Scientific Papers. Series B, Horticulture. Vol. LXVII, No. 1, 2023
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

INFLUENCE OF ROOTING MEDIA AND HORMONES ON *MANDEVILLA* VEGETATIVE PROPAGATION

Endre KENTELKY[1], Erzsébet DOMOKOS[1], Zsolt SZEKELY-VARGA[1], Monica BOSCAIU[2]

[1]Sapientia Hungarian University of Transylvania, Faculty of Technical and Human Sciences, Department of Horticulture, 2 Calea Sighişoarei, 540485, Târgu Mureş, Romania
[2]Universitat Politècnica de València, Mediterranean Agroforestry Institute (IAM), Camino de Vera s/n, 46022 Valencia, Spain

Corresponding authors emails: domokos.erzsebet@ms.sapientia.ro, zsolt.szekely-varga@ms.sapientia.ro

Abstract

Ornamental flowering plants are used worldwide for landscape design and as cut flowers. Most are imported from abroad and climatic conditions are different in their countries of origin. Although they produce seeds, these are often sterile and cannot germinate. Therefore, such species are multiplied vegetatively. In the present study it was investigated the propagation of two varieties of Mandevilla sanderi under the effect of three different rooting hormones (Incit 8, Radi-Stim® nr.1, Radi-Stim® nr.2), and two different rooting media (peat-perlite and peat). Untreated cuttings were considered as control. The results indicate that significant changes were obtained under the effect of the selected rooting stimulants, and that the rooting media did not influence the root initiation of the cuttings. Furthermore, no significant changes were observed on cuttings growth after transplantation. In conclusion, the current research shows that I8 and R2 increase the rooting of Mandevilla cuttings, and that the rooting media have no effect on the plants.

***Key words**: climbing plant, cuttings, Mandevilla, stimulants, propagation.*

INTRODUCTION

Floriculture is part of the horticultural industry and encompasses the production of flowering and ornamental plants for landscaping and floristry (Paiva, 2018; Wani et al., 2018). Floriculture in recent years has become the fastest growing industry in the commercial horticulture trades, due to people's rising living standards and demands (Manikas et al., 2020). With the increasing demand, flower nurseries need to find new and efficient/fast methods to propagate different species.

The genus *Mandevilla* Lindl. belongs to the family *Apocynaceae*, and is native to the American continent, with 191 species (The Plant List, 2021). It includes flowering climbing/liana species, and some shrubby herbs or epiphytes (de Sales et al., 2006). Plants of this genus are beloved as ornamentals in pots or containers, and are excellent for indoors or on balconies decoration (Kozak et al., 2019; Kozak et al., 2021). Because of the beauty of their flowers, *Mandevilla* species, known as rock trumpets, are among the most widely cultivated ornamental plants worldwide (Cordeiro et al., 2012).

Mandevilla sanderi (Hemsl.) Woodson (syn. *Dipladenia sanderi* Hemsl.), is known under its commercial name of “Brazilian jasmine” (Oder et al., 2016). At least 50 *Mandevilla* species are native to Brazil (Cordeiro et al., 2011; Favara et al., 2020). *M. sanderi* is a vine with funnel-shaped pink, white or red flowers, blooming between late spring and fall.

The species can be propagated by seeds, stem cuttings and also by micropropagation. Seed germination has the disadvantage that it requires favourable environmental conditions and seed-propagated plants may not retain the characteristics and genetics of the mother plants, and obtaining mature plants would take much longer. On the other hand, *M. sanderi* can be multiplied by micropropagation, with a high production rate of new plants (Cordeiro et al., 2014a; Cordeiro et al., 2014b). However, this type of propagation requires laboratory equipment and is too expensive for smaller nurseries to purchase. Vegetative propagation ensures that all characteristics of the parent plant are retained. The success of vegetative propagation is mainly affected by environmental factors, the quality of the growing medium and rooting hormones (Faust et al., 2014).

Plant hormones are naturally present in plants, although in low concentrations, and are organic substances that influence the physiological process, thus influencing plant functions and development, such as rooting, fruit ripening and plant growth (Mirihagalla & Fernando, 2020; Anfang & Shani, 2021), they may also have an effect on stomatal movement (Davies, 2010).

In floriculture, hormones are often used to stimulate root initiation of cuttings (Faust et al., 2014), on the other hand this process provides the basis for clonal multiplication of plants (Druege et al., 2016). Adventitious root formation is a critical phase for the survival and development of unrooted cuttings (Koroch et al., 2002), and involves biological, morphological and even physiological changes (Geiss et al., 2009; Zhang et al., 2017).

The present study investigated the influence of three rooting hormones commonly used in Romanian floriculture (Incit 8, Radi-Stim® nr. 1 and Radi-Stim® nr. 2) and of different rooting media (peat-perlite and peat) on two *M. sanderi* varieties. The influence of the hormones on rooting percentage, number of roots, root length, root volume was investigated, and their effect on the growth of plants, as only little information is available on this species vegetative propagation, especially with rooting hormones. We aimed to determine which rooting hormone and growth media are most suitable for the vegetative propagation of this species.

MATERIALS AND METHODS

Plant material and study site

The experiment was carried out between 22 March and 21 July 2021 in a commercial greenhouse with controlled temperature and humidity, located at Mureș County, Sărățeni (46°33'37.6" N 25°00'43.1" E). The mother plants were obtained from a local garden centre. Two varieties of *Mandevilla sanderi* were selected: 'Classic Red' (Red) - red flowers and 'Classic White '16' (White) - white flowers, both valuable as ornamental pot vines. The two varieties have medium-early flowering and are suitable for hanging pot cultivation. Apical cuttings were harvested from the mother plants and immediately immersed in the rooting hormones and planted in the specific growth media for each treatment. Humidity and temperature were measured using a Testo 175H1 (Testo Romania, Cluj-Napoca, Romania). Recorded humidity during the experiment was 70-95%, and the average temperature 16.87 °C (Figure 1).

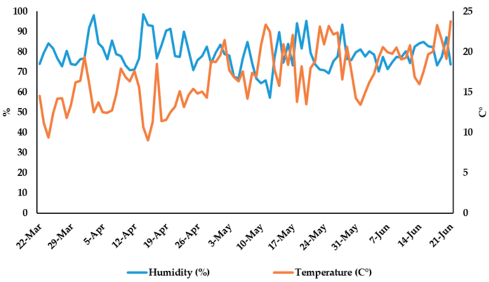

Figure 1. Average humidity and temperature during the greenhouse experiment

Growth media and rooting hormones

As substrates a mixture of peat-perlite (PP) (50-50%) and simple peat (P) were compared. The peat used in the experiment was Ageresti OÜ (Pärnu, Estonia). The pH of the substrate was 5-6.5, the fraction between 0 and 20 mm, and N:P:K content 14:10:18. Yet, we have supplemented the N:P:K content with 50-260 mg/L of N, 50-260 mg/L P_2O_5, and 50-340 mg/L of K_2O. The perlite granule size was 6 mm.

The selected rooting hormones for the treatments were Incit 8-I8 (0.8% 1–Naphthaleneacetic acid) (AMVAC Chemical UK Ltd., Surrey, UK), Radi-Stim® nr. 1 - R1 (CCDB Bios, Cluj, Romania), and Radi-Stim® nr. 2 - R2 (CCDB Bios, Cluj, Romania). *Mandevilla* cuttings without treatment were considered as control. The rooting hormones were selected because of their availability on the market for ornamental plants producers and for their successful use in previous studies for vegetative propagation (Panea et al., 1997; Vlad & Vlad, 2008; Jeberean & Bala, 2017; Vlad et al., 2019; Boboc et al., 2020).

Experimental design

On 17 May 2021 the cuttings from the first experiment were transplanted into 0.3 L pots in the previously mentioned growth media (PP and P), plants from the second experiment were transplanted on 7 July similarly to the first. After transplantation the plants were watered alternately with tap water and Universol Green 23-6-10 complex fertilizer (Holland Farming Agro SRL, Bucharest, Romania).

Data evaluation

Rooting percentage (% of the cuttings that developed at least one root), root volume (cm^3), number of roots, root length (cm) measurements were collected on the day of transplantation in larger pots of the cuttings. The volume of the roots was determined by filling a test tube with water in which the cuttings were immersed, and the volume of water displaced was measured. For both propagation periods growth (cm) measurements were made on day 0 on day 15 after transplantation.

Statistical analysis

Data were analyzed using Past 4 statistical software (Oslo, Norway). Data were tested for normality of errors and homogeneity of variance. All data were normally distributed. The significance of the differences between the treatments was tested by applying ANOVA, at a confidence level of 95%. When the ANOVA null hypothesis was rejected, Tukey's post hoc test was carried out to establish the statistically significant differences at $p < 0.05$.

Bars in the figures represent the means ± SE ($n = 30$). Different lowercase letters above the bars indicate significant differences between treatments, and uppercase letters indicate the significant differences between the two–growth media (Peat-Perlite and Peat), according to Tukey's test ($p < 0.05$).

RESULTS AND DISCUSSIONS

Rooting percentage

The rooting percentage of the *Mandevilla* varieties was affected in different ways by the applied rooting hormones (Figure 2). Small increases were observed in the red flower variety (peat-perlite growth medium) in the first propagation, under the influence of I8 and R2, on the other hand an inhibition of rooting percentage was recorded in the cuttings under the R1 treatment. However, in the peat substrate, high increases were recorded under the hormone treatments compared to the control (Figure 2a). According to the results obtained in PP, a small inhibition was observed in plants subjected to rooting hormones, however, in the P substrate significant increases were detected in the I8 and R2 treatments (Figure 2b). Here too, an increase in cuttings was observed under treatment I8 in PP growth medium, but no significant differences were recorded in P (Figure 2c). In white *Mandevilla* cuttings (second propagation) high increases in all three rooting hormones were observed in PP, on the other hand there was no significance in P (Figure 2d). An increase in rooting percentage was observed in the second propagation period among the white *Mandevilla* controls (Figure 2d), the root fitness of the cuttings increased significantly in the peat substrate. However, in the other results no differences were found when comparing growth media.

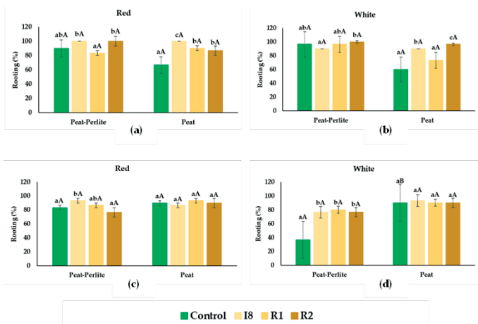

Figure 2. Influence of rooting stimulants (I8 - Incit 8; R1 - Radi-Stim® nr. 1; R2 - Radi-Stim® nr. 2) on rooting percentage of *Mandevilla*: (**a**) 'Classic Red' first propagation; (**b**) 'Classic White 16' first propagation; (**c**) 'Classic Red' second propagation; (**d**) 'Classic White 16' second propagation

Number of roots

As expected, the root number was significantly affected by the rooting hormones (Figure 3). A high increase in cuttings was detected in PP under R2 compared to the control. On the other hand, the number of roots of *Mandevilla* in peat was strongly influenced by all three hormone products (Figure 3a). No significant differences were determined between the control and the I8 treatment, but R1 and R2 greatly increased the number of roots in the PP growing medium. On P substrate, in the first propagation period, the number of roots of white *Mandevilla* cuttings was significantly increased by I8 and R2 hormones compared to the control (Figure 3b). In the second propagation period, the number of roots of red *Mandevilla* cuttings increased with I8 and R2 in peat-peat moss, however in peat significant differences were determined only in R2 (Figure 3c). Root number was greatly improved in the I8 treatment and in PP growth medium; no significance was observed in the other two treatments. A small inhibition of root number was recorded in R1/P compared to the control, also I8 and R2 increased root number, but by a small percentage (Figure 3d). Significant differences between growth media were observed in the second propagation period in the white cuttings (Figure 3d); in the peat substrate the number of roots was significantly higher than in peat-perlite only in the control and R2 treatments.

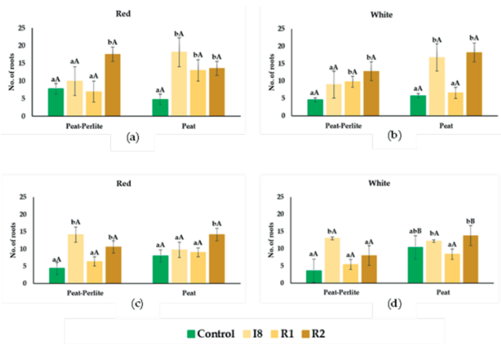

Figure 3. Influence of rooting stimulants (I8 - Incit 8; R1 - Radi-Stim® nr. 1; R2 - Radi-Stim® nr. 2) on number of roots of *Mandevilla*: (**a**) 'Classic Red' first propagation; (**b**) 'Classic White 16' first propagation; (**c**) 'Classic Red' second propagation, (**d**) 'Classic White 16' second propagation

Root length

Regarding root length, the hormones influenced the root growth in different ways, although in most cases their effect was positive (Figure 4). In the first propagation trial, rooting hormones increased the root length of the cuttings in all treatments/culture media compared to the control (Figure 4a). Root length of white cuttings was also positively affected under the treatments in both substrates; however, in the peat substrate no significant differences were found between control and R1 (Figure 4b). In the second propagation period, root length of red *Mandevilla* cuttings only increased in I8 and R2 on PP growing media, and in peat under R1 and R2 treatments (Figure 4c). As for the white cuttings in the second propagation period, their root length increased significantly with all three hormones compared to the untreated ones in PP. However, only small increases were observed in the peat substrate between treatments, and R1 even decreased root length (Figure 4d). When comparing growth media, increases in root length were detected in red cuttings in the second propagation period (Figure 4c), but only in the R1 treatments; root volume increased greatly in peat growth media compared to peat-perlite.

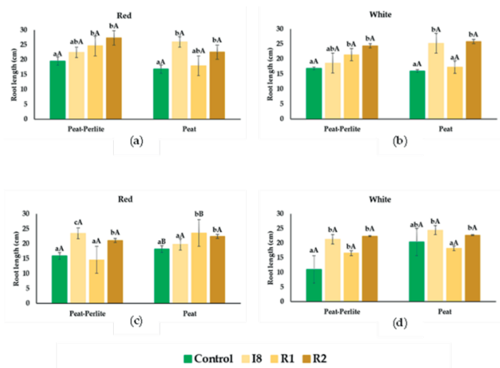

Figure 4. Influence of rooting stimulants (I8 - Incit 8; R1 - Radi-Stim® nr. 1; R2 - Radi-Stim® nr. 2) on root length of *Mandevilla*: (**a**) 'Classic Red' first propagation; (**b**) 'Classic White 16' first propagation; (**c**) 'Classic Red' second propagation; (**d**) 'Classic White 16' second propagation. Bars represent the means ± SE (n = 30)

Root volume

As expected, root volume significantly increased in almost all treatments compared to control (Figure 5). In the first propagation experiment rooting hormones highly increased the root volume of the *Mandevilla* cuttings on both growth media (Figure 5a). Similar to the previous results significant differences were determined when comparing the treated and untreated cuttings (Figure 5b). Under our experimental conditions significant differences between the growth media were observed in the second propagation time: the red variety´s root volume considerably increased on peat-perlite substrate in cuttings treated with I8 (Figure 5c) and that of white *Mandevilla* increased significantly on peat in the untreated plants (Figure 5d). No significant differences were found between the cuttings treated with R1 in PP, but the application of I8 and R2 highly increased the root volume. Although cuttings planted in peat showed an increased volume when subjected to the selected treatments (Figure 5c). In the white variety planted on PP growth medium, significant differences were determined when comparing I8 and R2 treated cuttings with the control, however in P only in the R2 treatment were found increments compared to the untreated cuttings (Figure 5d).

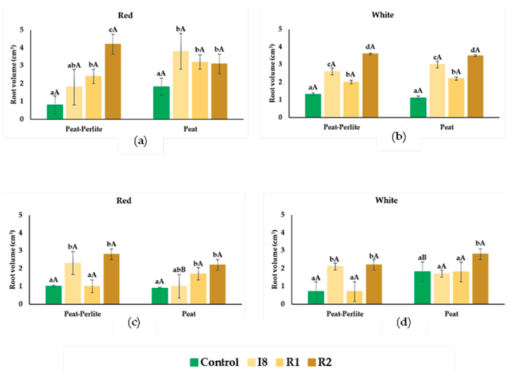

Figure 5. Influence of rooting stimulants (I8 - Incit 8; R1 - Radi-Stim® nr. 1; R2 - Radi-Stim® nr. 2) on root volume of *Mandevilla*: (**a**) ‘Classic Red’ first propagation; (**b**) ‘Classic White 16’ first propagation; (**c**) ‘Classic Red’ second propagation; (**d**) ‘Classic White 16’ second propagation

Growth

It was observed that rooting hormones can influence growth only to a minor extent (Figure 6). In the red *Mandevilla* cuttings from the first propagation experiment, only in the growth medium PP R1 did the growth of the cuttings increase significantly (Figure 6a). In the white cuttings, no significant differences were found in any of the treatments or growth media after 15 days of observation (Figure 6b). In the case of red cuttings in the second propagation period, significant increases were only recorded in peat-perlite in the R2 treatment; no significant differences were determined in the other variants (Figure 6c). Similar to the previous results, no significant changes were recorded in PP, and in P only growth inhibition was observed in treatment I8 compared to untreated cuttings (Figure 6d). Comparing the results of the growth media, it can be stated that the growth of cuttings in peat-perlite exceeded that of cuttings planted in peat only (Figure 6d).

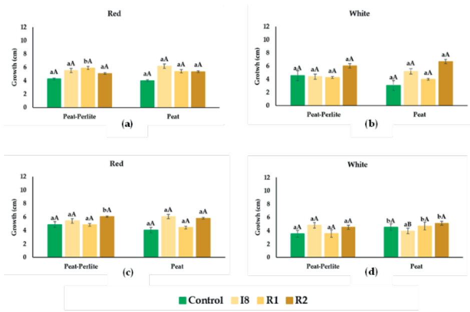

Figure 6. Influence of rooting stimulants (I8 - Incit 8; R1 - Radi-Stim® nr. 1; R2 - Radi-Stim® nr. 2) on growth of *Mandevilla*: (**a**) ‘Classic Red’ first propagation; (**b**) ‘Classic White 16’ first propagation; (**c**) ‘Classic Red’ second propagation; (**d**) ‘Classic White 16’ second propagation

The results of the present study indicate that appropriate rooting stimulants can have a positive influence on the rooting of Brazilian jasmine. Rooting hormones can influence the rooting ability of different ornamental plants to obtain maximum percentage of rooted cuttings in a short period of time (Chaudhari et al., 2018; Kumar et al., 2019; Kumar et al., 2020; Kaushik & Shukla, 2020; Sao, 2021). The addition of external hormones to unrooted cuttings can influence and accelerate the rooting process of the plants and may even influence plant growth. Rooting hormones application can improve recovery of the wounded surface, also can influence a rapid appearance of adventitious roots, which can highly increase the survival rate (Kentelky et al., 2021).

Growth and development of plants are affected by different factors, among which rooting media is one of the most vital factors which can have a major role in the adventitious rooting appearance (Kumar et al., 2019). For proper rooting and growth, the substrate must provide water, supply nutrients, permit gas exchange and should also support the plant (Younis et al., 2007; Waseem et al., 2013). Our findings indicate that the growth media in some cases induced changes in the measured parameters, but no distinguishable results were found, so we cannot state that one of the substrates is more efficient than the other for the rooting process. Therefore, we can assume that for rooting of *Mandevilla* both types of growth media are optimal to be used for vegetative propagation.

From our results, it can be concluded that the hormones enhanced the rooting percentage of the two *Mandevilla* varieties. However, it is important to mention that in the second propagation period in the peat growth medium there was no significant increase in the treated cuttings compared to the untreated ones. This could be explained by an effect of the planting substrate, with better peat retaining moisture better and ensuring a higher amount of nutrients for the unrooted cuttings. In a previous study Radi-Stim was reported to increase the rooting percentage of Campsis and Lonicera cuttings compared to another stimulator (Jeberean et al., 2016).

The application of rooting stimulants increased the number of roots; however, I8 and R2 induced greater increases than R1. In previous studies it was reported that Radi-Stim® nr. 2 increased the number of roots of *Laurus nobilis* by 85% compared to the control (Vlad & Vlad, 2008). Also, it was determined that 0.001% of 1-Naphthaleneacetic acid clearly increased the rooting percentage of *Ficus benjamina* L. (Topacoglu et al., 2016).

The data obtained show that rooting stimulants can have a clearly positive effect on the root length of *Mandevilla* cuttings. In our experimental conditions, I8 and R2 greatly increased root length in both varieties and propagation periods. On the other hand, the rooting hormone R1 did not report such a high increase, however in the first propagation period the red and white cuttings on PP substrate and in the second propagation experiment the red ones on P and the white ones on PP induced an increase in root length compared to the control. Previously Radi-Stim was found to positively influence the root length of *Bougainvillea brasiliensis* (Vlad et al., 2009).

The root volume of the cuttings was affected by the rooting hormones used, especially in the first propagation period, where all three stimulants increased the root volume in the two varieties. In the second propagation period, on PP substrate, only I8 and R2 showed significant effects and on peat the two Radi-Stim products determined significant changes. A similar influence was observed in peat-perlite on white variety's cuttings, although in peat only R2 increased the root volume. Previous studies have also reported great increases in root volume under different stimulants (Asănică et al., 2017).

From our results, it can be concluded that the rooting stimulator did not have strong effect on growth after 15 days. R1 increased the growth of the cuttings only in the PP growth medium in the red *Mandevilla* cuttings in the first propagation period. A positive influence was also observed in the second propagation period in the red cuttings in the same substrate, but in this case in the cuttings treated with R2. In the second propagation period of white cuttings in peat, an inhibition was determined in plants subjected to rooting hormone I8. Altogether, can be concluded that stimulants could have positive/beneficial effects on the rooting and survival rate of the cuttings (Nita & Iancu, 2009; Ghosh et al., 2017; Kumar et al., 2020).

CONCLUSIONS

The present study provides data on the comparison of three rooting hormones and two rooting media on the propagation of two varieties of *Mandevilla sanderi*. According to the results, it can be concluded that Incit 8, Radi-Stim® nr. 1 and Radi-Stim® nr. 2 have a positive effect on rooting of cuttings, but mostly when cuttings were treated with I8 and R2. These two rooting stimulants had a greater effect on the rooting percentage of the cuttings and also on the other measurements. However, none of the applied treatments showed any effect on the growth of the cuttings. With regard to the growth media, it was found that peat-perlite and peat did not influence the initiation of the roots of the cuttings or their growth. Regarding the differences between the two varieties could be concluded that in most of the case both varieties recorded almost similar data, although the 'Classic Red' variety growth was above the 'Classic White 16'.

ACKNOWLEDGEMENTS

The authors are grateful to John R. Akeroyd for his English language corrections. The author would like to express their special thanks to Szilárd Szántó for the help with this research.

REFERENCES

Anfang, M., & Shani, E. (2021). Transport mechanisms of plant hormones. *Current Opinion in Plant Biology*, *63*, 102055.

Asănică, A., Tudor, V., Sumedrea, D., Teodorescu, R.I., Peticilă, A., & Iacob, A. (2017). The propagation of two red and black currant varieties by hardwood cuttings combining substrate and rooting stimulators. *Scientific Papers. Series B. Horticulture*, *11*, 175–181.

Boboc (Oros), P., Catana, C., Gocan, T., Moldovan, G., Székely-Varga, Z., & Cantor, M. (2020). Influence of Culture Substrates and Biostimulators on *Passiflora* Rooting. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Horticulture*, 77.

Chaudhari, B.B., Bhatt, D., Chawla, S.L., Patel, M.A., & Bennurmath, P. (2018). Effect of rooting hormone and media on root induction in poinsettia (*Euphorbia pulcherrima* Willd.). *Journal of Ornamental Horticulture*, *21*, 7–12.

Cordeiro, S.Z., Simas, N.K., de Oliveira Arruda, R.D.C., & Sato, A. (2011). Composition of epicuticular wax layer of two species of *Mandevilla* (*Apocynoideae*, *Apocynaceae*) from Rio de Janeiro, Brazil. *Biochemical Systematics and Ecology*, *39*, 198–202.

Cordeiro, S.Z., Simas, N.K., Henriques, A.B., Lage, C.L.S., & Sato A. (2012). Micropropagation of *Mandevilla moricandiana* (a. DC.) Woodson. *In Vitro Cellular & Developmental Biology-Plant*, *48*, 620–626.

Cordeiro, S.Z., Simas, N.K., Henriques, A.B., & Sato, A. (2014a). *In vitro* conservation of *Mandevilla moricandiana* (*Apocynaceae*): short-term storage and encapsulation–dehydration of nodal segments. *In Vitro Cellular & Developmental Biology-Plant*, *50*, 326–336.

Cordeiro, S.Z., Simas, N.K., Henriques, A.B., & Sato, A. (2014b). Micropropagation and callogenesis in *Mandevilla guanabarica* (*Apocynaceae*), an endemic plant from Brazil. *Crop Breeding and Applied Biotechnology*, *14*, 108–115.

Davies, P.J. (2010). The plant hormones: their nature, occurrence, and functions. In: *Plant hormones. Dordrecht, Netherlands Springer*, 1–15.

de Sales, M.F., Kinoshita, L.S., & Simões, A.O. (2006). Eight new species of *Mandevilla* Lindley (*Apocynaceae*, *Apocynoideae*) from Brazil. *Novon, A Journal for Botanical Nomenclature*, *16*, 112–128.

Druege, U., Franken, P., & Hajirezaei, M.R. (2016). Plant hormone homeostasis, signaling, and function during adventitious root formation in cuttings. *Frontiers in Plant Science*, *7*, 381.

Faust, J.E., Dole, J.M., & Lopez, R.G. (2014). The floriculture vegetative cutting industry. *Horticultural Reviews*, *44*, 121–172.

Favara, G.M., Camelo-García, V.M., Silva, J.M., Silva, T.N., Mituti, T., Nagata, T., Kitajima, E.W., & Rezende J.A. (2020). Biological and molecular characterization of isolates of Catharanthus mosaic virus infecting *Mandevilla* sp. *Tropical Plant Pathology*, *45*, 461–465.

Geiss, G., Gutierrez, L., & Bellini, C. (2009). Adventitious root formation: New insights and perspectives. *Annual Plant Reviews*, *37*, 127–156.

Ghosh, A., Dey, K., Mani, A., Bauri, F.K., & Mishra, D.K. (2017). Efficacy of different levels of IBA and NAA on rooting of Phalsa (*Grewia asiatica* L.) cuttings. *International Journal of Chemical Studies*, *5*, 567–571.

Jeberean, M.G., Bala, M., Berar, C., & Silivasan, M. (2016). Research on rooting rate in *Campsis* cuttings and *Lonicera* cuttings treated with Atonik and Radistim under different cultural conditions. *Journal of Horticulture, Forestry and Biotechnology*, *20*, 18–21.

Jeberean, M.G., & Bala, M. (2017). The propagating trends of *Bougainvillea spectabilis* in various culture conditions treated with rhyzogene substances. *In: International Multidisciplinary Scientific GEOConference*, Sofia, *17*, 1169–1174.

Kaushik, S., & Shukla, N. (2020). A review on effect of IBA and NAA and their combination on the rooting of stem cuttings of different ornamental crops. *Journal of Pharmacognosy and Phytochemistry*, *9*, 1881–1885.

Kentelky, E., Jucan, D., Cantor, M., & Szekely-Varga Z. (2021). Efficacy of Different Concentrations of NAA on Selected Ornamental Woody Shrubs Cuttings. *Horticulturae*, *7*, 464.

Koroch, A., Juliani, H.R., Kapteyn, J., & Simon, J.E. (2002): *In vitro* regeneration of *Echinacea purpurea* from leaf explants. *Plant Cell*, *Tissue and Organ Culture*, *69*, 79–83.

Kozak, D., Parzymies, M., Świstowska, A., Marcinek, B., & Ismael, B.S. (2019). The influence of explants type and orientation on growth and development of *Mandevilla sanderi* (Hemsl.) Woodson *in vitro*. *Acta Scientiarum Polonorum Hortorum Cultus*, *18*, 111–119.

Kozak, D., Parzymies, M., Świstowska, A., Marcinek, B., & Pogroszewska, E. (2021). The influence of growth regulators and explant position on the growth and development of *Mandevilla sanderi* (Hemsl.) Woodson *in vitro*. *Acta Scientiarum Polonorum Hortorum Cultus*, *20*, 127–138.

Kumar, S., Malik, A., Yadav, R., & Yadav, G. (2019). Role of different rooting media and auxins for rooting in floricultural crops: A review. *International Journal of Chemical Studies*, *7*, 1778–1783.

Kumar, S., Muraleedharan, A., Kamalakannan, S., Sudhagar, R., & Sanjeevkumar, K. (2020). Effect of rooting hormone on rooting and survival of *Nerium* (*Nerium odorum* L.) var. Pink single. *Plant Archives*, *20*, 3017–3019.

Manikas, I., Malindretos, G., & Abeliotis, K. (2020). Sustainable Cities through alternative urban farming: the case of floriculture. *Journal of International Food & Agribusiness Marketing*, *32*, 295–311.

Mirihagalla, M.K.P.N., & Fernando, K.M.C. (2020). Effect of *Aloe vera* gel for inducing rooting of stem cuttings and air layering of plants. *Journal of Dry Zone Agriculture*, *6*, 13–26.

Nita, M., & Iancu, M. (2009). Radistim and indolil acetic acid influence on berries softwood cuttings rotting characteristics. *Scientific Papers of the Research Institute for Fruit Growing Pitesti*, *25*, 181–188.

Oder, A., Lannes, R., & Viruel, M.A. (2016). A Set of 20 New SSR Markers Developed and Evaluated in *Mandevilla* Lindl. *Molecules*, *21*, 1316.

Paiva, P.D.D.O. (2018). Horticulture and ornamental horticulture. *Ornamental Horticulture*, 24.

Panea, T., Popescu, S., Ungur, I., Mihaiescu, T., & Chitu, V. (1997). Radi-stim-a new bioregulator for rapid vegetative multiplication of the plants. *In: VIII International Symposium on Plant Bioregulation in Fruit Production*, *463*, 191–200.

Sao, B. (2021). Effect of rooting hormones in propagation of dahlia (*Dahlia variabilis* L.) through stem cutting. *Journal of Pharmacognosy and Phytochemistry*, *10*, 887–891.

The Plant List, Version 1.1. Published on the Internet. Available at http://www.theplantlist.org/ (accessed 7 December 2021).

Topacoglu, O., Sevik, H., Guney, K., Unal, C., Akkuzu, E., & Sivacioglu, A. (2016). Effect of rooting hormones on the rooting capability of *Ficus benjamina* L. cuttings. *Šumarski List*, *140*, 39–44.

Vlad, M., & Vlad, I. (2008). Stimulation of Striking Roots at the Cuttings of Laurel Tree (*Laurus nobilis*) with the Aid of Bioactive Sub-stances of the Radistim Type. *Notulae Botanicae Horti Agrobotanici*, *36*, 32–34.

Vlad, M., Vlad, I., & Bartha, S. (2019). The inducement of the rootedness process of *Hippophae rhamnoides* cutting using Radistim type bioactive substances. *Analele Universitatii din Oradea*, *32*, 83–86.

Vlad, M., Vlad, I., Mester, I., & Mester, D.G. (2009). The Inducement of the Rootedness Process of *Bougainvillea brasiliensis* Cutting Using Radistim Type Bioactive Substances. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca*, *Horticulture*, 66.

Wani, M.A., Nazki, I.T., Din, A., Iqbal, S., Wani, S.A., & Khan, F.U. (2018). Floriculture sustainability initiative: The dawn of new era. *In: Sustainable Agriculture Reviews. Cham*, Switzerland, *Springer*, *27*, 91–127.

Waseem, K., Hameed, A., Jilani, M.S., Kiran, M., Rasheed, M., Javeria, S., & Jilani, T.A. (2013). Effect of different growing media on the growth and flowering of stock (*Matthiola incana*) under the agro-climatic condition of Dera Ismail Khan. *Pakistan Journal of Agricultural Sciences*, *50*, 523–527.

Younis, A., Ahmad, M., Riaz, A., & Khan, M.A. (2007). Effect of different potting media on growth and flowering of *Dahlia coccinia* cv. mignon. *In: Europe-Asia Symposium on Quality Management in Postharvest Systems-Eurasia*, December, 2007, *804*, 191–196.

Zhang, W., Fan, J., Tan, Q., Zhao, M., Zhou, T., & Cao, F. (2017). The effects of exogenous hormones on rooting process and the activities of key enzymes of Malus hupehensis stem cuttings. *PLoS ONE*, *12*, e0172320.