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Fabrication and Performance Evaluation of U Shaped Hydroponic System

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A B S T R A C T

Present study was carried out for Fabrication and Performance Evaluation of U Shaped Hydroponic System under Protected Structures at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), College of Agriculture, IGKV, Raipur (C.G.) during the year 2017-18. The experiment was laid out with three treatments T_4 (U Shaped PVC pipe), T_5 (U Shaped UPVC pipe), T_6 (U Shaped CPVC pipe), of hydroponic system. The transplanting of seedlings of lettuce was done in perforated net pots with a media of coco-pit and vermiculite in 3:1 proportion and clay pellets. Irrigation was applied to the crop by ebb flow technique. The pH and EC of the hydroponic solution were maintained in the range of 5.5 to 6.5 and 1.5 to 2.5 dS/m respectively in the tank. Hydroponic system in the present study has been fabricated with the help of locally available material which reduced cost of construction substantially. Few specific things which are not easily available in local market viz., net pots, clay pellets etc. have been procured thorough online marketing. Effects of material on the growth of plants, EC and pH level of nutrient solution have also been studied and it is found that material has a very little or no effect on the growth as well as EC and pH aspects of nutrient solution at least in the first year of cultivation which might be changed in later years. Appearance wise good and moderately costlier UPVC pipes can be a better option for the design and construction of commercial hydroponic systems. Cost analysis of fabricated hydroponic Structure was also done

Introduction

Hydroponics culture is possibly the most intensive method of crop production in today's agriculture industry. In combination with greenhouses or protective covers, it is highly productive, conservative of water and land, and protective of the environment. There has been increasing interest in the use of hydroponics or soil less techniques for producing greenhouse horticultural crops. The overall advantages of this culture includes no need for soil contaminated with diseases labour for field management is reduced or eliminated economically feasible system with high yields water conservation; elimination of soil borne plant diseases better control of nutrients and lower concentration of nutrients required as there are no losses of nutrients from leaching.

Vertical farming has been proposed as an engineering solution to increase productivity per area by extending plant cultivation into the vertical dimension, thus enhancing land use efficiency for crop production. The large-

scale implementation of vertical farming involves stacking growth rooms, such as glasshouses and controlled environment rooms, on top of each other to construct food-producing high-rise buildings.

Among the many type of hydroponics system, U shape and A frame shaped system can be used in a small space like garden with maximizing the number of plants grown. The system can be done by small-scale growers or adapted into a much larger system. It can be constructed using inexpensive materials such as bamboo, plastic reservoir, PVC pipe and tubes to circulate the water and valves to control the flow of water drainage.

For applying the water and nutrients solution into the structure, the Ebb and Flow system has been followed. These system is works by temporarily flooding the grow channel with nutrient solution and then draining the solution back into the reservoir. This action is normally done with a submerged pump that is connected to a timer.

Materials and Methods

This methodology applied to the fabrication and performance evaluation of U shaped hydroponic system under protected structures. The experiment was conducted in the poly-house at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), College of Agriculture, IGKV, Raipur (C.G.) during the year 2017-18.

Experiment details

The experiment was laid out in the treatments comprised of combination of three type of hydroponic structure, which are as follows;

Treatments	Implements
$T_{4= 90\ mm}$	PVC pipe +U shaped+ Hydroponic solution + Coco-peat + Clay pellets +Vermiculite
$T_{5=88.90mm}$	UPVC pipe + U shaped +Hydroponic solution + Coco-peat + Clay pellets +Vermiculite
$T_{6=88.90mm}$	CPVC pipe + U shaped +Hydroponic solution + Coco-peat + Clay pellets +Vermiculite

Major components of U shaped ebb and flow hydroponic system

The components that will be included in this project are angle iron frame, PVC, UPVC, CPVC pipes, end caps, tank, control valve, micro tube, lateral pipe, submersible pump, barb, metal clamps, net pots, joiner. The measuring and cutting tools are used power cutter, drill machine, pH meter, EC and TDS meter.

Fabrication of U shaped ebb and flow hydroponic system

The hydroponic system using ebb and flow was established under the poly house for the study of different types of pipes and hydroponic nutrient solution on yield and structural parameters. The treatments comprised of three different types of pipes. The soil less media mixture of coco-peat, vermiculite (3:1) and clay pellets was used for the nursery establishment in the growing tray (pro-tray).

The seedlings of lettuce were transplanted in the net pots and there after placed in the hydroponic system. The hydroponic system was designed and developed with the help of locally available material and resources. U shape of hydroponic has to be rigid and strong as all parts are mounted on it. It was made by angle iron of mild steel of size 152.40×152.40 cm. The length of frame as 152.40 cm, height as 152.40 cm. The frame was made by angle iron.

U shaped frame was completed; PVC, UPVC and CPVC pipes were set and fixed to the frame with the help of clamp.

The length of each pipe was 152.40 cm and diameter of PVC, UPVC and CPVC pipes was 90 mm, 88.90 mm and 88.90 mm, respectively. Holes were made on these pipes with the help of drill machine and the distance between two holes was 26.67 cm. Submersible pump was used for the circulation of nutrient solution and aquarium air pump was used to get mixed few quantity of oxygen in nutrient solution for oxidation. U shaped structure shown in fig. 1.

Preparation of bed and media

Media consisted of composition of coco-peat and vermiculite in the proportion of 3:1 and clay pellets .

Transplanting operation

Near about one month old seedling were transplanted on the prepared pots and placed newly fabricated structures including A frame shaped hydroponic for the study.

Concentration of nutrients solution

Nutrient solution is the most important chemical of the hydroponic system. In the present study the nutrient solution were prepared by following two different methods which are Hoagland nutrient (Hogland and Anon 1950) and standard hydroponic solution (Keith Roberto 2003).

The solution were prepared by mixing different chemicals like calcium nitrate, potassium nitrate, sulphate of potash, monopotassium phosphate, magnesium sulphate, Fe chelated, with RO water. The pH of the RO water was 6.5 and 6.3 before and after mixing the chemical.

Results and Discussion

Length of lettuce leaf in U shape structure

The result revealed that there were variations in leaf of lettuce plants according to the treatments are respectively recorded after 7 days of transplanting 7 DAT, 14 DAT and 21 DAT. The average length of plant leaf in T_4 was more (6.58 cm) as compared to other two treatments i.e. T_5 and T_6 with 5.84 cm and 6.18 cm, leaf length respectively. The average length of plants leaf in case of T_4 was recorded to be more (9.12cm) in comparison to treatments T_5 (8.74 cm) and T_6 (8.64 cm). Length of leaf of lettuce leaf recorded after 21 days of transplanting revealed that the average length of plants leaf in T_4 was found to be maximum (10.82cm) as compared to treatments T_5 and T_6 with 10.79 cm and 9.31 cm, length respectively. This variation may be due to light effect.

Width of lettuce leaf in U shaped structure

Treatments wise width of plant leaf of lettuce are presented in respectively for observation related at 7 DAT, 14 DAT and 21 DAT. Plant leaf width recorded after 7 days of transplanting shown in fig 3 revealed that the maximum average length of plant leaf was found in case of T_6 (5.55cm), which was followed by T_5 and T_4 in which it was 4.68 cm and 4.46 cm, respectively. The variation may be due to variation in light. The average width of plants leaf in case of T_5 was found to be maximum (8.07cm) as compared to treatments T_4 (7.90 cm) and T_6 (6.59 cm). Similarly the average width of plants leaf was recorded to be maximum in case of T_5 (9.93 cm), where as in case of T_4 and T_6 it was found to be 9.91 cm and 8.27 cm, respectively. This variation may be due to light effect during experimentation. Fig:3 shows the average variation in plant leaf under different treatments at 7, 14 and 21 days after transplanting.

Values of pH of hydroponic solution and its consumption under different treatment in U shaped structure

Treatment wise the values of pH recorded each day or in interval of days change of the nutrient solution are showed suitable range of pH of the nutrient solution. At the range from 5.5 to 6.5, the plants easily absorbed nutrients from the nutrient solution. The interval of changing of nutrient solution depends upon pH range and the age of crop after transplanting. pH will increase because some of the nutrients and micro-nutrients began to precipitate out of the solution and can stick to the walls of the tank (reservoir) and pipes (growing chambers). The variation of consumption of pH changing the nutrient solution in T_4, T_5 and T_6 concentration is also shown is Fig.4 This variation is due to the precipitation of nutrients and micro-nutrients in the tank.

Values of EC of hydroponic solution and its consumption under different treatment in U shaped structure

The values of EC of hydroponic solution and its consumption of by the plants under different treatments and shows suitable range of EC of the nutrient solution. The interval of changing of nutrient solution depends upon EC range and the age of crop after transplanting. The EC values increase due to increase in salt concentration of nutrients solution. The variation of consumption of EC changing at different stages of crop grown under treatment T_4, T_5 and T_6 is shown in Fig 5 The EC in all the three treatments was increased due to increase salt concentration in the nutrients solution under different treatment.

Crop yield

The Total yield of lettuce was found to be U shaped structure total yield of lettuce was found to be 2 kg, 1.35 kg, and 1.50 kg, respectively under in T_4 (PVC pipe), T_5 (UPVC pipe), T_6 (CPVC pipe).

Cost of fabricated hydroponic structure

The cost of material (viz. pipe, iron frame, micro tube, end cap etc.) used for fabrication of the structures were calculated to check the economy of the hydroponic system. The cost of fabricated U shaped hydroponic structures for different type of pipe used in this study. The total cost of fabricated U shaped hydroponic structure with PVC Pipe was Rs. 3800.00 which was lowest as compared to other pipe material used in this study.

Table.1 Quantity of different nutrient solution used in the study

Chemical	Quantity (gm) for 30 l
Calcium nitrate ($ca(NO_3)_2$)	15.90
Potassium nitrate (KNO_3)	5.30
Sulphate of potash (K_2SO_4)	1.20
Monopitassium phosphate (KH_2PO_4)	3.70
Magnesium sulphate ($MgSO_4*7H_2O$)	6.40
Fe chelated	1.00
Combi	8.00
Total	41.50

Table.2 Cost of fabricated U shaped hydroponic structure

S.N.	Material	Quantity	PVC Rate (Rs)	PVC Amount (Rs)	UPVC Rate (Rs)	UPVC Amount (Rs)	CPVC Rate (Rs)	CPVC Amount (Rs)
1.	Angle iron frame	12 kg	100	1200	100	1200	100	1200
2.	Pipe	3 m	167.5	502.5	252.66	758	1012	3036
3.	End cap	2 pcs	40	80	161	322	161	322
4.	Micro tube	1/2 m	8	4	8	4	8	4
5.	Male barb	2 pcs	3	6	3	6	3	6
6.	Female barb	2 pcs	3.5	7	3.5	7	3.5	7
7.	Metal clamp	4 pcs	10	40	10	40	10	40
8.	16 mm L-joint	2 pcs	4.	8	4	8	4	8
9.	16 mm T-joint	2 pcs	4	8	4	8	4	8
10.	16 mm joiner	2 pcs	5	20	5	20	5	20
11.	Control valve	1 m	10	10	10	10	10	10
12.	40 mm PVC pipe	1 m	30	30	30	30	30	30
13.	40 mm L-joint	1 pcs	40	40	40	40	40	40
14.	40mm end cap	1 pcs	25	25	25	25	25	25
15.	Submersible pump	1 pcs	250	250	250	250	250	250
16.	Timer	1 pcs	1200	1200	1200	1200	1200	1200
17.	Tub	1 pcs	250	250	250	250	250	250
18.	Net cup	12 pcs	10	120	10	120	10	120
	Total			3800.5		4298.00		6576.00

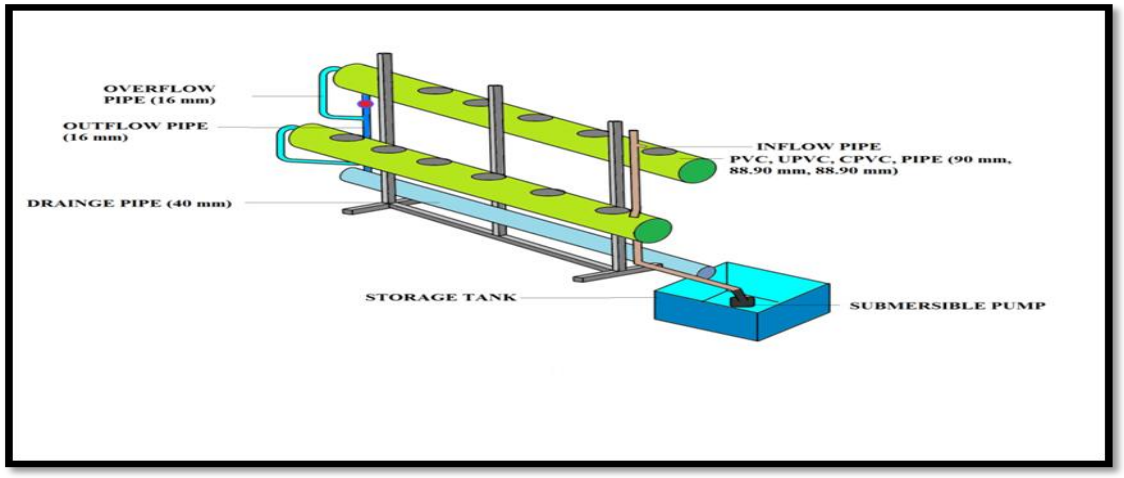

Fig.1 Isometric view of U shaped hydroponic structure

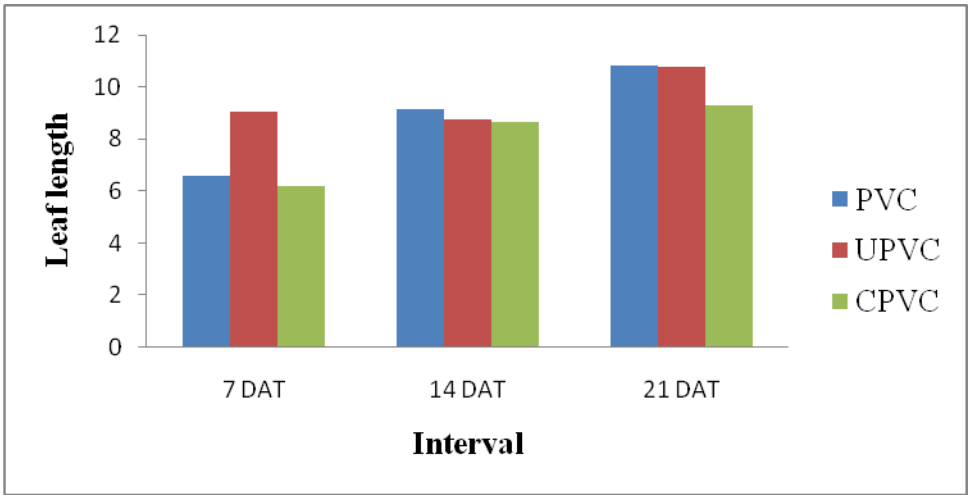

Fig.2 Bar diagram shows effect of Pipe material on length of lettuce leaf in U shapes structure

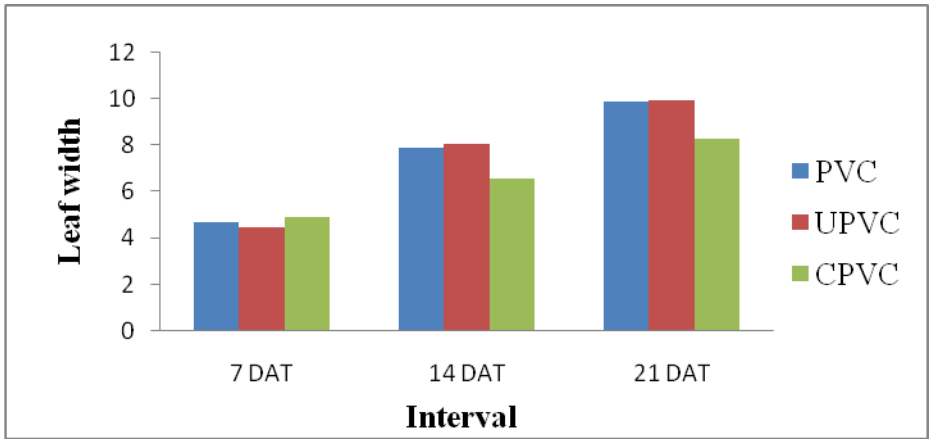

Fig.3 Bar diagram showing effect of Pipe material on width of lettuce leaf in U Shapes structure

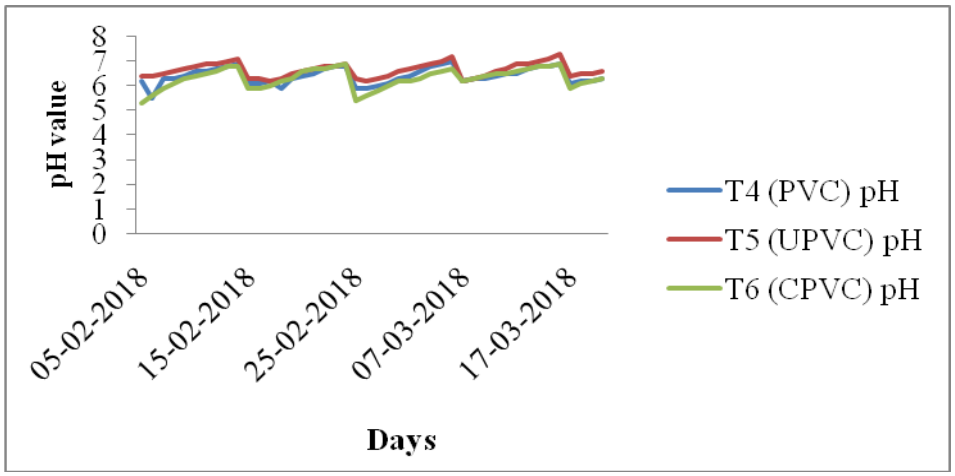

Fig.4 Values of pH of hydroponic solution after changing the nutrient solution under different treatment in U shaped structure

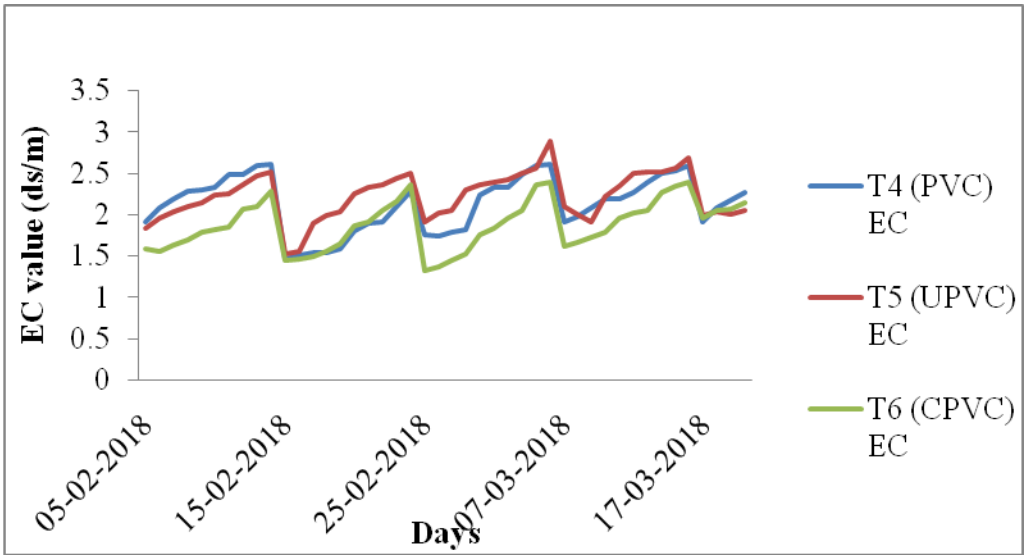

Fig.5 Values of EC of hydroponic solution after changing the nutrient solution under different treatment in U shaped structure

On the basis of results of this study following conclusions are drawn.

Design and developed U-shaped hydroponic system proved to be an acceptable technology for the cultivation of horticultural crops under protected condition with limited space requirements.

Commercially available hydroponic systems are very costly.

To test the prepared hydroponic solution the pH and EC of the solution in hydroponic system was maintained between 5.5 to 6.5 and 1.5 to 2.5 ds/m respectively.

Pipe material has a very little effect on the growth of the plants at least in the first year of cultivation. These pipe materials may effect few the growth of plants due to deterioration of the quality of pipe of used for multi years.

In the present study leafy vegetables Lettuce has been cultivated which had given satisfactory results in terms of growth and nutrient requirements.

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