International Journal of Environment and Climate Change

Volume 13, Issue 5, Page 290-300, 2023; Article no.IJECC.98187
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Influence of Aeroponic System on Growth and Yield Parameters of V-1 Mulberry

G. A. Nishchitha [a++*], S. Chandrashekhar [a#], R. N. Bhaskar [a†] and Chikkalingaiah [a‡]

[a] *Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru–560065, 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/v13i51770

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/98187

Original Research Article

Received: 25/01/2023
Accepted: 28/03/2023
Published: 31/03/2023

ABSTRACT

In an aeroponic system, nutrients are directly delivered to the plant roots, which results in the faster growth of crops. Furthermore, aeroponics has been extensively used as a research tool for many difficult-to-propagate plant species. The present investigation shows that the plants grown under the aeroponic system were recorded maximum for all the growth parameters except leaf area which was found maximum under nursery conditions. Among treatments, T_3 (three buds per cutting) recorded the maximum for all growth parameters followed by T_2 (two buds per cutting) and T_1 (one bud per cutting). The interaction effect between propagation systems and the number of buds per cutting showed significant results. S_1T_3 (three budded cuttings under aeroponic system) recorded maximum for growth parameters *viz.,* intermodal length (4.27 cm), plant height (44.39 cm), number of leaves (16.91), leaf yield (10.79 g/plant), whereas least was recorded by S_2T_1 *i.e.,* one budded

[++] *M.Sc. (Agriculture) Scholar;*
[#] *Professor of Sericulture;*
[†] *Professor (Rtd.);*
[‡] *Professor (GPB);*
**Corresponding author: E-mail: nishchitha.gv@gmail.com;*

cuttings under nursery (2.39 cm, 35.47 cm, 5.88, 4.84g /plant respectively) at 60 DAT. However, S_2T_3 recorded a maximum leaf area of 95.96 cm^2. From these results, it can be concluded that the aeroponic system could be effectively used for the production of V-1 mulberry saplings.

Keywords: Aeroponics; V-1 mulberry; nursery, growth and yield parameters.

1. INTRODUCTION

Mulberry (*Morus sp.*) is a typical woody plant belongs to the genus Morus and family Moraceae. It is cultivated for its economic importance in silk industry for its foliage which is the principle source of feeding for silkworm, *Bombyx mori* L. [1]. In India, mulberry is usually propagated by cuttings. Multiplication of plants by cuttings is most common, owing to its easy operation, rapidity of multiplication and less cost [2]. Although propagation through stem cuttings is possible and being used, poor rooting ability of promising genotypes is a major problem for large scale multiplication, thus, posing a serious problem for mulberry breeders [3].

Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for plant growth [4]. However, soils do pose serious limitations for plant growth too, at times. Some of them are presence of disease-causing organisms and nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion etc. [5]. Under such circumstances, soil-less culturing of plants could be introduced successfully [6]. Soilless culture is the technique of growing plants in soil-less condition with their roots immersed in the nutrient solution [7]. Various soilless culture systems are followed for crop production and Aeroponic system is one among them.

With the introduction of V-1 mulberry cultivar, farmers have switched over to whole shoot harvest which serve as pruning. Frequent pruning of shoot causes short fall of plant material for vegetative propagation. Further this plant material under protective irrigation condition causes problem in rooting under field condition. Under such circumstances, a new line of propagation and multiplication through aeroponic system can minimize the said problems and help for quick multiplication.

Although there are no much studies have been carried out regarding propagation of hard wood cuttings under aeroponics, an attempt has been made to propagate V-1 mulberry cuttings with different number of buds. Preliminary study has been conducted to know the performance of mulberry saplings under aeroponic system.

2. MATERIALS AND METHODS

The experiment was conducted by growing V-1 mulberry saplings both in an aeroponic chamber and nursery condition during 2020-21 at Department of Sericulture, UAS, GKVK, Bengaluru-65 in collaboration with Innova Technology Solutions Mysore Private Limited. The experiment was laid out in factorial CRD with 3 treatments and 6 replications.

2.1 Treatment Details

List 1. List of treatments use for the study

Systems of Propagation (S)	Treatments (T)	Treatment combinations
Aeroponic system (S_1)	One bud per cutting (T_1)	S_1T_1
	Two buds per cutting (T_2)	S_1T_2
	Three buds per cutting (T_3)	S_1T_3
Nursery system (S_2)	One bud per cutting (T_1)	S_2T_1
	Two buds per cutting (T_2)	S_2T_2
	Three buds per cutting (T_3)	S_2T_3

2.2 Layout of the Experiment

2.2.1 Description of aeroponic chamber and nursery bed

The aeroponic prototype was specifically designed for mulberry crop. The three important parts of aeroponic structure are root chamber, nutrient solution tank and automated nutrient misting system. The prototype was designed for experimental purpose by Innova Technology Solutions Mysore Pvt. Ltd. The root chamber of 4×2×1.7 feet was made of aluminium. The top of the root chamber had space to accommodate 18 saplings with a spacing of 15 cm apart (Plate 1).

The nutrient tank was connected with motor to pump the nutrient solution to root chamber with a minimum pressure of 60 psi. To ensure fine misting of nutrient solution to root chamber 40-100µ size nozzles were used, so that roots do not get injured due to pressure and large size of mist. This maintained the higher relative humidity inside the chamber. The motor was connected with automated timer set so that the time and duration of misting could be managed with different schedule of time.

Nursery bed measuring 300cm × 120cm (L× B) with a spacing 20 cm between rows and 8 cm between cuttings was prepared. The care had been taken to transfer more number of cuttings than aeroponic chamber to study root parameters.

The one, two and three budded cuttings were treated with 2000ppm IBA solution and were planted in trays filled with cocopeat and after 30 days of root development, the rooted cuttings with at least 18-20 roots were transferred to both aeroponic chambers and raised nursery bed. The readings were taken at 15, 30, 45 and 60 days after transplanting to both the systems.

2.2.2 Preparation of nutrient solution

The nutrient stock solution was prepared by dissolving each nutrient in one litre of deionized water separately. Later 100ml of each solution was taken and made up the volume to 10 litres of water and filled into nutrient tank. The protocol developed by Hoagland and Arnon [8] was modified for mulberry. Further, the dissolved nutrients were sprayed to the root zone directly by automizers at regular intervals.

Nutrients used : Urea – 30 g/L ; Potassium dihydrogen orthophosphate – 15 g/L; Calcium nitrate – 75 g/L; SOP – 50 g/L; Magnesium sulphate – 35 g/L; Micronutrients – 4 g/L

Concentration of different nutrients present in nutrient tank : $N(NO_3^-)$ – 107.43 ppm; $N(NH_4^+)$-240ppm; K-230ppm; P-30ppm; Mg- 30ppm; Ca-140.262 ppm; S-119.139 ppm; Fe – 0.669ppm; Zn – 1.004ppm; B-0.167ppm; Cu- 0.335 ppm; Mo-0.033ppm; Na- 5.571ppm; Cl-15.32ppm; Mn-0.335. The observations were made at an interval of 15, 30, 45 and 60 days after transplanting

3. RESULTS

3.1 Internodal Length (cm) and Plant Height (cm)

The growth parameters of V-1 mulberry was influenced by number of buds per cutting, systems of propagation and the interaction of both. In general, saplings grown under aeroponic system have recorded more plant height, internodal length, number of leaves and leaf yield compared to nursery grown saplings. The results showed that, maximum of 3.29 cm (internodal length) and 43.17 cm (plant height) was recorded at 60 days of transplanting in aeroponic system when compared to nursery conditions (2.83 cm and 39.99 cm respectively). Among treatments, with respect to the internodal length and plant height T_3 recorded maximum (3.62 and 45.07 cm respectively) followed by T_2 and T_1.

Among interaction effect, S_1T_3 recorded maximum of 4.27 cm and 46.90 cm internodal length and plant height respectively and the minimum was recorded by S_2T_1 (2.39 cm and 35.47 cm respectively) at 60 DAT. Similar trend was noticed at 15, 30 and 45 DAT. (Table 1 and Fig. 1).

3.2 Number of Leaves, Leaf Area (cm^2) and Leaf Yield (g/Plant)

Among the systems of propagation, the aeroponics system considerably recorded maximum number of leaves (14.99) and leaf yield (8.59 g/plant) compared to nursery condition (9.00 and 7.71 g/plant) at 60 DAT. However, leaf area was found maximum in nursery condition (75.82 cm^2) followed by aeroponic system (67.58 cm^2) at 60 DAT. Same trend was observed at 15, 30 and 45 DAT.

Among treatments T_3 showed maximum no. of leaves (14.34), leaf area (93.04 cm^2) and leaf yield (10.12 g/plant) followed by T_2 (12.58, 78.96 cm^2 and 9.24 g/plant) and T_1 (9.05, 43.12 cm^2 and 5.10 g/plant) respectively at 60 DAT. Among interaction effect, significantly higher number of leaves was recorded in S_1T_3 (16.91) followed by S_1T_2 (15.83), S_1T_1 (12.22), S_2T_3 (11.78), S_2T_2 (9.33) and least no. of leaves was recorded in one budded cutting under nursery (5.88) at 60 DAT. With respect to leaf yield (g/plant) S_1T_3 recorded maximum (10.79 g/plant) and S_2T_1 recorded minimum (4.84g/plant) at 60 DAT. The maximum leaf area was recorded by S_2T_3 (95.96 cm^2) followed by S_1T_3 (90.11 cm^2), S_2T_2 (81.93 cm^2), S_1T_2 (75.99 cm^2), S_2T_1 (49.58 cm^2) and least was recorded in S_1T_1 (36.66 cm^2) at 60 DAT. Same trend was observed at 15, 30 and 45 DAT (Table 2, Fig. 2 and Fig. 3).

4. DISCUSSION

In the present investigation, we the authors found that the three budded cuttings recorded maximum for all the above studied parameters followed by two budded cuttings and least has been recorded by one budded cuttings. These results are in line with the findings of Pooja and Sadatulla [9,10] who studied the effect of IBA concentrations (0, 1000, 2000 and 3000 ppm) on rooting of V-1 mulberry cuttings with varying number of buds (one, two, three and four) and found that significantly highest rooting percentage (89. 44%), length of longest root (10.65 cm), fresh weight of roots (1.48 g) number of sprouted cuttings (14.67), survival percentage (96.66%) were recorded in three budded cuttings whereas, number of leaves (10.60) and length of shoot (26.63 cm) was maximum in two budded cuttings treated with 3000 ppm of IBA and the results were on par with three budded cuttings treated with 3000 ppm of IBA while the lowest was recorded by one budded cuttings. These results can be attributed with the fact that the increase in root and shoot parameters might be due to better physiological maturity of cuttings coupled with better mobilization of secondary metabolites resulting in better root formation with the help of growth regulators (IBA at 200 ppm) [11]. Hence these results can be attributed to the higher shoot parameters recorded by three budded cuttings.

With respect to the systems of propagation *viz.,*aeroponic system and nursery, the present results are in line with the findings of Martin-Laurent et al. [12] who had reported that the *Acacia mangium* plants grown under aeroponics had longer internodal length, higher plant height and greater leaf area than those grown in sand. These results are in parity with findings of Traykova et al. [13] who stated that, the *Salvia officinalis* derived from aeroponically produced seedlings have recorded enhanced plant growth and yield to the tune of one fifth under aeroponic system. This was attributed to stimulated development of vigor root system in the plant and also shoot ramification. Movahedi and Rostami [14] studied the effect of aeroponic system on three medicinal plants *viz., Cichorium*, *Withania* and *Echinacea* and showed that the plants harvested after six months from aeroponic system have produced the highest plant height, the highest number of leaves, shoot dry weight, and shoot fresh weight in comparison with soil system. Further, Tabatabaei (2008) reported that leaf area (1.7m^2) of aeroponically grown valerian *(Valeriana officinalis* L. var. common) was higher than plants grown in soil. Fascella and Zizzo [15] have also reported that, the aeroponically grown anthurium produced the higher number of leaves, greater leaf size and petiole length.

Pagliarulo and Hayden [16] reported increased yield, short maturity time and overall quality in aeroponically grown *Urtica dioica*. It was also inferred by Tierno et al. [17] who evaluated different systems for production of quality cultivars in three potato cultivars (Agria, Monalisa and Zorba) under Aeroponics and greenhouse beds and reported that, Aeroponics system had shown 34 % to 87% higher tuber yield per plant and improved tuber weight (60%) for cultivars Zorba and Monalisa. These results are also in line with findings of El-Helaly and Darwish [18] who found 2.51 and 2.30 fold increase in the leaf yield of lettuce in hydroponic and aeroponic system respectively than in the sandy substrate after 6 weeks after transplanting.

Ferrini et al. [19] grown *Cannabis sativa var. Kompolti* under aeroponic system and found that the roots of aeropoically grown plants showed a 64-fold and 13-fold higher fresh (FW) and dry weight (DW) as compared to soil grown plants, respectively; the aerial parts showed a 39-fold and 44-fold higher FW and DW; the stems' average diameter and the mean leaves area increased by 3.89-fold and 8.9-fold, respectively. Aeroponically grown plants reached almost double the height (ca. 70 cm) as compared to soil grown (ca. 30 cm). They demonstrated that aeroponics applied to *C. sativa var. Kompolti* resulted in a significant modification in the yield of plant biomasses as compared to conventional soil cultivation. Indeed, the biomass of aeroponically grown plants (both the aerial parts and roots) after 8 weeks of cultivation strikingly outpaced that of conventional soil cultivation.

Khater et al. [20] showed that the shoot of basil plants grown in aeroponic (62.00 ± 2.65 cm) was taller than those of hydroponic system (57.83 ± 7.42 cm) and peatmoss slabs (48.77 ± 2.89 cm) at the vegetative and flowering stages after 4 weeks. They also confirmed that the aeroponically grown plants had higher fresh and dry mass of shoot when compared to other two systems.

List 2. Spray time and interval

Spray on time (sec)		Spray interval (min)	
6:30 AM to 6:30 PM	**6:30 PM to 6:30 AM**	**6:30 AM to 6:30PM**	**6:30 PM to 6:30 AM**
30 sec	30 sec	15 min	30 min

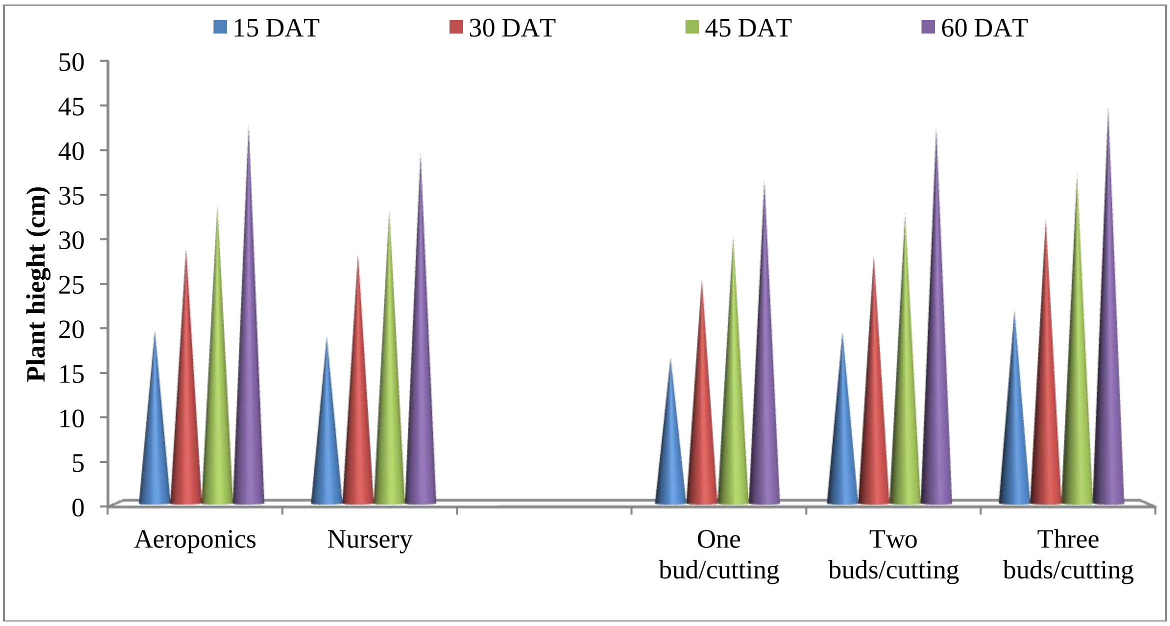

Fig. 1. Plant height (cm) of V-1 as influenced by systems of propagation and number of buds on cuttings at 15, 30, 45 and 60 days after transplanting

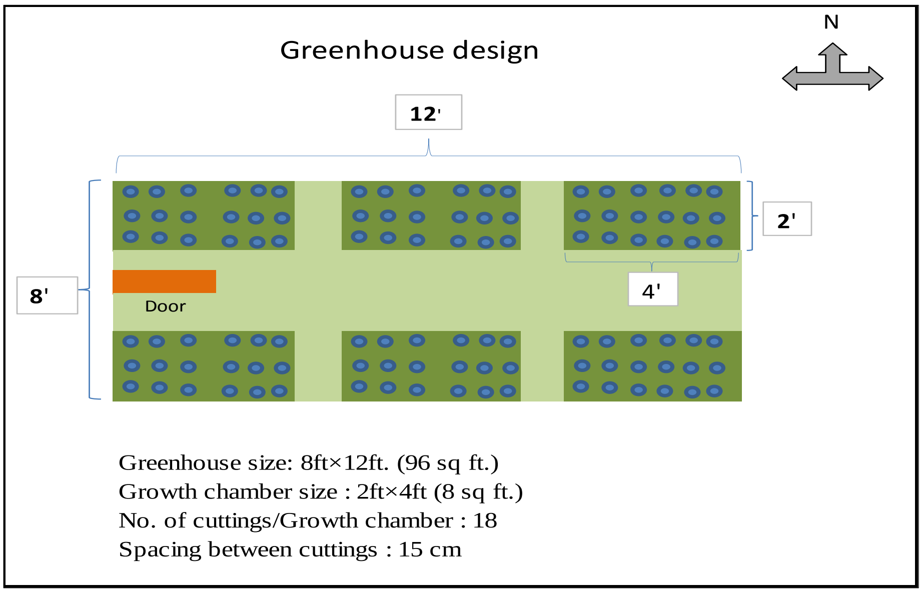

Plate 1. Aeroponic greenhouse design

Table 1. Internodal length (cm), and plant height (cm) of V-1 as influenced by aeroponic system and nursery conditions at different days after transplanting

Particulars	Internodal length (cm)				Plant height (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
				Systems of propagation				
S_1	1.21	2.13	2.89	3.29	19.74	29.1	33.95	43.17
S_2	1.36	2.01	2.66	2.83	19.06	28.42	33.47	39.99
F test	*	*	*	*	*	*	*	*
S.Em±	0.01	0.03	0.02	0.09	0.06	0.08	0.1	0.13
CD@ 5%	0.02	0.09	0.05	0.27	0.17	0.24	0.29	0.38
				No. of buds (Treatments)				
T_1	1.05	1.45	2.35	2.44	16.63	25.61	30.51	36.85
T_2	1.28	2.22	2.73	3.12	19.57	28.27	33.1	42.82
T_3	1.54	2.54	3.26	3.62	22	32.4	37.53	45.07
F test	*	*	*	*	*	*	*	*
S.Em±	0.01	0.04	0.02	0.11	0.07	0.1	0.13	0.16
CD@ 5%	0.03	0.11	0.06	0.33	0.2	0.3	0.36	0.47
				Interaction (S x T)				
S_1T_1	0.95	1.44	2.33	2.5	16.58	25.76	31.66	38.23
S_1T_2	1.25	2.17	2.69	3.1	20.14	28.94	32.4	44.39
S_1T_3	1.43	2.77	3.66	4.27	22.5	32.6	37.8	46.9
S_2T_1	1.14	1.45	2.36	2.39	16.68	25.45	29.35	35.47
S_2T_2	1.3	2.27	2.76	3.13	19	27.6	33.8	41.25
S_2T_3	1.65	2.32	2.87	2.97	21.5	32.2	37.25	43.25
F test	*	*	*	*	*	*	*	*
S.Em±	0.01	0.05	0.03	0.16	0.1	0.15	0.18	0.23
CD@ 5%	0.04	0.16	0.08	0.46	0.29	0.42	0.51	0.66

** - Significant at 5%*

Table 2. Number of leaves, leaf area (cm^2) and leaf yield (g/plant) of V-1 as influenced by aeroponic system and nursery conditions at different days after transplanting

Particulars	No. of leaves				Leaf area (cm^2)				Leaf yield (g/plant)
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT	60 DAT
					Systems of propagation				
S_1	4.14	6.7	8.35	14.99	29.94	44.14	54.81	67.58	8.59
S_2	4.27	5.73	7.44	9	33.31	50.7	63.73	75.82	7.71
F test	*	*	*	*	*	*	*	*	*
S.Em±	0.03	0.04	0.05	0.08	0.13	0.2	0.27	0.31	0.15
CD@ 5%	0.07	0.11	0.14	0.22	0.37	0.59	0.79	0.9	0.45
					No. of buds (Treatments)				
T_1	3.38	5.19	6.15	9.05	24.64	32.88	35.91	43.12	5.1
T_2	4.1	6.59	8.63	12.58	32.6	50.1	63.01	78.96	9.24
T_3	5.14	6.87	8.91	14.34	37.63	59.28	78.89	93.04	10.12
F test	*	*	*	*	*	*	*	*	*
S.Em±	0.03	0.05	0.06	0.09	0.16	0.25	0.34	0.38	0.06
CD@ 5%	0.09	0.14	0.17	0.27	0.45	0.72	0.97	1.1	0.18
					Interaction (S x T)				
S_1T_1	3.33	5.88	6.83	12.22	24.14	30.52	32.79	36.66	5.36
S_1T_2	4.05	7	9.05	15.83	30.52	45.52	56.1	75.99	9.63
S_1T_3	5.05	7.23	9.16	16.91	35.16	56.39	75.54	90.11	10.79
S_2T_1	3.43	4.5	5.46	5.88	25.14	35.25	39.03	49.58	4.84
S_2T_2	4.14	6.18	8.21	9.33	34.68	54.68	69.93	81.93	8.85
S_2T_3	5.23	6.5	8.66	11.78	40.11	62.18	82.25	95.96	9.45
F test	NS	*	*	*	*	*	*	*	*
S.Em±	0.04	0.07	0.08	0.13	0.22	0.35	0.47	0.54	0.09
CD@ 5%	0.13	0.19	0.24	0.38	0.63	1.02	1.37	1.56	0.26

**- Significant at 5%* *NS – Non significant*

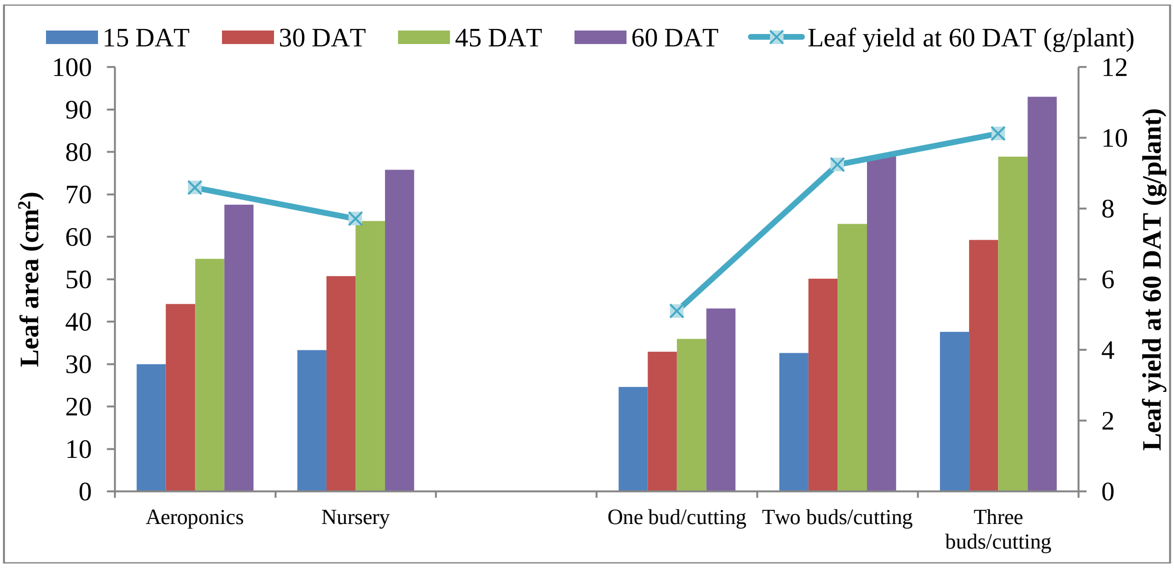

Fig. 2. Leaf area (cm^2) and leaf yield (g/plant) of V-1 as influenced by systems of propagation and number of buds on cuttings at 15, 30, 45 and 60 days after transplanting

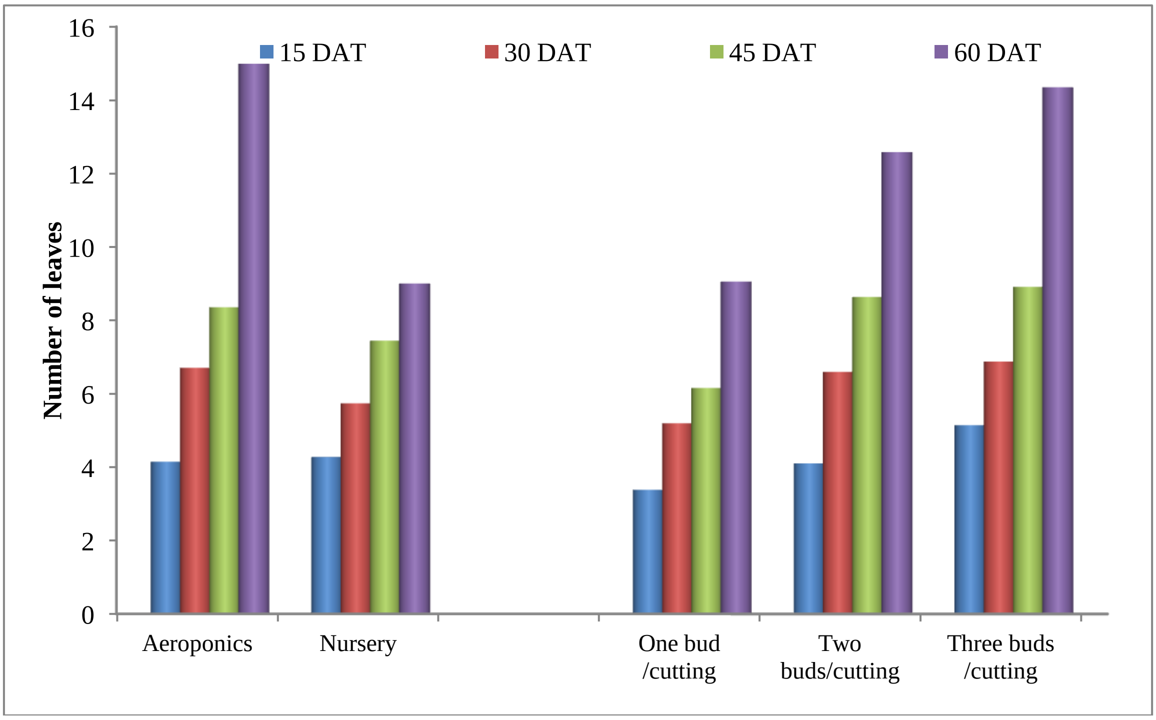

Fig. 3. Number of leaves of V-1 as influenced by systems of propagation and number of buds on cuttings at 15, 30, 45 and 60 days after transplanting

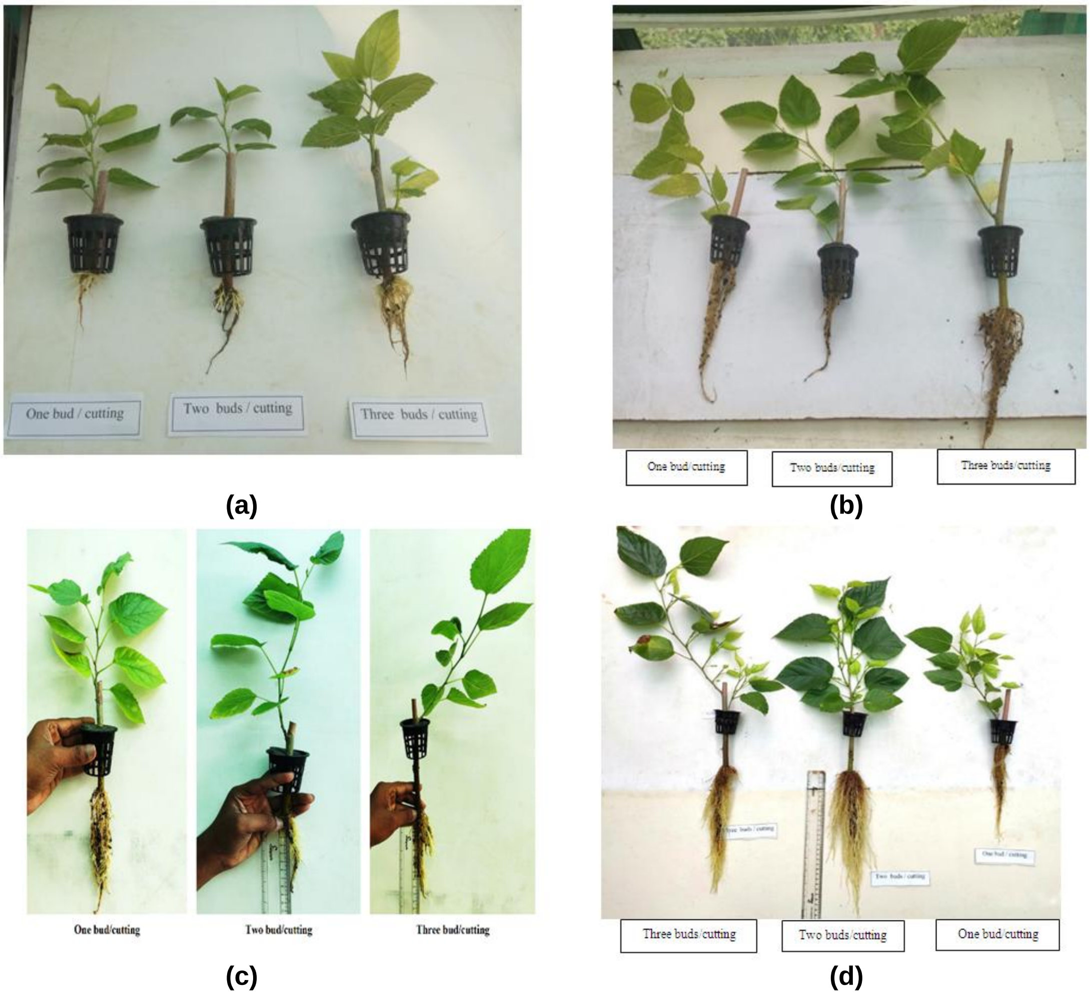

Plate 2. Mulberry saplings at (a)15 DAT (b) 30 DAT (c) 45 DAT and (d) 60 DAT in aeroponic chamber

These results may be due to the fact that the roots of aeroponics systems are hanged in mid-air inside containers or chambers at 100% humidity and fed up a fine mist of nutrient solutions. This system stimulates absorption of roots to much needed oxygen and nutrients, those increasing metabolism and rate of growth compared with soil [21]. It can be inferred that, the aeroponic system enhance the rates of plants growth by promoting the root aeration because, the root system is totally suspended in the air, giving the plant stem and roots system access to 100% of the available oxygen present in the air [22]. This is in line with the findings of Nishchitha et al. [23] who reported that the V-1 mulberry saplings grown under aeroponics had recorded maximum for root parameters *viz.,* longest root length, number of roots and root biomass when compared to nursery condition. Thus, the extensive oxygen availability likely represents the most important advantage of the aeroponic culture method over conventional and hydroponic ones [17].

5. CONCLUSION

It is concluded from the experimental results that, all plant and leaf parameters have recorded more in aeroponically grown saplings than nursery system. Further, the systems of propagation, number of buds per cutting and their interaction also revealed significant results at 15, 30, 45 and 60 DAT. Therefore, this technology can be exploited for V-1 mulberry multiplication [24].

ACKNOWLEDGEMENT

We the authors of research paper whole heartedly extend our sincere thanks to UAS, Bangalore for extending the laboratory facilities during our research program.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Benedetta C, Germana P, Germanà MA. In vitro response of two Sicilian genotypes of *Morus* (L.) through axillary bud culture. Caryologia. 2007;60(1-2):178-81.
2. Mutharaju. Effect of plant growth regulators, nutrients, season and agronomic practices on rooting and establishment of mulberry cuttings. M.Sc. (Agri) thesis, Univ. Agril. Bengaluru: Sci. 1993;1-154.
3. Fotadar RK, Ahsan MQ, Dhar KL, Dhar A. Screening of mulberry varieties for rooting and induction of rooting by the use of growth regulators. Sericologia. 1990; 30:347-61.
4. Ellis NK, Jensen M, Larsen J, Oebker N. Nutriculture systems-growing plants without soil. Station Bulletin No. 44. Lafayette, IN: Purdue University Press; 1974.
5. Beibel JP. Hydroponics -The science of growing crops without soil. Florida department of agric. Bull. 1960;180.
6. Butler JD, Oebker NF. Hydroponics as a hobby – Growing plants without soil. Circular 844. Urbana: Information Office, College of Agriculture, University of Illinois.1962;3-16.
7. Maharana L, Koul DN. The emergence of hydroponics. Yojana. 2011;55:39-40.
8. Hoagland DR, Arnon DI. The water culture method for growing plants without soil. Calif Agric Exp Stn Bull. 1938;347: 36-9.
9. Pooja HS, Sadatulla F. Effect of indole-3-butyric acid on growth of V-1 mulberry cuttings with varying number of buds in Bangalore. Int J Plant Soil Sci. 2022;34(24):9-13.
10. Pooja HS, Sadatulla F. Effect of IBA concentrations on rooting of mulberry cuttings with varying number of buds. J Pharm Innov J. 2022;11(12):1912-4.
11. Krishna KS. Influence of growth regulators on rooting of mulberry (*Morusalba* L.) with differential nodes and modes of planting. M.Sc. (Agri.) thesis, Univ. Agril. Sci. Bengaluru; 2015.
12. Martin-Laurent F, Lee S-K, Tham F-Y, He J, Diem HG, Durand P. A new approach to enhance growth and nodulation of *Acacia mangium* through aeroponic culture. Biol Fertile Soil. 1997;25(1):7-12.
13. Traykova B, Stanilova M, Nikolova M, Berkov S. Growth and essential oils of *Salvia officinalis* plants derived from conventional or aeroponic produced seedlings. Agric Conspec Sci. 2019;84(1): 77-81.
14. Movahedi Z, Rostami M. Production of some medicinal plants in aeroponic system. J Plants Prod. 2020;1:91-9.
15. Fascella G, Zizzo GV. Preliminary results of aeroponic cultivation of *Anthurium andreanum* for cut flower production. Proceedings of the VIIIth IS on protected cultivation in mild winter climates. Acta Hortic. 2007;(747):233-40.
16. Pagliarulo C, Hayden AL. Potential for greenhouse aeroponic cultivation of medicinal root crops. Proceedings of the Am Plasticult. Soc Conf., San Diego; 2002.
17. Tierno R, Carrasco A, Ritter E, De Galarreta JIR. Differential growth response and minituber production of three potato cultivars under aeroponics and greenhouse bed culture. Am J Potato Res. 2014;91(4):346-53.
18. El-helaly MA, Darwish OA. Effect of culture system; Aerponic, hydroponic and sandy substrate on growth, yield and chemical compositions of lettuce. Plant Arch. 2019;19(2):2543-50.
19. Ferrini F, Fraternale D, Donati Zeppa S, Verardo G, Gorassini A, Carrabs V et al. Yield, characterization, and possible exploitation of Cannabis sativa L. Roots Grown under aeroponics cultivation. Molecules. 2021;26(16):4889.
20. Khater E, Bahnasawy A, Abass W, Morsy O, El-ghobashy H, Shaban Y et al. Production of basil (*Ocimumbasilicum* L.) under different soillesscultures scientific reports. Nat Portfol. 2021;11(12754): 1-14.
21. Lakkireddy KKR, Kasturi K, Rao KRS. Role of hydroponics and aeroponics in soilless culture in commercial food productions research & reviews. J Agric Sci Technol. 2012;1(1):26-35.
22. Buckseth T, Sharma AK, Pandey KK, Singh BP, Muthuraj R. Methods of pre-basic seed potato production with special reference to aeroponics—A review. Sci Hortic. 2016;204:79-87.

23. Nishchitha GA, Bhaskar RN, Bharathi VP, Anusha HG. Aeroponic system is boon for rainfed mulberry cultivation and enhance productivity. J Pharm Innov J. 2023;12(3): 4480-4.

24. Li Q, Li X, Tang B, Gu M. Growth responses and root characteristics of lettuce grown in aeroponics, hydroponics and substrate culture. Horticulturae. 2018; 4(4):35.

© 2023 Nishchitha et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/98187