



## One Acre, Three Crops: The Science Behind Winning Crop Sequences

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### INTRODUCTION

Agriculture has always been constrained by the availability of land, water and nutrients. As the global population increases and cultivable land declines due to urbanization and environmental degradation, improving productivity from existing farmland has become a critical challenge. Smallholder farmers in many parts of the world depend on limited landholdings for food production and income generation. Under such conditions, efficient land use practices become essential for ensuring economic viability and food security. Sequential cropping systems, in which two or more crops are cultivated on the same field within a year, represent one of the most effective strategies for maximizing agricultural output. Among these systems, three crop sequences have gained particular attention because they allow continuous land utilization while improving resource efficiency and reducing ecological risks.

Crop sequencing involves more than simply planting crops one after another. It is a scientific approach that considers interactions among crops, soil nutrients, water availability, pest populations and climatic conditions. The success of a crop sequence depends on selecting compatible crops with complementary growth habits, nutrient demands and maturation periods. Traditional agricultural communities often practiced crop rotations based on empirical knowledge passed through generations. Modern agricultural science has refined these practices through research in soil science, agronomy, plant physiology and ecology. Today, crop sequences are increasingly designed using data-driven approaches that integrate climate forecasting, soil testing and precision agriculture technologies.

## Concept and Importance of Crop Sequencing

- ❖ Crop sequencing refers to the planned arrangement of crops in a specific order over time within the same field. The primary objective is to maximize productivity while maintaining or improving soil health and ecological balance.
- ❖ Sequential cropping systems increase cropping intensity by reducing fallow periods and ensuring continuous utilization of land resources. Instead of cultivating a single crop annually, farmers can harvest multiple crops from the same area within a year.
- ❖ The importance of crop sequencing extends beyond productivity

enhancement. Proper sequences improve nutrient cycling, reduce pest and disease pressure, conserve soil moisture and diversify farm income sources.

- ❖ Different crops influence soil properties differently. Legumes enrich soil nitrogen through biological nitrogen fixation, while deep-rooted crops improve soil structure and nutrient recycling from lower soil layers. Alternating crops with different root systems and nutrient requirements helps maintain soil fertility.
- ❖ Crop sequencing also contributes to climate resilience. Diversified systems reduce dependence on a single crop and lower the risk of complete crop failure due to adverse weather conditions or market fluctuations.

**Table 1:** Major Objectives of Scientific Crop Sequencing

Objective	Benefit
Efficient land use	Increased annual productivity
Nutrient management	Improved soil fertility
Pest suppression	Reduced pest and disease cycles
Water utilization	Better moisture efficiency
Economic diversification	Stable farm income

## Scientific Principles Behind Crop Sequences

Successful crop sequences are based on several agronomic and ecological principles.

### Crop Compatibility

Crops selected for a sequence should complement each other in terms of growth duration, nutrient demands and environmental requirements. Crops with overlapping peak resource demands may compete excessively for water and nutrients.

### Nutrient Dynamics

Different crops remove and contribute varying amounts of nutrients. Including legumes in crop sequences improves nitrogen availability through symbiotic fixation. Heavy nutrient-demanding crops should ideally follow legumes or crops that improve soil fertility.

Scientific nutrient budgeting ensures balanced nutrient cycling within the system.

### Root Architecture

Alternating shallow-rooted and deep-rooted crops improves soil resource utilization. Deep-rooted crops recover nutrients from deeper soil layers and improve soil aeration.

### Pest and Disease Management

Continuous cultivation of related crops encourages the buildup of pests and pathogens. Rotating crops from different botanical families interrupts pest life cycles and reduces disease incidence.

### Water Management

Crop sequences should align with rainfall patterns and irrigation availability. Drought-tolerant crops are often included during dry seasons to reduce water stress.

**Table 2:** Examples of Crop Functions in Sequential Cropping Systems

Crop Type	Primary Function
Legumes	Nitrogen fixation
Cereals	High grain productivity
Oilseeds	Economic diversification
Root crops	Soil structure improvement
Fodder crops	Livestock integration

### **Nutrient Cycling and Soil Fertility**

One of the most significant advantages of scientific crop sequencing is improved nutrient management. Continuous monocropping often depletes specific nutrients and leads to soil degradation. In contrast, diversified sequences enhance nutrient recycling and organic matter accumulation.

Leguminous crops such as soybean, mung bean and chickpea contribute biologically fixed nitrogen to the soil. This reduces dependence on synthetic nitrogen fertilizers and improves sustainability. Crop residues also play a critical role in nutrient cycling. Residues from cereals add carbon-rich organic matter, while legume residues decompose rapidly and release nitrogen.

Sequential cropping enhances microbial activity and soil biodiversity. Diverse root exudates support beneficial microbial communities involved in nutrient mineralization and disease suppression. Long-term studies demonstrate that well-planned crop rotations improve soil structure, water infiltration and cation exchange capacity.

### **Water Use Efficiency in Three Crop Systems**

Efficient water management is essential in intensive cropping systems where multiple crops are cultivated annually. Crop sequences are often designed according to seasonal rainfall distribution and irrigation availability. Crops with high water requirements are usually cultivated during rainy seasons, while drought-tolerant crops are grown during dry periods.

Conservation agriculture practices such as residue retention and minimum tillage improve soil moisture conservation. Sequential cropping also improves overall water productivity by increasing total output per unit of water used annually. Scientific irrigation scheduling based on crop growth stages and evapotranspiration rates further enhances efficiency.

### **Pest and Disease Management Through Crop Sequencing**

- ❖ Crop sequencing is an effective ecological tool for reducing pest and disease pressure.
- ❖ Monoculture systems create stable environments favourable for pest multiplication. Repeated cultivation of the same crop allows pests and pathogens to accumulate over time.
- ❖ Rotating crops disrupts pest life cycles by removing host plants and altering habitat conditions.
- ❖ Including non-host crops in sequences reduces populations of soil-borne pathogens and insect pests. For example, rotating cereals with legumes suppresses many cereal-specific diseases.
- ❖ Crop diversification also supports natural enemies such as predators and parasitoids by providing habitat and alternative food resources.
- ❖ Integrated pest management programs frequently incorporate crop sequencing as a preventive strategy.

### **Examples of Successful Three Crop Sequences**

#### **Rice, Wheat, Mung Bean Sequence**

This sequence is widely practiced in South Asia. Rice is cultivated during the monsoon season, followed by wheat in winter and mung beans in summer. Mung beans improve soil nitrogen levels and provide additional income while reducing fallow periods.

#### **Maize Potato Onion Sequence**

This intensive system is common in irrigated regions with high market demand for vegetables. Maize provides grain and biomass, potato offers high economic returns and onion enhances profitability.

#### **Soybean Wheat Fodder Maize Sequence**

This sequence integrates crop and livestock production systems. Soybeans enrich soil nitrogen, wheat provides grain and fodder and maize supports livestock feeding.



**Figure 1.** Example of a scientifically planned three crop sequence showing rice, wheat and mung bean cultivation on the same field across different agricultural seasons.

### Economic Benefits of Sequential Cropping

- ✓ Three crop systems often generate significantly higher annual income compared with single crop systems.
- ✓ Continuous land utilization improves labour efficiency and increases annual output per unit area.
- ✓ Diversified cropping reduces economic risks associated with price fluctuations and crop failure.
- ✓ Value addition opportunities increase when sequences include vegetables, pulses or oilseed crops with high market demand.
- ✓ Smallholder farmers particularly benefit from intensive cropping because it maximizes returns from limited land resources.

### Challenges in Three Crop Systems

Despite their advantages, intensive crop sequences face several challenges.

- ❖ Continuous cultivation may increase pressure on soil nutrients if residue management and fertilization are inadequate.
- ❖ Water scarcity limits the feasibility of intensive systems in some regions.
- ❖ Timely field operations are essential because delays in harvesting or planting can disrupt entire sequences.
- ❖ Labour shortages, mechanization constraints and market fluctuations may also affect profitability.
- ❖ Pest populations may adapt to certain rotation patterns if crop diversity is insufficient.

- ❖ Sustainable management practices are therefore essential for maintaining long-term productivity.

### Future Prospects of Sequential Cropping

- ❖ Future agricultural systems will increasingly rely on efficient resource utilization and climate-resilient practices.
- ❖ Research continues to develop improved crop varieties, conservation agriculture methods and digital farming tools for optimizing crop sequences.
- ❖ Agroecological approaches integrating crop diversification, soil conservation and ecological pest management will likely become more important.
- ❖ Urbanization and shrinking farmland may further encourage intensive production systems capable of generating higher output from smaller areas.
- ❖ Policy support, farmer training and investment in agricultural infrastructure will play crucial roles in promoting scientifically designed crop sequences.

### CONCLUSION

Scientific crop sequencing represents a powerful strategy for maximizing productivity, sustainability and resilience in modern agriculture. Three crop systems on one acre of land demonstrate how efficient planning and ecological understanding can transform limited resources into highly productive agricultural systems. Successful crop sequences rely on principles of nutrient cycling, crop compatibility, pest management and water

efficiency. When properly designed, these systems improve soil fertility, reduce environmental risks and enhance economic returns. As global agriculture faces increasing challenges from climate change, land scarcity and population growth, diversified sequential cropping systems offer practical solutions for sustainable food production. Future advances in agricultural science, precision farming and climate adaptation technologies will further strengthen the role of crop sequencing in achieving resilient and productive farming systems.

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