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e-Crop-Based Smart Farming

One of the best means to address many of the new challenges in agriculture is to adopt Smart Farming integrating Artificial Intelligence, mechanization and use of sensors. In this blog, Dr VS Santhosh Mithra illustrates how e-Crop-Based Smart Farming is revolutionizing farming in the state of Kerala.

CONTEXT

There is a need to enhance global food production by 70% in the next 30 years to feed the growing population. But this augmented production needs to come from a lower resouce base through the sustainable use of natural resources. Ensuring good quality and quick transportation are some of the other challenges in food production. These challenges can only be addressed by taking quick decisions based on processing different types of data. Smart farming is an approach that can help with this.

Comparison between Cassava grown using e-Crop-based smart farming and traditional farming practices

SMART FARMING

Smart Farming (SF) is a type of precision farming where different types of data collected from the field and other sources are integrated for farm decision making with the use of information and communication technologies (ICTs). To implement this, 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., need to be collected for taking timely and proper decisions. These data are very important, and 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.

Use of smart devices and sensors for data collection is one of the major factors for its success. The data collected is processed immediately. After processing the system takes a decision on what action is 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 it may be automatically switched on in their device. The whole process from data collection to action happens automatically. In this way resource utilization becomes more efficient and production increases.

Components of smart farming

SF has five components:

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 SF is concerned. Many of the SF devices include at least one or another 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 a decision on the action to be performed. The decision may be to fertigate, or to spray pesticide using drones, or maybe to 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, and this enables farming to reach new heights.

IMPORTANCE OF SMART FARMING

SF helps to achieve rich dividends by solving some pressing problems in farming. It is based on IoT devices such as e-Crop (discussed in detail below), 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 with 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. The pace at which new highly precise algorithms of image analysis are being developed is commendable. 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 farmers. Fluctuations in market price are 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 worth tapping into the potential of this great technology to create a better scenario in the agriculture sector.

SMART FARMING INITIATIVES OF ICAR-CTCRI

Electronic Crop (e-Crop)

This is an important technology developed by the ICAR-Central Tuber Crops Research Institute (CTCRI) on 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, such as respiration, growth, etc. The food stored in its storage organs are 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.

Electronic Crop

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 in real-time, in response to weather and soil parameter data collected from the field and generates agro advisories that are sent to the farmer's mobile as SMS.

This device can be used for giving real-time agro advisory of any crop that can go on to reduce yield gap and to achieve the 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 included in the advisories sent to the mobile phone as SMS. The farmer can then follow these strategies to increase yield to the desired level. Such appropriate diagnostic tools that help in the application of fertilizers at the demanded time and in smaller and frequent doses can help to reduce losses while maintaining or increasing crop yields.

This is an excellent device for precision farming which collects real-time data from the field and then generates advisories that are passed on to the farmer along with the strategies for crop management to help them care for the present and future status of the crops for better results. The data collected by the devices installed in different fields provide a very clear and realistic reading of the overall status of the crop at present, and in the future. This information will be useful to policy makers and planners as well as for averting market risks which usually emanate from an unexpected boom in production/supply, fall in prices, and so on. 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, fertilizers, soil types, locations, also to add 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 as:

1. This product calculates plot by plot yield gap daily, and quantifies N, P, K and water requirement to reduce it;
2. This information is sent to farmers daily as SMS;
3. 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%;
4. Reduced application of chemicals and water helps to save resources and minimizes damage to the environment;
5. Farmer's profit multiplies through the increase of yield as well as by the lowering of cost of cultivation.

Applications of the device

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

Self-learning crop models

A self-learning crop model development programme has already been 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 a crop simulation model can be reduced 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 fertigation system (eCBSFS) is an auto fertigation system, 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 to the 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, both 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 such as 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 labor shortage and increasing cost of fertilizers, eCBSFS is a good option to increase agricultural production at a lower cost.

e-Crop-based Smart Fertigation System

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

A 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. The app is connected with the e-Crop unit and farmers will then be able to get information about their cultivated crops and obtain daily as well as weekly advisories, which contain information about the amount of irrigation water and the correct fertilizers to be applied in the field for increasing 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. The mobile application is uploaded in Google Play Store.

Mobile app Krishi Krithya

FIELD EXPERIENCE WITH e-CROP-BASED SMART FARMING (eCBSF)

e-Crop-based smart farming was demonstrated in farmers' fields in five panchayats – Anad, Aruvikkara, Vembayam, Karakulam and Panavoor – of Nedumangadu block, Thiruvananthapuram district, Kerala. This initiative was headed by Dr VS Santosh Mithra, Principal Scientist, ICAR-CTCRI, with funding support from the 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. They followed two methods of cultivation, one by the method that they had been following for years, i.e., traditional farming (TF), and the other according to eCBSF.

Figure 1 depicts the yields obtained by traditional farming and smart farming in 4 crops. The increase in yield was obtained with reduced input application (Nitrogen, Phosphorus and Potassium fertilizers were applied at 49%, 73% and 57%, respectively as against the dosages in TF). The yields obtained through SF for Sweet potato, Cassava, Banana and Elephant Foot Yam (EFY) and Banana eCBSF yields were 218%, 187%, 152 % and 218% respectively, much higher than the corresponding TF yield.

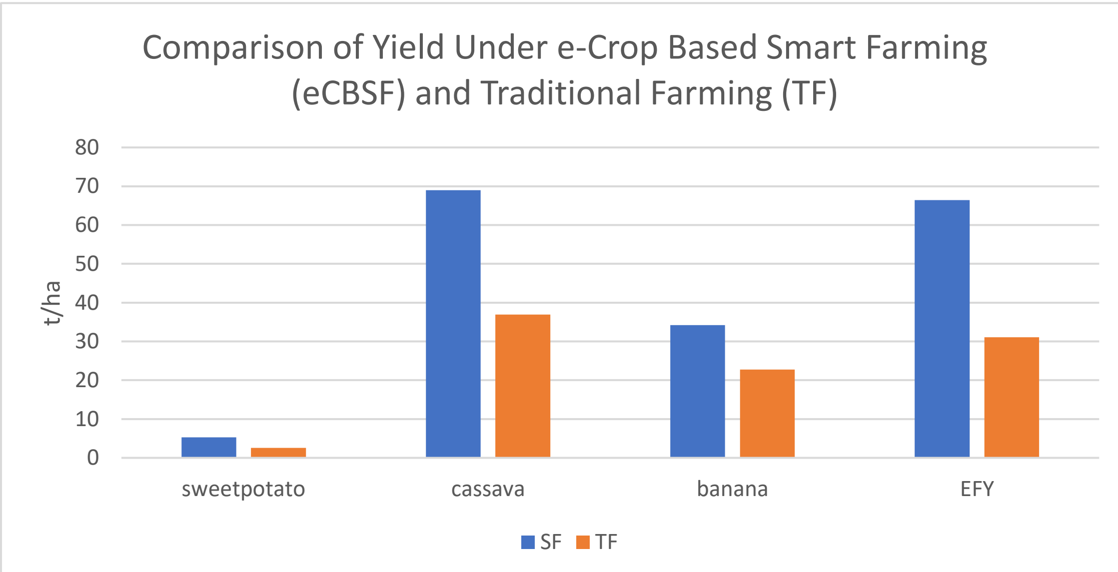

Figure 1: Comparison of eCBSF and TF

The potential yields (potY) predicted by the system through computer simulation are presented in Figures 2 and 3. Yield gap reduction is the main advantage of this technology. In the case of cassava and sweet potato the normal yield gap is around 50-60%. Through eCBSF, this gap is reduced to 5% and 8% for cassava and sweet potato, respectively.

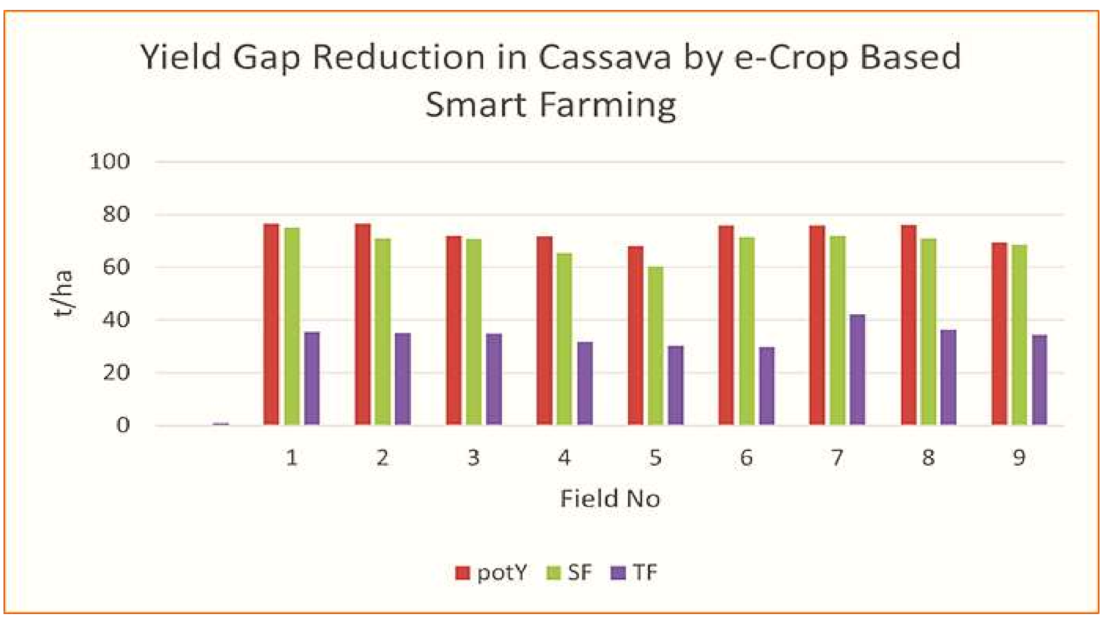

Figure 2: Yield gap reduction in cassava by e-CBSF

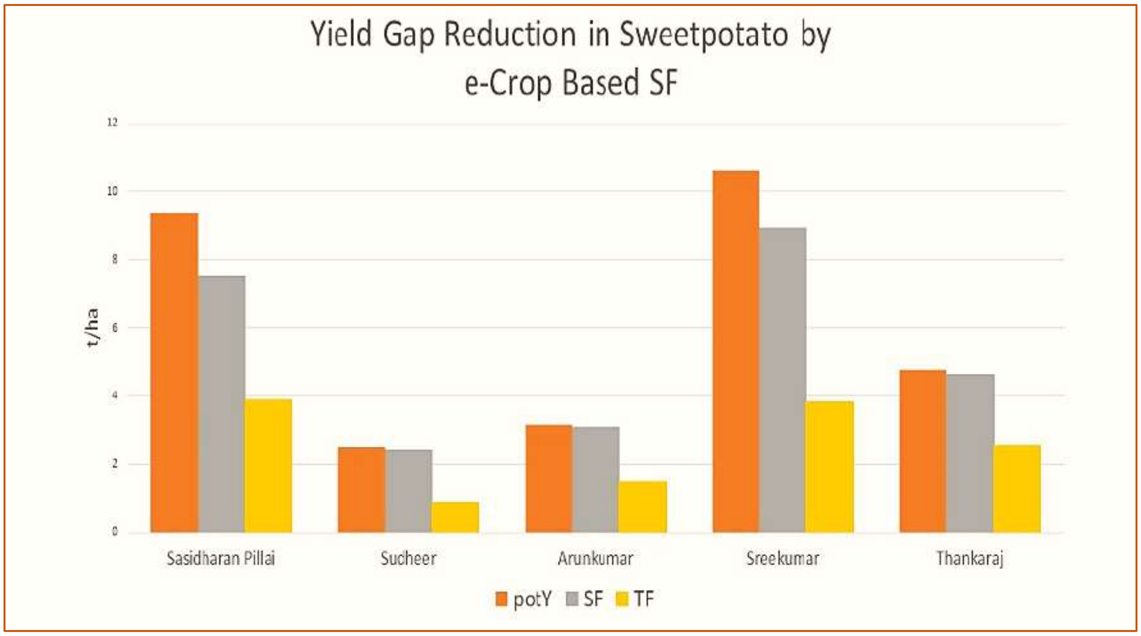

Figure 3: Yield gap reduction in sweet potato by e-CBSF

Implementation of eCBSFS in the fields are expected to benefit the farmers through 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 is needed. 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. With financial support from the Kerala State Planning Board, another study was conducted at two panchayats in Malappuram district, Kerala, to demonstrate eCBSF in cassava. This was also done for developing Artificial Intelligence-based self-learning models to make e-Crop intelligent so that it can be easily adapted to any crop.

Many are uneasy about the cost of smart farming technology. There is a general belief that small and marginal farmers cannot afford to adopt this technology. Another fear is that it leads to unemployment in the farm sector. Though the initial cost for setting up smart farming is high its benefits are innumerable. The total cost of setting up an e-Crop device is approximately INR 5 lakhs (approx. USD 6100), which includes the cost of the device also. One device caters to the farming needs of approximately 20 sq km area. Almost 1000-2000 small farmers with average landholding of 1 ha may be contained within this area.

Each farmer in this area therefore incurs a meagre cost of just INR 200-300 for setting up the eCBSF facility. This is in reference to the situation in Kerala. Once set up, it can be maintained for years with some very small maintenance cost. In states, such as Kerala, where collective efforts like group farming is already in practice, adoption of this technology is a feasible option.

ENDNOTE

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 shouldn't wait for a long time to adopt SF and the time is right now. Another green revolution through smart farming can revitalize our entire economy. Let us show the world how to do it and become a world leader in smart farming.

SUGGESTED READINGS

Mithra VSS. 2019. Electronic crop (e-Crop): An intelligent IoT solution for optimum crop production. Pages 177–189 *in* Advances in Information and Communication Technologies for adapting agriculture to climate change II (Corrales J, Angelov P and Iglesias J. eds). AACC 2018. Advances in intelligent systems and computing, Vol. 893. Cham: Springer.

1. YouTube link on e-Crop: https://youtu.be/KJ0r-cZg7PM
2. YouTube link on success story of eCBSF: https://youtu.be/sJkq0UAtV4U
3. YouTube link on success story of eCBSFS: https://youtu.be/LDtGFBDL1mA

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