LEAD LECTURE https://doi.org/10.58297/CVWI8125

Smart Farming for Smart Future of Agriculture

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Abstract

The domestication of animals and plant cultivation through the adoption of systematic farming practices, as well as the green revolution brought on by the invention of chemical fertilizers and the introduction of hybrid varieties a few decades ago, are just a few of the revolutions that have occurred in agriculture. Now it is the phase of agriculture revolution 4.0 triggered by the exponentially increased use of ICT in agriculture. The smart farming with the help of ICT technologies could bring out possible solution to the challenges faced in agriculture sector that includes lack of resources, climate change etc. The objective of the present investigation was to compare the yield and nutrient requirement (NPK) for cultivating sweet potato (*Ipomoea batatas*) unDer smart farming and farmer's practice as a field trial in a farmer's plot at Nedumangad block of Thiruvananthapuram district. Under smart farming practice, the agro advisory for cultivating the crop was given through SMS to the farmers in every ten days' interval. The advisory was generated based on the field's real-time weather parameters, crop stage, and initial soil analysis. Results revealed that smart farming plots recorded higher yields with lower nutrient application. This technology can be replicated in any crop including rice.

Key words: Smart farming, ICT, IOT, Crop simulation model

Introduction

Agriculture is as old as the history of mankind. Development of human beings is closely knit with agriculture and it played a very significant role in the development of other sectors of economy also. Over the years we aquired a lot of knowledge by doing, seeing and experiencing many things in farming and allied sectors. Current agricultural practices are framed on the sound knowledge we acquired over these years across different agro climatic conditions in different parts of the world. According to the United Nations' Food and Agriculture Organization (FAO, 2016), food production must increase by 60% in order to feed the increasing population. The challenge is further aggravated by the shrinking land area suitable for cropping, shortage of water and above all the big menace of climate change. Under these conditions, the strategy to increase food production should give focus on producing more from lower resource base, ensuring the quality of the produce and faster movement of the produce to the market.

Artificial Intelligence (AI), the technology which is booming very high in the present world is sufficiently capable to take up these challenges in a smart way. Smart farming (SF), the technology where the potentials of AI is integrated with mechanization, sensors and many other areas of information and communication technologies (ICT) is all set to revolutionalize food sector by another green revolution (Adamides *et al*., 2020).

Smart farming is the precision farming done with the help of modern information and communication technologies (ICT) (Shaikh *et al.,* 2022). 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. 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. These data are very important, and the nature and volume of data varies with the sectors and context. Collection and analysis of this data with the help of ICT technologies is the basis of Smart farming. Sustainable use of natural resources for increasing production and at the same time protecting the environment are the major objectives of smart farming (Saiz-Rubio, V. and Rovira-Más, F., 2020).

Use of smart devices and sensors for data collection is one of the major factors of its success. The data collected are 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 may be sent to the mobile of the farmer or automatically switch on the device. The whole process from data collection to action happens automatically. This way resource utilization become more efficient and the production increases. The components of smart farming are:

1. IoT devices
2. Software for mapping and data analysis
3. Sensors
4. Internet and
5. Machinery for various activities like production and processing

Devices under the category Internet of Things (IoT) is the most important component as far as smart farming is concerned. (Mohamed *et al.,*2021). Many of the smart farming devices include at least one or the other of the other four components. Components of IoT devices are connected through internet. The sensors collect data and through internet and it goes for processing. After processing of the data, the device takes decision about the action to be performed. The decision may be to do fertigation, spray pesticide using drones, send messages to farmers etc (Islam *et al.,* 2021). 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 by which farming reaches new heights (Bacco *et al*., 2019).

Materials and Methods

Smart Farming is a development that emphasizes the use of information and communication technology in the cyber-physical farm management cycle. New technologies such as the Internet of Things and Cloud Computing are the main driving force behind this concept (Sundmaeker *et al.,* 2016).

Field trial was conducted on Nedumangad block of Trivandrum district to compare the yield and nutrient requirement for raising sweet potato crop under farmers practice and smart farming.

Five farmers' plots were selected from the block, initial soil analysis was conducted and sweet potato was planted in 2 cents. One cent crop was raised according to smart farming and the remaining one cent was raised according to farmers practice.

Farmers were given agro advisory in every ten days' interval. The advisory mainly was generated based on the real time weather condition of the field, stage of the crop (represented by crop simulation model) and initial soil analysis (ie the nutrient available in the soil). The farmer's fields were managed using e Crop interface. Final crop yield and total nutrients applied was recorded.

eCrop

This is an important technology developed by ICAR-CTCRI for smart farming. Biological crop 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 are used by human beings and animals as their food. In contrast to biological crop, its electronic version i.e eCrop computes the quantity of food produced and stored in its storage organs by its biological counterpart. The biological processes involved in the food production are simulated in the eCrop with the help of mathematical formulae. This is a weather proof 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. As the part of the experiment, the devices were installed in Krishi bhavans of the corresponding panchayats where the trial plots are located. The weather parameters of the individual farmers' plots were calculated using the mathematical equation that represent the variation of weather parameters with change in latitude, longitude and altitude which is incorporated in the algorithm of the eCrop interface.

Crop simulation model

SPOTCOMS simulation model is used for representing the physiology of the sweet potato and simulating the growth in the system (Mithra, 2018).

eCrop Interface

e Crop web interface is the platform which facilitates the management of farming. There are different types of users based on the rights assigned to manage eCrop. They are:

a. Admin

b. Device Owner and

c. Farmer

Management of Farm using eCrop

Step 1: *Device Owner* adds new farmers for the e-Crop device coming under his purview. Then set up a new simulation for these farmers for their scenarios of crops, soils, varieties, devices etc which were already added by the *Admin*.

Step 2: Creation of *SimulationID*

When a new simulation is setup for the crop, variety, location, date of planting, eCrop device, cultivated area and farmer, a unique *SimulationID* is created, which can be used later for executing the simulation in a single step.

For each *Farmer*, unique *simulationID* is created first. The parameters required for generating this ID are:

1. Crop
2. Crop area
3. Variety
4. Date of Planting
5. Duration
6. Location (Latitude, Longitude and Altitude uniquely identifies the location)
7. Initial values of N,P,K and water in the soil.
8. Soil type
9. e-Crop Id
10. Farmer Id
11. Field Id

Step 3: Input management

In this section the user can add the information regarding the water, N,P and K which were available in soil at the time of planting as well as that added during planting and at later stages.

Step 4: Results of Simulation

Every ten days the crop growth is simulated using the web interface/mobile app using this *simulationID*. The advisory generated from the simulation is sent to the mobile of the farmer as well as to other mobile numbers included while creating the *simulationID*. The advisory contains the information on:

- Date of planting
- Cultivated area
- Normal Yield Predicted
- Variety of Crop
- Potential Yield Achievable as on date
- Water, Nitrogen, Phosphorous, Potassium required

Results of execution of simulation, reach the farmer's mobile through SMS. Fig 1 shows the view of SMS (Crop advisory generated by eCrop) on 10th June 2022. This SMS consist of the detailed data about the field. It includes date of planting, variety, location of field including latitude & longitude, cultivated area, potential yield achieved as on date in Tones. The advisory part of the SMS includes water and fertilizer requirements. It specifies the water requirement (Litres) for that day, next one week and for remaining crop duration in one dose. The fertilizer advisory includes the required amount (kg) of Nitrogen, Phosphorous and Potassium to be applied on that day, next one week and for the remaining total crop duration in one dose.

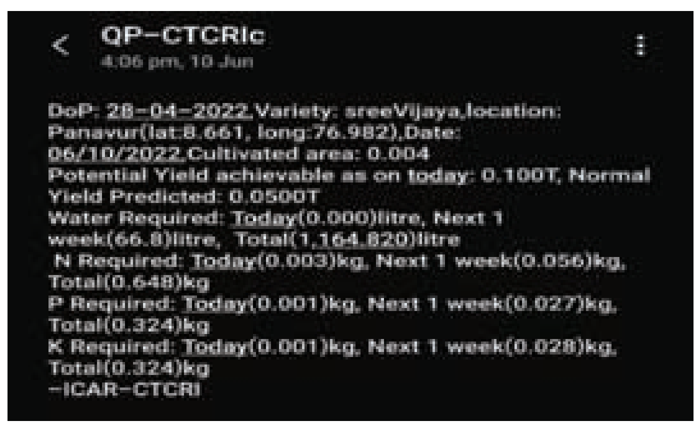

Figure 1: SMS received on farmers' mobile

Planting material and fertilizers

Sweet potato variety Sree bhadra was used in the study. Vine cuttings were planted according to standard recommendation of ICAR-CTCRI. Fertilizers used were Urea, Single super phosphate (SSP) and Murate of potash (MOP).

Results and Discussion

As the part of the experiment, sweet potato was planted in farmers plot in 2 cents. One cent was under farmers practice and the other was under smart farming. The crop was harvested and the observations recorded include final tuber yield and total nutrients applied for farmers plot and experimental plot separately. The result is illustrated in **Table 1**.

Table 1. Yield and applied nutrients under smart farming and farmers practice for sweet potato

Sl. No	Farmer	Panchayat	Yield (kg)		Nutrients applied					
			Smart farming	Farmers practice	Smart farming			Farmers practice		
					N	P	K	N	P	K
1	Farmer 1	Vembayam	30	15.6	0.154	0.091	0.1291	0.37	0.12	0.36
2	Farmer 2	Aruvikkara	9.657	3.475	0.115	0.098	0.135	0.2	0.1	0.2
3	Farmer 3	Aruvikkara	12.29	5.905	0.113	0.095	0.131	0.3	0.15	0.3
4	Farmer 4	Panavoor	35.7	15.32	0.101	0.068	0.139	0.25	0.12	0.25
5	Farmer 5	Thankaraj	18.5	10.25	0.134	0.07	0.166	0.2	0.1	0.2

The result shows that farmer 1 recorded 30 kg/cent under smart farming practice compared to 15.6 kg/cent under farmers practice. Farmer 2 recorded 9.675 kg/cent under smart farming practice compared to 3.475 kg/cent under farmers practice. Farmer 3 recorded 12.29 kg/cent under smart farming practice compared to 5.905 kg/cent under farmers practice. Farmer 4 recorded 35.7 kg/cent under smart farming practice compared to 15.32 kg/cent under farmers practice. Under smart farming practice NPK nutrients applied was found to be lower compared to farmers practice. Farmer 5 recorded 18.5 kg/cent under smart farming practice compared to 10.25 kg/cent under farmers practice. Under smart farming practice NPK nutrients applied was found to be lower compared to farmers practice.

From the results of the field trial in farmers plot it is clear that higher crop yield was obtained for sweet potato under the smart farming practice. Similar findings in improving the yield and profitability in the farms using IoT based precision agriculture was also suggested by (Padmapriya *et al.*, 2022). Based on the study conducted using *An Automated IoT based Fertilizer Intimation System* (Lavanya, G *et al.,* 2019) concluded that a low cost, accurate and intelligent IoT system that intimates the farmer about the fertilizer to be used at right time automatically through SMS in agricultural fields has significantly contributed in boosting the yield. (Rajeshkumar *et al.,* 2019) also concluded that farmers were benefitted with increased production by adopting smart crop field monitoring and automation irrigation system using IoT and thus relying on the real time information about the land and the crops.

Synthetic nitrogen fertilizers have been the most important factor contributing to direct N_2O emissions into the atmosphere as a consequence of their biodegradation by soil microorganisms (Chai *et al.,* 2019). In addition, only 50–60% of synthetic nitrogen fertilizers added to soil is usually taken up by crops the remaining gets leached out into water bodies (surface or groundwater) due to their high dissolution properties (Craswell, 2021).

Phosphorus availability to plants after chemical fertilization can vary depending on the type of fertilizer used and, even under the best conditions, only about 25% of applied P is taken up by plants during the first cropping season (van de Wiel *et al.,* 2016). Depending on the pH and moisture of soil, P can precipitate (at high pH due to the presence of calcium and magnesium and at low pH due to an iron and aluminum presence) (Chauhan *et al.,* 2021) or can be immobilized in soil (Bindraban *et al.,* 2020). The use of P fertilizers also leads to eutrophication (when P runs off to surface waters) (Du Preez *et al.,* 2020). Potassium has several beneficial roles in plant physiological and metabolic processes, including resistance to biotic and abiotic stresses and absorption and utilization of N and P by crops (Li *et al.,* 2019). On the other hand, potassium he highly soluble and gets leached off easily.

The application of nutrients mainly NPK fertilizers in the form of Urea, SSP, MOP was carried out in several split doses based on requirement of the crop under smart farming practice this can reduce the loss of fertilizers from soil. In contrast conventional farming methods fertilizers are applied in higher doses.

Conclusions

Smart farming involving AI and IoT in agriculture has developed applications and tools which help farmers in accurate and controlled farming by providing them with proper guidance about nutrition management, water management, crop rotation, timely harvesting, type of crop to be grown, optimum planting, pest attacks. From the present study regarding the field trial in farmers' plot, it has been concluded that, the sweet potato production/ yield has significantly improved in smart farming practice over the conventional farming method. It is clear from this that smart farming in agriculture helps farmers automate their farming and shifts to precise cultivation for higher crop yield and better quality while using fewer resources. The major challenge for smart farming is developing sensors that are required for extracting the spatial and resolution data, which cannot be measured as they vary significantly and hence pose difficulties in measuring them. Therefore, AI, IoT, and robotics in agriculture are expected to solve several challenges and enable higher quality and productivity. However, there is a need for a technology that integrates and applies these technologies to all aspects of farm management.

Acknowledgments

Authors are thank full to Director, ICAR-Central Tuber Crops Research Institute and State horticulture mission-kerala for the study mentioned in this article.

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