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Effects of Different Root Inducing Agents on Cutting Propagation of Tea (*Camellia sinensis*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: In commercial cultivations, vegetative propagation through rooting of cuttings is common, and IBA- based rooting hormone is often used. However, due to the need for non-chemical alternatives in organic cultivations, organic rooting substances have become increasingly important. Hence considering this, an experiment was conducted to investigate the effectiveness of different root-inducing agents on the propagation of tea cuttings.
Study Design: The experimental units were arranged in a completely randomized design.
Place and Duration of Study: The experiment was conducted in a special project nursery belonging to TSHDA (Tea Small Holding Development Authority) in Beralapanathara GN division of Pasgoda divisional secretariat in Matara, Sri Lanka.
Methodology: The nodal cuttings were pre-treated with six different root-inducing agents including water (control), *Aloe vera* gel, coconut water, honey charcoal mixture, potato juice and rooting

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hormone (0.3% IBA). Each treatment was replicated four times with 20 cuttings in each. Cuttings' survival percentage, rooting percentage, the number of roots, root length and fresh and dry weights of the roots were evaluated during three phases as 2nd, 4th and 6th week. The data were statistically analyzed using SAS statistical package and treatment means were compared using DMRT at 5% significance level.

Results: The results revealed that there were significant differences between the treatments on cutting performances. The cuttings treated with rooting hormone showed the highest values in rooting percentage (55.8%), sprouting percentage (72.3%), during the 4th week and root length (2.1cm) and root dry weight (0.254g) during the 6th week. Moreover, coconut water and *Aloe vera* gel showed no significant higher values in most of the measured variables compared to the rooting hormone.

Conclusion: Therefore, it can be concluded that coconut water and *Aloe vera* gel can be considered alternative rooting substances to the chemical-based rooting hormone for organic tea cultivations.

Keywords: Aloe vera gel; Camellia sinensis; IBA; Propagation.

1. INTRODUCTION

The tea plant (*Camellia sinensis* (L.) O. Kuntze), is a woody-perennial plant of which the tender shoots are used to make the end product. Tea is a popular healthy beverage worldwide and ranks next to water. Asian countries, mainly China, India and Sri Lanka generate more than half of the world's tea production. It is an important revenue source for tea- producing countries both in terms of earning foreign exchange and generating employment in the community [1].

Nurseries are the beginning of a planned plant production program and are needed to raise healthy, vigorous and uniform plants suitable for field planting. This can only be achieved by proper nursery operations. In a nursery, the time spent by the plant is money spent on maintenance. Reducing time will lower the cost of production. If nursery plants are healthy and vigorous, they will succeed in the field and reach the production stage earlier. These twin objectives will be served if procedures are evolved to obtain good quality uniformly grown plants in the shortest possible time [2].

Conventionally, propagation of shoots is obtained from mother bushes and, about 250 mother bushes are needed to obtain cuttings to plant a hectare [2]. Therefore, nurserymen face difficulties in obtaining cuttings for raising plants. Furthermore, growers find it difficult to transport large number of plants to fields manually as bagged plants are bulky and heavy and require vehicles. There is another unacceptable practice some growers adopt and that is: obtaining their cuttings from New Clearings, bushes rested from plucking, 'Tipping' fields, etc. Such methods would only give poor cuttings and thereafter poor quality plants which in turn would result in poor Re-Planted Clearings [3].

There are some findings on rooting of cuttings using *Aloe vera* gel, coconut and king coconut water, honey and charcoal mixture, Apple cider, vinegar, potato juice and cinnamon powder but there are very less number of scientific researchers to found the effectiveness of these rooting agents for tea cuttings. Most researchers compare different natural hormones on the vegetative propagation of different plants only. But specially do not base on tea cuttings. The research is to select the most effective naturally available which gives rapid and high-quality root formation of cutting nodes of tea in the tea nursery. Hence considering this, an experiment was conducted to investigate the effects of different root inducing agents on propagation of tea cuttings.

2. MATERIALS AND METHODS

The experiment was conducted in a special project nursery belonging to TSHDA (Tea Small Holding Development Authority) in Beralapanathara GN division of Pasgoda divisional secretariat in Matara, Sri Lanka.

The experiment was designed with six treatments with four replicates where each replicate had 20 cuttings. Experimental units were arranged in a completely randomized design (CRD) manner. The treatments were as follows;

T1 – Water (Control)
T2 - *Aloe vera* gel (100%)

T3 - Coconut water (100%)
T4 - Honey and charcoal mixture (1:1)
T5 – Potato juice (100 g potato in 100 ml of water)
T5 – Rooting hormone (0.3% IBA)

Only single node cuttings from the suitable shoots were selected and cuttings were taken from the middle portion of the shoot leaving the apical tender portion of basal mature portion cuttings with axillary flower buds, overgrown shoots and damaged mother leaf were discarded. For single-node cuttings, uppercut was made on the shoot closer to axillary buds without damaging it and the second cut was made 2-4 cm below the node. Potting media was prepared Topsoil (Citrus, Guatemala, kekilla cultivated land soil were used), in 7-inch height and 5-inch width polyethylene containers with 150 gauge thick. Plants were kept in a shade house and manual irrigation was practiced only on sunny days daily in the morning and manual weeding was performed when any weed was observed.

Plant growth data such as cutting survival %, rooting %, sprouting %, root number, root length (cm), root fresh (g) and dry weight (g) were collected at 2 weeks intervals. Collected data were analyzed using ANOVA procedures using SAS statistical software and treatment means were separated using DMRT at 5% significant levels.

3. RESULTS AND DISCUSSION

3.1 Survival Percentage

It was found that there were no significant differences among the treatments on survival percentage at 2nd week (Table 1). But, there were significant differences in 4th and 6th weeks after planting. The higher values in survival percentage were observed in application of rooting hormone and cuttings dipped in coconut water. This indicates that this particular treatment had a remarkably positive effect on the ability of plants to survive and persist over time. Those were followed by *Aloe vera* gel, honey and charcoal mixture and potato juice respectively. The lowest value in survival percentage was obtained in the control treatment.

In an experiment on *Parkia biglobosa*, Dunsin et al. [4] employed honey as an alternative application to induce rooting. Honey had a lower cutting mortality rate than the control. Honey can be used to treat *Hemigraphis* cuttings, according to Firth [5], and it resulted in a higher rate of rooting and heavier roots. Honey is commercially utilized as rooting, according to several sources [6]. It has been claimed that, in addition to growth regulators and hormones, sucrose is a major factor in roots (Abo et al. 2018). Oligosaccharides deposited in plant cell walls have a favorable influence on root induction and growth [7].

3.2 Rooting Percentage

No signs of rooting were observed during the second week following planting. Referencing Table 2, significant differences in rooting percentages were observed in various treatments during the fourth and sixth weeks after planting. Notably, the cuttings treated with rooting hormone exhibited the highest rooting percentage during the fourth week, followed by those treated with *Aloe vera* gel and coconut water. Similarly, in the sixth week, the treatments involving rooting hormone, coconut water, and *Aloe vera* gel exhibited the higher rooting percentage. Conversely, the cuttings dipped in water, which were used as the control group, exhibited the lowest rooting percentage.

Table 1. Effects of difference root inducing agents on survival rate of tea cuttings

Treatments	2nd week	4th week	6th week
T1 – Water (Control)	100a	56.5d	30.0d
T2 – *Aloe vera* gel	100a	80.3b	78.0bc
T3 – Coconut water	100a	90.0a	90.0a
T4 - Honey and charcoal mixture	100a	65.0c	70.0bc
T5 – Potato Juice	100a	68.0c	68.5c
T6 – Rooting Hormone	100a	92.8a	92.8a
Sig.	ns	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

Table 2. Effects of difference root inducing agents on rooting percentage of tea cuttings

Treatments	2nd week	4th week	6th week
T1 – Water (Control)	0	0.00d	29.8d
T2 – *Aloe vera* gel	0	32.3b	75.3ab
T3 – Coconut water	0	30.5b	80.8ab
T4 - Honey and charcoal mixture	0	20.5c	68.5b
T5 – Potato Juice	0	15.8c	50.4c
T6 – Rooting Hormone	0	55.8a	84.5a
Sig.	ns	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

According to Rout [8], after 3 weeks of potting medium transfer, Tea cuttings treated with a nutrient solution without growth regulators showed little response in root development. Most nodal cuttings treated with growth regulators produced root initiation 14 days after being transferred to the potting medium. IBA-treated nodal cuttings had a better rooting response than NAA and IAA-treated nodal cuttings. Cuttings treated with 75 ppm IBA had the highest percentage of rooting and the most roots per cutting. Ibironke [9] investigated IBA, Coconut water, and Tetracycline and discovered that coconut water treatment had a substantial influence on Murrayya cutting rooting. The primary type of auxin found in coconut water is Indole-3-acetic acid, which is found in plants [10].

3.3 Sprouting Percentage

Table 3 indicated that no sprouting was observed at 2nd week and there were significant differences between the treatments on sprouting percentage at 4th and 6th week. The highest sprouting percentage was observed in rooting hormone application during 4th week. It was followed by the other application methods respectively. The higher values in sprouting during the 6th were observed in rooting hormone and coconut water application. Those were followed by *Aloe vera* gel, honey and charcoal and potato juice not significantly.

Usman and Akinyele [11] employed coconut water at concentrations of 25 percent, 50 percent, and 100 percent to treat *Massularia acuminata* single node stem cuttings. They discovered that coconut water is more effective than IBA and NAA in terms of sprouting percentage and callus formation. Cuttings treated with coconut water had more leaves than IBA and NAA. Massoud et al. [12] observed that Rosemary cuttings treated with Honey, Yeast extract, and Coconut Milk demonstrated a 5.90 percent rooting percentage.

3.4 Number of Roots

The Table 4 indicated the effects of different root-inducing agents on the propagation of Tea cuttings. It revealed that there were significant differences between the treatments on the number of roots. Higher values in the number of roots were observed during the 6th week when the cuttings were treated with rooting hormone, coconut water and honey, charcoal mixture. The lowest root numbers were recorded in the cuttings treated with water, which was maintained as the control. Cuttings with a large number of roots will have a better chance of establishing themselves. Natural hormones are important in boosting the number of roots in cuttings. Faster cutting growth will be aided by an increase in the number of roots. Many studies have shown that natural compounds can increase the number of roots in horticulture crops.

Salicylic Acid, found in *Aloe vera* and cinnamon powder, aids in the rooting of cuttings. *Aloe vera* has been shown to root *Vitex diversifolia* semi-hardwood cuttings better than IBA [13]. *Aloe vera* leaf extract contains GA3 16 mg/100gm fresh weight, IAA 0.6 mg/100gm fresh weight, ABA 3.1 mg/100gm fresh weight, Glucose 3 g/100g, Protein 1.0 mg/g and all phytohormones and nutrients. Aloe plant extracts have been shown to contain almost 75 biologically active components, including several forms of salicylic acid, minerals, sugar, vitamins, saponins, lignins, and amino acids. This encourages cell survival and growth [14].

Table 3. Effects of difference root inducing agents on sprouting percentage of tea cuttings

Treatments	2nd week	4th week	6th week
T1 – Water (Control)	0	0.0c	0.0c
T2 – *Aloe vera* gel	0	40.8b	62.5b
T3 – Coconut water	0	30.3b	85.8a
T4 - Honey and charcoal mixture	0	42.5b	60.4b
T5 – Potato Juice	0	35.8b	55.8b
T6 – Rooting Hormone	0	72.3a	90.0a
Sig.	Ns	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

Table 4. Effects of difference root inducing agents on number of roots of tea cuttings

Treatments	4th week	6th week
T1 – Water (Control)	0.0c	2.3c
T2 – *Aloe vera* gel	4.5b	10.4b
T3 – Coconut water	6.5a	13.5a
T4 - Honey and charcoal mixture	6.0a	12.3ab
T5 – Potato Juice	2.0b	6.0c
T6 – Rooting Hormone	8.3a	14.0a
Sig.	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

3.5 Root Length

The study conducted on Tea cuttings revealed not significant variations among the different treatments in terms of their impact on root length. During the fourth week of the experiment, it was observed that the treatments involving the use of rooting hormone and coconut water did not lead to significantly higher root length values, as indicated in Table 5. This suggests that, despite the presence of these substances, there was no increase in root length at this particular stage of the experiment. In contrast, the treatments involving honey, charcoal mixture, and the application of water resulted in significant lower root length values. This implies that these treatments may not have been as conducive to the development of roots in the Tea cuttings, possibly due to a lack of essential growth-promoting factors or an inhibitory effect. Tea cuttings that were treated with rooting hormone. This treatment produced the highest root length values among all the tested treatments. Following this, the treatments involving the application of coconut water and *Aloe vera* gel also displayed relatively higher root length values compared to other treatments. These findings highlight the significant influence of different treatments on the root length of Tea cuttings. The use of rooting hormone stood out as particularly effective in promoting root growth, followed by the beneficial effects of coconut water and Aloe vera gel. On the other hand, treatments involving honey, charcoal mixture, and water showed relatively poorer results in terms of root length enhancement.

Aloe vera gel is said to contain IAA and could be utilized as an alternative hormone (El Sherif, 2017). *Aloe vera* gel contains growth hormones such as gibberellin and salicylic acid, which help the plant growth [15]. Many people have discovered that applying *Aloe vera* gel on cuttings helps them grow longer roots. *Dracaena purplecompacta* L. was studied using coconut water extract for propagation by softwood canes and cuttings for vegetative reproduction [16]. The effect of coconut water on adventitious root formation was validated in this investigation. Coconut Water extracts and natural IAA were tested in five different concentrations. For comparison, they performed another series of treatments with the same dose of real IAA rooting hormone. Dunsin et al. [4] found that cuttings of *Parkia biglobosa* treated with Moringa leaf extract had the largest root length compared to control, honey, and coconut water treatments.

Table 5. Effects of difference root inducing agents on root length (cm) of tea cuttings

Treatments	4th week	6th week
T1 – Water (Control)	0.31c	0.51d
T2 – *Aloe vera* gel	0.75b	1.75b
T3 – Coconut water	0.98ab	1.85b
T4 - Honey and charcoal mixture	0.38c	0.85c
T5 – Potato Juice	0.58b	0.95c
T6 – Rooting Hormone	1.24a	2.14a
Sig.	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

3.6 Root Fresh Weight

Analysis of tea cuttings revealed significant differences among the treatments in terms of their effect on root fresh weight. Analyzing the results presented in Table 6, it is clear that there was no statistically significant increase in fresh weight values at weeks 4 and 6 in treatments with rooting hormone, coconut water, and *Aloe vera* gel. In contrast, cuttings treated with water exhibited the lowest fresh root weight of all treatments tested. Notably, treatments with root hormones, potato juice, and *Aloe vera* gel did not significantly affect root fresh weight. This suggests that although these treatments are effective on root growth or vegetation growth of the other parts encouraged though, did not appear to be heavier strength.

Rawat et al. [17] reported that an experiment on *Rosmarinus officinalis* revealed that the highest fresh weight of roots per cutting was recorded 60 days after cuttings were planted with the application of 750 ppm IBA, which was statistically at par with IBA 1000 ppm and IBA 500 ppm and was superior to IAA treated cuttings. Untreated cuttings had the smallest fresh weight of roots per cutting (control). Similarly, at 90 DAP, IBA with a concentration of 750 ppm had the maximum fresh weight of roots per cutting, which was superior to other treatments as well as control. Cuttings treated with various doses of plant growth regulators aid in the mobilization and translocation of primary metabolites, resulting in improved root development and nutrient uptake. Padekar et al. [18], Rawat et al. [17], and Siddiqui et al. [19] all reported similar findings.

3.7 Root Dry Weight

The study revealed signficant variability in the effect of treatments on dry root weight of tea plants, as shown in Table 7. The treated effects of root hormone, potato juice and *Aloe vera* gel remained constant higher values reflected in dry weight revealed in the fourth week. This indicates that these treatments were favorable for root growth and development of the tea plants. Again, the most dramatic results were observed during the 6th week of the experiment. The use of rooting hormone at this time point resulted in the highest recorded dry weight of all treatments, indicating a strong positive effect on root growth followed by potato juice and *Aloe vera* gel, which also gave considerable dry root weight at this stage In contrast, the control treatment using water as the treatment had the lowest dry weight throughout the study. This means that root development has been comparatively better due to the absence of specific growth factors such as root hormones, potato juice and *Aloe vera* gel.

Table 6. Effects of difference root inducing agents on root fresh weight (g/cutting) of tea cuttings

Treatments	4th week	6th week
T1 – Water (Control)	0.80c	1.12d
T2 – *Aloe vera* gel	2.12a	2.94a
T3 – Coconut water	1.98ab	3.00a
T4 - Honey and charcoal mixture	1.74b	2.42b
T5 – Potato Juice	1.24b	1.58c
T6 – Rooting Hormone	2.24a	3.14a
Sig.	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

Table 7. Effects of difference root inducing agents on root dry weight (g/cutting) of tea cuttings

Treatments	4th week	6th week
T1 – Water (Control)	0.003b	0.007d
T2 – *Aloe vera* gel	0.135a	0.235b
T3 – Coconut water	0.140a	0.240b
T4 - Honey and charcoal mixture	0.010b	0.125c
T5 – Potato Juice	0.008b	0.130c
T6 – Rooting Hormone	0.150a	0.254a
Sig.	*	*

Means followed by same letter in a same column not significantly different at 5% significance level due to DMRT. '' represents significant and 'ns' not significant*

A study on *Pelargonium graveolens* by Rawat et al. [17], indicated that, under 750 ppm IBA, the maximum dry weight of roots per cutting was reported at 60 DAP, which was statistically comparable to IBA 1000 ppm and T2 IBA 500 ppm, and was superior to other treatments as well as control. However, with the 750 ppm IBA, which was superior to all other treatments, the largest dry weight of roots per cutting was recorded, whereas it was the lowest in untreated cuttings (control). Cuttings treated with IAA had a lower dry weight of roots. Tanuja et al. [20] found similar results. IBA treatment is also superior to IAA treatment, Yeshiwas et al. [21] also discovered that at 1000 ppm IBA concentration, the maximum root dry weight in stem cuttings of rose of Natal Break rootstock was attained.

4. CONCLUSION

Based on the present findings, it was observed that the application of rooting hormone on Tea cuttings showed superior values in most of the measured variables. Further application of coconut water and *Aloe vera* gel also showed nearly similar values in several measured variables. It can be concluded that coconut water and *Aloe vera* gel can be used as an alternative to the IBA-based rooting hormone in organic tea cultivations.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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