



Adoption of Precision Farming Techniques in Maize Production

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INTRODUCTION

Maize (*Zea mays* L.) is a staple food crop for over a billion people and a vital component of livestock feed and bioenergy production. However, maize yields are often limited by inefficient use of inputs such as water, fertilizer, and pesticides. Additionally, climate variability and increasing production costs have made traditional farming practices less effective.

Precision farming addresses these challenges by using technology to manage variability within fields. It enables farmers to apply inputs accurately and efficiently, ensuring that each plant receives the right amount of nutrients, water, and protection at the right time. This practice is increasingly being adopted in maize production across both developed and developing countries.

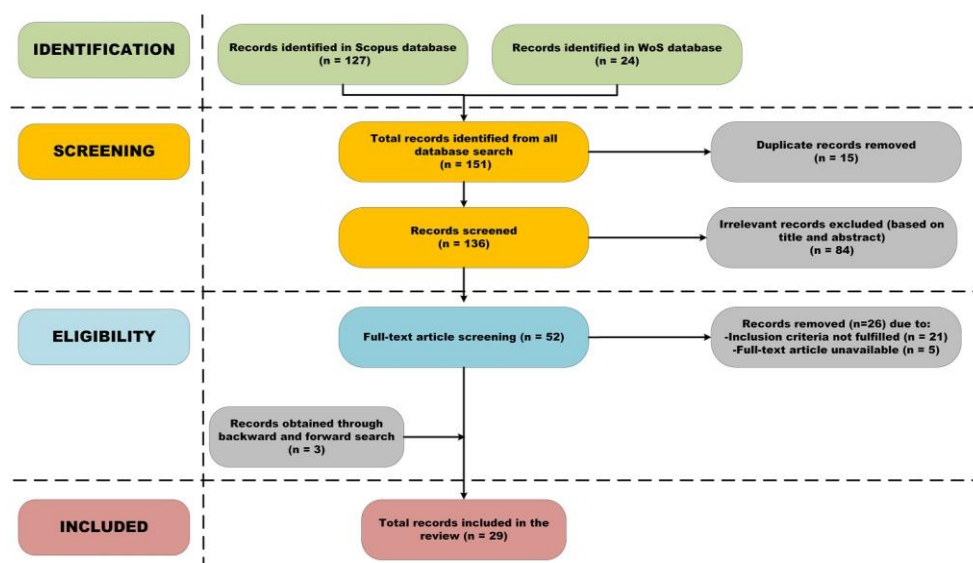
This article examines the key precision farming techniques applied in maize cultivation, their benefits, current adoption trends, barriers to implementation, and policy recommendations.

2. Core Precision Farming Techniques in Maize Production

Precision farming involves a suite of tools and technologies designed to monitor, measure, and respond to crop variability. The following are the major precision techniques used in maize farming:

2.1 Global Positioning System (GPS) and Geographic Information Systems (GIS)

GPS and GIS are foundational tools in precision agriculture. They allow farmers to create detailed field maps and record spatial variability in soil properties, yield, and crop health. With GPS-guided machinery, planting, spraying, and harvesting are more accurate, reducing input waste and overlap.



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2.2 Variable Rate Technology (VRT)

VRT enables site-specific application of inputs like seeds, fertilizers, and pesticides. For instance, nitrogen fertilizer can be applied more heavily in areas of the field with higher yield potential and reduced in lower-productivity zones. This leads to better nutrient use efficiency and lower environmental impact.

2.3 Remote Sensing and Drones

Remote sensing tools, including satellites and UAVs (drones), help monitor crop health, soil moisture, and pest/disease outbreaks. Using NDVI (Normalized Difference Vegetation Index) maps, farmers can detect stress early and respond precisely.

2.4 Soil and Yield Mapping

Soil sampling, combined with georeferenced data, helps create fertility maps. Yield monitors installed on harvesters provide real-time yield data, which can be analyzed to identify trends and problem areas for future planning.

2.5 Precision Planting

Modern seeders equipped with precision technology allow for uniform planting depth and spacing. In maize, this ensures even germination, better stand establishment, and more uniform crop development.

2.6 Irrigation Management Systems

In areas where water is scarce or expensive, precision irrigation systems such as drip irrigation, center pivots with soil moisture sensors, and automated controllers optimize water use and timing, improving both yield and water-use efficiency.

3. Benefits of Precision Farming in Maize Cultivation

3.1 Increased Yields and Productivity

By tailoring management practices to local conditions, precision farming can significantly improve maize yields. Field trials have shown yield gains of 10–25% with optimized input application compared to conventional methods.

3.2 Improved Input Efficiency

Precision agriculture reduces the overuse of fertilizers, pesticides, and water. VRT application cuts fertilizer costs by up to 20%, while precision irrigation can save 30–50% of water compared to flood irrigation.

3.3 Environmental Sustainability

Targeted use of chemicals reduces runoff and contamination of water bodies. Moreover, reduced input use lowers greenhouse gas emissions, contributing to climate-smart agriculture.

3.4 Cost Savings and Profitability

Although initial investment is high, long-term operational costs decrease. Increased yield and reduced waste contribute to higher net returns, especially for large-scale farmers.

3.5 Enhanced Data-Driven Decision-Making

Access to real-time data allows maize farmers to make better decisions about planting, fertilization, irrigation, and pest management. Seasonal planning becomes more efficient and responsive.

4. Current Adoption Trends

4.1 High Adoption in Developed Countries

In countries like the United States, Brazil, and parts of Europe, precision farming adoption in maize is widespread. Large-scale mechanized farms benefit from advanced technologies and data analytics platforms.

4.2 Growing Interest in Developing Regions

In sub-Saharan Africa and Asia, awareness of precision agriculture is growing. Projects funded by governments, NGOs, and agribusinesses have introduced GPS-based soil testing, SMS-based crop advisory services, and mobile apps for farmers.

For example, in Kenya, platforms like *Hello Tractor* and *iShamba* are helping smallholders access precision services via smartphone. In India, startups like *CropIn* and *NinjaCart* are offering digital solutions for maize producers.

5. Barriers to Adoption

Despite its advantages, several challenges hinder the widespread adoption of precision agriculture in maize production, especially among smallholder farmers.

5.1 High Initial Investment

Equipment such as GPS-guided tractors, drones, and VRT-enabled sprayers require substantial capital. Many smallholders cannot afford these technologies without subsidies or cooperative models.

5.2 Technical Complexity

Precision farming systems require training to interpret data, use software, and maintain

devices. Lack of technical knowledge is a major hurdle, especially in rural areas.

5.3 Inadequate Infrastructure

Reliable internet connectivity, electricity, and access to repair services are prerequisites for many digital tools. Poor infrastructure in rural areas limits adoption.

5.4 Data Privacy and Ownership Issues

Farmers may be reluctant to share field data with private companies or platforms due to concerns about misuse or lack of transparency.

5.5 Fragmented Land Holdings

In many regions, farms are small and fragmented, making it difficult to justify or implement advanced precision systems.

6. Strategies to Enhance Adoption

To increase the adoption of precision farming in maize production, stakeholders must address economic, technical, and institutional barriers.

6.1 Government Support and Subsidies

Governments can promote adoption through subsidies, tax incentives, and low-interest loans for precision equipment. They can also invest in infrastructure such as rural broadband and rural electrification.

6.2 Farmer Cooperatives and Shared Services

Farmer groups or cooperatives can collectively purchase and operate precision equipment. Custom hiring centers can rent GPS tractors or drones to smallholder farmers at affordable rates.

6.3 Capacity Building and Training

Training programs through extension services, NGOs, and private agritech companies are essential to teach farmers how to use and benefit from precision tools. Digital literacy should also be promoted.

6.4 Public-Private Partnerships

Collaborations between governments, tech companies, and research institutions can scale solutions by combining funding, technology, and farmer outreach.

6.5 Tailored Technologies for Smallholders

Low-cost, smartphone-based tools and sensors tailored to small plots are needed. Open-source software and scalable models can help democratize access to precision agriculture.

7. CONCLUSION

Precision farming offers transformative potential for maize production. It enables farmers to manage resources more efficiently, increase productivity, and adapt to climate variability. While adoption is high in developed economies, developing regions are rapidly catching up through innovative business models and digital solutions.

Overcoming financial, technical, and infrastructure barriers is key to mainstreaming these technologies. With targeted policy support, partnerships, and continued innovation, precision farming can drive sustainable maize production for both smallholders and commercial growers alike.

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