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Technological Advancements in Agronomy: From Drones to Artificial Intelligence

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Introduction

Agronomy helps us understand how to use soil efficiently. Moreover, it fails to ensure successful production of crops. Climate change, soil depletion and food security challenges are growing across the globe. Also, need to enhance sustainability and efficiency of agricultural input and management is more than before. Agronomy is using the latest technologies like drones, sensors, and analytics to meet these demands. It also includes AI. Smart farming tools are changing not only the collection and analysis of agronomic data but also the decision making, which has become more precise and sustainable (Gebbers & Adamchuk, 2010).

The article on Innovations of Agronomy brings various technological application and innovation in agronomy. These technologies are how they help in achieving precision agriculture or making farming more sustainable and the future best role of agronomists.

Precision Agriculture and Data-Driven Decision Making

Precision Agriculture is the technological advancement in agriculture. It uses technologies such as Global Positioning Systems (GPS), Geographic Information Systems (GIS), and Variable Rate Technology (VRT) for managing spatial and temporal variability in crop production. Data collection pertaining to each field and input customization according to that data increases the yield, lowers input costs and damages the environment less (Zhang et al., 2002).

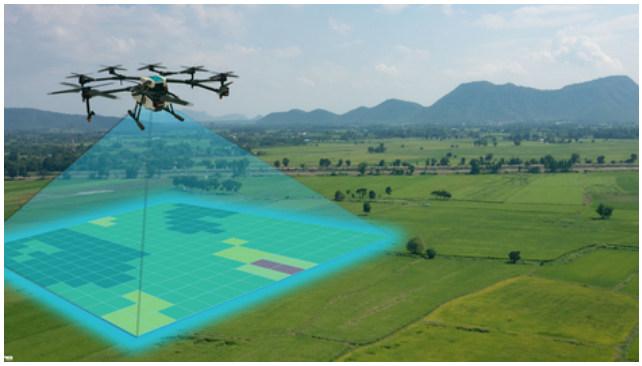
In modern times, PA systems take in live data that originates from sensors and remote platforms for optimizing planting, irrigation, fertilization, and pest control. These systems assist in moving away from reactive practices towards those that are predictive and prescriptive.

Drones and Remote Sensing

Drones, such as UAVs, have become essential tools for monitoring and research in agriculture. High-resolution RGB, multispectral, and thermal cameras on drones are useful for detailed imaging.

- NDVI (Normalized Difference Vegetation Index) is used to assess crop health.
- Catching disease, pests, and nutrient deficiencies early on.
- Soil mapping and moisture variability analysis.
- Yield prediction and biomass estimation.

According to Hunt et al. (2010), drone remote sensing offers higher resolution data and on-demand data acquisition as compared to satellite remote sensing of crop.



Sensors and the Internet of Things (IoT)

The farming IoT make use of connected sensors to watch over soil, plant and atmospheric conditions throughout the field constant. These include.

- Sensors to check the moisture, temperature and levels of nutrients in the soil.
- Plant sensors that monitor growth and transpiration as well as stress.
- Weather stations help with the decision-support of microclimate data.

Artificial Intelligence and Machine Learning

Artificial Intelligence, or more commonly referred to as AI, is making radical changes in making agronomic analyses with the ability to use huge spans of data to derive actionable insights. Applications of AI & Machine learning in agronomy includes.

· Predictive modeling of yield and disease outbreaks.
· Automated image recognition for plant diagnostics.
· Historical trend analysis to optimize usage of inputs.
· Creating decision support systems for managing farms in real time.

These systems enhance the speed and accuracy of agronomic decisions, lessen labor needs, and allow adaptive management reflecting highly variable environments (Kamilaris & Prenafeta-Boldú, 2018).

Robotics and Automation

Farm machinery is being increasingly automated and labor costs are increased. Robotic technologies are being applied to.

· Precision planting and harvesting.
· Automated weeding and crop scouting.
· Greenhouse management and phenotyping.

Robots make work more productive, cost less to operate, and can work any time. According to Bechar & Vigneault (2017), robotics can be exploited for high-throughput phenotyping to rapidly evaluate the traits of crops under various environmental settings.

Challenges and Future Outlook

Merging technology and agronomy are all positive things but the challenges remain.

· Cost and accessibility: Advanced tools are still inaccessible to many smallholder farmers.

· Data management will secure quality, interoperability, and security of data.

· Agronomists need digital skills to apply and make sense of data.

· Rural connectivity is poor; real-time data exchange is difficult.

Conclusion

Technology is changing the agronomy game with things like drones and sensors, AI and robots. These advances allow for more ecological and less wasteful crop and soil management. Although there are still issues with accessibility and uptake, the direction of agronomic science is very much towards digital. As agriculture becomes more complex, the agronomist will grow from an adviser in the fields to an expert who interprets data. Agronomy will therefore evolve into a key player on the global stage for food security and environmental resilience. For more content related to agronomy, please contact Fertilizer Association of India.

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