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COMPARATIVE ASSESSMENT OF HYDROPONIC AND GEOPONIC CULTIVATION SYSTEMS FOR SUSTAINABLE SPINACH, LETTUCE AND TOMATO CULTIVATION

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ABSTRACT

India being a developing nation, majority of its population is dependent on agriculture for livelihood but due to an alarming increase in population over few decades a tremendous pressure is raised on the farming community to meet the food requirements of the growing population, but we cannot deny the fact that sources of useful resources are depleting day by day and therefore we need to focus on alternative resources so that in future we can avoid the condition of food scarcity. Hydroponics could be one such alternative. Soil-free cultivation is recognized as hydroponics, is a resourceful farming technique that chiefly aims at blossoming plants in a land free habitat. It is a very unique method that is acquiring admiration due to its potential to give rise to excessive yields of crops in very less time and use very little expenditure. India is a developing country where its populations is constantly increasing at an alarming rate and to top it all, the fertility of the cultivable fertile soil is also gradually decreasing, and it is assumed that soon in near future it might become negligible, as a consequence, we need to depend on other technologies besides geoponics. In the present study, we focussed on the studies on comparative assessment of hydroponics and geoponics cultivation. The setup of hydroponics and geoponics was maintained at the Department of Microbiology DLSPG college Bilaspur Chhattisgarh during the rainy season of 2023. We used hydroponics solution, vermiwash and pure water as growth mediums, the assessment was carried out with three plant varieties viz: tomato, lettuce, and spinach. During the rainy season as we only wanted to test the efficacy of this technique within a short period of time, and it was found that hydroponics proved to be more effective than geoponics in all the three mediums as the growth rate in hydroponics cultivation was much higher than in geoponics cultivation system.
***Keywords*:** Geoponics, Hydroponics, Traditional Cultivating System Vermiwash, Nutrient Solution A&B

Introduction

The world's population is striving really hard to climb at a steady pace and in its effort to do so, the resources steadily decline and moreover current data suggests that, it is possible to reach 9.5 billion population in 2050, the current number of populations is recently six billion, with a per capita land area of 0.25 hectares, while the projected 2050 population is expected to be 9.5 billion. The use of chemical fertilizers for preventing crop damage has raised many health issues, though the crop production has increased but at the cost of human health. Thus, there is a requirement to look in for an alternative method for increasing crop yield that will have less health impact on the community (Syed *et al*., 2021). Thus, there is a requirement to opt for an effective, cheap, environmentally friendly approach for the farming of crops so that it affects a wholesome environment that will cause less health hazards (Pandey *et al*., 2009).

Hydroponic farming is recognized as a soil-less farming that utilizes mineral solutions instead of relying on soil for plant growth. It uses a nutrient-rich liquid, called the root nutrient solution, as the source of plant life. It is a scientific answer to the challenges of rising food demand while lessening the farmland availability. The process of cultivating plants in water is termed hydroponics, which also incorporates techniques for vertical gardening. The first motivation behind approving this method, is its ability to produce food using fewer land and water resources (Muhammad and Chowdhury *et al*., 2019). The process of cultivating crops in soil is termed geoponics, which refers to traditional farming. The present concern in geoponic cultivation is the water quality, which is declining fast because of the irregular use of chemicals causing groundwater contamination during the farming cycle, making water an essential commodity for future growers (Malik *et al*., 2018). In the present study, we focussed on the studies on comparative assessment of hydroponics and geoponics cultivation, an attempt was made to test the efficacy of this technique within a short period of time.

Materials and Methods

In the present study, we focussed on the studies on comparative assessment of hydroponics and geoponics cultivation, the setup of hydroponics and geoponics was maintained at the Department of Microbiology DLSPG College Bilaspur Chhattisgarh during the rainy season of 2023. We used hydroponics solution, vermiwash and pure water as growth mediums, the assessment was carried out with three plant varieties viz: tomato, lettuce, and spinach during the rainy season of 2023. All the three plant varieties were tested in both circulatory and non-circulatory hydroponic setup and the results were compared with the geoponics setup.

Preparation of circulating system

To make the circulatory system, a 3-inch PVC pipe was taken. The length of one PVC pipe was 10 feet. To make the circulatory system, one full 3-inch pipe and half PVC pipe were selected. Thus, three different PVC pipes of 5 feet each were required to make the circulatory system. With the help of a drill machine, the PVC pipe was cut into equal sizes in all three pipes. A 3-inch cap was used to cover the edges of the pipe. Plumbing glue was used to fix the cap to the pipe. The other end of the pipe was also covered with a cap but to drain the excess water, an "I socket" was fitted in the cap and a ½ inch water pipe was installed so that the nutrient solution or water could return from the system to the reservoir. This was done in all three PVC pipes. A small hole was made in the first end of the pipe to install the ½ inch water pipe and this pipe was connected to the water motor in the reservoir. Three buckets were used for the reservoir. A 2-lt. bucket was used as a sink or reservoir and the bucket was covered with a thermocol plate. A small plastic glass was used to grow the plant and small holes were created at its bottom so that the roots could spread and connect to the nutrient solution of the system. In this way, circulatory hydroponics system was made ready for growing plants. This hydroponics system consumed approximately 4.5 lit. water.

Fig. 1: Preparation of circulatory hydroponics system

Disinfection of circulatory hydroponics system

Before sowing seeds in the system, the system and seeds were disinfected. To disinfect the system, sodium hypochlorite solution was dissolved in the ratio of 1:4 and this sodium hypochlorite solution was run in the circulatory hydroponics system. After running the solution, the sodium hypochlorite solution was drained out and then the system was allowed to dry so that the chemical present in the system evaporates. Sterilized water was again run in the system as sodium hypochlorite is a harmful chemical that can have harmful effects on plants, the main reason for allowing the run of sterilized water is to completely remove the chemical from the hydroponics system. Knitted pots were also disinfected with the help of spirit cotton.

Sterilization of Cocopeat

The cocopeat (coconut husk) was used to grow the plant as the roots of the plant spread well and provide a base to the plant. Commercial cocopeat was washed thoroughly with water so that dust particles, pebbles and dirt were removed from it, after washing the cocopeat thoroughly, it was squeezed and dried thoroughly in the sun, after that with the help of an autoclave the Cocopeat was sterilized.

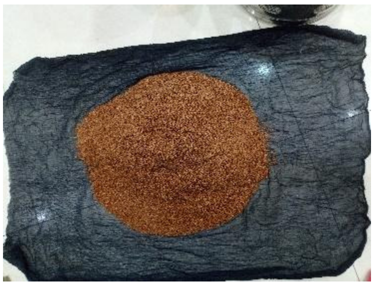

Fig. 2 : Sterilized Cocopeat

Preparation of non-circulatory system

Six thermocol boxes were used for the non-circulating hydroponic system. With the help of a blade, 2 holes were created in the cover of 6 boxes and 3 holes were created in the cover of one box. For growing the plants, small holes were created in the bottom of the plastic bowl so that the roots could spread. The plastic bowl was installed in the box. Thus, the non-circulating hydroponics system was ready. This hydroponics system consumed approximately 1.5 lit. water. The non-circulatory system was also disinfected using spirit cotton followed by rinsing with sterilized water

Fig. 3: Sterilized non-circulatory system

Preparation of geoponics system

Twelve plastic trays were used for geoponics cultivation, out of these, six trays contained sterilized soil, while the other six contained non-sterilized soil. 10 ml of Vermi-wash solution was added to 3 trays of sterilized soil each and 3 trays of non-sterilized soil each, further 3 trays of sterilized soil and 3 trays of non-sterilized soil were kept as control. Three seeds each of tomato spinach and lettuce were sowed in all the trays, moisture level was maintained by periodic spray of water in all the trays

Sowing of seeds in circulatory and non-circulatory hydroponics system

In circulatory and non-circulatory hydroponics, pots were fixed in the holes. 10 gm sterilized coco peat was filled. Tomato, spinach and lettuce seeds were sterilized prior to use. plantation was done with the help of tweezers in the pot by immersing the seeds of tomato, lettuce and spinach, there was no need to supply water from outside as the solution of the knitted pot system was in contact with the nutrient solution. Each pot has had three seeds sown into it. The procedure was repeated for three types of solution namely Gluco-vermiwash, Hydroponics Nutrient Solution (A and B) & Pure Water. Both the systems were run at the same duration of time and the results were noted accordingly.

Fig. 4 : Showing hydroponics solution (hydrogrow), gluco vermiwash, and seeds of Lettuce, spinach and tomato

Result and Discussion

Hydroponics System

A comparative study of three different types of seeds was conducted in nutrient solution (A & B), gluco vermi-wash and pure water and the set-up was repeated with the geoponics system .The monitoring system was set during rainy season of 2024 and it was observed that, in circulatory hydroponics cultivation system the growth of tomato and spinach was maximum in nutrient solution (A and B) and then in Gluco vermi-wash and finally very minimum in pure water sample .It was also observed that the growth of all the three seeds in non-circulatory system was same as in circulatory system, but with a slight difference in the growth pattern. In the similar way in the non-circulatory system also, maximum growth was observed in nutrient solution (A & B) then in Gluco-vermiwash and finally very minimum in pure water sample. Growth was monitored based on various parameters, including shoot length, root length, leaf color, and leaf count. The detailed observation is given in Figures from. 5-11 and Table from 1-6.

Fig. 5 : Growth of tomato in circulatory system

Fig. 6 : Showing root length of tomato

Fig. 7 : Growth of spinach in circulatory system

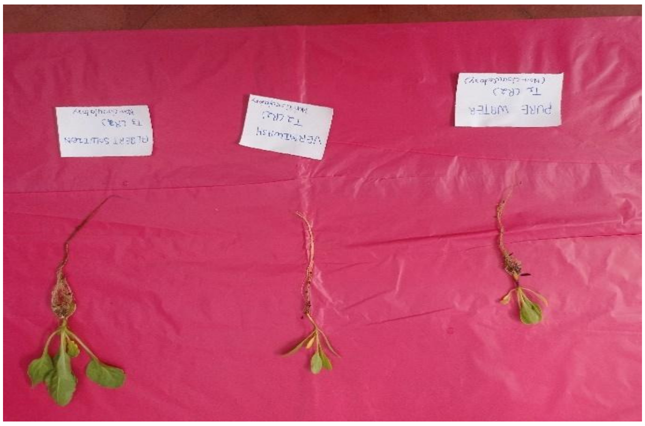

Fig. 8 : Showing root length of spinach

Fig. 9 : Growth of Lettuce in circulatory system

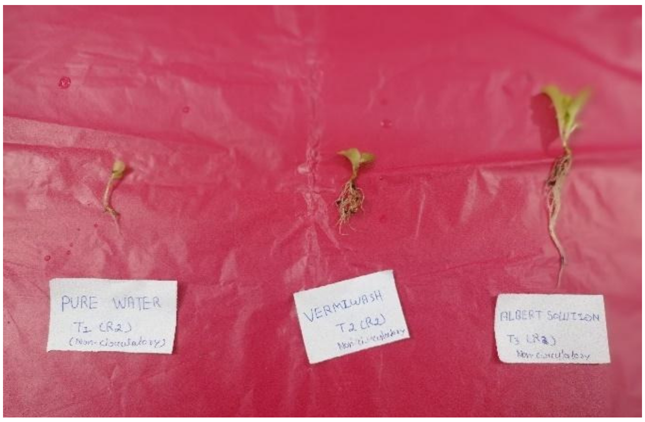

Fig. 10 : Showing root length of lettuce

Fig. 11: Showing growth of Tomato, Spinach and lettuce in non-circulatory system

Geoponics System

In the geoponic system of cultivation, the maximum growth was seen in tomatoes in non-sterilized soil which was sprinkled with vermi-wash solution, followed by the system sprinkled with pure water samples. Similarly, the growth of spinach and lettuce was also monitored in non-sterilized soil sprinkled with vermi -wash and pure water sample, it was noted that growth of Spinach was maximum as compared to Lettuce. The same setup was repeated with sterilized soil (vermi-wash and pure water). It was observed that the growth of all the three seedlings was the same as in the non-sterilized system but growth was less as compared to non-sterilized system. Comparison between the two systems was made on the basis of different parameters (shoot length, size of leaves, color and number of leaves). The detailed description is given in Table No. 7-9.

Table 1: Growth of tomato in circulatory hydroponics system

Parameters	Pure water sample	Gluco vermiwash solution	Nutrient solution A & B
Colour of leaves	Yellowish green	Green	Dark green
Size of leaves (Length)	1 cm	1.8 cm	2 cm
Size of leaves (Width)	0.4 cm	0.8 cm	1 cm
Number of leaves	12	16	27
Length of shoot	4 cm	8 cm	10 cm
Length of root	6 cm	15 cm	9 cm

Table 2: Growth of spinach in circulatory hydroponics system

Parameters	Pure water sample	Gluco vermiwash solution	Nutrient solution A & B
Colour of leaves	Light green	Green	Dark green
Size of leaves (Length)	1 cm	2.6 cm	3 cm
Size of leaves (Width)	0.6 cm	1.4 cm	2.4 cm
Number of leaves	3	5	7
Length of shoot	2 cm	4 cm	5 cm
Length of root	8 cm	12 cm	12 cm

Table 3: Growth of tomato in non-circulatory hydroponics system

Parameters	Pure water sample	Gluco vermiwash solution	Nutrient solution A & B
Colour of leaves	Yellowish green	Green	Dark Green
Size of leaves (Length)	0.8 cm	1.8 cm	3 cm
Size of leaves (Width)	0.4 cm	0.8 cm	1.3 cm
Number of leaves	8	12	17
Length of shoot	3 cm	5 cm	7 cm
Length of root	6 cm	10 cm	15 cm

Table 4: Growth of lettuce in circulatory hydroponics system

Parameters	Pure water sample	Gluco vermiwash solution	Nutrient solution A & B
Colour of leaves	Yellowish green	Green	Green
Size of leaves (Length)	0.6 cm	1.8 cm	3 cm
Size of leaves (Width)	0.4 cm	0.6 cm	1.5 cm
Number of leaves	3	3	3
Length of shoot	1 cm	3 cm	3.5 cm
Length of root	3 cm	4 cm	6 cm

Table 5: Growth of lettuce in non-circulatory hydroponics system

Parameters	Pure water sample	Gluco vermiwash solution	Nutrient solution A & B
Colour of leaves	Yellowish green	Mint Green	Light Green
Size of leaves (Length)	0.6 cm	1.8 cm	3 cm
Size of leaves (Width)	0.4 cm	0.6 cm	1.5 cm
Number of leaves	3	3	3
Length of shoot	1 cm	3 cm	3.5 cm
Length of root	3 cm	4 cm	6 cm

Table 6: Growth of spinach in non-circulatory hydroponics system

Parameters	Pure water sample	Gluco vermiwash solution	Nutrient solution A & B
Colour of leaves	Light green	Lime Green	Dark Green
Size of leaves (Length)	0.7 cm	1.6 cm	2.8 cm
Size of leaves (Width)	0.3 cm	0.5 cm	1.7 cm
Number of leaves	3	5	6
Length of shoot	2 cm	4 cm	6 cm
Length of root	3 cm	8 cm	6 cm

Table 7: Showing growth of tomato in geoponics cultivation system

Parameters	Sterilized soil + vermiwash	Non-sterilized soil +vermiwash	Sterilized soil (control)	Non-sterilized soil (control)
Colour	Green	Dark green	Yellowish green	Light green
Size (length)	1 cm	2 cm	1 cm	1.5 cm
Size (width)	0.6 cm	1.5 cm	0.4 cm	1 cm
Shoot	7 cm	11 cm	4.5 cm	8 cm
No. of leaves	15	22	13	19

Table 8: Showing growth of spinach in geoponics cultivation system

Parameters	Sterilized soil + vermiwash	Non-sterilized soil +vermiwash	Sterilized soil (control)	Non-sterilized soil (control)
Colour	Light green	Dark green	Lime green	Green
SIZE (Length)	2.3 cm	2 cm	1 cm	0.8 cm
SIZE (Width)	1.8 cm	1.5 cm	0.6 cm	0.5 cm
Shoot	4.5 cm	6 cm	3 cm	5 cm
No.of leaves	4	5	3	4

Table 9: Showing growth of lettuce in geoponics cultivation system

Parameters	Sterilized soil + vermiwash	Non-sterilized soil+vermiwash	Sterilized soil (control)	Non-sterilized soil (control)
Colour	Light green	Green	Yellowish green	Lime green
SIZE (Length)	1.5 cm	3 cm	0.7 cm	1.5 cm
SIZE (Width)	1 cm	1.9 cm	0.6 cm	0.5 cm
Shoot	2	4	1.5	3
No. of Leaves	3	3	2	3

Discussion

India is a developing country whose population is constantly increasing and cultivable land is constantly decreasing and the fertility of the remaining cultivable fertile land is gradually decreasing, which will be on the verge of zero in the coming time. The recent situation suggests and manifests that, the population in the world is continuously increasing with increasing food demand, so in the near future we can deal with food crisis, as the fertility of crops is getting low or is being lost day by day, the main reason behind this, might be the use of more and more chemical fertilizers. As a result, we need to depend on other technologies besides traditional farming (geoponics). Hydroponics is a new technology and its shining approval is due to its capability to produce higher yield crops in limited times (Vyshnav *et al*., 2023). Hydroponics technology is useful for those places where there is not enough water per land or where soil is not appropriate for farming. It covers less area than land and provides more yield than land farming (Agrawal *et al*., 2020). Thus, the food shortage in the world can be met by using hydroponics technology, (Yashdeep *et al*., 2023). For the coming generation, hydroponics agriculture system will prove to be more effective than geoponics because the growth rate of hydroponics is higher than geoponics. Apart from this, hydroponics cultivation does not require a large amount of water and neither does it require harmful chemical fertilizers.in the present study we used Hydroponic nutrient solutions (Hydro-grow nutrients) which comprises a premium range of two-part nutrient series precisely optimized for the comprehensive growth of plants. Hydro-grow nutrient solution (A & B) is a complete solution made up of two nutrient solutions A and B , it contains Nitrogen (N), Phosphorus (P_2O_2), Potash (K_2O), Magnesium (Mg), Zinc (Zn), Boron (B), Manganese (Mn), Copper (Cu), Calcium (Ca), Iron (Fe) macro, secondary & micro elements for plant nutrition and various beneficial substances like Amino Acids, Seaweeds & Humates. Gluco Plant Vermi wash, used in the study is a a liquid extract derived from vermicompost in an environment abundant with earthworms, and contains a substantial count of decomposer bacteria, mucus, vitamins, various bioavailable minerals, hormones, enzymes, and different kinds of antimicrobial peptides. Vermi wash acts as a plant tonic, aiding in the reduction of several plant diseases. When combined with cow urine, it functions as a biopesticide. Vermi-wash is a 100% organic product. Gluco plant vermi-wash contains Organic carbon (oc), nitrogen (N), Phosphorus (P), Potassium (K), Sodium (Na), Calcium (Ca), Copper (Cu), Iron (Fe), Magnesium (Mg), Manganese (Mn), Zinc (Zn), heterotrophs, Nitrosomonas, Nitrobacter and some decomposer Fungi.The probable use of hydroponics in rural areas and large metropolitan cities was researched by the authors (Panayotis Kinanlis *et al.*, 2018) who found out that factors such as current transport infrastructure, production volume, current farming and local demand appear to be more decisive for success of hydroponics farm. There have been many studies on the growing impact of hydroponics in agriculture. Various authors have focused on the hydroponics techniques namely, Drip, Ebb, NFT, their operations; benefits and limitations; performance of different crops (Sharma *et al*., 2018)

The authors (Srivani *et al.*, 2019) reviewed various physical and environmental variables that influence the plant growth for the justifiable and efficient farming system and came to the conclusion that soilless agriculture, (hydroponics) can be implemented efficiently with a Controlled Environment Agriculture System (CEA). They came to the conclusion that to encourage Hydroponics Farming it is essential to expand less costly hydroponic technology that can reduce reliance on manpower and reduce the overall cost of startup. Huo *et al.* (2020) studied the influence of microalgae on vegetable production and nutrient removal in greenhouse hydroponics. The primary objective of their research was to study the effect of microalgae on plant growth and nutrient removal. This effect was assessed for three vegetables (arugula, purple kohlrabi and lettuce) these were grown entirely using nitrate-rich synthetic wastewater in greenhouse hydroponics. The research was done under the three conditions: Natural microalgae, Microalgae added, and Microalgae-free, the effects of microalgae on vegetable growth and nutrient removal were revealed in greenhouse hydroponics.

Conclusion

The main objective of present study was to conduct a comparative study between hydroponic and geoponic cultivation methods. In our study we found that the growth of all the three seedlings (tomato spinach and lettuce) was greater in the hydroponics system than in the geoponic system. The Hydroponics system proved to be an important system of cultivation for the growth of plants. It does not require any harmful chemicals thus it proves to be an environmentally friendly approach as well. The present research manifested that soilless method of plant growth plays a magnificent role in areas where there is soil and water scarcity, improved physical characteristics of lettuce, spinach and tomato indicated an enhanced advantage of hydroponic technology

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