

Smart farm mechanization

Retrospective and prospective

C R Mehta^{1*}, P S Tiwari² and N S Chandel³

ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh 462 038

Smart technology in agriculture is an idea that refers to operating farms, utilizing modern sensors, controllers, actuators, along with information and communication technology (ICT) to enhance quantity and quality of crops. Smart farming involves not just individual machines but all farm operations. ICAR-CIAE, Bhopal has developed a web-based app that suggests machinery package based on agro-climatic region, state, district, cropping pattern and power source. App also provides an estimated cost of machinery package, list of manufacturers and their addresses. A smartphone based app 'KRISHI Yantra Mitra' is also available for selection of package of farm machinery to establish a custom hiring centre. Based on various inputs, a complete package of machinery is recommended by software for the selected region. Present Indian agriculture is highly labour intensive whereas smart agriculture is all about machines and technologies. Different types of sensors, instruments and machinery are being developed now-a-days for smart farming practices. A holistic, value-chain approach is necessary for smart agricultural mechanization, going beyond green production through precision agriculture and digital agriculture. There is a need of low cost, reliable and doable technologies suitable for small and marginal farmers to practice smart farming.

Keywords: App, Farm mechanization, Precision agriculture, Smart farming

SMART farming involves merging advanced technologies into existing agriculture to increase production and quality of product. Smart technology in agriculture is an idea that refers to operating farms, utilizing modern sensors, controllers, actuators, and information and communication technology (ICT) to enhance quantity and quality of crops. Most operations in farming, such as seedbed preparation, sowing/planting, pest/disease detection, crop health monitoring and management, irrigation scheduling and watering and harvesting can benefit from technological advancements. It also includes application areas such as monitoring of

animal health, feeding and processing, on-farm storage and product quality assessment including control within farm gate for initial storage. Major categories for smart farm mechanization (SFM)

technology applications in agronomy, horticulture, aquaculture and livestock farming are variable rate application, UAVs, UGVs and Internet of Things (IoT).

Smart farming involves not just individual machines but all farm operations. Farmers can use mobile devices such as smartphones and tablets to access real-time data about soil condition, plants health, weather, resource usage, manpower management, funding, etc. Focus is rather on access to data and application of these data in deciding how the collected information can be used in a smart way. This new idea of SFM centred on agricultural data has been expressed by several names viz.



Fig. 1. SPAD meter for input management.

agriculture 4.0, digital farming (DF), or smart farming. It was born when telematics and data management were combined to already known concept of precision agriculture (PA). As a result, smart farming is based on PA principles with farmers using systems that generate data in their fields, which will be processed in such a way to make proper strategy and operational decisions. Traditionally, farmers used to go to fields to check status of their crops and make decisions based on their experience. Advanced management systems within the context of smart farming are providing practical solutions.

Regarding willingness of adopting modern tools in agriculture, young farmers show a more positive attitude. It is also about empowering a new generation of highly qualified young farmers to bring full benefits of technology in order to support sustainable farming practices. This implies that young farmers will need to transform the existing land to more modern and competitive farms with purpose of maintaining viable food production while improving competitiveness of agri-food chain. A greater use of PA technologies with smart farming services is vital for not only improving a farm's financial performance, but also to meet food demand of an expanding population.

However, there are still important gaps in studies on a national scale to support strategic decisions in development of new research, innovation and market. It is necessary to study in context of smart farming solution in India on aspects such as which technologies and applications are used, the perception of benefits and main challenges and expectations. In this article, rapidly changing environment in smart farm mechanization of agriculture has been presented and approaches and strategies to make Indian agriculture smart, based on opportunities in different areas have been suggested.

SMART FARMING

Smart farm technology aims to establish an intelligent foundation system for farm management. It is a management concept using recent technologies such as PA and DF to improve input use efficiency as well as quality and quantity of farm produce. These techniques are supported by artificial intelligence (AI) for weather prediction, detection of stress, site-specific application of inputs, optimize crop planning for maximizing yield and profit. Applications of new technologies viz. PA, DF and AI are heralding start of a new revolution in agriculture. Recent and emerging technological developments such as IoT, UAVs and UGVs, are accelerating changes around agricultural mechanization across world. Taken together and deployed



Fig. 2. Real-time uniform rate spraying system.

effectively, these emerging trends and technologies have potential to usher in a new golden age of SFM.

Precision agriculture

Precision agriculture technologies can help to meet new challenges by applying right inputs, in right amount, at right place, at right time, and in right manner. Importance and success of PA lies in these five "R". Presently, research on PA is at initial stage and most of technologies in India are developed for laboratory and field purposes. PA technologies such as sensor based embedded system, guidance systems, variable-rate input technologies (VRTs), and automated machinery have been developed to map variability and manage it at field level.

Digital farming

Essence of DF lies in generating valuable information from data. It means to go beyond mere presence and availability of data and create actionable intelligence and meaningful added value from such data. DF also integrates both the concepts – precision farming and smart farming. DF technologies include cloud computing/big data analytics including block chain and smart contracts, IoT, digital communications and digital platforms. Government of India has planned to digitize farming system for sustainable agricultural productivity. Research institutions, universities and other organizations are working on DF to solve various agriculture related problems.

Artificial intelligence

Artificial intelligence (AI) based on machine learning (ML) and deep learning (DL) is not extensively used in Indian agriculture for automatic data collection, analysis, decision making and controlling various tasks. Use of AI with computer vision and robotics is able to build next-generation agriculture equipment, which can detect stresses in crops, assess nutrient deficiencies in soil, reduce chemical application, harvest high value crops and identify defects in fruits and vegetables. There is a growing interest in applying AI to develop smart farming practices to minimize yield losses.

Big data in agriculture

Concept of big data is a relatively new one, however it is expected that knowledge about its applications and importance for research will spread widely. Data mining is computing process of discovering patterns in large data sets involving methods at intersection of AI, ML statistics and database system. In SFM, main objective is to ensure profitability, efficiency and sustainability using big data gathered to guide both immediate and future decision-

making. Big data is an obvious need for agricultural industry. Vast majority of farmers, manufacturers and researchers have done good work for maintaining and increasing dataset using different agricultural practices. Big data need to be trained on different AI models for prediction or forecasting different agriculture practices or parameters.

Smart apps

One of the most recent uses of mobile devices in agriculture is development of monitoring protocols, systems for monitoring and managing farms and farm activities. About 94% of farmers are using mobile phones, especially in developing countries, where mobile phones may be only available for computing and communication technology. This number leads us to the conclusion that mobile technology may help farmers to improve their production.

INDIGENOUS TECHNOLOGIES FOR SMART FARM MECHANIZATION

Seed and fertilizer management

A few potential PA technologies such as controller based seed-cum-fertilizer drill, SPAD meter, NDVI based urea applicator and map based variable rate fertilizer applicator (VRFA) have been developed and tested at ICAR-CIAE, Bhopal. Low cost SPAD meter (Fig. 1) has been developed for indirect measurement of chlorophyll content of leaves. It is a compact hand-held, portable unit and can be plugged to OTG enabled android smartphone for display and logging of SPAD values. NDVI based on-the-go variable rate urea applicator has been developed for top dressing of need based urea in rice and wheat crops. It saves 8-15% urea in wheat and rice crops. Map based VRFA has application accuracy ranging from 89-98% at various discharge rates for 8×8 m grid.



Fig. 3. Automatic irrigation system for rice crop.

Crop health management

A number of technologies have been developed at ICAR-CIAE, Bhopal for crop health management. A hand held device based on DL models has been developed for identification of disease in soybean crop. It consists of a single-board micro-controller, display unit, RGB camera, DC power supply and other accessories. The device identifies

Yellow Mosaic disease of soybean in less than 20 sec with 90% accuracy by using images of plant leaves. Cost of device is about ₹ 10,000. A real-time uniform rate spraying system has been developed, which helps in uniform application of chemical and reducing loss of chemicals during turning at head lands (Fig. 2). An ultrasonic sensor based spraying system for orchard crop has been developed for pesticide application. This sprayer saves 45-50% chemical as compared to whole field spraying system. Punjab Agricultural University has developed

an electro-static nozzle for saving of pesticide and increasing efficacy in field and horticulture crops. A start-up has developed an intelligent and autonomous drone for spraying application in agriculture. Drone collects data, analyses them and generates disease map of a particular field with help of RGB, hyper, multi-spectral cameras and powerful sensors. Start-up is presently working

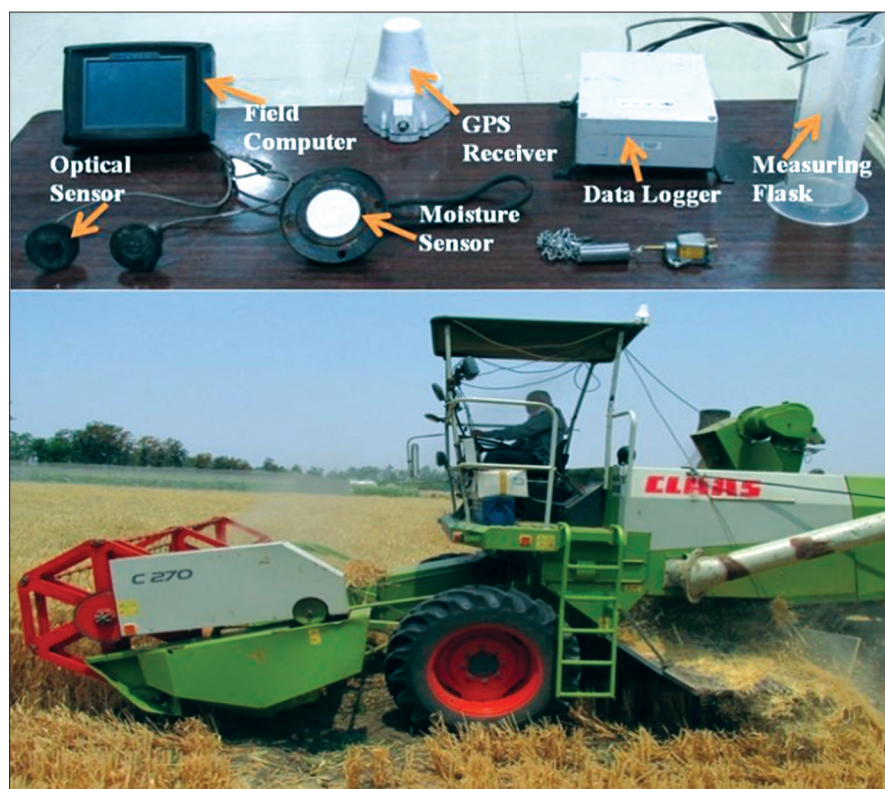


Fig. 4. Components of AYM and operation in wheat crop.

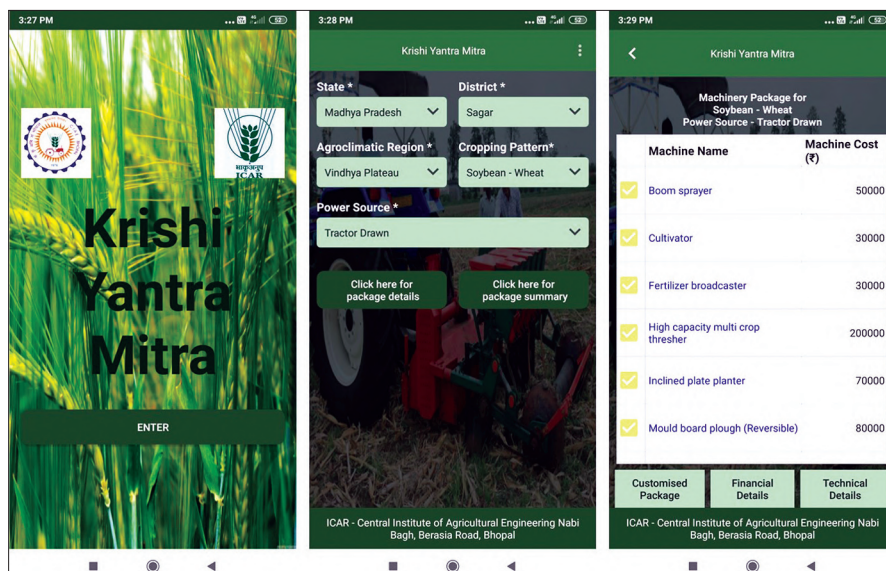


Fig. 5. Smartphone based Krishi Yantra Mitra App.

with input manufacturers and FPOs to provide services.

Results of these PA technologies are encouraging. However, their adoption is lacking due to lack of awareness among the farming community and cost of these technologies.

Precision irrigation

Sensors are now available for monitoring of soil and climatic parameters such as soil moisture, humidity and temperature for automated irrigation system. Real-

time soil moisture based precision irrigation system for field crops has been developed at ICAR-CIAE, Bhopal. This system monitors soil moisture variation in field using MP406 sensors and operates the irrigation pump based on threshold soil moisture values. It saves 7-8% water compared to conventional sprinkler irrigation. An automatic system consisting of sensors and micro-controller (Fig. 3) has also been developed to detect water level in the paddy field and transmit signal to controller wirelessly using RF

module to operate pump based on desired water level.

Real time irrigation scheduling using sensors can be achieved using Wireless Sensor Network, IoT and AI based technologies. Currently, automation is being practiced using embedded system with help of solenoid valves on a few Indian farms. However, these are small scale and limited to research level. Research in future should focus on development of compact and robust sensors, AI and IoT based irrigation systems.

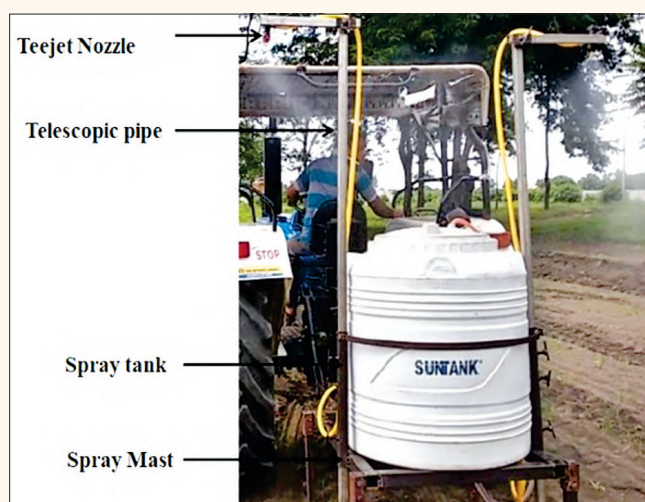
Harvesting and threshing

Spatial variability of yield is very important information for nutrient management, which can be automatically, collected using automatic yield monitoring (AYM) system. Components of AYM are GPS, moisture sensor, optical yield sensor, data logger and field computer (Fig. 4). These components have been installed on an indigenous grain combine harvester. Yield variability in paddy, wheat and soybean crops was studied using AYM at ICAR-CIAE, Bhopal.

¹Director, ²Head, ³Scientist, ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh. *Corresponding author's e-mail: cr.mehta@icar.gov.in

Ultra-low volume (ULV) spraying system

A ULV spraying system developed is the tractor-mounted sprayer that has been specifically designed for the control of migrant pests such as locusts, grasshoppers, and armyworm at the spray volumes of 0.5–3.0 l/ha. The sprayer can produce the droplets in the range of 50–100 µm. One nozzle has been mounted on each side having a discharge rate of 0.2–0.6 l/min. The performance of the sprayer was evaluated using water-sensitive paper. Water sensitive papers (WSP) were used to collect the spray droplets at a height of 1.5 m (top surface), 1 m (middle surface) and 0.5 m (bottom surface) from the ground. Deposit scan open-source image analysis software (USDA affiliated) was used for them to measure the droplet characteristics from WSP. The results have shown that the droplet range VMD varied from 195 to 450 µm at the pressure of 4 bar. The % coverage and deposits/cm² was 9.06, 16.3 and 9.62%, and 293.2, 235.6, 42.5 deposits for bottoms middle and top surface.



Source: ICAR Annual Report 2020