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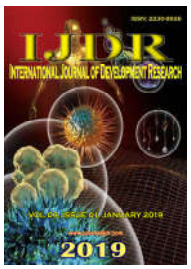

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

# EXPLORING SPROUTING AND GROWTH RESPONSE OF IXORA STEM CUTTINGS (*IXORA COCCCINEA*)

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**ABSTRACT**

A pot experiment was conducted during 2017-2018 to examine sprouting and growth responses of ixora stem cutting types of and ixora varieties. The cutting 4-6 inches in length of two ixora varieties viz. S.Yellow and N.Grant were taken from well grown plants of ixora. The cuttings included terminal and sub-terminal stem cuttings. The cuttings types viz. $C_1$-Terminal cuttings with two leaves, $C_2$-Terminal cuttings with four leaves, $C_3$-Sub-terminal stem cuttings with two leaves and $C_4$-Sub-terminal stem cuttings with four leaves. The results indicated that days to sprouting, number of sprouts cutting$^{-1}$, number of leaves cutting$^{-1}$ and fresh weight of the roots cutting$^{-1}$ were significantly affected by cutting types. However varietal effect and its interaction with cutting types were also observed significant for most of the parameters studied in the present study. The minimum mean days to sprouting (9.66) were recorded in response to the treatment where terminal cuttings with two leaves ($C_1$) and terminal cuttings with four leaves were planted. Terminal cuttings with four leaves ($C_2$) and terminal cuttings with two leaves ($C_1$) sprouted 88.33% with mortality 36.66% and 80.00% with mortality 41.66% of the plants. Whereas, sub-terminal stem cuttings with four leaves ($C_4$) and two leaves ($C_3$) sprouted 71.66% with mortality 26.66% and 76.66% with mortality 40.00% respectively. The maximum mean number of roots (18.66) and fresh weight of roots (1.67 g) were observed where terminal stem cuttings with two leaves ($C_1$) and sub-terminal stem cuttings with four leaves ($C_4$) were planted. On the basis of varietal comparison, the highest sprouting (81.66%) was observed in S.Yellow variety as compared to N.Grant. Whereas, N.Grant produced more number of roots (20.74) and fresh weight of roots (1.46 g). The interactive effect of varieties and ixora cuttings depicted maximum number of sprouts (4.62), number of leaves (9.25) in response to the treatment where sub-terminal stem cuttings with four leaves ($C_4$) were planted. However, maximum fresh weight of roots (2.24 g) was also observed from the plants where sub-terminal stem cuttings with four leaves were planted.



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## INTRODUCTION

Ixora (*Ixora coccinea* L.) is a popular hedging plant grown extensively in subtropical regions of world. It is a dense, multi-branched evergreen shrub belongs to the family Rubiaceae. It usually grows up to a height of 1.2–2 m, but some species also able to attain height of 3.6 meter. The plants have leathery leaves and produce large clusters of tiny flowers (Ellis *et al*. 2003). They produce orange, gold, pink and red flower and are suitable for indoor beautification, as they stay fresh for a long term after plucking. It grows very well in sunny conditions in moist but well-drained loamy soil and can withstand some darkness (Gilman, 1999).

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The profuse branching of Ixora makes it ideal for hedges, borders, screens, massed in flowering bed or grown as a specimen shrub or small trees and may be pruned at any time. It can also be grown in containers looking very distinguished as a patio or poolside plant (Gilman, 1999). The leaves of ixora contains several essential anticancer compounds including alkaloid, camptothecin, hence its leaves are well known for their use in treatment and medication of patients suffering from cancer disease (Saravanan and Boopalan, 2011). Roots are used for stomach troubles and dysentery, treatment for bloodshot eyes, sores and ulcers (Zacharieh *et al*., 1994). Several ornamental plants are known as "difficult to initiate adventitious roots" (Hall, 2003). Cuttings are ultimate method for beginning new plants. A cutting is a part of each separate plant part from a parent plant or stock plant which can

grow under the favorable conditions for regeneration, will result in a new plant similar to the mother plant (Hamilton and Midcap, 2003). Vegetative propagation by stem cutting in ixora is generally done by the use of terminal and sub-terminal stem cuttings. These cuttings were taken at various stages of growth and may contain of a plant's growing tip (terminal section) or sub-terminal stem sections and were referred to as tip cutting or stem cuttings respectively. Nursery propagators and amateur gardeners use vegetative propagation method by stem cuttings. In Ixora the rooting ability is moderate under natural conditions. Formation of adventitious root is a major step in vegetative propagation of woody or horticultural species, and complications associated with root development of cuttings commonly results in leading commercial losses (De Klerk *et al*. 1999 and Mohammed and Hamid, 2014). The successful outcomes of rooting of woody stem cuttings, most of the ornamental plants and fruit trees rely on primarily on the physiological stage of parent plant (Day and Loveys, 1998). In ixora, it is observed that sprouted cuttings usually die within few days. Under such conditions propagation through stem cuttings is the most common, successful and economical method to be applied for ixora multiplications. However, a wide variation is observed in different varieties. Therefore in the present study both terminal and sub-terminal stem cuttings were planted to explore sprouting and growth responses of ixora stem cuttings.

## MATERIALS AND METHODS

A pot experiment was conducted at Horticulture Department Faculty of Crop Production Sindh Agriculture University Tandojam during 2017-2018 to examine sprouting and growth responses of different cutting types. The terminal and sub-terminal stem cuttings of 4-6 inches in length with two and four leaves were planted. The two ixora varieties including Singapore Yellow and Nora Grant were used in the present study. The cuttings were planted in earthen pots containing (canal sediment+ soil + FYM at 1:1:0.5 ratio) and all the pots of both varieties were covered with polyethylene bags. The pots were irrigated at regular interval and all the required cultural practices including hoeing and weeding were performed. The data were recorded on parameters that included days to sprouting, number of sprouts cutting$^{-1}$, mortality percentage treatment$^{-1}$, number of leaves cutting$^{-1}$, rooting percentage treatment$^{-1}$, number of roots cutting$^{-1}$ and fresh weight of roots cutting$^{-1}$.

**Methods used for recorded observations**

**Days to sprouting:** Days to sprouting were counted from plantation up to the sprouting of the cuttings. The data was taken each replication and treatment wise.

**Number of sprouts cutting$^{-1}$:** Number of sprouts cutting$^{-1}$ was observed and counted daily after plantation for up to the completion of the experiment.

**Sprouting percentage treatment$^{-1}$:** Sprouting percentage treatment$^{-1}$ was checked on every alternative up to 7$^{th}$ day of plantation and the sprouting percentage was calculated by using following equation as described by Larsen and Andreasen (2004).

$GP=\sum n/ N \times 100$

Where is number of sprouted cuttings at each counting and N is total number of cuttings in each treatment.

**Mortality percentage treatment$^{-1}$:** Mortality percentage treatment$^{-1}$ was observed throughout the final data after all observations.

**Number of leaves cutting$^{-1}$:** Numbers of leaves cutting-1 were calculated daily up to the completion of the experiment.

**Rooting percentage treatment$^{-1}$**: Rooting percentage treatment$^{-1}$ was observed after one week of plantation for up to the one month of plantation. The rooting percentage was calculated-by using following method

$$\text{Rooting percentage} = \frac{\text{Number of rooted cuttings X 100}}{\text{Total number of planted cuttings}}$$

**Number of roots cutting$^{-1}$:** Number of roots cutting$^{-1}$ was counted at the end of root formation per treatment. For the purpose, the cuttings were taken out from the polythene bags and adhered soil to the cutting was discarded from the cuttings to count the roots easily per cutting.

**Fresh weight of roots cutting$^{-1}$:** The fresh weight of the roots was recorded when the number of roots cutting$^{-1}$ was recorded. The fresh weight of the counted number of roots of each sample was recorded in a weighing balance and the data was recorded.

**Statistical analysis**

The data of all the parameters were individually subjected to the analysis of variance techniques. Subsequently, the significant means were separated by the least significant difference (LSD) test by using the Statistix Ver 8.1 computer software program (Statistix, 2006).

## RESULTS

**Days to sprouting:** The days to sprouting was significantly affected by various terminal and sub-terminal stem cuttings. However, varietal effect was non-significant but its interaction of cutting types x varieties was observed significant ($P<0.05$). On the basis of mean of cutting types, sub-terminal stem cuttings with four leaves ($C_4$) was observed the maximum mean days (15.66) to sprouting followed by the sub-terminal stem cuttings with two leaves ($C_3$) (13.44) (Table 1). While the terminal cuttings with two leaves ($C_1$) and terminal cutting with four leaves ($C_2$) took minimum days (9.66) to sprout. On the basis of varietal comparison, the maximum days to sprouting (12.33) was observed in S.Yellow as compared to the N.Grant (11.88).

**Number of sprouts cutting$^{-1}$:** The number of sprouts cutting$^{-1}$ were significantly influenced by the varieties and cutting types of ixora ($P<0.05$). The interactive effect of the varieties and cutting types of ixora was also observed significantly. On the basis of mean of cutting types, sub-terminal stem cuttings with four leaves ($C_4$) produced the maximum number of sprouts (3.96) cutting$^{-1}$ followed by the sub-terminal stem cuttings with two leaves ($C_3$) (3.39) and terminal cuttings with two leaves ($C_1$) (2.52) (Table 1). While, the terminal cuttings with four leaves ($C_2$) exhibited the minimum number of sprouts cutting$^{-1}$ (2.40).

**Table 1.**

| Types of cuttings | Days to sprouting | | Mean | Number of sprouts cutting$^{-1}$ | | Mean | Sprouting percentage treatment$^{-1}$ | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | S. Yellow | N. Grant | | S. Yellow | N. Grant | | S. Yellow | N. Grant | |
| $C_1$.Terminal cuttings with two leaves | 9.00 d | 10.33 cd | 9.66 C | 2.62 c | 2.42 c | 2.52 C | 93.33 a | 66.66 ab | 80.00 |
| $C_2$. Terminal cuttings with four leaves | 9.00 d | 10.33 cd | 9.66 C | 2.41 c | 2.39 c | 2.40 C | 90.00 a | 86.66 a | 88.33 |
| $C_3$. Sub- terminal stem cuttings with two leaves | 13.00 bc | 13.88 b | 13.44 B | 3.24 b | 3.54 b | 3.39 B | 93.33 a | 60.00 ab | 76.66 |
| $C_4$. Sub- terminal stem cuttings with four leaves | 18.33 a | 13.00 bc | 15.66 A | 3.30 b | 4.62 a | 3.96 A | 50.00 b | 96.66 a | 73.33 |
| Mean | 12.33 | 11.88 | | 2.89 B | 3.24 A | | 81.66 | 77.33 | |

**Table 2.**

| Types of cuttings | Mortality percentage treatment$^{-1}$ | | Mean | Number of leaves cutting$^{-1}$ | | Mean |
|---|---|---|---|---|---|---|
| | S. Yellow | N. Grant | | S. Yellow | N. Grant | |
| $C_1$.Terminal cuttings with two leaves | 26.66 b | 56.66 a | 41.66 | 5.22 c | 4.84 c | 5.03 C |
| $C_2$. Terminal cuttings with four leaves | 46.66 a | 26.66 b | 36.66 | 4.83 c | 4.78 c | 4.80 C |
| $C_3$. Sub- terminal stem cuttings with two leaves | 53.33 a | 26.66 b | 40.00 | 6.46 b | 7.10 b | 6.78 B |
| $C_4$. Sub- terminal stem cuttings with four leaves | 50.00 a | 3.33 c | 26.66 | 6.64 b | 9.25 a | 7.94 A |
| Mean | 44.16 A | 28.33 B | | 5.79 B | 6.49 A | |

**Table 3.**

| Types of cuttings | Rooting percentage treatment$^{-1}$ | | Mean | Number of roots cutting$^{-1}$ | | Mean | Fresh weight of roots (g) cutting$^{-1}$ | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | S. Yellow | N. Grant | | S. Yellow | N. Grant | | S. Yellow | N. Grant | |
| $C_1$.Terminal cuttings with two leaves | 73.33 b | 43.33 c | 58.33 | 19.55 ab | 17.77 b | 18.66 | 1.06 cd | 0.85 d | 0.96 C |
| $C_2$. Terminal cuttings with four leaves | 53.33 c | 73.33 b | 63.33 | 10.10 c | 25.44 a | 17.77 | 0.50 e | 1.22 c | 0.86 C |
| $C_3$. Sub- terminal stem cuttings with two leaves | 46.66 c | 73.33 b | 60.00 | 8.77 c | 20.22 ab | 14.60 | 1.14 c | 1.54 b | 1.34 B |
| $C_4$. Sub- terminal stem cuttings with four leaves | 50.00 c | 96.66 a | 73.33 | 9.66 c | 19.55 ab | 14.49 | 1.11 cd | 2.24 a | 1.67 A |
| Mean | 55.83 B | 71.66 A | | 12.02 B | 20.74 A | | 0.95 B | 1.46 A | |

On the basis of varietal comparison, the maximum number of sprouts (3.24) was observed in N.Grant as compared to the S.Yellow (2.89).

**Sprouting percentage treatment$^{-1}$:** The sprouting percentage treatment$^{-1}$ was not significantly influenced by the main factors (varieties and cutting types). The results in Table 1 represent that there is no significant effect of the main factors (varieties and type of cuttings) on sprouting percentage treatment$^{-1}$. However, their interaction was observed significantly. Terminal cuttings with four leaves ($C_2$) produced the maximum sprouting percentage (88.33 %) treatment$^{-1}$ followed by terminal stem cuttings with two leaves ($C_1$) (80.00 %) and sub-terminal stem cuttings with two leaves ($C_3$) (76.66). While, the sub-terminal stem cuttings with four leaves ($C_4$) exhibited the minimum sprouting percentage (73.33 %) treatment$^{-1}$. In case of varietal response, the sprouting percentage treatment$^{-1}$ was higher (81.66 %) in ixora variety S.Yellow (V1) as compared to variety N.Grant (V2) with (77.33 %) sprouting percentage treatment$^{-1}$.

**Mortality percentage treatment$^{-1}$**: The mortality percentage treatment$^{-1}$ was not significantly influenced by the cutting types. However, the significant effect was observed on the basis of varieties and their interactive effect with the cutting types. The data about mortality percentage is presented in Table 2. The terminal cuttings with two leaves ($C_1$) showed the maximum mortality (41.66 %) followed by the sub-terminal stem cuttings with two leaves ($C_3$) (40.00 %), while the terminal cuttings with four leaves ($C_2$) exhibited (36.66 %) and the minimum mortality percentage treatment$^{-1}$ was observed in sub-terminal stem cuttings with four leaves ($C_4$) (26.66 %). In case of varietal response, the mortality percentage treatment$^{-1}$ was higher (44.16 %) in ixora variety S.Yellow (V1) as compared to variety N.Grant (V2) with (28.33 %) fresh weight of roots.

**Number of leaves cutting$^{-1}$**: The number of leaves cutting$^{-1}$ was significantly influenced by the varieties and cutting types of ixora ($P<0.05$). However, the interactive effect of the varieties and cutting types of ixora was also observed significant and the data are presented in Table 2. On the basis of mean of cutting types, sub-terminal stem cuttings with four leaves ($C_4$) produced the maximum number of leaves (7.94) cutting$^{-1}$ followed by the sub-terminal stem cuttings with two leaves ($C_3$) (6.78) and terminal cuttings with two leaves ($C_1$) (5.03).

While, the terminal cuttings with four leaves ($C_2$) exhibited the minimum number of leaves cutting$^{-1}$ (4.80). On the basis of varietal comparison, the maximum number of leaves (6.49) was observed in N.Grant as compared to the S.Yellow (5.79).

**Rooting percentage treatment$^{-1}$**: The analysis of variance (ANOVA) indicated that the rooting percentage was not significantly influenced by the type of cuttings, while the ixora varieties interactive effect of cutting types x varieties was observed significant ($P<0.05$) and the data are presented in Table 3. The sub-terminal stem cuttings with four leaves ($C_4$) showed maximum rooting percentage (73.33 %) treatment$^{-1}$ followed by the terminal cuttings with four leaves ($C_2$) (63.33 %), while the sub-terminal stem cuttings with two leaves ($C_3$) exhibited (60.00 %) and the minimum rooting percentage (58.33 %) treatment$^{-1}$ was observed in terminal cuttings with two leaves. On the basis of varietal comparison, the maximum rooting percentage (71.66 %) treatment$^{-1}$ was observed in N.Grant as compared to the S.Yellow (55.83 %).

**Number of roots cutting$^{-1}$:** The results revealed that number of roots cutting$^{-1}$ was non-significantly affected ($P<0.05$) by cutting types of ixora varieties; while the varieties and interactive effect of cutting types x varieties on the number of roots cutting$^{-1}$ was significant ($P<0.05$). The data presented in Table 3 depicts that the mean maximum number of roots (18.66) produced from the terminal cuttings with two leaves. These results are statistically similar with the results (17.77) obtained from the terminal cuttings with four leaves ($C_2$). While, sub-terminal stem cuttings with four leaves ($C_4$) produced minimum number of roots (14.49) cutting$^{-1}$ and these results are also statistically similar with the results (14.60) obtained from the sub-terminal stem cuttings with two leaves ($C_3$). On the basis of mean varietal comparison, N.Grant produced the maximum number of roots (20.74) cutting$^{-1}$ as compared to the S.Yellow variety (12.02).

**Fresh weight of roots (g) cutting$^{-1}$:** It is evident from the results presented in (Table 3) that maximum fresh weight of roots (1.67 g) was recorded when sub-terminal stem cutting with four leaves were planted. While mean fresh weight of roots decreased to 1.34 g when the sub-terminal stem cutting with two leaves ($C_3$) were used for ixora planting. Moreover, the fresh weight of roots was observed decreased to 0.96 g and the lowest fresh weight of roots (0.86 g) was recorded when terminal cutting with two leaves ($C_1$) and terminal cutting with four leaves ($C_2$) were used for plantation, respectively. In case of varietal response, the fresh weight of roots was higher (1.46 g) in ixora variety N.Grant (V2) as compared to variety S.Yellow (V1) with 0.95 g fresh weight of roots. The interactive effect of cutting types and varieties indicated that the highest fresh weight of roots (2.24 g) was recorded in N.Grant variety where sub-terminal stem cuttings were used for plantation.

## DISCUSSION

Stem cuttings (Terminal and sub-terminal) are generally used for propagation of ixora. These cuttings are taken at various stages of growth and may persist of a plant's increasing tip (terminal section) or sub terminal stem sections and called as tip cutting or stem cuttings consecutively. Leaf bud cuttings are improved type of stem cuttings (Hartmann *et al*. 2002). Cutting length; node position, leaf number attached and leaf area is important factor that affects the root growth (Lu, 2002). Significant effect of cutting type with or without leaves for propagation of coleus on the rooting and subsequent overwintering of cuttings has been observed (Hartmann *et al*. 2002).The current study was undertaken to explore sprouting and growth responses of cutting types in ixora varieties. The results were recorded on days to sprouting, number of sprouts cutting$^{-1}$, sprouting percentage treatment$^{-1}$, mortality percentage treatment$^{-1}$, number of leaves cutting$^{-1}$, rooting percentage treatment$^{-1}$, number of roots cutting$^{-1}$ and fresh weight of roots cutting$^{-1}$. The study showed 88.33% sprouting in ixora when terminal cuttings with four leaves were used. These results are partially supported by Adugna (2015) who evaluated the growing behavior of stem cuttings of *vanilla planifolia* and *vanilla fragrans* and reported that cuttings and nodes was not significantly influenced the sprouting percentage of *vanilla planifolia* and *vanilla fragrans* cuttings. Meng *et al*. (2015) concluded that coleus response to cutting and other irrigation related inputs was variable and sprouts number varied with the availability of water and cutting type. The varietal behavior of ixora planted through cuttings differed significantly to sprouting. In the present study, mortality percentage was not significantly affected by the type of cuttings. This is in agreement with the investigation of Das (2015) who reported that mortality of plants was mainly influenced by cutting type and sprouts from thick cuttings and thin cuttings of four nodal length survived better than other treatments. Meng *et al*. (2015) evaluated plant mortality increased from cuttings in ornamentals due to use of untreated cuttings for nutrients. Garibaldi *et al*. (2011) results are in similarity with the findings of the present research regarding mortality of plants and reported that the plant mortality was also associated with the variety being used. Idun *et al*. (2011) reported that stem cutting types and their relations did not significantly influence the number of days to sprouting. Shah *et al*. (2006) studied the root development and formation in two various types of cuttings (softwood and hardwood). Softwood cuttings observed the rapid sprouting (16.7 days) obtained in cuttings. Okunlola and Ibironke, (2013) reported the highest mean sprouting percentage and number of leaves in semi hardwood and hardwood cuttings in duranta Elgimabi (2008) concluded the best outcomes in number and length of both roots and leaves of the stem cuttings of ixora under polyethylene sheets with water mist. Boby and Bagyaraj, (2003) concluded that modes to the plants for multiplication mostly in ornamental plants play major role in rooting and number of nodes and leaves intact with cutting used affected the rooting capability of the cuttings. Idun *et al*. (2011) who found that there is no significant differences in the stem cutting types of *ficus benjamina* in the number of days to sprouting, number of stem cuttings and also the number of roots per cutting as well. In the present study, number of leaves was significantly influenced by the type of cuttings and highest number of leaves was higher in sub-terminal stem cuttings with four leaves as compared to other cuttings. Hartmann *et al*. (2002) who also concluded that the type of cutting (with or without leaves) chosen for propagation significantly affects rooting and subsequent overwintering of cuttings in softwood. Hussein (2008) evaluated rooting and plant growth of *thumbergia grandiflora* by using stem cuttings (defoliated) of 25 cm in length with three nodes. The cuttings produced significant increase in rooting %, number of roots plant$^{-1}$, number of leaves and fresh weight of root. Idun *et al*. (2011) concluded that there were significant differences in the stem cuttings related to the number of leaves that were produced in the 8$^{th}$ week. Heel cutting produced maximum number of

leaves (2.63) that was significantly different than rest of the treatments. Lu (2002) studied that cutting length; node position, leaf number attached and leaf area were significant factor affecting the root formation. Christopher *et al*. (2002) reported that rooting after 21 days examined that cuttings contained all leaves (six) produced more leaves per cutting than rest of the treatments. Lu (2002) reported that leaf number of cutting was significantly affected by the cutting type in ornamentals. Irfan *et al*. (2011) found that the different size of cuttings 5cm, 10cm, 15cm and 20cm without leaf for propagation were planted and revealed that leaves per cutting were significantly influenced by the cutting type. The study further showed that the earliest sprouting of ixora were recorded when terminal cutting with two leaves and terminal cutting with four leaves were used (9.66 days); and sub-terminal stem cutting with four leaves produced heavier fresh roots (1.67g). The main step is asexual propagation is the formation of adventitious roots. The development of adventitious root formation is influenced by internal and external factors (Davis *et al*. 1988). Irfan *et al*. (2011) who revealed that the different size of cuttings significantly affected the fresh weight of roots of ornamental plants propagated through cuttings and revealed that maximum fresh root weight (1.27 g) was higher in 5 cm cuttings as compared to other sizes. Karunarathna and Harris (2016) concluded that during establishment of cutting of ixora, the higher percentage of roots cutting$^{-1}$ was observed (77%, 32% and 63% respectively) in those cuttings treated with coconut water. Mallesh *et al*. (2009) illustrated that fresh root weight of coleus cutting was significantly influenced by cutting size and type of nodes etc. David *et al*. (2008) revealed that the effect of cutting type on the fresh weight of roots was significantly affected. Shah *et al*. (2006) concluded that the impact of the cutting type on number of leaves plant$^{-1}$ was significantly affected. Means number of leaves plant$^{-1}$ demonstrates that highest numbers of leaves plant-1 (7.0) were counted in hardwood stem cuttings. Miller (2014) demonstrated the types of soft cutting viz. terminal cuttings generally rooted greater than sub-terminal or basal cuttings. Okunlola and Ibironke (2013) evaluated the different types of stem cuttings (softwood, semihardwood and hardwood) and lengths (10cm and 20cm) of duranta. However, the hardwood stem cutting of 20cm length gave the best results in terms of rooting and growth behavior of duranta. In contrast Miller (2014) reported that rooting percentages in sub-terminal cuttings were better than terminal cuttings. In present study rooting was not affected by the type of the cuttings. The outcomes are in agreement with the outcomes of (Rodriguez-Perez *et al*. 2009) they narrated that type of cutting (terminal and basal cuttings from the last flush of growth) did not have an overall effect on rooting. In several species, cuttings from basal and medial positions revealed best rooting, whereas in other species apical cuttings showed best rooting Al-Saqri and Alderson (1996). In addition, Day and Loveys, (1998) also declared that the development of rooting by woody stem cuttings and the most of ornamental plants rely on the physiological stage of the donor plant, and they also observed the rooting differs with the type of cutting, the species rooted and the environmental conditions. In contrast to our results, Sabatino *et al*. (2014) illustrated the better rooting was observed from terminal cuttings with apex in combination with indole butyric acid for 7 minutes dip. They evaluated the best results for rooting percentage from sub-terminal cuttings as compared to terminal cuttings without apex; they also reported maximum number of roots from the terminal cuttings with apex (18.5) and terminal cuttings without apex (20.1). Coleus rooting from cuttings with all leaves showed superior rooting Christopher *et al*. (2002). They reported that rooting in cuttings with all leaves had better growth, indicating all cuttings rooted of good quality; cuttings with half leaves (three) had a root rating of 2.97 indicating fewer roots and inferior quality. Rakshapal *et al.* (2009) reported that rooting percentage was highly affected by the type of cutting used for coleus propagation. Vakouftsis *et al*. (2009) reported that rooting percentages were higher for apical semi-hardwood and hardwood cuttings than for basal semi-hardwood and hardwood cuttings rooted (only hardwood cuttings). Most proficient rooting (66.7-89.7%) can be achieved using apical shoot cuttings planted with two leaves. Elgimabi (2008) evaluated that the best rooting and vegetative growth followed by the cutting with leaves.

**Conclusion**

It is concluded that terminal and sub-terminal stem cuttings with four leaves produced the best results for most of the observed parameters. However, type of cuttings had no effect on number of roots, sprouting, rooting and mortality percentage. On the basis of varietal comparison, N.Grant observed the best ixora cultivar in terms of sprouting and growth related attributes.

## REFERENCES


Adugna, M., D. Belew and D. Tilahun. 2015. Influence of rooting media and number of nodes per stem cutting on nursery performance of vanilla (*Vanilla planifolia* Andr. Syn. *Vanilla fragrans*). J. Hort. & For. 7(3):48-56.

Al-Saqri, F and P.G. Alderson. 1996. Effects of IBA, cutting type and rooting media on rooting of *Rosa centifolia*. J. Hort. Sci. 71,729-737.

Christopher, J., Hamilton, R. Evert and Emino. 2002. The influence of cutting size, leaf area and shipping on coleus cutting quality parameters including rooting. Proc. Fla. Stat. Hort. Soc. 115:134-136.

Das, k. 2015. Sprouting and survival of *coleus forskohlii* stem cuttings by hormonal pre treatment. J. plant. nutri. 35(1):587-592.

David, G., G. Clark and P. Nguyen. 2008. Development of new coleus cultivars for shade tolerance and cut foliage production. J. Environ. Hort. 35(4):315-321.

Davis, T.D., Haissig, B. E. and Sankhla, N. 1988. Adventitious root formation in cuttings. Adv. Plant. Sci. ser. (2): Pp 315.

Day, J.S and B.R. Loveys. 1998. Propagation from cuttings of two woody ornamental Australian shrubs, Boroniamegastigma and Hypocalymmaangustifolium, Endl. (White myrtle). *Australian J. Exp. Agric.* 38:201-206.

Elgimabi, M.E.N.E. 2008. Effect of season of cutting and humidity on propagation of (*Ixora coccinea* ). Adv. Biol. Res. 2(5-6):108-110.

Garibaldi, A., D. Bertetti, A. Poli and M.L. Gullino. 2011. First report of verticillium wilt caused by verticillium dahlia on coleus verschaffeltii in Italy. *J. Plant Sci.* 95(4):878-885.

Gilman, E.F. 1999. *Ixora coccinea*. University of Florida, Cooperative Extension Service. *Inst. of Food and Agric. Sci. Fact Sheet* FPS-291, pp. 1-3.

Hamilton, D.F and J.T. Midcap. 2003. Propagation of woody ornamentals by cuttings. In Florida Cooperative Extension Service, Inst. of Food and Agric. Sci., University of Florida, Gainesville, 32611.

Hartmann, H.T., D.E. Kester, F.T. Davies and R.L. Geneve. 2002. Plant Propagation: Principles and practices. 7th ed. Prentice-Hall, Upper Saddle River, NJ, USA., CD.(PLS.3221/5221) 880.pp.

Hussein, M.M.M. 2008. Studies on the rooting and the consequent plant growth on the stem cuttings of *Thunbergia grandiflora,* (roxb ex rottl.) roxb effect of different planting dates. World J. Agric. Sci. 4(2):125-132.

Idun, I.A., P. Kumah and H.V. Adzraku. 2011. Rooting and vegetative growth responses of "difficult to-root" *Ixora coccinea* and *Ficus benjamina* cv.'starlight' to different stem cutting types and soilless media. *Afric. J. Plant. Sci.* 5(13):773-780.

Irfan, A., M.T. Siddiqui, R.A. Khan, M. Kashif and T.M. Butt. 2011. Root growth of *Morus alba* as affected by cutting size and low polythene tunnel. *J. Orna. Hort. Plants.* 1:35-41.

Karunarathna, B and K.D. Harris. 2016. Effect of coconut water on the cutting establishment of ixora (*Ixora coccinea*) *Int. J. Adv. Res. Rev.* 1(11):27-33.

Larsen, S.U. and C. Andreasen 2004. Light and heavy turfgrass seeds differ in germination percentage and mean germination thermal time. *Crop Sci.* 44(5):1710-1720.

Mallesh, S.B, R. Yashodha, A.N. Hegde, P.U Mokashi and Krishnaraj. 2009. Bioefficacy of rhizobacteria on root knot/wilt complex in coleus and ashwagandha. Karnataka *J. Agri. Sci.* 22(5):1116-1120.

Meng, L.L., J.F. Song, J. Wen, J. Zhang and J.H. Wei. 2015. Effects of drought stress on fluorescence characteristics of photosystem II in leaves of coleus (*Plectranthus scutellarioides*). *J. Plant. Sci.* 31(1):124-130.

Miller, R.J. 2014. Evaluation and propagation of Chinese wingnut, pterocaryastenoptera, as a new bioenergy feedstock. MSc. Thesis. Graduate College of the Univ. Illinois Urbana-Champaign, Urbana Illinois. 32(1):1-2.

Mohammed, A.A.F and A.E.Y. Hamid. 2014. Vegetative propagation of Peltophorium petrocarpum (DC) Backer ex k.Heyne: A multi-purpose tree. *Net J. of Agric. sci.* 2(4):113-116.

Okunlola, A. Ibironke. 2013. The effects of cutting types and length on rooting of *Duranta repens* in the nursery. *Global. J. Inc.* (USA). 13(3):1-4.

Rakshapal, S., T.N. Parameswaran, E.V.S.P. Rao, E.V.S. Puttanna, K.A. Kalra Srinivas, K.V.N.S. Bagyaraj and D.J. Divya. 2009. Effect of arbuscular mycorrhizal fungi and pseudomonas fluorescens on root-rot and wilt, growth and yield of *Coleus forskohlii*. *Biocontrol Sci. Tech.* 19(4):835-841.

Rodriguez-Perez, J.A., M.C. Vera-Batista, A.M. de Leon-Hernandez and I. Rodriguez- Hernandez. 2009. Vegetative cutting propagation of protea hybrid 'Susara' (Proteaceae). Europ. *J. Hort. Sci.* 74(4):175-179.

Sabatino, Leo, F. D'anna and G. Iapichino. 2014. Cutting type and IBA treatment duration affect *teucrium fruticans* adventitious root quality. *Not. Bot. Hort. Agrobo,* 42(2):478-481.

Saravanan, P and E. Boopalan. 2011. Occurrence of Camptothecin an Anticancer Drug from *Ixora coccinea* Linn. *Int. J. Applied Bio*. 2(2):30-34.

Shah, M., A.M. Khattak and N. Amin. 2006. Effect of different growing media on the rooting of *Ficus binnendijkii* 'amstel queen' cuttings. *J. Agric. Bio. Sci.* 1(3):15-17.

Statisticx. 2006. Statistix 8.1 user guide, version 1.0. Analytical Software, PO Box 12185, Tallahassee FL 32317 USA. Copyright © 2006 by Analytical Software.

Vakouftsis, G., T. Syros, S. Kostas, A.S. Economou, P. Tsoulpha, A. Scaltsoyiannes and D. Metaxas. 2009. Effect of IBA, time of cutting collection, type of cuttings and rooting substrate on vegetative propagation in *cupressus macrocarpa* 'goldcrest'. Prop. Orna. Plants. 9(2):65-70.

Zacharieh, R., N. Sudhakaran and C.R. Panikar. 1994. Antiinflammatory and antimiotic activities of lupeol isolated from leaves of *Ixora coccinea* Linn. *Ind. J. Pharma. Sci.,* 6(2):129-132.

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