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Effect of Variety and Growth Regulator Concentration on Success of Air Layering in Plum

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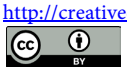

Abstract

The experiment was conducted at the Regional Spices Research Center, BARI, Gazipur during June 2016 to October 2017 to evaluate the effect of genotype and growth regulator (IBA) on the success and performance of plum air layering. Air layering was done on two plum varieties (BARI Alubokhara-1 and PD Gaz 004) using seven levels of IBA concentration (viz. 0, 1000, 2000, 3000, 4000, 5000 and 6000 ppm) under a complete randomized (factorial) design (CRD). Significant variation was observed on rooting, establishment and death of layers due to variety and IBA concentrations except rooting and separation time. The un-fruiting line PD Gaz 004 showed outstanding performance in rooting and survivability of layers over BARI Alubokhara-1. Poor rooting and lower establishment caused very high mortality of layers in BARI Alubokhara-1. Rooting and survivability, number of roots, length of roots and leaf production increased with the increasing levels of IBA concentration up to 5000 ppm. The maximum (10 out of 10) rooting success of layer with 65.83% and 59.17% establishment from PD Gaz004 was obtained when 3000 and 4000 ppm IBA was used, respectively. In BARI Alubokhara-1, the highest rooting success (3.08), establishment rate (29.42%), number of root (4.28/layer) and root length (5.08 cm) were recorded with 4000 ppm IBA concentration.

Keywords

Growth Regulator, Layering, Plum, Success

1. Introduction

Alubokhara or Plum (*Prunus domestica*) is a valued species in the family Rosa-

ceae native to Europe and Asia. *Prunus domestica* is believed to have originated in the area of the Caucusus and Asia Minor [1]. Plums and their juice contain mild laxatives including phenolic compounds, sorbitol, dietary fiber that are thus common home remedies for constipation [2]. Plums also have a high antioxidant content which retards aging [3]. In Bangladesh, the demands of plum usually meet up by importing from other countries like India, China, Turkey, South Korea and Pakistan [4]. After several years evaluation of various germplasm, one was found superior in respect of adaptability, yield and yield attributes, quality, pest and disease tolerance and released as "BARI Alubokhara-1" from the Spices Research Center of Bangladesh Agricultural Research Institute in 2013 [5]. This variety produces more number of fruits (1221/plant/year) in June-July and yielded 10.29 kg/plant or 6.43 t/ha. Fruits are attractive dark red colored, sour sweet taste (TSS 10.6%), medium size (3 × 2.74 cm, 8.67 g) and globular shape having high nutritive and medicinal properties. This variety performed well in past five years and adopted well in the environment of Bangladesh with low disease and pest infestation [4]. The description of BARI Alubokhara-1 is published in the BARI website http://www.bari.gov.bd/ and broadcasted several times on Bangladesh Television in 2014 to 2016. Huge demands of saplings are observed after mass media broadcasting and website publication. Vegetative propagation is essential to disseminate this variety for increasing its cultivation maintaining genetic purity of the variety. Air layering and cutting are most used and popular means of Alubokhara propagation [6]. In rainy season of Bangladesh, many fruit plants showed good shoot and root growth in cuttings and air layering. Little information is available on successful use of plant growth regulator *i.e.* Indole-3 butyric acid (IBA) for root initiation in Plums in various countries, but no such reports are available in Bangladesh condition. IBA 1000 $mg{\cdot}L^{-1}$ was the best in the rooting of plum cuttings [7]. Vegetative propagation using IBA is eco-friendly and no harmful reports so far are known on use of IBA for cuttings and layering establishment. The alternate way of vegetative propagation is grafting on seedlings of the same species. But Alubokhara seeds showed shy germination and death rate of germinated seedlings are very high. Therefore, the present study was designed for development of a successful vegetative propagation of plum with a view to increase its production and profitability through rapid dissemination of BARI Alubokhara-1. The main objectives of experiment were:

1) Standardization of IBA concentration for air layering propagation techniques of Alubokhara (plum) in the environmental condition of Bangladesh.

2) To increase success of layering using growth regulators and appropriate variety.

2. Materials and Methods

The experiment was conducted at the Regional Spices Research Center, BARI, Gazipur located in about 40 km North to Dhaka city with 23˚59'29" North lati-

tude and 90˚24'50" East longitude and an elevation of 8.50 m from the sea level during June 2016 to October 2017. The experiment was conducted using a complete randomized design (factorial) using two factors comprising two plum varieties/lines (BARI Alubokhara-1 and PD Gaz 004) and seven levels of IBA concentration (0, 1000, 2000, 3000, 4000, 5000 and 6000 ppm). Soil mixture was prepared with 50% loamy soil and 50% well decomposed cow dung and kept for 2 weeks before use for layering. Treatment wise hormone solution was taken with a dropper bottle and applied 3/4 drops 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 was consisting of 10 layering shoots and a total of 30 for 3 replications was used for each treatment and tagged properly. A total of 420 layering were done for seven IBA concentrations. The cut portions was surrounded with 150 - 200 g of moist soil mixture, covered with polythene and tied tightly with jute rope thus called the "stool" or "mount". When a number of roots were established and seen over polythene, the air layering seems suitable to separate from the mother plant. A half cut was given at 2 - 3 cm below the cut portion or just below the stool of air layering. After one week the layering was separated by final cut from the previous cut place and extra branches and leaves were trimmed out. The trimmed layering shoot was planted in previously prepared 7" × 10" polythene bag removing the layering polythene and kept one week under shade followed by 2 weeks in partial shade for establishment. When a number of roots and shoots were established, the air layering seems suitable to plant in the field. Data on length and number of roots per layering was counted breaking the stool at time of separation while success of detached layers and number of leaves was counted at 30 days after separation. The sample of 5 layers was broken and the numbers of roots were counted and lengths of roots were measured with a digital slide calipers. After separation from the mother plants, success of detached layers and number of leaves were counted at 30 days of planting in the polythene bag. The data were compiled properly and analyzed statistically by MSTAT and MS-Excel Program and mean comparison was done following Dancan's Multiple Range Test [8].

3. Results and Discussion

Both the factors, variety and growth regulator showed different extent of variations in respect of rooting time and success as well as growth of root and shoot in plum layering during two years experimentation.

3.1. Effect of Variety on Success of Air Layering

BARI Alubokhara-1 was significantly reluctant in rooting compared to the line PD Gaz 004 for successful layering (**Table 1**). BARI Alubokhara-1 took more time for rooting (41.15 days) and separation (51.8 days) while PD Gaz-004 showed early rooting (33.9 days) and separation (44.2 days). The maximum number of successful layers (8.77) was recorded in PD Gaz-004 but it was much

Table 1. Effect of variety on success on rooting time and success of plum layering.

Variety	Days to rooting			Days to cut			Successful layers (no)			% Dead layers		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
BARI Alubokhara-1	37.0a	45.3a	41.15a	46.0a	57.6a	51.8a	2.11b	3.40b	2.76b	78.89a	45.14a	61.65a
PD GAZ004	33.5b	34.3b	33.90b	42.5b	45.8b	44.2b	9.53a	8.02a	8.77a	4.72b	9.30 b	7.01b
Significance level	NS	**	*	*	**	*	**	**	**	**	*	**
CV (%)	3.34	4.88	4.11	4.42	5.63	5.03	12.35	12.50	12.43	14.52	14.83	14.67

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.

lower (2.76) in BARI Alubokhara-1 out of 10 layering. The death rate of BARI Alubokhara-1 was very high (61.65%) while in PD Gaz-004 only 7.01% layer was died after separation. Early and profuse rooting resulted less death percentage in PD Gaz 004 while delayed and shy rooting caused higher death rate in BARI Alubokhara-1 may be due to the varietal characteristics under Bangladesh environment.

Table 2 showed the varietal effect on rooting, establishment and growth performances of layering. PD Gaz 004 also showed significantly higher establishment rate (61.38%) better rooting (4.38/layer), longer roots (5.46 cm) and leaf initiation (14.1/plant) compared to BARI Alubokhara-1 which had only 22.26% success, 3.76 roots/layer, 4.44 cm root length and 12.1 leaves/layer.

Better root growth resulted higher success rate in PD Gaz-004 might be due to the cumulative deposited energy because this line flowered only but it does not produce any fruits.

One the other hand, BARI Alubokhara-1 had profuse bearing with very good number of fruits which used some photosynthetic energy and food materials during fruit production.

3.2. Effect of IBA Concentration

IBA concentration had significant effect on the success of layering (Table 3). 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 very close among the concentration though it was significant at 5% level. The number of successful layer was significantly higher ((≥6)) with the concentration of IBA 2000 ppm to 6000 ppm and it was lower in control (4.29/10). These findings are partially resembled with the findings [9] where the highest rooting percentage in plum was obtained with IBA treatment of cuttings with 2000 $mg{\cdot}l^{-1}$ during summer. But these findings are differed in respect of IBA concentration with the report [7] and [10] who obtained the highest success using 1000 ppm IBA in plum cutting and layering. Another findings [11] showed he maximum success (87.5%) of plum cuttings from 1500 ppm K-IBA solution.

Table 2. Effect of variety on establishment and growth performance of plum layering.

Variety	% Established			No. of roots/layer			Length of root (cm)			Leaves/plant		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
BARI Alubokhara-1	15.00b	29.52b	22.26b	3.5b	4.01	3.76	4.16b	4.72	4.44b	10.20b	14.00	12.10b
PD GAZ004	51.81a	70.95a	61.38a	4.5a	4.26	4.38	5.63a	5.28	5.46a	13.10a	15.00	14.10a
Significance level	**	**	**	NS	NS	NS	**	NS	*	**	NS	*
CV (%)	14.52	15.23	14.88	11.21	5.34	8.28	9.82	4.38	7.01	12.87	5.40	9.14

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. Effect of IBA concentration on success of rooting time and plum layering.

IBA	Days to rooting			Days to cut			Successful layers (no)			% Dead layers		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
0	37.96a	46.79a	42.38a	46.63a	59.04a	52.84a	4.29d	2.96d	3.63b	57.08a	19.40b	38.24a
1000	35.92 b	41.00b	38.46b	44.75b	52.38a	48.57ab	5.46c	4.88c	5.17ab	45.42b	20.25b	32.83b
2000	35.25bc	38.75c	37.00b	44.54b	50.92a	47.73b	6.33ab	6.04b	6.19a	36.67d	24.35ab	30.51b
3000	34.63cd	38.08c	36.36b	43.17c	50.21a	46.69b	6.25ab	7.00a	6.63a	37.50cd	28.90ab	38.20a
4000	34.17de	37.92c	36.05b	43.29c	49.79a	46.54b	6.50a	6.79a	6.65a	35.00cd	30.00a	32.50b
5000	33.91e	38.17c	36.04b	43.14c	49.71a	46.43b	6.29ab	6.33b	6.31a	39.10cd	34.85a	35.96ab
6000	33.75e	37.96c	35.86b	43.00c	49.75a	46.38b	6.08b	6.00b	6.04a	39.17	22.75b	30.96b
Significance.	**	*	*	*	*	*	**	**	*	**	*	*
CV (%)	3.34	4.88	4.11	4.42	5.63	5.03	12.35	12.50	12.43	14.52	14.83	14.68

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.

There was significant variation on number of dead layers after separation from the mother plant, rooting and leaf production with various levels of IBA treatment. 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 [4].

IBA concentration significantly affected on the establishment and growth of plum layering (**Table 4**). Higher concentration of IBA resulted more number (≥4) of longer (≥5 cm) roots compared to control and lower concentration of IBA. Number of leaves was increased with increasing IBA concentration up to 4000 ppm.

The highest number of leaves (13.89/layer) was recorded from the application of 4000 ppm IBA and the lowest (11.07/layer) was found from 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. Previous report [11] showed that growth regulator enhanced rooting and germination

Table 4. Effect of IBA concentration on establishment and growth of plum layering.

IBA	% Established			No. of roots/layer			Length of root (cm)			Leaves/plant		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
0	17.50d	25.00d	21.25c	3.36c	3.83d	3.60b	3.98b	4.59d	4.29b	10.29c	11.84d	11.07b
1000	27.90c	43.33c	35.62b	3.71bc	4.02c	3.87ab	4.47b	4.86c	4.67ab	11.03bc	14.15c	12.59ab
2000	37.50ab	55.00b	46.25a	4.30a	4.11bc	4.21a	5.25a	5.02b	5.14a	12.71a	14.81b	13.76a
3000	42.10a	61.25a	51.68a	4.27a	4.25a	4.26a	5.19a	5.14ab	5.17a	11.95abc	14.90ab	13.43a
4000	41.30a	60.42a	50.86a	4.46a	4.29a	4.38a	5.43a	5.134ab	5.28a	12.57ab	15.21ab	13.89a
5000	37.60b	54.58b	46.09a	4.25a	4.28a	4.27a	5.24a	5.174a	5.21a	11.97abc	15.37a	13.67a
6000	34.20b	52.08b	43.14ab	4.03ab	4.19ab	4.11a	5.05a	5.10ab	5.08a	11.27abc	11.90f	11.59c
Significance	**	**	**	**	**	**	**	**	**	**	**	*
CV (%)	14.52	15.23	14.88	11.21	5.34	8.28	9.82	4.38	7.10	12.87	5.40	9.14

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.

increasing α-amylase activities in the seeds and plant.

3.3. Combined Effect of Variety and IBA Concentration

Both the variety and line showed incremental rate of rooting and success of layers with increasing IBA concentration up to a certain level (Table 5). BARI Alubokhara-1 took the maximum time for rooting (46.5 days) and detachment (57.1 days) of layers in control treatment (without IBA). Early rooting (32.5 days) and cut time (42.8 days) was observed in PD Gaz 004 with 6000 ppm IBA application. The maximum (9.59 out of 10) rooting success of layer was obtained from PD Gaz 004 with 3000 IBA concentration while it was very poor (0.96/10) in BARI Alubokhara-1 in control. The Highest percentage of dead layers (71%) was recorded in BARI Alubokhara-1 with 3000 ppm IBA and it was the lowest (3.35%) in PD Gaz 004 with 2000 ppm IBA treatment.

Establishment rate and rooting significantly affected with the combined effect of variety and IBA but number of leaves was similar (Table 6). The highest establishment rate (73.33%) was recorded in PD Gaz 004 with 3000 ppm IBA but it was only 5.42% in BARI Alubokhara-1 without IBA. The line PD Gaz 004 showed better rooting (4.58 roots/layer) root length (5.68 cm) and leaf production (14.60/layer) with higher doses (5000 - 6000 ppm) of growth regulator (IBA).

The number of leaves per layer at 30 days after separation showed insignificant variation with different level of IBA or varieties. Among BARI Alubokhara-1, the highest establishment rate (34.29.42%), number of roots (4.21/layer) and root length (4.99 cm) and leaves (13.30/layer) was recorded with 4000 ppm solution.

Table 5. Combined effect of variety and IBA concentration on success of plum layering.

Var.	IBA	Days to rooting			Days to cut	Successful layers (no)			% Dead layers		
		2015	2016	Mean		2015	2016	Mean	2015	2016	Mean
BARI Alubokhara-1	0	39.9	53.0a	46.5a	57.1	0.83f	1.08g	0.96d	91.67a	33.0c	62.34b
	1000	37.8	46.9ab	42.4a	52.8	1.42f	2.58f	2.00cd	85.83a	33.0c	59.42b
	2000	37.0	44.3ab	40.7ab	51.9	2.67c	3.58e	3.13c	73.33c	42.0c	57.67b
	3000	36.3	43.3b	39.8ab	50.2	2.50de	4.83d	3.67c	75.00bc	67.0b	71.00a
	4000	35.8	43.1b	39.5ab	50.1	3.08cd	4.42d	3.75c	69.17cd	50.0bc	59.59b
	5000	35.6	43.5b	39.6ab	50.0	2.63de	3.83e	3.23c	73.75bc	58.0bc	65.88ab
	6000	35.4	43.2b	39.3ab	50.0	2.17e	3.50e	2.84cd	78.33b	33.0c	55.67b
PD GAZ004	0	36.0	40.6bc	38.3ab	48.6	7.75b	4.83d	6.29b	22.50e	5.80bc	14.15c
	1000	34.0	35.1c	34.6b	44.4	9.50a	7.17c	8.34ab	5.00f	7.50b	6.25d
	2000	33.5	33.3c	33.4b	43.6	10.0a	8.50b	9.25a	0.00f	6.70b	3.35d
	3000	33.0	32.9c	32.9b	43.2	10.0a	9.17a	9.59a	0.00f	10.80ab	5.40d
	4000	32.6	32.8c	32.7b	43.0	9.92a	9.17a	9.55a	0.83f	10.00ab	5.42d
	5000	32.3	32.8c	32.6b	42.8	9.96a	8.83ab	9.39a	0.40f	11.70a	6.05d
	6000	32.1	32.8c	32.5b	42.8	10.00a	8.50b	9.25a	0.00f	12.50a	6.25d
Significance.		NS	*	*	NS	**	*	*	**	*	*
CV (%)		3.34	4.88	4.11	5.03	12.35	12.50	12.43	14.52	14.83	14.68

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 6. Combined effect of variety and IBA concentration on establishment and growth of plum layering.

Variety	IBA	% Established			No. of roots /layer			Length of root (cm)			Leaves/ plant
		2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	
BARI Alubokhara-1	0	3.33g	7.50d	5.42h	2.52e	3.69	3.11b	2.78e	4.24	3.51b	9.70
	1000	9.17g	22.50d	15.84g	3.08de	3.90	3.49ab	3.36e	4.57	3.97b	11.37
	2000	18.33f	31.67cd	25.00f	4.13ab	4.02	4.08a	4.85bcd	4.77	4.81ab	13.23
	3000	18.33f	41.67bcd	30.00de	3.88bc	4.13	4.01a	4.64cd	4.89	4.77ab	12.65
	4000	29.42f	39.17bcd	34.29d	4.28ab	4.13	4.21a	5.09a-d	4.89	4.99ab	13.30
	5000	23.33f	32.50cd	27.92e	3.80bc	4.10	3.95ab	4.67cd	4.84	4.76ab	12.70
	6000	17.50f	31.67cd	24.59ef	3.31cd	4.13	3.72ab	4.25d	4.83	4.54ab	11.85
PD GAZ004	0	31.67e	42.50bcd	37.09d	4.21ab	3.96	4.09a	5.18abc	4.95	5.07ab	12.40
	1000	46.67d	64.17abc	55.42c	4.34ab	4.13	4.24a	5.57ab	5.14	5.36a	13.80
	2000	56.67bc	78.33a	67.50ab	4.48ab	4.20	4.34a	5.65ab	5.26	5.46a	14.40
	3000	65.83a	80.83a	73.33a	4.65ab	4.36	4.51a	5.75ab	5.38	5.57a	14.18
	4000	59.17ab	81.67a	70.42a	4.64ab	4.45	4.55a	5.76ab	5.37	5.57a	14.48
	5000	55.00bc	76.67a	65.84ab	4.68a	4.47	4.58a	5.85a	5.50	5.68a	14.55
	6000	50.83cd	72.50ab	61.67b	4.74a	4.25	4.50a	5.86a	5.37	5.62a	14.60
Significance		**	*	*	**	NS	*	**	NS	*	NS
CV (%)		14.52	15.23	14.88	11.21	5.34	8.28	9.82	4.38	7.10	9.14

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.

IBA accelerates cell division and root initiation at high humidity and temperature resulted more rooting and leaves with higher doses of IBA in layering. The result from this observation was partially resembled with some findings such as [9] gets maximum success with 2000 ppm IBA. Another researcher [11] obtained from 1500 ppm IBA while [9] and [7] got the maximum success with 1000 ppm IBA concentration. All the findings were varied because those experiments were conducted in different environment, soils, climates and times. These findings are resembled with the findings [12] observed versatile variation of plums rooting with various weather and chemical treatments. Saplings produced from layering of the un-fruiting line PD Gaz-004 is kept for cleft grafting of BARI Alubokhara-1 scions in next season for the production of grafted saplings of BARI Alubokhara-1.

4. Conclusion

Variety and IBA concentration significantly influenced on the success and rooting of layers under Bangladesh condition. Plum layering using 3000 to 4000 ppm IBA solution seems better for successful vegetative propagation in Bangladesh.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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