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Influence of growth regulators and length of cuttings on the propagation potential of *Piper pedicellatum* C. DC. –A threatened wild leafy vegetable of North-East India

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Abstract

Piper pedicellatum C. DC. is a wild leafy vegetable belonging to the family Piperaceae and is categorized as threatened species. It is one of the widely used popular leafy vegetable plants in Arunachal Pradesh, Manipur and Sikkim, locally known as *Rahre*, *Raro* or *Rori*. The species is rich in vitamin A, Vitamin C, minerals, dietary fibre, antioxidants, protein, and energy and is also used as an ethnomedicinal plant. An experiment was conducted to study the effect of growth regulators IBA and IAA and length of stem cuttings on the propagation potential of *P. pedicellatum* C. DC in the Forestry Nursery of North Eastern Regional Institute of Science and Technology during the years 2018 and 2019. The experiment revealed that the performance of stem cuttings, *viz.*, time taken for first sprouting, maximum sprout per cutting, length of sprouted shoot, number of leaves per cutting, and maximum fresh weight of shoot, are found better in the treatment of T_4 (L_1 + IBA 1500 ppm), T_7 (L_1 + IAA 1500 ppm), T_{11} (L_2 + IBA 1500 ppm) and T_{14} (L_2 + IAA 1500 ppm) respectively. Similarly, the maximum number of roots per cutting, root length, fresh and dry weight of roots were also recorded in the treatment of T_4 (L_2 + IAA 1500 ppm) at par with T_{11} (L_1 + IBA 1500 ppm) during both the year. The mean maximum survival rate of cuttings with a higher percentage of rooting was observed in T_{11}, which is at par with T_7, T_{14}, and T_4. Although L_2 cuttings showed better performance than L_1 cuttings the difference was not so prominent. Stem cuttings, irrespective of their length, treated with IBA 1500 ppm and IAA 1500 ppm showed significantly superior performance over those treated with lower concentrations of IBA and IAA. The outcome of the present study indicated that the *P. pedicellatum* can be exploited for conservation, domestication, and cultivation through the vegetative propagation technique, with standardization of its production technology for the adoption of commercial cultivation of the threatened species.

Keywords: Growth regulator, *Piper pedicellatum,* propagation, *Rahre,* stem cutting, underutilized, wild leafy vegetable.

Introduction

Wild vegetable plants are an important source of nutrients, vitamins, and minerals for ethnic communities in and around forests everywhere (Jeyaprakash *et al.*, 2017). Leafy vegetables serve as indispensable constituents of the human diet supplying the body with protein, vitamins, minerals, antioxidants, and certain hormone precursors in addition to dietary fibers and energy, thus, helping in immunity-boosting, providing nutritional security, and combating malnutrition. Underutilized vegetables refer to edible plant species which are not cultivated at a large scale commercially (Khan and Kakde, 2014). They are naturally grown on wastelands, forests, fields, homestead gardens, *etc.*, and collected from their natural habitat. Underutilized vegetables have immense potential to contribute to a particular pocket of food production because they are well-adapted to existing and adverse environmental conditions and are generally resistant to pests and diseases (Pandey *et al.*, 2014). Indigenous vegetables are valuable for diversifying production systems, which may lead to higher incomes for farmers.

North-East India is bountiful in the diversity of wild edible plants, particularly the vegetables. Propagation and cultivation techniques of underutilized vegetable plants are urgently needed to reduce the pressure of erosion threats to these resources (Singh *et al.*, 2012). *P. pedicellatum* C. DC. is an indigenous wild leafy vegetable plant (Fig. 1) that belongs to the family Piperaceae and is locally known by various names like *Rahre*, *Rohri,* or *Raro* among the different tribal communities of Arunachal Pradesh. In India, the species is found in moist tropical and sub-tropical forests in the state of Arunachal Pradesh, Manipur, and Sikkim. It is one of the most important edible wild leafy vegetables widely used by the tribal people of Arunachal Pradesh and also used as ethnomedicine. Leaves and tender shoots of *Rahre* are used as vegetables by the tribal people of Arunachal Pradesh, Manipur, and Sikkim (Chanchal *et al.*, 2015). The species is an erect shade-loving shrub that thrives best under conditions with cool shade, considerable humidity, and a good supply of soil moisture with adequate uniformly distributed rainfall. It is widely distributed in India's eastern Himalayan region without agronomic care (Kalita *et al.*, 2014). This species has been categorized as threatened by the IUCN due to loss of habitat and unsustainable collection of multiple parts from the forests and wild sources and the plant is globally significant under Conservation Assessment and Management Priorities (Puni *et al.*, 2011; Ved *et al.*, 2015;).

So far, despite its tremendous importance, little research has been done on developing this plant's mass propagation and cultivation technique (Muthu and Rimo, 2018). Studies should be done to assess the cultivable potential of wild leafy vegetables and to develop propagation and agro-techniques to bring more potential wild species under domestication for sustainable utilization of natural resources (Konsam *et al.*, 2016). Among the leafy vegetable, many species show potential for vegetative propagation. The easiest and most successful propagation method of Piper species is through stem cuttings, as the stem nodes can produce new roots and shoots (Panda *et al.*, 2018). As *P. pedicellatum* is one of the highly demanded and heavily extracted wild vegetables in one hand and already included in a threatened category on the other, the cultivation and management of the species is highly deserved. In this context, the present experiment was conducted to find the best propagation techniques using the stem cuttings and application of hormones

Fig. 1. a. *P. pedicellatum* plant, b. Bundle of leaves sold as a leafy vegetable in the markets

Materials and methods

The study was conducted at Forestry Nursery of North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh ($27^0 7^/ 38^{//}$ N and $93^0 44^/ 19^{//}$ E at an altitude of 112 m) from September to December consecutively during 2018 and 2019. The average monthly maximum temperature range was 32^0 C (September) to 26.9^0 C (December), whereas the minimum monthly mean temperature ranged from 23.9^0 C (September) to 12^0 C (December) during the experiment period. The highest monthly mean rainfall was recorded from 470.7 mm (September) to the lowest 18.8 mm (December), and the relative humidity ranged from 86% (September) to 73.8% (December) during the experimental period. The soil texture of the experimental plot was sandy, well-drained with pH 5.9 and organic carbon 0.07%.

The experiment was laid out in Factorial Randomized Block Design (RBD) with three replications consisting of 14 treatments involving two levels of factor A [L_1 stems cutting (5-10 cm) with two nodes and L_2 stem cuttings (15 - 20 cm) with 3-4 nodes] as well as seven levels of Factor B [Indole Butyric Acid (IBA) and Indole-3 Acetic Acid (IAA) each at 500, 1000 and 1500 ppm and distilled water as control]. The treatment combinations: T_1=L_1+ distilled water (control), T_2=L_1 + IBA 500 ppm, T_3= L_1+ IBA 1000 ppm, T_4= L_1 + IBA 1500 ppm, T_5= L_1+ IAA 500 ppm, T_6= L_1 + IAA 1000 ppm, T_7=L_1 + IAA 1500 ppm, T_8=L_2+ Distilled water (control), T_9= L_2 + IBA 500 ppm, T_{10}= L_2+ IBA 1000 ppm, T_{11}= L_2 + IBA 1500 ppm, T_{12}= L_2+ IAA 500 ppm, T_{13}= L_2 + IAA 1000 ppm and T_{14}=L_2+IAA 1500 ppm. Planting materials of *P. pedicellatum* were collected from the natural habitat of Papum Pare district in Arunachal Pradesh.

Stem cuttings were prepared from pencil-thickness tender apical shoots maintaining proper polarity. The basal portions of the stem cuttings were treated with IBA and IAA solutions by the quick dip method. A total 672 number of treated cuttings were planted, with 16 numbers per nursery bed of 1 x 1 m size in partially shaded areas. Cuttings were watered twice a week throughout the experimental period. Observations were recorded for the various shoot and root parameters of the stem cuttings and data obtained from the experiments were statistically analyzed by Fisher's Analysis of Variance (ANOVA) method.

Results and discussion

The experiment conducted to determine the growth performances of the vegetable species clearly indicated that the concentration of the IAA and IBA and the cutting length significantly affected the species' regeneration. These effects were clearly observed in sprouting, leaf formation, rooting, dry and fresh weigh of shoots, *etc.*

Effects on shoots: Data presented in Table 1 shows a significant effect among the different treatments in days taken to first sprout in cuttings. Minimum days to first sprout were observed in T_4 and T_{14} at par with T_2 and T_5, while the maximum time taken to first sprout was noticed in T_8. L_1 cuttings sprouted slightly earlier than L_2 cuttings, while the mean 12.25 DAP was taken for sprouting in G_6 over the G_0 (15.83 DAP). Sprouting of the cuttings indicates the initiation of rooting. This might be because auxins induce stimulus for the regeneration of roots.

The mean maximum number of sprouts (2.17) was also found in T_{14} against the mean minimum sprouts produced in T_8 (Table 1). Significant effects were also observed among the growth regulators. The mean maximum number of sprouts (2.11) was recorded in G_6 over the control G_0 (1.20). This might be due to the more physiological activities influenced by the growth regulators in cuttings due to early rooting and sprouting. The mean maximum length of the sprouted shoot resulted in T_4 (7.17 cm) at par with T_{11} (7.14 cm), while the mean minimum length was observed in T_1 (3.88 cm). The mean maximum length of the shoot was recorded in G_3 (7.16 cm) against the mean minimum length of the shoot under control G_0 (4.50 cm) (Table 1)

The maximum number of leaves per cutting was recorded in T_{14} followed by T_{11} (Table 2). This might be due to the initiation of the maximum number of roots and leaves, which help in better nutrition and water absorption in T_{14} and T_{11}. The mean highest fresh and dry weight of shoots per cutting was recorded in G_6, whereas the lowest result was observed under G_0 (control). The highest fresh weight of the shoot was found in T_{14}, which was *at par* with T_{11} and T_7, followed by T_4.

Effects on rooting: Significant effect was also observed among different treatments of growth regulators for root parameters of *Rahre* stem cuttings. The maximum number of roots per cutting (>18) was observed in the treatment T_{14} which was at par with T_{11} (>17)) (Table 3). Moreover, the maximum length of the root was also recorded in T_{14} and G_6 (>10 cm). The rooting performance was also significantly higher in T_{14} and G_6, with a mean value >71%, along with T_7 and T_{11}. The highest fresh mean weight was also found in T_{14} (1.13 g) and G_6 (1.12 g).

It has been established that the higher hormone concentration has

Table 1. Effect of growth regulators and cutting length on days taken to first sprout, numberof sprouts per cutting and length of sprouted shoot of *Piper pedicellatum* cuttings

Treatments	Days taken to first sprout (DAP)			Number of sprouts per cutting			Length of sprouted shoot (cm)			Number of leaves		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Factor A (Length of cuttings)												
L_1 (5 - 10 cm)	12.47	13.15	12.81	1.43	1.67	1.55	5.69	5.80	5.75	2.41	2.47	2.44
L_2 (15 - 20 cm)	13.85	14.05	13.95	1.49	1.73	1.61	6.00	6.22	6.11	2.33	2.53	2.43
CD (0.05)	0.99*	0.95*	-	0.21*	0.21*	-	0.45*	0.36*	-	0.27*	0.25*	-
Factor B (Growth regulators)												
G_0 (Control)	15.33	15.83	15.58	1.14	1.25	1.20	4.56	4.43	4.50	1.66	1.84	1.75
G_1 (IBA 500 ppm)	13.00	13.50	13.25	1.38	1.56	1.47	5.70	5.90	5.80	2.56	2.49	2.53
G_2 (IBA 1000 ppm)	12.83	12.83	12.83	1.56	1.72	1.64	6.20	6.34	6.27	2.55	2.60	2.58
G_3 (IBA 1500 ppm)	12.00	14.17	13.09	1.83	2.00	1.92	7.20	7.11	7.16	2.83	3.00	2.92
G_4 (IAA 500 ppm)	13.33	13.33	13.33	1.17	1.67	1.42	5.40	5.73	5.57	2.11	2.22	2.17
G_5 (IAA 1000 ppm)	13.17	13.50	13.34	1.33	1.62	1.48	5.45	5.60	5.53	2.06	2.23	2.15
G_6 (IAA 1500 ppm)	12.50	12.00	12.25	1.84	2.11	1.98	6.38	6.92	6.65	2.84	3.17	3.01
CD (0.05)	1.84*	1.79*	-	0.39*	0.40*	-	0.85*	0.67*	-	0.49*	0.47*	-
Treatments (A x B)												
T_1 (L_1 + Control)	14.00	15.33	14.67	1.18	1.29	1.24	3.83	3.93	3.88	1.78	1.89	1.84
T_2 (L_1 + IBA 500 ppm)	11.67	13.33	12.50	1.44	1.56	1.50	5.31	5.62	5.47	2.56	2.44	2.50
T_3 (L_1 + IBA 1000 ppm)	12.67	12.67	12.67	1.55	1.67	1.61	6.58	6.45	6.52	2.66	2.55	2.61
T_4 (L_1 + IBA 1500 ppm)	11.33	13.67	12.50	1.89	1.89	1.89	7.31	7.02	7.17	2.78	2.89	2.84
T_5 (L_1 + IAA 500 ppm)	12.67	12.33	12.50	1.11	1.78	1.45	5.06	5.40	5.23	2.11	2.22	2.17
T_6 (L_1 + IAA 1000 ppm)	12.33	12.33	12.33	1.33	1.56	1.45	5.08	5.32	5.20	2.11	2.33	2.22
T_7 (L_1 + IAA 1500 ppm)	12.67	12.33	12.50	1.55	2.00	1.78	6.61	6.81	6.71	2.89	3.00	2.95
T_8 (L_2 + Control)	16.67	16.33	16.50	1.11	1.22	1.17	5.28	4.94	5.11	1.56	1.78	1.67
T_9 (L_2 + IBA 500 ppm)	14.33	13.67	14.00	1.33	1.56	1.45	6.08	6.17	6.13	2.55	2.55	2.55
T_{10} (L_2+ IBA 1000 ppm)	13.00	13.00	13.00	1.56	1.78	1.67	5.83	6.22	6.03	2.44	2.66	2.55
T_{11} (L_2 + IBA 1500 ppm)	12.67	14.67	13.67	1.78	2.11	1.95	7.08	7.20	7.14	2.89	3.11	3.00
T_{12} (L_2 + IAA 500 ppm)	14.00	14.33	14.17	1.22	1.55	1.39	5.75	6.06	5.91	2.11	2.22	2.17
T_{13} (L_2 + IAA 1000 ppm)	14.00	14.67	14.34	1.33	1.67	1.50	5.83	5.89	5.86	2.00	2.11	2.06
T_{14} (L_2 + IAA 1500 ppm)	12.33	11.67	12.00	2.11	2.22	2.17	6.14	7.03	6.59	2.78	3.34	3.06
S Em$\pm$	0.29	0.28	-	0.06	0.06	-	0.17	0.16	-	0.09	0.09	-
CD (0.05)	2.60*	2.54*	-	0.55*	0.56*	-	1.18*	0.95*	-	0.70*	0.67*	-

* Significant at P=0.05, DAP = Days after planting, ppm= Parts per million

Fig. 2. Shooting and rooting performance of *P. pedicellatum* cuttings under different treatments

Table 2. Effect of growth regulators and cutting length on fresh and dry weight of shoots, number of roots per cutting and length of longest root of *Piper pedicellatum* cuttings

Treatments	Fresh weight of shoot (g)			Dry weight of shoot (g)			Number of roots per cutting			Length of longest root (cm)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Factor A (Length of cuttings)												
L_1 (5 - 10 cm)	0.75	0.75	0.75	0.17	0.19	0.18	13.53	13.77	13.65	6.95	7.27	7.11
L_2 (15 - 20 cm)	0.89	0.93	0.91	0.21	0.23	0.22	13.19	13.67	13.43	8.33	8.53	8.43
CD (0.05)	0.09*	0.09*	-	0.02*	0.02*	-	0.73*	0.68*	-	0.50*	0.45*	-
Factor B (Growth regulators)												
G_0 (Control)	0.41	0.41	0.41	0.09	0.10	0.10	6.50	6.83	6.67	4.47	4.62	4.55
G_1 (IBA 500 ppm)	0.76	0.78	0.77	0.17	0.18	0.18	11.33	12.00	11.67	6.35	6.67	6.51
G_2 (IBA 1000 ppm)	0.99	0.98	0.99	0.24	0.24	0.24	15.83	15.83	15.83	7.08	8.77	7.93
G_3 (IBA 1500 ppm)	1.07	1.11	1.09	0.27	0.27	0.27	17.00	17.00	17.00	9.02	9.53	9.28
G_4 (IAA 500 ppm)	0.66	0.67	0.67	0.16	0.18	0.17	12.50	13.00	12.75	9.00	8.98	8.99
G_5 (IAA 1000 ppm)	0.78	0.80	0.79	0.16	0.18	0.17	12.67	13.00	12.84	5.95	6.60	6.28
G_6 (IAA 1500 ppm)	1.05	1.60	1.33	0.25	0.30	0.28	17.67	18.33	18.00	9.63	10.17	9.90
CD (0.05)	0.16*	0.15*	-	0.05*	0.04*	-	1.37*	1.28*	-	0.94*	0.83*	-
Treatments (A x B)												
T_1 (L_1 + Control)	0.37	0.39	0.38	0.08	0.09	0.09	5.67	6.33	6.00	3.43	3.90	3.67
T_2 (L_1 + IBA 500 ppm)	0.65	0.69	0.67	0.15	0.16	0.16	10.33	10.67	10.50	6.37	6.50	6.44
T_3 (L_1 + IBA 1000 ppm)	1.01	0.97	0.99	0.24	0.23	0.24	16.00	15.67	15.84	9.17	8.33	8.75
T_4 (L_1 + IBA 1500 ppm)	1.07	1.06	1.07	0.27	0.26	0.27	16.67	16.33	16.50	8.37	9.03	8.70
T_5 (L_1 + IAA 500 ppm)	0.49	0.50	0.50	0.13	0.15	0.14	14.33	14.67	14.50	8.33	8.45	8.39
T_6 (L_1 + IAA 1000 ppm)	0.57	0.58	0.58	0.13	0.14	0.14	15.00	15.33	15.17	4.57	5.07	4.82
T_7 (L_1 + IAA 1500 ppm)	1.08	1.11	1.10	0.25	0.29	0.27	16.67	17.33	17.00	8.43	9.13	8.78
T_8 (L_2 + Control)	0.45	0.44	0.45	0.11	0.11	0.11	7.33	7.33	7.33	5.50	5.33	5.42
T_9 (L_2 + IBA 500 ppm)	0.86	0.87	0.87	0.19	0.20	0.20	12.33	13.33	12.83	6.33	6.83	6.58
T_{10} (L_2+ IBA 1000 ppm)	0.97	0.99	0.98	0.24	0.25	0.25	15.67	16.00	15.84	9.00	8.70	8.85
T_{11} (L_2 + IBA 1500 ppm)	1.07	1.16	1.12	0.26	0.28	0.27	17.33	17.67	17.50	9.67	10.03	9.85
T_{12} (L_2 + IAA 500 ppm)	0.83	0.84	0.84	0.19	0.21	0.20	10.67	11.33	11.00	9.67	9.50	9.59
T_{13} (L_2 + IAA 1000 ppm)	0.99	1.02	1.01	0.20	0.22	0.21	10.33	10.67	10.50	7.33	8.13	7.73
T_{14} (L_2 + IAA 1500 ppm)	1.03	1.21	1.12	0.25	0.31	0.28	18.67	19.33	19.00	10.83	11.20	11.02
S Em$\pm$	0.04	0.04	-	0.01	0.01	-	0.61	0.6	-	0.34	0.33	-
CD (0.05)	0.23*	0.22*	-	0.07*	0.05*	-	1.95*	1.82*	-	1.33*	1.18*	-

* Significant at P=0.05

significant effects in longer cutting (L_2) in rooting. This might be due to the influence of growth regulators on metabolic activities and increased carbohydrates. Similar findings were also reported by Patel *et al.* (2017) in fig, Panda *et al.* (2018) in *Piper* species, and Hossain and Gony (2020) in strawberry, and Singh and Chahal (2021) in citrus rootstock.

The survival rate of cuttings (%): The highest survival rate was recorded in T_{11}, followed by T_7 and T_4, while the lowest survival percentage was observed in T_1 (Table 4). The mean highest survival rate also resulted in T_7 and T_{11} (71.88 %) coupled with the mean maximum survival rate in G_6 (70.28 %), the lowest results were observed in T_1 and G_0, respectively. However, no prominent difference in the survival rate of cuttings was noticed between L_1 and L_2 cuttings. The results conform with Pandey *et al.* (2011) in stem cuttings of *Ginkgo biloba*. Panda *et al.* (2018) also reported a similar survival rate in *P. haridasanii* stem cuttings. The increase in survival percentage of the stem cuttings in T_{11}, T_7, and T_4 might be due to profuse root and shoot production of cuttings as influenced by the growth regulator's concentration.

It was observed that among the different treatments with IBA and IAA, the maximum concentration of both the hormone *i.e.*, IBA 1500 ppm and IAA 1500 ppm showed comparatively better results in both the lengths cutting *i.e.*, L_1 (5-10 cm) and L_2 (15-

Table 3. Effect of growth regulators and cutting length on rooting perfornmance, fresh and dry weight of roots and the survival rate of *Piper pedicellatum* stem cuttings

Treatments	Rooting performance (%)			Fresh weight of roots (g)			Dry weight of roots (g)			Survival Rate (%)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Factor A (Length of cuttings)												
L_1 (5 - 10 cm)	56.11	59.39	57.75	0.67	0.69	0.68	0.22	0.23	0.23	54.14	56.81	55.48
L_2 (15 - 20 cm)	55.18	58.41	56.80	0.69	0.71	0.70	0.27	0.29	0.28	51.77	55.33	53.55
CD (0.05)	5.07*	4.55*	-	0.03*	0.03*	-	0.03*	0.03*	-	3.62*	2.98*	-
Factor B (Growth regulators)												
G_0 (Control)	37.92	41.00	39.46	0.24	0.24	0.24	0.08	0.08	0.08	37.50	39.55	38.53
G_1 (IBA 500 ppm)	52.30	54.38	53.34	0.42	0.43	0.43	0.18	0.20	0.19	50.95	53.05	52.00
G_2 (IBA 1000 ppm)	56.20	58.42	57.31	0.77	0.77	0.77	0.29	0.30	0.30	54.17	56.25	55.21
G_3 (IBA 1500 ppm)	71.88	72.92	72.40	1.10	1.11	1.11	0.38	0.38	0.38	68.70	71.88	70.29
G_4 (IAA 500 ppm)	50.25	53.33	51.79	0.74	0.76	0.75	0.28	0.30	0.29	44.80	45.83	45.32
G_5 (IAA 1000 ppm)	49.08	58.25	53.67	0.41	0.44	0.43	0.14	0.17	0.16	45.83	54.08	49.96
G_6 (IAA 1500 ppm)	71.83	73.95	72.89	1.08	1.12	1.10	0.37	0.40	0.39	68.67	71.88	70.28
CD (0.05)	9.50*	8.52*	-	0.07*	0.07*	-	0.08*	0.07*	-	6.78*	5.55*	-
Treatments (A x B)												
T_1 (L_1 + Control)	34.00	38.17	36.09	0.23	0.25	0.24	0.06	0.07	0.07	35.42	37.42	36.42
T_2 (L_1 + IBA 500 ppm)	60.42	62.50	61.46	0.35	0.37	0.36	0.11	0.12	0.12	58.17	60.25	59.21
T_3 (L_1 + IBA 1000 ppm)	64.33	66.67	65.50	0.82	0.80	0.81	0.31	0.29	0.30	62.50	64.58	63.54
T_4 (L_1 + IBA 1500 ppm)	70.83	72.92	71.88	1.06	1.05	1.06	0.33	0.31	0.32	66.58	70.83	68.71
T_5 (L_1 + IAA 500 ppm)	44.25	48.33	46.29	0.75	0.77	0.76	0.29	0.30	0.30	41.67	43.75	42.71
T_6 (L_1 + IAA 1000 ppm)	46.08	52.08	49.08	0.46	0.48	0.47	0.14	0.17	0.16	43.75	47.92	45.84
T_7 (L_1 + IAA 1500 ppm)	72.92	75.00	73.96	1.05	1.09	1.07	0.31	0.33	0.32	70.83	72.92	71.88
T_8 (L_2 + Control)	41.83	43.83	42.83	0.25	0.24	0.25	0.09	0.09	0.09	39.58	41.67	40.63
T_9 (L_2 + IBA 500 ppm)	44.17	46.25	45.21	0.49	0.50	0.50	0.26	0.27	0.27	43.75	45.83	44.79
T_{10} (L_2+ IBA 1000 ppm)	48.08	50.17	49.13	0.73	0.74	0.74	0.27	0.30	0.29	45.83	47.92	46.88
T_{11} (L_2 + IBA 1500 ppm)	72.92	72.92	72.92	1.13	1.17	1.15	0.42	0.44	0.43	70.83	72.92	71.88
T_{12} (L_2 + IAA 500 ppm)	56.25	58.33	57.29	0.73	0.75	0.74	0.28	0.30	0.29	47.92	47.92	47.92
T_{13} (L_2 + IAA 1000 ppm)	52.08	64.42	58.25	0.36	0.40	0.38	0.13	0.16	0.15	47.92	60.25	54.09
T_{14} (L_2 + IAA 1500 ppm)	70.25	72.92	71.59	1.11	1.15	1.13	0.43	0.47	0.45	66.50	70.83	68.67
S Em$\pm$	2.23	2.16	-	0.05	0.05	-	0.02	0.02	-	2.02	2.07	-
CD (0.05)	13.42*	12.06*	-	0.09*	0.09*	-	0.10*	0.09*	-	9.57*	7.85*	-

* Significant at P=0.05

20 cm). Although the longer length of the stems with 3-4 nodes (L_2) performed better than the shorter length with two nodes, no significant difference of rooting and shooting effect was observed between the lengths of stem cuttings. However, the longer stem cuttings normally have a better success rate as it contains more nodes, increasing the area for rooting and shooting.

The outcome of the present investigation suggested that the vegetative propagation of *P. pedicellatum* by stem cuttings was promising and could be utilized for mass propagation, domestication and cultivation of this potential horticultural crop. However, production technology should be standardized for domestication and adoption of commercial cultivation of the threatened leafy vegetable plant. As the species is shade-loving and profusely grow as understory shrubs, it can be the best component of tropical and subtropical climate agroforestry systems in the country's northeastern region. Moreover, it could also be one of the best NTFP for forest management planning and activities.

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