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Fabrication and performance evaluation of a shaped frame hydroponic system for leafy garlic

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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 leafy garlic 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. 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.

Keywords: Hydroponic system, a shaped frame, PVC pipe, UPVC pipe, CPVC pipe, EC and pH level

Introduction
Improper irrigation management practices not only waste scarce and expensive water resources but also decrease crop yield. In the present-day context, improvement in irrigation practices, including schedules and methods, is needed to increase crop production and to sustain productivity levels.

For mitigation of the above problem the hydroponics system was taken into the consideration. The word hydroponics was coined by Gericke (1936) to describe the cultivation of edible and ornamental plants in a solution of water and dissolved nutrients. The simple meaning is derived from the hydro meaning water and ponos meaning labour. In this method of cultivation plants are provided with the nutrients required for growth by a nutrient solution. (Keith Roberto, 2003).

The combination greenhouse hydroponics is a clear example of how horticulture could meet the objectives of a sustainable horticulture, with more efficient use of inputs: water and fertilizers. Hydroponics is highly productive and fit for automation. The selection of growing system and media depends on availability, ease of use, cost and environmental aspects. The hydroponics media selected should be inert and have desirable properties like good aeration, porosity and water holding capacity to enhance the growth and development of plants. (Joseph and Muthuchamy, 2014) [5].

Growers all over the world are using hydroponic techniques due to the lack of a large water supply or fertile farmland. Home gardeners have used hydroponics on a smaller scale to grow fresh vegetables year round and to grow plants in smaller spaces, such as an apartment or balcony. Greenhouses and nurseries grow their plants in a soilless, peat- or bark-based growing mix. The nutrients then are applied to the growing mix through the water supply. Therefore, this is also a type of hydroponics. (Sorenson, 2009) [10].

Materials 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 three type of hydroponic structure, which are as follows;

Table 1: Show the Treatments Implements

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, and 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 hydroponic system was designed and developed with the help of locally available material and resources. 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. A shaped frame structure shown in fig. 1

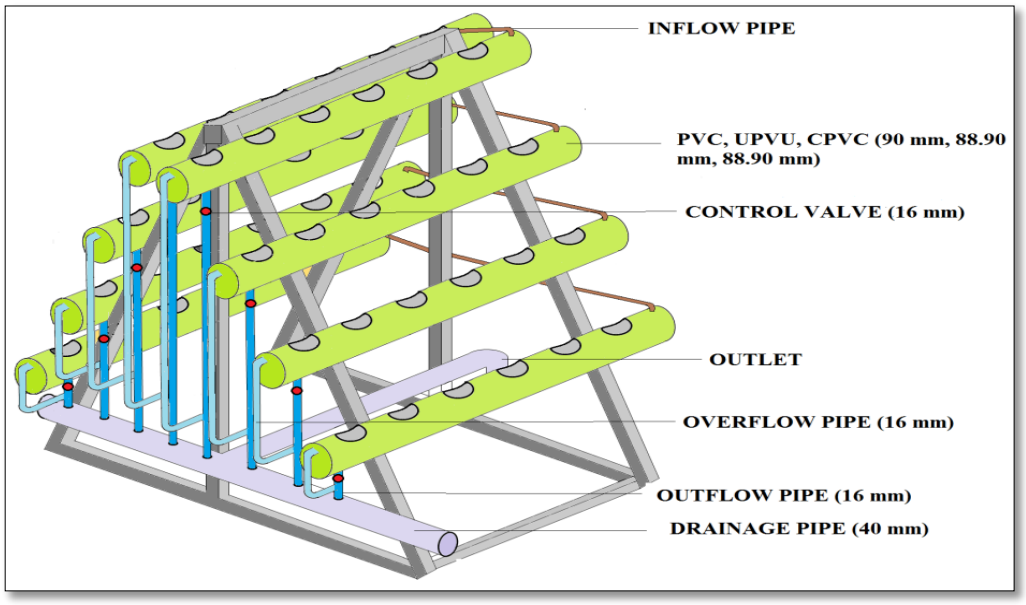

Fig 1: Isometric view of A shaped frame hydroponic structure

Preparation of Bed and Media

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

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.

Table 2: Quantity of different nutrient solution used in the study

Chemical	Quantity (gm) for 100 l
Calcium nitrate (ca(NO_{32})	55.80
Potassium nitrate (KNO_3)	18.40
Sulphate of potash (K_2SO_4)	4.06
Monopitassium phosphate (KH_2PO_4)	12.2
Magnesium sulphate ($MgSO_4*7H_2O$)	21.31
Fe chelated	3.35
Combi	40.00
Total	155.30

Results and Discussion

Length of leafy garlic leaf in A frame structure

The result revealed that there were variations in leafy garlic 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 leafy garlic plant was recorded to be 11.58 cm, which was followed by T_2 (10.04 cm) and T_3 (11.02 cm), respectively. The variation in length of leaf may be due to light effect. Variation in leaf of leafy garlic 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 leafy garlic plant i.e 17.13 cm, followed by T_2 and T_3 in which length was 16.66 cm and 16.37 cm, respectively. The variation in leaf of leafy garlic plants as per the treatment which was recorded after 21 days of transplanting (21 DAT) with the help of measuring tape. In case of PVC pipe T_1 Maximum length of leaf of leafy garlic plant was found to be 22.02 cm, which was followed by T2 and T3 with 20.83 cm and 20.46 cm, leaf length respectively. Variation may be because of light which effected on its growth effect. Effect of pipe material on average width of leafy garlic leaf as recorded after 7, 14, 21 days of transplanting are compared and shown in fig 2

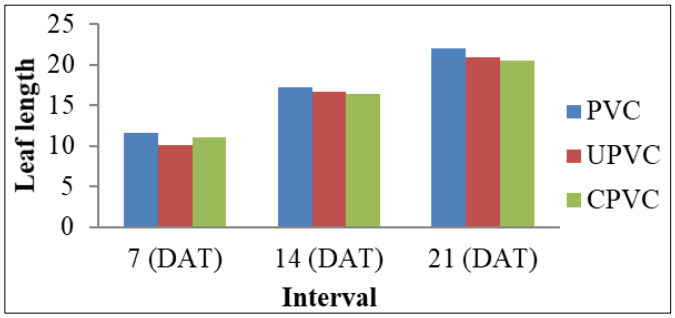

Fig 2: Bar diagram shows effect of Pipe material on length of leafy garlic in A frame shapes structure

Number of leaf of leafy garlic in A frame structure

The result obtained related to number of leafy garlic leaf are showed the variation in number of leaf of leafy garlic 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 4.60 number of leaf of leafy garlic plants was recorded in case of T_1 which was followed by T_2 and T_3 with 3.8 and 3.8 number of leaf respectively. These values were taken after 14 days of transplanting (14 DAT) with the help of measuring tape. Treatment T_1 showed more number of leaf of leafy garlic plant 8.80 which was followed by T_2 and T_3 having number of leaf 7 and 8, respectively. The treatment wise variation in number of leaf of leafy garlic plants. These values were recorded after 21 days transplanting (21 DAT), simply measuring tape was used. The T_1 shows maximum number of leaf of leafy garlic plant 13.60, which was followed by T_2 and T_3 with 11.00 and 12.20, number of leaf respectively.

Fig 3: Growth of leafy garlic

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. 4. This variation is due to the precipitation of nutrients and micro-nutrients in the tank.

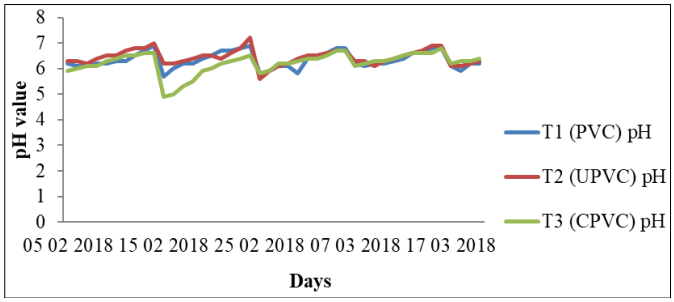

Fig 4: pH values of hydroponic solution after changing the nutrient solution in A shaped frame structure under different treatment

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. 5. The EC in all the three treatments was increased due to increase salt concentration in the nutrients solution under different treatment.

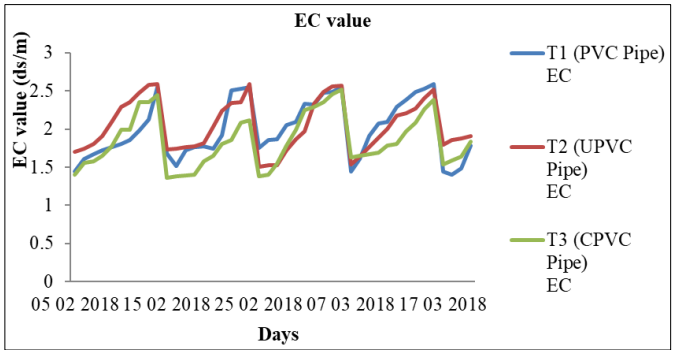

Fig 5: Values of EC of hydroponic solution after changing the nutrient solution under different treatment in A shaped frame structure

The yield of leafy garlic was found to be 120 gm, 117gm, and 117.50 gm, per plant 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 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.

Crop yield

Table 3: 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				9641.00		12599.00		21711.00

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

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