# Integrated Farming Systems for Sustainable Horticulture Development: A Review on Intercropping Practices and Benefits

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**Abstract:** This review examines the transformative potential of Integrated Farming Systems (IFS) in modern agriculture, with particular emphasis on intercropping strategies and their impact on sustainable farming practices. The study analyzes how IFS approaches, incorporating diverse elements such as crop-livestock integration, agroforestry, and systematic crop rotation, contribute to agricultural resilience and productivity. Through comprehensive analysis of recent research, this paper demonstrates that IFS, especially when combined with intercropping techniques, delivers multiple benefits: enhanced soil health, improved pest management, efficient water utilisation, and increased crop diversity. The findings indicate that integrated approaches not only boost agricultural output but also promote environmental stewardship and economic stability for farmers. This review further highlights the critical role of these systems in addressing contemporary agricultural challenges, including climate change adaptation, resource conservation, and food security concerns.
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## 1. Introduction

### 1.1 Overview of Integrated Farming systems (IFS)

Modern agriculture faces multiple challenges, including food safety concerns, accessibility issues, and quality maintenance amid growing population pressures (Sharma *et al.*, 2023). Among these are the increasing environmental effects, reduced resource capital, and low farm revenue/rate of return which are some of the risks that affect the sustainability of the agricultural production systems (Fatima *et al.*, 2023). The ideas of intensive farming have been adopted over time to improve the rate of farming as a result of population pressure, high consumption rates and industrialisation that was witnessed in the twentieth century has some negative impacts like degrading the habitat, decreasing biodiversity and food insecurity (Sheng *et al.*, 2018). The problems are as follows: Agricultural growth rate is still low in Africa, crop yields are declining, high levels of hunger and malnutrition, reduction in the available land area to produce crops, climatic change affect agricultural water resource in agriculture. These problems lead to high input costs, reduction in revenues and finally loss of employment (Prakash *et al.*, 2015). The increase mechanisation and the use of better equipment in the farming practices however has also contributed to the increased use of energy in the agriculture sector but this comes with some negative impacts on the ecology and some health complications such as animal feeds, fossil energy, pesticides and fertilisers, electricity, mechanical means among others The increase in energy use in the agriculture practices has been as a result of the modern techniques of farming as stated by Kumar *et al.*, 2019. (To avert the impacts of highly mechanised and commercialised farming systems, aspects of sustainability and selection for better production efficiency have been promoted by means of the herd management (McKenzie *et al.*, 2016). Consequently, the farmers and anyone with interest in the farming business must find value in the theory being promoted and respect the notion of an ecological farming. Similarly, IFS is another complex method which also possesses the ability to give immediate solutions towards the aforementioned immediate problems relating food and nutritional insecurity of the farmer's livelihood and may have a positive impact towards the conservation of the environment (Fatima *et al.*, 2023).

Today's farming systems must deliver on five important goals; to feed the growing population, provide income for farmers, preserve and enhance biological resources, reduce emissions of greenhouse gases, and adapt to the changing climate. Contemporary farming methods of the world's agriculture are complex and composite farming systems; crop production is the tree crops, cereals, vegetables, fisheries, livestock production, and bee keeping among others. The farming system is a complex structure obtain from the various factors including labour, land, capital and management, which is in a steady state of change. These components are nevertheless not separable as they are closely linked and influence the effectiveness and stability of the farming system, (Behera *et al.*, 2020).

Integrated Farming Systems rely on intercropping as a vital strategy, enhancing farm productivity by 265% and employment by 143%. By diversifying crops, intercropping promotes nutrient recycling, improves soil quality, conserves biodiversity, and increases soil organic carbon. This approach makes IFS climate-resilient, reducing greenhouse gas emissions. While small farmers face adoption challenges, prioritising intercropping in IFS fosters sustainable agriculture, boosting resilience and ecosystem services, and ensuring a sustainable agricultural sector (Paramesh et al,. 2022).

### 1.2 Importance of horticulture in agriculture

Horticulture is the branch of agriculture that particularly deals with the cultivation of plants such as fruits, vegetables, flowers, trees, shrubs, and herbs as well as herbal plants. Horticulture food chain play a vital role in the satisfaction of the ever growing world population through food production. Its prospects are more preferable for a sustainable and environment friendly structure in ecosystem. They are plants that are cultivated to be beautiful as their purpose is closely connected to the existence of mankind. (Muhammad *et al.*, 2021). It is important to bring the quality and safety of horticultural crops/produce into focus. Horticulture is an important sub-field of plant science that deals with diverse crops. The definitions of horticulture available in the literature are as under and have undergone slight modification over a period of time due to changes in the objectives and domains of horticulture. First, horticulture in anthropological terminologies referred to as "the production of crops within an enclosure" (Bailey, 1939). In the earlier periods the horticultural crops were cultivated within the confined area marked with boundary walls which was called garden. As time went on the necessity for food grew and the cultivation of horticultural crops continued to spread to the open fields with no limitations and for business (Denisen, 1979). According to Janick (1986) the term horticulture was defined as the division of agriculture that deals with plants that are grew and managed intensively for food, medication or for beauty. This definition of the horticulture involves cultivating, processing and marketing of fruits, vegetables and ornamental plants in the modern world (Acquaah, 2005).

It is reported in a study carried out by Muhammad Jafar Jaskani *et al.* (2021) that the horticulture sector can have viable prospects for improving earning, eradicating poverty and diminishing socio-economic inequality. Horticultural products bear the potential of creating foreign exchange via agricultural export. There has been a progressive enhancement in the export earnings of the horticultural crops which has been observed in the recent past. Population projection of the world is expected to reach, 8 billion people by the year 2025 as estimated by Gelsdorf in 2010. One of the issues that are rising when it comes to feeding this growing population is hunger which is currently affecting 1 billion people and malnutrition that affects more than 3 billion people. The horticulture industry is among the biggest industries that can significantly enhance food security, employment, and boost the economy. According to WHO Food Security is defined as; "It is a situation where people regularly obtain adequate, proper and safe food to meet their nutritional requirement and food preferences necessary for a healthy lifestyle". The three pillars of food security include food accessibility, availability and consumption/nutrition; horticulture can support these pillars and provide better chances for enhanced food security, nutrition and incomes and employment. Fruits, vegetables and nuts horticulture products are again essential for daily human consumption as they contain micronutrients, fibre, vegetable proteins and bio-functional product. Vegetables particularly the leafy ones are recognised to contain vitamins A and C, iron, calcium and some other minerals.

That horticultural food intake could be a sustainable means of combating nutrients could therefore be understood in terms of dietary diversification. Moreover, the fruits and vegetables are considered as important in the prevention of non-infectious diseases.

## 2. Integrated Farming Systems: Origin and Components

### 2.1 Origin and history of IFS

At the agricultural property of Lautenbach in the Federal Republic of Germany, in 1978, a significant division was established between a "traditional" farming system and an IFS, which uses less input. On the 245 hectares, the Lautenbach Project got its start in 1978. The goal of the study was to distinguish between the two farming systems—"integrated" and "conventional" in terms of both productivity and ecological impacts. Titi and Ipach (1989), Akinrinola *et al*. (2023) and Olowoake and Akinrinola (2024) examined the impact of both agricultural strategies on the components of soil fauna.

The study conducted by Titi and Ipach (1989) on the Lautenbach farm demonstrated that the integrated farming system had lower population densities of the plant parasite species *Ditylenchus dipsaci* and *Heterodera avenae* whereas the conventional farming system had higher densities of saprophytic and predatory nematodes. Fertiliser is used sparingly in integrated farming, although it is used optimally in conventional farming. To increase income, catch crops such as vegetables are sown in between main crops and clover (*Trifolium alexandrinum*), which is also utilised as a feed crop. Fisheries, cattle, and crops are the main elements of an integrated system of farming. Numerous other businesses, such as biogas, agroforestry, and mushrooms, have been incorporated to reduce waste and obtain higher returns on nutrients. The selection of IFS components takes into account several factors such as the type of soil, rainfall patterns, crop growth season duration, local market conditions, and so on. The application of IFS elements on any farm is also influenced by the requirements and available resources of the farmers. (Prasad Lal *et al.*, 2023).

2.2 **Sustainability benefits of IFS**

Bhati *et al.*, 2024, reports that when compared to single enterprise farms, IFS can significantly increase farm profitability (265%) and job opportunities (143%). In addition, IFS can improve soil quality indicators, reduce the need for external input purchases, recycle nutrients, and conserve biodiversity. Adoption of IFS can also improve soil organic carbon and reduce greenhouse gas emissions. IFS is promoted as a viable tactic to reduce greenhouse gas emissions, boost agricultural productivity, and restore degraded pastures (Gill *et al.*, 2010). Environmental pollution can be decreased and resilient, productive, and sustainable systems can be created through better agronomic management and biodiversity protection. According to Bell *et al*. (2014), combining perennial forages with cropping techniques including alley cropping, agroforestry, and intercropping offers a variety of ways to improve carbon sequestration and nutrient availability while lessening the effects of climate change. IFS is a workable approach to lower nutrient loss and greenhouse gas emissions through improved nutrient recycling and the use of crop leftovers as animal feed, according to Barbosa *et al.* (2015).

**3. Intercropping: A Key Practice in IFS**

**3.1 Definition and concept**

Intercropping is a cornerstone of IFS which offers a viable solution to address shrinking agricultural space, environmental degradation, and unsustainable farming practices. By cultivating multiple crop species simultaneously, intercropping maximises yield per unit area, mitigates pests and diseases, minimises pollution, and optimises resource utilisation (Turan *et al.*, 2022). This approach promotes diversified resource utilisation, soil conservation, water efficiency, and reduced chemical dependence, enhancing overall productivity and ecosystem services (Dodiya et al, 2018; Blessing et al, 2022). In contrast to monoculture systems reliant on chemicals, intercropping in IFS fosters soil health, water conservation, and climate change mitigation, providing a sustainable alternative to address soil degradation, water pollution, and air emissions (Samantha et al, 2020). By embracing intercropping, farmers can promote sustainable agriculture, enhance ecosystem services, and ensure long-term food security.

An integrated cropping system incorporating intercropping, strip rotation, soil mulching, and reduced tillage enhances sustainability. Sixteen field experiments (2006-2017) showed that intercropping boosts annual crop yields by 15.6-49.9% and farm returns by 39.2%, while decreasing the environmental footprint by 17.3%. Intercropping is a crucial component, promoting resource efficiency and synergy. Smallholder farmers can adopt this integrated system to increase food production while minimising ecological impact. By prioritising intercropping, IFS can achieve dual goals: enhanced productivity and reduced environmental degradation, ensuring a sustainable agricultural future (Chai *et al*., 2021; Adeola *et al*., 2024).

**3.2 Adoption of intercropping practices in horticultural system**

Intercropping practices in IFS, has been a traditional farming method in China for thousands of years, promoting efficient utilisation of environmental resources, steady yields, and minimised input usage (Feike *et al.*, 2010; Hong *et al.*, 2017). The common practices of intercropping systems in Intercropping Systems in Integrated Horticultural Farming are presented in Table 1. As intensive vegetable cultivation depletes resources, intercropping offers a sustainable alternative (Table 2), with benefits including boosted household income (Table 3), especially for lower-income families (Min *et al.*, 2017). Factors influencing adoption include farm size, education, access to extension services, available funds, ethnicity, wealth, labour availability, and plot characteristics (Kota *et al.*, 2021; Min *et al.*, 2017). Successful intercropping systems, such as maize-vegetable and cotton-vegetable, have been developed and disseminated through state extension services, with farmers citing efficient land use and plant health benefits (Feike *et al.*, 2010). However, challenges persist, including intensified crop management, labour requirements, and knowledge gaps (Himanen *et al.*, 2016). Recent studies highlight the significance of education, mass media exposure, inheritance, age, caste, annual income, landholding size, and extension contacts in influencing intercropping adoption (Boora *et al.*, 2023). By understanding these factors, policymakers and practitioners can promote intercropping as a vital component of IFS, enhancing sustainable agriculture and food security.

**4. Benefits of Intercropping in Horticultural Systems**

**4.1 Space efficiency and yield maximisation**

Intercropping optimises land use by combining plant species with complementary characteristics, resulting in higher overall yields compared to monocultures (Li *et al.*, 2020b). For example, a study by Abd El-Gaid *et al.* (2014) found that intercropping tomatoes and common beans in a 1:3 ratio resulted in the highest Land Equivalent Ratio (LER) values of 1.26 and 1.25 in consecutive seasons.

Table 1. Common Intercropping Systems in Integrated Horticultural Farming

| Intercropping System | Description | Example Crops | Key Principle |
|---|---|---|---|
| Row intercropping | Crops planted in alternate rows | Tomato + onion | Spatial separation of root/foliar space |
| Strip intercropping | Crops grown in wider strips | Vegetables + legumes | Combines independent management with diversity |
| Mixed intercropping | Crops grown without distinct rows | Leafy vegetables + herbs | Increases diversity and complementary interactions |
| Relay intercropping | Second crop planted before first is harvested | Maize + legumes | Efficient use of temporal space |
| Agroforestry intercropping | Trees with annual crops | Fruit trees + annual vegetables | Integrates perennial and annual production |

Source: Melkamu (2023)

**4.2 Nutrient and water use efficiency**

Intercropping enhances fertiliser efficiency through greater humus accumulation, diverse root systems, and varying rates of nutrient absorption by different crops (Dodiya *et al.*, 2018; Akinrinola *et al.*, 2022). Leguminous intercrops, in particular, can fix nitrogen, reducing the need for synthetic fertilisers (Dowling *et al.*, 2021). Additionally, intercrops can improve fertiliser retention by reducing runoff and erosion (Andrews *et al.*, 2020; Adeola *et al.*, 2023).

**4.3 Soil fertility preservation**

Legume intercrops play a crucial role in increasing soil fertility and biodiversity while enhancing crop production and reducing fertiliser use (Marcos-Perez *et al.*, 2023; Adeola *et al.*, 2023; Adeola *et al.*, 2024). A study comparing monoculture broccoli with various broccoli-fava bean intercropping arrangements found that intercropping systems maintained soil organic carbon levels and increased soil total nitrogen, available phosphorus, and exchangeable potassium (Marcos-Perez *et al.*, 2023).

**4.4 Pest and disease management**

Intercropping can help decrease insect pest populations and disease incidence, though its effectiveness varies depending on the specific pests and crops involved (Singh *et al.*, 2017; Akinpelu *et al.*, 2019). For example, intercropping cabbage with tropical basil (*Ocimum gratissimum* L.) in South Benin significantly reduced pest abundance and damage to cabbage (Yarou *et al.*, 2017). Similarly, intercropping melons with aromatic plants like peppermint, lavender, and rosemary showed positive effects on reducing aphid populations (Raisi *et al.*, 2020).

**Table 2. Agronomic and Environmental Benefits of Intercropping**

| Benefit Category | Observed Effect | Mechanism Involved | Contribution to Sustainability |
|---|---|---|---|
| Enhanced biodiversity | More beneficial arthropods | Diverse crop niches support natural enemies | Reduces pest pressure |
| Weed suppression | Lower weed density | Shading and competition | Reduces herbicide use |
| Improved nutrient use | Efficient nutrient uptake | Niche complementarity (e.g., legumes + cereals) | Reduces fertilizer reliance |
| Yield stability | More stable output | Resource partitioning | Resilience to climate variability |
| Soil health improvement | Better structure and fertility | Root diversity and organic matter addition | Long-term soil sustainability |

Sources: FAO (2023), Rakotomalala et al. (2023)

Table 3. Socio-Economic Benefits of Intercropping for Horticulture Development

| Benefit | | Description | Relevance for Smallholder Farmers |
|---|---|---|---|
| Income diversification | | Multiple crops harvested at different times | Better cash flow and reduced risk |
| Reduced input costs | | Lower pesticide/fertilizer use | Higher profitability |
| Food security | | More diverse production | Improved household nutrition |
| Climate resilience | | Greater tolerance to climatic stress | Supports adaptation to variability |
| Improved resource efficiency | | Higher productivity per unit land | More food from limited land |

Sources: Anchal and Sharma (2025), Ullah et al. (2025)

### 4.5 Risk management and economic benefits

Intercropping serves as a risk management strategy by diversifying crops within the same land area. This approach spreads the risk of crop failure, as adverse conditions affecting one crop may not impact others as severely. For instance, intercropping cauliflower with lettuce maintains cauliflower yield while providing additional lettuce harvest, optimising resource utilisation and reducing financial risks associated with input costs (Turan *et al.*, 2022).

## 5. Challenges and Limitations of IFS and Intercropping

Despite the numerous benefits, implementing IFSs and intercropping practices faces several challenges:

1. Technical Complexity: Farmers may lack the knowledge and skills required to integrate different farming components effectively.
2. Economic Viability: Initial implementation costs can be high, especially for small-scale farmers, and financial benefits may take time to materialise.
3. Market Access: Traditional supply chains may struggle to handle the diverse range of products produced in IFS.
4. Land and Water Availability: Limited land and water resources may constrain the expansion of integrated systems in densely populated or water-scarce areas.
5. Policy and Institutional Support: Inadequate policy frameworks and institutional support can hinder the scaling up of IFS initiatives.
6. Social Acceptance: Traditional farming methods and cultural norms may impede the adoption of IFS, necessitating education and awareness-building efforts.

## CONCLUSION

Research on Integrated Farming Systems and intercropping practices demonstrates their significant positive impact on horticulture and overall agricultural sustainability. IFS improves environmental stewardship, productivity, and profitability through diverse agricultural techniques. Intercropping, as a key component of IFS, enhances crop diversity, pest control, and soil health management, reducing risks and building resilience in farming enterprises.

The adoption of IFS and intercropping practices holds great potential for striking a balance between agricultural production and environmental preservation. These approaches promote resource efficiency, biodiversity conservation, and a reduction in chemical inputs, all of which contribute to sustainable practices in horticulture and beyond.

### Future Research Directions

To further advance the adoption and effectiveness of IFSs and intercropping practices, several areas require additional research:

1. Development of location-specific study modules on farming systems for various holding sizes, agro-climatic conditions, and socio-economic circumstances.
2. Creation of policies that promote IFS on a broad scale, including financial support mechanisms for initial implementation.
3. Long-term studies on soil nutrient dynamics under continuous cropping and the regeneration of manurial resources in multi-system approaches.
4. Integration of soilless farming methods (e.g., hydroponics) with sustainable practices and precision agriculture to increase resource efficiency and crop diversity.
5. Assessment of the economic viability and market potential for diverse products from IFS and intercropping systems.
6. Development of tailored extension and training services to educate farmers about the benefits and operations of IFS and intercropping.

By addressing these research gaps and overcoming the identified challenges, IFSs and intercropping practices can play a crucial role in promoting sustainable horticultural development and ensuring food security for future generations.

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**References**

1. Abd El-Gai MA, Al-Dokeshy MH, Nasse MTD. Effects of intercropping system of tomato and common bean on growth, yield components and land equivalent ratio in New Valley Governorate. Asian Journal of Crop Science 2014;6(3):254–261. https://doi.org/10.3923/ajcs.2014.254.261
2. Acquaah G. Horticulture: principles and practices. Pearson Education Inc.; 2005. Upper Saddle River, NJ, USA.
3. Adeola RO, Akinrinola TB, Fagbola O. Maize and soya bean response to the residual influence of early-season cropping system and fertiliser applications. Chilean Journal of Agricultural and Animal Sciences 2024;40(1):33–43. https://doi.org/10.29393/CHJAAS40-4MSRO30004
4. Adeola RO, Akinrinola TB, Fagbola O. Performances of maize and soybean as influenced by intercropping and fertilizer sources in the Northern Guinea Savanna agro-ecology of Nigeria. Journal of Central European Agriculture 2023;24(3):667–680. https://doi.org/10.5513/JCEA01/24.3.3753
5. Akinpelu OA, Fagbola O, Aminu-Taiwo BR, Akinrinola TB. Influence of plant parasitic nematode control amendments on soil pH, bacteria and fungi population under three plantain varieties. Nigerian Journal of Horticultural Science 2019;24(2):121–131. https://www.hortson.org.ng/images/Journals/2019volume/Akinpelu_et_al_2019.pdf
6. Akinrinola TB, Adedokun OT, Olowoake AA. Performance of African scarlet garden egg and associated soil microbial populations as affected by single super phosphate fertiliser in Ibadan, Nigeria. Nigerian Journal of Ecology 2023;19(2):82–95. https://nigerianjournalofecology.org/wp-content/uploads/2025/04/82-95-NJE-19_2-Akinrinola-et-al.pdf
7. Akinrinola TB, Nwagboso IO, Fagbola O. Responses of okra and soil microbial population changes to the application of Tithonia manure. International Letters of Natural Sciences 2022;85:1–11. https://doi.org/10.56431/p-8l2von
8. Anchal AK, Sharma S. Intercropping: a sustainable holistic approach. International Journal of Research in Agronomy 2025;8(4):2757–2768. https://www.agronomyjournals.com/archives/2025.v8.i4.B.2757
9. Andrews JS, Sanders ZP, Cabrera ML, Hill NS, Radcliffe DE. Simulated nitrate leaching in annually cover-cropped and perennial living-mulch corn production systems. Journal of Soil and Water Conservation 2020;75(1):91–102. https://doi.org/10.2489/jswc.75.1.91
10. Bailey LH. The standard cyclopedia of horticulture. Macmillan; 1939. New York, USA.
11. Barbosa FA, Soares-Filho BS, Merry FD, Azevedo HO, Costa WLS, Coe MT, Batista ES, Maciel TC, Sheepers LC, Oliveira AR. Cenários para a pecuária de corte amazônica. IGC/UFMG; 2015. p. 1–154.
12. Bell LW, Moore AD, Kirkegaard JA. Evolution in crop–livestock integration systems that improve farm productivity and environmental performance in Australia. European Journal of Agronomy 2014;57:10–20. https://doi.org/10.1016/j.eja.2013.04.007
13. Bhati P, Saikia AR, Chaudhary S, Bahadur R, Nengparmoi T, Talukdar N, Hazarika S. Integrated farming systems for environmental sustainability: a comprehensive review. Journal of Scientific Research and Reports 2024;30(1):143–155. https://doi.org/10.9734/jsrr/2024/v30i11834
14. Blessing DJ, Gu Y, Cao M, Cui Y, Wang X, Asante-Badu B. Overview of the advantages and limitations of maize–soybean intercropping in sustainable agriculture and future prospects: a review. Chilean Journal of Agricultural Research 2022;82(1):177–188. https://doi.org/10.4067/S0718-58392022000100177
15. Boora S, Kaur B, Tyagi R, Bishnoi DK, Manisha, Rohit. Extent of adoption of intercropping practices among farmers of Haryana. Indian Journal of Extension Education 2023;59(1):1–6. https://doi.org/10.48165/IJEE.2023.59105
16. Chai Q, Nemecek T, Liang C, Zhao C, Yu A, Coulter JA, Wang Y, Hu F, Wang L, Siddique KHM, Gan Y. Integrated farming with intercropping increases food production while reducing environmental footprint. Proceedings of the National Academy of Sciences 2021;118(38):e2106382118. https://doi.org/10.1073/pnas.2106382118

17. Denisen EL. Principles of horticulture. 2nd ed. Collier Macmillan Publishers; 1979. London, UK.
18. Dodiya TP, Gadhiya AD, Patel GD. Effect of intercropping in horticultural crops: a review. International Journal of Current Microbiology and Applied Sciences 2018;7(2):1512–1520. https://doi.org/10.20546/ijcmas.2018.702.182
19. Dowling A, Sadras VO, Roberts P, Doolette A, Zhou Y, Denton MD. Legume–oilseed intercropping in mechanised broadacre agriculture: a review. Field Crops Research 2021;260:107980. https://doi.org/10.1016/j.fcr.2020.107980
20. Fatima S, Nausheed R, Hussain SM, Fatima I, Begum N, Siddiqua R. Assessment of soil fertility status of mango orchard at Vikarabad farmhouse, Telangana State. Acta Botanica Plantae 2023.
21. Feike T, Chen Q, Graeff-Hönninger S, Pfenning J, Claupein W. Farmer-developed vegetable intercropping systems in southern Hebei, China. Renewable Agriculture and Food Systems 2010;25(4):272–280. https://doi.org/10.1017/S1742170510000293
22. Food and Agriculture Organization. Intercropping enhances agroecosystem services and functioning: current knowledge and perspectives. FAO; 2023. https://www.fao.org/agroecology/database/detail/en/c/1028831
23. Gelsdorf K. Global challenges and their impact on international humanitarian action. OCHA Occasional Policy Briefing Series 2010.
24. Gill MS, Singh JP, Gangwar KS. Integrated farming system and agricultural sustainability. Indian Journal of Agronomy 2010;54(2):128–139.
25. Himanen SJ, Mäkinen H, Rimhanen K, Savikko R. Engaging farmers in climate change adaptation planning: assessing intercropping as a means to support farm adaptive capacity. Agriculture 2016;6(3):34. https://doi.org/10.3390/agriculture6030034
26. Hong Y, Heerink N, Jin S, Berentsen P, Zhang L, van der Werf W. Intercropping and agroforestry in China: current state and trends. Agriculture, Ecosystems & Environment 2017;244:52–61. https://doi.org/10.1016/j.agee.2017.04.019
27. Janick J. Horticulture science. W.H. Freeman and Company; 1986. San Francisco, USA.
28. Kota S, Malavath R, Reddy R, Thirupathi I. Adoption of intercropping practices by cotton farmers in Mancherial District of Telangana State. International Journal of Plant & Soil Science 2021;33:46–52. https://doi.org/10.9734/IJPSS/2021/v33i730449
29. Kumar S, Kumar R, Dey A. Energy budgeting of crop–livestock–poultry integrated farming system in irrigated ecologies of eastern India. Indian Journal of Agricultural Sciences 2019;89:1017–1022. https://doi.org/10.56093/ijas.v89i6.90826
30. Lal SP, Mahendra A, Rozi A, Verma M. Origin and history of integrated farming system: grassroots experiences and revival through agrotourism. In: Entrepreneurship in Integrated Farming System. Daya Publishing House; 2023. p. 1–15.
31. Li C, Hoffland E, Kuyper TW, Yu Y, Zhang C, Li H, Zhang F, van der Werf W. Syndromes of production in intercropping impact yield gains. Nature Plants 2020;6(6):653–660. https://doi.org/10.1038/s41477-020-0680-9
32. Marcos-Pérez M, Sánchez-Navarro V, Zornoza R. Intercropping systems between broccoli and faba bean enhance crop production and soil fertility. Scientia Horticulturae 2023;312:111834. https://doi.org/10.1016/j.scienta.2023.111834
33. McKenzie FC, Williams J. Sustainable food production: constraints, challenges and choices by 2050. Food Security 2015;7:221–233. https://doi.org/10.1007/s12571-015-0441-1
34. Dugassa M. Intercropping as a multiple-advantage cropping system: a review. International Journal of Research in Agronomy 2023;6(1):44–50. https://doi.org/10.33545/2618060X.2023.v6.i1a.167
35. Min S, Huang J, Bai J, Waibel H. Adoption of intercropping among smallholder rubber farmers in Xishuangbanna, China. International Journal of Agricultural Sustainability 2017;15(3):223–237. https://doi.org/10.1080/14735903.2017.1315234
36. Olowoake AA, Akinrinola TB. Impact of biochar amended with compost and arbuscular mycorrhizal inoculation on soil chemical properties and yield of cowpea. Technoscience Journal for Community Development in Africa 2024;3:72–82.
37. Paramesh V, Ravisankar N, Behera U, Arunachalam V, Kumar P, Rajkumar RS, et al. Integrated farming system approaches to achieve food and nutritional security and climate resilience in India. Food and Energy Security n.d. https://doi.org/10.1002/fes3.321
38. Raisi A, Aroiee H, Nabavi Kalat SM, Nemati H. Intercropping effect of melon cultivars and medicinal plants on pest control and yield. Iranian Journal of Medicinal and Aromatic Plants Research 2020;35(6):967–976. https://doi.org/10.22092/ijmapr.2019.125923.2535
39. Rakotomalala AA, Ficiciyan AM, Tscharntke T. Intercropping enhances beneficial arthropods and

controls pests: a systematic review and meta-analysis. Agriculture, Ecosystems & Environment 2023;356:108617. https://doi.org/10.1016/j.agee.2023.108617

40. Samantha GC, Hashemi M, Sadeghpour A, Jahanzad E, Afshar RK, Liu X, Herbert SJ. Understanding intercropping to improve agricultural resiliency and environmental sustainability. Advances in Agronomy 2020;162:199–256. https://doi.org/10.1016/bs.agron.2020.02.004
41. Singh A, Weisser WW, Hanna R, Houmgny R, Zytynska SE. Reduce pests, enhance production: benefits of intercropping at high densities for okra farmers in Cameroon. Pest Management Science 2017;73(10):2017–2027. https://doi.org/10.1002/ps.4636
42. Titi E, Ipach U. Soil fauna in sustainable agriculture: results of an integrated farming system at Lautenbach, FRG. Agriculture, Ecosystems & Environment 1989;27:561–572.
43. Turan M, Erenler S, Ekinci M, Yildirim E, Argin S. Intercropping of cauliflower with lettuce for sustainable fertilizer management. Sustainability 2022;14(13):7874. https://doi.org/10.3390/su14137874
44. Ullah F, Saqib S, Qin-Zheng H, Zaman W, Xiong YC. Intercropping for sustainable agroecosystems: enhancing biodiversity and mitigating greenhouse gas emissions. Mitigation and Adaptation Strategies for Global Change 2025;30:10263. https://doi.org/10.1007/s11027-025-10263-4
45. Yarou BB, Assogba Komlan F, Tossou E, Mensah CA, Simon S, Verheggen F, Francis F. Efficacy of basil–cabbage intercropping to control insect pests in Benin. Communications in Agricultural and Applied Biological Sciences 2017;82:1–8.
46. Yıldırım E, Ekinci M. Intercropping systems in sustainable agriculture. Ziraat Fakültesi Dergisi 2017;12(1):1–10.

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