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e-Crop based smart farming in horticultural crops

The agricultural sector is facing the critical challenge of increasing food production by 60% over the next 25 years to feed a growing global population. Smart farming (SF), leveraging Artificial Intelligence (AI) and modern Information and Communication Technologies (ICT), offer promising solutions to these challenges. SF integrates technologies such as Internet of Things (IoT) devices, sensors, and automated systems for precision farming, enabling efficient resource utilization and increased productivity. Key components of SF include data collection, real-time monitoring, and automated decision-making processes that optimize inputs like water and fertilizers, ultimately enhancing crop yields while conserving natural resources. Notably, e-Crop, an innovative SF device developed by ICAR-CTCRI, provides real-time agro-advisories based on weather and soil data, helping farmers achieve optimal yields with reduced input. This technology not only aids in improving productivity but also plays a significant role in pest and disease management, crop forecasting, and market predictions. Successful implementation of e-Crop in Kerala demonstrated significant yield improvements, showcasing the potential of SF to revolutionize farming practices. The integration of AI and smart farming technologies promises a new Green Revolution, driving agricultural sustainability, resource efficiency, and economic growth.

TODAY, agriculture faces the formidable challenge of increasing food production by 60% over the next 25 years to feed a growing global population. This challenge is intensified by decreasing arable land, water shortages, and the pervasive threat of climate change. Under these constraints, strategies to enhance food production must emphasize achieving more with fewer resources, ensuring quality, and optimizing market access. Artificial Intelligence (AI), a rapidly advancing technology, holds significant promise in addressing these challenges efficiently. Smart farming (SF), which harnesses AI alongside mechanization, sensors, and various information and communication technologies (ICT), is poised to lead a new Green Revolution in the food sector.

Smart farming

Smart farming (SF) is the precision farming done with the help of modern information and communication technologies (ICT). It is based on the incorporation of ICT into machinery, equipment, and sensors in agricultural production systems. Data plays a very important role in modern agriculture. A large volume of data needs to be collected from the field as well as from other sources. Data on weather, soil, pest and diseases, marketing, production, processing, livestock, fisheries etc. are to be collected for taking timely and proper decisions. The nature and volume of data varies with the sector and context. Collection and analysis of this data with the help of ICT technologies is the basis of SF. Sustainable use of natural resources for increasing production and at the same time protecting the environment are the major objectives of SF. Use of smart devices and sensors for data collection is one of the major factors of its success. The data collected is processed immediately. After processing, the system takes a decision on what action to be performed. If the action decided is to switch on the fertigation device, the message to switch it on may be sent to the mobile of the farmer or the device can be automatically switched on. The whole process from data collection to action happens automatically. This way resource utilization becomes more efficient and production increases.

Components of smart farming are IoT devices, Software for mapping and data analysis, Sensors, Internet and Machinery. Devices under the category Internet of Things (IoT) is the most important component as far as SF is concerned. Many of the SF devices include at least one or the other of the other four components of SF. Components of IoT devices are connected through the internet. The sensors collect data and through the internet, it goes for processing. After processing the data, the device takes the decision about the action to be performed. The decision may be to do fertigation, spray pesticide using

drones, send messages to farmers etc. These actions will be performed through actuators or through any other means. IoT devices play a very important role in implementing AI for precision farming.

Importance

SF helps to achieve rich dividends by solving some pressing problems in farming. It is based on IoT devices like e-Crop, which helps to do precision farming in a very smart way. This way conservation of resources and natural ecosystem becomes possible and at the same time better yield at lower input application is also achieved. Farmers get correct information from the field regularly even if they are away from the field. Inclusion of auto fertigation, drone-based input application etc. adds to precise and timely interventions which are essential for any crop. Image analysis has a lot of applications in agriculture. Algorithms for correct identification of pests and diseases occurrence play a very important role in its management. By applying these algorithms, farmers will be able to manage pests and disease problems in their crops very efficiently. Predictive analysis algorithms of AI are important for accurate forecasting of pests and disease occurrence as well as yield.

Marketing is another important area of importance to the farmers. Fluctuations in market price is a very serious matter. AI has the capability to make accurate forecasting on demand, supply, and price of spices. Another area of AI application in marketing is the efficient sorting and grading of the products based on different quality parameters.

A lot of work is yet to be done before the AI based technologies come into practice. But it is always better to tap into the potential of this great technology to create a better scenario in the agriculture sector.

Smart farming initiatives

Electronic crop (e-Crop)

This is an important technology developed by ICAR-CTCRI for SF. Biological crops produce food through photosynthesis using solar radiation and CO_2 in the presence of sunlight and water. The food produced will be stored in its storage organs after utilizing a portion of it for performing its life processes like respiration, growth etc. The food stored in its storage organs is used by human beings and animals as their food. In contrast to biological crops, its electronic version, i.e. e-Crop computes the quantity of food produced and stored in its storage organs by its biological counterpart. The biological processes involved in food production are simulated in the e-Crop with the help of mathematical formulae. This is a weatherproof electronic device which works directly in the field. Sensors in the device are used for collecting data on weather and soil parameters. The data collected by the sensors are sent to the control unit for processing from where it is sent to the cloud. Sensors are positioned on the exterior of the box. This system simulates crop growth real-time, in response to weather and soil parameter data collected from the field and generates agro-advisory and send it to the farmer's mobile as SMS.

This device can be used for giving real-time agro-advisory of any crop to reduce yield gap and to achieve targeted yield. Weather parameters of the day; the potential yield that can be achieved by the crop after its stipulated duration as per its present crop condition and anticipated weather scenarios; N, P, K and moisture required to be applied to achieve this targeted yield etc. are part of the advisory received in the mobile phone as SMS and the farmer can follow these strategies to increase the yield to the desired level. Such appropriate diagnostic tools that help in the application of fertilizers at the time of demand and in smaller and frequent doses can help to reduce the losses while maintaining or increasing the yield from the crops. This is an excellent device for precision farming, which collects the data real-time from the field, generates advisory and inform the farmer about the present and future status of the crops as well as the strategies to manage the crop to get better results. The data collected by the devices installed in different fields give a very clear realistic overall status of the crop at present and in future. This information will be useful to the policy makers and planners as well as for averting the market risk which usually emanates from an unexpected boom in production/supply, fall in prices etc. If information about the production is known well in advance, sufficient precautions can be taken to avoid such risks.

A web interface is used to manage smart farming with e-Crop. This web interface resides in the cloud and communicates with the control unit. The main function of this interface is to add users and their privileges, and input various values of crops, fertilizer, soil type, locations, adding new device etc., according to the privileges assigned to different users.

Problems solved by e-Crop: The e-Crop helps to achieve higher productivity by reducing yield gap. This product calculates plot-by-plot yield gap daily and quantifies, N, P, K and water requirement to reduce it. This information is sent to the farmers daily as SMS. Through the daily/frequent application of nutrients and water, its total requirement for the entire season is less (about 25-50% reduction), whereas yield increases at least by 100%. Reduced application of the chemicals and water, saves resources and minimizes damage to the environment. Farmer's profit multiplies by the increase of yield as well as by the lowering of the cost of cultivation.

Applications of the device

- Crop yield as well as pest and disease forecasting and agro-advisories are generally done at macro-level. Crop cutting experiments which are being followed for this purpose are elaborate, tedious, costly, and less accurate. Same forecasting can be done more accurately at local, regional, and national level by e-Crops with much more accuracy.
- e-Crop forecasts from different fields can be integrated at national/state/regional levels.
- The device informs farmer about the happening of the crop through SMS, even if he is far away from the field.

Electronic crop device

Self-learning crop models

Self-learning crop model development programmes are already initiated, and field trials are being undertaken in Malappuram district of Kerala. This study aims at making e-Crop intelligent so that the device develops the model of a crop from the real-time field data. Thus, the time required for developing crop simulation model can be saved and the benefit of e-Crop based smart farming can be extended to any crop easily.

e-Crop based smart fertigation system (eCBSFS)

e-Crop based smart farming system (eCBSFS) is a system and method for automatic fertigation of crops, which helps in the application of nutrients and water to crops as per the quantities and interval calculated by e-Crop. e-Crop generates agro-advisory to reduce yield gap and realize potential yield at reduced input application. The advisory contains daily requirements of N, P, K and water to reduce the yield gap and it is sent to the farmer as well as e-Crop Based Smart Fertigation System (eCBSFS) in the form of SMS. This device receives and processes messages. The relay system inside the device has a series of motors, which are connected to nutrient (NPK) containers and the water source as well as to the irrigation system. As per the quantity mentioned in the SMS, the nutrients and water are pumped out from the containers and water tank to the mixing tank. Water and nutrients are thoroughly mixed in the mixing tank and the mixture is applied to the field via suitable irrigation system like drip, sprinkler etc. The daily application of fertilizer and water based on the advisory can further improve crop yield and minimize the loss of resources. Under the prevailing scenario of shortage of labour and increasing cost of fertilizers, eCBSFS is a good option to increase agricultural production at lower cost of cultivation.

e-Crop based smart farming system

Krishi Krithya, mobile app for e-Crop based smart farming

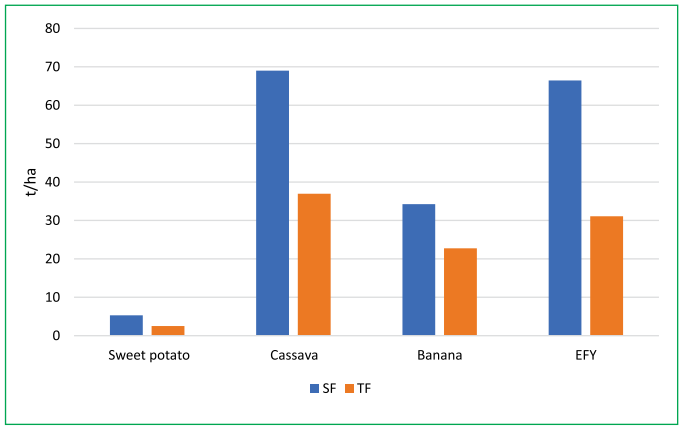
Mobile application named Krishi Krithya app was developed for smart farming. The app can be operated by registered users only. Every farmer after successful registration creates an account in the application by creating a personal User ID and Password. Application is connected with e-Crop unit and the farmers are able to get information about their cultivated crops and obtain daily as well as weekly advisories, which contains information about the amount of irrigation water and the number of fertilizers to be applied in the field for increasing the yield. The basic information such as date of planting, crop name, location, latitude, longitude, altitude, variety, and soil type of the crops can be viewed. The app is developed for android operating system and the crops included are cassava, sweet potato and elephant foot yam.

Success story of e-crop based smart farming (eCBSF)

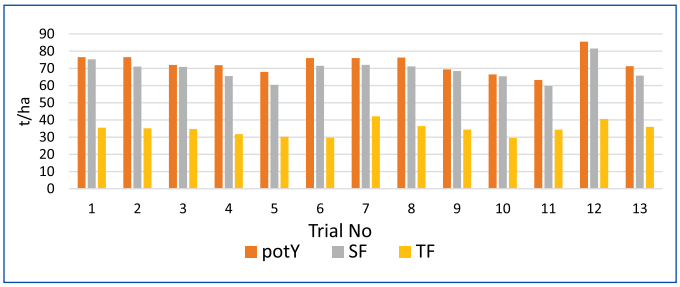
e-Crop based smart farming was demonstrated in the farmers' fields in five panchayats (Anad, Aruvikkara, Vembayam, Karakulam and Panavoor panchayats), Nedumangadu block, Thiruvananthapuram district, Kerala. This initiative was undertaken with the funding support of State Horticultural Mission-Kerala (SHM-K). Five farmers each were selected from these panchayats for the demonstration of e-Crop based Smart Farming (eCBSF), which was conceived and proven successful through different trials since 2014. Farmers followed two methods of cultivation, one by the method they have been following for years, i.e. traditional farming (TF) and the other according to eCBSF. The harvesting of the crop started during October. Sweet potato was harvested first. The tuber yield obtained under SF was 218% of TF practices. With the financial support of Kerala State Planning Board, another study was conducted at two panchayats in Malappuram district, Kerala to demonstrate

Krishi Krithya Mobile app

Comparison of yields under TF and eCBSF in cassava and banana plantation



Comparison of yield under e-Crop based smart farming (eCBSF) and traditional farming (TF) in different crops



Yield gap reduction in cassava by eCBSF

eCBSF in cassava as well as for developing AI based self-learning models to make e-Crop intelligent so that it can be adapted to any crop easily.

The increase in yield was obtained at a reduced input application. Nitrogen, phosphorus and potassium fertilizers were applied at 49, 73 and 57%, respectively of the dosages in TF. Similarly, for Cassava, Elephant Foot Yam (EFY) and Banana, eCBSF yields were 187, 218 and 152%, respectively of the corresponding TF yield. Yield gap reduction is the main advantage of this technology. In case of cassava and sweet potato, the normal yield gap is around 50-60%. Through eCBSF, this gap was reduced to 5% and 8% for cassava and sweet potato respectively. Implementation of eCBSFS in the fields, is expected to benefit the farmers by more automation as well as increased yield at reduced input application. The yield increase is mainly because the crop is getting the required inputs, whenever it needs. It is given as per the requirement of the crop and hence, whatever is given is fully absorbed by the crop without wasting anything and leaving it in the soil, which might have led to environmental pollution.

Features of smart farming

Main objective of smart farming is to minimize the input application and simultaneously increase the productivity many folds. Smart farming is ultimately precision farming, which helps to extract maximum genetic potential without adding any pressure on the natural resources. Reduced use of natural resources results in its conservation and also reduction in the environmental pollution. Many are apprehensive about the cost of smart farming technology. There is a general belief that small and marginal farmers cannot afford to adopt this technology. Another apprehension is that it leads to unemployment in the farm sector. Though the initial cost for setting up of smart farm is high, its benefits are innumerable. Once set up, it can be maintained for years with some meager maintenance cost. In states like Kerala where collective efforts like group farming is already in practice, adoption of this technology in the similar way is a feasible option.

Smart farming is not a new concept. It is getting enriched day-by-day with the developments in ICT and AI. Developed countries have already jumped into smart farming to realize another green revolution with this technology. We should not wait for long to adopt it for the benefit of our people and environment. This is the right time. Another Green Revolution through smart farming will restructure our entire economy.

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