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Effect of plant growth regulators on rooting survival of air layering in Litchi (*Litchi chinensis*) cv. Purbi

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Abstract

The present investigation entitled “Effect of Plant Growth Regulators on Rooting and Survival of Air Layering in Litchi (*Litchi chinensis* Sonn.) cv. Purbi” was conducted during 2025-2026 at the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was laid out in Randomized Block Design (RBD) with twelve treatments and three replications to study the effect of different concentrations and combinations of IBA and NAA on rooting and vegetative growth of litchi air layers. The results revealed that growth regulator treatments significantly improved rooting and growth parameters compared to control. The treatment T₁₁ (IBA 3500 ppm + NAA 1000 ppm) recorded the earliest root initiation (24.86 days), maximum root length (11.10 cm), number of roots per layer (28.40), shoot length (14.10 cm), newly emerged leaves (30.59), rooting percentage (88.92%) and survival percentage (80.18%). The maximum root thickness was observed under T₉ (IBA 3000 ppm + NAA 1000 ppm) (5.78 mm). The superior response of combined auxin treatments was attributed to enhanced cell division, differentiation and root primordia formation. The study concluded that combined application of IBA 3500 ppm + NAA 1000 ppm was most effective for improving rooting, survival and vegetative growth of litchi air layers under Prayagraj agro-climatic conditions and may be recommended for commercial propagation of quality planting material.

Keywords: Litchi, air layering, IBA, NAA, rooting, survival, growth regulators

Introduction

Litchi (*Litchi chinensis* Sonn.) belonging to the family Sapindaceae is an important subtropical evergreen fruit crop, widely known for its attractive red pericarp, juicy translucent aril and pleasant flavour. It is highly preferred by consumers due to its excellent taste and nutritional value. The fruit contains considerable amounts of sugars, vitamin C, minerals and bioactive compounds such as phenolics, flavonoids and anthocyanins, which contribute to its antioxidant activity and health benefits (Pareek, 2016; Zhang *et al.*, 2020) ^[9, 15]. Due to its high market demand and export potential, litchi has become an economically important fruit crop in many tropical and subtropical regions.

India is one of the leading producers of litchi, with major cultivation areas in Bihar, West Bengal, Jharkhand and Uttar Pradesh. The expansion of commercial litchi cultivation requires a continuous supply of healthy and uniform planting material. However, litchi is highly heterozygous in nature and propagation through seeds results in genetic variation, delayed bearing and poor uniformity in fruit quality. Therefore, vegetative propagation is preferred for maintaining genetic purity and desirable characteristics of superior cultivars.

Air layering is the most widely used method for commercial propagation of litchi because it is simple, economical and capable of producing true-to-type plants. However, rooting behaviour in litchi air layers is often irregular due to slow root initiation, poor root growth and low survival after separation from the mother plant. The formation of weak root systems affects nutrient absorption and reduces the establishment of young plants in the nursery and field conditions. Therefore, improving rooting efficiency and survival percentage is essential for successful litchi propagation.

Plant growth regulators, especially auxins, play a major role in stimulating adventitious root formation. Indole-3-butyric acid (IBA) and Naphthalene Acetic Acid (NAA) are commonly used auxins that enhance cell division, elongation and differentiation during root

development. According to Hartmann and Kester (2011) [4], auxins promote root initiation by stimulating the formation of root primordia and increasing physiological activity at the rooting region.

IBA is considered one of the most effective auxins for vegetative propagation because of its stability and strong rooting ability. Bhambota *et al.* (1968) [3] reported that application of growth regulators improved rooting success in litchi air layering. Yadav *et al.* (2020) [14] observed that IBA treatments significantly enhanced rooting percentage, number of roots and survival of litchi layers. They suggested that improved rooting response was associated with increased carbohydrate accumulation. The effect of IBA concentration varies with crop species, cultivar and environmental conditions. Higher concentrations may improve rooting up to an optimum level, while excessive application can negatively affect root development due to hormonal imbalance. Singh *et al.* (2021) [11] reported that suitable IBA concentration reduced the time required for root initiation and increased root biomass in litchi air layers. Similar findings were reported by Abbas *et al.* (2019) [2], who observed improved root formation and vegetative growth with IBA application.

NAA also plays an important role in improving root development by promoting cell differentiation and elongation. The combined use of IBA and NAA is considered more effective because both auxins perform complementary functions during root formation. Kumar and Patel (2022) [6] reported that combined application of IBA and NAA produced better rooting percentage and improved root architecture compared to individual treatments. Sharma *et al.* (2023) [10] further stated that balanced auxin concentration is necessary for producing healthy and functional roots in vegetative propagation.

Root quality is an important factor determining the success of air layering. Longer, thicker and well-developed roots improve water absorption, nutrient uptake and plant establishment after transplanting. Souza *et al.* (2020) [12] reported that auxin-treated air layers showed better root growth and survival compared to untreated plants. Similar positive effects of auxins have also been reported in other fruit crops such as guava, pomegranate and citrus, where growth regulator application enhanced rooting and vegetative growth.

Although air layering is widely practiced in litchi, the response of plants to growth regulators varies under different agro-climatic conditions. The lack of standardized recommendations for suitable auxin concentration limits the production of quality planting material. Therefore, evaluation of different concentrations and combinations of IBA and NAA is necessary to develop an efficient propagation technique for local conditions.

Materials and Methods

Experimental Site

The present investigation entitled “Effect of Plant Growth Regulators on Rooting and Survival of Air Layering in Litchi (*Litchi chinensis*) cv. Purbi” was conducted during the year 2025-2026 at the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was carried out from August 2025 to January 2026 under the agro-climatic conditions of Prayagraj. The study was undertaken to evaluate the influence of different concentrations and combinations of plant growth regulators on rooting

behaviour, vegetative growth and survival of litchi air layers.

Experimental Material and Treatment details:

Healthy, uniform and disease-free branches of litchi cv. Purbi were selected for air layering. The selected shoots were of similar age and vigour to maintain uniformity among treatments. The experiment was laid out in a Randomized Block Design (RBD) with twelve treatments and three replications. Each treatment was assigned randomly within each replication to minimize experimental variation. The treatments included T₀-Control, T₁-IBA 2500 ppm, T₂-IBA 3000 ppm, T₃-IBA 3500 ppm, T₄-NAA 800 ppm, T₅-NAA 1000 ppm and combined applications of IBA and NAA, namely T₆-IBA 2500 ppm + NAA 800 ppm, T₇-IBA 2500 ppm + NAA 1000 ppm, T₈-IBA 3000 ppm + NAA 800 ppm, T₉-IBA 3000 ppm + NAA 1000 ppm, T₁₀-IBA 3500 ppm + NAA 800 ppm and T₁₁-IBA 3500 ppm + NAA 1000 ppm. These treatments were applied to evaluate their individual and combined effects on rooting, survival and vegetative growth performance of litchi air layers. Air-layered plants were maintained under uniform cultural practices throughout the experimental period.

Preparation and Application of Treatments

The experiment consisted of different concentrations of Indole-3-butyric acid (IBA) and Naphthalene Acetic Acid (NAA) applied individually and in combination. The growth regulators were prepared in required concentrations and applied at the rooting region of selected branches during air layering. The treated layers were properly wrapped and maintained under suitable conditions until root emergence. The effect of different treatments was evaluated based on rooting, root growth, shoot development and survival characteristics.

Observation recorded

Root initiation

Root initiation in air layering is the process by which new roots begin to form from a stem or branch that is still attached to the parent plant. The observation was made daily until root emergence was seen in each treatment. Early root initiation is considered a sign of better hormonal response and rooting efficiency.

Root length (cm)

Root length was recorded using a scale from the base of the shoot to the tip of the longest root on each rooted air layer. Measurements were taken at 30, 60, and 90 DAT to monitor the progressive development of the root system

Rooting percentage (%)

Rooting percentage refers to the proportion of air-layered branches that successfully form roots out of the total number of branches treated. Rooting percentage was calculated as the proportion of successful rooted layers out of the total number of layers prepared per treatment.

Rooting Percentage (%) = (Number of rooted layers/Total number of layers) × 100

Survival percentage (%)

Survival percentage was calculated after transplanting the rooted layers. It represents the ability of the plantlets to survive and establish successfully post-separation from the

mother plant. This is an important commercial trait since survival affects the final plant population and profitability.

Shoot length (cm)

Shoot length of the layered plants was recorded after 90 days of layering from the point of rooting to the tip of the shoot using a measuring scale.

Number of leaves

Number of leaves in air layering of litchi refers to the appearance of fresh, young leaves from the layered branch during or after the rooting period. This parameter indicates the extent of vegetative development. The total number of fully developed and healthy leaves on each rooted plant was counted at 90 DAT.

Results and Discussion

The data obtained during the present investigation on the effect of different concentrations and combinations of plant growth regulators on air layering in litchi (*Litchi chinensis*) cv. Purbi were statistically analysed and presented in the following table. The treatment effects were evaluated based on rooting behaviour, root development, survival ability and vegetative growth parameters of air layers. The results are discussed in comparison with previous research findings to interpret the influence of IBA and NAA treatments under the agro-climatic conditions of Prayagraj.

Root initiation (days)

The results presented in the table, indicated that growth regulator treatments significantly affected the time required for root initiation in litchi air layers. The earliest root initiation was observed in T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 24.86 days, followed by T₁₀ (IBA 3500 ppm + NAA 800 ppm) with 25.94 days. The maximum duration for root initiation was recorded in the control treatment (41.74 days), indicating delayed rooting without hormonal application. The improved response under combined treatments may be due to the synergistic effect of IBA and NAA in enhancing cell division and early differentiation of root initials. Similar findings were reported by Hartmann and Kester (2011)^[4], who stated that auxins play a key role in adventitious root formation. Singh *et al.* (2021)^[11] also reported early root initiation in litchi air layers with suitable auxin application.

Root length (cm)

The application of growth regulators significantly improved root elongation in litchi air layers. The maximum root length was recorded under T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 11.10 cm, followed by T₉ (IBA 3000 ppm + NAA 1000 ppm) with 10.89 cm. The minimum root length was observed in the control treatment (5.86 cm), showing poor root development in untreated layers. The superior performance of combined treatments might be due to enhanced auxin activity, which promotes cell expansion and differentiation of root tissues. Similar results were reported by Kumar and Patel (2022)^[6], who observed better root growth with combined IBA and NAA application in litchi. Taiz and Zeiger (2015)^[13] also explained that auxins regulate cellular activities responsible for root elongation.

Root thickness (mm)

The data regarding root thickness presented in the table, showed significant variation among the treatments. The

maximum root thickness was recorded in T₉ (IBA 3000 ppm + NAA 1000 ppm) with 5.78 mm, followed by T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 5.61 mm. The minimum root thickness was recorded in the control treatment (2.12 mm), which produced weaker roots. Increased root thickness under treated conditions indicates better structural development and stronger root establishment. The combined application of auxins possibly enhanced cambial activity and accumulation of metabolites at the rooting zone. Similar improvement in root quality due to auxin application was reported by Sharma *et al.* (2023)^[10] in vegetative propagation studies. These findings suggest that balanced auxin concentration improves both root formation and root strength.

Number of roots per layer

The maximum number of roots per layer was recorded under T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 28.40 roots, followed by T₈ (IBA 3000 ppm + NAA 800 ppm) with 27.56 roots. The minimum number of roots was observed in the control treatment (6.86 roots), indicating poor root proliferation in the absence of growth regulators. The higher root production under combined auxin treatments may be attributed to enhanced cell division, differentiation and stimulation of root primordia formation at the layering site. The synergistic effect of IBA and NAA might have improved physiological activity and carbohydrate mobilization, resulting in better root initiation and multiplication. Similar findings were reported by Yadav *et al.* (2020)^[14], who observed increased root number with auxin application in litchi air layering. Kumar and Patel (2022)^[6] also reported that combined application of IBA and NAA improved root architecture and produced a greater number of roots compared with individual treatments.

Rooting percentage (%)

Rooting percentage showed significant variation among different treatments. The highest rooting percentage was recorded under T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 88.92%, followed by T₉ (IBA 3000 ppm + NAA 1000 ppm) with 87.75%. The lowest rooting percentage was observed in the control treatment (47.58%). Higher rooting success in treated layers may be associated with enhanced auxin concentration at the rooting site, which stimulates root initiation and development. Yadav *et al.* (2020)^[14] reported that IBA application significantly improved rooting percentage and survival in litchi air layers. Similar observations were also recorded by Abbas *et al.* (2019)^[2], who found improved rooting efficiency with auxin treatments in litchi.

Survival percentage (%)

The maximum survival was recorded under T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 80.18%, followed by T₉ (IBA 3000 ppm + NAA 1000 ppm) with 78.34%. The minimum survival percentage was observed in control treatment (58.21%). Higher survival in treated layers may be due to the development of a vigorous root system that improves water absorption and nutrient uptake after detachment. The findings are supported by Souza *et al.* (2020)^[12], who reported better establishment and survival of auxin-treated air layers. Improved root development ultimately contributed to better plant establishment under nursery conditions.

Shoot length (cm)

Shoot growth was significantly affected by the application of growth regulators. The maximum shoot length at 90 DAT was recorded in T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 14.10 cm, followed by T₉ (IBA 3000 ppm + NAA 1000 ppm) with 13.61 cm. The minimum shoot length was observed in the control treatment (9.89 cm). The increased shoot growth under combined treatments may be attributed to better root development and improved nutrient absorption capacity. Meena *et al.* (2016) [7] reported that auxin application enhanced vegetative growth by improving rooting and plant vigour. Similar results were obtained by Abbas *et al.* (2016) [1], who observed improved shoot development in growth regulator-treated litchi air layers.

Number of newly emerged leaves

The number of newly emerged leaves was significantly influenced by different growth regulator treatments. The maximum number of leaves was recorded under T₁₁ (IBA 3500 ppm + NAA 1000 ppm) with 30.59 leaves, followed by T₉ (IBA 3000 ppm + NAA 1000 ppm) with 28.65 leaves. The minimum number of leaves was recorded in control treatment (6.00 leaves). Higher leaf production under treated conditions indicates better vegetative growth and physiological activity of plants. The improved leaf development may be associated with enhanced root growth and better nutrient uptake. Similar findings were reported by Mumtaz *et al.* (2022) [8], who observed increased vegetative growth parameters with auxin application in litchi propagation.

Table 1: Effect of Plant Growth Regulators on Rooting and Survival of Air Layering in Litchi (*Litchi chinensis*) cv. Purbi

Treatment	Days to Root Initiation	Root Length (cm)	Root Thickness (mm)	Shoot Length at 90 DAT	Rooting%	No. of Roots	New Emerged Leaves	Survival% (90 DAT)
T ₀ (Control)	41.74	5.86	2.12	9.89	47.58	6.86	6	58.21
T ₁ (IBA 2500 ppm)	31.4	7.89	3.84	11.28	63.49	17.57	19.06	65.59
T ₂ (IBA 3000 ppm)	30.03	8.51	4.18	11.71	71.09	19.17	19.28	67.8
T ₃ (IBA 3500 ppm)	30.79	7.1	4.56	12.02	75.59	22.71	20.04	71.63
T ₄ (NAA 800 ppm)	32.17	6.78	3.05	10.62	58.82	15.67	13.23	63.47
T ₅ (NAA 1000 ppm)	35.81	5.89	3.42	10.92	55.16	14.38	14.04	61.89
T ₆ (IBA 2500 + NAA 800 ppm)	30.45	9.29	4.88	12.21	78.49	23.17	21.2	72.38
T ₇ (IBA 2500 + NAA 1000 ppm)	28.78	10.09	5.16	12.65	81.09	24.75	21.07	73.44
T ₈ (IBA 3000 + NAA 800 ppm)	26.74	10.39	5.42	12.91	85.66	27.56	22.58	74.21
T ₉ (IBA 3000 + NAA 1000 ppm)	30.72	10.89	5.78	13.61	87.75	26.62	28.65	78.34
T ₁₀ (IBA 3500 + NAA 800 ppm)	25.94	9.77	5.36	13.03	85.08	25.4	26.55	74.26
T ₁₁ (IBA 3500 + NAA 1000 ppm)	24.86	11.1	5.61	14.1	88.92	28.4	30.59	80.18
F-Test	S	S	S	S	S	S	S	S
S.E.M (±)	0.26	0.89	0.12	0.06	0.16	0.15	0.14	0.09
C.D. at 5%	0.75	0.26	0.36	0.2	0.48	0.46	0.41	0.26
C.V	1.44	1.8	4.18	0.98	0.4	1.37	1.2	0.21

Conclusion

The present investigation clearly demonstrated that the application of growth regulators significantly influenced rooting, shoot growth and survival parameters in air layering of Litchi under the agro-climatic conditions of Prayagraj. Among all the treatments, the combined application of IBA and NAA proved more effective than their individual application and control. Treatment T₁₁ (IBA 3500 ppm + NAA 1000 ppm) showed superior performance with respect to early root initiation, maximum root length, root thickness, rooting percentage, number of roots per layering, shoot length, number of newly emerged leaves and survival percentage. The enhanced performance under combined treatments may be attributed to the synergistic effect of auxins, which stimulated physiological and biochemical activities responsible for better root and shoot development. Therefore, it may be concluded that the application of IBA 3500 ppm in combination with NAA 1000 ppm is highly effective and can be recommended for successful propagation of litchi through air layering under Prayagraj agro-climatic conditions.

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