



Agronomy and Soil Science: Partners for Food Security

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INTRODUCTION

Food security has become one of the most critical issues of the 21st century. The global population, currently estimated at 8 billion, is projected to reach nearly 10 billion by 2050, placing unprecedented pressure on agriculture to produce more food. According to the Food and Agriculture Organization (FAO), global food demand will need to increase by at least 50 percent by mid-century to meet human nutritional needs. However, this challenge is compounded by the shrinking availability of arable land, declining soil fertility, climate variability, and growing competition for water and other natural resources.

Despite technological advancements in agriculture, hunger and malnutrition remain widespread. The FAO's *State of Food Security and Nutrition in the World 2023* reported that around 735 million people face chronic hunger, and nearly 2.4 billion people lack regular access to nutritious food. These numbers highlight that food security is not only about producing sufficient calories but also about ensuring access to diverse and nutrient-rich diets. Vegetables, pulses, and cereals grown in healthy soils form the foundation of such diets, underscoring the importance of sustainable production systems that are grounded in both agronomy and soil science.

Healthy soils are central to sustainable agriculture. They provide essential nutrients, store and filter water, support biodiversity, and regulate atmospheric gases by storing carbon. Yet, soils are under increasing stress. The FAO estimates that one-third of the world's soils are moderately to highly degraded due to erosion, salinization, compaction, acidification, and chemical contamination. Each year, around 24 billion tons of fertile soil are lost globally through erosion, leading to reduced crop yields and declining farm incomes. Soil degradation is particularly severe in South Asia and sub-Saharan Africa, regions that are also hotspots for food insecurity.

This is where the discipline of agronomy becomes critical. Agronomy focuses on optimizing the use of soil, water, and biological resources to produce crops more efficiently. It provides practical solutions such as crop diversification, integrated nutrient management, and conservation tillage that enhance productivity while protecting natural resources. Advances in agronomic research also emphasize climate adaptation through the use of drought-tolerant varieties, precision irrigation, and modified sowing patterns to cope with unpredictable weather patterns.

The partnership between agronomy and soil science is not simply complementary but interdependent. Soil science generates the knowledge of soil properties, fertility status, and degradation processes, while agronomy applies this knowledge to design effective cropping systems and management practices. For example, soil testing reveals nutrient deficiencies, and agronomists translate this into site-specific fertilizer recommendations. Similarly, understanding soil-water interactions enables agronomists to devise irrigation schedules that maximize water use efficiency.

Therefore, integrating agronomy with soil science is essential for achieving global food security. This partnership ensures that

agricultural intensification does not come at the expense of soil health and environmental stability. By combining knowledge of the soil ecosystem with innovative crop production techniques, farmers can achieve higher yields, greater resilience to climate change, and long-term sustainability. As the world faces the dual challenge of feeding a growing population and preserving natural resources, strengthening this partnership will be fundamental in building resilient agricultural systems capable of nourishing both people and the planet.

The Importance of Soil in Agriculture

Soil as a Living System

Soils are not inert matter but dynamic ecosystems that contain minerals, organic matter, air, water, and billions of organisms. These components interact to regulate nutrient cycles, support root growth, and influence plant productivity.

Soil Degradation and Food Security Risks

Global agriculture faces severe soil degradation caused by erosion, nutrient depletion, salinization, compaction, and contamination. The Food and Agriculture Organization (FAO) estimates that one-third of the world's soils are degraded, threatening the foundation of global food systems.

Table 1. Soil Functions Essential for Food Security

Soil Function	Contribution to Agriculture	Example Impact on Crops
Nutrient cycling	Supplies nitrogen, phosphorus, potassium, and micronutrients	Grain filling in cereals, vegetable quality
Water regulation	Stores and supplies water to plants	Drought resilience in wheat and maize
Habitat for organisms	Hosts microbes for nitrogen fixation and pest suppression	Improved legume productivity
Carbon storage	Sequesters carbon and mitigates climate change	Climate resilience for crops

Agronomy: Science of Efficient Crop Production

Crop and System Management

Agronomy designs systems that maximize production while maintaining ecological balance. Practices such as crop rotation, intercropping, and cover cropping sustain soil fertility, reduce pest pressures, and stabilize yields.

Efficient Input Use

Agronomists develop strategies to optimize fertilizer, pesticide, and water use. Precision farming technologies, including remote sensing and soil mapping, allow farmers to apply inputs

exactly where and when they are needed, reducing costs and environmental impacts.

Climate Adaptation through Agronomy

Agronomy plays a vital role in adapting agriculture to climate change. By introducing stress-tolerant crop varieties, shifting planting dates, and designing water-saving irrigation systems, farmers can maintain yields under unpredictable weather conditions.

The Intersection of Soil Science and Agronomy

Soil Testing and Fertilizer Management

Soil science provides critical information about soil nutrient status and fertility, while agronomy

applies this knowledge to design fertilizer schedules that match crop needs. This integration reduces over-fertilization and enhances yield.

Conservation Agriculture

Conservation practices such as minimum tillage, residue retention, and diversified rotations combine soil preservation with agronomic efficiency. These practices increase soil organic matter, reduce erosion, and improve crop resilience.

Agroforestry and Integrated Systems

Agroforestry, where trees are integrated into farming systems, demonstrates how soil science and agronomy work together to improve soil fertility, reduce erosion, and enhance biodiversity while supporting crop and livestock productivity.

Case Studies of Soil and Agronomy Synergy

1. **Rice-Wheat Systems in India:** Integrated nutrient management, where chemical fertilizers are combined with farmyard manure and compost, increased yields by 15 to 20 percent compared with conventional practices, while also improving soil health.
2. **Conservation Tillage in Maize Systems (USA):** Farmers practicing minimum tillage reduced soil erosion by 70 percent and improved water infiltration, maintaining competitive yields over decades of use.
3. **Legume Intercropping in Sub-Saharan Africa:** Planting legumes such as cowpea alongside maize improved soil nitrogen levels naturally, reduced fertilizer demand, and contributed to improved household food security.

Table 2. Integrated Practices Linking Soil Science and Agronomy

Practice	Soil Science Role	Agronomy Role	Impact on Food Security
Soil testing and fertilization	Identify deficiencies and nutrient balance	Prescribe balanced input use	Higher yields and lower costs
Conservation agriculture	Maintain soil organic matter	Adjust tillage and crop rotations	Sustainable long-term productivity
Legume integration	Enhance nitrogen fixation	Incorporate into cropping systems	Reduced fertilizer dependency
Precision irrigation	Monitor soil moisture	Design efficient irrigation schedules	Increased water productivity

Challenges to Integration

Despite the potential, many barriers hinder the effective integration of soil science and agronomy:

- Limited access to soil testing services for smallholder farmers.
- High costs of precision agriculture technologies.
- Lack of awareness about soil health among farmers.
- Policy frameworks that emphasize short-term yields over long-term sustainability.

The Way Forward

Strengthening Research and Extension

Stronger collaboration between soil scientists, agronomists, and extension workers is needed to translate laboratory research into on-farm solutions.

Policy Support and Incentives

Governments can provide subsidies or incentives for sustainable practices such as cover cropping, organic amendments, and conservation tillage.

Farmer Education and Participation

Training programs and farmer field schools should be established to promote knowledge of soil health and agronomic practices, ensuring adoption at the grassroots level.

CONCLUSION

Agronomy and soil science together provide the foundation for achieving global food security in an era of rising challenges. Healthy soils supply the essential nutrients, water, and biological diversity that crops require, while agronomy ensures that these resources are used wisely through improved crop management, efficient input use, and resilient farming systems. When combined, these disciplines create farming practices that not only boost productivity but also protect the environment and improve the livelihoods of farming communities.

The urgency of this partnership is underscored by growing threats such as soil degradation, climate change, and population growth. Without fertile soils and sustainable crop

management, future generations will struggle to produce enough food. Yet with integrated approaches such as conservation agriculture, integrated nutrient management, crop diversification, and precision farming, agriculture can become both more productive and more sustainable.

Food security is not just about producing more food but about producing it in ways that safeguard soil health, reduce environmental harm, and ensure resilience against climate stress. Strengthening collaboration between agronomists, soil scientists, policymakers, and farmers is essential to develop and scale up innovative practices. By investing in research, farmer education, and supportive policies, societies can build agricultural systems that feed the world today while preserving soil resources for tomorrow.

In this way, agronomy and soil science, as true partners, offer a pathway to resilient and

sustainable food systems that can meet the nutritional needs of a growing global population while protecting the planet that sustains us all.

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