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PLANTS IN DIFFERENT CLIMATIC CONDITIONS - HYDROPONIC SYSTEM

The word 'Hydroponics' has originated from Greek word hydros, meaning water and ponos, meaning labour. In fact, it is a method of growing plants in nutrient solution without soil, therefore, often also referred as soil less culture. Aztecs are regarded as first people in the world, who developed art and science of hydroponics by growing crop plants on rafts made up of bushes and reeds in form of large water fields, known as Chinampas, sometimes tied together to form floating islands of one to three hundred feets.

The method of hydroponics received scientific momentum in mid-nineteenth century. An agricultural chemist W. Knops of Wurzburg, Germany is called the "father of water culture". Today, hydroponics is regarded as established science. The advantage of hydroponics include: no digging, no crop rotation, very few weeds, large yields, less labour, low irrigation, better control over results and it is clean. Moreover, hydroponics can be practised in place where natural agriculture is not possible. On the whole, it is a simple and cost effective method to grow the plants and could be exploited effectively to solve the food problems of the world to some extent.

Basic Hydroponic Systems

The hydroponic system has been categorized into six different types viz., wick, water culture, ebb and flow, drip, nutrient film technique (NFT) and aerioponic.

NFT system has constant flow of nutrient solution, so no timer is required for submersible pumps. The nutrient solution is pumped into the growing tray (usually a tube/pipe) and flows over the roots of the plants and then drains back into reservoir. Normally system functions very well but is very susceptible to power supply interruptions and pump failures as roots dry out very rapidly, when the flow of nutrient is interrupted. Hydroponic gardening systems can be designed according to ones requirement and can be modified according to the climatic condition of a particular place.

The Present System

Structure

The present system is designed on the basis of NFT. It can be used in varied climatic conditions, from hot tropical to temperate with desired modification. The

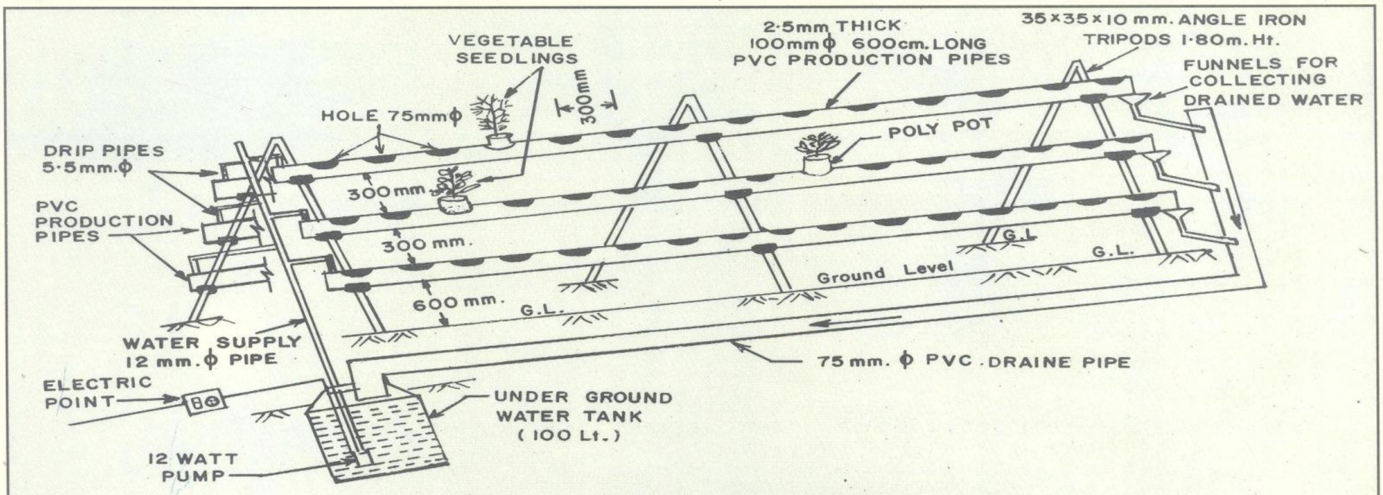

Fig.1 AN INNOVATIVE HYDROPONIC SYSTEM.

diagram of the system is given in Fig. 1. The whole system was fixed on three inverted V-shaped angle iron stands with above ground height of 1.80 m and 45 cm buried on ground for fixing the stand. On both the side of stands, there are six PVC pipes of 6 m long (2.5 mm thick and 10 cm diameter) i.e., three in one side and three in another which are fixed in such a manner that first of two PVC pipes run parallel to each other at a height of 60 cm above the ground. The second and third sets of PVC pipes are placed in same pattern (second 30 cm above the first set and third 30 cm above the second set). Each pipe was fixed in slightly slanting manner towards distal end. These pipes are termed as PVC production pipes.

In each PVC production pipe, a hole of 7.5 cm diameter was made at a distance of 25 to 30 cm, thus each PVC production pipe had 20 such holes. The holes were made in such fashion that at each side of the stand holes on one pipe were not just above or below to other. The PVC production pipes were closed through a cap at one side and the distal end they were open (having a funnel in each to drain the water). At the side of close head of PVC production pipe, a 100 liters capacity PVC water tank was installed below the ground level. A 1.2 cm diameter plastic pipe (water supply pipe) was put in the water tank which had a height of 1.8 m i.e., up to the top of inverted V-shaped angle stand. This pipe was covered by a small pump (submerged) of 12 watts to lift the water. One dripper (5.5 mm diameter) was placed in each PVC production pipe through a small hole. At the distal end, funnel in each PVC production pipe was connected to a plastic pipe, which ultimately joined to a PVC drain pipe of 7.5 cm diameter. This pipe drained the water back to the tank. The entire system was placed in a nylon net house, which allowed only 50% sunlight to reach.

Function and Production

The holes (7.5 cm diameter) made in fixed distance on PVC production pipes function as a production point. In each hole, a perforated polythene pot of 12.0 cm height with a diameter of 5.0 cm is kept. In this polypot (polybag) 5.0 g moss is filled upto 5.0 cm height, which act as a anchoring medium and as well as absorbent of running nutrient mixed water used by the plants for growth and production. The nutrient mix used was water soluble complete plant food. According to compositional detail, it contained 18% total nitrogen of which 6.9 % is amonical nitrogen, 4.4% nitrate nitrogen and 6.7% urea; 30% available phosphate; and 18% soluble potash. Micronutrient composition was as: Boron 0.02%, organic complex copper 0.05%, organic complex iron 0.10%, organic complex manganese 0.05%, molybdenum 0.0005% and organic complex zinc 0.05% by weight.

For experimentation tomato (*Lycopersicon esculentum*) was grown as a test crop in the system. Seedlings of tomato were put on moss filled polybags during first week of November 2009. One polybag was kept in one hole with one seedling. One gram nutrient mix was mixed in one liter water. During first fortnight after planting the seedlings, Plant grow mixed water was run in the system for four hours (2 hours in the morning and 2 hours during the afternoon). After that during second fortnight nutrient mixed water was supplied for 5 hours (2 hours in the morning and 3 hours in the afternoon). It was observed that after one month, root starts growing vigorously and they slowly protruded out of the holes of polybags. At this stage, larger amount of nutrient mixed water is needed, therefore, water was run in the system for eight hours (3 hours in morning and 5 hours in afternoon i.e., from 8 AM to 11 AM and then 1.00 PM to 6.00 PM). This continued for one month. After 60 to 65 days, flowering started on the plants and simultaneously the process of increase in fruit size and picking of matured ones continued. Thus, after 60 days nutrient mixed water was run 24 hours in the system. This was done till the last picking. Though incidence of insect and fungal attacks was extremely low, however, as a protective measure recommended insecticides/pesticides was sprayed two times, first at the flowering time and other during initial stage of fruit formation.

Table 1. Tomato (*Lycopersicon esculentum*) production in present hydroponics model*

No. of Pipes	Total Plants	Height of Angle iron stand (m)	Cost of Assembly (Rs.)	Production per system (kg)
6	120	1.8	5400	72**
9	180	1.8	6400	108 (50)***
11	220	2.1	7200	132 (83)
13	260	2.4	8000	156 (117)
15	300	2.7	8800	180 (150)
Control (on field of 7.2 m^2 under drip system)	80	-	2550****	60

* Surface area of model: 6m x 1.2m (7.2m^2)

** Actual yield observed

*** Figures in parenthesis represent percent increase in yield as compared to actual production (in 6 PVC pipe system), if number of PVC production pipes increased in the system.

**** Unpressurized drip irrigation, cost includes drippers, over head tank and other minor attachments.

Fig. 2. Hydroponics model at Silviculture and Agroforestry nursery, CAZRI, Jodhpur with tomato as a test crop (INSET: A full view of present hydroponic system; Crop grown is not tomato

During first fifteen days 20 liters of nutrient mixed water was consumed and to replenish this water 20 liters of water with 20 g nutrient mix was filled in the tank. In next of 15 days, 25 liters nutrient mixed water, followed by 75 liters in another 30 days was consumed. This water was replenished as and when required by the mixing nutrient mix @ 1 g/liter of water. After 60 days nutrient mixed water was consumed @ 7.0 to 7.5 liters/day till last picking, as during this period water was run through out 24 hours. The consumed water was replenished as and when needed.

Actual and Projected Yield

The surface area covered by present system was 7.2 m^2 (6.0 x 1.2 m). Vertically system contained six pipes in which 120 plants of tomato were grown. During entire course of vegetative and reproductive growth, and as well as till last picking of tomato only 720 liters of nutrient mixed water was consumed by the crops. Some part of water might have evaporated, which could not be estimated. Total 72 kg of tomato was harvested (Table 1). The same unit of land area was also planted with tomato crop using drip irrigation that yielded 60 kg of tomatoes. About 17000 liters of water was consumed to produce 60 kg tomato. The present system is quick, flexible and height of main stem could be increased to 2.7 m and 15 PVC production pipes can be attached to it. In a projected estimate, 15 PVC production pipes 300 plants could be grown and 150 % more yield in comparison to six pipes assembly (present system) could be obtained with only 1800 liters of water (Table 1).

Epilogue

Vertical growth system, like that of present one provides solution to some extent to rapidly increasing food costs caused by transportation/ fuel cost, and use of heavy growth promoting and protecting chemicals in field agriculture. More over, present hydroponic system requires only 4.2 – 10.6 % water than that utilized through drip system on the field. This system can work in variety of environments and may be used in urban, suburban, country side, desert areas, cold conditions, etc.

In general, the present system can be assembled easily as depicted in Fig. 2 and will be easily scalable from very small to large food production situation. At the present, there are no examples of a locally sustained urban community anywhere in the world. Urban sustainability is yet to be realized primarily because urban agriculture's main challenge is lack of growing space. The present vertical growing system offers great promise for production of vegetables which can increase urban food supply with limited space and water. The primary advantage of present system in high density vertical production which allows using much reduced physical footprint and fewer resources to conventional agriculture.

L. N. Harsh, J.C. Tewari and J. K. Lohia

Forthcoming Conferences and Events

International Conference on Environmental Science and Applications, 10 - 12 September 2010 at Singapore Contact: iceea@vip.163.com and http://www.iceea.org/

International Conference on Environmental Challenges: A Global Concern, 15 - 16 October 2010 at Jalandhar, Punjab, India, Contact: http://www.kmvjla.org/confevs

Annual International Conference on Soils, Sediments, Water and Energy, 18 - 21 October 2010 at Amherst, Massachusetts, United States, Contact: http://www.UMassSoils.com

Conference on Challenges of Improving Agricultural Production per Unit Area and Ways of Its Development in the Agricultural Sector, (Dates n.a.) October 2010 at Aleppo, Syria Contact http://www.icarda.org/EventsCalendar.htm

The 50th Science Week Conference: "Agricultural Productivity Increase, Challenges and Means of Development", 28 - 30 November 2010 at Der-Azzor, Syria Contact: http://www.icarda.org/EventsCalendar.htm

10th International Dryland Development Conference (IDDC), (Dates n.a.) December 2010 at Oman Contact: http://www.icarda.org/EventsCalendar.htm

Recent CAZRI publications

Status of Centre-State Co-ordination in Agricultural Research Education and Extension Region-IV. Proceedings of the 20th Meeting of ICAR Regional Committee VI. 176p. 2008, CAZRI, Jodhpur.

Trends in Arid Zone Research in India. Eds: Amal Kar, B.K. Garg, M.P. Singh and S. Kathju, 481p. 2009, CAZRI, Jodhpur.

Perspective Research activities of Arid Legumes in India. Eds: D. Kumar and A. Henary. 214p. 2009, CAZRI, Jodhpur.

CAZRI Golden Jubilee (1959-2009) Orations. Eds: P.C. Pande, S. Kathju, Amal Kar, R.S. Tripathi, N.V. Patil. 44p. 2009, CAZRI, Jodhpur.

Alternative Farming Systems suitable for Kachchh Region of Gujarat. Eds: Devi Dayal, M. Shamsudheen and Bhagirath Ram. 22p. 2009, CAZRI, RRS Bhuj, Gujarat.

SOUVENIR: International Conference on Nurturing Arid Zones for People and the Environment: Issues and Agenda for the 21st Century, November 24-28, 2009. Ed: P.C. Moharana. 53p. 2009, CAZRI, Jodhpur.

Mashrum Utapadan Prodyogiki. Eds: S.K. Singh, Rakesh Pathak and Anjaly Pancholy. 20p. 2009, CAZRI, Jodhpur. (Hindi)

20 Years of CAZRI Regional Research Station Kukma-Bhuj. Eds: Devi Dayal, Bhagirath Ram, M. Shamsudheen, M.L. Swami and N.V. Patil. 38p. 2009, CAZRI, RRS Bhuj, Gujarat.

Research Highlights: CAZRI, RRS Pali (1959-2009). Eds: P.P. Rohilla, S.S. Rao and B.L. Jangid. 56p. 2009, CAZRI, RRS Pali.

Marukrishi Taknik Avam Prabandhan. Eds: Amal Kar and Madhubala Charan. 90p. 2009, CAZRI, Jodhpur.

Rainwater harvesting through Tanka in Hot Arid Zone of India. Eds: R.K. Goyal and V.C. Issac. 33p. 2009, CAZRI, Jodhpur.

Nostalgia: A Collection of Narratives on CAZRI and its People by the Cazrians. Eds: S. Kathju, Amal Kar and P.C. Pande. 105p. 2009, CAZRI, Jodhpur.

Kishan Jagrukta Karyakarm Mausam Adharit Krishi Sewa. Eds: A.S. Rao and Surendra Poonia. 19p. 2010, CAZRI, Jodhpur.

VISIT ABROAD

Dr. O.P. Yadav, Cairus, Australia, from 10.8.2009 to 14.8.2009 to participation in the 14th Australian Plant breeding Conference (APBC) & 11th Congress of the Society for the Advancement of Breeding Research in Asia and Oceania (SABRAO).

Dr. Dheeraj Singh, Nairobi, Kenya, from 23.8.2009 to 28.8.2009 to attend the 2nd World congress on Agro Forestry.

Dr. Dheeraj Singh, Rome, Italy, from 11.11.2009 to 13.11.2009 to attend the 4th Annual Conference on food Security and Sustainable Development: Challenges for the Governance of International relations.

Dr. Amal Kar, Dr. L.N. Harsh and Dr. M. Patidar, Iran, from 5.12.2009 to 11.12.2009, to participate as an Expert for conducting a Training Course on Sustainable Management of Natural Resources in Arid and Semi-Arid Areas.

Dr. Uday Burman, Washington University in St. Louis, USA from 15.1.2010 to 15.3.2010 attended Training in the Area of Nano Technology with emphasis on effect of nanoparticles on plants.

Dr. J.C. Tarafdar, Washington University in St. Louis, USA, from 1.3.2010 to 29.4.2010, attended Training in the Area of Exposure to Methods to Use of Microbes as Bio Nano Factories, its Purification and Characterization.

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