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Rooting behavior of certain foliage ornamentals grown under hydroponic nutrient solutions

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ABSTRACT

The hydroponics is an alternative sustainable production system under conditions in which resources are limited. Hence, an experiment was conducted with Hoagland & Arnon solution, Cooper's solution, Saparamadu's solution and Mattson and Peters solution and a control with Irrigation water to study the rooting behavior of five plants viz., Devil's ivy (Epipremunm aureum), Wandering jew (Zebrina pendula), Arrowhead plant (Syngonium podophyllum), Philodendron (Philodendron erubescens), Boat lily (Tradescantia spathacea) under passive hydroponic vertical garden module. The pH was monitored for acidity and basicity range and EC were monitored for salt concentration in all the nutrient solution periodically. Observation on root parameters was observed at 30, 60 and 90 days after planting. Results revealed that number of roots, root length and root weight exerted maximum values in those characters under T_3 (Cooper's solution). Minimum rooting with lowest weight was recorded in T_4 (Saparamadu solution) at all the stages of observation in devil's ivy. Whereas in other two foliage ornamentals viz., Arrowhead plant(Syngonium podophyllum) and Philodendron (Philodendron erubescens) recorded lowest root parameters in T_1 (Irrigation water) under 30, 60 and 90 days minimum number of roots, root length and root weight was recorded under T_4 (Saparamadu solution). However, maximum dry matter was recorded under Hoagland & Arnon solution in all the three foliage ornamentals at all the three stages of observations.

Keywords: Hydroponics, Vertical garden, foliage ornamentals, nutrient solution

INTRODUCTION

Due to rapid increase in population explosion the per capita availability of living space is declining which is considered as a major issue in urban communities. Therefore, the challenge for the urban landscape designers is to create landscape within limited space considering the ecological and environmental impacts. Vertical garden is one of the approach of green building envelope with green facades and green living walls creates a richer ecosystem, enhances biodiversity, improves mental health, alleviates environmental externalization generated by urban areas (Pollution, runoff and heat island effect etc). Selection of plants grown under indoor environments with limited space is narrowing down the choice of ornamental flora. To be grown under urban minimal spaces, foliage ornamentals are the best option among the softscape components in ornamental industry.

On the other hand hydroponics is an alternative sustainable production system under conditions in which resources are limited. Hydroponics is a very young science which has commercial basis during recent days. Hydroponic crop production has significantly increased in recent years worldwide as it allows a more efficient use of water and nutrients as well as better climate control. Further, the crops grown under hydroponic culture are of good quality with increased productivity. Among the various factors affecting hydroponic production systems, the nutrient solution is considered to be one of the most important determining factors of crop growth and production. An ideal nutrient solution should satisfy Arnon's criteria of essentiality in adequate quantity and in available forms, in addition to proper physiochemical conditions i.e. aeration, pH and EC suitable for crop growth. Further, in passive hydroponic systems which are convenient for growing ornamental plants in urban space, the nutrient solution is playing vital role as the solution is maintained without changing (or) circulation for a period of more than two weeks. Over continuous maintenance of the a plant in same solution for two weeks leads to drastic changes in dissolved oxygen content, EC and pH of the nutrient solution and there by affects the plant growth.

For development of a passive hydroponic system to grow ornamental plants in indoor condition it is important to identify suitable plants and appropriate nutrient solution to boost the growth and ornamental value of the plants. Hence, in this present experiment five foliage ornamentals were selected to grow under various nutrient solutions under passive hydroponic systems.

MATERIALS AND METHODS

The present experiment was carried out in the Department of Horticulture, Annamalai University, Annamalai Nagar (Tamil Nadu) during 2017- 2019 with four different nutrient formulations *viz.,* Hoagland & Arnon solution (1938), Cooper's solution (1979), Saparamadu's solution (2010) and Mattson and Peters solution (2014) and a control with Irrigation water for growing foliage ornamentals under passive hydroponic vertical garden module with four replications in completely randomized block design. The pH was monitored for acidity and basicity range and EC for salt concentration in all the nutrient solution periodically. The following three plants *viz*., Devil's ivy (*Epipremunm aureum*), Arrowhead plant (*Syngonium podophyllum*) and Philodendron (*Philodendron erubescens*) were chosen for the experiment. The experiment unit was designed out in 62" X 2.5". PVC pipe closed at both ends. The pipes were fitted with a drainage outlet and slots of 1.5" were made at the top to accommodate five plants and the plants were grown in 2" net pots. The entire experiment set up was fabricated in an angular iron rod with 5 layers of PVC pipes for five treatments at different heights. All the pipes filled with 5 litres of four different nutrient solutions, *viz*., T2 - Hoagland & Arnon (1938), T3-Cooper's (1979), T4- Saparamadu (2010), T5-Mattson and Peters (2015) and irrigation water as control (T1). Three plants were selected at random from each treatment and tagged for the recording various biometric observations in all the treatments. Observation on root parameters *viz.,* number of roots plant $^{-1}$, root length (cm), root weight (g plant^{-1}) and dry matter production (g plant^{-1}) were observed at 30, 60 and 90 days after planting.

RESULTS AND DISCUSSION

In the present experiment, more number of roots (53.4, 230.2 and 345.4 in Devil's ivy, 230.1, 266.9 and 281.1 in Arrowhead plant and 72.3, 101.6 and 146.2 in Philodendron were recorded in the treatment T_3 (Cooper's solution) in all the three stages i.e. 30, 60 and 90 days of observations respectively (Table1). Interestingly, the minimum number of roots (28.3, 78.5 and 128.5 at 30, 60 and 90 days of observations respectively) was observed under the treatment T_4 (Saparamadu solution) in Devil's ivy in all the three stages of observations. In contrast with the above result, minimum number of roots (78.3 in Arrowhead plant and 32.1 in Philodendron) was recorded in T_1(Irrigation water) at 30 days of observation. However, at 60 and 90 days of observation, minimum number of 94.1 and 97.2 in Arrowhead plant, 54.2 and 50.7 in Philodendron) was observed in those plants grown under T_4 (Saparamadu solution). The data on root length also exerted similar results in producing the lengthy root (21.5, 31.4 and 49.1 cm in Devil's ivy, 17.2, 25.6 and 33.3 cm in Arrowhead plant and15.6, 36.7 and 62.7 cm in Philodendron) in the treatment T_3 (Cooper's solution) at 30, 60 and 90 days. However, the shortest root in Devil's ivy was observed in T_1 (Irrigation water) which recorded 12.5, 23.5 and 36.5 cm at 30, 60 and 90 days respectively (Table.1). As like the number of roots, the other two foliage ornamentals showed similar results for 30 days of observations for minimum root length (8.01 and 10.3 cm at 30, 60 and 90 days respectively) under the treatment T_1(Irrigation water) in Arrowhead plant and Philodendron respectively. However, at 60 and 90 days, the treatment T_4 (Saparamadu solution) recorded the minimum root length of 15.6 and 16.7 cm in arrow head plant and 14.6 and 19.5 cm in philodendron, respectively.

Among the different nutrient solutions, plants grown under the treatment T_3 (Cooper's solution) produced maximum root weight (4.62, 10.0 and 32.6 g plant^{-1} in Devil's ivy, 6.33, 8.31 and 10.54 g plant^{-1}in Arrowhead plant and 4.13, 5.59 and 7.26 g plant^{-1}in Philodendron) at all the three stages (Table2). However, minimum root weight was observed in T_1 (Irrigation water) for Devil's ivy at 30, 60 and 90 days respectively. Eventually, the data on 60 and 90 days showed minimum root weight values under the treatment T_4 (Saparamadu solution) at all the three stages.

Table 1: Effect of different nutrient solutions on number of roots plant $^{-1}$ and root length (cm) of foliage ornamentals

Treatments	Devil's ivy (*Epipremnum aureum)*						Arrowhead plant (*Syngonium podophyllum)*						Philodendron (*Philodendron erubescens*)					
	Number of roots			Root length (cm)			Number of roots			Root length (cm)			Number of roots			Root length (cm)		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	34.1	110.2	210.4	12.5	23.5	36.5	78.3	184.3	201.3	8.01	17.9	23.3	32.1	79.4	96.6	10.3	21.9	23.2
T_2	50.2	151.7	250.6	14.3	28.3	42.1	211.4	248.1	269.2	15.3	22.6	28.9	66.2	89.7	119.7	13.3	30.9	50.9
T_3	53.4	230.2	345.4	21.5	31.4	49.1	230.1	266.9	281.1	17.2	25.6	33.3	72.3	101.6	146.2	15.6	36.7	62.7
T_4	28.3	78.5	128.5	10.5	25.4	38.5	176.3	94.1	97.2	10.8	15.6	16.7	58.4	54.2	50.7	11.9	14.6	19.5
T_5	40.4	99.6	135.0	13.7	26.5	40.2	206.8	238.9	256.4	13.9	19.3	26.6	58.0	82.0	105.9	10.6	19.7	25.0
SE(d)	0.86	6.22	6.35	0.32	0.31	0.86	3.14	2.63	3.02	0.56	0.93	1.27	2.11	2.53	2.76	0.94	1.07	1.02
CD (P=0.01)	1.74	12.4	12.7	0.67	0.64	1.78	6.32	5.28	6.04	1.12	1.88	2.55	4.23	5.08	5.55	1.88	2.14	2.04

T_1-Irrigation water (Control), T_2-Hoagland & Arnon solution, T_3-Cooper's solution, T_4-Saparamadu solution, T_5-Mattson and Peter's solution

Table 2: Effect of different nutrient solutions on root weight (g) and Dry matter production (g plant $^{-1}$) of foliage ornamentals

Treatments	Devil's ivy (*Epipremnum aureum)*						Arrowhead plant (*Syngonium podophyllum)*						Philodendron (*Philodendron erubescens*)					
	Root weight (g)			Dry matter (g plant $^{-1}$)			Root weight (g)			Dry matter (g plant $^{-1}$)			Root weight (g)			Dry matter (g plant $^{-1}$)		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	1.82	4.73	6.54	0.94	2.34	3.75	2.98	3.87	4.16	1.94	2.04	2.89	2.07	3.59	4.13	1.73	2.34	3.02
T_2	3.53	7.95	15.2	2.53	6.07	12.3	5.77	7.45	9.91	3.80	5.01	6.89	3.53	4.93	6.45	3.44	4.68	6.35
T_3	4.62	10.0	32.6	1.92	4.35	10.4	6.33	8.31	10.54	3.46	4.47	5.94	4.13	5.59	7.26	2.94	4.11	5.68
T_4	2.34	5.84	7.71	1.16	2.93	4.04	3.11	3.41	3.66	2.04	2.32	2.49	2.67	2.81	3.59	2.22	3.12	4.01
T_5	2.95	6.35	13.6	1.58	3.85	5.85	5.21	7.04	8.33	3.12	4.22	5.55	3.16	4.42	5.60	2.63	3.68	4.66
SE(d)	0.49	0.49	1.42	0.16	0.49	1.19	0.32	0.30	0.27	0.13	0.24	0.15	0.24	0.26	0.37	0.18	0.15	0.21
CD (P=0.01)	0.98	0.99	2.87	0.34	0.98	2.23	0.64	0.62	0.55	0.28	0.48	0.32	0.48	0.52	0.76	0.36	0.31	0.42

The superiority of the treatment T_3 (Cooper's solution) in producing more number of roots, lengthy roots and increased root weight may be due to the availability of nutrients which nourishes the root zone for better uptake of nutrients. The root density increases as new roots are produced. The regeneration of new roots is essential for normal plant development, as the majority of nutrients are absorbed through younger root tissues. Further, phosphorus and potassium are the two main nutrients that support root growth in plants. Specifically, they encourage plants to produce new roots and strengthen the existing roots. This means that nutrient solution was high in phosphorus and potassium formulations and this leads to production of more roots. It is evident from the composition of Cooper's solution that, the increased P and K content might have influenced the mobilization and uptake of nutrients by the active roots produced in larger quantities by all the foliage ornamentals. Further, the increase in root number and length due to the presence of P which enhanced the permeability of root membrane stimulating the growth of roots and increasing the proliferation of root hairs. The results are in accordance with the findings of Kilinc *et al.*(2007) in oil palm seedlings and Li and Cheng (2014) in cucumber.

It is clear that Devil's ivy is a hardy plant that can thrive well under minimal nutrition which also has the capability to absorb nutrition by roots. On the other hand, plants were grown under the treatment T_4 (Saparamadu solution) produced the lowest root growth (number of roots, root length and weight of roots) at 60 and 90 days in Arrowhead plant and Philodendron. The composition of nutrients and the total ionic concentration determines the growth and development. The total ions were dissolved in the salt solution that exerts a force called osmotic pressure. Hence, EC of the solution is a good indicator of the amount of ions to the plants in the root zone (Nemali and Van Iersel, 2004). Sonneveld and Voogt (2009) suggested the optimal EC for hydroponic solution is 1.5 to 2.5 dS m^{-1}. Higher EC hinders nutrient uptake through roots by increasing osmotic pressure (Samarakoon *et al.,* 2006).

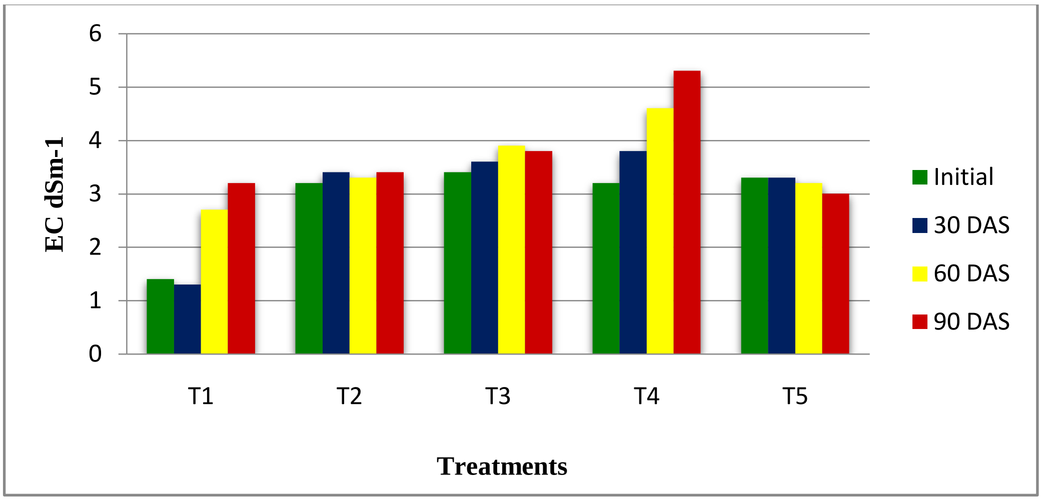

Figure 1: Effect of EC on performance of foliage ornamental plants

The treatment T_2 (Hoagland & Arnon solution) showed its superiority in obtaining maximum dry matter production (2.53, 6.07 and 12.3 g $plant^{-1}$ in Devil's ivy, 3.80, 5.01 and 6.89 g $plant^{-1}$in Arrowhead plant and 3.44 , 4.68 and 6.35 g $plant^{-1}$ in Philodendron) at 30, 60 and 90 days respectively (Table2). The increased nutrient content in Hoagland & Arnon solution facilitates the uptake of roots and assimilates through biochemical reactions to create some of the most important compound in the plants such as nucleic acids and proteins. The results of the present investigation corroborates with the findings of Wahome *et al.*(2011) in Gypsophila, Gashgari *et al.*(2018) in cucumber and Singh *et al.*(2011) in Anthurium. It is evident from the Fig.1 that the EC of the Saparamadu solution was gradually increased from 3.2 to 5.3 dSm^{-1}especially during 60 and 90 days. Hence, the reduced root growth was observed underSaparamadu solution (T_4) due to the improper relationship of mutual exchange ratio of anions:(NO_3, H_2PO_4 and SO_4) and cations (K^+, Ca^{2+}, Mg^{2+}) are reported to create a negative impact on root absorption and ultimately on plant growth as suggested by Tellez and Merino (2012). Further, nutrient availability for plant uptake at pH above 7 may be restricted due to precipitation of Fe^{2+}, Mn^{2+}, PO_3^{-4}, Ca^{2+} and Mg^{2+} to insoluble and unavailable salts as reported by (Resh, 2004). Similar results are also obtained by Keat and Kannan (2015) in Chinese cabbage, Gruda (2009) and Chadirin *et al.*(2007) in soilless cultivation.

From the results it may be concluded that the root parameters exerted maximum values in plants grown under Cooper's solution. Minimum rooting with lowest weight was recorded in Saparamadu solution at all the stages of observation in devil's ivy. Whereas in Arrowhead plant and Philodendron recorded lowest root parameters in Irrigation water at 30, 60 and 90 days and minimum number of roots, root length and root weight were recorded under Saparamadu solution.

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