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Prominent Technological Advancement in Agriculture over the Decades

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Agriculture is the lifeline for the global population, which is estimated to grow by 33% to almost 10 billion in 2050. Agriculture uses nearly 40% of the land surface of our planet. It employs 1.3 billion people globally, which is half the labor available. Although the share of employment generated by agriculture varies widely, it remains the second biggest employment provider worldwide after the services industry. Much has changed in the field of agriculture over the years. While some traditional methods and technologies remain, more efficient, effective, and innovative technological advancements in agriculture are creating new opportunities and transforming how farming is done. This has changed how crops are grown and led to more efficient methods of resource management.

Agricultural technology, also known as "agritech," encompasses a broad range of disciplines and devices that improve agricultural output. That includes vehicles, robotics, computers, satellites, drones, mobile devices, and software. The use of big data analytics and artificial intelligence (AI) technology in agriculture is also an example of how the farming sector is embracing technological advancement. Changes in farming and field management during the past few decades have been revolutionary. The employment of modern, state-of-the-art technology in agriculture can be credited with much of the recent success in crop management and increased harvests.

Today, the impact of technology on agriculture is undeniable. Some of prominent technologies are described below.

Furrow Irrigated Raised Bed (FIRB) System of Planting

In raised bed planting systems, wheat or other crops are planted on the raised beds in ridge- furrow system. This system is often considered more appropriate for growing high value crops that are more sensitive to temporary water logging stress. Farmers often raise crops such as cotton, maize-soybean and wheat on the raised beds. Recent work shows that system of raised bed planting of crops may be particularly advantageous in areas where groundwater levels are falling and herbicide-resistant weeds are becoming a problem. This tillage and crop establishment option also facilitates crop diversification and intercropping of wheat, chickpea and Indian-mustard with sugarcane, maize with potato, mint with wheat, rice with soybean, and pigeon pea with sorghum or green gram.

Potential of Raised Beds

In FIRB system, water moves horizontally from the furrows into the beds (subbing) and is pulled upwards in the bed towards the soil surface by capillarity, evaporation and transpiration, and downwards largely by gravity. In determining the dimensions of the beds, factors such as spacing between tractor tyres, soil types, rainfall and groundwater conditions, salinity and irrigation water quality and requirements of crops grown in rotation are of prime importance. For developing a permanent system of bed planting, factors like irrigation and fertilizer management, crop residue management, inter-tillage and weed management must be considered together. On the raised beds, two rows of rice, wheat, maize or chickpea are generally grown.

Fig 1. a. Raised bed planting; b. Intercropping on Raised bed

Advantages of FIRB

- On an average it uses, 30% less water than flatbed methods and improves crop yields by more than 20%. FIRB planting saves 30% to 50% wheat seed compared to flatbed planting.
- Better upland crop production is possible in the wet monsoon because of better drainage.
- Fertilizer efficiency can be increased due to better placement
- Better tillering, increased panicle/ear length and bolder grain.
- Bed planting facilitates irrigation before sowing and thus provides an opportunity for weed control prior to planting.
- Weeds between the beds can be controlled mechanically, early in the crop cycle.
- Herbicide dependence is reduced, and hand weeding and rouging between rows are easier.
- On raised beds, border effects allow the canopy to intercepts more solar radiation.
- Yield of rice transplanted on FIRB is comparable with traditional rice culture with as much as 25%-50% saving in irrigation water.
- Compaction of soil is limited only to the furrows used as tramlines (tractor tracks).

Protective Structures

Followings are the various protective structures which can be used to increase the crop production and quality of the produce.

1. **Net houses:** These are used to reduce adverse effect of scorching sun and rains in vegetables, ornamentals and herbs.
2. **Plastic low tunnels:** These are used to raise early nurseries of vegetables and flowering annuals.
3. **Green houses:** These are framed structure covered with a transparent material in which crops could be grown under controlled environment. The environmental conditions refer to light, temperature, air composition and nature of root medium.
4. **Walk in Tunnel:** It is most popular type greenhouse which is small semi spherical structure frame made of materials like wood or plastic, iron, G.I. pipes and covered with polyethylene or fiber reinforced plastics. Maximum numbers of walk-in tunnel type green houses have been installed in Kashmir valley region. The various sizes of tunnel type green houses that were being utilized by the farmers and installed by different development departments are 40 sq. m (4 m x 10 m), 80 sq. m (5 m x 16 m) and 54 sq. m (9 m x 6 m).
5. **Trench:** This is a very simple, cheap and common greenhouse structure especially for the Ladakh region of the state and, thus, has unlimited potential in the region. The various sizes of the trenches are (9 x 3 x 0.9 m) and (10 x 4 x 1 m) respectively. In this pit type of structure, wooden poles are used to hold UV stabilized polyethylene film. The polyethylene is also covered by an additional polyethylene film or woolen or cotton sheet during night to reduce heat loss in extreme winter.
6. **Double layered Polycarbonate Greenhouse:** The glazing material used in the green house is double layer polycarbonate. The normal dimension of the green house is 16.8 x 9.1 m with a center height of 3.3 m and a side height of 1.8 m. The variation in temperature between outside and inside conditions is 20° C.
7. **Polyench Greenhouse:** This type of greenhouse combines the trench and green house technology for achieving more temperature inside green house during peak winter. The glazing material utilized in the green house is polyethylene, FRP, double layer and triple layer polycarbonate. The normal recommended dimensions of the greenhouse are (18 m x 4.5 m x 0.8 m).
8. **Solar Polyhouse Drier:** Field Research Laboratory (DRDO), Leh has designed and developed a low cost non-conventional zero energy based solar polyhouse drier for scientific and hygienic dehydration of surplus fruits and vegetables like apricot, apple, cauliflower, cabbage, tomato, etc. when there is a glut in the market and to facilitate its availability during the snow bound winter. The drier works on the principle of greenhouse effect where it traps the solar radiation and maintains the temperature inside between 55-69° C. Provision has also been made for removal of hot and moist air from the chamber. It reduces drying period by 40 – 50 % as compared to sun drying.

Modern greenhouses

Today, in large part due to the tremendous recent improvements in growing technology, the industry is witnessing a blossoming like no time before. Combined, the entire global greenhouse market currently produces about $350 billion worth of vegetables annually, of which U.S. production comprises less than 1%.

- **Hardening units for tissue cultured plants:** Hardening of tissue culture raised plants is very crucial for successful field transfer. The commercially multiplied tissue culture plantlets of ornamentals, fruits, species and vegetables are hardened in green house under congenial environmental conditions before planting them in open fields.
- **Transgenic greenhouses**: Development of transgenic plants having industrial, economic, pharmaceuticals, nutritional and environmental importance is need for sustainable production in near future. The transgenic need is to be introduced with cautions in hills and mountain region.
- **Hydroponics:** It allows growing if plants in nutrient solutions with or without use of an artificial medium. High economic value crops are grown in hydroponic systems.
- **Aeroponics:** It is the modified form of hydroponics wherein nutrient mist is provided periodically at plant roots. This technology may have applications in Himalayas.
- **Green house technology:** Green house is the framed or inflated structures cover with transient material large enough to grow crops under partially or fully controlled environmental conditions to get optimum growth and productivity.

Modern techniques in agriculture

Blockchain and food traceability

Blockchain's ability to track owner records and tamper with security can be used to solve pressing problems in the current food system such as food fraud, safety recalls, supply chain inefficiencies, and food traceability. Its unique decentralized structure ensures verified products and practices, creating a transparent marketplace.

Mechanization of agriculture

Capacity building of farmers through hand-holding, making modern machines available especially to small farms, and tackling affordability issues through policy will lead to greater adoption of mechanization services going forward. Agricultural mechanization has the potential to, directly and indirectly affect yields through a reduction in post-harvest losses and an increase in harvest gains.

Climate/ weather prediction through artificial intelligence

A major advance in agriculture is the use of artificial intelligence (AI). Modern equipment and tools based on AI enable data gathering and assist in precision farming and informed decision-making. Drones, remote sensors, and satellites gather 24/7 data on weather patterns in and around the fields, providing farmers with vital information on temperature, rainfall, soil, humidity, etc.

Agriculture Sensors

Communications technology has evolved rapidly in India and made smart farming a possibility. Sensors are now being used in agriculture to provide data to farmers to monitor and optimize crops given the environmental conditions and challenges. These sensors are based on wireless connectivity and find application in many areas such as determining soil composition and moisture content, nutrient detection, location for precision, airflow, etc. Sensors help farmers save on pesticides, and labor, and result in efficient fertilizer application. They allow farmers to maximize yields using minimal natural resources.

Indoor Vertical Farming

Indoor vertical farming can increase crop yields, overcome limited land area, and even reduce farming's impact on the environment by cutting down the distance traveled in the supply chain. This new concept can be defined as the practice of growing produce stacked one above another in a closed and controlled environment. Its key attribute is that it can significantly reduce the amount of land space needed to grow plants compared to traditional farming methods.

Precision agriculture

Precision agriculture has found a huge opportunity to grow. A recent report by Grand View Research, Inc. predicts the precision agriculture market to reach $43.4 billion by 2025. The emerging new generation of farmers is attracted to faster, more flexible startups that systematically maximize crop yields.

Agriculture and artificial intelligence

These can monitor plant health, soil conditions, temperature, humidity, and more. The idea is to give farmers a better understanding of what's happening on the ground through advanced technology that can tell them more than the naked eye can see. And not only is it more accurate, it's also faster.

Benefits of Technology in Agriculture

The implementation of smart agricultural technology is advantageous for all players in the agri-food chain. With its use in optimizing and automating agricultural operations and field activities, growers and landowners can now save significant amounts of time and effort. These are just a few examples:

- using less water, fertilizer, pesticides, and other inputs allows agricultural producers to cut costs and keep more of their profits;
- by preventing or drastically reducing the amount of chemical runoff into waterways, businesses lessen agriculture's impact on the environment and take steps toward greater sustainability;
- increasing crop yields while decreasing labor inputs;
- lowering barriers to accessing agricultural insurance and financial services as well as market and technological data;
- mitigation of the damage that could be caused by pests, natural calamities, and bad weather in agriculture with the help of affordable, always-on agricultural monitoring systems;
- increase in farm income through improved product quality and increased quality controls;
- timely recognizing nutrient deficiency in plants;
- ability to foresee potential problems on the farm through the visualization of production patterns and trends gleaned from an analysis of current and historical agricultural data.

Conclusion and Way forward in Agriculture Technology

Agricultural technology has come a long way beyond the basics of planting, maintaining, and harvesting crops. From more resistant seeds to improved agricultural production planning and processing, many crucial improvements have been made in recent years. Improvements in agriculture technology can even enhance field-to-table distribution and logistics.

Rapid progress is also being made in the realm of agricultural software and technology, which facilitate both in-field labor and the management of different components of the food supply chain. Previously, monitoring the fields used to require going there in person, but now this may be done from afar. As a novel method for field observation, agricultural satellite technology is ideal for this purpose.

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