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Development of portable type inverted T shape hydroponics system with automatic irrigation system

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Abstract

Soil: Human life is connected with soil. Soil and agriculture complement each other. Just as the survival of fish without water and living beings without air is impossible, agriculture once became impossible without soil. But we all know that if a miracle had a similar name, it would be science. In today's time, science and technology have developed a lot, and now that agriculture is possible without soil, soilless farming techniques are very popular these days. The name hydroponics is very popular in this context. The challenges of soil-based agriculture have now been reduced. This paper is based on the development of a portable-type inverted T-shaped hydroponics system, and additionally, automation is provided using a microcontroller-based automatic irrigation system to study the benefits of the developed structure as compared to the existing ones.

Keywords: Hydroponics, portable, inverted t shape, automated irrigation system, benefits

1. Introduction

There are seven planets in the solar system, but life is possible only on Earth because all the facilities necessary for life, like water, food, etc., are available here. Along with this, all the facilities for growing food on fertile land are also available, like land, soil, etc. Agriculture is a very powerful weapon. Earlier, it was believed that if a person did not have land, he could not do anything for farming. With time, science has progressed so much that now both land and soil are not necessary for farming. Today, soilless culture has given a new look to agriculture; now we can do farming even in the balcony or room of our house. Hydroponics is also one such technology that pro motes soilless farming. Hydroponics is a technology that enables farming by creating structures. Till now, various shapes have been developed, like the A shape, the U shape, etc., but we have given it a new shape, which is the inverted T shape. Along with this, we have provided complete automation with the help of a microcontroller, which we have named the Automatic Irrigation System. This study has been able to reduce various challenges faced in the structure of hydroponics. The comparison of the developed structure and the existing one is also discussed.

2. Literature Survey

Several developments in the structure of hydroponics have been done by many scholars or scientists. Some of these which are considered are discussed.

Nicholas A. Heredia (2014) [11] have studied about "Design, Construction, And Evaluation of a Vertical Hydroponic Tower" and they concluded that the tower and systems were designed and constructed successfully. The system produced high-quality leafy lettuce at a rapid pace. Construction and repairs took up a significant amount of time. Swiss Chard grew better in the low drip system than expected. Swiss Chard roots do not like complete submergence in water. Different growing mediums can be used for hydroponic plants. The cost of the project was higher than anticipated. Cost cutting measures can be taken, such as using a cheaper pump. Presoaking hydro ton and adding vinegar can adjust pH levels.

Kavita Krishan, *et al* (2020) [9] have studied Study on fabrication and performance of A-shaped hydroponic system and they concluded that A-frame hydroponic system is suitable for horticultural crops in limited space. pH and EC of hydroponic solution were maintained within acceptable ranges and pipe material has minimal effect on plant growth in the first year and the conclusions are UPVC pipe material is recommended for commercial hydroponic systems and design and developed A-frame hydroponic system proved to be an acceptable technology for the horticultural crops under protected cultivation. Cost analysis: PVC pipe had the lowest cost (Rs. 9641.00) and CPVC had the highest cost (Rs. 21711.00).

Kamta Dixit, *et al* (2022) [6] have studied "Automated Irrigation System Based on Soil Moisture Sensor" and they concluded that the model of automatic plant irrigation system is tested on two different soils, both soils moisture content is measured by the soil moisture sensor and it is compared to the threshold values which are set by the user in the code. Moisture level sensed by the probes in the first soil is lower than the threshold value so the pump automatically feeds water to the crop until it meets the limit and when it comes to the second soil, it is already wet,

indicating that the moisture content is significant. The pump remains turned off in this situation. Moisture content is monitored in the serial monitor in Arduino software. The use of automated irrigation is successful and it will help to reduce the man work and time and also to save the water.

3. Portable Inverted T Shape Structure

This structure comes with Inverted T Shape frame with six PVC pipes in which three are placed in front and other three are placed in back. The structure contains twelve hooks which holds the PVC pipes and also the hooks can be easily adjusted to provide the required slope. Eight wheels are attached or placed in the bottom of the structure to provide portability. The gap between two PVC pipes is one foot. The total height of the structure is six feet if the height of wheel is included than the total height of structure is 6.29 feet. The structure is firstly designed with the help of AutoCAD software. The front, side and top view is prepared.

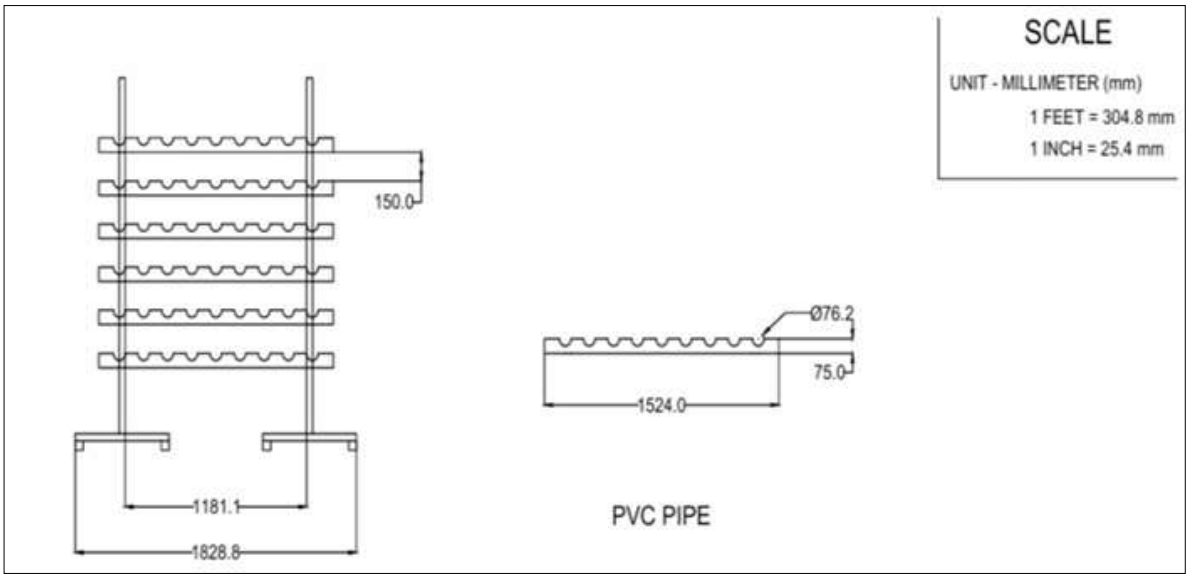

Fig 1: Front view of the portable inverted t shape hydroponics structure

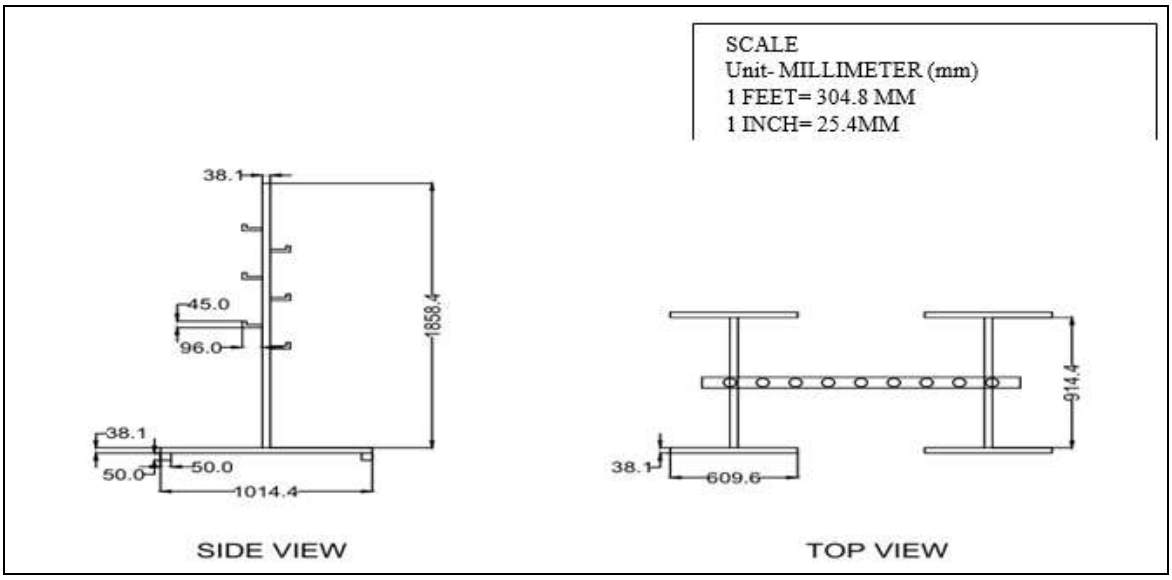

Fig 2: Side and top view of the portable inverted t shape hydroponics structure

4. Automatic Irrigation System

Soil Moisture Sensing setup is a system installed in Inverted T Shape Hydroponic Structure which facilitates it with auto-irrigation facility. It senses the moisture of the media and if its moisture content is not up to the desired limit it turns ON the pump and if founds the moisture content of media desirable, then turns OFF the pump automatically. It has sensors placed in the middle pipe's middle cup from which it detects the moisture content. The system works on the principle of sensing and actuation. The soil moisture sensor is intended for the measurement of moisture in the soil which is connected to a microcontroller (in our case an Arduino UNO). After sensing, the sensor sends.

The moisture content of the soil in that section. If it is below the desired level, the Arduino will send a signal to the relay which would actuate the pump. If it is above or equal to the desired level than the relay will keep the motor off.

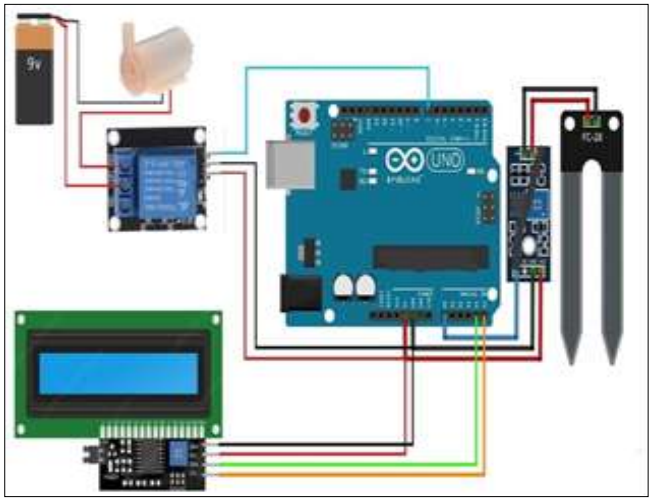

Fig 5: Circuit of Automatic Irrigation System

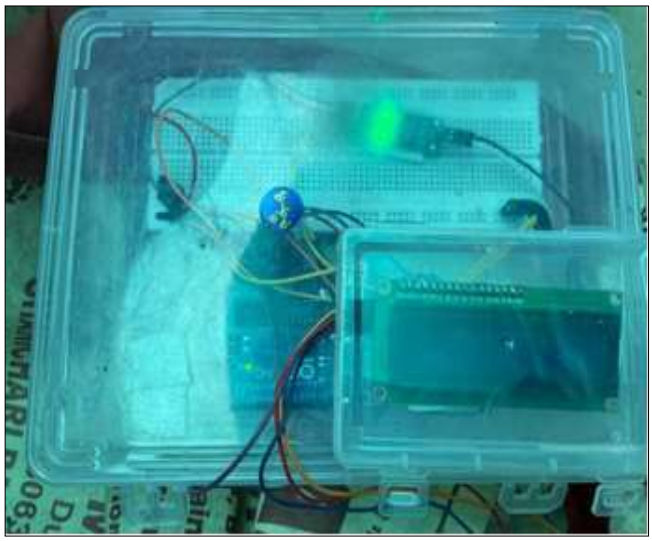

Fig 6: Automatic Irrigation System

The system lies in the category of NFT (Nutrient film technique) system. It works on semi continuous nutrient cycle. The nutrient water is stored in the tank. With the help of pump, it gets lifted to the top pipe. From there onward these water flow by the action of gravity. No extra pumping is required. The grow cup touching the lower surface of the pipe takes the flowing water inside. The cups are filled with mixture of coco peat and Vermicompost in 2:1 ratio in which by the capillary action the water gets distributed in the entire cup. The roots take the nutrients and moisture from the saturated media. As the plant grows taller the roots get expanded and comes out of the cups from the holes provide of the cups. The extra remaining water moves ahead and then gets transferred to the next pipe via an outlet at the downward end of the PVC pipe. The water gets transferred to the next pipe only if it attains a specific head inside the PVC pipe as the grommet and take-offs are fitted at some elevation inside the pipe. The rising of water unto that particular head, makes it possible to move further to another pipe via take-off. After moving to every pipe and through every cup from top to bottom finally water reaches to a final outlet and it gets collected in the collection tank. Then with the help of pump this water is again circulated when the sensor senses the dry condition.

Fig 7: Hydroponics System

4. Methodology

The goal of every hydroponic system is to provide an optimized nutrient solution for plant roots. The delivery method can often involve some type of growing medium, used to anchor the plant or create a matrix that supports the availability of nutrients and water. The interaction between the plant, the growing substrate and the nutrient solution determines the effectiveness of the growing medium.

To test the success of the inverted T shaped hydroponics system, we selected a lettuce crop in which 2 varieties of lettuce were grown, the first was Lolo Rosso and the second was Iceberg and we also grew both of these varieties in soil and then compared the lettuce grown in hydroponics system and the lettuce grown in soil. The procedure includes-

4.1 Sowing of Seeds

Seeds are carefully placed in each section of grow tray. Coco peat and Vermicompost mixture are used in the ratio 2:1 as the growing medium. After placing the seeds tray is covered with a plastic cover and after one day plastic cover is removed. 6 seeds 3 of each variety is sown on the pots filled with soil for detailed study.

4.2 Development of the Hydroponics System

- First comes the construction of the portable inverted T shape frame the requirements are metal pipes, hooks and wheels.
- Preparation of PVC pipes for placing the grow cups. In this study a 5ft PVC pipe is considered each PVC pipe contains 9 holes.
- Adjustment of the PVC pipes in the frame, slope adjustment and Nutrient solution preparation.
- The most important part is providing connection of the pipes with the tank with the help of drip pipes, gromets, take off and connectors to provide proper flow and inlet and outlet for the nutrient solution.

4.3 Development of the Automatic Irrigation System

- A soil moisture sensing unit is developed using arduino Uno which provides the automation to the hydroponic system.
- The circuit is placed at the centre of the structure with the help of plastic chair. The sensor is settled on the plant number 5. The circuit is covered with a cloth bag.

4.4 Daily Observation

Daily observation includes

- TDS checking.
- pH Checking,
- Plant height and No of Leaves
- Level of water
- Watering the plants grown in soil

5. Result and Discussion

5.1 Data Comparison of lettuce growth in soil and hydroponics structure

Data are presented in figure 8, from which it can be observe that for week 1 the plant height was between 1.8 to 2.5cm for the 'Lollo Rosso' variety of lettuce (plant number 1, 2 and 3) grown in soil and the plant height was 2 to 2.9 for the same variety grown in hydroponics system. The plant height was between 3.1 to 4.2 cm and for the 'Ice Berg' variety of lettuce (plant number 4, 5 and 6) grown in soil and the plant height was 4.0 to 4.4cm for the same variety grown in hydroponics system. For week 2 the plant height was between 2.5 to 2.8cm for the 'Lollo Rosso' variety of lettuce (plant number 1, 2 and 3) grown in soil and the plant height was 2.5 to 3.9 for the same variety grown in hydroponics system. The plant height was between 4.1 to 6.5 cm for the 'Ice Berg' variety of lettuce (plant number 4, 5 and 6) grown in soil and the plant height was 5.0 to 8.9cm for the same variety grown in hydroponics system. For week 3 the plant height was between 4.2 to 6.3cm for the 'Lollo Rosso' variety of lettuce (plant number 1, 2 and 3) grown in soil and the plant height was 4.5 to 11.5 for the same variety grown in hydroponics system. The plant height was between 8.5 to 10.6 cm for the 'Ice Berg' variety of lettuce (plant number 4, 5 and 6) grown in soil and the plant height was 14.2 to 18.2cm for the same variety grown in hydroponics system.

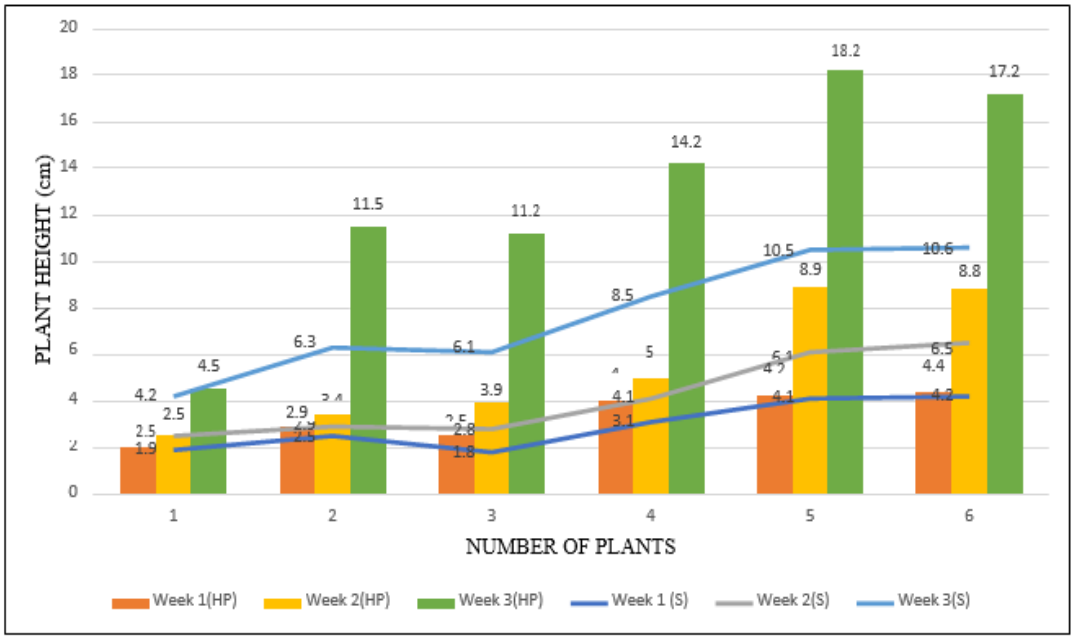

Fig 8: Graph of Plant Height Comparison

5.2 Cost Estimation

Table 1: Cost Estimation

S. No	Material	Quantity	Cost (rs)
1	Frame	--	1890.00
2	PVC Pipe	30 ft	1140.00
3	End Cap	12	420.00
4	Tee Joint	1	4.00
5	L joint	2	8.00
6	Submersible Pump	1	320.00
7	Tank	1	20.00
8	Grow Cups	54	224.00
9	Take off	12	60.00
10	Gromet	12	60.00
11	Growing Media	6 packet Cocopeat, 3 Vermicompost	180.00
12	Nursery Preparation	2 packets seeds, 2 Grow tray	150.00
13	SMS Circuit	9 Components	1483.00
14	Other Accessories	Hand Bit Drill Paint, etc	210.00
15	Drip pipe	6m	72.00
		Total	Rs. 6241

5.3 Appearance

The iceberg lettuce is light green and ball-shaped in appearance. Recognized for its light green, tightly packed leaves, iceberg lettuce is known for its crunchy texture making it versatile and crowd-pleasing. The Lollo Rosso variety of lettuce is Lollo rosso is light green in the middle, and deep red-maroon around the borders defines the frilly and curled, fan-shaped leaves. It develops as a tightly packed, rosette-shaped plant with single-branched leaves that do not produce a head.

Fig 9: Lollo Rosso Variety of Lettuce

Fig 10: Ice berg Variety of Lettuce

7. Conclusion

7.1 Portable Type Inverted T Shape Structure

- The portability of the structure is justified. The wheels perfectly provide portability to the structure and also after locking the wheels by aligned it horizontally it provides stability in the uniform plane topography.
- The Inverted T shape is a very good choice because the length of the pipes is not fixed, we can adjust it according to the number of plants.
- The slope of the pipes is adjustable because of the adjustable hook provided on the structure.
- The structure doesn't need any external support in the center as compared to any other structure like A shape and U shape.
- The cost of the inverted T shape structure is less than any other structure.
- The iceberg variety of lettuce is not successful in the Inverted T shape structure.
- The Lollo Rosso Variety of lettuce is successful in the Inverted T Shape Structure.
- The performance of structure after providing the green shade is better.

7.2 Automated Irrigation Circuit

- The cost of the circuit is moderate and the performance of the circuit is satisfactory.
- The maintenance cost of circuit is very less.
- The circuit should not keep in direct contact with the surrounding.
- The automated circuit is successful with the hydroponics system.
- The main motive of energy and water saving by providing automation is fulfilled.
- The daily monitoring of water level for hydroponics

system is very easy with the automated irrigation system.

7.3 Comparison

- The comparison between the lettuce grown in soil and lettuce grown in the hydroponic structure conclude that the performance of the lettuce grown in hydroponics gives positive results.
- The growth of the lettuce in the hydroponic system is faster than the lettuce grown in soil.
- The lettuce number of leaves is more in the hydroponic structure as compared to the lettuce grown in soil.
- The Lollo Rosso Variety of lettuce is successful in the inverted T shape structure as compared to the other iceberg variety. Overall, the Portable Type Inverted T Shape Hydroponic Structure with Automated Irrigation System is successful.

7.4 Future Scope

- This structure should be tested in fully protected area or under protected cultivation.
- The performance of structure should be tested at different slopes.
- The upgradation in circuit should be suggested for future work.
- The performance of structure should be tested with IOT.
- Structure should be tested without providing automation.

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