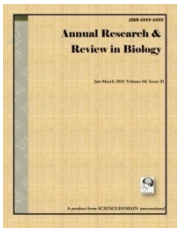

Annual Research & Review in Biology
4(18): 2892-2900, 2014

SCIENCEDOMAIN *international*
www.sciencedomain.org

Enhanced Rooting of Leaf Bud Cuttings of *Schefflera arboricola* Using Mycorrhizal Fungi

Bidarnamani Fatemeh[1*] and Mohkami Zaynab[1*]

[1]Institute of Agricultural Research, University of Zabol, Zabol, Iran.

Authors' contributions

Author BF wrote the protocol, managed the statistical analyses and wrote the manuscript. Author MZ managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

Received 16th November 2013
Accepted 11th March 2014
Published 15th May 2014

ABSTRACT

Aims: *Schefflera arboricola* is an evergreen shrub in the family Araliaceae. Beside Mycorrhizae are symbiotic associations which can enhance rooting of horticulture plants. Although commercially produced inoculum of mycorrhizal fungi is readily available to horticulturist, cultivar specific responses to inoculation are unclear. The objective of this study was to evaluate the effect of the inoculation with mycorrhizal fungi on the rooting of cuttings of *Schefflera arboricola*.
Study Design: The rooting test of cuttings involved a one-factor (inoculation) randomized block design with 3 replication plots with 27 cuttings.
Place and Duration of Study: This experiment was executed in the greenhouse of Research Institute in University of Zabol in Iran on May 2013. Duration of experiment was approximately 45 days.
Methodology: This experiment was carried out by application of 2 species of *Glomus* as mycorrhizal fungi and their blend to rooting media on *Schefflera* cuttings and comparison of them to non-inoculated cuttings. Parameters such as rooting, number of root, total length of root, root fresh and dry weight per each cutting were measured.
Results: The result showed Using mycorrhizal fungi in rooting substrate increased root initiation, number of rooted cuttings and number of roots per each cutting compared to control treatments. Although the effect of MF on root length wasn't significant, the greatest total root length per cutting was observed in *G. mosseae* fungi with nearly 55 cm, whiles cutting in control treatments had 2.97 cm total root length. Also the effect of MF on root fresh and dry weight wasn't significant, but in these characteristics mosseae treatments

**Corresponding author: Email: f.bidarnamani65@uoz.ac.ir, zaynabmohkami@uoz.ac.ir;*

was better than the others. Observation of roots by microscope showed Symbiosis between plants and fungi. Thus application of mycorrhizal fungi can enhanced the rooting of *Schefflera* cuttings and greenhouse owner can use this way for acceleration to ornamental plants production.

Keywords: Rooting; Glomus intraradices; Glomus mosseae; schefflera cuttings; mycorrhizal fungi.

1. INTRODUCTION

Schefflera arboricola is a plant in the Araliaceae family, native to the islands of Taiwan and Hainan, China. It is an evergreen shrub which can reach to 3-4 m tall [1].

Mycorrhizal fungi are specialized organisms that live on plant roots in relationship that is mutually beneficial. The host plant supplies the fungus whit carbohydrates producted during photosynthesis. In return, the fungus grows an extensive network in to the soil, transferring water and nutrients to the roots and providing a protective environment [2].

VAMF[1] are one type of mycorrhizal fungi that are commonly associated with the roots of horticultural crops. Approximately 150 species of AMF[2] are known to form symbiotic associations with up to 80% of land plants [3].

The addition of mycorrhizal fungi into the rooting substrate during cutting propagation can increase rooting in different plants [4,5,6].

Mycorrhizal roots usually grow faster, are larger, and more physiologically active than non-mycorrhizal roots. The improved nutrient uptake is more obvious in low fertility soil [7]. AMF are capable of assisting the plant with uptake of potassium, nitrogen, zinc, copper. As a result of that capability, AMF can increase plant dry weight [8]. Aeroponically produced of AMF inoculums shows tremendous impact on plant growth and health which permit a satisfactory reduction of chemical fertilizer and pesticide inputs [9].

In regards to adventitious root formation, both endo- and ectomycorrhiza can enhance adventitious root formation of cuttings. They can be enhanced root initiation and root development. The ectomycorrhiza are capable of producing auxins, gibberellins, and other phytohormones. With some of the more difficult- to- root plant species, it may be useful to try combinations of mycorrhiza and auxines to stimulate better root formation. The ectomycorrhiza *Glomus intradices* increased adventitious rooting of softwood cuttings and liner plant development of desert willow [10].

There was a significant effect of commercial mycorrhizal inoculant, potting medium, and a significant interaction between both factors for shoot height and dry mass in plant nursery conditions [11].

A vesicular- arbuscular mycorrhizal fungus in a peat-based medium significantly increased survival, callus development, and rooting percentage of *Sciadopitys verticillata* cuttings over no inoculated cuttings [4].

---

[1]: *Vesicular–Arbuscular Mycorrhizal Fungi*
[2]: *Arbuscular Mycorrhizal Fungi*

Inoculation with *Piriformospora indica* dramatically enhanced the number and length of the adventitious roots in pelargonium and poinsettia. Root colonization parameters suggest that; The interaction between the endophyte and cuttings had already occurred before physical contact [12].

In some roses cultivars the combination of VAMF inoculum and rooting hormones can increase root initiation and potentially increase the quality of rooted cutting produced [13].

When inoculum of ectomycorrhiza fungi was added to the rooting medium, the percentage of rooted cuttings and the root volumes on cuttings of bearberry and hackberry were significantly greater than those of the uninoculated controls. In some tests, inoculum of one fungus enhanced rooting of one cultivar of bearberry, but not another, suggesting a specific interaction between the cultivar and fungus [14].

The number of roots per cutting was significantly higher in presence of mycorrhizal fungi when compared to control, whit a similar observation for total root dry weigh and results were equal or better than using only a rooting hormone [13].

Mycorrhizal inoculation of rooting substrate positively affected fresh weight, dry weight and total shoot length of *Verbena* plants and dry weight and total shoot length of *Torenia* plants. Mycorrhizae improved leaf color of all three species [15].

The addition of mycorrhizal fungi into the rooting substrate during cutting propagation can increase rooting in different plants. However, few of these studies were conducted in production nurseries. Although commercially produced inoculums of VAMF is readily available to horticulturalists, the relationship, if any, between inoculum quantity and plant response is unclear [13].

Incorporation of mycorrhizal inoculum into rooting media during cutting propagation can increase the quantity of rooting and the quality of rooted cuttings for different cultivars of woody horticultural crops [16].

2. MATERIALS AND METHODS

This experiment was executed in the greenhouse of Research Institute in University of Zabol in Iran in 2013. This trial involved four treatments: control uninoculated plants, plants inoculated with *Glomus intraradices,* plants inoculated with *Glomus mosseae*, and plant inoculated with 2 inoculants (*G. intraradices* + *G. mosseae*).

On May 2013 cuttings were taken with 15-20 cm length, 3-4 nodes and 2-3 leaves from greenhouse Schefflera plants. cuttings were dipped for 5 s in 4000 $mg \cdot L^{-1}$ rooting hormone solution Indol-3-butyric acid (IBA) then stuck in 150 × 70 × 10 cm flats filled with a custom blend of small perlite/cocopeat/sand (1:1:1 by volume). Cuttings were placed under mist (each 0.5 hours, 1 minute mist) and watered as needed in a greenhouse with no bottom heat. The rooting test of cuttings involved a one-factor (inoculation) randomized block design with 3 replication plots with 27 cuttings. Two nodes of these cuttings were stuck vertically into the rooting substrate in flats. It was used 100g mycorrhizal fungi in each meter of media. There are 30-50 spores of fungi in 1 gr of them. Cuttings were covered with a cotton sheet to reduce transpiration losses and sun ray. The nursery standard disease and pest control were performed during the rooting period.

The experiment was conducted with 324 sources of cuttings (each treatment had 81 cuttings) to evaluate the effect of mycorrhizal fungi on rooting of schefflera cuttings. Forty-five days after transplanting the cuttings, factors such as number of rooted cuttings, number of rootlet in each cutting, total root length in each cutting, fresh and dry weight of root were measured. Also the roots of inoculated cutting were sawn by microscopic for observation of mycorrhizal fungi hyphae. First part of root section, after washing by aquapura crush by Lamella, then colored by red Methyl, Afterwards the hyphae of fungi was sawn by microscope. Data analyzed by SPSS software with significance at P≤ 0.05 and average comparison had done by Duncan way.

3. RESULTS AND DISCUSSION

Data analysis by SPSS showed the effect of mycorrhizal fungi on rooting of schefflera cuttings is significant.

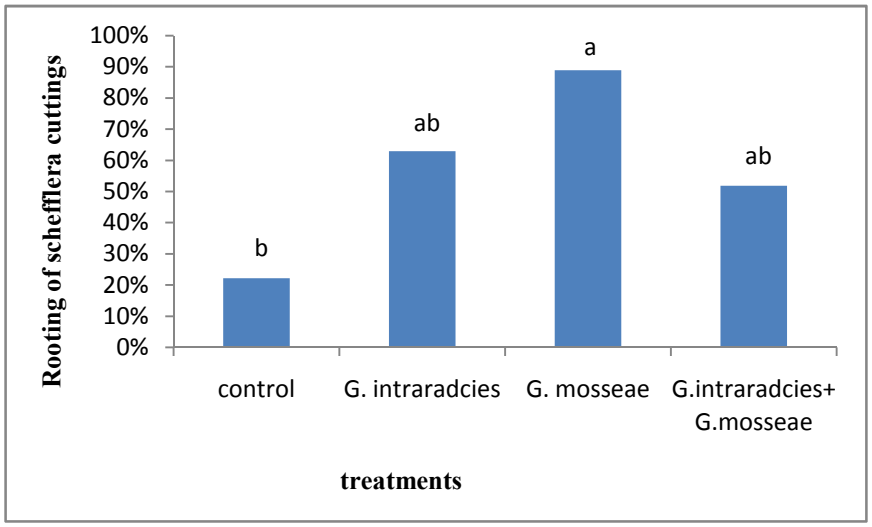

Chart 1. Effect of mycorrhizal fungi on rooting of schefflera cutting (P≤ 0.05). Treatments with the same letters were not significantly different

Adventitious roots formation in cuttings of *schefflera* was obviously induced by inoculation with mycorrhizal fungi. According to above diagram (Chart 1), adding mycorrhizal fungi into the rooting substrate influenced rooting of schefflera cuttings compared to controls significantly. *G. mosseae* had the most rooting of cutting, but it hadn't had significant differences to *G. intraradices* and *G. intraradices* + *G. mosseae* treatments. Only *G. mosseae* treatments had significant effect to control in rooting characteristic which cutting in this treatment had rooting about four times more than Control. These differences showed that in ornamental plants schefflera, it can utilize mycorrhizal fungi for acceleration of rooting.

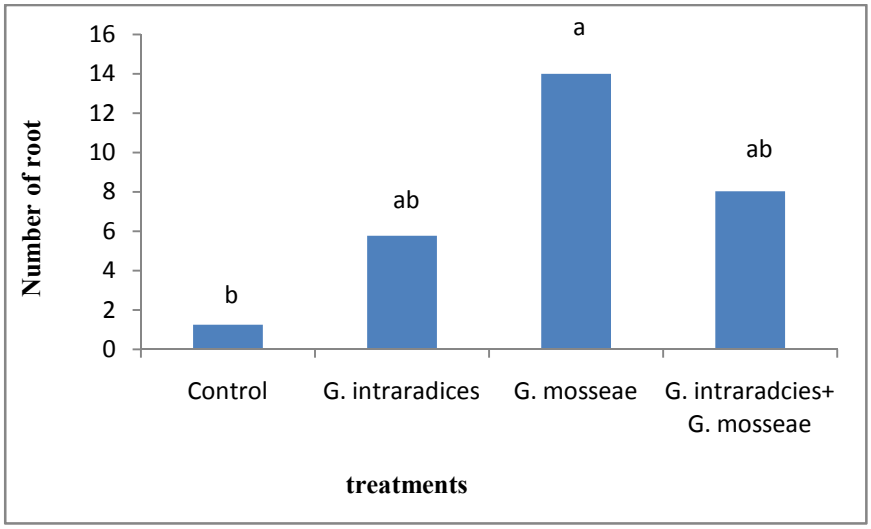

Chart 2. Effect of mycorrhizal fungi on number of roots in schefflera cutting (P≤ 0.05). Treatments with the same letters were not significantly different

Data analyzes showed the effect of mycorrhizal fungi on number of roots per cuttings were significant. Number of roots averaged over four treatments indicated effect of *G. mosseae* fungi hadn't had significant difference than *G. intraradices* and *G. intraradices* + *G. mosseae*, despite the greater number of roots was observed in this treatment.

The effect of VAMF on length of roots hadn't had significant effect but the diagram (Chart 2) showed the greatest root length was observed in *G. mosseae* treatments.

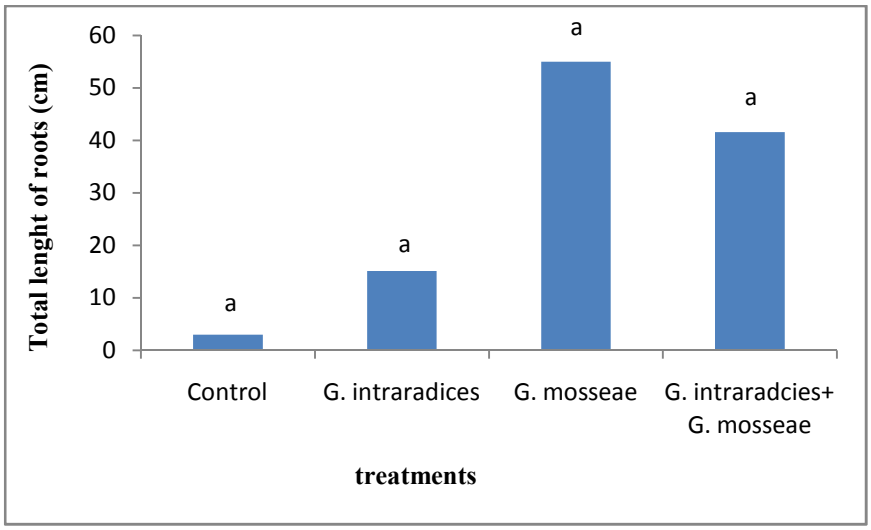

Chart 3. Effect of mycorrhizal fungi on total length of root in schefflera cutting (P≤ 0.05). Treatments with the same letters were not significantly different

At the end of the trial schefflera cutting inoculated with *G.mosseae* had formed nearly 14 roots with a total length of 55 cm compared with 1.26 roots with a total length of 2.97 cm in the non-inoculated controls. Differences in number of roots and their length (Chart 3) were very significant between high treatment and control. So utilization of mycorrhizal fungi specifically *G. mosseae* eventuate qualitative and quantitative characteristics in cuttings. So utilization of *G. mosseae* showed better results than *G.intraradices* and *G.mosseae+ G.intraradices* for having a good cutting in this foliage plant (Table 1).

Effect of mycorrhizal fungi on *schefflera* cutting in this trial hadn't had significant differences on root fresh and dry weights. But *G.mosseae* was high than the other treatments in these characteristics, too.

Mycorrhization significantly increased the length and fresh and dry weights of osteospermum root. AMF increased the length and fresh weight of geranium roots, too, which conform to our result [17]. Root growth and functional during rooting of cuttings are dependent mainly on carbohydrates originating from current photosynthesis. After inoculation the fungus competes for assimilates with developing root system, particularly in conditions of low irradiation during rooting of cuttings. It is well known, that the mycorrhizal plants can compensate the higher carbohydrate demand by increase in rate of photosynthesis [18].

During rooting photosynthesis rate can rather be regulated by sink strength, because development of root system and fungus development take place at the same time creating high carbon demand. The increase in sink strength of root system of mycorrhizal *Trifoliumrepens* was suggested to be the cause of increased photosynthesis over non mycorrhizal plants [19].

Increase in the rate of photosynthesis in mycorrhizal plants can be also mediated by increased by P nutrition [18]. Water status of cuttings during rooting process is very important for cutting survival and subsequent growth. Mycorrhizal symbiosis usually promotes transpiration and stomatal conductance [20]. However, in some plants AMF colonization resulted in no effects [21] or even decrease in these parameter values [22].

According to Fig. 1, Hyphae extend out from roots into rooting medium in cuttings that inoculated with mycorrhizal fungi.

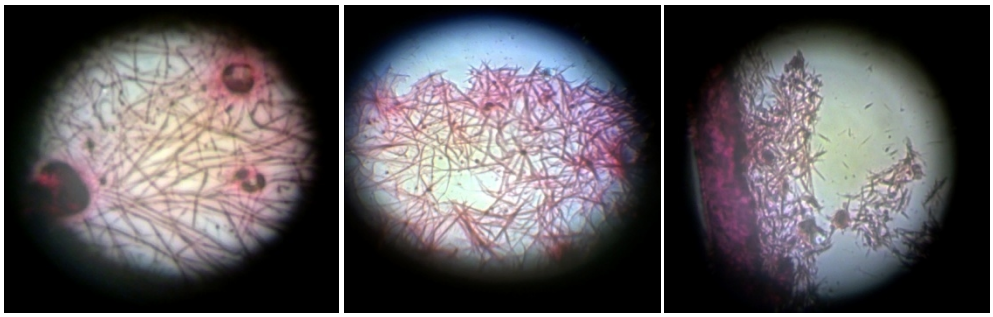

Fig. 1. Rooting inoculum with *G. intraradices* (right picture); *G. mosseae* (middle picture); *G. intraradices* + *G. mosseae* (left picture)

Table 1. Mean square of schefflera cuttings characteristics and their significant words

Treatments	Rooting (%)	Number of root	Total roots length (cm)	Root fresh weight (gr)	Root dry weight (gr)
Control	22.2[b]	1.26[b]	2.963[a]	0.0670[a]	0.0159[a]
G. intraradices	63.0[ab]	5.78[ab]	15.152[a]	0.2311[a]	0.1111[a]
G. mosseae	88.9[a]	14[a]	54.996[a]	0.6157[a]	0.2030[a]
Mix (*G. intraradices* + *G. mosseae)*	51.9[ab]	8.04[ab]	41.607[a]	0.3552[a]	0.1733[a]

Mean square of some characteristics on schefflera cutting showed the effect of mycorrhizal fungi treatment on rooting and number of root was significant, but total roots length, root fresh weight and root dry weight wasn't significant (P≤ 0.05).

4. CONCLUSION

The result of this experiment and other literature suggest that adding mycorrhizal fungi into the rooting medium can achieve a rooting response that is better than the response obtained by using rooting hormone alone. So application of mycorrhizal fungi can use as a stimulant ingredient in rooting of cutting in ornamental plant especially in hardwood-cuttings and it causes upheaval in ornamental plant production industry.

Mycorrhizal symbiosis may enhance the root system's ability to absorb soil elements of low mobility, by means of a network of mycelia, thus promoting plant growth. So probably lengthen of roots in *G*. *mosseae* treatment in our experiment is due to better absorption of nutrient than the other treatments.

In soilless substrates lacking indigenous mycorrhizal fungi, mycorrhizal inoculation and colonization has been found to increase crop uniformity, reduce transplant mortality, and increase productivity of geranium, onion, *Cyclamen persicum*, *Euphorbia pulcherrima*, *Verbena* spp. *Rosa* spp., *strawberry*, *pineapple*, and *Vaccinium corymobsum* [23].

It is possible that differences in rooting percentages, root number and root growth resulting from adding VAMF into the rooting medium are not only a response to the VAMF, but could also be predicable to other micro-organisms in the inoculum [14].

Inoculation increased the number of root initials emerging from *Viburnum dentatum* L. stem cuttings, which conform to our result [15]. About the reason of increasing the cutting rooting by MF, Hassig [24] expressed many changes in metabolism are known to occur during adventitious root formation including changes in amino acids and proteins important for enzyme function and nitrogen metabolism, and changes in carbohydrates. The result of Scagel [16] on miniature roses showed differences in protein and amino acids between cuttings exposed to inoculum and cuttings with no inoculum were detectable within two to four days after cutting while differences in carbohydrates were detectable within four to seven days after cutting.

In our trial mycorrhization significantly stimulate the growth of root systems of *schefflera* cuttings. This stimulation is connected with higher photosynthetic activity of *schefflera* leaves. The root colonization of bedding plants after inoculation with AMF resulted in higher quality cuttings. It seems to be possible that AMF inoculated cuttings would be more resistant to transplanting stress and grow better during later stages of plant development than inoculated ones.

The mycorrhizal inoculation can be a possible biotechnology used in horticulture for better derivation of nutrients from substrates and for improvement of growth of horticultural crops.

Application of two species of *Glomus* genus in this experiment showed *G. mosseae* is better than G. intraradices and their combination than the Control. According to Figure 2, inoculum rooting by mycorrhizal fungi had more rootlets and more lengthy roots that increase quality of cuttings due to better efficiency in absorbing water and nutrients.

It is considerable although it was said mycorrhizal fungi application can increase rooting of ornamental plant, Schefflera cuttings. Thus greenhouse owner should evaluate the cost and benefit of using mycorrhizal fungi. As well as benefits derived from Mycorrhizae will depend on production goals or objectives.

Fig. 2. Non-inoculated rooting of cutting (right picture) and inoculated rooting of cuttings with mycorrhizal fungi (left picture) have shown.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hanafy MS, Saadawy FM, Milad SMN, Ali RM. Effect of some natural extract on growth and chemical constituents of Schefflera arboricola plants. Journal of Horticultural & Ornamental Plants. 2012;4(1):26-33.
2. Lanthier M. Mycorrhizal Fungi: Impact of commercial products in nursery propagation. International Plant Propagators' Society, Combined Proceedings. 2007;56:496-508.
3. Ahulu EM, Andoh H, Nonaka M. Host-related variability in arbuscular mycorrhizal fungal structures in roots of Hederarhombea, Rubusparvifolius and Rosea multiflora under control conditions. MYCORRHIZA. 2007;17:93-111.
4. Douds DD, Bécard Jr, Pfeffer PE, Doner LW. Effect of Vesicular–Arbuscular Mycorrhizal Fungi on Rooting of *Sciadopitys verticillata* Sieb & Zucc Cuttings. Hortscience. 1995;30(1):133–134.
5. Linderman RG, Call CA. Enhanced rooting of woody plant cutting by Mycorrhizal Fungi. Journal of the American Society for Horticultural Science. 1977;102(5):629-632.
6. Verkade SD, Hamilton DF. Effect of Endo mycorrhizal Inoculum on root initiation and development of *Viburnum dentatum* L. Cuttings. Journal of Environmental Horticulture. 1987;5(2):80-81.

7. Maronek DM, Hendrix JW, Kiernan J. Mycorrhizal Fungi and their importance in horticultural crop production. Horticultural Review. 1981;3:172-213.
8. Falkowski G, Matysiak B. The use of arbuscular mycorrhizal fungi in container production of selected ornamental conifers under organic mineral fertilization level. Journal of Fruit and Ornamental Plant Research. 2010;18(2):335-348.
9. Singh Sh, Srivastava K, Badola JC, Sharma AK. Aeroponic production of AMF inoculum and its application for sustainable agriculture. Wudpecker. Journal of Agricultural Research. 2012;1(6):186–190.
10. Davies FT Jr. How Mycorrhizal Fungi Can Benefit Nursery Propagation and Production Systems? Combined Proceedings International Plant Propagators' Society. 2008;58:539-548.
11. Corkidi L, Edith BA, Donald MF, Allen M, Downer J, Bohn J, Evans M. Assessing the infectivity of commercial Mycorrhizal inoculants in plant nursery conditions. Journal of Environmental Horticulture. 2004;22(3):149–154.
12. Druege U, Baltruschat H, Franken Ph. *Piriformospora indica* promotes adventitious root formation in cuttings. Scientia Horticulturae. 2007;112:422–426.
13. Scagel CF. Cultivar specific effects of Mycorrhizal Fungi on the rooting of miniature rose cuttings. Journal of Environmental Horticulture. 2001;19(1):15-20.
14. Linderman RG. Mycorrhizal interactions with rhizosphere microflora: the mycorrhizosphere effect. Phytopathol. 1988;78(3):366-371.
15. Sramek F, Dubsky M. Testing of efficacy of arbuscular mycorrhizal product Symbivit on three species of balcony plants; 2003. Available: http://www.vukoz.cz/
16. Scagel C. Effect of mycorrhizal fungi on rooting in woody horticultural crops. Proceedings of the International Symposium on Adventitious Root Formation. 2000;1.
17. Nowak J, Nowak SJ. Co_2 enrichment and mycorrhizal effects on cutting growth and some physiological traits of cuttings during rooting. Acta Science. 2013;12(6):67-75.
18. Black KG, Mitchell DT, Osborne BA. Effect of mycorrhizal-enhanced leaf phosphorus status on carbon partitioning, translocation and photosynthesis in cucumber. Plant Cell Environ. 2000;23:797–809.
19. Wright DP, Scholes JD, Read DJ. An effect of VA mycorrhizal colonization on photosynthesis and biomass production of *Trifolium repens*. Plant Cell Environ. 1998;21:209–216.
20. Augé RM. Water relations, drought and vesicular-arbuscular mycorrhizal symbiosis. Mycorrhiza. 2001;11:3–42.
21. Syvertsen JP, Graham JH, Influence of vesicular-arbuscular mycorrhizae and leaf age on net gas exchange of *Citrus* leaves. Plant Physiol. 1990;94:1424–1428.
22. Mathur N, Vyas A. Influence of VA mycorrhizae on net photosynthesis and transpiration of *Ziziphus mauritiana*. J. Plant Physiol. 1995;147:328–330.
23. Scagel CF. Enhanced rooting of Kinnikinnick cuttings using mycorrhizal fungi in rooting substrate. HortTechnology. 2004;14(3):355-363.
24. Hassig BE. Metabolic process in adventitious rooting of cuttings. In: Jackson MB (ed) New Root Formation in Plants and Cuttings. Martinus Nijhoff Pub; 1986.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=520&id=32&aid=4576