BIOPONICS: EMERGING TOOL TO ENHANCE CROP PRODUCTIVITY AND QUALITY IN SUSTAINABLE MANNER

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Abstract

Subsistence of agriculture, conservation of biodiversity and protection of environment are the three major pillars for sustaining the harmonious balance with the complex series of ecosystems on earth. For providing concrete base to the above mentioned pillars, organic farming could be seen as the most viable option. Studies reported till date indicated the yield decrease or farmer’s dissatisfaction with organic farming during initial years, later stabilized results were observed. Reason for yield decline may be the habit of Indian soils/ varieties/ hybrids to usage of excess synthetic inputs or the breakage of resistance of certain crops towards diseases and pests due to overuse of pesticides. Solution to this problem is increasing the production of crops under protected conditions with soil-less media. This media will be free of any soil-borne diseases plus it already have sufficient amount of nutrients within, for maintaining the health of crops. Organic nutrients could be used for fertilization in hydroponic/ aeroponic chambers for sustaining the growth and productivity of crops. Furthermore, focus must be on developing varieties which could survive better/ give better response to organic inputs with durable resistance to insect-pests and diseases. Multiple disease resistant varieties could be used. India is already leading in terms of export of organic products and elevation in business is expected in coming years. Hence by facilitating hydro/aeroponics with organic inputs i.e. by promoting bioponics, monetary increase in terms of yield and quality could be expected for raising farmer’s income.

Keywords: biodiversity, bioponics, organic, soil-less cultivation, sustainability

Introduction

Rising demand of food production to feed ever-increasing population in 2050s is indicating immense need for producing more and more food either through area expansion or intensification of agricultural land. Both these area expansion and intensification are considered as major ecological threats to nature. These both results in biodiversity loss as well as contributes towards declining soil-health, human health and environment due to indiscriminate use of chemical fertilizers and pesticides.

vegetable consumption due to fear of getting infected by viral diseases from animal meat. This again will be an alarming situation for producing more food from limited area. Concern now a days, is not only for elevating the food production, focus is on producing nutritious and quality diets as well. Win-win situations are needed to combat this
all. Technological interventions, particularly involvement of precision or hi-tech horticulture strategies is the only possible solution to produce more from same piece of land. Vertical farming, hydroponics, Aeroponics and establishing plant factories are some of the ways to increase the productivity in more sustainable manner. Furthermore, linking these all with organic solutions will again contribute to produce less contaminated consumables and environment-friendly farming. Moreover, farmers could be benefitted with higher prices of quality produce.

**History of soil-less cultivation**

Soil-less culture was basically originated in when the work of Francis Bacon was published in the book *Sylva Sylvarum* in 1627, year after his death. He had grown some terrestrial plants without the use of soil and he termed it as water culture. With the advent of time, advances were made and in 1699, Woodward while working on spearmint reported that less pure water give better results than distilled water, further, Sachs and Knop in 1859-75 contributed towards soil-less cultivation technique by publishing work related to nutrient recommendations. Detailed history of soil-less cultivation involves the role of Dr. Gericke (1937) who worked on and coined the term “Hydroponics”. Later in 1957, Went advocated the use of term Aeroponics for growing the plants without water solutions. Here nutrients are provided by misting plants with nutrients directly on hanging roots. In 2005, William Texiera coined another term “Bioponics” where he mentioned of growing the plants under soil-less cultivation but with organic/natural inputs. This has to be considered as a revolutionary approach where besides increasing yield and quality from less area, one can protect the environmental and human health as well. Flow-chart indicating the landmarks in revolution of soil-less cultivation is represented as Figure 1.

![Flow-chart indicating the landmarks in revolution of soil-less cultivation](image)

*Figure 1: History of soil-less cultivation*
Need of Bioponics/ Why Bioponics

“Health is Wealth” is a proverb used very commonly. Basically, it relates a person’s wealth to his health indicating health is as important as wealth. Another commonly used proverb “Healthy mind in Healthy body” again indicates the importance of health for proper functioning of life. Healthy person will always have a healthy life. But now days, problems related to human health are appearing on regular basis. Millions of people are suffering from malnutrition and hidden hunger problems. Most of the society is anaemic due to Iron (Fe) deficiency. On one side deficiency of essential nutrients is observed as a major problem, residual effects of harmful elements are posing detrimental effects to human health on another side. Most of the foods are considered toxic due to high residues of pesticides/ toxic elements in them. Even exports of some of the crops (example Basmati Rice of Punjab) are banned due to high toxic residues. Thus there is an urgent need to produce foods keeping in mind minimum acceptable residual limits.

Bioponics in relation to vegetable production

Bioponics could play a key role in cultivation of vegetables as these crops require lesser amount of fertilizers (doses and number) as compared to cereal crops. Another advantage is the more variability/number of short duration leafy vegetable crops suitable for cultivation in soil-less media’s. Further, area under tomatoes, lettuce, spinach, red amaranth and cucumber cultivation under hydroponics is increasing day by day. It was revealed by many scientific studies that growth rate of hydroponically grown vegetables is 30-50% faster than the plants grown in soil based conditions with 25% higher yields. Specific conditions with respect to light, humidity, pH and temperature can be created along with variable rate application of natural fertilizers for successful vegetable production. Some of the studies related to Bioponics are presented in Table 1.
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<thead>
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<th>Aspect</th>
<th>Recommendation</th>
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<td>(a)</td>
<td>Conducted study on lettuce production in plant factory using Bioponics and observed that it greatly reduces the nitrate concentration of all lettuces and increased the fresh mass of ‘Frilly’ lettuce.</td>
<td>Fang and Chung (2018)</td>
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<td>(b)</td>
<td>Studied the impact of goat manure derived hydroponic nutrient system (GMDHNS) and commercial hydroponic nutrient system (CHNS) on fruit quality of tomato and reported that lycopene content and fruit quality was better in GMDHNS than CHNS.</td>
<td>Mowa et al. (2018)</td>
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<td>(c)</td>
<td>Studied seedling production of Pak Choy (<em>Brassica rapa</em> L.) under hydroponic system using Organic and Inorganic Nutrients and reported that combination of both organic and inorganic prove good for seedling growth parameters and leaf indices with positive correlations among them.</td>
<td>Priadi et al. (2017)</td>
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<td>(d)</td>
<td>Discussed about different growing media’s (mineral and organic media) community wise, their stability and functionality in soilless culture systems and concluded that these differences in communities can be used to develop strategies to move towards a sustainable horticulture with increased productivity and quality.</td>
<td>Grunert et al. (2016)</td>
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<td>(e)</td>
<td>Excellent review discussing the present status and future prospective along with advantage of organic hydroponic culture systems over natural soil-based systems on the yield, quality and nutritious value of end products of vegetables.</td>
<td>Barman et al. (2016)</td>
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<td>(f)</td>
<td>Analysed nitrogen transition with enriched nitrifying soil microbes and microbial communities under organic hydroponic systems and reported that two processes are involved. One degrades the organic nitrogen fertilizers to NO₃ through microbial enrichment process and the other is enriches the nitrifying microbial activity in crop cultivation using organic fertilizer.</td>
<td>Saijai et al. (2016)</td>
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<td>(g)</td>
<td>Study was conducted to observe the effect of organic hydroponics against gray mould of lettuce and reported that use of organic amendments significantly reduced gray mold lesions in lettuce (cultivated hydroponically) and cucumber (cultivated in soil and foliar sprayed with nutrient solution).</td>
<td>Chinta et al. (2015)</td>
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<td>(h)</td>
<td>Conducted a study in arid Namibia and compared the effect of different organic manures (chicken manure, goat manure, cow manure) on spinach under hydroponic conditions and reported that the conventional hydroponic fertilizer yielded more than new manure treatments and goat manure yielded high than the chicken and cow manure.</td>
<td>Mova (2014)</td>
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<td>(i)</td>
<td>Conducted a study on microbial mineralization of organic nitrogen into nitrate for promoting the use of organic fertilizer in hydroponic vegetable production and advocated the direct use of organic fertilizer after using microbial culture solution.</td>
<td>Shinohara et al. (2013)</td>
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<td>(j)</td>
<td>Reported that organic hydroponic system leads to suppression of <em>Ralstonia solanacearum</em> bacterial wilt disease by forming a rhizosphere biofilm on roots.</td>
<td>Fujiwara et al. (2012)</td>
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<td>(k)</td>
<td>Production of lettuce was done using nutrient film technique (NFT) with organically derived nutrient solution and observed that the plant growth in case of organic system is slower than conventional inorganic hydroponic solution.</td>
<td>Atkin et al. (2004)</td>
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Future Prospects and Conclusion

Organic hydroponics can cope up the limitations of insufficient land, decreasing water levels and hazardous impacts of chemical fertilizer for maintaining the crop productivity in eco-friendly environment. The future of protected cultivation and bioponics depends greatly on the development of production systems that are cost-effective in comparison to open field agriculture. Increase in crop yields and reduce unit costs of production with the introduction of new technologies like artificial lightning, good agricultural practices and breeding nutrient use efficient cultivars with better pest and disease resistance. Monetary increase in terms of yield and quality could be expected from protected cultivation which in result could raise farmer’s income.

References


