Original Research Article

Standardization of Hydroponic Growing Media and Nutrient solution application Intervals for Optimal Growth in *Syngonium podophyllum* Schott. cv. 'White Butterfly'

ABSTRACT

Hydroponics can be said as a way to skip soil. It is the method of growing plants in soilless media along with external supply of nutrient solutions. The selection of plants suitable for cultivation in indoor environments with restricted space is becoming increasingly crucial in contemporary times. *Syngonium podophyllum* Schott. cv. 'White Butterfly' is a very important plant in current scenario with bewitchingly beautiful ornamental foliage. Four types of soil less media were taken for the experiment including, metal jelly (10mm), vermiculite, expanded clay balls and quartz sand. 150% dose of Hoagland solution was applied to plants through drip system till it reach 70% field capacity. The nutrient solution was applied in four levels such as daily, alternate days, two days intervals and three days intervals. Growth parameters like number of leaves per plant, leaf area, plant height and number of roots were observed in every 15 days interval up to four months. Highest mean number of leaves were obtained for vermiculite media when nutrient solution was applied at daily interval basis at 120 DAP (16.8). This treatment was also found on par with alternate days nutrient solution application in combination with vermiculite media (14.6), daily nutrient solution application in metal jelly media (14) and alternate days nutrient solution application in quartz sand media (15.4). While clay ball media with alternate days interval of nutrient solution application was found superior in terms of leaf area (267.60 cm^2), plant height (30.56cm) and root length (58.94 cm) characteristics at 120 DAP.

Keywords: Clay ball, Hoagland solution, Interval, Vermiculite

1. INTRODUCTION

Hydroponics, an emerging field, holds promise as a sustainable production system in situations where resources are limited. As methods like hydroponics can ensure faster growth, quality and productivity of crops should be greatly promoted (Lakhiar *et al*, 2018). Hydroponics can be said as a way to skip soil. It is the method of growing plants in soilless media along with external supply of nutrient solutions. This method ensure efficient usage of nutrients and water along with proper control over pest factors and climate. Hydroponics is believed to have its roots in the ancient city of Babylon. But Dr. William. F. Gericke of California University was first to succeed in hydroponics by growing tomato, potato, beets, fruits and flowers (Prakash *et al.,* 2020). The diminishing per capita living space, driven by a rapid population increase, is emerging as a significant concern in urban areas. The selection of plants suitable for cultivation in indoor environments with restricted space is becoming increasingly crucial in contemporary times. *Syngonium podophyllum* was introduced to India as an ornamental plant from China or Singapore (Chowdhury *et al*., 2021). *Syngonium podophyllum* is widely grown as an ornamental foliage plant prized for its effectiveness in purifying indoor air. Its remarkable ornamental appeal is enhanced by its capability to filter pollutants, and its preference for low light conditions makes it an ideal choice for indoor gardening. *Syngonium podophyllum* Schott. cv. 'White Butterfly' is a very important plant in current scenario. Beyond its ornamental value, it is characterized by a high content of phenolic compounds, making it important, especially in species of medicinal interest (Sand and Antofie, 2022).

2. MATERIALS AND METHODS

The study was carried out at Department of Floriculture and Landscaping, College of Agriculture, Vellayani, Thiruvananthapuram during 2023. The experiment was laid out in completely randomized design (CRD). Four types of soil less media were taken for the

experiment including, metal jelly (10mm) (M_1), vermiculite (M_2), expanded clay balls (M_3), and quartz sand (M_4). *Syngonium podophyllum* Schott. cv. 'White Butterfly' of 3-4 leaf stage was planted in grow bag system in media culture technique of hydroponics (Mariyappillai *et al.,* 2020). 150% dose of Hoagland solution was applied to plants through drip system till it reach 70% field capacity and an outlet for excess solution coming out from the grow bags were collected and circulated back to the nutrient tank (Anaswara *et al*., 2022). The nutrient solution was applied in four levels such as daily (A_1), alternate days (A_2), two days intervals (A_3) and three days intervals (A_4). Experiment comprised of total 16 treatment combinations and were replicated five times. Totally 80 plants were used for the experiment. Growth parameters like number of leaves per plant, leaf area, plant height and number of roots were observed in every 15 days interval up to four months (Dhanraj, 2020). Number of leaves per plant were counted by selecting five observational plant from each treatment. Leaves were counted and average was calculated for each treatment. Five observational plants itself were selected for calculating leaf area. The leaf area was determined using a graphical method, where three mature leaves were selected from each plant, and their respective areas were measured in square centimetres (cm^2). Subsequently, the average leaf area was computed. Plant height was calculated by measuring height from the base to the tip of longest leaf. The average value was calculated and expressed in centimetres (cm). Number of rots were counted from the five observational plants and later averaged. Timely observation and management of electrical conductivity and pH of the nutrient solution were done in every three days intervals. pH was maintained between 5.5-6.5 (Tellez *et al*., 2007) and electrical conductivity (EC) between 1.5-2.5 (Sonneveld and Voogt, 2009). The acquired observations were statistically analyzed using KAU grapes software (Gopinath *et al.,* 2020).

3. RESULTS AND DISCUSSION

3.1. Number of leavers per plant

The relevant quantitative characters were measured and summarized in table 1, 2, 3 and figure 1. The effect of different media on number of leaves of *Syngonium podophyllum*

Schott. cv. 'White butterfly' showed that there is a significant impact throughout the crop period. Plants in vermiculite media showed highest number of leaves throughout the crop period with highest number of leaves per plant at 120 days after planting (DAP). The highest mean number of leaves observed at 120 DAP was 12.75 leaves/plant. Effect of nutrient solution application intervals on number of leaves per plant showed significant increase throughout the observation period with highest number of leaves for alternate days interval application of nutrient solution from 15 DAP-30 DAP and which was on par with daily application. Highest number of leaves were observed for daily application of nutrient solution from 45 DAP-120DAP. Highest mean number of leaves per plant were observed in daily application of nutrient solution at 120 DAP (13.30), which was found as on par with alternate days interval application at 120 DAP (12.50). Lowest number of leaves were consistently obtained when nutrients were applied at three days interval. The interaction effect of both media and application intervals on number of leaves were found significant. Highest mean number of leaves were obtained for vermiculite media when nutrient solution was applied at daily interval basis at 120 DAP (16.8). This treatment was also found on par with alternate days nutrient solution application in combination with vermiculite media (14.6), daily nutrient solution application in metal jelly media (14) and alternate days nutrient solution application in quartz sand media (15.4). Increased number of leaves might be due to proper water holding capacity and there by nutrient availability. All the macro and micro nutrients are essential for plant growth and development. Among them, N, P, K are very essential for any plant to grow. Nitrogen is crucial for the development of stems and roots in plants, as it is a key element that plant roots can uptake in the form of nitrate ($NO3^-$) and ammonium ($NH4^+$). These absorbed nitrogen compounds are subsequently transformed into proteins and protoplasm in the leaves and stems, supporting overall plant growth. Vermiculite media with a nutrient solution application on alternate days has resulted in the continual achievement of the highest number of leaves. This practice consistently enhanced plant characteristics by ensuring the optimal delivery of nutrients to the root zone. As a result, plants continuously received the necessary nutrients, leading to improvement in their overall health and

development. This result is in conformity with Chaudhary *et. al.* (2018) in oriental group of *Lilium* and Sarmah (2017) in hydroponically grown tuberose, gladiolus and marigold. Wahome *et. al*. (2011) also reported that better aeration and nutrient holding capacity of vermiculite based media might be the cause of enhanced growth in gypsophylla.

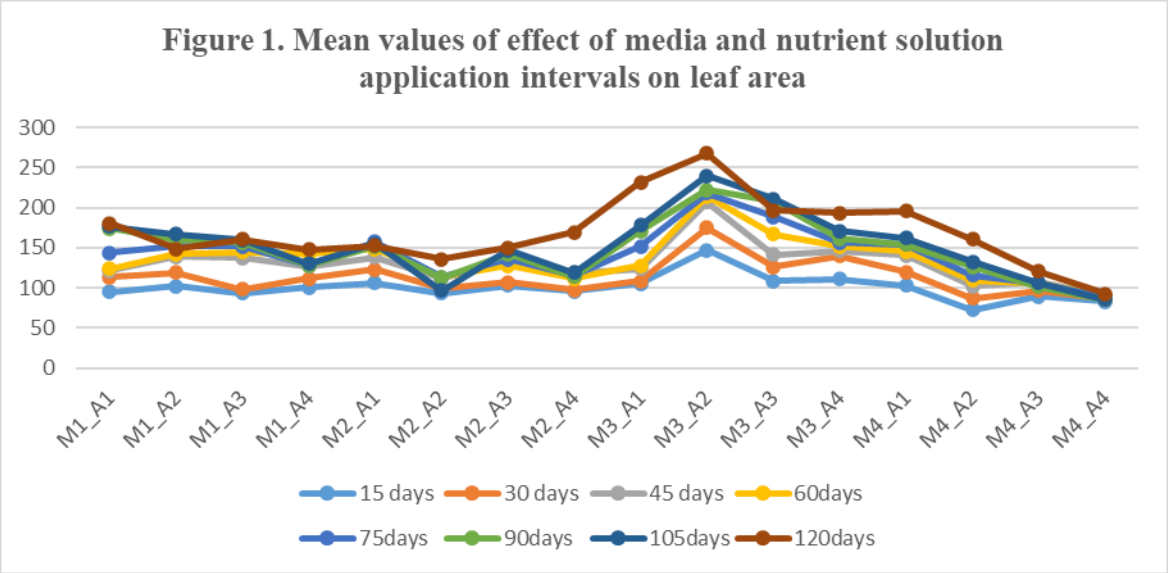
Table1. Mean values of effect of media and nutrient solution application intervals on number of leaves per plant

Treatments	15DAP	30DAP	45DAP	60DAP	75DAP	90DAP	105DAP	120DAP
Media (M)								
M1	5.05	5.50	5.75	6.40	7.4	8.30	8.95	9.30
M2	6.05	6.85	7.05	8.70	9.7	10.60	11.70	12.75
M3	3.50	4.10	4.40	5.95	7.1	7.80	9.15	10.05
M4	4.90	5.60	5.80	7.15	8.0	8.65	9.80	10.65
CD	0.843	0.819	0.924	1.235	1.208	1.482	1.392	1.792
SEm(±)	0.298	0.29	0.327	0.437	0.428	0.524	0.493	0.634
Application Intervals (A)								
A1	5.55	6.25	6.85	8.65	9.95	11.05	12.25	13.30
A2	5.70	6.35	6.80	8.45	9.55	10.50	11.20	12.50
A3	4.30	4.80	5.00	5.95	6.70	7.15	8.50	8.85
A4	3.95	4.65	4.35	5.15	6.00	6.65	7.65	8.10
CD	0.843	0.819	0.924	1.235	1.208	1.482	1.392	1.792
SEm(±)	0.298	0.29	0.327	0.437	0.428	0.524	0.493	0.634
M×A								
M_1A_1	7.0	7.6	8.4	10.2	11.6	12.6	13.2	14.0
M_1A_2	5.4	5.4	6.0	6.2	7.6	8.8	9.0	9.4
M_1A_3	4.6	5.2	5.6	5.6	5.8	6.6	7.4	7.4
M_1A_4	3.2	3.8	3.0	3.6	4.6	5.2	6.2	6.4
M_2A_1	6.6	7.4	8.4	10.2	11.8	13.4	15.0	16.8
M_2A_2	7.6	8.6	8.6	11.4	11.8	12.8	13.2	14.6
M_2A_3	4.8	5.6	6.0	7.4	8.2	8.2	9.2	9.6
M_2A_4	5.2	5.8	5.2	5.8	7.0	8.0	9.4	10.0
M_3A_1	3.6	4.6	4.8	7.0	8.0	8.8	11.0	12.6
M_3A_2	3.6	4.0	4.8	6.0	7.6	8.4	9.2	10.6
M_3A_3	3.4	3.4	3.6	5.0	6.2	7.0	8.8	8.8
M_3A_4	3.4	4.4	4.4	5.8	6.6	7.0	7.6	8.2
M_4A_1	5.0	5.4	5.8	7.2	8.4	9.4	9.8	9.8
M_4A_2	6.2	7.4	7.8	10.2	11.2	12.0	13.4	15.4
M_4A_3	4.4	5.0	4.8	5.8	6.6	6.8	8.6	9.6
M_4A_4	4.0	4.6	4.8	5.4	5.8	6.4	7.4	7.8
CD	0.74	1.638	1.847	2.469	2.416	1.32	2.784	3.583
SEm(±)	0.597	0.58	0.654	0.874	0.855	1.049	0.986	1.268

3.2. Leaf area (cm^2)

Effect of growing media and nutrient application interval had significant effect on leaf area of plants individually throughout the experiment. The leaf area consistently increased throughout the experiment in clay ball media with highest value obtained at 120 DAP (222.37 cm^2). Nutrient solution application at alternate days interval application was found obtaining highest leaf area from 15 DAP- 60DAP. From 60DAP-120DAP, daily application was found superior. But these two levels of applications were on par with each other throughout the experiment period with highest leaf area of 190.125 cm^2 at 120DAP. The interaction of growing media and nutrient application intervals were found to have significant effect throughout the experiment period. Alternate days nutrient solution application in expanded clay ball media was found superior in terms of leaf area throughout the experiment. Highest value for leaf area at 120 DAP was 267.60 cm^2. Also the final leaf area value was found to be on par with the treatment having daily nutrient solution application in expanded clay ball media. Lowest leaf area was obtained in quartz sand media when nutrients were applied in three days interval throughout the experiment. The increased leaf area while grown under clay ball media might be due to better oxygen and water holding capacity. This property makes the media to hold nutrient solution very effectively and there by aid in better plant growth. The heightened availability of nitrogen and phosphorus has facilitated and stimulated cell division and enlargement, ultimately resulting in a significant increase in leaf breadth and there by leaf area. This increased supply of essential nutrients had played a crucial role in promoting the fundamental processes of cell growth, leading to a substantial expansion of the leaf surface area. The enhanced presence of nitrogen and phosphorus had contributed to a flourishing environment for cellular activities, fostering both the multiplication and enlargement of cells. Consequently, this nutritional enrichment had directly translated into a notable augmentation of the overall size and breadth of the leaves. The ready accessibility of nutrients in water culture could be impacting the length of the leaves. Providing a constant stream of nutrients, water, and oxygen accelerates plant growth by optimizing nutrient absorption and facilitating improved transport of photosynthates. Overall increase in the length and breadth of leaves ultimately resulted in increase in leaf area. These results are in

conformity with Boudaghpour and Hashemi (2008). Sarmah *et al.* (2020) reported that elevated concentrations of hoagland solution increased leaf area and dry weight of salvia. The accumulation of biomass in plants can be influenced by the diverse chemical composition of nutrient solution, aligning with the research findings reported by Li and Cheng (2014).



3.3. Plant height (cm)

Effect of growing media significantly influenced height of plants till 120 DAP. Plants were found tallest at 120 DAP (26.79 cm) in expanded clay ball media, which was significantly different from other treatments. Effect of nutrient application intervals were also significantly influenced height of plants. Tallest plants were obtained for alternate days interval application of nutrient solution at 120 DAP (24.71cm), which was found to be on par with daily application (23.03 cm). Lowest plant height was recorded when nutrient solution was applied in three days interval throughout the experiment. The data on interaction effect of different growing media and nutrient solution application intervals indicated that there was significant difference in plant height between the treatments throughout the experiment. Tallest plants were observed when nutrients applied in alternate days interval for expanded

clay ball media (30.56cm) and which was found on par with daily application of nutrient solution in expanded clay ball media (28.8 cm). As reported by Romero Aranda *et al*. (2001), proper supply of nutrients always effect stomatal conductance, photosynthesis and transpiration. So that proper nutrient availability influence growth characters of plant. Nitrogen, phosphorus, potassium, phosphorus, potassium, calcium, boron, magnesium and sulphur are the elements which are directly linked to plant height as reported by Neto, *et al.* (2015). Proper availability of these elements might be the reason for increased plant height in clay ball media.

Table2. Mean values of effect of media and nutrient solution application intervals on plant height

Treatment	15DAP	30DAP	45DAP	60DAP	75DAP	90DAP	105DAP	120DAP
Media (M)								
M1	12.620	14.180	15.530	16.270	16.770	17.465	19.425	19.725
M2	11.765	12.970	14.375	16.190	17.750	18.475	20.155	20.435
M3	13.265	15.115	17.170	20.930	22.930	23.750	26.170	26.790
M4	11.590	13.285	14.665	16.795	18.165	18.795	20.365	20.775
CD	1.217	1.376	1.329	1.283	1.065	1.12	1.86	1.911
SEm(±)	0.431	0.487	0.47	0.454	0.377	0.396	0.658	0.676
Application intervals (A)								
A1	12.945	14.68	16.095	18.660	19.855	20.770	22.720	23.030
A2	13.715	15.30	17.390	19.745	21.395	21.620	24.230	24.710
A3	11.330	12.90	14.645	16.815	18.390	19.400	21.525	21.960
A4	11.250	12.67	13.610	14.965	15.975	16.695	17.640	18.025
CD	1.217	1.376	1.329	1.283	1.065	1.12	1.86	1.911
SEm(±)	0.431	0.487	0.47	0.454	0.377	0.396	0.658	0.676
M×A								
M_1A_1	14.74	16.38	18.28	19.72	19.48	20.38	23.18	23.30
M_1A_2	12.56	13.92	15.34	15.84	17.16	17.76	18.48	18.74
M_1A_3	12.14	14.02	15.18	16.20	16.94	17.72	21.00	21.64
M_1A_4	11.04	12.40	13.32	13.32	13.50	14.00	15.04	15.22
M_2A_1	12.96	14.38	16.06	17.24	18.98	19.56	20.84	21.28
M_2A_2	12.64	13.42	16.42	18.72	20.06	21.06	22.94	23.36
M_2A_3	11.00	12.42	12.72	14.92	16.64	17.10	19.90	19.96
M_2A_4	10.46	11.66	12.30	13.88	15.32	16.18	16.94	17.14
M_3A_1	12.04	13.68	14.92	20.68	22.82	24.56	26.70	26.98

M_3A_2	17.60	19.98	22.86	26.02	28.00	26.70	29.68	30.56
M_3A_3	11.84	13.48	16.16	19.24	21.08	22.88	24.88	25.52
M_3A_4	11.58	13.32	14.74	17.78	19.82	20.86	23.42	24.10
M_4A_1	12.04	14.28	15.12	17.00	18.14	18.58	20.16	20.56
M_4A_2	12.06	13.88	14.94	18.40	20.36	20.96	25.82	26.18
M_4A_3	10.34	11.68	14.52	16.90	18.90	19.90	20.32	20.72
M_4A_4	11.92	13.30	14.08	14.88	15.26	15.74	15.16	15.64
CD	2.434	2.753	2.658	2.567	2.13	2.239	3.721	3.821
SEm(±)	0.862	0.974	0.941	0.908	0.754	0.793	1.317	1.353

3.4. Root length (cm)

Effect of different growing media significantly influenced root length from 15DAP-120DAP. Longest roots were observed in expanded clay ball media at 120 DAP (49.30cm) and were significantly different from all other treatments. Lowest root length was observed for vermiculite media throughout the experiment. Effect of nutrient solution application intervals on root length was also found significant in the whole experiment. Longest roots were observed in nutrient solution application at an Interval of three days (35.915 cm) at 120 DAP. The data on interaction effect of different growing media on nutrient solution application intervals revealed that, there was significant difference among the treatments throughout the experiment. Highest value for root length was observed when expanded clay ball media was applied with nutrient solution in alternate days interval at 120 DAP (58.94 cm) and which was found as on par with three days interval application of nutrients in metal jelly media at 120 DAP (56.84 cm). Smaller roots were found when nutrient solution applied in two days interval to the plants in the whole observation period. Expanded clay ball media is highly resistant to fungus and bacteria. So it is a very much recommended media for hydro cultivation methods as recommended by Boudaghpour and Hashemi, (2008). The higher levels of phosphorus (P) and potassium (K) may have played a role in affecting the mobilization and absorption of nutrients by the increased number of active roots produced in

larger quantities by syngonium. The elongation of roots is attributed to the presence of phosphorus, which enhances the permeability of the root membrane, thereby promoting root growth and augmenting the proliferation of root hairs. These results were in accordance with Dhanasekaran and Jasmine (2019).

Table3. Mean values of effect of media and nutrient solution application intervals on root length

Treatments	15DAP	30DAP	45DAP	60DAP	75DAP	90DAP	105DAP	120DAP
Media (M)								
M1	17.260	19.775	22.82	26.155	27.205	28.560	29.605	32.87
M2	9.765	10.445	11.72	13.020	14.335	15.315	15.650	16.02
M3	23.455	29.140	32.88	37.630	39.695	42.020	46.465	49.30
M4	12.975	16.090	19.15	21.935	23.965	26.015	28.180	30.10
CD	2.441	2.975	3.276	3.529	3.618	3.747	3.282	1.712
SEm(±)	0.864	1.053	1.159	1.249	1.281	1.326	1.162	0.606
Application interval								
A1	15.935	18.265	20.955	24.020	25.265	26.635	29.365	31.235
A2	16.410	19.950	23.085	26.400	28.515	30.520	32.325	34.010
A3	13.540	16.055	18.560	21.405	22.760	24.435	25.830	27.130
A4	17.570	21.180	23.970	26.915	28.660	30.320	32.380	35.915
CD	2.441	2.975	3.276	3.529	3.618	3.747	3.282	1.712
SEm(±)	0.864	1.053	1.159	1.249	1.281	1.326	1.162	0.606
M×A								
M_1A_1	20.12	23.32	27.82	31.16	31.94	33.12	33.86	36.84
M_1A_2	10.66	12.10	14.72	17.34	18.38	19.56	20.32	20.82
M_1A_3	9.92	10.40	12.18	14.70	15.14	16.24	16.60	16.98
M_1A_4	28.34	33.28	36.56	41.42	43.36	45.32	47.64	56.84
M_2A_1	9.40	9.92	10.76	12.80	13.64	14.46	14.86	15.16
M_2A_2	9.92	10.90	12.66	14.22	17.00	18.50	18.78	19.36
M_2A_3	9.40	10.00	10.96	11.82	12.44	13.28	13.60	14.02
M_2A_4	10.34	10.96	12.50	13.24	14.26	15.02	15.36	15.54
M_3A_1	23.38	27.66	31.00	35.64	37.46	39.60	47.80	50.74
M_3A_2	29.58	36.34	41.56	47.30	49.68	52.18	55.92	58.94
M_3A_3	20.56	26.28	29.90	35.14	36.92	39.54	42.24	44.80
M_3A_4	20.30	26.28	29.06	32.44	34.72	36.76	39.90	42.72
M_4A_1	10.84	12.16	14.24	16.48	18.02	19.36	20.94	22.20
M_4A_2	15.48	20.46	23.40	26.74	29.00	31.84	34.28	36.92
M_4A_3	14.28	17.54	21.20	23.96	26.54	28.68	30.88	32.72

M_4A_4	11.30	14.20	17.76	20.56	22.30	24.18	26.62	28.56
CD	4.883	5.951	6.552	7.058	7.236	7.493	6.565	3.423
SEm(±)	1.728	2.106	2.319	2.498	2.561	2.652	2.324	1.212

4. CONCLUSION

It is evident from the study that nutrient application and different soil less growing media can influence growth of plants to a great extent. Vermiculite media with alternate days application of nutrient solution, metal jelly with daily application of nutrient solution and quartz sand media with alternate days interval of nutrient solution application were reported with highest number of leaves. While clay ball media with alternate days interval of nutrient solution application was found superior in terms of leaf area, plant height and root length characteristics. This suggests that the choice of both the growing medium and the frequency of nutrient solution application plays a crucial role in influencing various aspects of plant development in *Syngonium podophyllum* Schott. cv. White Butterfly. The success of clay ball media in promoting overall plant development highlights the importance of tailoring growing conditions to the specific needs of the plant species under consideration. This study also paves a foundation to future studies regarding soil less cultures and hydroponic plant cultivation.

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