Original Research Article

INFLUENCE OF AEROPONIC SYSTEM ON GROWTH AND YIELD PARAMETERS OF V-1 MULBERRY

ABSTRACT

In aeroponic system nutrients are directly delivered to the plant roots, which results in a 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 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 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 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 (4.27cm), plant height (44.39cm), number of leaves (16.91), leaf yield (10.79g/plant), whereas least was recorded by S_2T_1 *i.e.,* one budded cuttings under nursery (2.39cm, 35.47cm, 5.88, 4.84g/plant respectively) at 60 DAT. However, S_2T_3 recorded maximum leaf area (95.96cm^2). From these results it can be concluded that, the aeroponic system could be effectively used for the production of V-1 mulberry saplings.

Key words : Aeroponics, V-1 Mulberry, nursery, yield parameters

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. (Chiancone *et al*., 2007).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 (Mutharaju, 1993). 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 (Fotadar *et al.,* 1990).

Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for plant growth (Ellis *et al.,* 1974). 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. (Beibel, 1960). Under such circumstances, soil-less culturing of plants could be introduced successfully (Butler and Oebker, 1962). Soilless culture is the technique of growing plants in soil-less condition with their roots immersed in the nutrient solution (Maharana and Koul, 2011). Various soilless culture systems are followed for crop production and Aeroponic system is one among them.

Qiansheng *et al.* (2018) evaluated aeroponics, hydroponics and soilless culture for lettuce and measured the shoot and root parameters. The plants cultivated in aeroponics system were recorded significantly enhanced root and shoot ratio compared to hydroponics and soilless culture. It was observed that, aeroponic system was found to be superior for high value crop cultivation.

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.

MATERIAL AND METHODS

The experiment was conducted by growing V-1 mulberry saplings both in 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.

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

Layout of the experiment

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 cuttings were treated with 2000ppm IBA solution and after 30 days of root development, the rooted cuttings with at least 18-20 roots were transferred from cocopeat to both aeroponic chambers and raised nursery bed.

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 (1938) 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

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

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.

RESULTS AND DISCUSSION

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 increased number of days. 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. However, 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 2.83cm 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 of 2.39 cm and 35.47 cm S_2T_1 at 60 DAT. Similar trend was noticed at 15, 30 and 45 DAT. (Table 1 and Fig.1).

The above results are in parity with the findings of Martin-Laurent *et al.* (1997) who had reported that the *Acacia mangium* plants grown under aeroponics had longer internodal length than those grown in sand. Also they reported that, the *Acacia mangium* tree saplings attained 1 m in height after only 4 months in aeroponic culture system. According to them the plants grown under aeroponics had greater heights than those grown in sand. It was also confirmed by Traykova *et al.* (2019) who have recorded enhanced plant growth in *Salvia officinalis* under aeroponic system. This was attributed to stimulated development of vigor root system in the plant and also shoot ramification.

It was also inferred by Movahedi and Rostami (2020) who studied the effect of aeroponic system on three medicinal plants *viz., Cichorium, Withania* and *Echinacea*. The results showed that, the plants harvested after six months from aeroponic system have produced the highest plant height, in comparison with soil system as reflected in the present study when the days after transplanting increased from 15 to 60 days there was a tendency increase in the plant height from 22.50 to 46.90 cm and 21.50 to 43.25 cm under both the systems.

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

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. Same trend was observed at 15, 30 and 45 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 (Table 2, Fig. 2 and Fig. 3).

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. Martin-Laurent *et al.* (1997) has reported increased leaf area for *Acacia mangium* plants grown under aeroponic system than those grown in sand. 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 (2006) have also reported that, the aeroponically grown anthurium produced the greater leaf size and petiole length. However, these findings does not holds good for our study as the mulberry grown under soil grown condition recorded maximum for leaf area in the present findings.

The present findings are in close confirmity with Fascella and Zizzo (2006) who reported higher number of leaves for aeroponically grown anthurium. Further, Pagliarulo and Hayden (2002) reported increased yield, short maturity time and overall quality in aeroponically grown *Urtica dioica*. Further, it was inferred by Tierno *et al.* (2014) who evaluated different systems for production of quality cultivars in three potato cultivars (Agria, Monalisa and Zorba) under Aeroponics and greenhouse beds. They 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 in parity with findings of Traykova *et al.* (2019) 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. These results were also in line with findings of El-Helaly and Darwish (2019) who also 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.

These results are further in agreement with Movahedi and Rostami (2020) who studied the effect of aeroponic system on three medicinal plants *viz.*, *Cichorium*, *Withania* and *Echinacea*. The results showed that, the plants harvested after six months from aeroponic system has produced the highest number of leaves, shoot dry weight, and shoot fresh weight in comparison with soil system.

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

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.

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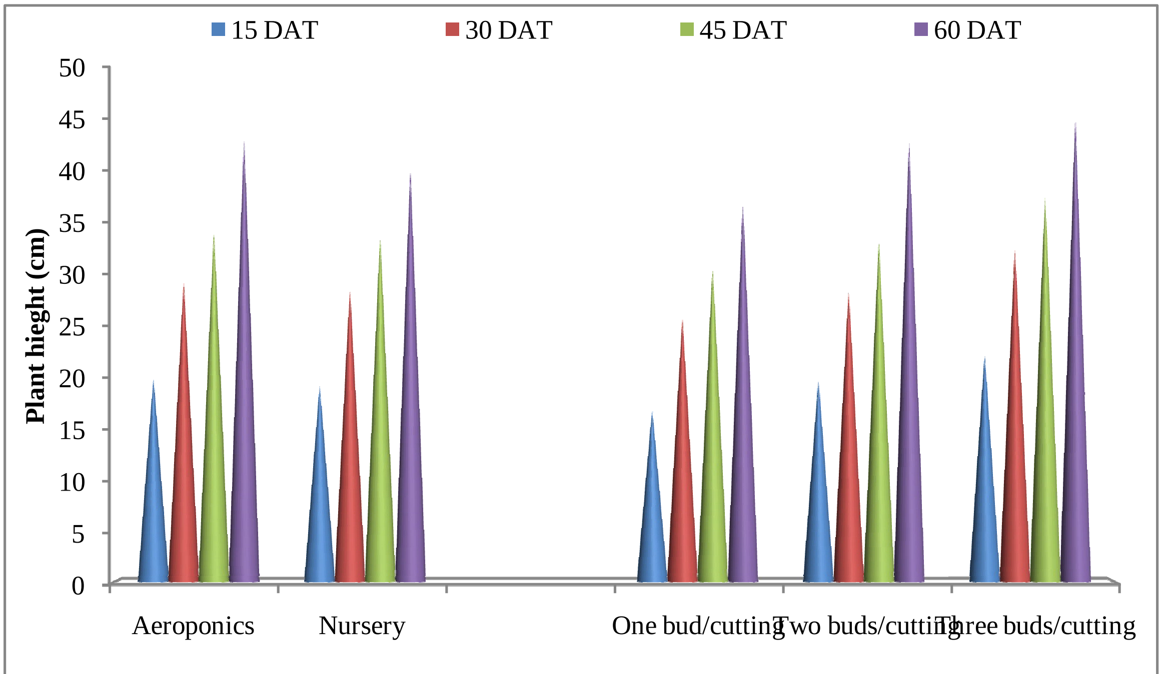

Fig. 1. Plant height (cm) of V-1 as influenced by systems of propagation and number of buds on cuttings at 15, 30, 45 and 60 days after transplanting.

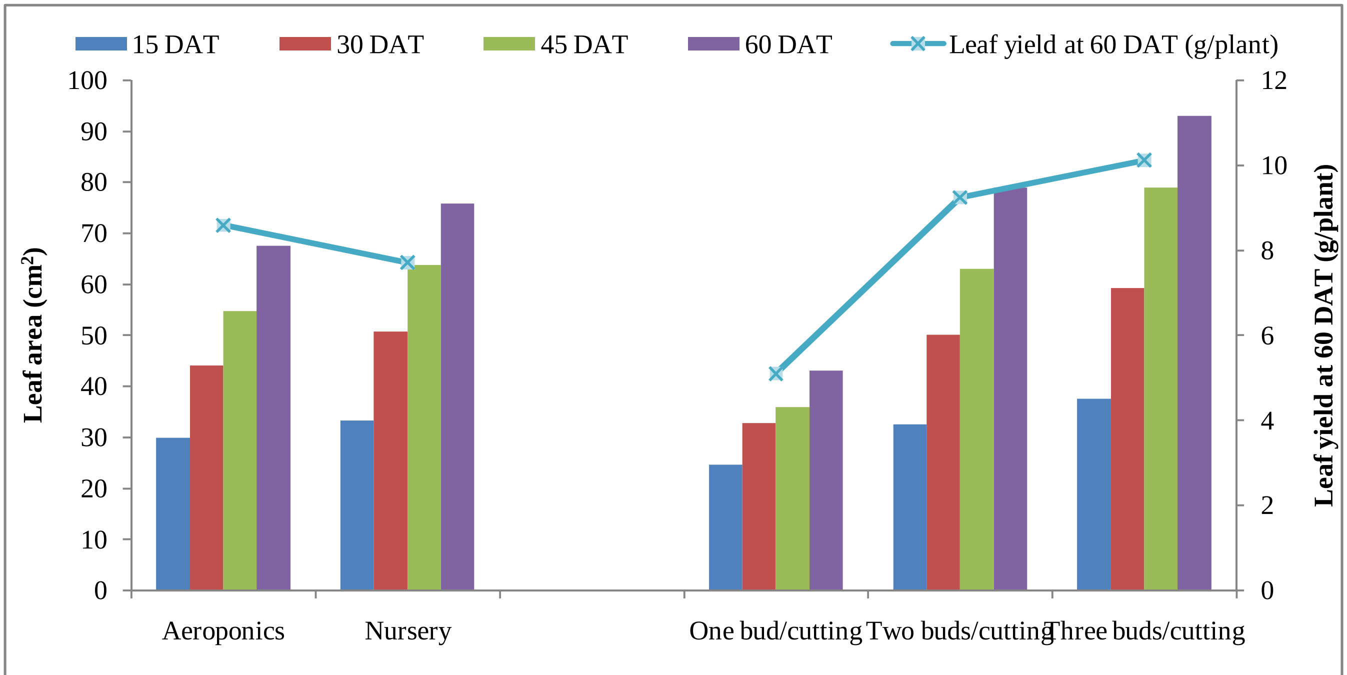

Fig. 2 Leaf area (cm^2) and leaf yield (g/plant) of V-1 as influenced by systems of propagation and number of buds on cuttings at 15, 30, 45 and 60 days after transplanting.

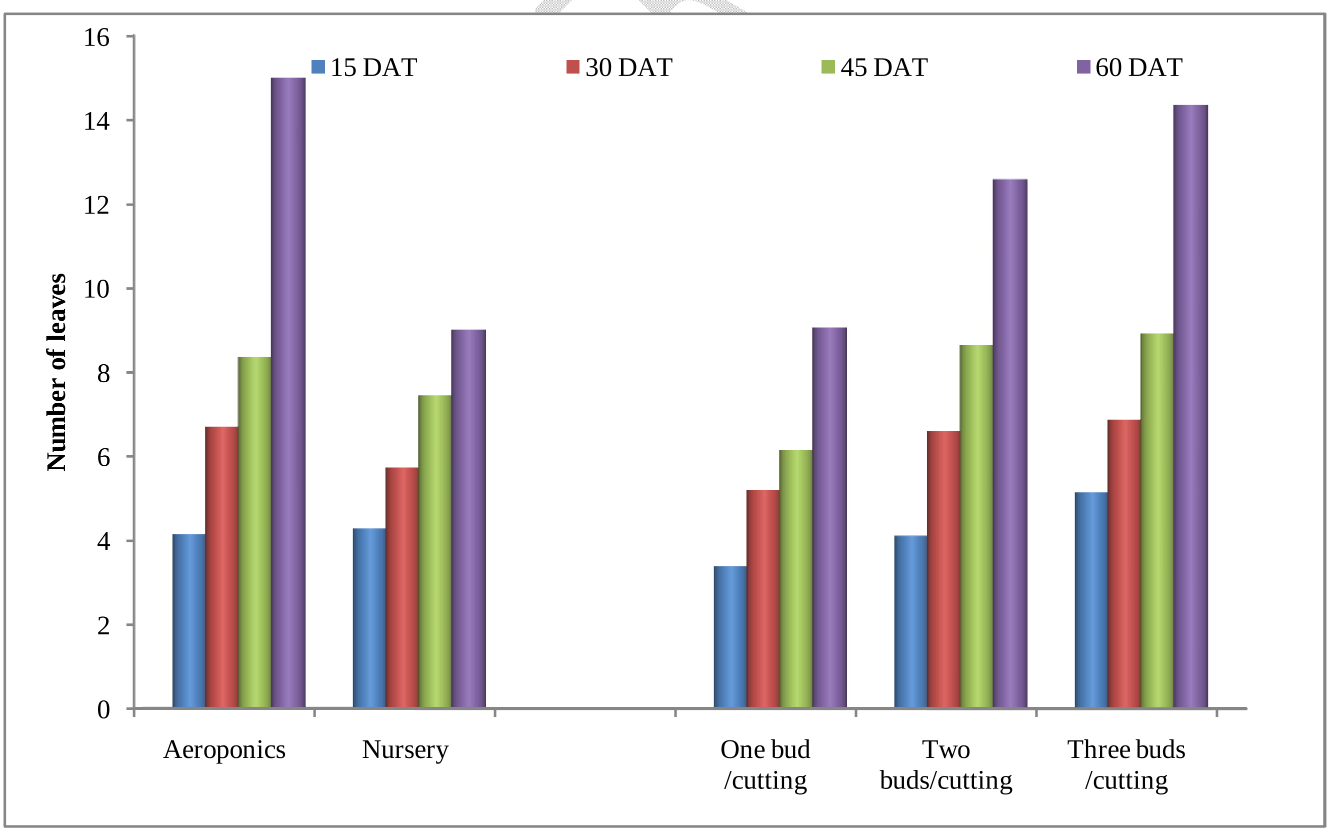

Fig. 3 Number of leaves of V-1 as influenced by systems of propagation and number of buds on cuttings at 15, 30, 45 and 60 days after transplanting.

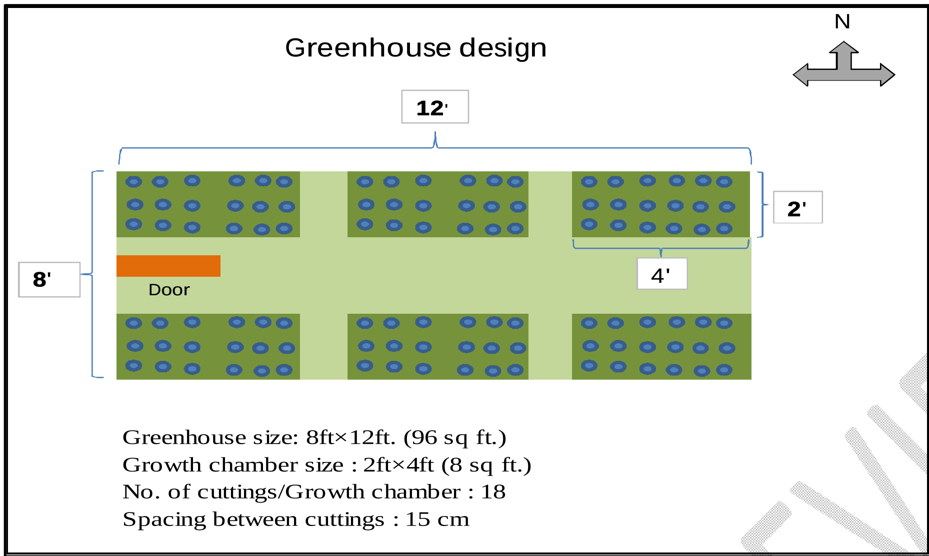

Plate 1. Aeroponic greenhouse design

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