

Intercropping: A Resurgent Strategy for Sustainable Agriculture in the 21st Century

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Abstract

With modern agriculture confronting major challenges like climate change, resource scarcity, and the need to feed a rising global population, an ancient practice, intercropping, is seeing a significant resurgence. By growing multiple crops together, intercropping offers a comprehensive way to build more resilient, productive, and sustainable farming systems (Li 2016). This article will discuss intercropping's uses, benefits, and drawbacks, its place in modern farming, and its recent progress and future prospects.

Keywords: Sustainable Agriculture, Crop Diversification, Resource Use Efficiency, Pest Management, Climate Resilience

Introduction

Intercropping, also known as mixed cropping or polyculture, is a farming technique where farmers grow two or more crops close together, either in the same row, in alternating rows, or in strips. The main idea behind this method is to get the most out of available resources and take advantage of helpful interactions between different plant types. This approach stands in stark contrast to monoculture, which involves cultivating a single crop over a large area, often resulting in less biodiversity and a greater need for external inputs like fertilizers or pesticides. Various types of intercropping exist:

- Mixed Intercropping: Two or more crops are sown together without a distinct row arrangement.
- Row Intercropping: Crops are planted in alternating rows or strips.
- Relay Intercropping: A second crop is sown after the first crop has established but before it is harvested, allowing for sequential harvesting.
- Strip Intercropping: Crops are grown in separate strips wide enough for independent cultivation, but close enough to interact.
- Trap Cropping: A “trap crop” is planted to attract pests away from the main cash crop.
- Push-Pull System: Combines repellent plants to “push” pests away from the main crop with attractant plants (trap crops) to “pull” them towards a specific area.



Figure 1. Intercropping of Maize with Legume

Uses and Advantages of Intercropping

The benefits of intercropping are numerous and address many of the limitations of conventional monoculture systems (Li 2016).

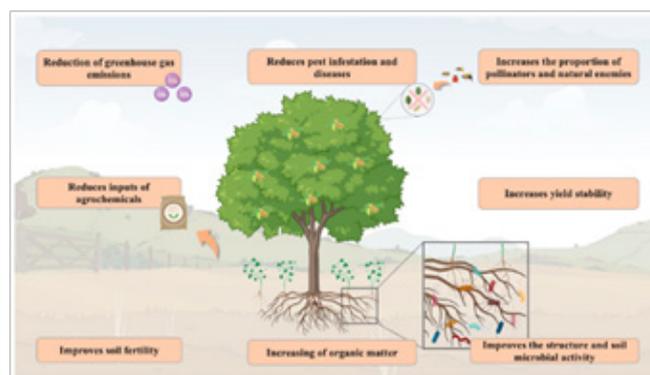


Figure2. Benefits of intercropping

1. Increased Productivity and Resource Use Efficiency:

1. Higher Yields: Intercropping boosts overall yield per unit area, as quantified by the Land Equivalent Ratio (LER), because different crops efficiently use resources like light, water, and nutrients from varying soil depths and at different times. For example, taller crops can capture sunlight while shorter, shade-tolerant crops thrive underneath them. (Zhang et al. 2025).

- o **Optimized Water Use:** Crops with varying rooting depths can access water from different soil profiles, improving overall water use efficiency, especially in arid and semi-arid regions.
- o **Enhanced Nutrient Cycling:** Leguminous crops like beans and peas enhance soil fertility by fixing atmospheric nitrogen, making it available for neighboring non-leguminous plants and reducing the need for synthetic fertilizers.. (Akchaya et al. 2025).

2. Improved Soil Health and Fertility:

- o **Increased Organic Matter:** Diverse root systems contribute to greater soil organic matter accumulation, improving soil structure, water retention, and microbial activity.
- o **Reduced Soil Erosion and Compaction:** Continuous ground cover provided by multiple crops, especially those with different root structures, helps to prevent soil erosion from wind and water, and reduces soil compaction.

3. Natural Pest and Disease Management (Bybee-Finley and Ryan 2018).

- o **Pest Deterrence:** The presence of multiple plant species can confuse pests, making it harder for them to locate their preferred host plants. Some intercrops release biochemicals that repel specific pests.
- o **Attraction of Beneficial Insects:** Certain intercrops can attract natural enemies of pests, such as predatory insects and parasitoids, promoting biological pest control.

4. Economic Benefits:

- o **Increased Income:** Multiple marketable products from the same land can lead to higher overall profitability.

- o **Reduced Input Costs:** Less reliance on synthetic fertilizers, pesticides, and herbicides translates to lower production costs.

Challenges of Intercropping

Despite its numerous benefits, intercropping faces several hurdles, particularly in highly mechanized agricultural systems:

- **Complex Management and Labor:** Intercropping demands meticulous planning, including selecting compatible crop combinations and optimizing planting strategies. Tasks like planting, weeding, and harvesting are often more time-consuming and labor-intensive than in monoculture due to the varied needs and timelines of multiple crops.
- **Potential for Crop Competition:** Without careful planning, intercropped plants can excessively compete for essential resources like light, water, and nutrients, potentially reducing yields for some crops.
- **Complex Pest and Disease Management:** While intercropping generally reduces pest and disease pressure, certain crop combinations can inadvertently host specific pests or diseases, complicating control efforts and integrated pest management strategies.
- **Harvesting and Marketing Hurdles:** Different maturity times among intercrops necessitate staggered harvesting, adding logistical complexity. Marketing mixed or combined produce can also be more challenging than selling uniform monoculture crops.
- **Nutrient Imbalance:** While some intercrops (like legumes) enhance nitrogen, other combinations can lead to an imbalanced extraction of different nutrients from the soil, requiring specific fertilization approaches to maintain soil health.

Research advancements in intercropping

Current research in intercropping aims to boost its effectiveness and broader application by focusing on:

- **Mechanization and Automation:** Developing specialized machinery for planting, cultivating, and harvesting intercropped fields to reduce labor and increase efficiency.
- **Breeding for Intercropping:** Creating new crop varieties specifically suited for intercropping, with traits like shade tolerance and synchronized maturity.
- **Microbial Interactions:** Investigating the complex relationships between plants and soil microbes in intercropped systems to improve nutrient cycling and suppress diseases (Akchaya et al. 2025).
- **Climate-Smart Intercropping:** Exploring intercropping as a strategy to enhance climate change adaptation, carbon sequestration, and greenhouse gas reduction.
- **Pest and Disease Ecology:** Gaining deeper understanding of how intercropping disrupts pest cycles, attracts beneficial insects, and influences disease dynamics, including the “push-pull” strategy (Bybee-Finley and Ryan 2018).
- **Socio-economic Aspects:** Assessing the economic viability of intercropping for farmers and improving market access for diversified produce, as demonstrated by projects like LEGUMINOSE (Innovative Farmers 2025).

The Future of Intercropping

Intercropping is poised to play an increasingly vital role in the future of sustainable agriculture. Key trends and future directions include:

- **Increased Adoption in Diverse Climates:** While traditionally prevalent in tropical regions, research is expanding intercropping's application to temperate and considering factors like shorter growing seasons and specific crop requirements.
- **Integration with Digital Agriculture:** The use of sensors, drones, and AI for monitoring crop growth, nutrient status, and pest outbreaks in intercropped fields will enable more precise and efficient management.
- **Consumer Demand for Sustainable Products:** Growing consumer awareness about environmentally friendly food production will likely drive demand for crops grown using practices like intercropping.
- **Policy Support and Incentives:** Governments and agricultural organizations are likely to offer more incentives and support for farmers adopting diversified and sustainable farming practices, including intercropping.

Conclusion

Intercropping, which combines ancient farming practices with modern agricultural research, is a potent strategy for creating a more sustainable and reliable food system. By utilizing its benefits and actively working to overcome its drawbacks through continuous research and innovation, intercropping can play a vital role in boosting agricultural output, improving environmental well-being, and strengthening farming communities globally.

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