Journal of Applied and Natural Science
14(4), 1176 - 1182 (2022)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Response of Indole 3 butyric acid during air layering on root and shoot induction behavior in Guava (*Psidium guajava* L) CV Sardar (L-49)

Shaileja Bansal
Department of Horticulture, School of Agriculture, Lovely Professional University (LPU), Phagwara-144411(Punjab), India
Homraj Sahare*
Department of Horticulture, School of Agriculture, Lovely Professional University (LPU), Phagwara-144411(Punjab), India
Gurpreet Singh
Department of Horticulture, School of Agriculture, Lovely Professional University (LPU), Phagwara-144411(Punjab), India

*Corresponding author: Email: homrajsahare82@gmail.com

Article Info
https://doi.org/10.31018/jans.v14i4.2842
Received: June 8, 2022
Revised: October 28, 2022
Accepted: November 5, 2022

How to Cite
Bansal, S. *et al.* (2022). Response of Indole 3 butyric acid during air layering on root and shoot induction behavior in Guava (*Psidium guajava* L) CV Sardar (L-49). *Journal of Applied and Natural Science*, 14(4), 1176 - 1182. https://doi.org/10.31018/jans.v14i4.2842

Abstract
Air layering is practiced as it has assured to produce true to type plants and early and better rooting is observed when treated with Indole-3-butyric acid (IBA). A field experiment was conducted to study the Rooting and shooting behaviour in Guava (*Psidium guajava* L.) air layering under different concentrations of IBA during 2019 in guava orchard located at Maheru, Lovely Professional University, Phagwara, Punjab. A total of ten treatments with three replications comprising T_1–Control, T_2- IBA@ 5 g, T_3- IBA@ 6 g, T_4- IBA@ 7 g, T_5- IBA@ 8 g, T_6- IBA@ 9 g, T_7- IBA@ 10 g, T_8- IBA@ 11 g, T_9- IBA@ 12 g, T_{10}- IBA@ 5000 ppm (Liquid) were applied. Thirteen observations of the root and shoot characters were recorded and analyzed in factorial design of RBD. The results indicated that IBA@ 8 g (T_5) performed better than control and produced the best results in root parameters and shoot parameters such as the number of days to root (31.7), primary roots (59.30), primary root length (8.74 cm), primary root diameter (0.89 mm), secondary roots (45.57), secondary root length (5.73 cm), fresh root weight (0.93 g) and dry root weight, (0.81g) number of side shoots (6.87), length of side shoots (4.10 cm), length of longest side shoots (6.01 cm) and number of leaves per air layer (33.93). The existing guava production is not able to meet our present demand of guava fruits to the increasing population of the country. It is commonly propagated by seed. However, the seedlings produced are not true to type and they also take much longer to bear fruits than asexually propagated materials as the juvenile phase is eliminated in asexually propagated plants. Therefore, in the present study, guava air layering plants treated with the IBA@ 8 g are true to type and do not take much time to bear fruits, thus contributing to quality guava production.

Keywords: Auxin, Air-layering, Guava, IBA, Rooting powder

INTRODUCTION

Guava (*Psidum guajava* L.) is a common and major fruit of India with high nutrient content, pleasant fragrance, and good flavors, also known as poor man's apple (Saroj and Singh, 2020). Guava belongs to family Myrtaceae and tropical American origin (Angulo-Lopez *et al.,* 2021). Guava, being a hardy crop, is grown in a variety of soil and climatic conditions. However, the suited are red loams, medium black and other well drained soils. According to National Horticulture Board, in India, guava acquires 4th position in area and production after mango, banana and citrus. During 2017-18, the area under guava was recorded to be 265,000 hectares with a production of 4054 MT (Glance, 2018). Guava is considered as 'common man's apple' and 'the apple of tropics' because it is available for an extended period of time during the year at an exceptionally reasonable price. The major components of guava fruits are vitamin C (250 mg/100 g fresh fruits), carbohydrates (13%) and minerals (calcium 29 mg, phosphorus 10 mg and ironk0.5 mg/100 mg fresh fruits). It is very rich in vitamin C as it contains 4-6 times more vitamin C than citrus fruit (Glance, 2018). Air layering in guava is the most exploited method for commercial production in India (Singh *et al.,* 2019). Local farmers use soil and

compost as rooting media and wrap them with gunny bags. This decreases the mortality rate of the layers as soil and gunny bags do not hold water for a longer duration causing the death of the layers due to evaporation (Saroj and Singh, 2020). Most farmers use IBA in liquid or paste forms while propagating the plants through air layering. These liquid solutions should be freshly prepared before their use. During application, there is a problem with absorption of Indole 3 butyric acid (IBA) by stem. Rooting powder may be a better alternative, along with honey. This rooting powder need not to prepared freshly every time. Only a small quantity is required to apply on air-layered stem. This study's main objective was to find an alternative to the liquid formulation of IBA hormone and its suitability for propagating guava through air layering.

MATERIALS AND METHODS

The experiment was carried out to find rooting and shooting behavior in Guava (*Psidium guajava* L. cv. L-49) air layering under different concentrations of IBA during February and June 2019 in guava orchard located at village Maheru, Department of Horticulture, School of Agriculture, Lovely Professional University. The experimental treatment for the present investigation comprised 10 levels of IBA treatments; 5 g, 6 g, 7 g, 8 g, 9 g, 10 g, 11 g and 5000 ppm (Liquid) at two levels of application; February (M1) and June (M2). Ten air layers per treatment were used, which was replicated three times. Magnesium silicate was used as base material and honey was used for lathering the girdled shoots. The layering operation was done in the second fortnight of February and June 2019, respectively. Selected mature 1 year old shoots were girdled by removing 2.5 cm ring of bark to expose the fleshy tissues for absorption of the applied growth regulator. Girdled portion was lathered with honey and formulations of growth regulator were applied with a soft camel hairbrush to the upper cut surface.

To cover the exposed region, sphagnum moss and cocopeat were used in 1:1 ratio in the form of a moist ball without disturbing the applied growth regulator. The ball was covered with black polythene and both ends were secured firmly using gunny thread. In the case of control treatment, however, only talc (carrier) and honey were applied. All the air layers were separated from the mother plants two months after air layering. The detached air layers were soaked in water and the sphagnum moss sticking to the roots was removed carefully using forceps to avoid damage to the roots.

Observations related to root parameters and shoot parameters were recorded, like the number of days to root, primary roots, primary root length, primary root diameter, secondary roots and dry root weight etc. These were recorded on the basis of five random competitive layers 60 days after layering for root parameters.And for shoot, parameters like a number of side shoots, length of side shoots, length of longest side shoots, and number of leaves per air layer were recorded 30 days after transplanting and evaluated as per the standard procedure. The experiment was laid out in a factorial randomized complete block design. Differences between the two means were compared at 5% level of significance. There are 10 treatments of IBA where the base material is magnesium silicate, and honey was used for lathering the girdled shoots. Ten air layers were used for each treatment which was replicated three times. This experiment was performed twice, in February and June. Data were analyzed for normal distribution using the Shapiro-Wilk test. Mixed-model ANOVA with PROC GLIMMIX was used in SAS 9.4 version (SAS Institute, Cary, North Carolina, USA). For mean separation, the SAS PDMIX was performed using least significant difference (LSD) test. Valid conciliations were drawn after determining the significance of the difference between the treatments at 5 per cent probability.

RESULTS AND DISCUSSION

The data from Table 1 shows the number of days taken to root in relation to different formulations of growth regulator (IBA) treatment in Guava (*P. guajava)* L. cv. L-49 was found to be significant ($p<0.05$). Among the different treatments, T_5 (IBA@ 8 g) recorded significantly ($p<0.05$) minimum days to root (31.7) as against the longest duration of 49.60 days in T_1 (control) untreated air layers. In the case of time of application, June took a minimum number of days to root, i.e. 34.82 days, compared to February, which took 46.94 days. The interaction between treatment and time of application did not have any significant effect in the case of days to root (Table 2). The number of primary roots per air layer in relation to different formulations of IBA treatments was found to be significant ($p<0.05$). Among the different treatments, T5 (IBA@ 8 g) recorded the significantly ($p<0.05$) maximum number of primary roots (59.30), followed by T10 (IBA@ 5000 ppm) 55.03 when compared with the lowest number of primary roots (3.57) in T1 (control; Table 1). This can be attributed to guava being a hard-to-root crop, which is why untreated layers showed poor results. Stem treated with IBA hormone promoted more growth by meristematic cell division. In the case of time of application, the maximum number of primary roots was obtained in June, i.e. 39.13, as compared to February, which obtained 27.85 primary roots. The interaction of treatment and time of application did not significantly affect the number of primary roots. Main cause of having higher values in IBA treated layered stem cuttings are due to the synergistic effect of the honey, which has antimicrobial properties, as well

as the IBA auxin hormone, which is responsible for cell division in the apical portion of the roots

Averaging across the time of application, T5 (IBA@ 8 g) resulted in a significantly ($p<0.05$) higher primary root length (6.99 cm) than all other IBA treatments (Table 1).

The higher primary root length was found in June than in February, with a mean value of 6.03 cm. The interaction of treatment and time of application significantly ($p<0.05$) affected primary root length. T5 M2 (IBA@ 8 g) recorded a maximum root length of 8.74 cm in June compared to all other treatment and month combinations, as shown in Table 2. As June's temperature and relative humidity was suitable for root induction, root induction in June was found to be maximum. In February, T1-M1 (control) recorded the minimum primary root length of 1.86 cm. The second best treatment after T5M2 was T1 0M2 (IBA@ 5000 ppm) 7.47 cm primary root length in June, followed by T2M2 (IBA@ 5 g) with primary root length of 7.26 cm in June. The highest mean length of longest root proposed that IBA at high concentration encouraged faster growth of roots resulting in longest length. Parmar *et al.,* 2018 recorded the longest primary root length of 8.93 cm with the treatment of IBA@ 8000 ppm. Lal *et al*. (2007) recorded the longest primary root length of 8.45 cm with IBA@ 7500 ppm in Sardar variety of guava.

Results suggested that T5 resulted in a significantly ($p<0.05$) higher primary root diameter than the other treatments. Comparing months, June resulted in significantly ($p<0.05$) higher (by ~ 17%) primary root diameter than February. T5 M2 (IBA@ 8 g) recorded a significantly ($p<0.05$) highest primary root diameter of 0.89 mm against the lowest recorded value of primary root diameter of 0.29 mm in T1M1 (control) in February. Among the other treatment combinations, T5M2 recorded the significantly highest value of primary root diameter (0.89 mm), which was at par with T10M2, T3M2, T2M2 and T5M1 (0.81. 0.74, 0.73 and 0.73) respectively. Layers prepared during June recorded higher root diameters. Kumar (2009) also observed conspicuous effects in litchi layers which were due to the higher concentration of IBA. Slow translocation and higher stability of IBA at higher concentrations might be attributed to an increase in the mean root thickness.

The number of secondary roots induced by various concentrations of IBA treatments was notably higher (Table 1). The data revealed that T5 (IBA@ 8 g) recorded the maximum number of secondary roots (45.57) followed by T10 (IBA@ 5000 ppm) 41.07. The considerably lowest number of secondary roots was recorded with T1 control (3.77). Secondary roots observation in treatment June (M2) performed better than February (M1) with a mean number of secondary roots of 34.13 and 22.79, respectively. Treatment and month exerted a significant ($p<0.05$) effect on the number of secondary roots; however, the interaction of treatment and month was not significant ($p<0.05$). T5 (IBA@ 8 g) 5.73 cm and T10 (IBA@ 5000 ppm) 5.43 cm resulted in significantly ($p<0.05$) higher secondary root length than T1 (control), T3 (IBA@ 6 g), T7 (IBA@ 10 g), T8 (IBA@ 11 g) and T9 (IBA@ 12g). June (M2) performed better than February (M1), with a mean secondary root length of 5.18 cm and 3.46 cm, respectively. Treatment and month significantly ($p<0.05$) influenced secondary root length; however, the interaction was not significant. Parmar *et al.* (2018) reported that the maximum root length of 5.83 cm was obtained in guava from IBA @ 8000 ppm in guava layers, which agreed with the present experimental results.

Fresh root weight induced by different concentrations of growth regulator IBA treatments was significantly ($p<0.05$) higher (Table 1). T5 (IBA@ 8 g) recorded a significantly ($p<0.05$) higher fresh weight of roots (0.93 g), followed by T10 (IBA@ 5000 ppm) with a fresh root weight of 0.83 g. The minimum fresh root weight was observed in T1 (control), having mean value of 0.16 g. The fresh root weight was significantly ($p<0.05$) higher in June, i.e. 0.69, as compared to February, which resulted in a fresh root weight of 0.37 g. Treatment and month showed a significant ($p<0.05$) influence on the fresh root weight. The interaction of treatment and month did not exert any significant ($p<0.05$) effect. The dry root weight induced by different concentrations of growth regulator IBA treatments was significantly ($p<0.05$) higher. T5 (IBA@ 8 g) recorded a significantly ($p<0.05$) higher dry root weight of 0.81g followed by T10 (IBA@ 5000 ppm) with a dry root weight of 0.75 g. Parmar *et al.,* 2018 recorded the dry root weight of 0.78g with IBA @ 8000 ppm. External application of auxin further stimulates the movement of natural auxin and other materials in a downward direction from the leaves and shoots tips which accu-mulate at the incision made on the shoot resulting in the formation of roots with higher freshness and dry weight. The minimum dry root weight was observed in untreated air layers T1 control 0.13 g. Dry root weight was considerably higher in June as compared to February. The effect of treatment and month was significant for the dry root weight. However, the interaction between treatment and month did not significantly affect the dry root weight. This may be due to the external application of auxin and active growing month up to June will result in the formation of roots with more dry weight, as reported by Maurya et al., (2012). Similar results were also reported in litchi crops for IBA treatment by Noor *et al*. (2002) and Baghel *et al.,* (2016).

Treatment, month and the interaction between treatment and month had a significant influence on the number of side shoots at 30 day interval. The data pertaining to the number of side shoots at 30 day interval in air-layers as influenced by different combinations of

Table 1. Effect of various concentrations of IBA and time of application on root parameters of guava air layers. Mean values include the observations, n= 15

Treatment details (g/Kg)	Number of days to root	Number of Primary roots	Primary root length (cm)	Primary root diam-eter (mm)	Number of Secondary roots	Secondary root length (cm)	Fresh root weight (g)	Dry root weigh t (g)
T_1 Control	49.60	3.57	3.11	0.29	3.77	3.04	0.16	0.16
T_2 IBA, 5 g	38.93	37.47	5.41	0.59	28.17	4.64	0.60	0.54
T_3 IBA, 6 g	39.57	35.07	5.20	0.69	32.10	3.38	0.53	0.49
T_4 IBA, 7 g	41.70	30.23	5.47	0.66	31.20	5.02	0.40	0.36
T_5 IBA, 8 g	31.77	59.30	6.99	0.81	45.57	5.73	0.93	0.81
T_6 IBA, 9 g	37.77	39.23	5.27	0.68	30.60	4.58	0.53	0.49
T_7 IBA, 10 g	38.63	20.73	4.26	0.58	20.43	3.65	0.45	0.41
T_8 IBA, 11 g	45.30	22.63	4.01	0.56	19.37	3.72	0.42	0.38
T_9 IBA, 12 g	45.87	31.63	4.64	0.46	32.33	4.02	0.44	0.40
T_{10} IBA,5000 ppm	39.67	55.03	5.54	0.65	41.07	5.41	0.83	0.75
C.D.	3.48	10.48	1.19	0.11	8.02	1.06	0.19	0.16
SE(m)	1.21	3.65	0.41	0.04	2.79	0.37	0.07	0.06
M_1 (February)	46.94	27.85	3.940	0.55	22.79	3.46	0.37	0.33
M_2 (June)	34.82	39.13	6.039	0.64	34.13	5.18	0.69	0.63
C.D.	1.56	4.69	0.530	0.05	3.59	0.47	0.09	0.07
SE(m)	0.54	1.63	0.185	0.02	1.25	0.16	0.03	0.03

IBA: Indole 3 butyric acid

Table 2. Interaction effect of different concentrations of IBA and time of application on root parameters of guava air-layers (Mean values include the observations, n= 15)

Treatment details (Factor T X M)	Number of days to root	Number of pri-mary roots	Primary root length (cm)	Primary root diam-eter (mm)	Number of secondary roots	Secondary root length (cm)	Fresh root weight (g)	Dry root weigh t (g)
T_1M_1 (Control, Feb)	58	2.47	1.86	0.29	1.8	1.71	0.156	0.14
T_1M_2 (Control, June)	41.2	4.67	4.37	0.3	5.73	4.37	0.16	0.17
T_2M_1 (IBA 5 g, Feb)	47.47	32.87	3.55	0.44	20.47	3.09	0.38	0.34
T_2M_2 (IBA 5 g, June)	30.4	42.07	7.26	0.73	35.87	6.18	0.82	0.75
T_3M_1 (IBA 6 g, Feb)	47.4	31.8	4.95	0.63	28.6	2.95	0.32	0.29
T_3M_2 (IBA 6 g, June)	31.73	38.33	5.45	0.74	35.6	3.81	0.75	0.70
T_4M_1 (IBA 7 g, Feb)	46.27	25.93	4.28	0.6	25.07	3.85	0.35	0.31
T_4M_2 (IBA 7 g, June)	37.13	34.53	6.65	0.72	37.33	6.2	0.46	0.41
T_5M_1 (IBA 8 g, Feb)	37.87	43.8	5.23	0.73	33.93	4.87	0.60	0.52
T_5M_2 (IBA 8 g, June)	25.67	74.8	8.74	0.89	57.2	6.59	1.26	1.09
T_6M_1 (IBA 9 g, Feb)	43.67	30.6	4.61	0.71	24	3.78	0.37	0.34
T_6M_2 (IBA 9 g, June)	31.87	47.87	5.93	0.64	37.2	5.39	0.69	0.64
T_7M_1 (IBA 10 g, Feb)	44.07	20.87	4.1	0.59	21.13	3.51	0.34	0.31
T_7M_2 (IBA 10 g, June)	33.2	20.6	4.41	0.58	19.73	3.79	0.55	0.51
T_8M_1 (IBA 11 g, Feb)	50.67	21.4	2.99	0.44	17.33	2.57	0.28	0.25
T_8M_2 (IBA 11 g, June)	39.93	23.87	5.03	0.68	21.4	4.87	0.55	0.51
T_9M_1 (IBA 12 g, Feb)	50.13	26.6	4.21	0.59	26.6	3.64	0.34	0.30
T_9M_2 (IBA12 g, June)	41.6	36.67	0.07	0.34	38.07	4.41	0.53	0.50
$T_{10}M_1$ (IBA 5000ppm Liquid, Feb)	43.87	42.2	3.61	0.49	29	4.59	0.52	0.48
$T_{10}M_2$ (IBA 5000 ppm Liquid, June)	35.47	67.87	7.47	0.81	53.13	6.23	1.13	1.02
C.D.	NS	NS	1.67	0.15	8.02	NS	0.28	0.23
SE(m)	1.71	5.16	0.58	0.05	2.79	0.52	0.10	0.08

IBA: Indole 3 butyric acid

Table 3. Effect of different concentrations of IBA and time of application on shoot parameters of transplanted guava air layers (Mean values include the observations, n= 15)

Treatment details (g/Kg)	Number of side shoots at 30 day interval	Length of side shoots at 30 day interval (cm)	Length of longest side shoots at 30 day interval (cm)	Number of leaves per air layer at 30 days interval	Survival percentage of separated air-layers.
T_1 Control	1.90	1.64	2.41	10.00	43.33
T_2 IBA, 5 g	4.20	2.56	3.79	18.30	70
T_3 IBA, 6 g	3.83	2.37	3.57	19.80	50
T_4 IBA, 7 g	3.37	2.26	3.45	14.10	56.67
T_5 IBA, 8 g	5.83	3.17	4.89	26.77	86.67
T_6 IBA, 9 g	4.13	2.51	3.58	21.17	46.66
T_7 IBA, 10 g	4.63	2.73	3.67	20.13	53.33
T_8 IBA, 11 g	4.70	2.17	3.39	20.60	36.66
T_9 IBA, 12 g	3.30	1.40	2.66	12.47	40
T_{10} IBA, 5000 ppm (Liquid)	5.90	3.38	4.85	25.50	83.34
C.D.	0.63	0.21	0.36	2.23	16.02
SE(m)	0.20	0.08	0.13	0.78	5.57
M1 (February)	3.31	1.78	2.89	15.11	52.00
M2 (June)	5.05	3.06	4.36	22.66	61.33
C.D.	0.28	0.10	0.16	1.00	7.16
SE(m)	0.10	0.03	0.056	0.35	2.49

IBA: Indole 3 butyric acid

IBA, months, and interaction are furnished in Table 3 and 4. Although T_5 performed better in June, it decreased the number of side shoots by ~30% in February. The lowest number of side shoots was observed in T_1 (control) than all other treatments. Overall, averaging across time of application, T_5 and T_{10} performed significantly ($p<0.05$) better than all other IBA treatments. Averaging across treatments, June had a significantly ($p<0.05$) higher number of side shoots than February. The interaction significantly ($p<0.05$) influenced the number of side shoots at 30-day intervals. Results showed that T_5M_2 (IBA @ 8g), T_2M_2 (IBA @ 5g) and $T_{10}M_2$ (IBA @ 5000 ppm) in June did not vary significantly ($p<0.05$) from each other and had a number of side shoots with a mean value of 6.87, 6.00 and 6.20 respectively.

Singh and Mahato (2016) recorded a similar number of shoots (6.473) in air layers of guava variety Pant Prabhat planted in June. In the case of length of side shoots T_5M_2 (IBA @ 8g) performed better with 4.10 cm mean length when compared with all other treatments. However, it did not vary significantly from $T_{10}M_2$ (IBA @ 5000 ppm) with 3.91 cm in June. A significant ($p<0.05$) decrease in the length of side shoot was observed under T_5 (IBA @ 8g) in February, i.e., T_5M_1 with 2.23 cm as compared to June. The length of the side shoot was significantly ($p<0.05$) lower for T_9M_1 (IBA @ 12 g) in February (1.11 cm) than all other treatments, which did not vary significantly ($p<0.05$) from T_1 (control) in February (1.37cm). It might be due to a higher concentration of IBA stimulating a higher number of roots with faster growth, resulting in better absorption of nutrients and more sprouts and their growth.

Overall, T_5M_2 (IBA @ 8g) with 6.01 cm length and $T_{10}M_2$ (IBA @ 5000 ppm) with 5.83 cm in June contributed significantly ($p<0.05$) higher the length of the longest side shoot than all other treatments. The length of the longest side shoot was significantly ($p<0.05$) lower for T_1M_1 (control) 1.81 cm and T_9M_1 (IBA @ 12 g) 2.01 cm in February than all other treatment and time of application combinations. Treatment 5 (IBA @ 8 g) and 10 showed a significantly ($p<0.05$) higher number of leaves per air-layer than all other IBA treatments. T_5M_2 (IBA @ 8 g) in June resulted in a significantly ($p<0.05$) higher number of leaves per air-layer with a mean value of ~34 than all other treatment and time of application combinations. The second best treatment after T_5M_2 (IBA @ 8 g) was $T_{10}M_2$ (IBA @ 5000 ppm) in June, which resulted in mean value of ~30 leaves per air-layer. Parmar *et al.* (2018) recorded similar values for number of leaves of 35.08, 34.00 and 41.67 with IBA @8000 ppm combined with sphagnum moss, cocopeat and a combination of both, respectively.

The data revealed that all the IBA treatments significantly ($p<0.05$) recorded higher proportion of survival of rooted layers. The highest percentage of survival (86.67%) was noted in the layers which had received T_5 IBA @ 8 g followed by T_{10} IBA 5000 ppm which recorded survival percentage of 83.34%. T_8 IBA @11 g recorded the lowest survival percentage of 36.66%. The

Table 4. Interaction effect of different concentrations of IBA and time of application on shoot parameters of transplanted guava air layers (Mean values include the observations, n= 15)

Treatment details (Factor T X M)	Number of side shoots at 30 days interval	Length of side shoots at 30 day interval (cm)	Length of longest side shoot at 30 days interval (cm)	Number of leaves per air layer at 30 days interval	Survival percentage of separated air-layers
T_1M_1 (Control, February)	1.40	1.37	1.81	6.47	33.33
T_1M_2 (Control, June)	2.40	1.91	3.00	13.53	53.33
T_2M_1 (IBA 5 g, February)	2.40	1.67	2.91	12.00	66.67
T_2M_2 (IBA 5 g, June)	6.00	3.46	4.66	24.60	73.33
T_3M_1 (IBA 6 g, February)	2.53	1.53	2.99	19.53	46.67
T_3M_2 (IBA 6 g, June)	5.13	3.22	4.14	20.07	53.33
T_4M_1 (IBA 7 g, February)	2.47	1.66	2.81	12.67	53.33
T_4M_2 (IBA 7 g, June)	4.27	2.87	4.09	15.53	60.00
T_5M_1 (IBA 8 g, February)	4.80	2.23	3.76	19.60	80.00
T_5M_2 (IBA 8 g, June)	6.87	4.10	6.01	33.93	93.33
T_6M_1 (IBA 9 g, February)	3.40	1.82	3.11	18.67	40.00
T_6M_2 (IBA 9 g, June)	4.87	3.21	4.05	23.67	53.33
T_7M_1 (IBA 10 g, February)	4.07	1.95	2.85	14.80	46.67
T_7M_2 (IBA 10 g, June)	5.20	3.51	4.48	25.47	60.00
T_8M_1 (IBA 11 g, February)	3.60	1.65	2.73	15.60	33.33
T_8M_2 (IBA 11 g, June)	5.80	2.69	4.05	25.60	40.00
T_9M_1 (IBA12 g, February)	2.80	1.11	2.01	10.60	33.33
T_9M_2 (IBA12 g, June)	3.80	1.68	3.31	14.33	46.67
$T_{10}M_1$ (IBA 5000 ppm (Liquid), February)	5.60	2.85	3.88	21.13	80.00
$T_{10}M_2$ (IBA 5000 ppm (Liquid), June)	6.20	3.91	5.83	29.87	86.67
C.D.	0.90	0.30	0.51	3.15	NS
SE(m)	0.31	0.11	0.18	1.10	7.88

IBA: Indole 3 butyric acid

higher success rate of survival after transplanting the rooted air-layers can be attributed to the possession of better root characteristics like the higher number and length of roots. Also, weather conditions in June provide favorable conditions for enhancing shooting combined with IBA treatment (Rymbai and Reddy, 2010, Baghel *et al*., 2016).

Conclusion

It was concluded that T_5 (IBA @ 8 g) treatment was the best for root parameters and shoot parameters of guava layers. However, in most of the cases, observations were *at par* with T_{10} (IBA @ 5000 ppm in liquid form) and T_2 (IBA @ 5 g). This indicated that layering needs some physiological stimulation and a better environment for favourable rooting. Concerning survivability of rooted layers, maximum survival (86.67%) (30 days after separation) was noted in the layers treated with T_5 (IBA @ 8 g). Besides this, the treatment also produced more new shoots, leaves, and a higher length of new shoots in separated air layers.This study revealed that a high concentration of IBA @ 8gm T_5 was found suitable for roots parameters, shoots parameters and survival per cent of guava air layers of L49 under Punjab region conditions in the month of June to find out suitable time and dose of auxin for propagating guava plants through air layering in Doaba region of Punjab. Further studies are recommended to check the effects of IBA on fruit quality and guava production.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Angulo-López, J. E., Flores-Gallegos, A. C., Torres-León, C., Ramírez-Guzmán, K. N., Martínez, G. A. & Aguilar, C. N. (2021). Guava (*Psidium guajava* L.) Fruit and Valorization of Industrialization By-Products. *Processes*, 9 (6), 1075.
2. Baghel, M., Raut, U. A. & Ramteke, V. (2016). Effect of IBA concentrations and time of air-layering in guava cv. L-49. *Research Journal of Agricultural Sciences*, **7** (1), 117-120.
3. Parmar, J. P., Tiwari, R., Gautam, K. K., Yadav, L. & Upadhyay, N. (2018). Effect of Indole 3-butyric acid (IBA), rooting media and their interaction on different rooting and growth characteristic of air-layers in guava (*Psidium guajava* L. cv. L-49). *Journal of Applied and Natural Science*, *10*(1), 241-246.
4. Rymbai, H. & Reddy, G. S. (2010). Effect of IBA, time of layering and rooting media on air-layers and plantlets survival under different growing nursery conditions in guava. *Indian Journal of Horticulture*, *67*(4), 99-104.
5. Saroj & Singh, K. K. (2020). Vegetative Propagation of Guava (*Psidium Guajava* L.) Through air Layering: A review. *Plant Archives*, *20*(1), 1179-1188.

6. Singh, G., Sahare, H. & Deep, M. (2019). Recent Trends in Guava Propagation-A Review. *Biosciences Biotechnology Research Asia*, *16*(1), 143-154.
7. Singh, K. K. (2018). A review: Macro-propagation of guava (*Psidium guajava*). *Journal of Pharmacognosy and Phytochemistry*, *7*(2), 2629-2634.
8. Lal, S., Tiwari, J. P., Awasthi, P. & Singh, G. (2007). Effect of IBA and NAA on rooting potential of stooled shoots of guava (Psidium guajava L.) cv. Sardar. *Acta Horticulturae*, *735*, 193.
9. Singh, K. K. & Mahato, S. (2016). Influence of indol-3-butyric acid (IBA) and various time on rooting of guava (Psidium guajava L.) air layering. *Journal of Plant Development Sciences*, *8*(4), 193-196.
10. Kumar, P. (2009). Influence of plant growth regulators and various hardening treatments on rooting and survival of air layers in litchi (*Litchi chinensis* Sonn.) M.Sc. Ag. (Horticulture) Thesis. G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. NAGAR, UTTARAKHAND (India).
11. Glance, H. S. A. A. (2018). Horticulture Statistics Division Department of Agriculture. Cooperation & Farmers' Welfare Ministry of Agriculture and Farmers' Welfare Government of India.
12. Noor, E. J., Faridullah, K. W., Mohammad, I., Haji, M. & Asghar, A. (2002). Effect of different concentrations of IBA on rooting of Litchi in air layering. *Sarhad Journal of Agriculture* 19(1).
13. Maurya R. K., Ray N R, Chavda J. C., Chauhan V. B. & Patil, A. K. (2012). Evaluation of different organic media and water holding materials with IBA on rooting and survival of air layering in guava (*Psidium guajava* L.) cv. Allahabad Safeda. *The Asian Journal of Horticulture* 7(1), 44 -47.