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Impact of cutting size and IBA concentration on underexploited leafy vegetables of Assam

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Abstract

Underutilized leafy vegetables are essential for a balanced human diet, offering vital micronutrients, vitamins and minerals, but they lack national or global recognition due to limited commercial exploration. This research aimed to standardize production techniques and ensure the availability of planting material for commercial cultivation. The experiment focused on three lesser-known leafy vegetables of Assam: Masundari, Pirali paleng, and Xoru manimuni, using treatments of N1: 1 node, N2: 3 nodes, N3: 5 nodes cutting size, and H1: distilled water, H2: 25 ppm, H3: 50 ppm, H4: 75 ppm IBA concentration to assess growth performance in both nursery and main field conditions. The results indicated that 5-node cuttings treated with 75 ppm IBA, followed by 50 ppm, showed the best growth performance in terms of rooting, growth, and yield parameters with the highest benefit-cost ratio, making this treatment highly effective for large-scale propagation and commercial cultivation.

Key words: Growth, IBA, node cutting, Masundari, Pirali paleng, Xoru manimuni, underutilized

Introduction

The northeastern region of India is rich in subtropical flora and agrobiodiversity, where wild and semi-cultivated crops are abundant. These uncultivated plants hold ecological, social, and cultural importance, fulfilling the daily food and nutritional needs of rural communities. Indigenous populations in remote areas have traditionally relied on these species during periods of scarcity. Additionally, underutilized leafy vegetables contribute significantly to human socio-economic development and have applications in medicine and cultural rituals. They are rich in antioxidants, fiber, vitamins, and minerals (Verma *et al.*, 2023). Limited dietary diversity has led to malnutrition, making it challenging to obtain essential nutrients from regular diets (Banerjee, 2015). Therefore, there is increasing attention on the nutritional and therapeutic benefits of wild plants to diversify human diets (Anju, 2011).

Cultivating and consuming these crops can help overcome nutritional deficiencies and improve socio-economic conditions. Despite being labeled as “agricultural weeds” by policymakers, these lesser-known leafy vegetables are now recognized as essential sources of nutrients rather than mere survival food in developing nations. However, their underutilization is due to factors such as lack of standardized cultivation methods, inadequate propagation techniques, limited processing and value addition facilities, research constraints, insufficient policy support, and inadequate marketing and supply chain channels.

These leafy vegetables possess considerable potential to enhance food security and nutritional diversity in the region; however, their cultivation is frequently constrained by inadequate rooting and low survival rates resulting from suboptimal propagation techniques. This research seeks to establish standardized, cost-effective methods to enhance rooting success, plant vigor, and yield by systematically examining the impacts of various cutting sizes and IBA concentrations. This will enhance large-scale cultivation and conservation of indigenous species while also yielding economic advantages for smallholder farmers through increased crop availability and profitability. The study ultimately tackles agricultural sustainability and nutritional challenges, representing a crucial advancement in advocating for underutilized leafy vegetables as significant elements of Assam’s agro-biodiversity and food system.

The objective of this paper was to identify the optimal cutting size and IBA concentration to enhance rooting, growth, and yield performance of underutilized leafy vegetables in Assam, promoting their commercial cultivation and socio-economic benefits for small and marginal farmers.

Materials and methods

The study was conducted at the Experimental Farm of the Department of Horticulture, Assam Agricultural University, Jorhat, during 2021 and 2022. The experimental site, located at 26°45’ N latitude and 94°12’ E longitude at an elevation of 87 meters above mean sea level, featured uniform topography. The region experienced an annual rainfall of approximately 2300 mm, with average humidity ranging from 75% to 88%. The first experiment utilized a Factorial Randomized Block Design with three replications for each leafy crop. The factors included three node cuttings (N1: 1 node, N2: 3 nodes, N3: 5 nodes) and four IBA concentrations (H1: distilled water, H2: 25 ppm, H3: 50 ppm, H4: 75 ppm). Cuttings of the underutilized crops Masundari (*Houttuynia cordata*), Pirali paleng (*Talinum fruticosum*), and Xoru manimuni (*Hydrocotyle sibthorpioides*) were planted in trays (1 and 3 nodes) and poly sleeves (5 nodes) filled with a potting media mixture of sand and vermicompost (1:1) in November. The cuttings were lightly irrigated immediately after planting and watered daily. To ensure proper aeration, the rooting media was periodically loosened, and weeding was done as needed. Rooting parameters (rooting percentage, length of the longest root, root diameter, fresh weight, dry weight, root numbers, and days to new leaf emergence) were analyzed from five randomly selected cuttings in the nursery. Based on these analyses, four best and one poorest treatment combinations for each crop were selected. Rooted cuttings, 25-30 days old, from the respective treatment combinations were then planted in the main field plots (2.0 m x 1.8 m) to observe growth performance. The second experiment in the main field followed a Randomized Block Design with five treatments and four replications for each crop. During the growing stage, irrigation was applied twice daily, and manual weeding was performed. Harvesting occurred 60 days after transplanting, and various growth and yield parameters (survival percentage, plant height, plant spread, number of branches, leaf number, and yield) were recorded from five randomly selected plants. The experimental data obtained were statistically analysed by Fisher's Analysis of Variance (ANOVA) method.

Results and discussion

Nursery stage: The study aimed to assess the growth performance of underexploited leafy vegetables, and the results clearly showed that the concentration of IBA and cutting length had a significant impact on the regeneration and growth characteristics of the plant. The data presented in (Tables 1,2,3) indicated that treatment combinations N3H3 had the highest rooting percentage in Masundari (91.00%), Xoru manimuni (99.67%), and N3H4 had the highest rooting percentage in Pirali paleng (100.00%). The elevated percentage of rooting could be attributed to higher IBA concentrations and longer cuttings containing 3-5 nodes, which likely led to greater carbohydrate accumulation, ultimately enhancing the rooting ability and initial growth of seedlings (Tiwari *et al.*, 2022; Yesuf, 2021). Additionally, the use of IBA might have impacted the overall phenolic content and peroxidase activity, contributing to the rise in rooting percentage. These findings align with those of Kumar and Fatmi (2021), who reported similar enhancements in rooting with higher IBA

Table 1. Effect of size of cutting and IBA concentration on growth parameter of Masundari at nursery stage

Treatment	Rooting percent-age	Length of longest root(cm)	Root diameter (mm)	Fresh weight of roots (g)	Dry weight of roots (g)	Root number	Days to new leaf appear-ance
N_1H_1	71.33	4.17	0.14	0.16	0.06	7.67	22.13
N_1H_2	86.67	5.83	0.14	0.28	0.13	9.00	16.40
N_1H_3	88.33	7.67	0.15	0.66	0.33	10.00	15.67
N_1H_4	75.67	5.00	0.12	0.31	0.16	9.00	20.40
N_2H_1	76.67	5.50	0.13	0.34	0.27	15.67	18.27
N_2H_2	85.67	8.33	0.17	0.56	0.20	17.33	13.00
N_2H_3	87.00	11.50	0.17	0.92	0.16	24.67	12.20
N_2H_4	82.67	6.83	0.15	0.75	0.38	16.00	13.60
N_3H_1	82.00	9.50	0.13	1.32	0.19	20.00	16.40
N_3H_2	90.67	13.17	0.15	2.55	0.55	42.33	13.00
N_3H_3	91.00	16.33	0.17	2.86	0.72	45.00	10.00
N_3H_4	87.00	13.00	0.15	1.88	0.27	33.33	14.27
SEd(±)	2.67	0.76	0.04	0.30	0.15	2.40	0.61
CD (5%)	5.53	1.57	NS	NS	0.31	4.99	1.80

Table 2. Effect of size of cutting and IBA concentration on growth parameter of Pirali paleng nursery stage

Treatment	Rooting percent-age	Length of longest root(cm)	Root diameter (mm)	Fresh weight of roots (g)	Dry weight of roots (g)	Root Number	Days to new lea-fappear-ance
N_1H_1	91.00	5.50	0.30	0.12	0.01	5.00	21.00
N_1H_2	92.67	8.67	0.40	0.16	0.05	8.67	18.33
N_1H_3	88.33	9.00	0.33	0.21	0.17	10.00	17.67
N_1H_4	93.67	11.00	0.43	0.26	0.15	11.00	16.13
N_2H_1	92.33	7.00	0.33	0.10	0.05	8.33	17.93
N_2H_2	95.00	8.50	0.50	0.42	0.16	11.00	15.40
N_2H_3	98.67	9.67	0.50	0.48	0.13	12.33	14.93
N_2H_4	99.33	10.33	0.60	0.60	0.24	15.33	14.40
N_3H_1	95.00	8.50	0.43	0.84	0.18	12.33	17.47
N_3H_2	99.00	12.67	0.53	0.99	0.35	19.67	15.67
N_3H_3	100.00	14.00	0.63	1.07	0.37	25.33	12.67
N_3H_4	100.00	15.17	0.63	1.20	0.57	29.00	12.00
SEd(±)	2.80	0.77	0.09	0.17	0.07	2.39	0.39
CD (5%)	5.80	1.59	0.20	0.36	0.15	4.97	1.14

Table 3. Effect of size of cutting and IBA concentration on growth parameter of Xoru manimuni at nursery stage

Treatment	Rooting percentage	Length of lon-gest root (cm)	Root diameter (mm)	Fresh weight of roots (g)	Dry weight of roots (g)	Root Number	Days to new leaf appearance
N_1H_1	68.00	5.33	0.10	1.54	0.17	7.33	17.00
N_1H_2	91.67	7.33	0.13	1.38	0.06	10.33	12.67
N_1H_3	92.67	8.67	0.20	1.76	0.11	12.67	10.47
N_1H_4	81.00	5.00	0.10	1.68	0.02	9.00	14.00
N_2H_1	69.00	6.33	0.10	1.69	0.20	7.00	16.60
N_2H_2	92.33	7.00	0.17	2.22	0.67	10.33	9.20
N_2H_3	99.33	7.67	0.17	2.57	0.60	13.00	9.00
N_2H_4	86.67	8.00	0.17	1.90	0.44	9.67	10.93
N_3H_1	82.67	9.00	0.17	3.40	0.29	9.00	14.93
N_3H_2	98.33	12.00	0.17	3.97	0.82	9.33	10.07
N_3H_3	99.67	12.00	0.17	4.37	1.17	13.33	7.47
N_3H_4	93.00	10.67	0.20	3.87	0.50	14.33	10.13
SEd(±)	3.53	0.80	0.04	0.20	0.11	0.76	0.50
CD (5%)	7.33	1.67	NS	0.41	0.32	1.08	1.47

concentrations. However, current results differ from those of Patel *et al.* (2017) in fig and Braun and Wyse (2019) in hazelnuts which showed less rooting success with higher doses of IBA, suggesting species-specific responses to IBA. Maximum root lengths of 16.33 cm in Masundari and 12.00 cm in Xoru manimuni were recorded in N3H3. In Pirali paleng, the maximum root length of 15.17 cm was found in treatment N3H4. The interaction impact of cutting size and IBA concentrations on root diameter for Masundari and Xoru manimuni was found to be non-significant. Nonetheless, the highest values were found in N3H3 (0.17 mm) for Masundari and N3H4 (0.20 mm) for Xoru manimuni. In Pirali paleng, notable effects in root diameter (0.63 mm) were observed in N3H4. The growth in root length and root diameter could potentially be attributed to the application of auxin, which stimulates root elongation and facilitates the translocation of metabolites and metabolism of carbohydrates. Jan *et al.* (2015) also reported an increase in root length and diameter in olive with increasing IBA concentration, irrespective of the cutting type. The interaction impact on the fresh weight of Masundari was found to be insignificant. However, the treatment combination of N3H3 produced the highest value (2.86 g), while the lowest was in N1H1 (0.16 g). For Pirali paleng and Xoru manimuni, fresh weights of 1.20 g in N3H4 and 4.37 g in N3H3 were observed, respectively. The treatment N3H3 resulted in the highest dry weight of roots in Masundari (0.72 g) and Xoru manimuni (1.17 g), which was comparable to N3H2. In Pirali paleng, the highest dry weight of roots (0.57 g) was observed in N3H4. The higher fresh weight and dry weight observed might be the result of growth regulators influencing metabolic processes and enhancing carbohydrate levels. Ganjure *et al.* (2014) also observed the same effect with 1000 ppm IBA concentration in chrysanthemum. Similar results were also documented by Singh and Negi (2014) in *Tecoma stans*. However, the results differ from Hossain and Gony (2020), who showed maximum fresh and dry weight of roots at 200 ppm and 100 ppm, instead of 300 ppm IBA concentration in strawberry. In treatment N3H3, the highest root number (45.00) was observed, which was statistically similar to N3H2 (42.33) in *Masundari*. In Pirali paleng and Xoru manimuni, the highest root numbers were observed in N3H4 (29.00 and 14.33), respectively, followed by N3H3. The increased number of roots following auxin application is a common occurrence in various herbaceous perennial crops (Hartmann *et al.*, 2002). The initiation of early and increased root formation per cutting due to auxin application leads to the highest number of roots. This could also be due to the impact of IBA treatment on cell wall flexibility, which promotes cell division, stimulates callus development, and enhances root growth. Kaushik and Shukla (2020) reported similar results in marigold cuttings treated with a high concentration of 300 ppm IBA, which induced the maximum number of roots per plant. Similar findings were observed by Jan *et al.* (2015) in olive plants.The lowest number of days to new leaf appearance was observed for Masundari (10.00 days) and Xoru manimuni (7.47 days) in N3H3, and for Pirali paleng (12.00 days) in N3H4. Early leaf emergence may be attributed to the role of auxins, which are recognized for their ability to stimulate root regeneration through the enhancement of hydrolysis, mobilization, and utilization of stored carbohydrates (Siddiqua *et al.*, 2018). This is in accordance with the findings of Rajamanickam *et al.* (2021) and Gupta *et al.* (2024).

Main field: According to Tables 4,5,6, the treatment combination N3H3 showed the highest survival percentage for Masundari (98.25%) and Xoru manimuni (100%). For Pirali paleng, the highest survival percentage (98.75%) was found in treatment N3H4, which was statistically similar to N3H3. The high survival rates in the main field can be attributed to the abundant root and

Table 4. Effect of size of cutting and IBA concentration on growth parameter of Masundari in field conditions

Treatments	Survival after transplanting (%)	Height of the plant (cm)			Spread of the plant (cm)			Number of branches per plant			Leaf number		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
N_1H_1	88.75	4.50	9.00	14.00	7.75	10.13	14.75	1.00	1.75	3.00	3.50	12.50	18.50
N_2H_2	82.50	5.00	11.75	15.25	8.25	12.25	19.00	1.25	2.00	3.75	4.38	13.50	19.50
N_2H_3	95.50	5.88	12.88	17.88	10.00	13.00	21.00	1.50	2.50	4.00	5.25	16.25	28.25
N_3H_2	96.25	6.00	14.00	18.00	10.75	14.25	22.50	1.75	3.25	5.25	6.13	17.25	34.00
N_3H_3	98.25	6.50	16.50	19.50	11.00	18.25	24.25	2.00	4.25	6.25	7.00	17.50	39.50
SEd (±)	4.87	1.68	1.99	1.73	1.42	2.09	1.59	0.42	0.79	0.89	1.48	1.62	3.95
CD (5%)	10.60	NS	4.33	3.77	NS	4.55	3.45	NS	1.73	1.93	NS	3.54	8.61

Table 5: Effect of size of cutting and IBA concentration on growth parameter of Pirali paleng in field conditions

Treat-ments	Survival after transplanting (%)	Height of the plant (cm)			Spread of the plant (cm)			Number of branches per plant			Leaf number		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20DA T	40DA T	60 DAT	20 DAT	40 DAT	60 DAT
N_1H_1	83.75	10.25	17.00	21.00	17.75	28.75	43.75	1.25	3.00	9.00	40.50	114.00	230.75
N_2H_3	90.75	11.75	19.75	24.25	20.00	29.75	44.50	2.50	5.00	11.25	63.00	190.00	314.75
N_2H_4	95.00	12.50	22.25	29.25	23.00	33.25	48.25	3.25	5.25	12.50	75.25	199.50	370.75
N_3H_3	96.75	13.50	26.75	33.75	26.00	39.25	54.25	3.75	5.50	13.00	78.75	209.00	418.00
N_3H_4	98.75	16.00	28.38	37.63	27.00	43.00	58.00	4.00	6.75	14.75	93.50	256.50	467.75
SEd (±)	2.16	1.70	2.70	3.17	3.69	2.62	2.55	0.94	0.88	1.62	13.60	33.54	43.08
CD (5%)	4.70	NS	5.88	6.90	NS	5.71	5.56	NS	1.92	3.53	29.63	73.08	93.87

Table 6. Effect of size of cutting and IBA concentration on growth parameter of Xoru manimuni in field conditions

Treatments	Survival after transplanting (%)	Height of the plant (cm)			Spread of the plant (cm)			Number of branches per plant			Leaf number		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
N_1H_1	65.00	2.37	3.25	4.75	5.25	8.37	12.12	1.25	1.50	3.25	12.50	21.75	66.00
N_2H_2	70.00	2.75	5.25	7.25	5.75	9.25	12.87	1.75	1.75	4.50	15.00	25.50	67.75
N_2H_3	85.00	2.75	5.50	7.50	6.00	8.87	13.12	1.75	2.00	4.75	17.50	26.75	71.50
N_3H_2	95.00	4.25	7.25	9.25	10.00	13.00	17.12	2.00	2.25	5.00	20.00	28.50	77.50
N_3H_3	100.00	6.50	9.50	11.50	11.00	14.00	18.25	2.50	3.00	5.50	25.00	35.75	78.25
SEd (±)	6.19	0.82	1.29	1.34	2.17	1.93	1.97	0.52	0.52	0.629	4.95	3.05	2.66
CD (5%)	13.49	1.80	2.83	2.92	NS	4.20	4.30	NS	NS	1.37	NS	6.66	5.80

Table 7. Effect of size of cutting and IBA concentration on yield and economics of *Masundari*, Pirali paleng and Xoru manimuni

Treatments	*Masundari*				Pirali paleng				Xoru manimuni			
	Yield/plant (g)	Yield/plot (g)	Total yield (q/ha)	B:C	Yield/plant (g)	Yield/plot (g)	Total yield (q/ha)	B:C	Yield/plant (g)	Yield/plot (g)	Total yield (q/ha)	B:C
N_1H_1	22.25	445.00	12.36	0.42	139.25	2785.00	77.36	0.78	33.75	675.00	18.75	0.81
N_2H_2	28.25	565.00	15.69	0.69	262.50	5250.00	145.83	2.18	39.75	795.00	22.08	1.11
N_2H_3	35.25	705.00	19.58	1.11	327.50	6550.00	181.94	2.97	47.00	940.00	26.11	1.50
N_3H_2	50.50	1010.00	28.05	1.85	467.25	9345.00	259.58	4.29	49.25	985.00	27.36	1.58
N_3H_3	71.25	1425.00	39.58	3.03	502.00	10040.00	278.88	4.68	56.25	1125.00	31.25	1.94
SEd (±)	1.89	37.82	1.05		6.50	130.03	3.61		6.67	133.48	3.71	
CD (5%)	4.12	82.39	2.29		14.17	283.32	7.87		14.54	290.83	8.08	

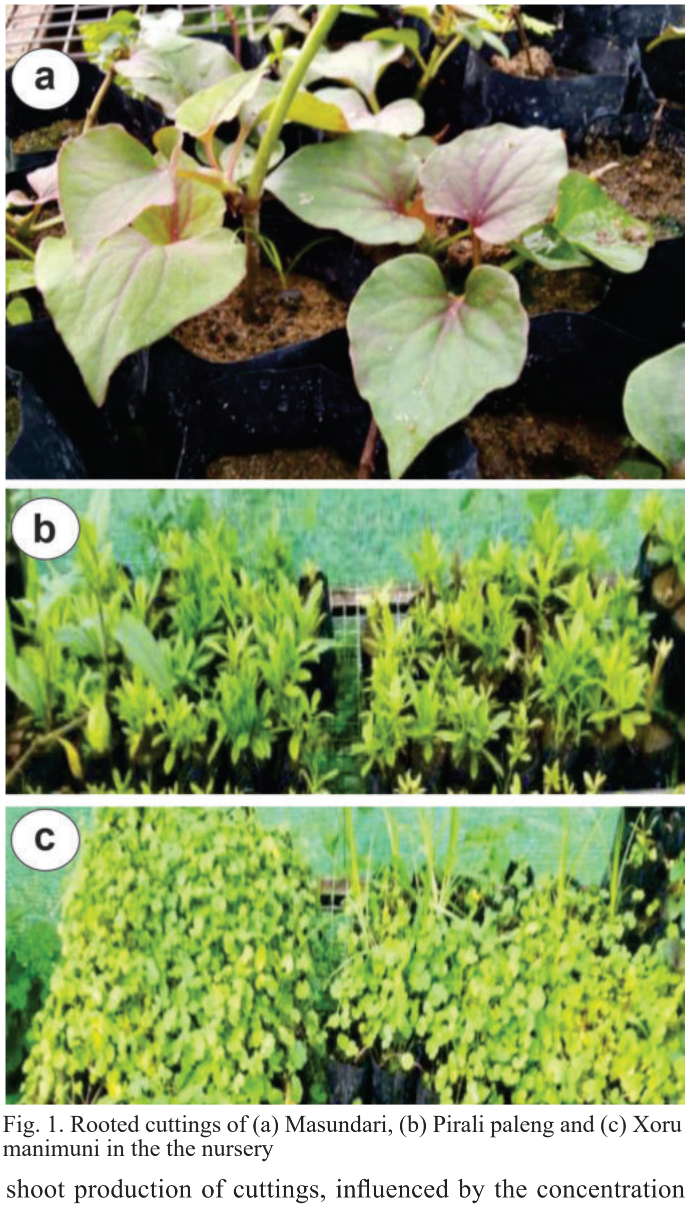

Fig. 1. Rooted cuttings of (a) Masundari, (b) Pirali paleng and (c) Xoru manimuni in the the nursery

shoot production of cuttings, influenced by the concentration of growth regulators. Similar results were observed in olive by Jan *et al.* (2015). The highest plant heights were recorded in Masundari (16.50 cm and 19.50 cm) and Xoru manimuni (9.50 cm and 11.50 cm) at 40 days after transplanting and 60 DAT (days after transplanting) in treatment combination N3H3. For Pirali paleng, the highest plant height (28.38 cm and 37.63 cm) was recorded in treatment N3H4, followed by N3H3. The rise in plant height as the IBA concentration increased could be attributed to the development of a greater number of roots, allowing the plants to absorb an ample amount of nutrients from the soil, ultimately reaching their maximum height (Khan *et al.,* 2020). Gjeloshi *et al.* (2013) similarly observed the tallest plant height at 3000 and 4000 ppm IBA, while noting the negative impact of higher concentrations (5000 and 6000 ppm) on plant height in kiwi cuttings. The greatest plant spread for Masundari (18.25 cm and 24.25 cm) and Xoru manimuni (14.00 cm and 18.25 cm) was exhibited in N3H3 at 40 DAT and 60 DAT, respectively. In Pirali paleng, the maximum plant spread of 43.00 cm and 58.00 cm was observed under treatment N3H4, followed by N3H3 at 40 DAT and 60 DAT. The production of leaves boosted the photosynthesis process, relative growth rate, and lateral branching growth of shoots, consequently enhancing plant spread (Malaviya *et al.*, 2022). Rehana (2019) observed the same effect in terminal cutting of crossandra for plant height and plant spread at a high concentration of 3000 ppm IBA.The highest number of branches and leaf numbers at 40 DAT and 60 DAT in Masundari (4.25, 6.25 branches and 17.50, 39.50 leaves) and Xoru manimuni (3.0, 5.5 branches and 35.75, 78.25 leaves) were recorded in treatment combination N3H3. In Pirali paleng, the highest branch numbers at 40 DAT (6.75) and 60 DAT (14.75) and leaf numbers (256.50 and 467.75) at 40 DAT and 60 DAT were observed in N3H4. The formation of a greater number of branches with the use of growth regulators could be attributed to the robust root system, which improved nutrient uptake under the influence of IBA application, affecting cell division in the vascular cambium, cell expansion, and differentiation control various cambial types, resulting in an increased number of branches (Padekar, 2018; Devi *et al.*, 2016). For the growth and development of leafy stem cuttings, leaves play a crucial role. Through photosynthesis and transpiration, leaves facilitate the movement of solutes, water, and hormones like auxin and cytokinin within the cutting, while also influencing temperature regulation. They provide essential carbohydrates, mineral nutrients, and hormones such as auxins (Tiwari *et al.*, 2022). The maximum number of leaves per cutting could be attributed to the activation of the maximum number of roots, facilitating improved nutrient uptake and water absorption. Devana *et al.* (2018) reported that a higher concentration of IBA (2000 ppm) resulted in the maximum number of leaves in 15-20 cm long mulberry cuttings. Comparable findings were reported by Samad (2022) in *P. pedicellatum*, a wild leafy vegetable. Jan *et al.* (2015) also found an increased number of branches and leaves in olive with increasing IBA concentration. The data presented in Table 7 indicated that the highest yield per plant (71.25 g and 56.25 g), highest per plot yield (1425.00 g and 1125.00 g), and yield per hectare (39.58 q/ha and 31.25 q/ha) in Masundari and Xoru manimuni were recorded in treatment N3H3.

In Pirali paleng, the highest yield per plant (502.00 g), highest per plot yield (10040.00 g), and yield per hectare (278.88 q/ha) were found in treatment N3H4. These results align closely with the findings of Rehana (2019), who reported the highest flower yield of crossandra at high concentrations of IBA. The highest benefit-cost ratio in Masundari (3.03), Pirali paleng (4.68), and Xoru manimuni (1.94) was recorded in N3H3, N3H4, and N3H3, respectively. This might be due to the increased number of leaves and plant spread resulting in higher fresh biomass, ultimately increasing the yield per plant, per plot, and per hectare area.

Based on the study, it can be concluded that the treatment combinations N3H4 (5 nodes + 75 ppm IBA) and N3H3 (5 nodes + 50 ppm IBA) produced the most favorable outcomes for rooting, growth, and yield of underexploited leafy vegetables in Assam. The findings suggest that using 5 node cuttings with IBA concentrations can effectively facilitate mass propagation and support the commercial cultivation of these nutritionally valuable crops.

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