enhancing cell division resulted the maximum success of layering compared to control as well as lower level of IBA concentration (Mozumder, et. al., 2014). There was significant variation of death of layers after detaching from the mother plant, rooting and leaf production with various levels of IBA treatment (Table 2.2). A number of air layering shoots were died in the polybag after separation from the mother plant. Application of IBA resulted more number ( $\geq 2$ ) of longer ( $\geq 6$  cm) roots compared to control. Number of leaves increased with increasing IBA concentration.

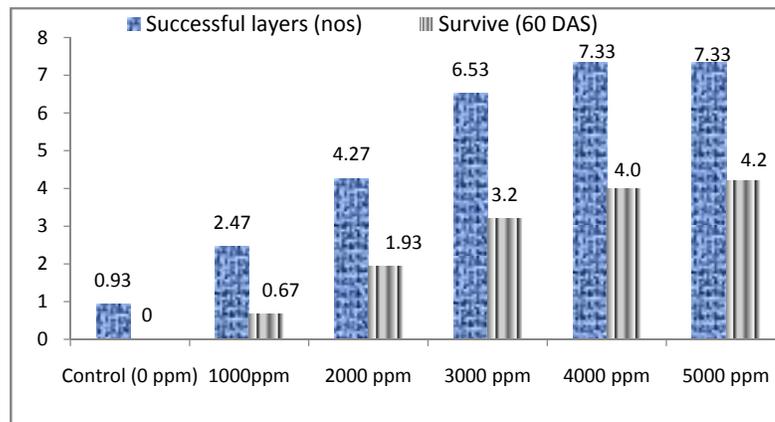


Fig.2.2.Success and establishment rate of bay leaf layering at different IBA concentrations

The highest number of leaves (4.98/layer) was recorded from the application of 5000 ppm IBA which was statistically similar in all IBA levels and it was nil (0/layer) in control. This result corroborates with the findings of Misra and Singh(1990) that all IBA and NAA concentrations significantly increased rooting of air layers. Highest percentage rooting was obtained with 5000 ppm IBA (95%) compared with 21.7% in the control). This treatment also resulted in the highest

percentage survival of rooted air-layers (68.3%) compared with 5% in the control). IBA was more effective than NAA in promoting rooting in air-layers. IBA helps to accelerate cell division and root initiation in upper parts of the cut portion of the plant resulted more rooting and leaves with higher doses of IBA.

### Combined effect of layering time and IBA concentration in cinnamon

Layering time and IBA concentration showed significant effect on rooting and success rate of layers (Table 2.3a and 2.3b) in Cinnamon.

Table 2.3a. Combined effect of layering time and IBA on success of Cinnamon propagation

Time	IBA Conc.	Days to root visible	Days to Separation	Successful layers (nos)	Rooting (%)	Survive (60 DAS)
April	1000	84.0	95.0	2.67	26.67	0.67
	2000	76.7	95.0	4.67	46.67	1.67
	3000	72.0	87.0	6.33	63.33	3.67
	4000	72.0	87.0	7.33	73.33	4.67
	5000	71.7	87.0	7.33	73.33	4.67
	Control	96.7	118.3	1.00	10.00	0.00
May	1000	80.0	95.0	2.67	26.67	1.00
	2000	72.7	93.3	4.33	43.33	2.67
	3000	64.7	87.0	6.33	63.33	3.33
	4000	64.0	87.0	7.67	76.67	4.33
	5000	64.0	87.0	7.67	76.67	4.67
	Control	91.3	110.0	1.33	13.33	0.00
June	1000	80.7	95.0	2.67	26.67	1.00
	2000	74.7	91.7	4.33	43.33	2.00
	3000	71.3	85.0	6.67	66.67	3.67
	4000	70.3	85.0	7.67	76.67	4.00
	5000	70.3	85.0	7.67	76.67	4.33
	Control	90.7	111.7	1.00	10.00	0.00
July	1000	80.3	95.0	2.67	26.67	0.67
	2000	74.3	95.0	4.67	46.67	2.67
	3000	67.3	88.3	7.33	73.33	3.33
	4000	67.3	88.3	7.67	76.67	4.33
	5000	66.3	88.3	8.00	80.00	4.66
	Control	82.0	90.0	0.67	6.67	0.00
August	1000	80.7	95.0	1.67	16.67	0.00
	2000	74.3	95.0	3.33	33.33	0.67
	3000	73.0	90.0	6.00	60.00	2.00
	4000	71.3	90.0	6.33	63.33	2.67
	5000	71.0	90.0	6.00	60.00	2.67
	Control	136.0	150.0	0.67	6.67	0.00
Significance		NS	NS	*	*	
CV%		16.66	18.10	10.93	10.93	7.59

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' , '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively.

August layering with lower concentration of IBA or control treatment took more time compared to April, May, June and July month's layering for root initiation and separation of layers from the mother plant.

Table 2.3b. Combined effect of layering time and IBA on success of Cinnamon propagation

Time	IBA Conc.	Establish (% 60 DAS)	% Dead at 60 DAS	Roots Layer	Length of root (cm)	No branch	Leaves /layer
April	1000	22.22	77.78	1.67	5.33	1.67	4.50
	2000	35.00	65.00	2.83	7.97	2.33	5.00
	3000	56.19	43.81	2.67	7.97	2.47	5.03
	4000	62.50	37.50	2.94	8.07	2.43	4.93
	5000	62.50	37.50	2.79	7.93	2.47	4.77
	Control	0.00	100.00	0.00	0.00	0.00	0.00
May	1000	38.89	61.11	2.00	8.30	2.00	4.87
	2000	61.11	38.89	2.42	8.23	2.58	4.50
	3000	53.33	46.67	2.49	8.93	2.51	4.78
	4000	56.55	43.45	2.48	8.77	2.62	5.07
	5000	61.31	38.69	2.70	9.00	2.30	4.73
	Control	0.00	100.00	0.00	0.00	0.00	0.00
June	1000	38.89	61.11	2.33	8.53	2.33	4.33
	2000	48.89	51.11	2.77	8.00	2.42	4.85
	3000	55.56	44.44	2.80	7.93	2.56	4.93
	4000	52.38	47.62	2.42	8.20	2.53	4.82
	5000	57.14	42.86	2.63	8.90	2.42	5.13
	Control	0.00	100.00	0.00	0.00	0.00	0.00
July	1000	22.22	77.78	1.67	4.97	1.67	3.33
	2000	51.59	48.41	2.40	8.83	2.47	4.93
	3000	43.92	56.08	2.90	8.57	2.67	5.33
	4000	55.56	44.44	2.95	7.57	2.49	5.37
	5000	57.94	42.06	2.85	7.80	2.61	5.27
	Control	0.00	100.00	0.00	0.00	0.00	0.00
August	1000	0.00	100.00	0.00	0.00	0.00	0.00
	2000	16.67	83.33	1.67	4.93	1.33	2.67
	3000	31.27	68.73	2.42	7.80	2.42	4.42
	4000	41.11	58.89	2.33	6.90	2.67	4.67
	5000	43.49	56.51	2.25	7.03	2.92	5.00
	Control	0.00	100.00	0.00	0.00	0.00	0.00
Significance CV%		6.68	8.61	6.09	6.07	10.64	6.41

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' , '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.

Early rooting (64 days) was found in May layering with 4000 and 5000ppm IBA concentration while it was significantly delayed (136 days) in August layering without IBA treatment. Bay leaf layers took about 12-13 weeks to separation that was slightly affected due to layering time but greatly for hormone application. The number of successful layer was significantly higher in July layering (8.0, 80%)with 5000ppm IBA closely followed by May, June and August

(7.67, 76.67%) with 4000 & 5000 ppm IBA application and the success was nil (0.67, 6.67%) in July and August layering without IBA. The lower success without IBA may be due to fall of temperature and lower hormonal activity hampered rooting. Significant variations on survivability of layers after detaching from mother plant, rooting and leaf production due to layering time with various IBA concentrations (Table 2.3a and 2.3b). The maximum number and rate of survived layers (4.67, 61.31%) was found in July layering with 5000 ppm IBA treatment followed by May Layering (4.66, 57.94%) with 5000 ppm IBA while no layers were survived finally without IBA application.

Higher concentration IBA results more number of roots in early June-July layering compared to control and lower concentration of IBA treatment in later layering might be the cause of such variation. The number and length of root did not differ significantly with the range of 1.67 to 2.95 per layers and 5.33-9.0 cm at 60 days with the combination of differed IBA concentration and time of layering (Table 3.b). Number of branches and leaves were increased with increasing IBA concentration in all months of layering. This result slight different from the findings of Kakonet *et al.*, 2008 who showed that among different varieties BARI guava-1 showed the best performance with IBA at 1200 ppm concentration among the treatments having significant effect on almost all parameters. The maximum number of leaves (5.37/layer) per layer was recorded from the application of 5000 ppm IBA in July layering and lowest (2.67/layer) was found from 2000 ppm IBA in the August layering. There was no successful layering in April, July and August without IBA that had no roots or leaves. IBA accelerate cell division and root initiation at a high temperature and humidity resulted more rooting and leaves with higher doses of IBA in May to July layering

Singh (2001) found that use of IBA was beneficial in enhancing the callus formation, number, length and diameter of both primary and secondary roots and survival of air-layered twigs. This findings are partially similar with the report of Rymbai *et al.* (2010) that air layers of guava have been successfully achieved by exogenous application of IBA at 4000 ppm. The result from these observations were fully or partially resembled with some findings such as Sharma *et al.*; (1989) also got maximum success with 2000 ppm IBA, Andrea *et al.* (1996) obtained from 1500 ppm IBA while Canli and safer (2009) and Neto *et al.* (2006) got the maximum success with 1000 ppm IBA concentration. Yadav (1989) found that highest concentration of IBA (5000 ppm) proved significantly better for rooting and survival of air layers of kagzi lime. All the findings were varied because those experiments were conducted in different plants species, environment, soils, climates and times.

### **Conclusion**

Success of layering was not satisfactory with or without IBA treatment. Layering time and IBA concentration significantly influence on the success and rooting of layers under Bangladesh condition. May to July layering using 4000 ppm IBA treatment found better on successful air layering for vegetative propagation of Cinnamon in Bangladesh.

## Experiment 3 of set A

### Effect of method and time of cinnamon grafting on *cassia* rootstocks

#### Effect of grafting methods

Effect of different grafting methods on various parameters like days to bud break, days to cut, number of success and percent success length of shoot leaves per plant, survivality at 60 days of cinnamon are presented in Table 3.1& Fig. 3.1. All the parameters varied significantly. The highest days was required for bud breaking in contact grafting method which was about thirty seven days and sixteen days was required in side grafting method.

Table 3.1. Effect of different grafting methods on Cinnamon

Grafting method	Days to bud break	Days to cut	Success (%)	Survive (%) at 60 days	Dead %at 60 days	Branch /graft	Length of shoot (cm)	Leaves/plant
Cleft	13.13c	15.76c	78.00b	83.73a	16.28b	2.48b	10.69b	5.81b
Side	16.08b	19.86b	50.00c	68.76b	31.26a	2.20c	9.70c	5.47b
Contact	37.08a	92.38a	85.24a	88.35a	11.64b	2.97a	26.75a	11.64a
Significance	**	**	**	**	**	**	**	**
CV%	4.08	2.49	13.14	12.36	20.31	14.69	7.83	12.60

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively

In cleft grafting, bud breaking observed after thirteen days. Graft was removed after fifteen days from cleft grafting and ninety two days was required for removing the graft from contact grafting. In side grafting, graft removed after nineteen days from mother plant. The highest number of success was recorded in contact grafting (8.52) followed by side grafting (7.81) and cleft grafting (5.0) (Fig. 3.1). The highest percentage of success also found in contact grafting (85.24) followed by side grafting (78.0) and side grafting (50.0). This findings partially corroborates the findings of Talukderet *al.*, (2015) that cleft grafting showed better performance than side or vineer grafting in Mandarin.

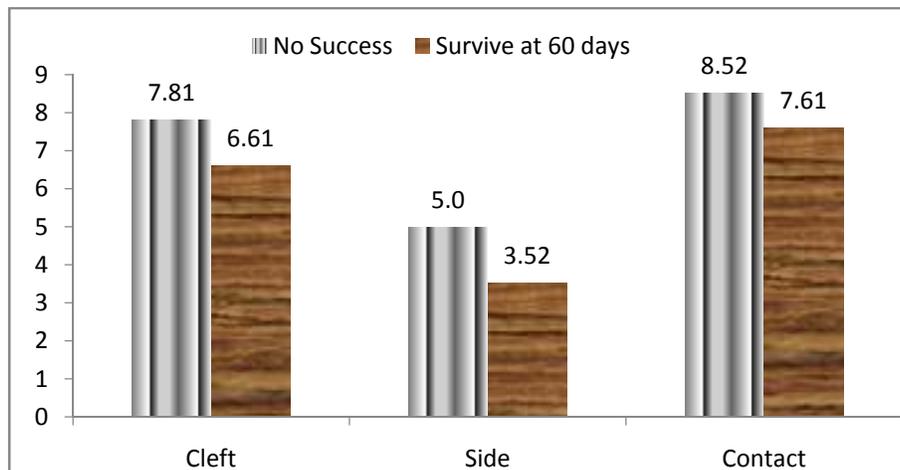


Fig.3.1: Success and survival of different type of grafting

Maximum graft survive (7.61) at sixty days after separation recorded from contact grafting and minimum (3.52) was observed from side grafting (Fig. 3.1). In side grafting, survival rate of graft was 6.61 at sixty days. The highest percentage of survival of graft at sixty days was 83.73 from cleft grafting method and the lowest from side grafting (68.76)method. As well as, the lowest percentage of dead of graft at sixty days was 11.64 from contact grafting method followed by 16.28 from cleft grafting method. The highest percentage of dead of graft at 60 days was 31.26 recorded from side grafting (31.26) method followed by cleft grafting (16.26) and the lowest incontact grafting (11.64). Number of branches was highest (2.97) in contact grafting method and lowest was (2.20) in side grafting method. The highest length of shoot was observed in contact grafting method which was 26.75 cm followed by 10.69 cm in cleft grafting method and the lowest length (9.7cm) of shoot was recorded from side grafting method. Maximum leaves per plant (11.64) was noted in contact grafting method and minimum leaves per plant (5.47) was noted inside grafting method.

### Effect of grafting time

The present study reveals that the grafting time differed significantly with respect to number of days taken to bud break (Table 3.2 & Fig.3.2). The maximum number of days for bud breaking in grafted plants (27.78 days) was recorded in September month followed by August month(24.89 days) and July month (23.11 days) and the minimum (18.44) was in April. The plants grafted in the month of June required the moderate days bud breaking (21.56 days). The maximum days (46.2 days) was recorded to cut the grafts from plant in the month of September followed by August (44.8 days) and July (43.0 days). However, the minimum days (40.67 days) was recorded in grafts cut from the plants during March.

Table 3.2. Effect of grafting time on success and shoot growth in Cinnamon

Grafting Time	Days to bud break	Days to cut	Success (%)	Survive(%) at 60 days	Dead (%) at 60 days	Branches /graft	Length of shoot (cm)	Leaves /Plant
March	18.89f	40.67d	73.33a	85.94ab	14.05cd	3.02a	18.1a	8.68a
April	18.44f	40.89d	76.67a	88.78a	11.21d	2.90a	18.08a	8.77a
May	19.89e	41.0d	81.11a	88.89a	11.11d	2.73ab	16.93a	8.27a
June	21.56d	42.1c	77.78a	86.43ab	13.56cd	2.67ab	15.76b	8.08ab
July	23.11c	43.0c	73.33a	77.37bc	22.62bc	2.43bc	15.37b	7.33bc
August	24.89b	44.8b	64.44b	73.03c	26.97b	2.24c	13.44c	6.62cd
September	27.78a	46.2a	51.11c	61.53d	38.46a	1.8444d	12.32c	5.73d
Significance	**	**	**	**	**	**	**	**
CV%	4.08	2.49	13.14	12.36	50.31	14.69	7.83	12.60

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns', '\*', and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.

The higher grafting success (81.11%) was reached by grafting in May followed by 77.78% in June, April (76.67%), March and July (73.33%). The lowest grafting success rate (51.11%) was observed when grafted during September. The highest percentage of graft survival at 60 days (88.89%) was recorded in plants grafted during May followed by April (88.78%) of graft survival at

60 days. The lowest percentage of graft survival (61.53%) was recorded in grafts prepared during September. The lowest percentage of dead (11.11) at 60 days occurred in the month of May.

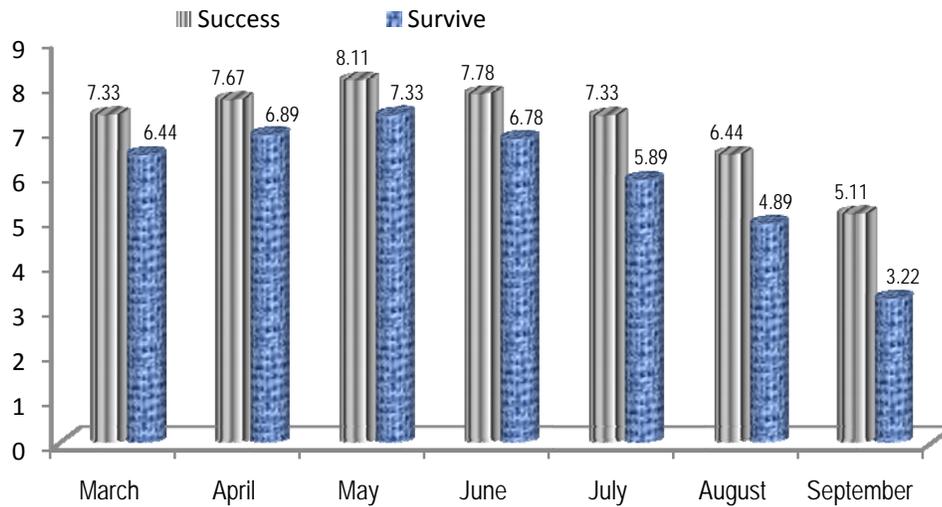


Fig. 3.2. Success and survivability incinnamon grafted at different times.

Number of branches was recorded highest (3.02) from graft in March month and lowest (1.84) was found in September. As well as the highest shoot length (18.1 cm) obtained from grafted plant in March month and lowest shoot length (12.32cm) from grafted plant in September month and Leaves per plant also found highest (8.77) from grafted plant in the month of April and lowest leaves per plant (5.73) in September.

### Combined effect of time and grafting method in cinnamon

In Table-3.3, the average time required for bud breaking of grafts was significantly influenced by the different months and grafting methods. The longest time (45.67 days) required for bud breaking was found in contact grafting in September month while it was early (14.22 days) in contact grafting in May. The longest time (95 day) required for detachment of cleft graft from the mother trees when grafted in August and September. Quickest graft bond opening was done in April (14.7 days) closely followed by March grafting (15 days). The highest percentage of grafting success 9.33 (93.3%) recorded in April May and June while lowest was 3.33 (33.3%) in was side grafting method and the month was September.

Table 3.3. Combined effect of time and method of Cinnamon grafting

Method	Grafting time	Days to bud break	Days to cut	No Success	% Success	Survive at 60 DAS
Cleft	March	12.3klm	15ij	7.67bcd	76.6bcd	7.00cde
	April	11.7lm	14.7j	8.33abc	83.3abc	7.33bcd
	May	11.3m	15ij	9.0ab	90.0ab	8.33abc
	June	12.0m	15ij	8.67abc	86.6abc	7.33b-e
	July	13.7ijk	15.3hij	8.0abc	80.0abc	6.67de
	August	14.0hij	16.7ghi	7.33cde	73.3cde	6.00ef
	September	17.0g	18.7ef	5.67fg	56.6fg	3.67ghi
Side grafting	March	13.7ijk	17.0fgh	5.67fg	56.6fg	4.33gh
	April	13.0jkl	18.0fg	5.33fg	53.3fg	4.33gh
	May	14.7hi	18.0fg	6.0ef	60.0ef	4.67fg
	June	15.3h	18.0fg	5.33fg	53.3fg	4.33gh
	July	17.0g	20.33e	5.00fg	50.0fg	3.00hij
	August	18.0g	22.67d	4.33gh	43.3gh	2.33ij
	September	20.7f	25.0c	3.33h	33.3h	1.67j
Contact grafting	March	30.7e	90.0b	8.67abc	86.7abc	8.0a-d
	April	30.7e	90.0b	9.33a	93.3a	9.0a
	May	33.7d	90.0a	9.33a	93.3a	9.0a
	June	37.3c	93.3a	9.33a	93.3a	8.67ab
	July	38.7c	93.3a	9.00ab	90.0ab	8.0a-d
	August	42.7b	95.0a	7.67bcd	76.7bcd	6.33e
	September	45.7a	95.0a	6.33def	63.3def	4.33gh
Level of Significance		**	**	*	*	*
CV%		4.08	2.49	13.14	13.14	16.76

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively

Table 3.3. Combined effect of time and method of Cinnamon grafting (Contd.)

Method	Grafting time	Survive %	Dead %	Branches /graft	Shoot length (cm)	Leaves/plant
Cleft	March	90.0abc	10.0fgh	2.80bcd	12.00e	6.27ef
	April	87.8abc	12.17fgh	2.90bc	12.00e	6.77de
	May	92.6ab	7.40gh	2.63cde	11.40e	6.10efg
	June	84.8a-d	15.13e-h	2.56cde	10.63efg	6.13efg
	July	83.3a-d	16.67e-h	2.2defg	11.13e	5.43e-i
	August	81.9a-d	18.05e-h	2.46cde	9.03f-i	5.33e-i
	September	65.5e-h	34.44a-d	1.80fgh	8.60hi	4.63ghi
Side	March	75.3c-f	24.76c-f	2.63cde	10.06e-h	6.27ef
	April	82.2a-d	17.77e-h	2.50cde	10.6e-h	6.03e-h
	May	77.7b-e	22.22d-g	2.56cde	10.833ef	6.13efg
	June	81.1a-e	18.89d-h	2.50cde	10e-h	6.00e-h
	July	60.0fgh	40.00abc	2.13efg	10.1e-h	5.10f-i
	August	55.0gh	45.00ab	1.70gh	8.63ghi	4.467hi
	September	50.0h	50.00a	1.33h	7.667i	4.30i
Contact	March	92.6ab	7.40gh	3.63a	32.23a	13.50a
	April	96.3a	3.703h	3.30ab	31.63a	13.50a
	May	96.3a	3.703h	3.00bc	28.57b	12.57ab
	June	93.3ab	6.67gh	2.93bc	26.63bc	12.1ab
	July	88.79	11.20fgh	2.97bc	24.87c	11.47bc
	August	82.1a-d	17.85e-h	2.57cde	22.67d	10.07c
	September	69.0e-g	30.95bcd	2.40c-f	20.70d	8.27d
Level of significance		*	*	*	**	*
CV%		12.36	50.31	14.69	7.83	12.60

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively.



Pic: 3.1-2. Differentiation of Bay leaf, Cassia and Cinnamon



Pic: 3.3-8 Cleft grafting in Cinnamon and bayleaf on Cassia rootstock

In the study, grafting methods and time had significant influence on percentage of survivability at 60 days of graft detachment. The highest survival 90.0 (90.0%) was recorded in contact grafting with the month of April and May grafting while the lowest (50.0%) in side grafting with September month. The lowest percentage (3.70) of dead at 60 days of graft recorded in treatment combination of contact grafting method with the month of April and highest (50.0) was found from side grafting in September.

Slow growth habit and hard wood with less food materials in shoot causes lower survivability of detached cinnamon scions grafted on cassia rootstock (Waman and Bohra, 2018). The fall of temperature and slower active growth period resulted lower success in later months. The method of grafting and time had significant influence on length of shoot. This result partly conforms the report of Remaet *al.*, (1997) which mentioned that grafting is more appropriate in cinnamon, than cutting and layering due lower survivability. The contact grafting in March produced the highest length of shoot (32.33cm). While minimum length of shoot (7.66 cm) was obtained from side grafting occurred in the month of September. The highest number of leaves per plant (13.5) was found in contact grafting method with the month of March which was statistically similar with in April, May and June months contact grafting while it was the lowest (4.3) for from side grafting in the month of September.

### Conclusion

From the above study, contact grafting method found suitable for cinnamon grafting on cassia rootstock followed by cleft grafting method. In case of grafting time, May and June found best for grafting in cinnamon among other treatments.

### Experiment 4 of set A

#### Effect of method and time of grafting bay leaf scion on *cassia* rootstocks

Effect of different grafting methods on various parameters like days to bud break, days to cut, number of success and percent success, length of shoot leaves per plant, survivability and dead at 60 days of bay leaf are presented in Table 4.1 and Figure 4.1. All the parameters varied significantly.

Table 4.1. Effect of method on bayleaf grafting

Grafting method	Days to bud break	Days to cut	Success (%)	Survive (%) at 30 days	Dead (%) at 60 days	Branches /graft	Length of shoot	Leaves/ Plant
Cleft	29.71b	33.29b	19.05b	39.29b	60.71b	1.74b	7.34b	4.62b
Side	29.81b	32.46b	8.57c	11.90c	88.09a	0.62c	1.90c	1.14c
Contact	47.57a	95.00a	75.24a	90.65a	9.34c	3.61a	26.76a	20.21a
Significance	**	**	**	**	**	**	**	**
CV%	7.19	4.61	19.09	45.06	40.41	48.93	25.43	20.12

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively

The highest day (47.57 days) was required for bud breaking in contact grafting method and 29.81 days was required in side grafting method. In cleft grafting, bud breaking occurred after twenty nine days which was lowest among others. Graft was cut after 95 days from contact grating that was highest days required for graft cut from plant and 32.46 days was required for removal of graft from side grafting method. In cleft grafting method, graft removed after 33.29 days from mother plant which was lowest.

The highest number of success was recorded in contact grafting (7.52) followed by cleft grafting (1.90) and side grafting (0.86) (Fig.4.1). The highest percentage of success also found in contact grafting (75.24) followed by cleft grafting (19.05) and lowest was from side grafting method (8.57) (Table 4.1).

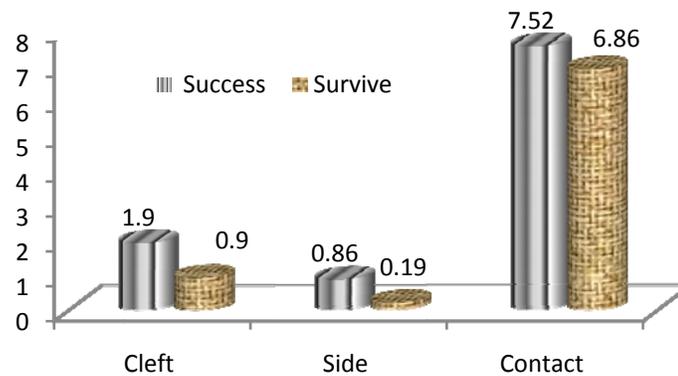


Fig.4.1 Success and survive graft using different grafting methods

Maximum number (6.86) of graft survival at 60 days was observed from contact grafting method and minimum survival of graft (0.19) was observed from side grafting method (Fig.4.1). The lowest percentage of survival of graft at 60 days was 11.90 from side grafting method followed by 39.29% from cleft grafting method (Table 4.1). The highest percentage of survive of graft at 60 days was 90.65 from contact grafting method. As well as, the lowest percentage (9.34) of dead graft at 60 days recorded from contact grafting method followed by cleft grafting method (60.71). The highest percentage (88.09) of dead graft at 60 days was recorded from side grafting method. Number of branches was highest (3.61) in contact grafting method and 7.34 cm in cleft grafting method and the lowest length (1.90 cm) of shoot was recorded from side grafting method. A maximum leaves per plant (20.21) was noted in contact grafting method and minimum leaves per plant (1.14) was noted inside grafting method.

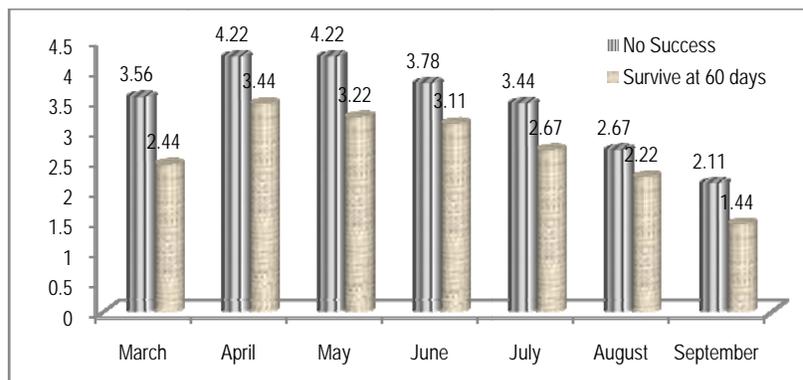
### Effect of grafting time on success and shoot growth in bay leaf

Table 4.2 reveals that the effect of grafting time differs significantly on differed parameters of bay leaf. The minimum number of days (30.33 days) for bud breaking was recorded in the month of March followed by April month (31.44 days) and May month (32.89 days). Whereas, the maximum number of days (39.89 days) required for bud breaking in grafted plants was recorded in September month. The maximum days (58.33 days) was recorded to cut the grafts from grafted plant in the month of September followed by August (57.22 days) and July (56.33 days). However, the minimum days (44.11 days) was recorded in March for cutting the grafts from plants and in April month it took 40.89 days to cut the grafts from plants which was statistically similar. In the month of May it requires 50.56 days to cut the grafts from plants. The average percentage of grafting success rate reached up to 30%, in which the highest grafting success rate (42.22%) was reached by grafting in the month of April and May that was statistically similar followed by 37.78% grafting success rate obtained in the month of June. The lowest grafting success rate (21.11%) was found in plant grafted during September followed by 26.67% grafting success rate observed in August.

**Table 4.2. Effect of grafting time on success and shoot growth in bay leaf**

Grafting Time	Days to bud break	Days to cut	% Success	% Survive at 30 days	% Dead at 60 days	No branch	Length shot	Leaves /Plant
March	30.33d	49.111c	35.56b	50.93ab	49.07bc	2.49ab	15.57a	9.92ab
April	31.44cd	49.11c	42.22a	66.02a	33.98c	2.71a	16.46a	10.94a
May	32.89c	50.56c	42.22a	51.85ab	48.15bc	2.42ab	13.98ab	10.18ab
June	36.22b	54.44b	37.78ab	50.62ab	49.38bc	2.20abc	12.09bc	9.26bc
July	39.67a	56.33ab	34.44b	43.06bc	56.94ab	1.72bcd	10.53cd	7.60cd
August	39.44a	57.22a	26.67c	41.47bc	58.53ab	1.36cd	8.49de	6.91de
September	39.89a	58.33a	21.11c	27.04c	72.963a	1.03d	6.9e	5.8e
Significance	**	**	**	**	**	**	**	**
CV%	7.19	4.61	19.09	45.06	40.41	48.93	25.43	20.12

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively



**Fig.4.2 Success and survival of grafts at different grafting times**

The data presented in Table Fig.4.2, success and survive graft using different grafting methods revealed that highest percentage of graft survival at 60 days (66.02%) was recorded in plants grafted during April month followed by May month (51.85%) of graft survival at 60 days. The lowest percentage of graft survival (27.02%) was recorded in grafts prepared during September month. The lowest percentage (33.98%) of grafting dead at 60 days occurred in the month of April followed by 48.15% of grafting dead at 60 days recorded in May. Number of branches emerged from the graft was recorded highest (2.49) in March grafting and lowest number of branches (1.03) was found in September grafting. As well as highest shoot length (16.46 cm) obtained from grafted plant in April month and lowest shoot length (6.9cm) from grafted plant in September month and Leaves per plant also found highest (10.94) from grafted plant in the month of April and lowest leaves per plant (5.8) recorded in September month.

### Combined effect of time and method of Bay leaf grafting

In Table 4.3, the average time required for bud breaking of grafts was significantly influenced by different months and grafting methods.

Table 4.3. Combined effect of time and method of Bay leaf grafting

Treatment	Days to bud break	Days to cut	No Success	% Success
M <sub>1</sub> T <sub>1</sub>	21.67h	25.00f	3.00f	30.00f
M <sub>1</sub> T <sub>2</sub>	22.00h	25.00f	2.33fgh	23.33fgh
M <sub>1</sub> T <sub>3</sub>	27.00g	28.67f	2.67fg	26.67fg
M <sub>1</sub> T <sub>4</sub>	31.67ef	35.33de	2.33fgh	23.33fgh
M <sub>1</sub> T <sub>5</sub>	33.67de	38.33bcd	1.67ghi	16.67ghi
M <sub>1</sub> T <sub>6</sub>	35.00de	39.67bc	0.67ij	6.67ij
M <sub>1</sub> T <sub>7</sub>	37.00d	41.00b	0.67ij	6.67ij
M <sub>2</sub> T <sub>1</sub>	25.00gh	27.33f	1.33hij	13.33hij
M <sub>2</sub> T <sub>2</sub>	25.00gh	27.33f	1.33hij	13.33hij
M <sub>2</sub> T <sub>3</sub>	26.67g	28.00f	1.00ij	10.00ij
M <sub>2</sub> T <sub>4</sub>	29.00fg	33.00e	0.67ij	6.67ij
M <sub>2</sub> T <sub>5</sub>	33.67de	35.67cde	1.00ij	10.00ij
M <sub>2</sub> T <sub>6</sub>	34.33de	37.00b-e	0.33j	3.33j
M <sub>2</sub> T <sub>7</sub>	35.00de	39.00bcd	0.33j	3.33j
M <sub>3</sub> T <sub>1</sub>	44.33c	95.00a	6.33de	63.33de
M <sub>3</sub> T <sub>2</sub>	47.33bc	95.00a	9.00a	90.00a
M <sub>3</sub> T <sub>3</sub>	45.00bc	95.00a	9.00a	90.00a
M <sub>3</sub> T <sub>4</sub>	48.00abc	95.00a	8.33ab	83.33ab
M <sub>3</sub> T <sub>5</sub>	51.667a	95.00a	7.67bc	76.67bc
M <sub>3</sub> T <sub>6</sub>	49.00ab	95.00a	7.00cd	70.00cd
M <sub>3</sub> T <sub>7</sub>	47.67abc	95.00a	5.33e	53.33e
Significance	**	**	**	**
CV%	7.19	4.61	19.09	19.09

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively

Here, T = different times and M = different grafting methods (T<sub>1</sub>= March, T<sub>2</sub>= April, T<sub>3</sub>=May, T<sub>4</sub>=June, T<sub>5</sub>= July, T<sub>6</sub>= August, T<sub>7</sub>= September and M<sub>1</sub>= Cleft grafting, M<sub>2</sub>= Side grafting, M<sub>3</sub>= Contact grafting)

The highest time (51.66 days) required for bud breaking was found in the treatment combination (M<sub>3</sub>T<sub>5</sub>) of contact grafting in July month while it was the lowest (21.67 days) in treatment (M<sub>1</sub>T<sub>1</sub>) which was found in cleft grafting with March month.

The highest percentage of grafting success recorded in treatment M<sub>3</sub>T<sub>2</sub> and M<sub>3</sub>T<sub>3</sub> combination of contact grafting in April and May month and lowest was in M<sub>2</sub>T<sub>6</sub> and M<sub>2</sub>T<sub>7</sub> treatment combination that was side grafting method and the month was August and September which was statistically similar. In the study, grafting methods and time had significant influence on graft of survivability at 60 days of graft. The highest (96.29%) survival of graft at 60 days recorded in M<sub>3</sub>T<sub>4</sub> treatment combination which was contact grafting with the month of June and there was no success observed in M<sub>1</sub>T<sub>7</sub>, M<sub>2</sub>T<sub>4</sub>, M<sub>2</sub>T<sub>5</sub>, M<sub>2</sub>T<sub>6</sub> and M<sub>2</sub>T<sub>7</sub> treatment combination.

Table 4.3. Combined effect of time and method of Bay leaf grafting (contd.)

Treatment	Survive at 60 days	%Dead at 60 days	No branch	Length shot	Leaves/ Plant
M <sub>1</sub> T <sub>1</sub>	1.33e	52.78bcd	2.17c-h	11.00f	6.83de
M <sub>1</sub> T <sub>2</sub>	1.33e	44.44cde	2.33b-g	10.87f	7.33d
M <sub>1</sub> T <sub>3</sub>	1.33e	50.00bcd	2.50a-g	10.37f	6.17def
M <sub>1</sub> T <sub>4</sub>	1.33e	44.44cde	2.83a-f	9.63f	6.67de
M <sub>1</sub> T <sub>5</sub>	0.67ef	66.67abc	1.67e-h	6.73fg	3.67fg
M <sub>1</sub> T <sub>6</sub>	0.33f	66.67abc	0.67hi	2.80gh	1.67gh
M <sub>1</sub> T <sub>7</sub>	0.00g	100.00a	0.00	0.00	0
M <sub>2</sub> T <sub>1</sub>	0.33f	83.33ab	1.33f-i	3.47gh	1.67gh
M <sub>2</sub> T <sub>2</sub>	0.67ef	50bcd	2.00d-h	6.87fg	4efg
M <sub>2</sub> T <sub>3</sub>	0.33f	83.33ab	1.00ghi	3.00gh	2.33gh
M <sub>2</sub> T <sub>4</sub>	0.00g	100.00a	0.00	0.00	0.00
M <sub>2</sub> T <sub>5</sub>	0.00g	100.00a	0.00	0.00	0.00
M <sub>2</sub> T <sub>6</sub>	0.00g	100.00a	0.00	0.00	0.00
M <sub>2</sub> T <sub>7</sub>	0.00g	100.00a	0.00	0.00	0.00
M <sub>3</sub> T <sub>1</sub>	5.67c	11.11ef	3.97a	32.23a	21.27ab
M <sub>3</sub> T <sub>2</sub>	8.33a	7.5f	3.80ab	31.63ab	21.50ab
M <sub>3</sub> T <sub>3</sub>	8.00ab	11.11ef	3.77abc	28.57abc	22.03a
M <sub>3</sub> T <sub>4</sub>	8.00ab	3.7f	3.77abc	26.63bcd	21.10ab
M <sub>3</sub> T <sub>5</sub>	7.33b	4.17f	3.50a-d	24.87cde	19.13bc
M <sub>3</sub> T <sub>6</sub>	6.33c	8.93f	3.40a-d	22.67de	19.07bc
M <sub>3</sub> T <sub>7</sub>	4.33d	18.89def	3.10a-e	20.70e	17.40c
Significance	**	NS	NS	NS	NS
CV%	21.26	40.41	48.93	25.43	20.12

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively.

Here, T = different time and M = different grafting methods (T<sub>1</sub>= March, T<sub>2</sub>= April, T<sub>3</sub>=May, T<sub>4</sub>=June, T<sub>5</sub>= July, T<sub>6</sub>= August, T<sub>7</sub>= September and M<sub>1</sub>= Cleft grating, M<sub>2</sub>= Side grafting, M<sub>3</sub>= Contact grafting).

The lowest percentage (3.70) of dead graft at 60 days of grafting was recorded in treatment combination ( $M_3T_4$ ) of contact grafting method with the month of June and hundred percent dead of graft at 60 days found in  $M_1T_7$ ,  $M_2T_4$ ,  $M_2T_5$ ,  $M_2T_6$  and  $M_2T_7$  treatment combination. Grafting method and time had significant influence on length of shoot (Table 4.3).

The contact grafting method occurred in May produced the highest length of shoot (28.57cm) while minimum length of shoot (2.80 cm) was obtained from cleft grafting occurred in the month of August.

The highest number of leaves per plant (22.03) was found in the grafts that received the treatment combination ( $M_3T_3$ ) of contact grafting method with the month of May.  $M_3T_2$ ,  $M_3T_3$ ,  $M_3T_4$ , while it was the lowest (1.66) for the treatment combination ( $M_1T_6$ ) of cleft grafting method with the month of August which was statistically similar with the treatment combination of  $M_2T_1$ .

### Conclusion

It may be concluded from the above study that, contact grafting method was successful for bayleaf grafting on cassia rootstock. In case of grafting time, April to June found best for bayleaf grafting on cassia rootstock among other treatments.



Pic: 4.1. Contact grafting of Cinnamon

## Experiment Set -B: Processing

### Experiment-5: Effect of fermentation and drying on the quality in bay leaf

#### Effect of fermentation

Different fermentation levels showed significant variation in appearance and weight loss during treatment application but final weight of samples were almost similar in all the treatments Table 5.1. Longer time fermentation results more weight loss during fermentation, darker color, dull and poor appearance with less attractiveness. Control treatment showed better shiny bright colour with good appearance.

Table 5.1. Effect of drying in bayleaf

Weathering/ Fermentation	Sample weight (g)			Quality			Crispiness
	Fresh	After treat	Final	Pungency	Color	Appearance	
24 hours	100	83.83	56.06	good	light grey	medium	mixed
48 hours	100	75.40	55.30	good	medium grey	dull	mixed
Control	100	93.75	55.69	good	bright light grey	good	mixed
Significance	-	*	NS				
CV%	-	9.30	11.9				

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively.

#### Effect of drying

Different drying temperature and method showed insignificant variation in appearance and weight loss during treatment application but finally difference were found in respect of weight, pungency and crispiness (Table 5.2). Drying in oven at higher temperature (50-60 °C) results more weight and pungency loss during drying, and became more crispy and fragile. Drying under shade and at 40°C in oven seems better having good aroma and pungency.

Table 5.2. Effect of drying in bayleaf

Weathering	Sample weight (g)			Quality			Crispiness
	Fresh	After treat	Final	Pungency	Color	Appearance	
40°C (36 hr)	100	84.13	56.66ab	good	bright light grey	good	less
50°C (24 hr)	100	84.50	53.84b	medium	bright light grey	good	medium
60°C (16 hr)	100	84.78	52.76b	less	bright light grey	good	high
Shade dry (72 hr)	100	83.88	59.46a	good	bright light grey	good	less
Sun dry (48 hr)	100	84.93	54.04b	medium	bright light grey	good	high
Significance	-	NS	*	-	-	-	-
CV%	-	9.30	11.9	-	-	-	-

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*\*' and '\*\*\*' means not significant, significant at 5% and 1% probability level, respectively.



Pic. 5. Drying of different pretreated bay leaf

### Combined effect of fermentation and drying

Different pretreatment and drying temperature resulted significant variation in appearance and final weight loss, pungency and crispiness (Table 5.3). Longer time fermentation and drying in oven at higher temperature (50-60°C) results more weight and pungency loss, poor appearance and became more crispy and delicate. Control treatment (no weathering), drying at 40°C and under shade in oven seems better having good aroma, pungency and appearance.

Thin layer spreading under shade without weathering is to be followed for bay leaf drying instead of delay and sun drying for better quality bayleaf.

Table 5.3. Combined effect of fermentation and drying in bay leaf

Pre-treatment	Drying Temp.	Sample weight (g)			Quality			
		Fresh	After treat	Final	Pungency	colour	Appearance	Crispiness
24 hours weathering	40°C	100	83.28	55.97ab	good	light grey	medium	less
	50°C	100	84.12	54.55ab	medium	light grey	medium	medium
	60°C	100	84.13	52.60b	less	light grey	medium	high
	Shade dry	100	83.77	61.14a	good	medium grey	medium	less
	Sun dry	100	84.36	53.24b	medium	light grey	medium	high
48 hours weathering	40°C	100	75.33	56.72ab	good	medium grey	dull	less
	50°C	100	74.84	52.81b	less	medium grey	dull	medium
	60°C	100	76.25	52.60b	less	medium grey	dull	high
	Shade dry	100	75.19	59.04a	less	medium grey	dull	less
	Sun dry	100	78.01	53.89b	less	medium grey	dull	high
Control	40°C	100	93.78	57.30ab	good	bright light grey	good	less
	50°C	100	94.55	54.16b	medium	bright light grey	very good	medium
	60°C	100	93.96	53.09b	less	bright light grey	very good	high
	Shade dry	100	92.69	58.20a	good	medium grey	good	less
	Sun dry	100	92.43	54.98ab	medium	bright light grey	good	high
Significance level		--	NS	*	--	--	--	--
CV%		--	9.30	11.9	--	--	--	--

Means having same letter(s) or without letter are not significantly different by DMRT. 'ns' '\*' and '\*\*' means not significant, significant at 5% and 1% probability level, respectively

## Experiment-6:

### Effect of pre-treatment and drying temperature on the quality of cinnamon quills

Different pretreatment and drying system showed significant variation in quality and weight loss during treatment application and final weight of samples in all the treatments.

#### Effect of Pre-treatment

Different pretreatment showed significant variation in appearance and weight loss during treatment application but final weight of samples had a little difference in all the treatments (Table 6.1). Boiling water treatment resulted rapid coloring of boiling water during treatment application. Both the vapor treatment and boiling water treatment enhanced drying with rapid weight loss after one hour of treatment. Loss of soluble ingredient in water and death of cells might be the cause of rapid weight loss of cinnamon bark. Control treatment (no pre-treatment) resulted better aroma, pungency with higher percentage of final weight (41.72%). Longer time pre-treatment in boiling water causes more weight loss, declination of aroma and pungency due to dispersion of soluble particles into boiling water.

Table.6.1 Effect of Pretreatment in cinnamon quills production

Treatment	Barkweight (g)			Color	Pungency (1-10 OLT)	Flavor (1-10 OLT)	Appearance
	Fresh	1 hr. aftertreatment	Dry wt.(g)				
20 Sec in BW	100	83.24c	39.75b	Brown	5.54b	5.04ab	
40 Sec in BW	100	80.40d	38.47b	Brown	5.28b	4.72b	
2 Min vapor treatment	100	86.89b	40.35ab	Brown	5.80b	5.30a	
Control (no pre-treat)	100	93.48a	41.72a	Brown	6.64a	5.62a	
Significance	--	**	*	--	*	*	
CV%	--	5.85	3.22	--	11.94	9.12	

#### Effect of drying temperature

Different drying temperature and method showed insignificant variation in appearance and weight loss during treatment application but finally difference were found in respect of weight, pungency and crispiness (Table 6.2). Drying under shade and at 40°C in oven seems better having good aroma and pungency (6.25 & 6.35) with higher dry weight percentage. Drying in oven at higher temperature (50-60 °C) results more weight, aroma and pungency loss during drying. Loss of volatile oils and aromatic component at high temperature and direct sunlight might be the cause of dryness, weight loss and pungency declination.

Table 6.2 Effect of drying and retreatment in cinnamon quil production

Treatment	Bark weight (g)			Color	Pungency (1-10 OLT)	Flavor (1-10 OLT)	Appearance
	Fresh	1 hr after treatment	Dry wt.(g)				
40°C (48 hr)	100	85.89	40.56a	Brown	6.35a	5.43a	
50°C (36 hr)	100	86.13	39.85ab	Brown	5.75ab	5.08ab	
60°C (24 hr)	100	85.79	39.48b	Brown	5.33b	4.78b	
Shade dry (96 hr)	100	86.29	40.59a	Brown	6.25a	5.63a	
Sun dry (72 hr)	100	85.93	39.88ab	Brown	5.40b	4.95ab	
Significance	--	NS	*	--	*	*	
CV%	--	5.85	3.22	--	11.94	9.12	

**Combined effect of pretreatment and drying**

Different pre-treatment and drying temperature resulted significant variation in appearance and final weight loss, pungency and aroma (Table 6.3). Longer time fermentation and drying in oven at higher temperature (50-60 °C) results more weight and pungency loss, but good appearance and became more hard and fragile. Control treatment (pre-treatment), drying at 40°C and or under shade in oven seems better having good aroma, pungency and appearance.

Table 6.3 Combined effect of pretreatment and drying in cinnamon quil production

Pre-treatment	Drying temp.	Barkweight (g)			Color	Pungency (1-10 OLT)	Flavor (1-10 OLT)	Appearance
		Fresh	1 hr. aftertreatment	Dry wt.(g)				
20 Sec in BW	40°C	100	83.23b	40.19	Brown	6.0b	5.2b	
	50°C	100	82.82b	39.45	Brown	5.4c	5.0bc	
	60°C	100	83.16b	38.95	Brown	5.0c	4.7bc	
	Shade dry	100	83.73b	40.37	Brown	6.1b	5.5ab	
	Sun dry	100	83.24b	39.78	Brown	5.2c	4.8bc	
40 Sec in BW	40°C	100	79.86b	38.88	Brown	5.7bc	5.0bc	
	50°C	100	80.54b	38.25	Brown	5.3c	4.5c	
	60°C	100	80.13b	37.96	Brown	4.9cd	4.3c	
	Shade dry	100	80.77b	39.13	Brown	5.8bc	5.3b	
	Sun dry	100	80.72b	38.12	Brown	4.7d	4.5c	
2 Min vapor treatment	40°C	100	86.74ab	40.83	Brown	6.2b	5.6ab	
	50°C	100	87.28ab	40.32	Brown	5.9bc	5.3b	
	60°C	100	86.92ab	39.93	Brown	5.4c	4.9bc	

	Shade dry	100	87.06ab	40.45	Brown	6.0b	5.7ab
	Sun dry	100	86.43ab	40.21	Brown	5.5bc	5.0b
Control (no pre-treat)	40°C	100	93.74a	42.33	Brown	7.5a	5.9a
	50°C	100	93.86a	41.37	Brown	6.4ab	5.5ab
	60°C	100	92.93a	41.08	Brown	6.0b	5.2b
	Shade dry	100	93.58a	42.39	Brown	7.1a	6.0a
	Sun dry	100	93.31a	41.42	Brown	6.2b	5.5
Significance		--	*	NS	--	*	*
CV%		--	5.85	3.22	--	11.94	9.12

- BW-boiling water



Pic: 6. Fresh and Processed Bark of Cinnamon at different pretreatment and drying

Drying at high temperature (60°C or above) or sundrying reduce quality of cinnamon and bayleaf. So, bay leaf and cinnamon should be dried under shade or in oven at 40°C temperature.

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

1. Air layering of bay leaf and cinnamon in May -June using 4000ppm IBA found better among all other time and treatments.
2. In case of bay leaf, only contact grafting resulted good success ( $\leq 80\%$ ) while cleft and side grafting showed very poor success ( $\leq 20\%$ ).
3. Both contact ( $\leq 80\%$ ) and cleft grafting ( $\leq 60\%$ ) are suitable in April to July in cinnamon. Partial success was found in side and vineer grafting ( $\leq 50\%$ ).
4. Fresh bay leaf without weathering, shade drying for 7 days or 24 hours oven drying at 40°C in oven is suitable for better quality bay leaf processing.
5. Shade drying for 7 days or drying in oven at 40°C for 36 hour found better for cinnamon processing.
6. For good quality cinnamon production, outer layers of phloem (dead cells and epidermis) should be removed.

## **B. Implementation Position**

### **1. Procurement:**

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (#)	Financial (Tk)	Phy (#)	Fin (Tk)	
Office equipment File cabinet					All are purchased properly through RFQ
• Laptop	01	20000.00	01	20000.00	
• Camera	01	60000.00	01	60000.00	
• UPS	01	25000.00	01	25000.00	
• Printer	01	10000.00	01	10000.00	
• Scanner	01	20000.00	01	20000.00	
(b) Lab & field equipment					Purchased properly
• Glass wears	lot	15000.00	lot	15000.00	
• Balance	02	31000.00	02	31000.00	”
(c) Other capital items					
• Bicycle	01	15000.00	01	15000.00	
<b>Total (a &amp; c capital)</b>		<b>160000.00</b>		<b>160000.00</b>	

### **2. Establishment/renovation facilities:**

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
1. Solar dryer	-	-	Repair	Repaired	Need based
2. Mini Nursery shade fencing and irrigation	-	-	Repair	Repaired	Need based

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

Description	Number of participant			Duration	Remarks
	Male	Female	Total		
(a) Training: Trainers training on propagation and processing technologies for bayleaf and cinnamon	29	11	40	1 day	Trainers training
(b) Workshop	-	-	-	-	-

## **C. Financial and physical progress**

Items of expenditure/activities	Total approved budget (Tk)	Fund received (Tk)	Actual expenditure (Tk)	Balance/ unspent (Tk)	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	247829	247829	247829	0	100%	Rest of the fund including Required GOB fund (BDT 28356) is not received yet
B. Field research/lab expenses and supplies	840000	796150	796135	15	98%	
C. Operating expenses	161536	140167	140052	115	97%	
D. Vehicle hire and fuel, oil & maintenance	148600	146072	144680	1392	99%	
E. Training/workshop/seminar etc.	90000	83950	83950	0	100%	
F. Publications and printing	25000	21250	21250	0	97%	
G. Miscellaneous	62035	53230	52580	650	98%	
H. Capital expenses	160000	160000	160000	0	100%	
<b>Total</b>	<b>1735000</b>	<b>1648648</b>	<b>1646476</b>	<b>2172</b>	<b>100%</b>	

**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)
a)To develop standard propagation techniques for rapid dissemination of bay leaf and cinnamon to ensure quality sapling production.	Two experiment was conducted to develop propagation technology for cinnamon and bay leaf	a) May to July layering with 4000ppm IBA application is better on successful air layering for layering of bay leaf in Bangladesh. b) May to July layering using 4000ppm IBA application is better on successful air layering for layering of Cinnamon in Bangladesh. c) Contact grafting method is the best method for bay leaf grafting on cassia rootstock during April to June. d) Contact as well as cleft grafting is better for cinnamon grafting on cassia rootstock during May and June.	Farmers/ nurserymen will be benefited by using this successful propagation technology
b) To develop processing techniques for bay leaf and cinnamon for quality leaf and quill production.	Two experiment was conducted to develop processing technology for cinnamon and bay leaf	a) Thin layer spreading under shade without weathering is the best for bay leaf drying instead of delay and sun drying for better quality bayleaf. b) Bay leaf and cinnamon should dry under shade or in oven at 40 <sup>0</sup> C temperature for better quality. Drying at high temperature (60 <sup>0</sup> C or above) or sun drying reduce quality of cinnamon and bay leaf.	Farmers/ growers will be benefited by using cinnamon and bay leaf processing technology
c) Enhance quality sapling production to increase cultivation and expansion and domestic production of cinnamon and bay leaf.	Trainers training was conducted to DAE, Research officers to disseminate the technology	One booklet and two BTV program on propagation and processing of bay leaf and cinnamon	Users can be used these booklet and viewing BTV program (4.01.19 7.30 AM, 05.01.19 2.30 PM )

**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.	01 booklet	-	Processing for printing in the press
Journal publication	04 Full scientific Papers	-	02 Papers sent to Journal
Information development	Propagation technology 02 Processing technology 02	-	-- --
Other publications, if any	Popular Article 01	- BTV Program 02	Send to Editor Telecasted 4 times in BTV

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

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

1. Air layering bay leaf and cinnamon in May to June with 4000 ppm IBA gave the highest success and establishment.
2. Cleft and Contact grafting methods of cinnamon in April to June gave the highest success and establishment.
3. Without pretreatment or vapor treatment for 2 minutes with shade drying for 7 days oven drying at a temperature 40<sup>0</sup>C for 36 hours is suitable for cinnamon Processing.
4. Bay leaf should be dried in shade or in oven at 40<sup>0</sup>C for 24 hours without weathering rather than sun drying and drying at high temperature ( $\leq 50^{\circ}\text{C}$ ).

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

1. Optimization of vegetative propagation techniques of bay leaf and cinnamon though air layering.
2. Standardization of grafting time and method for cinnamon and bayleaf.
3. Processing of cinnamon and bay leaf in natural and artificial environment.



Pic 7: Evaluation team visiting Sub Project activities

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

1. Improved production technology of cinnamon and bay leaf with vegetative propagation through grafting and air layering using growth regulator.
2. Processing of cinnamon and bay leaf in natural and artificial environment.

**iv. Policy Support**

1. Cinnamon and bay leaf propagation technology will help in more and quality sapling productions thus enhance dissemination of improved variety and increase production to reduce import of cinnamon.
2. Improved processing technology ensure better quality quill of cinnamon and bayleaf production for obtaining higher price for the farmers.

**G. Information regarding Desk and Field Monitoring**

- i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.): Regularly monitored the progress of sub-project activities from the desk through meeting, consultations and supervising the concerned staff.
- ii) Field Monitoring (time & No. of visit, Team visit and output): Two times field visit
  - a) Two times visit was done by 6 member BARC monitoring team in January and May, 2018.
  - b) One time visit was done by 5 member BARI monitoring team in April 2018.

**H. Lesson Learned (if any)**

- i) Drying at high temperature (60C or above) or sundrying reduce quality of cinnamon and bayleaf
- ii) Rainy season is suitable for Bark collection from cinnamon tree.
- iii) Removal of outer layer (Epidermis and dead cells) is essential for better quality cinnamon quills

**I. Challenges (if any)**

- i) Skilled grafter/gardener required to get more success in grafting.
- ii) Skilled laboratory technician and laboratory facilities for volatile oil estimation facilities of cinnamon and bay leaf are not yet available in Bangladesh.

Signature of the Principal Investigator  
Date: 31 January 2019.

Seal

Counter signature of the Head of the  
organization/authorized representative

Date .....

Seal

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