Review Article
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Recent trends in agriculture: vertical farming and organic farming

Abstract

Advancements in the field of science and technology along with the global urbanization are the major factors driving the course and evolution of agricultural research. Rise in per capita income in developing nations, occupational changes and global linkages have changed the food preferences. These trends along with the increase in population pose a challenge to agriculture for producing more & better food. Increase in the productivity of agriculture by employing techniques of conventional (20th century) agriculture is posing a limitation. The threat to environment, due to dependence on chemical fertilizers and pesticides for increasing productivity and pest management respectively is major constraint affecting the global food production. These trends suggest that new innovations in agriculture are inevitably needed and these innovations should be integrated with the main stream agriculture (the big agriculture as we may call). Vertical farming and organic farming are the research areas to fight these constraints. Vertical farming employs vertical stacking of the farms therefore small land can be utilized for more production. In addition, this technique is well suited for the rapidly growing global urban population as the demands of food supply can be met from within the cities and thus reducing the transportation cost and environment deterioration caused by fuels in the process. Organic farming on the other hand is based on the principles of minimization of the chemical inputs in the agriculture and hence is environment friendly. Thus, these techniques can be utilized for increasing the production and productivity to meet the growing food demands.

Keywords: agricultural trends, urban agriculture, vertical farming, organic farming, sustainability, climate change

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Introduction

Most challenging task for agricultural sciences today is to ensure for continuous and enough supply of food to growing human civilization. Urban centers throughout the world have experienced substantial increase in population; this growth is accompanied with change in food habits and rising concerns for food quality. Here, food quality refers to the optimum levels of the nutrition in the food along with the minimized amount of the chemical (pesticides/fertilizers) residues used in the production of the crop. Agriculture is also entrusted with a role of restoring environmental imbalance created due to injudicious/ indiscriminate use of the chemicals in the agriculture. Along with these issues, increasing demands for fuel crops for sustaining the rapidly growing economies is needed. According to the estimates of UN population projection, world population could reach 9.15billion by 2050, thus the expected rate of increase in world population will be 2.25 percent over the next forty years[1] and thus provides for a potentially huge market for food grains and food production needs to be doubled to meet this demand. It is projected that to feed the global population by 2050 require 70 percent increase in global food production with food production from developing countries needs to be doubled.[2] Environmental stress (climate change) and shortage of water and land resources are major constraints haunting this task. Though the advances in science and information technology has resulted in more comfortable world with global linkages, these advances has led to changes in agricultural practices. In recent past production and productivity of crops have increased along with the increase in fertilizer and pesticide consumption, this trend is more conspicuous in developed and industrial countries with developing countries like China have made their presence felt by around 2 fold increase in cereal yield since 1961. In developing countries, due to lack of financial resources and knowledge of technical advancements farmers are unable to shift to practices of modern intensive agriculture[3] and hence remain isolated from global linkages.

Increase in long distance food trade, diet changes and increase in the food based retail industries are the indicators, suggesting that globalization has affected food systems world-wide.[4] At the same time these trends have created a concern for environmental problems as excessive use of chemicals is not desirable in agriculture for preservation of environment, biodiversity and soil quality. Thus, increasing global trade and easy accesses to chemical and technology has contributed to changes in agricultural systems. Recent trend in agriculture has seen rise in organic agriculture, vertical farming and intensive agriculture to accommodate the demands of increasing world population and address the rising concern for environmental issues. Vertical farming shall help in meeting the food & other demands of the rapidly growing urban population. On the other hand organic farming will help in increasing the harmony between the environment and anthropogenic activities done for agriculture.

Vertical farming

Concept of vertical farming was given by Professor Despommier;[5] the farm uses conventional farming methods such as hydroponics and aeroponics to produce more yields faster. Vertical farming can be defined generically as a system of commercial farming whereby plants, animals, fungi and other life forms are cultivated for food, fuel, fiber or other products or services by artificially stacking them

vertically above each other. Vertical farming is large scale agriculture in urban high rise structures. The concept foresees the cultivation of fruits, vegetables, medicinal, fuel producing plants and other plant products in the cities.[6] (www.verticalfarms.com.au) and their sales directly within the cities, thereby reducing the transportation costs and efficient utilization of land and water resources.[6] Vertical farming is a step ahead technology from green houses as it involves harnessing of resources in vertical arrays and can feed the demands of food supply with the resources of mega cities. Vertical farming includes three types of farming:

i. Phrase vertical farming was used by Gilbert Ellis Bailey in his book "Vertical Farming" in 1915. He discussed the utopian concept of vertical farming. He introduced the concept of underground vertical farming, presently followed in Netherlands.[7]

ii. In the second category, Vertical farming is done in open air or in mixed use sky scrapers for climate control and consumption. This is a sustainable type of farming for personal or community use and it may not be for commercial purposes. A modified form of this concept involves cultivation of crops in the periphery of sky scrapers to provide them ambient amount of light.

iii. Third category involves cultivation of plant and animals in the sky scrappers in the closed system for large scale cultivation. These systems under trials at various locations (Singapore, Canada, London).

iv. A vertical farm of 9300 m2 (roughly the size of a city block) with 30 stories should provide around 15,000 people with 2000 kcal of nutrition per day.[6]

Advantages of vertical farming

Increase in production and availability in crops: This farming technology confirms crop production all year-round irrespective of the environmental conditions. According to "The encyclopedia of earth, 2010" A 30 storey high building with a basal area of 5 acres (2.02ha) has the potential of producing crop yield equivalent to 2,400 acres (971.2ha) of traditional horizontal farming. Expressed in ratio, this means that 1 high-rise farm is equal to 480 traditional horizontal farms.

Production of organic crops: Vertical farming will facilitate production of organic crops in large scale production. Further, adoption of this technology will help in reduction in use of chemical pesticides.

Conservation and recycling of natural resources: The vertical farming technology includes hydroponics and aeroponics which consumes very less amount of water than utilized in the conventional agriculture. Thus, helps in conservation and recycling of the water resources. Further, urban sewage waste can be used in composted and recycled form in vertical farming, which will further help in recycling of the resources.

Environment friendly: Vertical farming will reduce the dependency on land resources and help in regrowth of forests. Further, due to less use of equipments, it will lead to decrease in CO_2 emission, thus help in conservation of the environment.

Sustainable urban growth: Vertical farming, applied with a holistic approach in combination with other technologies, will help urban areas to absorb the expected rise in population and yet still remain food sufficient. However, traditional farming will continue because many crops are not suited to indoor farming.

Key issues challenging the adoption of vertical farming are

i. Uniform practices cannot be adopted for vertical farming due to variable weather conditions in different regions of the world.

ii. Lack of crop varieties suitable for the vertical farming. This aspect needs immediate attention from the researchers, as in the absence of suitable varieties adoption of this technique will be difficult.

iii. Lack of knowledge and skills required for farming practices in urban populations.

Organic farming

Organic farming also known as ecological agriculture[8] or biodynamic agriculture,[9] works in harmony with nature i.e. the agricultural practices followed in organic agriculture do not cause any harm to the environment. Due to eco-friendly nature of the organic farming it is considered as an viable alternative in comparison to chemical based farming, in a scenario where excessive use of chemical based fertilizers and pesticides have raised the concerns for ecotoxicity and health hazards.[10–12] Nutrient management in organic agriculture is based on agronomic practices like crop rotations, soil fertility building via nitrogen and nutrient recycling using organic material like crop residues, farmyard manure and minimization of use of chemical based fertilizers.[13] Control of pest populations in organic farming relies on use of resistant crops, crop rotation, increase in predators for natural control of the pests and increase in genetic diversity along with the judicious use of water resources and animal husbandry.[14]

According to the latest survey of FiBL-IFOAM (Research institute of organic agriculture- International Federation of Organic Agriculture Movements) conducted in the end of 2012, data on organic agriculture is available from 164 countries and 37.5million hectare land is cultivated organically worldwide including those in the process of conversion. The data suggest that there is an increase in organically cultivable land in 2012 by 0.5 percent, and around 1.9million producers are engaged in the organic farming.[15] A shift to organic agriculture brings about significant changes in the agricultural practices for example: restricted use of synthetic fertilizers and pesticides, increases of other inputs such as organic materials, labor, farm machinery, cultural practices (e.g., crop rotation), and require better knowledge of biological processes.[16] These changes require training of the farmers in organic agriculture and increase in the awareness in current trends. Production methods in organic farming are variable and depend upon the variables like local environment. In organic farming use of synthetic fertilizers and pesticides is discouraged. The nutrition and disease management is done by incorporation of organic materials and crop rotation.[17]

Advantages of organic farming

Sustainability: Organic agriculture considers the medium- and long-term effect of agricultural interventions on the agro-ecosystem. Production of food is accompanied with establishment of ecological balance to prevent soil sterility or pest problems.

Ecological services: The impact of organic agriculture on natural resources favors interactions within the agro-ecosystem and environmental variables. Ecological services derived include soil

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forming and conditioning, soil stabilization, waste recycling, carbon sequestration, nutrients cycling, predation, pollination and habitats.

Biodiversity: Organic farming help in conservation of the environment and hence biodiversity. Lack of use in chemical pesticides, helps in maintain and recolonizing of the beneficial species in the area, including wild flora and fauna. The number of studies on organic farming and biodiversity increased significantly within the last years. A recent study reporting on a meta-analysis of 766 scientific papers concluded that organic farming produces more biodiversity than other farming systems.[18]

Challenges faced in organic farming

i. Highly labor intensive

ii. Effective organic inputs are not available in appropriate quantity and time.

iii. Lack of adoption in standardized agronomic practices for organic farming.

Discussion

Achieving sufficiency in food production along with the conservation of the environment are the major objectives of the agriculture presently. The constraints in achieving this task are: limiting land and water resources along with the degradation of the environmental health due to excessive use of chemicals for nutrition and pest management in agriculture. Anthropogenic activities for development have resulted in further degradation of environment and have spurred the rate of climate change. Global efforts have been initiated for reducing the effects of climate change on earth in general and agriculture in particular. These steps should be complimented with the innovations in production techniques employed in agriculture and also scientific utilization of the indigenous knowledge which is proven as more sustainable.

The two different methodologies of agriculture elaborated above can be integrated in the current agriculture system without many disturbances and can be adopted on a global scale. Vertical farming, which is a recent concept in agriculture, has great potential considering the falling land resources for agriculture due extensive urbanization and increase in per capita income of the developing nations. The methodology though a new concept for the developing nation, is of great promise and can efficiently meet the challenge in terms of quantity, quality and variety. Organic farming on the other hand is a well known concept in agriculture, but requires further exploration and integration of scientific knowledge for incorporation in the main stream agriculture to feed the growing demands. These two different methodologies, with separate principles are promising avenues for global agriculture and require further exploration in terms research and integration in main stream for healthier environment and well fed world.

Conclusion

Thus, in conclusion changing demographic trends and technological advancements are delivering new innovations in the field of agriculture. These emerging technologies are required to be used judiciously to meet the growing demands from modern agriculture. Vertical farming and organic farming can be adopted as the viable alternatives for the conventional agriculture to meet the changing demands and needs of mankind. Further, constraints in adoption of such practices should be addressed and linkages between researchers and farmers should be created for suitable measures.

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Conflict of interest

The author declares no conflict of interest.

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