

# CONTRIBUTIONS OF EMERGING INNOVATION TECHNOLOGIES IN HORTICULTURAL PRODUCTION FOR SUSTAINABLE DEVELOPMENT

BY

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## Abstract

This paper reviewed emerging innovations in horticulture for sustainable development. It focuses on robotics, sensors, ICT, mechanization and production technology. This technology aims at improving the profitability of fruits and vegetables production globally. The technologies made all production processes from seeding to packaging possible with greater efficiency. Production processes can be robotized to improve the reliable connection to market demands. Sensors are introduced in horticulture using the latest techniques rooted from medical and industrial research. Tomato seedlings can be sorted at a speed of 40,000 piece per hour and measures the full 3D geometric features which appeared impossible when done manually. Innovations in greenhouse horticulture using smart phones can register the location of a pest or disease, classify plants, to measure growth and to control machinery. Nowadays automated guided vehicles (AGVs) are used to carry harvest trollies from the central lane to the sorting and packaging area. Similarly, driving forces that led to innovation in greenhouse horticulture such as cost reduction, value chain, waste production and quality loss, insect pests damage and poor seed quality was reviewed. Finally, the paper emphasizes the contributions of robots in seeding, cultivating, and harvesting crop to a high level of reliability, and quality control that has never before recorded in food production.

**Keywords:** Innovation, technologies, robots, sensors, greenhouse.

## Introduction

As the Nigeria's population continues to expand, horticultural production process and control are mainly traditional. Even in areas where farmers adopted the use of greenhouse horticulture, the production processes are still often done manually. Moreover, the traditional method of food production is under pressure from a changing climate as well as dwindling land and water resources. Horticultural production entails a lot of labour such as crop sensing, crop maintenance,

harvesting and packaging of food for human consumption.

The innovative technology is therefore changing the idea of traditional method of growing systems, using sensors, robotics and mechanization. This new technology could also improve the productivity of quality, reliability to deliver in the requested amount, reducing the time taken to market and reducing costs in the entire production chain. In many developing countries, Nigeria's rate of post-harvest loss for fruits and vegetables

exceeds 50%. These great losses can only be reduced by cold storage facilities but virtually absent due to high cost of equipment, poor power supply, lack of information and technical know-how. (Steindor, 2020) New technologies should add value to the product and open ways to continuous improvement for sustainable development of a nation in the area of Horticulture.

### Concept of Horticulture

The term horticulture is derived from the Latin words *hortus*, meaning garden, and *cultura*, meaning cultivation (The New Webster's Dictionary of the English Language, international edition, 2004). It is quite impossible to give an exact definition of horticulture. Neither is it easy to enumerate its scope. Nonetheless, substantial enlightenment on the concept, scope, and definition of horticulture can be obtained from the writing of various authorities in the field. According to Louisiana State University, Ag Center (2011), horticulture is the science and art involved in the cultivation, propagation, processing and marketing of ornamental plants, flowers, turf, vegetables, fruits, and nuts. Horticulture is unique among plant sciences because it not only involves science and technology, but it also incorporates art and principles of design.

Bareja (2011) defined horticulture as the art and science of plant production for both beauty and utility, rather than staple crops, horticulture focuses on value-added, luxury crops. Based on the above definitions, Horticulture can be viewed as the branch of agriculture concerned with intensively cultured plants directly used by people for food, medicinal purposes and for aesthetic gratification. But also includes the cultivation of garden crops, landscape ornamentals, and the interaction of science and art in the process of production.

### The major areas of horticulture

According to Ben Bareja (2022) and other scholars in the field, the major areas of

horticulture include:

- Arboriculture is the study and the selection of plant, care, and removal of individual trees, shrubs, vines, and other perennial woody plants.
- Turf management includes all aspects of the production and maintenance of turf grass for sports, leisure use or amenity use.
- Floriculture includes the production and marketing of floral crops. Study of flower cultivation.
- Landscape horticulture includes the production, marketing and maintenance of landscape plants.
- Olericulture includes the production and marketing of vegetables.
- Pomology includes the production, processing and marketing of fruits or cultivation of fruits
- Viticulture includes the production and marketing of grapes.
- Oenology includes all aspects of wine and winemaking.
- Postharvest physiology involves maintaining the quality of and preventing the spoilage of plants.

### Horticulture Production Medium

1. Nursery
2. Plantations
3. Orchards
4. Groves
5. Gardens
6. Vine yards
7. Greenhouse

### Importance of Horticulture

1. Income generation
2. Employment opportunities
3. Industrial development
4. Food value
5. Nutritional value
6. Aesthetic value
7. Export value
8. Religious and sacred value

## Problems Associated with Traditional Horticulture

1. Pests and diseases
2. Unpredictable climate
3. Poor storage and processing facilities
4. Poor transportation facilities and access roads
5. Poor access to good inputs
6. Lack of finance
7. High fuel costs
8. Poor marketing system
9. Break down of irrigation system
10. Shortage of skilled labour

## Reasons for Innovations in Horticultural Production

There are numerous driving forces for innovation in greenhouse horticulture, few important ones are follows:

**(1) Cost Reduction:** Cost reduction is one of the most important driving forces for innovation in greenhouse horticulture. In greenhouse production of vegetables and flowers, the labour cost, investments in energy-systems, installations and machinery and variable cost account higher percentage. Use of low cost engineering of green house and installation, mechanization with right choosing of good cultivars that require less labour and climate integration strategies to reduce energy cost are paramount important. (Pekkeriet, & Van Henten, 2009)

**(2) Value Chain:** Adding value to the product is another important reason for innovation in horticulture. Because there is a growing demand that products should be safe, clean and healthy. Pekkeriet, Van Henten, and Campen (2015) stated that, the position in the chain improves the marketing of the product, not only excellent quality will generate more value, also speed and reliability of the deliveries are key factors to become successful.

**(3) Waste Production and Quality Loss:** These are common in horticultural production. The quality requirements are not very well defined and people are not able to concentrate with constant quality standard in

mind, because:

(i) poor quality products slip through the chain until they reach consumer, but also accepted quality products become waste or second class due to labour assessment.

(ii) it is very difficult to produce close to 100% first class natural products due to pests and diseases, extreme climate events and also the differences in providing a constant quality of water and nutrients. Technology and standard that can objectify quality and can decrease waste or second class production are important due to improved process control (Pekkeriet, Van Henten, Campen, 2015).

**(4) Insect Pest Damage:** Insect pests affect crops at all stages of growth there by reducing the yield of crops and transmitting some viral diseases. This may result in sell of damaged produce or use of high level of pesticides by farmers which can be dangerous to both farmers and consumers (Steindor, 2020)

**(5) Poor Seed Quality:** high humidity causes rapid seed spoilage that results in poor germination and stand establishment, lower productivity and reduced market value (Steindor, 2020).

## Types and Techniques of Emerging Innovations in Horticultural Technology for Sustainable National Development

There are robots that automatically seeds, water, weeds, and harvest your crop to a greater efficiency. Technology promises to achieve a level of efficiency in food production that a human could never attain (Stiendor, 2020). Some of the technologies will be discussed below:

**(1) Sweeper:** This is one of the recent robotic technology that select and harvest ripe sweet peppers, by moving up and down crop rows on a mobile unit. A series of moving cameras are used to create a 3D image of the plants and fruits and combine with colour spectral imaging senses to monitor the ripeness of the fruit in a dense population. All robotic sensors to control robotic harvesting are using 3D sensors (Pekkeriet, Van Henten, & Campen 2015).

**(2) IRIS Scout Robot:** This type of robot can be used to detect pests, disease and nutrient deficiencies in pepper and tomato crops. The robot also has the ability to count fruits, assess their colour and measure their size to predict yields. A successful research using X-ray is done to detect long-horned beetles in small imported trees (Jansen, Hemming, 2010).

**(3) Phenobot:** This robot scans tomato crops in glasshouse by using a 3D light field camera to predict the number of fruits per plants and measure the quantity of harvested fruits. It can also detect botrytis symptoms using chlorophyll fluorescence measurements and directly target fungicide to affected areas.

**(4) Trimbot 2020:** This is a garden trimming robot which will navigate using a user-defined garden map to avoid obstacle over varying garden terrain. It also trim bushes, hedges and other plants to restore them to their decorative or ideal shape (TrimBot project, 2020).

**(5) Pasteur Sensor Tags:** This sensor chips measure temperature, relative humidity and light in order to predict the true shelf life of fresh produce like strawberries, avocados and roses by monitoring product quality to avoid or reduce food waste.

**(6) Augmented Reality Glasses:** This is an eye wear for monitoring plants health by using reflectance at specific wavelength in the visible and near-infrared range can enhance the difference between healthy and unhealthy plants. The glasses have special camera that can calculate the difference and shown on the screen you are looking at.

**(7) Potato Seed Disease Detector:** This is camera with cutting-edge hyper-spectral imaging that can find diseases of potatoes seed at early stage when symptoms are not visible to the human eye. A classifier is built to distinguish between stem and leaf disorders using few captured images.

**(8) Picknpack:** This is an automated packing system which significantly reduces both waste of food and packaging materials. It is flexible in packaging exercise as well as the ability to assess product quality and then sort and separate to the right package or crate.

Packaging designs, types, quantities and product combinations are changing all the time and every retailer has his own idea about distinctive products. Packaging lines should adjust to these changes in a flexible way. This picknpack project has this approach (Sikkema, 2012).

**(i) Gerbera Scout:** This scout for gerbera crops uses high tech sensors and data management systems to monitor crops for growth, pests and diseases. Moving systems were developed for gerbera, cut roses, tomatoes and sweet peppers, (Pekkeriet, Van Henten, & Campen 2015).

**(ii) Fluorescence Techniques:** In this technique, a red laser beam is directed towards the object. Chlorophyll strongly reacts under red light while a camera records the fluorescence image. Recording one image with a red laser and one without, then subtracting these images from each other using software, produces an image of a product's photosynthetic activity. The sensor detects photosynthetic capacity of plants, ripeness, shelf life and quality of fruits, vegetables and flowers and also detect stress and diseases of plants. This technique develops from using laser beams to high power LEDs which makes the measurement much more robust, cheaper and faster (Jalink, 2009).

**(1) Computer Vision of 3D Geometric Features:** Computer vision in horticulture is used to classify plants, to measure growth, to detect pests and diseases, and control machinery. With the use of smart phone running on iOS or Android you may able to download apps that can register the location of a pest or disease (Rohrig, 2012).

**(2) CoolBot:** This electronic device overrides an air conditioner's temperature gauge, tricking it into working harder while preventing component from freezing. An insulated room with a CoolBot can be converted into a cool room to store fresh produce before sale, to maintain quality and extend shelf life. A cool storage facilities are high cost, and the CoolBot is one option for



reducing the costs of a cold room. (Stiendor, 2020).

### **Challenges in Using or Adopting Innovative Technologies in Horticulture**

**(1) High cost of equipment:** the equipment are very expensive to procure and maintain by our local farmers.

**(2) Poor power supply and high cost of fuel:** Electricity power supply in this country will not support the use of new innovative technology and fuel is too costly.

**(3) Poor financing:** horticultural production requires a huge capital for improved production. Lack of financial strength of our farmers coupled with the bureaucratic nature of credit facilities and lack of standard subsidies has affected farmers' ability to take risk and expand production.

**(4) Lack of technical know-how:** the new techniques of production requires highly skilled personnel to man the machines and techniques. Unfortunately, the supply of well skilled man power is deficient.

**(5) Lack of information about new technology:** a good and timely researched information is vital to the farmers, because recent information about production in the world can be extended to them. Unfortunately, extension workers are too ill-equipped for the work. This is couple with dogmatic and adamant attitude to change by the farmers. Also information about market is very important, knowledge of what to produce when to sell, where to sell is equally essential.

**(6) Unstable policies and programmes:** frequent political changes in leadership coupled with contradicting government policies bring about fear and uncertainty by farmers to sink huge money in the procurement of equipment to invest in to the business.

**(7) Poor marketing system:** Nigeria is lacking organized market for agricultural produce. The aim of commercial production is profit making but this cannot be achieved due to non-functional food commodity boards,

poor pricing policies and poor market channels among many others.

### **Summary**

- (1) Use of robotics, sensors, ICT, mechanization, could raise the level of reliability and quality control.
- (2) Robots can seed, cultivate, and harvest plants to a high level of reliability and quality control that has never before recorded in food production.
- (3) Specific technologies are available at market to help the horticultural production.
- (4) CoolBot can be used to substitute the expensive cool storage to store fresh produce before sell.
- (5) Use of pest-exclusion nets provide an inexpensive, reusable and safe method of managing insect pests.
- (6) High seed quality can be obtained through the use of drying beads which can provide a widely adoptable method for drying seeds and to maintain seed quality during storage to lead to higher germination rates

### **Conclusion**

Without these innovations, it's worth mentioning that climate changes effect on crop growth and the threat of over population could decimate the human race. Innovation in agriculture is not just interesting it's essential to our survival.

### **Recommendations**

1. Provision of subsidies and good timely agricultural loan without interest.
2. Provision of solar energy to provide power and subsidized fuel price will help.
3. Farmers should be trained on the most recent agricultural technology.
4. Provision of mass literacy programmes for farmers to update their knowledge.
5. Number of specialized training institutes should be increased so as to produce adequate and trained manpower.
6. There should be continuity of

government programmes and proper implementation of policies. stabilize the price and provide ready markets through commodity boards.

7. Provision of good marketing system to

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