



Technological Advancements and Innovation in Sugarcane, Okra, Wheat, and Rice

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Abstract: This study to evaluate the role of technology and innovation in agriculture with special reference to sugarcane, okra, wheat, rice, and pea. India is an agriculture-based economy where nearly 60% of population engaged in agricultural activities. The Indian agricultural sector, traditionally known as the low-tech and subsistence oriented, now has the potential to generate employment and provide its contribution in the economy and food security. In the year 2021-22 agriculture contributes 18.8% in GVA (Gross Value Added) of the country. Agriculture sector practices increased to 3.9% in 2021-22 from 3.6% in 2020-21 that shows the resilience of the sector during the corona pandemic. Agriculture plays a key role in the Indian economy and technological advancement have significantly improves the productivity and resource efficiency.

With the use of technology better and more output can be gained in less time, less efforts, and less resources. Technology adaption saves the time and completes the work done automated with high rate of accuracy than manual work such as – use of seed drill machine. Modern machinery, improved seeds variety, irrigation technology, fertilizer and soil technology, digital agriculture, pest and disease control technology enhances the productivity and increased the farmers income.

The study focuses on the role of technology and innovation in the cultivation of selected crops: sugarcane, okra, wheat, rice, and pea. These crops are selected due to their economic importance and wide distribution among different states in India. The research is based on the secondary data collected from the journals, reports, and government publications related to agricultural technology and crop productivity.

The findings of the study shows that adaption of modern technologies and innovation can enhance the crop productivity, resource use proficiency, and farm profitability across the selected crops. Technology introduction in agriculture not only helps to increase productivity but also helps to reduce waste, save time, reduce labor dependency, and environmental degradation. However, all the farmers are not able to adapt technologies due to various reasons such as cost, lack of awareness, accessibility, and technical knowledge.

The study concludes that technology and innovation are essential drivers of the sustainable agriculture growth and farmer income enhancement in India. Overall, integrating modern technologies ensure better production and sustainable agricultural system in major crops such as sugarcane, okra, wheat, rice, and pea.

Keywords: Sustainable Agriculture, productivity, technology, innovation, fertilizers, resource efficiency;



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Introduction

Agriculture is the practice of cultivating plants and rearing animals to produce food, fiber, and other useful products. Agriculture is the backbone of the Indian economy. It is one of the oldest and most important activities of human being. It fulfills the basic needs of the human being and provide them a sense of security as it leads to foods, economic development, and sustainable livelihood for millions of people around the world. Agriculture is an important industry for feeding the growing worlds population, provide employment and generate income opportunities for farmers and rural communities. It plays a crucial role in daily life, the food we eat, clothes we wear, shelter, fuel, medicine all are connected to agriculture in various means. It provides the raw material to various industries such as textiles, chemicals, and papers.

Agriculture also helps to protect the environment by create a buffer zone between urban and rural areas. It constitutes the forestry, horticulture, pomology, olericulture, and various other branches that generate a source of income for rural communities and helps to maintain global economic stability. It can contribute to positive outcomes such as water storage and purification, and the maintenance of rural landscape.

Agriculture is the backbone of the livelihood for nearly 45% to 65% of India's population and contribute approximately 17% to 18% in the GDP. With the continuous increment in the population role of agriculture become crucial to overcome the risk of food security and to face the challenge of unemployment, land resources, and increasing demand of food.

Land is the basis of agriculture and other rural land uses, encompassing soils, climate, vegetation, topography and other natural resource. Land holding in India also a challenge as the percentage of marginal farmers with less than 1 hectare of land has decreased and many moves away from agriculture, signaling a shift in labor. This leads to the land pressure and continuous use of agricultural land for infrastructure use reduced the net sown area. Nowadays the agriculture also faced an issue of soil erosion, land degradation, and nutrient depletion among the soil that leads to the less productivity. High use of chemical fertilizers and lack of crop rotation by the farmers create a problem of lack of nutrients and soil degradation.

In India most of the farmers practicing the traditional farming and heavily depend upon the rain for irrigation purpose. Climate changes also pose critical challenges to global agriculture by disrupting food production through erratic weather, increase in temperature, change in the pattern of rain, and other climatic events. These climatic conditions affect the productivity of several crops that leads to poor quality and losses for the farmers. Drought and change in pattern of the rain leads to downfall in the water level of the groundwater and affects the irrigation process of the crops, it also affecting the sowing and harvesting time of the crops that leads to the decrease in the production. Change in temperature and humidity develops the favorable conditions for the pests and diseases in the crop, this attack cause a harmful effect on the crop in both ways quantitative and qualitative.

Climate challenges are responsible for the reduction in crop production, decrease in the income of farmers, danger for food security and increase in input costs in the farming.

Due to various reason such as population growth, climatic challenges, dependency on traditional method of farming, less production, high input costs, and market related challenges there is a need to introduce and adapting new technologies that helps to overcome these challenges. In present time, when increasing population and food security becomes major problem only by adopting new technologies can help farmers to increase income, productivity, and quality. The necessity of introduces the technology in agriculture are as follows:

➤ Need of increase productivity

As population increase and food security problem increase leads to increase in demand of food, but on the other hand the farming land continuously decreases. In this situation technology can play a crucial role through produce more production in less area. Modern machinery, hybrid seeds,

integrated fertilizer management, and crop protection techniques can lead to better production in less areas.

➤ **Scarcity of labor and increment in input costs**

In modern time the rural population is also attracted toward the urban life that create a lack of labor availability and increase in input cost whether it is labor cost or other input costs affects the income of the farmers. But machinery likes tractor, threshers, harvesters, seed drill, etc. make easy for farmer to manage time, cost, and labor.

➤ **Need of irrigation management**

With the decrease in groundwater level and irregular pattern of rain it is necessary to adapt a better method irrigation that provide exact amount of water to crops and prevent water loss. Sprinkler method and drip irrigation methods are the modern methods that make it possible to provide irrigation in less water. These methods help in water conservation and increase productivity.

➤ **Security from climate challenges and conditioning soil health**

Modern weather forecasting techniques and weather apps provide the necessary information to the farmer on time that helps to take the usual measure and decisions and reduce loss.

Soil tester helps to calculate the nutrient availability in the soil and prepare a nutrient management plan for the field. It helps the farmer to stable soil fertility and prevent farmer to use unnecessary or excessive fertilizers.

Agriculture faces the continuous changes conditions such as increasing population, fixed resources, climatic challenge, and water resources. So, the role of innovation is important in agriculture. Innovation refers to the adoption of new techniques, new methods, or new thought process, that enhance the productivity, quality, and profit. Innovation plays a important role in the increase in production and productivity, complete use of available resources, reduce labor cost, crop protection and quality improvement, agriculture market and increase in income of the farmers.

To understand the role of technology and innovation the study of different crops is necessary. In this research sugarcane, okra, wheat, rice, and pea are the selected crop, because these crops have a great impact in Indian agriculture and also represent the different categories such as:

Cereal crops – wheat, rice

Cash crop – sugarcane

Vegetable crop – okra

Pulse crop - pea

Review of literature

Importance of Technology in Agriculture

Agriculture is the basis for food security and survival. Mankind living in the world majorly depends upon the agricultural practices for their survival. Technology affects various practices of agriculture such as fertilizers, seed technology, and pesticides. New age technologies focus on robotics, automation, nano fertilizers, precision farming, and more. In 1960s during the green revolution, India managed to achieve self-efficiency in foodgrain production by adopting modern methods of agriculture like fertilizers, pesticides, and high-quality seeds.

- **Bruinsma (2017)** examined that the adoption of technology in agriculture has significantly increased agricultural productivity These technologies, including digital tools and their innovation, such as aerial imagery, drones, and satellites, sensors, the internet of things, mobile applications among others have automated farming and transformed it into a data-driven industry as farmers can now manage their farms and cropping activities on real-time and with much ease. Technological advancements in the agricultural sector have empowered agriculturalists, businessmen, and investors to extend their potential in delivering agricultural

activities during a time when food security is being threatened by climate change and population growth. Evidently, increased mechanical automation, the extensive utilization of pesticides and fertilizers, stressing the importance of industrial farming and soil management have made agricultural production possible at a time when farms and the number of farmers are steadily diminishing.

- **FAO; Evenson & McKinsey; Anyan & Frempong (2019)** Their study is based on **information** and communication technology (ICT) is fundamental in the dissemination of agricultural information. ICT enables the collection and sharing of accurate and timely information in relation to farmers' needs, and in a format that is easily accessible and consumable by the farmers, for instance on weathercast, market and pricing, financial access and support, etc. Essentially, ICT enables the dissemination of knowledge to farmers and connects various stakeholders and members of the value-chain in agriculture such as the farmers and consumers, agricultural financial and credit facilities, agricultural research institutions, policymakers, agricultural input manufacturers, agricultural training, support, and extension service providers among others. The applications of ICT in agriculture have ranged from supporting land preparations, planting and the pre-harvest activities, harvest operations, and post-harvest activities including market access and yield preservation.
- **Smith & Jones (2020)** Innovations like remote sensing, drones, automated irrigation, and mobile-based advisory services have shown positive impacts on crop management and yields.
- **Zhang et al.** Precision agriculture—using GPS, sensors, and data analytics—can optimize input use (fertilizers, water) and reduce cost while increasing yield.

Objective of the study

- The main objective of the study is to initiate the role of technology and innovation in agriculture. Under this it is studied that how technology affect the productivity and income generation of the crops. Technology makes it easy to farmer to deal with various farming practices such as weather forecasting, drone, farm machinery, mobile apps for various purposes such as pest and disease detection, market inspection, purchase agricultural inputs etc.
- To examine the innovation in the selected crops: sugarcane, okra, wheat, rice, and pea. It shows the result of various innovation adapted by the farmers in the modern agriculture. In sugarcane various different method of cultivation is introduced in the current scenario, in okra various genetic seed are introduced that are immune towards the YVMVs (Yellow Vein Mosaic Viruses). Same in wheat and rice various new techniques are launched and different irrigation techniques (drip irrigation, sprinkler irrigation) introduced in pea.
- To analyze the impact on the productivity by comparing with the traditional method of farming. High production and high productivity are the major goal of introducing technology and innovation into the field. It also helps to assess the benefits to the farmers by reducing agricultural input costs and increase farmers income.

Research Methodology

- **Research design:** This study is done to describe the different type of techniques and innovations used in selected crops and check their impact on the productivity and profitability. Both quantitative and qualitative approaches have been used to get comprehensive results.
- **Sources of Data:** The study is based on both primary and secondary data. Primary data were collected from the fields through asked frequent questions and taking interviews while secondary data collected from agriculture journal, research articles, government reports and published literature were used to understand technological development in crop production.
- **Sampling Method and Sample Size:** A purposive selected method was used for selecting respondents. A total sample of 50 farmers from different villages of district Baghpat was considered for data collection.

- **Data Analysis Technique:** Percentage analysis and Average (Mean) Analysis are used.

From the above farmer 80% used the high yielding varieties seeds, 70% used modern machinery, 40% used drone spraying in their crops, 20% used modern irrigation technique and 60% used the mobile apps for weather forecasting, pest and disease detection etc.

Crop-wise Technological Innovation Analysis

1. Sugarcane

Sugarcane is one of the important sugar crops. Sugarcane is mainly produced for its juice that contain 10% to 20% of sucrose and 85% of water content. Sugarcane is such type of crop that has a great economic importance. Its juice used to produce white sugar, jaggery etc. Its bagass is used in electricity production and paper industry while its molasses is used to produces alcohol. The top part that is green is used for fodder purpose. Major sugarcane produces nations of the world are India, Brazil, China, and Cuba. India grows nearly 24% of total area of sugarcane growing in the world. Major sugarcane producing state of India are Uttar Pradesh, Maharastra, Tamil Nadu, Karnataka etc.

Technological Innovations in Sugarcane

- **Tissue culture plants:** For the sowing method farmers used traditional method by transplanting sugarcane piece using the ridge and furrow method to ensure proper drainage and root development. But nowadays new innovation and technology are introduced in the agriculture sector, so tissue culture is a new method to grow new seedling from the single tissue in a short time and also helps to reduce the wastage of the sugarcane pieces. This technique helps to grow multiple plants with similar quality of parent plant.
- **Drip irrigation:** Drip irrigation is the new and mostly adopted technique of irrigation in the modern era. In this method pipes are set near the root part of the plants and irrigate the crop by drop by drop. This technique reduces the loss of water and also helps to distribute the proper and exact amount of fertilizer to the crop in dilute form with water. The mixture of fertilizers with the irrigation water is known as fertigation. This helps in reduces the labor cost, extra fertilizer cost, and increase the production of the crop.

2. Okra (Bhindi)

Okra is an important vegetable crop, it is produced for various purpose & its useful Products such as okra powder etc. it is a green-color vegetable contains appropriate amount of fiber, protein & vitamins. Okra also has its economic value as India is the Largest producer and exporter of okra. okra is well known for its nutritional value & Adaptability in various conditions. Okra is rich source of vitamin a & also an anti -oxidants. Okra farming in 2025-26 is shaped by the fusion of modern advancement

Researchers & seed companies now focused on breeding and developing new improved varieties that are drought tolerant, pest-resistance etc. These innovations are cropping cycles & ensuring consistent production. Major technology advancement and innovation that are adapted in okra cultivation are as follows:

- **Hybrid Seeds**

introduction of new varieties that are very useful for the farmer has been take place as these varieties produced high production & provides an economic strength to the farmer. These varieties are pest- resistance, drought & physical condition tolerant and also resistant to the viruses such as Yellow Vein Mosaic Virus (YVMVs) varieties.

Drip Irrigation

Drip irrigation is the modern method of irrigation in which water is supplied slowly & directly to the roots of the plant with the help of pipes & drippers. Drip irrigation also helps in fertigation process. In which fertilizer is dissolved in water and run through the pipes.

Wheat

Wheat is a major staple crop grown primarily in rabi season in India. major wheat producing states are Panjab, Haryana, and Uttar Pradesh. Wheat is rich in carbohydrates & nutrients such as iron, vitamin B. Since the green revolution began in 1960s with adoption of new varieties & technology and fertilizers reduces the loss of the crops & increase the production.

Technological Innovations in wheat

➤ High – yielding varieties

After the green- revolution introduced in India, new varieties of wheat are Adopted by the farmers, new same-dwarf varieties of wheat include HD2967, HD3086, DBW187, And DBW222. These varieties are designed for timely sown, irrigated conditions. These new varieties also resistance to rust and terminal heat.

➤ Zero Tillage

It is a new technique in which the crops are grown without cultivating the soil. In this method the seeds are directly sown into the field after harvesting the first crop.

➤ Combine Harvester

Combine Harvester is a modern- day agricultural machine used to harvest crops in one process in the specific ways, the operation that are done together by combine harvester are reaping, threshing &winnowing.

Rice

Rice is a vital tropical cereal crop, providing -rice is cultivated in kharif season in hot & humid conditions temperature ranges between 21°C to 37°C. rice is a crop that need extensive water, flooded fields are used to manage weeds & pests. Major rice producing countries are China, India, Indonesia etc. nearly 90% of world's total rice is grown in Asia. The crop is harvested once the grains turned golden and the plant matures. Rice is rich in carbohydrates, moderate protein & low fiber.

SRI Method

SRI method means the system of rice intensification, is a climate-smart, Agroecological methodology for increasing rice productivity by planting Younger seedlings (8-12 days old) singly with wider spacing (25cm * 25cm) In a square pattern.

It used less amount of water, fewer seeds and organic input this method increased the yield comparatively to traditional methods.

➤ Drone technology

In this modern era, drone technology don't need any introduction and its Benefits are also too for. Drone technology used for spraying fertilizers And pesticides. It also helps in the monitoring of the crops. And detecting Disease early.

➤ Biotechnology & genetic Engineering

Biotechnology & genetic engineering also contribute in the agriculture by Developing improved varieties for example golden rice (vitamin A) which Helps to fight against malnutrition and improves crop resistance.

Result and Discussion

The result revealed that the adoption of modern technology and innovation in these crops leads to a significant increase in the production whether it was sugarcane, okra, wheat, and rice. Through adopting the modern technologies such as drip irrigation, HYV seeds, drone technology for spray purpose all lead to help farmers and save the time and money also. The result of these practices can be easily seen in the crop production. These findings suggests that the adoption of modern

technology and innovation in agriculture lead to a better future of farmers and helps them to achieve the goal to double their income. The better production may be due to a better crop management and efficient use of resources but we can't deny the contribution of technological advancements and innovation in the results. The innovation such as drip irrigation and fertigation helps to save water and resources by applying water with nutrients to the root zone of the plants and also produced its economic importance. Hybrid and HYV seeds provide protection from different pests and disease as they are resistant to these as in okra and some of the variety focused on the nutrition availability to the common people such as golden rice variety rich in vitamin A.

It is the era when whole world is participating the rat race of modernization role of agriculture increased specially for the developing countries like India as it's nearly 65% of population depends on the agriculture and its sector for their livelihood. In such a situation significance of technological advancements and innovation in agriculture is increased as it's provided a significant increase in the production or yield. It is essential to use the available technology and crop specific innovation that are effective in increasing production and decrease in agriculture input. As the productivity increased, farmer income and level of living standards also become better. Farmers have to understand that if they want to compete with the modern era they have to adopt these technologies and innovation and keep the proper knowledge of the upcoming technology or innovation in agriculture field in future.

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