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Fabrication and Performance Evaluation of a Shaped Frame Hydroponic System

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ABSTRACT

Present study was carried out for Fabrication and Performance Evaluation of A Shaped frame 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_1 (A-frame PVC pipe), T_2 (A-frame UPVC pipe), T_3 (A-frame 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.

Key words: *Hydroponic systems, Root system, Yields, Floor area*

INTRODUCTION

Hydroponics is a method of growing plants in water based nutrient rich solution. It does not use soil instead the root system is supported using an inert medium such as perlite, clay-pellets and vermiculite. The basic premise behind hydroponics is to permit the plants roots to come in direct touch with the nutrient solution. While also having access to oxygen which is essential for perfect growth. It permits for stable to high running head yields, diseases and pest are easier to get rid of than in soil because the system can be mobile, it is easy to harvest and there is no pesticides damage.

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The most important advantage of hydroponics is that it uses less water than soil and that it can be used in places where in-ground agriculture or gardening are not possible. Vertical farming has been suggested 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. These growth systems expand crop production into the vertical dimension to produce a higher yield using less floor area. Examples of VFS include the use of vertical columns vertically suspended grow bags conveyor-driven stacked growth systems A-frame designs and plant factory approaches.

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 tank. This activity is normally done with a submerged pump that is attached to a timer. When the timer turns the pump on nutrient solution is pumped into the grow channel and when it close the pump the nutrient solution flows back into the tank. The setting of timer is depending upon the size and type of plants, temperature and humidity and the type of growing medium used.

MATERIAL AND METHODS

This methodology applied to the fabrication and performance evaluation of A 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 six type of hydroponic structure, which are as follows;

Treatments	Implements
$T_{1= 90\ mm}$	PVC pipe +A-frame+ Hydroponic solution + Coco-peat + Clay pellets +Vermiculite
$T_{2=88.90mm}$	UPVC pipe +A-frame +Hydroponic solution + Coco-peat + Clay pellets +Vermiculite
$T_{3=88.90mm}$	CPVC pipe +A-frame +Hydroponic solution + Coco-peat + Clay pellets +Vermiculite

Major Components of A frame ebb and flow hydroponic system

The planning for fabrication and performance evaluation of A shaped hydroponic system. In this section, the components selection will be discuss. 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 A shaped frame 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 during the first week of February 2018. The hydroponic system was designed and developed with the help of locally available material and resources. Although, some specific things which were not available at local level, have been procured through on-line purchase. A shaped frame of hydroponic system has to be rigid and strong as all parts are mounted on it. It was made by angle iron of mild steel of size 152.40×182.88×91.44 cm. The length of frame was 152.40 cm, height 182.88 cm and width 91.44 cm.

A 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. A shaped frame structure shown in fig. 1.

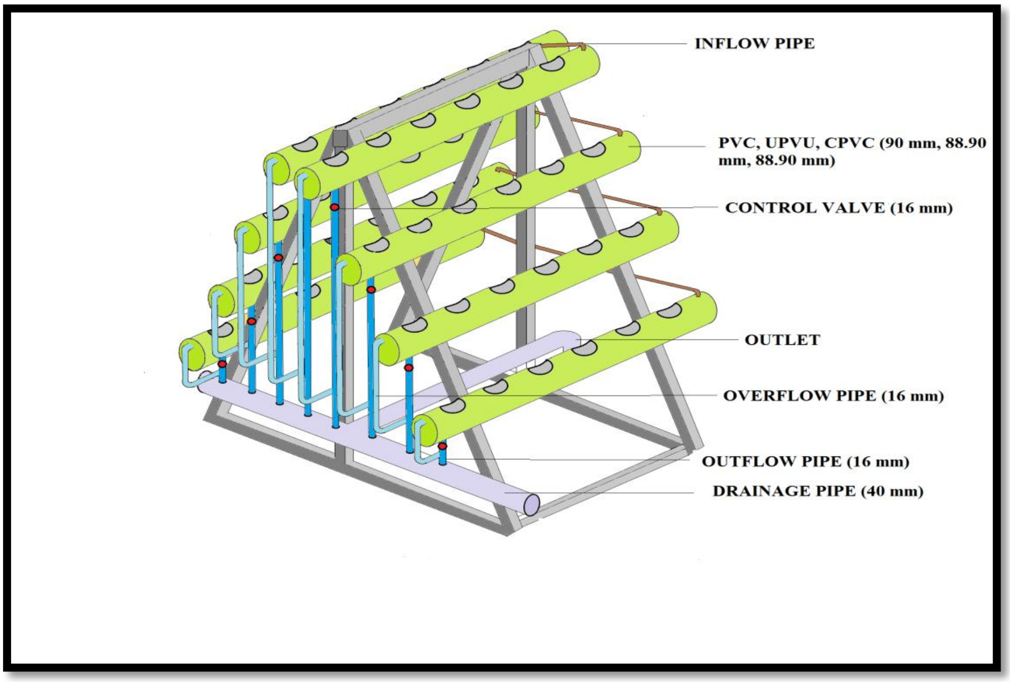

Fig. 1: Isometric view of a shaped frame hydroponic structure

Preparation of Bed and Media

Media consisted of composition of coco-peat and vermiculite in the proportion of 3:1 and clay pellets .Total mass of media coco-peat and vermiculite used was 4 kg (coco-peat 3 kg and vermiculite 1 kg) to fill up 48 net pots. Each pot content 70.38 gm of media.

Transplanting Operation

Near about one month old seedling were transplanted on 5th February 2018 in 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.

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

Chemical	Quantity (gm) for 100 l	Quantity (gm) for 30 l
Calcium nitrate ($ca(NO_3)_2$)	55.80	15.90
Potassium nitrate (KNO_3)	18.40	5.30
Sulphate of potash (K_2SO_4)	4.06	1.20
Monopitassium phosphate (KH_2PO_4)	12.2	3.70
Magnesium sulphate ($MgSO_4*7H_2O$)	21.31	6.40
Fe chelated	3.53	1.00
Combi	40.00	8.00
Total	155.30	41.50

RESULTS AND DISCUSSION

Length of lettuce leaf in A shaped frame structure

The result revealed that there were variations in leaf of lettuce plants according to the treatments. These values of length of leaf were taken after 7 days of transplanting (7 DAT) with the help of measuring tape. In case of PVC pipe (T_1) average length of leaf of the lettuce plant was recorded to be 6.95 cm, which was followed by T_2 (6.34 cm) and T_3 (6.94 cm) respectively. The variation in length of leaf may be due to light effect. Variation in leaf of lettuce plants 14 DAT was observed and according to the treatments. These values were recorded with the help of measuring tape. The T_1 shows maximum average length of leaf of lettuce plant i.e. 8.96 cm followed by T_2 and T_3 in which length was 8.92 cm and 8.33 cm, respectively. Treatments showing the more length of leaf because they were more exposed to sunlight. The variation in leaf of lettuce plants as per the treatments which were recorded after 21 days of transplanting (21 DAT) with the help of measuring tape. Maximum length of leaf of lettuce plant was found to be 11.60 cm, which was followed by T_2 and T_3 with 10.77 cm and 10.0 cm, leaf length respectively. Variation may be because of light which effected on its growth. Table shows that the more length of leaf was recorded more exposed to light. Effect of pipe material on average leaf length of lettuce plants were compared as shown in a bar diagram (fig.2) for different time recorded during the experimentation. Maximum leaf length was recorded in case of treatment (T_1).

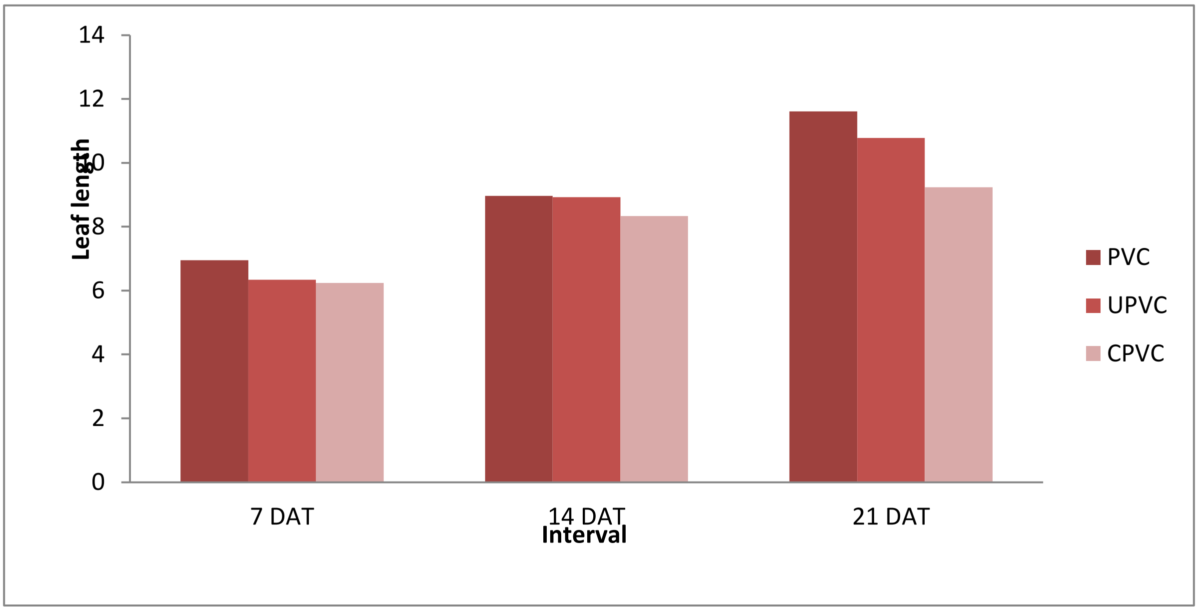

Fig. 2: Bar diagram showing effect of Pipe material on lettuce leaf length in A shapes frame structure

Width of lettuce leaf in A shaped frame structure

The result obtained related to width of lettuce the variation in leaf of lettuce plants as per the treatments. These values were taken on after 7 days of transplanting (7 DAT) with the help of measuring tape. Maximum average width (5.52 cm) of leaf of lettuce plants was recorded in case of T_1 which was followed by T_2 and T_3 with 5.36 cm and 5.27 cm, leaf length respectively. The variation in leaf of lettuce plants for different treatments. These values were taken after 14 days of transplanting (14 DAT) with the help of measuring tape. Treatment T_1 showed more width of leaf of lettuce plant 8.58 cm, which was followed by T_2 and T_3 having leaf length 8.25 cm and 7.29 cm, respectively. Variation in width of leaf may be due to sunlight. The treatment wise variation in width of leaf of lettuce plants these values were recorded after 21 days of transplanting (21 DAT), simply measuring tape was used. The T_2 shows maximum width of leaf of lettuce plant

(10.77cm) which was followed by T_1 and T_3 with 10.44 cm and 8.82 cm, leaf width respectively. Effect of pipe material on average width of lettuce leaf as recorded after 7, 14, 21 days of transplanting are compared and shown in fig.3

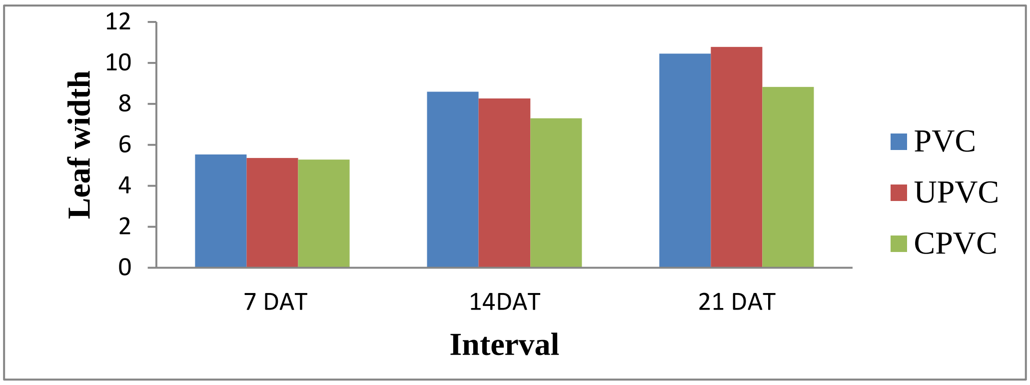

Fig. 3: Bar diagram shows effect of Pipe material on width of lettuce leaf in a shapes frame structure

Fig. 4: Growth of lettuce 21 days after transplanting

Values of pH of Hydroponic solution and its consumption under different treatment in A shaped frame structure

Treatment wise the values of pH recorded each day or in interval of days after changing the nutrient solution are 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_1, T_2 and T_3 concentration is also shown is Fig. 5. This variation is due to the precipitation of nutrients and micro-nutrients in the tank.

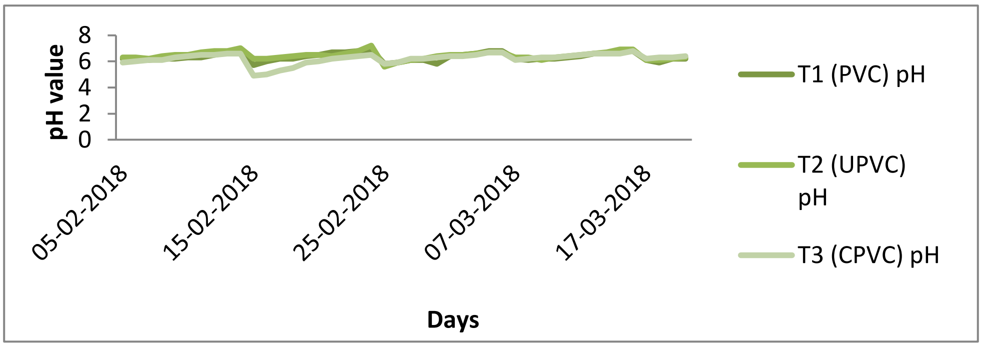

Fig. 5: pH values of hydroponic solution after changing the nutrient solution in a shaped frame structure under different treatment

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

The values of EC of hydroponic solution and its consumption of by the plants under different treatments are suitable range of EC of the nutrient solution. At the range from 1.5 to 2.5ds/m, the plants easily absorbed nutrients from 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_1, T_2 and T_3 is shown in Fig. 6. The EC in all the three treatments was increased due to increase salt concentration in the nutrients solution under different treatment.

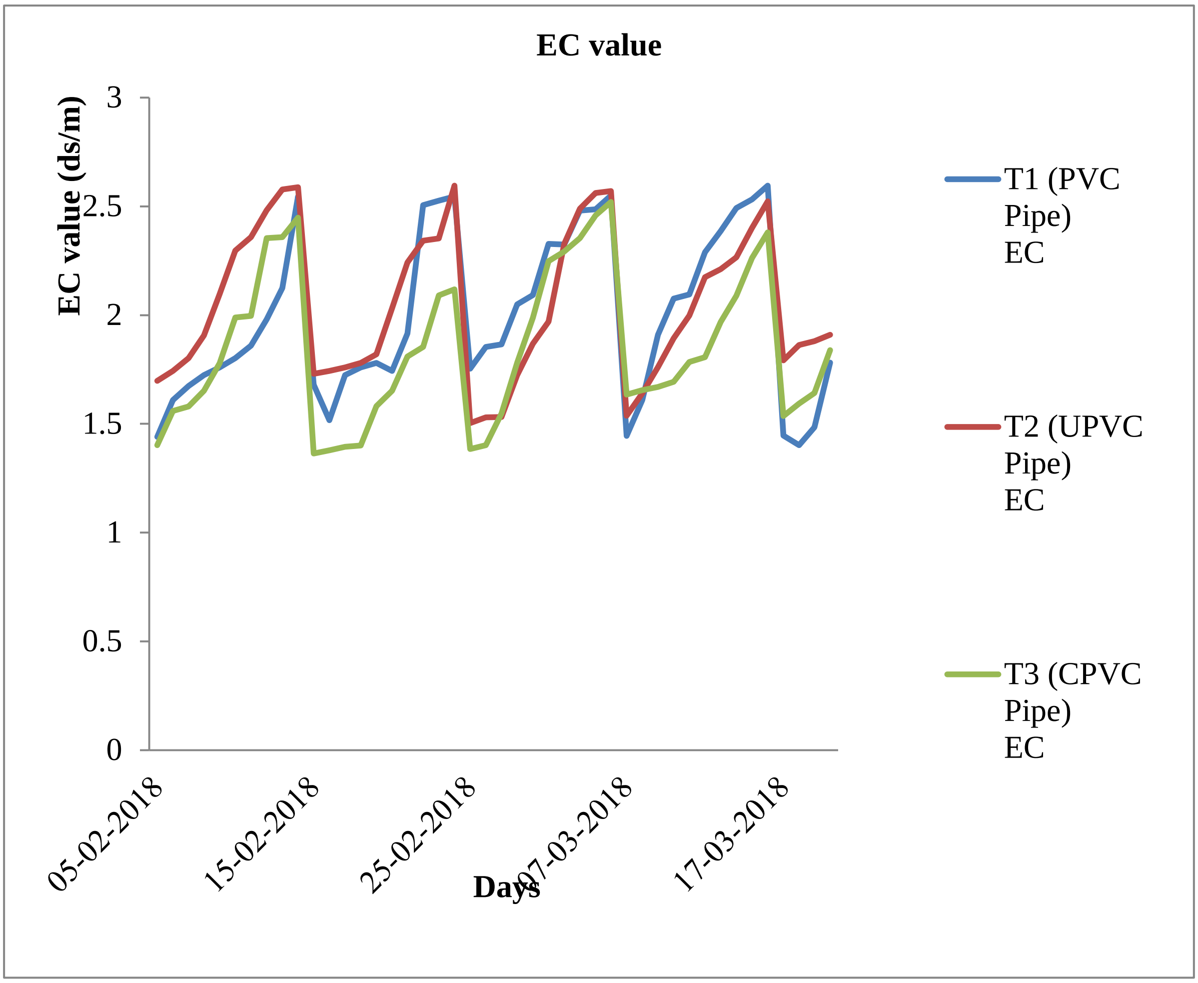

Fig. 6: Values of EC of hydroponic solution after changing the nutrient solution under different treatment in a shaped frame structure

Crop yield

The Total yield of lettuce was found to be 10 kg, 9.45 kg and 9.30 kg under T_1 (PVC pipe), T_2 (UPVC pipe), T_3 (CPVC pipe) respectively in case of A shaped frame structure.

Cost of Fabricated Hydroponic Structure

The cost of material (viz. pipe, iron frame, micro tube, end cap etc.) used for fabrication of the different types of the structures were calculated to check the economy of the hydroponic system. The cost of fabricated A shaped frame hydroponic structures for different type of pipe used in this study. The total cost of fabricated A shaped frame hydroponic structure with PVC Pipe was Rs. 9641.00 which was lowest as compared to other pipe material used in this study.

Table 2: Cost of fabricated a shaped frame 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	25 kg	100	2500	100	2500	100	2500
2.	Pipe	12 m	168	2010	252.7	3032	1012	12144
3.	End cap	16 pcs	40	640	161	2576	161	2576
4.	Micro tube	5 m	8	40	8	40	8	40
5.	Male barb	8 pcs	3	24	3	24	3	24
6.	Female barb	8 pcs	3.5	28	3.5	28	3.5	28
7.	Metal clamp	16 pcs	10	160	10	160	10	160
8.	16 mm L-joint	8 pcs	4	32	4	32	4	32
9.	16 mm T-joint	8 pcs	4	32	4	32	4	32
10.	16 mm joiner	16 pcs	5	65	5	65	5	65
11.	Control valve	8 pcs	10	80	10	80	10	80
12.	40 mm PVC pipe	4 m	30	120	30	120	30	120
13.	40 mm T-joint	1 pcs	40	40	40	40	40	40
14.	40mm end cap	2 pcs	25	50	25	50	25	50
15.	40 mm L-joint	1 pcs	40	40	40	40	40	40
16.	Submersible pump	1 pcs	700	700	700	700	700	700
17.	Timer	1 pcs	1200	1200	1200	1200	1200	1200
18.	Tub	1 pcs	1400	1400	1400	1400	1400	1400
19.	Net cup	48 pcs	10	480	10	480	10	480
	Total			9641		12599		21711

CONCLUSIONS

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

1. Design and developed A-frame hydroponic system proved to be an acceptable technology for the cultivation of horticultural crops under protected condition with limited space requirements. Few specific things like net pots, clay pellets are not easily available not only in Raipur but in most of the local markets of medium level cities.
2. 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.
3. 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 growths of plants due to deterioration of the quality of pipe of used for multi years.
4. Results revealed that the UPVC pipe material found to be better than PVC and CPVC pipe material. Cost of UPVC pipe material also found to be high. Durability of UPVC pipe material may be better than other two pipe materials. Commercial cultivation of crops under hydroponic system with UPVC pipe material is recommended for use.

REFFERENCES

1. Ghamande, V. M., Medhekar R., Mathew A., Kalake N., Patil, B., Bhandia, D., Growing Plants Using Nutrient Medium (Hydroponics). *International journal of advanced research in education & technology*. **3 (2):** 164-165 (2016).
2. Heredia, A.N., Design construction, and evaluation of a vertical hydroponic tower.*Agricultural engineering,* 1-34 (2014).
3. Joseph, A. and Muthuchamy, I., Productivity, quality and economics of

tomato (*lycopersicon esculentum* mill.) cultivation in aggregate hydroponicsa case study from coimbatore region of tamilnadu. *Indian Journal of Science and Technology*. **7(8):** 1078–1086 (2014).
4. Kaur, H., Sharda, R., Sharma, P., Effect of Hoagland solution for growing tomato hydroponically in greenhouse. *HortFlora research Spectrum* **4:** 310-315 (2016).
5. Keith, R., How To Hydroponic. 4th Eidition, The Futuregarden Press, New York, 1-120 (2003).
6. Mishra, L. R. and Jain, P., Design and implementation of automatic hydroponics system using ARM processor. International journal of advanced research in electrical, electronics and Instrumentation Engineering.**4 (8):** 6935-6940 (2007).
7. Patwardhan, A., Design of flood and drain vertical hydroponic system. *Agricultural engineering.*19-28 (2016).