International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 2103-2111, 2023; Article no.IJECC.103183
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Root Microbial Inoculants and Chitosan on Growth of Aglaonema (*Aglaonema commutatum*) Cuttings

Bashaboina Sunil [a*], P. Prasanth [b++], Lakshminarayana [c#] and Praneeth Kumar [b†]

[a] Department of Floriculture and Landscape Architecture, College of Horticulture, Rajendranagar, Hyderabad-500030, SKLTSHU, India.
[b] Floriculture Research Station, ARI, Rajendranagar, Hyderabad-500030, SKLTSHU, India.
[c] College of Horticulture, Rajendranagar, Hyderabad-500030, SKLTSHU, India.

Authors' contributions

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

Article Information

DOI: 10.9734/IJECC/2023/v13i102871

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103183

Original Research Article

Received: 27/05/2023
Accepted: 03/08/2023
Published: 04/09/2023

ABSTRACT

The present study highlights the effect of root microbial inoculants and chitosan on growth of Aglaonema (*Aglaonema commutatum*) cuttings. During October to April 2020-2021, a field investigation was conducted at Floriculture Research Station, (Agricultural Research Institute) Rajendranagar, Hyderabad, Telangana, India. The experiment consisted of two factors. The treated cuttings were put in polybags with Red soil, sand, and FYM (2:1:1) medium. *Psuedomonas* liquid formulations and VAM powder form were employed for treatment of cuttings. Treated cuttings were placed in polybags, and the soil surrounding the cuttings was tightly compacted. In solitary polybags, a single cutting was planted. Among the different treatments P_1 (Top cutting) with S_5

[++] Senior Scientist (Hort.) and Head;
[#] Associate Professor (Hort.);
[†] Scientist;
**Corresponding author: E-mail: sunil.ilaiah@gmail.com;*

(VAM - 5 g / kg media + IBA - 1000ppm) recorded best results in least number of days taken for sprouting (27.70 days), number of leaves per cutting (4.54), fresh weight of leaf (3.10 g), shoot length (28.96 cm) and shoot girth (13.00 mm) and days taken to finishing stage (125 Days). Whereas, P_1 - (Top cutting) with S_6 - (Pseudomonas fluorescence - 5 ml / kg media + IBA – 1000 ppm) recorded best results in growth rate (0.054 g).

Keywords: Root microbial; chitosan; aglaonema.

1. INTRODUCTION

"Aglaonema commutatum, often known as Chinese evergreen, is a member of the Araceae family. The genus name is derived from the Greek words 'aglaos' (bright or clear) and 'nema' (thread) in reference to the stamens. It is an evergreen perennial that looks similar to Dieffenbachia (dumb cane) and is classified as an aroid" [1]. It may reach a height of 20" and has thick, elliptic to lance-shaped dark green leaves (4-8" long and 2-3" broad) with striking silver-grey spots on upright, often branching stems. It is a houseplant that hardly ever blooms. Each axillary flower (characteristic of the arum family) has a small, creamy-white spadix enclosed by a pale green spathe, and blooming normally occurs in late summer or early fall.

Houseplants can absorb harmful substances from the air, according to the National Aeronautics and Space Administration (NASA), which found this in 1989. This work served as the foundation for further research on indoor plants such as Chinese Evergreen and their ability to purify the air. Plants, while less powerful than air purifiers, are more natural, cost effective, and soothing. For every 100 square feet, NASA advises two or three plants in 8 to 10-inch pots. Some plants are more effective than others at eliminating specific pollutants. Aglaonema grows best in 73 to 90 percent shade (about 1000 to 2400 foot-candles), with the maximum shade level needed when temperatures surpass 95°F [2]. Production of planting material in bulk through vegetative propagation byusing cuttings is peremptory to meet the great demand of planting material of *Aglaonema*. Further, the root induction and growth is very low by conventional methods of propagation. There is need to find out different methods to encourage fast root induction and growth of the plant to produce more plants in finished stage. One among the different methods is use of various root inducing substances that can promote rooting and enhance fast growth of plants propagated through cuttings.

"Chitosan is a biopolymer, a chitin derivative, and a perfectly harmless substance for the environment. This chemical has distinct features such as bioactivity and biocompatibility [3]. Chitosan can stimulate a variety of biological activities in plant tissues, including the accumulation of phytoalexins, the creation of proteinase inhibitors, and the increase of lignification. Pseudomonas also belongs to the Plant Growth Promoting Rhizobacteria (PGPR) group of bacteria, which plays an essential role in plant growth promotion, induced systemic resistance, biological pathogen control, and so on. Pseudomonas fluorescens BBc6 improves rooting and root elongation in de-rooted shoot hypocotyls of Norway spruce" (Karabaghli and colleagues, 1998). Mycorrhizal fungi such as Vesicular-Arbuscular Mycorrhizal Fungi (VAMF) are frequently found on the roots of horticultural crops. The ideal uses for commercially available VAMF inoculum are still being researched.

"The effects of VAMF root colonisation are expected to be greatest when colonisation occurs as early in plant growth as feasible. To maximise the benefits of VAMF colonisation in horticultural production systems, inoculum should be present during radicle emergence in seed germination, adventitious root formation in cutting propagation, or prior to the acclimation phase of tissue culture production" [4]. "Auxins, particularly NAA and IBA, are extensively used in horticulture to increase root initiation and rooting in plant cuttings. High auxin concentrations, on the other hand, restrict root elongation and promote adventitious root development" [5].

Pseudomonas and VAMF are crucial for cutting roots, and chitosan has a variety of biological effects in plant systems. Aglaonema is a common indoor ornamental plant that is grown from stem cuttings but develops slowly. In order to better understand how root microbial inoculant and chitosan alone and in combination with IBA affect the induction of rooting and cutting growth, the current experiment was created.

2. MATERIALS AND METHODS

The experiment was conducted from November 2020 to March 2021 at the Floriculture Research Station, (Agricultural Research Institute) Rajendranagar, Sri Konda Laxman Telangana State Horticulture University, Hyderabad.

The experiment consisted of two factors. Factor I: Two levels in portion of cutting i.e.; Top cutting (P_1), Middle cutting (P_2) and Factor II: Eight levels of bio-fertilizers, S_1 - VAM (Vesicular Arbuscular Mycorrhizae) - 5 ml / kg of media, S_2 - Pseudomonas fluorescence - 5 ml / kg of media, S_3 - Chitosan – 1000 ppm, S_4 – IBA (Indole-3-Butyric Acid) - 1000 ppm, S_5 – VAM - 5 ml / kg of media + IBA - 1000ppm, S_6 – Pseudomonas fluorescence - 5 ml / kg of media + IBA - 1000 ppm, S_7 – Chitosan – 1000 ppm + IBA - 1000 ppm and S_8- Control (without treatment).

Three replications of the experiment were used in its FCRD (Factorial Completely Randomized) design. Top cuttings, measuring 15-20 cm long with 3–4 buds, and middle cuttings, measuring 10 cm long with 2–3 buds, were selected for the therapy. The cuttings were given 1% Bavistin treatment to prevent the development of a fungal disease. They are then exposed to chitosan, microbial inoculants (*Pseudomonas fluorescence* and VAM), and IBA. The treated cuttings were put in polybags with Red soil, sand, and FYM (2:1:1) medium. *Psuedomonas* liquid formulations and VAM powder form were employed for treatment of cuttings. Treated cuttings were placed in polybags, and the soil surrounding the cuttings was tightly compacted. In solitary polybags, a single cutting was planted.

Five randomly selected rooted cuttings were taken out from polybags at 180 days after planting of cuttings with care and observations was recorded i.e., days taken for sprouting, number of leaves per cutting, fresh weight of leaf (g), shoot length (cm), shoot length (cm), shoot girth (cm), days taken for finish stage and growth rate (gm^{-2} day^{-1}).

3. RESULTS AND DISCUSSION

3.1 Days Taken for Sprouting

Table 1 shows the data collected on the number of days required for sprouting as impacted by the amount of cuttings and root microbial inoculants, chitosan, and IBA.

The amount of cuttings and the root development stimulants had a substantial impact on how long Aglaonema cuttings took to sprout. The treatment combination of P_1S_5 (Top cutting + VAM - 5 g / kg media + IBA - 1000ppm) recorded minimum number of days for sprouting (27.70 days), which was followed by P_1S_1 (Top cutting + VAM - 5 g / kg media) (29.21 days), P_1S_3 (30.00 days) and P_1S_6 (30.09 days). Whereas, the treatment combination P_2S_8 (Middle cutting + Control) recorded maximum number of days taken for sprouting (72.35 days). The other treatment combinations recorded intermediate values. The acceleration of sprouting with PGPR'S and auxins combination might be due to synergetic effect. "Mycorrhizal infection influences plant physiology by boosting photosynthetic rates, shifting the location of photosynthates in shoots and roots, and altering mineral intake from soil, all of which affect the nutritional makeup of host tissues. This shift in tissues causes structural and biochemical changes in root cells, as well as changes in membrane permeability. Auxins aid in cell proliferation and differentiation, resulting in increased shoot development, leaf area, and plant dry weight" [6].

3.2 Number of Leaves per Cutting

Table 1 and Fig. 1 show the data collected on the number of leaves per cutting as impacted by the portion of cuttings and root microbial inoculants, chitosan, and IBA.

The interaction between portion of cuttings and root growth stimulants on number of leaves per cutting of Aglaonema cuttings was significant. The treatment combination of P_1S_5 (Top cutting + VAM - 5 g / kg media + IBA - 1000ppm) recorded highest number of leaves per cutting (5.21), which was at par with P_1S_6 (Top cutting +(*P. fluorescence* 5 ml/kg + IBA – 1000 ppm) (4.94) and P_1S_2 (4.57). Whereas the treatment combination P_2S_8 (Middle cutting + control) recorded lowest number of leaves per cutting (1.00) and the other treatment combinations recorded intermediate values.

The outcome demonstrates that the application of VAM, P. fluorescence, and IBA combinations (VAM + P. fluorescence + IBA 1000 ppm) considerably enhanced the number of leaves. The application of PGPR'S caused more leaves to be seen, which may be related to cuttings' increased ability to absorb nutrients. These results are in accordance with the finding of Kumar et al. [7] in China aster. Similar finding was also observed by Kumar et al. [8]. Increase

in number of leaves may be due to vigorous growth and early initiation of root induced by the PGPR'S and IBA [9]. Similar finding was observed by Waseem et al. [10] in chrysanthemum.

3.3 Fresh Weight of Leaf (g)

Table 1 and Fig. 1 show the results on fresh weight of leaf as impacted by the proportion of cuttings and root microbial inoculants, chitosan, and IBA.

The interaction between portion of cuttings and root growth stimulants on fresh weight of leaf of Aglaonema cuttings was significant. The treatment combination of P_1S_5 (Top cutting + VAM - 5 g / kg media + IBA - 1000ppm) recorded highest fresh weight of leaf (3.10 g), which was followed by P_1S_6 (Top cutting + *P. fluorescence* 5 ml/kg + IBA – 1000 ppm) (3.05 g). Whereas the treatment combination P_2S_8 (Middle cutting + control) recorded lowest fresh weight of leaf (0.67 g). The other treatment combinations recorded intermediate values.

The increased number of leaves might be attributed to PGPR's and IBA-induced strong growth and early root initiation, which absorbed more nutrients and so generated more leaves. Similar result was reported by Stancato et al. [9] in Rhipsali grandiflora, Sohn et al. [11] in chrysanthemum.

3.4 Shoot Length (cm)

Table 2 and Fig. 1 show the data collected on shoot length as impacted by the proportion of cuttings and root microbial inoculants, chitosan, and IBA.

Table 1. Effect of portion of cuttings and root growth stimulants (microbial inoculants, Chitosan and IBA) on days taken for sprouting, number of leaves per cutting and fresh weight of leaf (g)

Root growth stimulants (s)	Days taken for sprouting			Number of leaves per cutting			Fresh weight of leaf (g)		
	Portion of cuttings (p)			Portion of cuttings (p)			Portion of cuttings (p)		
	P_1 Top cutting	P_2 Middle cutting	Mean	P_1 Top cutting	P_2 Middle cutting	Mean	P_1 Top cutting	P_2 Middle cutting	Mean
S_1-VAM - 5 g / kg media	29.21	55.66	42.43	4.33	1.32	2.83	2.09	1.19	1.64
S_2-*P. fluorescence*- 5 ml / kg media	33.13	64.29	8.71	4.57	1.28	2.93	2.14	1.63	1.88
S_3-Chitosan – 1000 ppm	30.00	63.54	46.77	4.21	1.20	2.71	2.12	1.30	1.71
S_4-IBA - 1000 ppm	29.99	55.78	42.88	4.14	1.51	2.83	2.11	1.52	1.81
S_5-VAM-5 g /kg media + IBA-1000 ppm	27.70	52.14	39.92	5.21	2.10	3.65	3.10	1.81	2.45
S_6-*P. fluorescence* (5ml/kg) + IBA-1000 ppm	30.09	56.11	43.10	4.94	1.85	3.40	3.05	1.74	2.39
S_7-Chitosan– 1000 ppm + IBA-1000 ppm	42.80	68.11	55.45	4.04	1.61	2.83	2.70	1.72	2.21
S_8-Control (untreated)	64.81	72.35	68.58	4.18	1.00	2.59	1.00	0.67	0.83
Mean	35.96	52.41		4.45	1.48		2.29	1.45	
	P	S	P X S	P	S	P X S	P	S	P X S
SEm ±	0.50	1.00	1.41	0.11	0.18	0.25	0.01	0.02	0.03
CD at 5%	1.44	2.88	4.08	0.31	0.48	0.70	0.04	0.06	0.08

The outcome demonstrates that the administration of VAM, P. fluorescent, and IBA in combination considerably lengthened the shoots. It is well known that PGPR'S improves nutrient uptake by plants as well as nutrient accumulation in plants, making it a crucial biological component that contributes to the effectiveness of nutrient uptake as well as use. Cruz et al. [12] reported that "VAM inoculation to Senna spectabilis increased total shoot length".

Similarly, IBA enhanced the shoot length of terminal cuttings in the current study, possibly due to active root development and a greater number of roots per cutting, which boosted water and nutrient intake. Furthermore, auxin promotes cell division, cell elongation, and protein synthesis, which may have resulted in improved healthy vegetative development [13]. Ganjure et al. [14] discovered similar results in chrysanthemum.

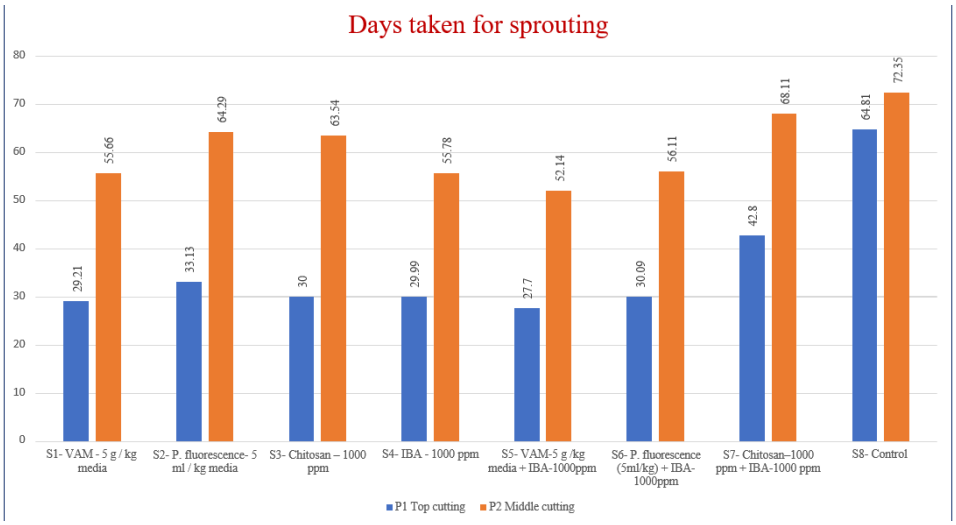
3.5 Shoot Girth (mm)

The data recorded on shoot girth as influenced by the portion of cuttings and root microbial inoculants, chitosan and IBA are presented in Table 2 and Fig. 1.

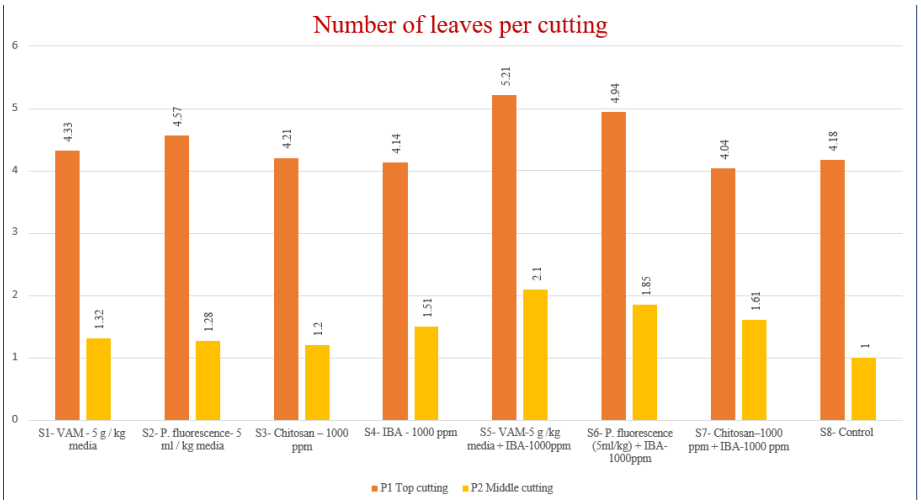
The shoot girth of Aglaonema cuttings was significantly affected by the cutting portion and root development stimulants. Maximum shoot girth (13.00 mm) was obtained by the treatment combination P1S5 (Top cutting + VAM - 5 g / kg medium + IBA - 1000 ppm), which was followed by P1S6 (Top cutting + P. fluorescence 5 ml/kg + IBA - 1000 ppm) (12.00 mm). Whereas the treatment combination P_2S_8 (Middle cutting + Control) recorded minimum shoot girth (3.68 mm). The other treatment combinations recorded intermediate values.

Table 2. Effect of portion of cuttings and root growth stimulants (microbial inoculants, Chitosan and IBA) on shoot length (cm), shoot girth (mm) and growth rate

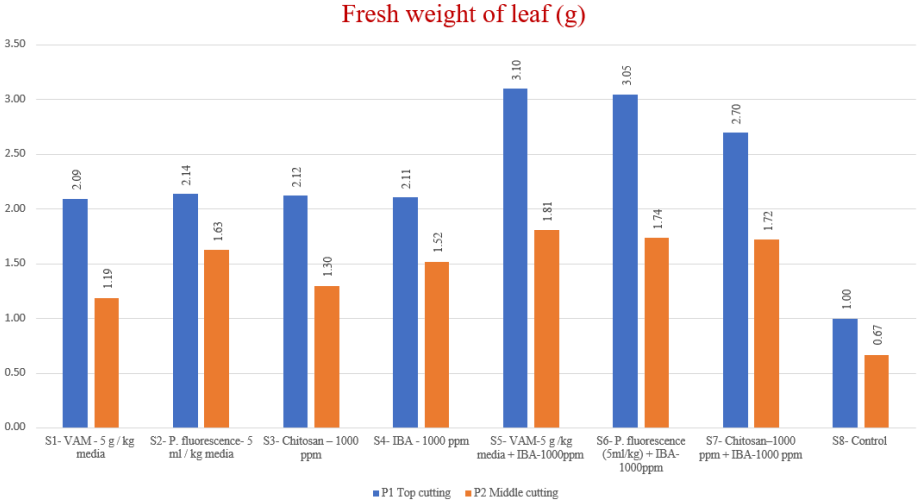
Root growth stimulants (s)	Shoot length (cm)			Shoot girth (mm)			Growth rate		
	Portion of cuttings (p)			Portion of cuttings (p)			Portion of cuttings (p)		
	P_1 Top cutting	P_2 Middle cutting	Mean	P_1 Top cutting	P_2 Middle cutting	Mean	P_1 Top cutting	P_2 Middle cutting	Mean
S_1-VAM - 5 g / kg media	16.90	5.10	11.00	10.00	4.21	7.10	0.037	0.019	0.028
S_2-*P. fluorescence*- 5 ml / kg media	19.89	6.31	13.10	10.11	4.64	7.37	0.043	0.018	0.031
S_3-Chitosan – 1000 ppm	16.78	5.90	11.34	9.21	3.79	6.5	0.041	0.021	0.031
S_4-IBA - 1000 ppm	20.12	7.24	13.68	11.17	5.01	8.09	0.041	0.017	0.029
S_5-VAM-5 g /kg media + IBA-1000 ppm	28.96	8.80	18.88	13.00	5.53	9.26	0.046	0.021	0.033
S_6-*P. fluorescence* (5ml/kg) + IBA-1000 ppm	28.06	7.94	18.00	12.00	5.31	8.65	0.054	0.022	0.038
S_7-Chitosan– 1000 ppm + IBA-1000 ppm	25.62	7.64	16.63	11.79	5.24	8.65	0.045	0.017	0.031
S_8-Control (untreated)	6.01	4.80	5.40	4.51	3.68	4.09	0.024	0.009	0.017
Mean	20.29	6.71		10.22	4.67		0.041	0.018	
	P	S	P X S	P	S	P X S	P	S	P X S
SEm ±	0.09	0.19	0.26	0.05	0.07	0.15	0.0008	0.0010	0.0024
CD at 5%	0.27	0.54	0.77	0.15	0.21	0.44	0.0024	0.0029	0.0068


Days taken for sprouting
80
70
60
50
40
30
20
10
0
29.21
55.66
33.13
64.29
30
63.54
29.99
55.78
27.7
52.14
30.09
56.11
42.8
68.11
64.81
72.35
S1- VAM - 5 g / kg media
S2- P. fluorescence- 5 ml / kg media
S3- Chitosan – 1000 ppm
S4- IBA - 1000 ppm
S5- VAM-5 g /kg media + IBA-1000ppm
S6- P. fluorescence (5ml/kg) + IBA-1000ppm
S7- Chitosan–1000 ppm + IBA-1000 ppm
S8- Control
P1 Top cutting
P2 Middle cutting

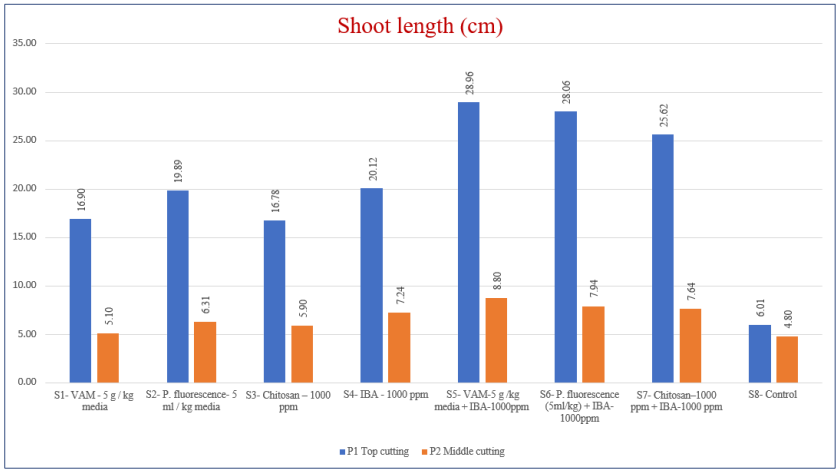
(i)


Number of leaves per cutting
6
5
4
3
2
1
0
4.33
1.32
4.57
1.28
4.21
1.2
4.14
1.51
5.21
2.1
4.94
1.85
4.04
1.61
4.18
1
S1- VAM - 5 g / kg media
S2- P. fluorescence- 5 ml / kg media
S3- Chitosan – 1000 ppm
S4- IBA - 1000 ppm
S5- VAM-5 g /kg media + IBA-1000ppm
S6- P. fluorescence (5ml/kg) + IBA-1000ppm
S7- Chitosan–1000 ppm + IBA-1000 ppm
S8- Control
P1 Top cutting
P2 Middle cutting

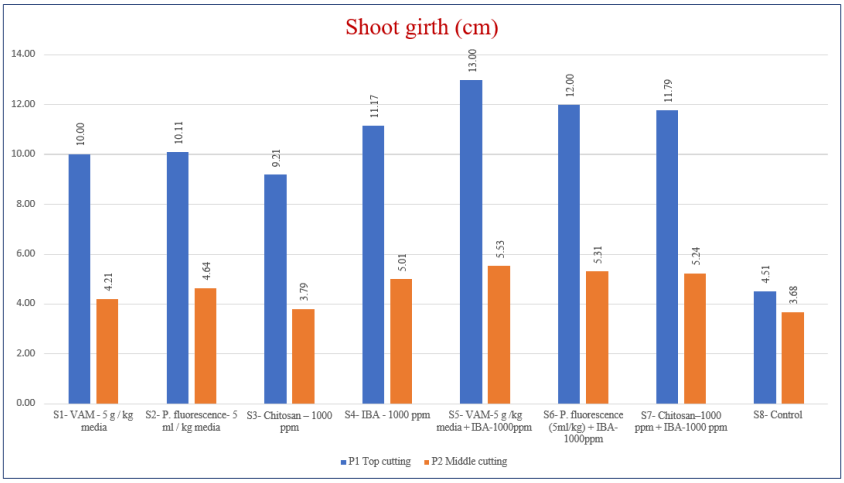
(ii)


Fresh weight of leaf (g)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.09
1.19
2.14
1.63
2.12
1.30
2.11
1.52
3.10
1.81
3.05
1.74
2.70
1.72
1.00
0.67
S1- VAM - 5 g / kg media
S2- P. fluorescence- 5 ml / kg media
S3- Chitosan – 1000 ppm
S4- IBA - 1000 ppm
S5- VAM-5 g /kg media + IBA-1000ppm
S6- P. fluorescence (5ml/kg) + IBA-1000ppm
S7- Chitosan–1000 ppm + IBA-1000 ppm
S8- Control
P1 Top cutting
P2 Middle cutting

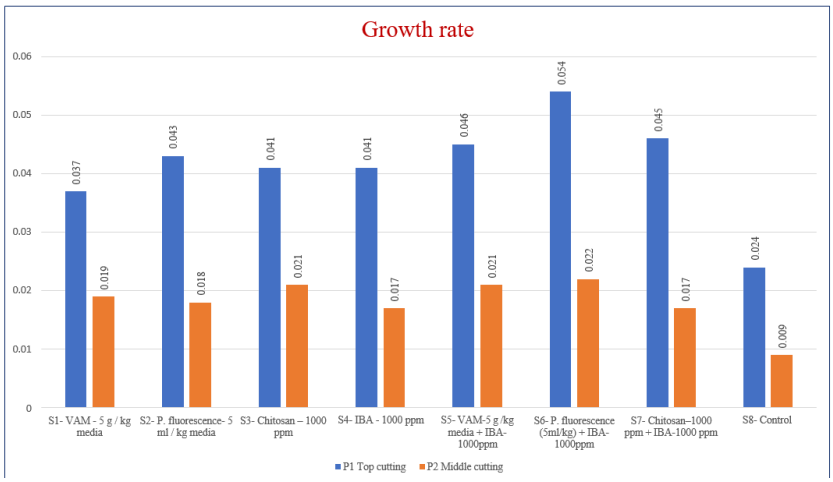
(iii)



(iv)



(v)



(vi)

Fig. 1. Effect of portion of cuttings and root growth stimulants (microbial inoculants, Chitosan and IBA) days taken to sprouting, number of leaves per cutting, fresh weight of leaf (g), shoot length (cm), shoot girth (cm) and growth rate

Table 3. Effect of portion of cuttings and root growth stimulants (microbial inoculants,chitosan and IBA) on days taken to finishing stage of Aglaonema (*Aglaonemacommutatum* L.)

Root growth stimulants (S)	Number of days taken formarketable stage	
	P1 Top cutting	P2 Middle cutting
S1- VAM - 5 g / kg media	160 Days	2 Leaf stage
S2- *P. fluorescence*- 5 ml / kg media	150 Days	2 Leaf stage
S3- Chitosan - 1000 ppm	165 Days	2 Leaf stage
S4- IBA - 1000 ppm	165 Days	2 Leaf stage
S5- VAM-5 g / kg media + IBA-1000ppm	120 Days	2 Leaf stage
S6- *P. fluorescence* -5ml/kg + IBA-1000ppm	130 Days	2 Leaf stage
S7- Chitosan-1000 ppm + IBA-1000 ppm	135 Days	2 Leaf stage
S8- Control	180 Days	2 Leaf stage

"The use of PGPR's causes the formation of special structures known as apostles and vesicles, which aid in the transfer of nutrients from the soil into the root system and have a significant effect on plant height, number of branches, leaf area, and girth" [15]. The synergistic effect of PGPR'S and auxins (IBA) enhanced the rooting parameters and there by increased water and nutrient uptake. Further increase in cell division and differentiation enhanced vegetative growth.

3.6 Growth Rate

Table 2 and Fig. 1 show the data collected on growth rate as impacted by the amount of cuttings and root microbial inoculants, chitosan, and IBA.

The interaction between cutting portion and root growth stimulants on Aglaonema cutting rooting % was significant. The treatment combination of P_1S_6 (Top cutting + *P. fluorescence* 5ml/kg + IBA – 1000 ppm) recorded maximum growth rate (0.054). Which was followed by P_1S_5 (Top cutting + VAM - 5 g / kg media + IBA – 1000 ppm) (0.046). Whereas, the treatment combination P_2S_8 (Middle cutting + Control) recorded lowest growth rate (0.009).

The results demonstrate that using P. fluorescence and IBA together (*P. fluorescence* + IBA-1000ppm) considerably boosted the growth rate. *P. fluorescence* promotes plant development directly or indirectly by producing plant growth compounds, enhancing nutrient absorption from the soil, and having antagonistic effects on some pathogenic microbes.

Further, "Pseudomonas strains with Arbuscular Mycorrhizal Fungi (AMF) induces the plant growth, probably due the hormone production and increased photosynthates which have a direct influence on growth of plant" [16]. Auxins promote cell elongation by increasing wall-loosening proteins such as elastin, which helps the plant develop Karthik et al., [17].

3.7 Days Taken to Finishing

Table 3 and Fig. 1 show the results on days taken to completion stage as impacted by the amount of cuttings and root microbial inoculants, chitosan, and IBA.

With respect to top cuttings, the finishing stage (4 Leaf stage) ranged from 120 to 180 days, while with middle cuttings, it only reached 2 Leaf stage. The amount of cuts combined with root growth stimulators has an effect on the number of days needed to reach the finishing stage. The treatment combination of P_1S_5 (Top cutting + VAM - 5 g / kg media + IBA – 1000 ppm) recorded minimum days taken to finishing (120 days), which was followed by P_1S_6 (Top cutting + *P. fluorescence* 5 ml / kg + IBA - 1000ppm) (130 days). Whereas, the treatment combination P_1S_8 (Top cutting + Control) has reached the marketable stage at 180 days [18].

4. CONCLUSION

The current study found that among the various combinations of treatments, T5 (P1S5) (Top cutting + VAM - 5 ml / kg of media + IBA - 1000ppm) produced the best results in terms of the shortest number of days required for sprouting (27 70 days), the number of leaves per cutting (4.54), the fresh weight of a leaf (3.10 g), shoot length (28.96 cm), and shoot girt.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Chen J, Henny RJ, Mc Connell DB. Development of new foliage plant cultivars. Trends in new crops and new uses. 2002;466-472.
2. Henny RJ, Chase AR, Osborne LS. Aglaonema Production Guide. Apopka Foliage Plant Research. 1991;91-2.
3. Dias AMA, Cortez AR, Barsan MM, Santos JB, Brett CMA, De Sousa HC. Development of greener multi-responsive Chitosan Biomaterials doped with Biocompatible ammonium ionic liquids. ACS Sustainable Chemistry and Engineering. 2013;1(11):1480-1492.
4. Chang DC. Management of mycorrhizas in Agriculture, Horticulture and Forestry. Kluwer Academic Publishers. Netherlands. 1994;65–81.
5. Susaj EL, Irena K. Effect of different NAA and IBA concentrations on rooting of vegetative cuttings of Two Rose cultivars. Research Journal of Agricultural Science. 2012;44(3):121-127.
6. Gollan JR, Wright JT. Limited grazing pressure by native herbivores on the invasive seaweed Caulerpa taxifolia in a temperate Australian estuary. Marine and freshwater Research. 2006;57:685-694.
7. Kumar P, Raghava SPS, Misra RL. Effect of Biofertilizers on growth and yield of China aster. Journal of Ornamental Hort. 2003;6(2):85-88.
8. Kumar KR, Singh KP, Raju DVS. Symbiotic Effect of *Arbuscular mycorrhizal* Fungi on Growth and Flowering of Micro propagated Plants of Chrysanthemum (*Chrysanthemum dendranthemum*). International Journal of Bio-resource and Stress Management. 2014;5(3):369-374.
9. Stancato GC, Aguiar FFA, Kanashiro S and Tavares AR. Rhipsali grandiflora Haw. Propagation by stem cuttings. Scientia Agricola. 2003;56:185-190.
10. Waseem K, Jilani MS, Jaskani MJ, Khan, MS, Kiran M, Khan GU. Significance of Different Plant Growth Regulators on the Regeneration of Chrysanthemum Plantlets (*Dendranthema morifolium* L.) through Shoot Tip Culture. Pak. Journal of Botanical. 2011;43(4):1843-1848.
11. Sohn BK, Kim KY, Chung JS, Kim WS, Park MS, Kang JG, Rim YY, Kim TH. Hyun LJ. Effect of the different timing of AMF inoculation on plant growth and flower quality of chrysanthemum, Scientia Horticulturae. 2003; 98(2): 173-183.
12. Cruz RED, Husain TA. Effect of vesicular *Arbuscular mycorrhiza* (VAM) fungi inoculation on coppicing ability and drought resistance of Senna spectabilis. Pak. J. Bot. 2008;40(5):2217-2224.
13. Kumaresan M, Kannan M, Sankari A, Chandrasekhar CN, Vasanthi D. Phytochemical screening and antioxidant activity of *Jasminum multiflorum* (Pink Kakada) leaves and flowers. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):1168-1173.
14. Ganjure SL, Gawande MB. Golliwar VJ. Response of IBA and Rooting Media on Rooting of Cutting in Chrysanthemum. International Journal of Science and Research. 2012;3(7):1306-1310.
15. Rabin CP, Chikkaswamy BK. Effects of VAM and Biofertilizers on some Medicinal Plants. International Journal of Current Microbiology Applied Science. 2014;3(6): 1016-1027.
16. Matheus CA, Freitas SS. Effect of Pseudomonas putida on chrysanthemum growth under greenhouse and field conditions. African Journal of Agricultural Research. 2018;13(6):302-310.
17. Karthik P and Mohapatra PP. Role of Auxin on growth, yield and quality of Tomato. International Journal of Current Microbiology and Applied Sciences. 2017; 6(11):1624-1636.
18. Karbaghil C, Frey PK, Sotta B, Tacon FL. Invitro effects of *Laccaria bocolor* S238N and *Pseudomonas fluorescens* strain BBc6 rooting of de-rooted shoot hypocotyl of Norway spruce. Tree physiology. 1998;18: 103-111.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103183