

Artificial Intelligence...

Application in Agriculture

Kanika¹, Priyanka², Latika³ and Daksh Kumar⁴

ICAR-National Institute for Plant Biotechnology, New Delhi 110 012

Artificial intelligence is different from natural intelligence displayed by humans and other living organisms. It encompasses working ecosystem of intelligent agents. In the line of cognitive scientific behavior, an ability in devices are developed using principles of computer science (programming), electronics and communication (sensors), and mechanical engineering (powering energy). These agents including devices perceive their environment and take actions that maximize their chances of successfully achieving their goals. In lay mans' language it is "ability of a system to correctly interpret external data, to learn from these data, and use those learning to achieve specific goals and tasks through flexible adaptation". It is a process of a machine mimicking the cognitive functions that are associated with brain functions such as learning and subsequently solving the problem based on that learning. AI is any technology that emulates human performance by learning, reaching conclusions, understanding complex content. AI is applicable to any intellectual task.

Key words: Artificial Intelligence, Automation, Predictive Analytics

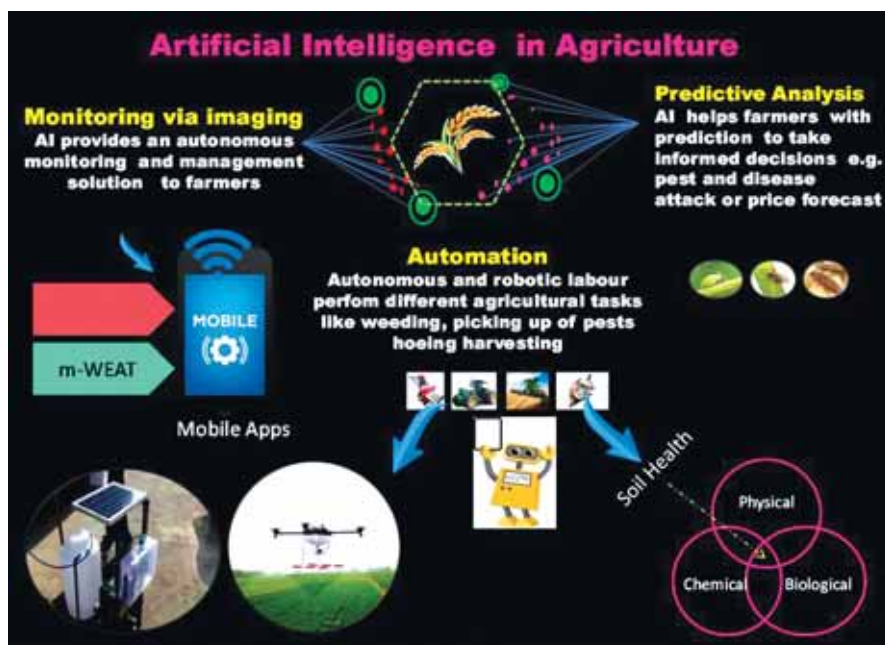
VARIABILITY in weather patterns such as increase in temperature, changes in precipitation levels, etc can affect farmers, especially those who are dependent on rains for their crops. Dependence on rain and climate change has made Indian farmers extremely vulnerable to crop loss. Insights from Artificial Intelligence and its application in different field of agriculture will help reduce uncertainty and risk in agriculture operations and enhance their preparedness of farmers to handle the crisis. Use of cloud Machine Learning (ML) and AI for prediction of future situations and issuing advisories for sowing, pest control and commodity pricing, are some of the major initiative towards creating increased income and providing stability for the agricultural community. Dependence on rain and climate change has made Indian farmer farmers extremely vulnerable to crop loss. Insights from AI

through the agriculture life cycle will help reduce uncertainty and risk in agriculture operations and enhance their preparedness to handle the different types of crisis. Use of AI in agriculture can potentially transform the lives of millions of farmers in India and world over.

Technology played an important role; a big proportion of the gains can be attributed to simply plowing more land and using surplus irrigation. To meet the increasing demand of burgeoning population, the big question now is, how to get most from every acre? Artificial intelligence holds the promise of driving an agricultural revolution at a time when we must produce more food using fewer resources. The combination of, the Internet of Things (IoT) and artificial intelligence technologies, such as machine learning, computer vision, and predictive analytics, allow farmers to analyze real-time data of

various kind such as weather conditions, temperature, soil moisture, plant health etc. Armed with these weapons in our armor we will be able to confront one of the biggest challenges of this century: feeding 1.5 billion people by 2030, under climate change scenario in India. Climate change and anticipated population growth requires us to use more innovative approaches to make agriculture more profitable. As a result, AI is steadily becoming an important player in technological evolution of agriculture.

Welcome to digital agriculture, where technologies such as AI, ML, Satellite Imagery and advanced analytics are empowering small-holder farmers to increase their income through higher crop yield and greater price control. Agriculture industry is being transformed by data science and artificial intelligence.



Major Applications of AI in Field crops

The major applications of AI in field crops fall into two major categories:

Imaging based insight generation for monitoring

Employing images from drone copters satellitessystems, it is possible to rigorously monitor crops and field. This identifies areas where thinning/ resowing is required, or where water/ fertilizer/ pesticides need to be applied, thus optimizing use of resources in field crops etc.

Multispectral imaging of the crops followed by image processing leads to faster alerts in real time which accelerate preventive actions. Commercial ecosystems are available which has built in drones, IoT Platform and Visual Recognition apps for real time image analysis. Combination of Computer vision technology, data analytics and IoT ensures that the farmers can make early interventions to reduce the damage to crops.

Pests and disease havealways caused huge losses to the farmers. Nearly 20 to 40% of all global crops are lost each year, due to plant pests and diseases. Avoiding these huge losses depends on speedy accurate identification and taking corrective steps. This is where AI-based technologies are helping us. Imaging, sensing and subsequent analysis in

the real time ensure that problem areas are identified. Drones satellites take multispectral images of the fields from a height. The images are then processed and problem areas are identified. The problems in these areas areidentified and corrective steps can be taken in the specific part of the field. This helps in fast and accurate identification of pest and diseases, assessing water and nutrient deficiency or variable rate of seed application.

Some of the examples of use of imaging based monitoring and management are one such app using drone technology to monitor plant health in field was developed by SkySquirrel Technologies Inc. Their applications use computer vision to record images from grape vineyards using the drones and uploading the captured data to a cloud drive. Algorithms are used to integrate and analyze the captured images and data to provide a detailed report on the health of the vineyard, specifically w.r.t diseases. Once the disease is identified preventive step can be taken to control it. Other similar apps are also available in the market. These help in identification and control of the pest infection. In these cases all a technician/farmers need to do is take a picture of the pest/disease and run the app. The picturesare processed in their image classification and machine learning software to check

through a number of pest/disease images and the culprit is identified. When a positive identification is made, the app immediately provides pre-populated remediation solutions, to decide treatment plans, including optimum level of agrochemicals to be used. These pesticidesneed to be sprayed onlyin the infested part of field. Moreover, every time a picture is clicked and processed, it enhances the recognition and classification capabilities of the Machine Learning (ML) algorithms of the apps. Example of othersuch apps include android mobile app PestID. These applications have proven how Cloud computing, Machine learning and android technologies can be used efficiently to help the farmer take corrective measures. The next level of automation in this scenario is Internet of Things (IoT) technology which is more useful for big commercial farms. Here, the sensors in the field or drones are connected to on-board electronic systems, which transmit the data to an internet server, where images are processed, insects and diseases identified and counted. Depending on the severity of infestation, use of agrochemicals may or may not be required. The farmer receive a ready-made report and remedies on his smartphone. Suchconnected application arehelping farmers toapply the right amount of agrochemical, at the right time in order to combat pests and diseases in more cost-effective manner. These application areenhancing the effectiveness and efficiency of the control processes by integrating an array of tools such as chemical pesticides, biological control agents, light traps and pheromones.

Degradation of soil quality causes a negative impact on the agriculture economy. Agricultural tech startup PEAT, has developed a deep learning application called Plantix. This application identifies potential defects and nutrient deficiencies pests and diseases in soil by correlating particular foliage patterns with certain soil defects, plant pests and diseases. The image recognition app identifies possible defects through images captured by the user's smart phone camera. Users are then

provided with soil restoration or pest disease control solutions. A number of other such applications are being developed by various tech companies. These apps will allow farmers to apply nutrient /fertilizers, pesticide only in the specific part of the field and save on expensive inputs. This can reduce the amount of agrochemicals and water used. Most of these softwares can be used across mobile devices.

In other apps, images of various crops, captured under white light and UVA light, are analysed to determine the maturity of the crop in the field. This enables the farmers to create different levels in the fields to devise a harvesting strategy. This will economise the harvesting process and help the farmers in charting a strategy for selling or storing his produce.

Some commercial ventures providers are providing soil analysis services to farmers. They are using ML tools to provide information about strengths and weaknesses of their soil. They also carry out in-depth analysis of their soils contents, microbial evaluation along with pathogen screening of their field soil. The farmers are provided with the remedial strategies. This reduces losses to crops and ensures high crop production.

Information on land cover performance and farmland condition is generated using remote sensing technique. Spatial and temporal evaluation of individual plots or plants is possible after advent of these technologies. As these analysis are carried out quickly, these will help the scientist in advocating strategies to farmers, to maximize crop production. This leads to reduction in time gap between analysis, issuing of advisory and adaptation thereby improving quality and quantity of crops.

Automation

Automation helps in addressing the challenges in the management of human labour. The problem of labour scarcity in agriculture, in certain seasons leads to rise in wages, thereby, increasing the input cost. Lack of laborers has reportedly led to huge revenue losses in key

farming sectors. This is especially so for crops such as fruits and vegetables, where, labor requirements are highest. Machine vision technologies and robotics, have potentially revolutionary applications in agriculture. These technologies have led to development of new robotic harvesters which can 'sense' and performs an array of tasks such as harvesting delicate fruits and berries. Companies are developing and programming autonomous robots to handle essential agricultural tasks such as weeding hoeing pest control, harvesting crops etc. A large number of intelligent automation application are developed which are ready to take the slack from the human beings working manually in the agriculture fields. Independent robots, which are capable of sensing processing and performing a spectrum of functions in the field that too at a higher volume and faster pace as compared to human being. Some of their examples include Oz, Agriboot, SITTIA etc.

The ability to control weeds is important for farmers and a continuous challenge. Companies are using automation and robotics to help farmers find more efficient ways to remove weeds from their fields. One example is a robot called *See & Spray* developed by Blue River Technology. It uses computer vision to monitor and precisely spray herbicide on the weed plants. Precision spraying will help in preventing development of herbicide resistance and reduce the input cost. Other robots can uproot or burn the weed plants using lasers.

- RIPPA (Robot for Intelligent Perception and Precision Application) is a four-wheeled, GPS-guided mobile robot that can move around a farm on battery or solar power to examine crops and collect data. It serves as a platform for a variety of add-ons.
- VIIPA (Variable Injection Intelligent Precision Applicator) is a robotic weed killer. It integrates directly onto RIPPA to sprays the weedicides using a directed micro-dose. This system is designed to automatically apply the correct dose of fluid required anywhere

on the farm at high speed. This makes application of agrochemicals and water very economical.

- Ladybird another mobile ground robot conducts sensing and manipulation tasks autonomously in the field. Applications like this are set to transform the way farmers monitor and harvest a wide array of vegetables.

These are mobile, omnidirectional, robot empowered with artificial intelligence. They have autonomy to conduct a full range of sensing and manipulation tasks, including mapping, classification, detection, weeding etc. AI-driven technologies are emerging to help improve efficiency and to address challenges facing the industry including, crop yield, soil health and herbicide-resistance. Agricultural robots are poised to become a highly valued application of AI in this sector.

Predictive analytics

Machine learning models are being developed to track and predict impact of various factors such as change in weather conditions on crop yield. By analyzing disparate data sources such as temperature, weather, soil analysis, moisture, and historic crop performance, AI systems are providing predictive insights as to which crops to grow in a particular season. It is also guiding the farmers about optimal dates of sowing and harvesting in a specific area, thereby reducing damages and improving crop yields. AI-powered predictive analytics could also warn of increased risks for disease and pest attacks, allowing for more strategic use of agrochemicals, reducing their overall requirements. This technology is assisting farmers in enhancing their crop yield and product quality. It is done by analyzing and correlating large amount of structured and unstructured data from multiple sources to extract insights to enhance crop yield.

Precision agriculture

Precision agriculture means application of precise and correct amount of inputs like water, fertilizer, pesticides etc. at the right time to the

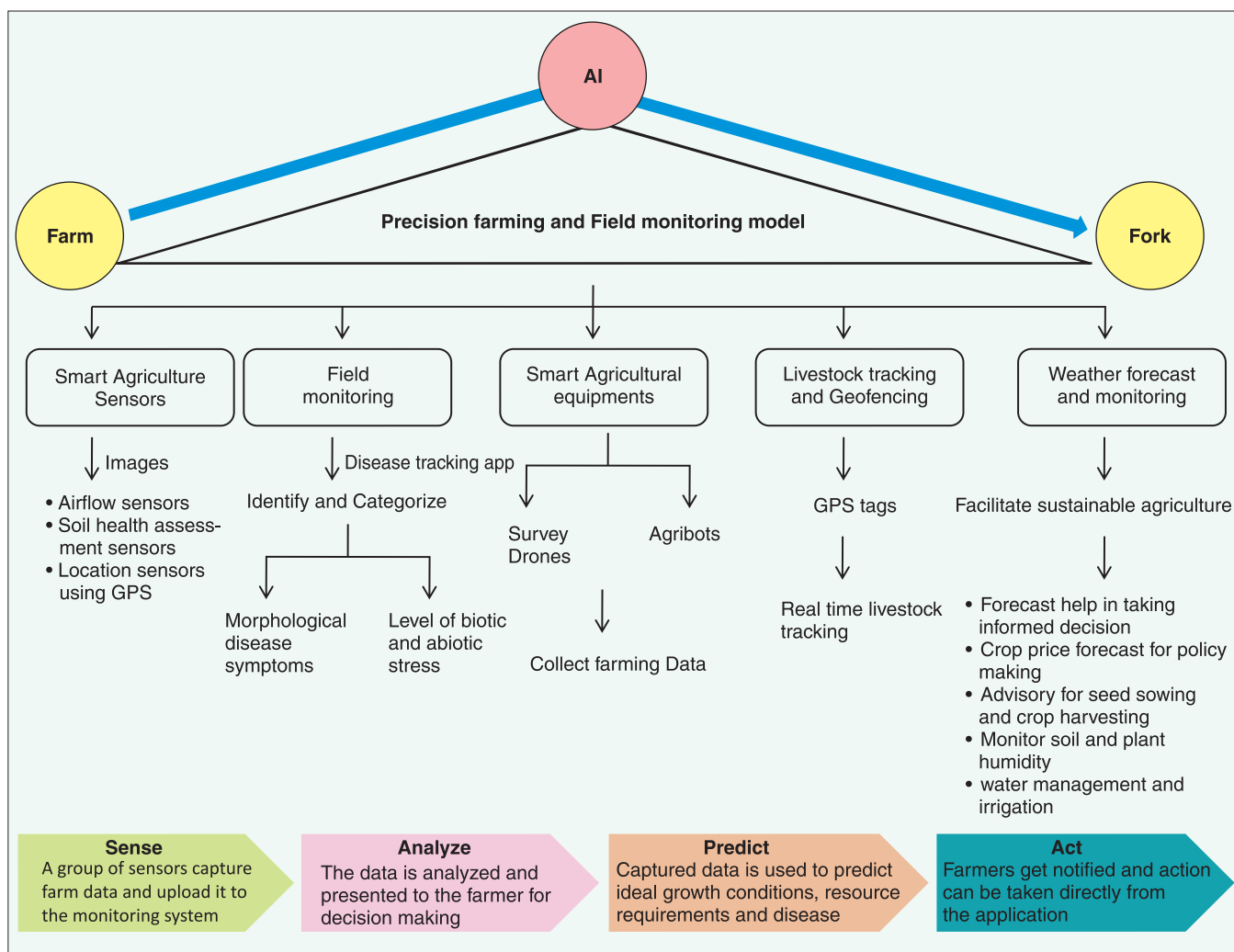


Fig. 1. Precision farming and field monitoring model

crop, for increasing its productivity and maximizing its yields. Precision agriculture management practices can significantly reduce the amount of agrochemicals and other crop inputs used while boosting yields. Farmers thus obtain a better return on their investment by saving on water, pesticide and fertilizer. Application of right amount of agrochemicals in the right place and at the right time, is proving beneficial for crops, soil and groundwater. This is another applications of artificial intelligence in agriculture. It is based on the concept that variations exist in the environmental conditions on a more granular level than farmers were previously able to track.

Using modern technologies such as satellite imaging, sensor data and autonomous drone surveillance of fields, engineers have been able to train AI systems to optimize the use of inputs on a precise level, i.e. apply just the right amount of

agrochemical, only in the part of the field that requires it, thus maximizing yields while preserving resources. Precision agriculture reduces the pressure of agriculture on environment by allowing more efficient use of machinery. Efficient use of nutrients or pesticides is reducing the use of inputs, thereby saving costs and reducing harmful runoff into the environment. AI allows the growers to completely control what goes into the plant. Sensors monitor the crop progress toward perfect ripeness, in cases even adjusting conditions to accelerate or slow the pace of maturation.

Predictive analysis in agriculture is not limited to cultivation of crops only. Karnataka government has started price forecasting project for agricultural commodities using historical data and short-term arrivals. This has been done to protect farmers from price crash or shield the consumers from high

inflation. Karnataka government get price forecasts for essential commodities such as split red gram for 3 months in advance for planning for the Minimum Support Price (MSP). This has proved that digital agriculture supported by advanced technology platforms will truly benefit farmers.

Multivariate agricultural commodity price forecasting model was developed to predict future commodity arrival and the corresponding prices. These models use remote sensing data from geo-stationary satellite images to predict crop yields through every stage of farming. This data along with other inputs such as historical sowing area, production, yield, weather, among other datasets, are used to predict the timing of arrival of grains in the market as well as their quantum, which would determine their pricing.

Various ecosystems are available which are providing data based

predictions to farmers, which are helping in increasing productivity with digital tools. These innovative products are helping farmers in increasing profitability by enabling better informed operating decisions.

When agricultural productivity and food quality are so important, data might well find new solutions to age-old problems and pave the way for the future. The amount of agricultural data that can potentially be captured and analysed has given the humans, a new ability, to predict changes and identify opportunities. In the coming years, applications of machine learning for various agricultural activities are expected to rise exponentially. Machine learning-enabled solutions are being used by agricultural organizations and farmers worldwide to enhance farm productivity. The combination of the Internet of Things and artificial intelligence technologies, such as machine learning, computer vision, and predictive analytics, is allowing farmers to analyze data of weather conditions, temperature, soil moisture, plant health, and crop prices in the market in real-time. The machine learning has been embedded into most of the apps developed for tasks. This will ensure that the farming data is becoming richer and more robust. AI guided farming requires considerable processing power using efficient AI algorithms.

Field application of AI

Few examples of AI field application are discussed here:

- United Phosphorous (UPL) has developed Pest Risk Prediction app in collaboration with Microsoft. It uses AI to predict in advance the risk of pest attack during a particular crop growing season. The farmers receive automated voice calls suggesting the risk of pest attacks on their cotton crop and preventive steps to be taken manage the attack. These advisories are based on weather conditions and crop stage. It enables the farmers to take preventive step to reduce the damages. Nearly three thousand marginal farmers with less than five acres of land holding in fifty

villages across in Telangana, Maharashtra and Madhya Pradesh are part of this project. Such applications are helping the farmers to plan in advance, thereby reducing crop losses due to pests.

- ICRISAT in collaboration with Microsoft has developed an AI Sowing App using Machine Learning and Power BI. The app sends sowing advisories to participating farmers on the optimal date to sow. Farmers do not need to install any sensors in their fields. All they need is a simple phone capable of receiving text messages. To calculate the crop-sowing period, historic climate data of the region is analyzed using AI. To determine the optimal sowing period, the Moisture Adequacy Index (MAI) is calculated. The real-time MAI is calculated from the daily rainfall recorded. The future MAI is calculated from weather forecasting models for the area. Ten sowing advisories were initiated and disseminated until the harvesting was completed. The farmers following the AI based advisories reported 10% to 30% improvement in their crop yields. Various ecosystems are available which are providing data based predictions to farmers, which are helping in increasing productivity with digital tools. These innovative products are helping farmers in increasing profitability by enabling better informed operating decisions.
- Seed companies have started using AI technology to analyze large amounts of data to identify varieties which will give highest yields under a given set of conditions. The geneticists need to know how sun light, rain, location, terrain and could affect growth and profits for thousands of different types of genotypes. For this, breeders collect thousands of data points from combines, weather stations, DNA marker labs and drones for strip of land. While data collection is plentiful, deriving insights from that data requires engineering

resources to spin up a cluster and write custom algorithms to get at the heart of the data. It is not an easy task. AI technology once again comes to their rescue. One of the example is softwareEureqa from Nutonian. This AI software automatically builds and interprets analytics models from these data. The results are presented in simple form and data scientists is not required to interpret the results. Applications like this, reduces the time, required in processing the information. Using such softwares, results are displayed in minutes which otherwise would have taken months to cobble from the spreadsheets.

- AI has also enabled the geneticists to refine their questions and draw meaningful insights from data. Plant breeding is tedious and time-consuming process. Breeding and testing varieties at many locations is a multi-year process that requires collaboration among researchers. Breeders may not note down on paper all that they observe. Conventional plant breeding depends, heavily on the skill and knowledge of the breeder. Breeders select plants on the basis of phenotypes or observable characteristics. These phenotypes are a product of their genetic make-up, the environment and the interaction between the two. It is during this part that the information is lost in translation. Digitisation will enable speed and accuracy in data collection and compilation. Instead of notebooks, researchers now record data with hand-held devices that scan, transfer information quickly to the internet, and disclose field locations with the help of satellites. By scanning bar codes at the trial plots, information is relayed quickly and accurately about the crops under observation.
- Artificial intelligence and machine learning are deployed to make sense of the data by recognising the patterns. For crop improvement purposes, plants need to be selected, for characteristics that can be passed

on to their progeny. Features such as the Genomic Estimated Breeding Value have a high correlation with the actual performance and can be derived by DNA profiling the plants under trial. In crops such as rice and wheat whose genomes have been sequenced this is not difficult to achieve. Such tools eliminate the need for field trials in early generations as the selection can be done from seedlings grown in trays in labs. With modern techniques and digitization of the system, desirable traits can be bred in plants more quickly. AI has allowed linking of plant genetics, genomics, robotics real time sensing and computer sciences to analyze huge data from fields and wet labs to efficiently identify genotypes or genes which can be used for crop improvement in a very short period of time as compared to when traditional techniques were used.

- AI is also helping to automate and streamline tasks in data-intensive industries traditionally ruled by rigorous science and good old-fashioned human analysis. Some MNCs, are collaborating on

research based on big data analytics and machine learning in the field of agriculture.

When agricultural productivity and food quality are so important, data might well find new solutions to age-old problems and pave the way for the future. The amount of agricultural data that can potentially be captured and analysed has given the humans, a new ability, to predict changes and identify opportunities. In the coming years, applications of machine learning for various agricultural activities are expected to rise exponentially. This will ensure that the farming data is becoming richer and more robust. AI guided farming requires considerable processing power using efficient AI algorithms.

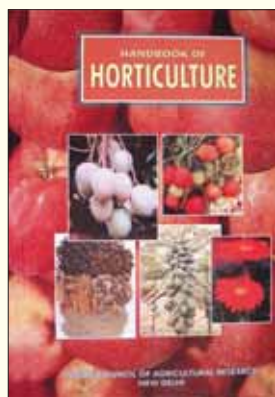
CONCLUSION

Agriculture today stands armed with drones and robots programmed to gather data from production fields in order to advance precision agriculture or 'smart farms'. Interconnected technologies and high-performance analytics are helping farmers in understanding real time data. Farmers are drawing insights as how to increase crop yield, improve

farm management, make environment friendly decisions on the level of resources needed and where to apply them. Farm productivity is set to increase in times to come to come as cognitive computing in agriculture continues to grow. This is transforming the ordinary farms into digitally controlled 'smart' farms. It is required that farmers are trained in modern AI technologies. This will ensure that the technologies are used and continue to improve. Extensive testing and validation of emerging AI applications in the field is very important as agriculture is affected by environmental factors that cannot be controlled unlike other industries. The next step in this direction is to combine more complex machines, improve contextual data collection techniques and highly developed software. Farmers are eager for this technology to relieve some of the inevitable challenges in agriculture.

^{1,2}ICAR-National Institute for Plant Biotechnology, Lal Bahadur Shastri Building, I.A.R.I. Campus, New Delhi 110 012; ³School of Computer Science and Engineering of Ansal University, Gurgaon 122 003; ⁴School of Engineering, Jawaharlal Nehru University, New Delhi 110 067.

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