



Multiple cropping potential in sustainable agriculture and doubling up income of farmers in India: A review

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Abstract

In order to increase agricultural productivity in constrained farming areas, marginalized small-holder farmers have traditionally used the multiple cropping agriculture system. In this paper, the practices used by marginalized farmers in general are highlighted, along with a brief assessment of the advantages of multiple cropping. Because of the distinct seasonality and growth behavior, it is typically believed that various cropping approaches encourage companion crops to efficiently utilize various resources such as water, air, nutrients, water, space and light in temporal as well as spatial dimensions. In a situation, where safety of food and nutrition are major concerns, multiple cropping may be a practical approach to deal with uncertainties and changes. In challenging or difficult environments, the final result of multiple cropping could be seen as an increase in agricultural output, a guarantee of subsistence, and an increase in farm income. Multiple cropping produces a variety of food products. By implementing a mixed/interpreting system, farmers can alleviate agrarian suffering. As a result, even if the selling price of one harvest is lower than the others, multiple cropping makes it possible to receive multiple crops at once. Farmers may produce more food, quadruple their revenues, and contribute more to international development by using certain cropping patterns. For small scale farmers who make up the major fraction in emerging nations like India, the significance of multiple cropping is plainly implied by this.

Keywords: Cropping system; intercropping; multiple cropping; Indian farming; sugarcane

1. Introduction

Enhancing agricultural yields is necessary to prevent famines and malnutrition as a result of the expanding global population's requirement for increased food production. Prior strategies concentrated on growing the agricultural sector in order to increase agricultural output, which helped to improve security of food. About 45% overall increase of food production per person has been done, but for country like India with vast population this level has been deemed to be inadequate. To combat agrarian issues and promote farmers' well-being, income from agriculture is essential. To improve farmer welfare, lessen agrarian distress, and create parity between farmer and non-farmer incomes, the primary goal of doubling farmer income is essential. Food production must increase to meet the demands of an expanding global population. Doubling farmers' income by 2022 is a difficult but necessary goal. To double farmers' incomes, a three-pronged strategy centered on developmental activities, technological advancements, and legislative reforms in agriculture is required (<http://vikaspedia.in/agriculture/policies-and-schemes>). The uses of many farms can effectively double a farmer's revenue. Multiple cropping, a sort of miscellaneous cropping, is a technique in agricultural for growing more than one crops on the same piece of land at a time in a given year (Andrews, 1976). It is essential to grow different crops together in the majority of their growing periods in the multiple cropping systems at same time. However, they can be planted or harvested at different time. One major crop and one or more additional crops are typically grown together in intercropping with the main crop having the greatest economic or food production value.

Small farmers can boost land productivity and use of labor per unit of land available by engaging in this method, which involves intensifying land use (Seran and Brintha, 2010). Furthermore, by biologically fixing atmospheric nitrogen, intercropping grains and legumes can significantly replace the mineral nitrogen in the soil. As a result, this kind of patters for cropping is highly significant to enhance the fertility of soil. These patterns for cropping are an old method of intensive farming, not a recent development in agricultural science. These cropping patterns have been used around the world to increase land productivity in a limited space during the growing period by increase in labor intensity and use of land to gain higher profits and more stable agricultural earnings (Joshi, 2007).

All available environmental resources are used in these kinds of cropping systems to increase crop yield per unit area per unit time. Compared to monocropping, the biological efficiency of intercropping is increased by the use of a greater soil mass (Francis, 1989). These farming systems have numerous socio-economic, biological, and ecological benefits. This method appeals to smallholder farmers as a way to intensify land use while enhancing the production ability of the land and use of labor per unit of land available (Seran and Brintha, 2010). Tropical locations, which have longer growing seasons, higher temperatures, and greater rainfall, are those where intercropping patterns are more prevalent (Fininsa, 1996). Intercropping systems are generally more common in underdeveloped nations. Although intercropping has a long history, agricultural experts have paid it very little consideration. Recently, some interest has been raised as one of the options for adapting to climate change

(Degla et al., 2016). In India, multiple cropping is a widespread practise, primarily used by smallholder farmers. An intercropping system's characteristics change according on the soil, the climate, the local community's preferences, and the economic circumstances. Many scientists have used intercropping systems and demonstrated their effectiveness when compared to monocropping. Minimizing the danger of complete crop failures and obtaining diverse crops to use for his family's food and revenue are two most critical causes for small scale farmers for intercropping (Steiner, 1982). Additionally, intercropping systems make the use of water and nutrients available better, capture more radiation, decrease the danger of pests and diseases, reduce weed growth, and positively affects the physical condition of soil. In particular, the crops of cereal and legume in intercropping, improve and maintain fertility of soil, are more effective at using the growth factors (Ofori and Stern, 1987).

While intercrops like seasonal vegetables (cucurbits, brinjal, squash and lady's finger) and legumes (soybeans, groundnuts, mung beans) can be grown in orchards under tropical conditions, intercrops such as pea, garlic, radish, onion, kidney bean, chayote, potato, parsley and other crops available locally can be grown in subtropical and temperate regions to provide healthy and Along with weed control in the orchards, this will benefit growers economically (Sanginga and Woomeer, 2009).

2. Cropping system in India

The soil types and climatic factors that control the entire setting of agro-ecology for sustenance and the suitability of a single or a group of crops for growing govern Indian agriculture. In India, Kharif, Rabi and Zaid are the three distinct seasons in agriculture. Beginning with the South-West Monsoon, the Kharif season is when tropical crops including rice, bajra, jute, cotton, pigeonpea and jowar, are grown. The season Rabi lasts from October through November, when winter officially begins, until March through April. After the harvest of the crops for Rabi, the short-lived spring and summer agricultural season known as Zaid begins. In India the cropping systems are of four types, including (a) the rainy season cropping system, which is used to grow cotton, rice, sorghum, pearl millet (bajra), maize, and groundnuts, (b) winter cropping systems: sorghum, chickpea, wheat, barley, and oats are all farmed in this system, (c) plantation and other commercial crops: Important crops farmed in this system include sugarcane, tobacco, potatoes, jute, tea, coffee, coconuts, rubber, and spices & condiments, (d) mixed cropping: this system include cultivation of maize, sorghum, and pearl millet alongside pulse and some oilseed crops.

3. Multiple cropping in Indian farming systems

The physical, social, and economic considerations were taken into consideration when farmers decided which crops to be cultivated. On occasion, they rotate a specific crop combination over a period of time, while growing a variety of crops on their farms. However, it is notable that the finest techniques for farming adhere to specific cropping patterns always and cropping systems to increase productivity and preserve soil fertility. The concept of cropping pattern is dynamic since it shifts throughout both place and time. It can be described as the percentage of land that is currently planted with different crops. To put it another way, it is an annual pattern and geographical configuration for seeding and un-seeding over a specific region. Cropping pattern in India is governed by climate, temperature, rainfall, type of soil and technology. India's patterns of cropping are influenced by

rainfall, the environment, temperature, the kind of soil, and technology. The primary crops can be used as the basis crop and other potential alternative crops can be used to depict the cropping patterns in India. In order to classify crops, it is crucial to recognize them and the agro-climatic conditions they are displaying. For illustration, the categories of wheat, barley, and oats are combined. Fig. 1 shows different advantages of multiple cropping systems.

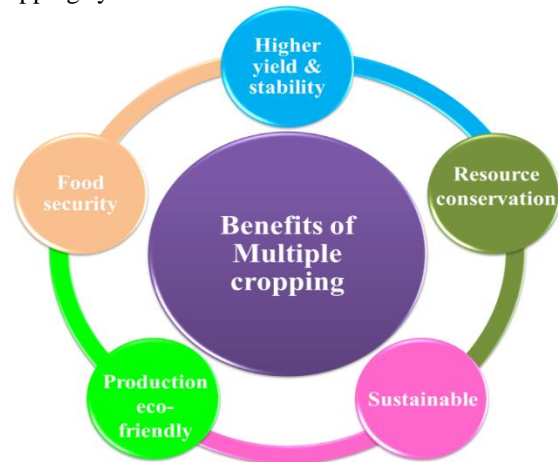


Fig. 1 Benefits of intercropping system

4. Multiple crops farming potential

There are several ways for improving production of food, including increase in cropping intensity, using various crops, using balanced input levels, and implementing efficient plant protection systems. The most successful method out of those is multiple cropping. Annual food crops, vegetables, fruit, fodders, trees, and perennial crops can all be planted multiple times (Degla et al. 2016). Through the use of mixed crops, the nation might be able to produce enough food on its own and export the extra to make money to pay for further programs. By definition, multiple cropping makes efficient inputs utilization including land, soil, water, fertiliser, labour, economical input, and all other variables of production. Row or seed intercropping, mixed cropping and relay cropping are all significant multiple cropping types that are used with key crops like legumes, cereals, vegetables, fruits, forage and fodder, as well as several other economically significant crops (Aiyer, 1942). Following are some examples of some crops that are regularly inter planted.

5. Sugarcane based cropping patterns

India after Brazil was the second-largest sugar producer with 70–80 t/ha output at an average globally. As an important cash crop, sugarcane accounts for 3% of total cultivated land or around 5 million ha, and for gross agricultural output value roughly 7.5% of the Nation. After cotton and the textile industry, the sugarcane industry is the second largest provider to employment. About 6 million farmers depend on the production of sugarcane for their livelihood, and the majority of agricultural labourers make a living by working on sugarcane. After implementing cutting-edge sugarcane cultivation techniques, farmers who are farming the crop can increase their income. The inter and multiple-cropping strategies used by sugarcane farmers not only increase their overall income but also allow them to increase it in nation's different regions. Minor crops in intercropping are mixed with or sown between major crops in rows in a specific ratio. For instance, when the major crop establishment takes a little time and there is least competition between major crop and the intercrops, a successful implant of mustard, onion, maize, melons, garlic, potato, coriander, okra, and fenugreek can be

done between the rows of sugarcane. The sowing and harvesting dates of the crops in intercropping could also vary. Sugarcane intercropping depends on the season in which it is grown. As a result different auxiliary crops within the main crop might be cultivated. One of the main farming systems used in India is one centred on rice.

6. Cropping patterns based on rice

Cropping systems based on rice are a combination of agricultural techniques that include primary crop, rice which is followed by the farming of further crops like various pulses, vegetables, cereals, fibre, and oil seeds crops. In many areas, rice intercropping and other suitable crops are also very common. Rice is intercropped with cowpea, maize, finger millet, small millet, and pigeonpea in Kerala.

Making tiny plots into thriving ecosystems, such as utilizing fishes and ducks in flooded fields of rice for controlling weeds and pests and provide nutrients to the plants with their excreta, could help small-scale farmers to increase output and reduce the costs. Ducks and fish can complement the farmer's diet with extra protein and perhaps improve the production of the land. In exchange, the fish and duck can help to remove some weeds and pests from the field of rice (Mukherjee, 2013).

7. Cropping patterns based on maize

7.1. Intercropping with legumes

In maize based as well as rice based farming systems legumes are significant. The following maize-based farming systems are used in uplands and incorporate legumes: maize-chickpea + mustard; maize-lentil + mustard; maize + cowpeas-mustard/wheat; maize-chickpea + barley/wheat; maize + pigeonpea-fallow; maize + soybean- mustard/wheat-pigeonpea- fallow; maize + black gram-mustard/wheat (Yadav, 2003). The ability of inter-crop components to occupy various niches is a result of their morphological and physiological variations (Keating and Carberry 1993). As a result, mixed stands of crops have the potential to use natural resources more effectively and convert them to biomass than pure stands. Legumes are intercropped with forage to enhance forage quality and preserve soil production. Cereal and legume mixtures are widely utilized to produce fodder.

8. Intercropping with medicinal plants

The global demand for medicinal and aromatic plants (MAPs), which play a significant role in boosting rural economies, is rising (Rawat and Puni, 2009). In general, plants of medicinal and aromatic values exhibit good vegetative development when inter-planted with horticultural crops, according to research (Ravitchandirane and Haripriya, 2011). Ashwagandha, Stevia, Khus, Coleus, Gotu Kola, Aloe Vera, Calendula, Basil, Rosemary, Thyme, etc. are often used in cooking daily, have positive effects on health, and are widely utilized by pharmaceutical businesses for therapeutic purposes. It can be advised to farmers to plant medicinal crops on a wide scale based on current market pricing.

9. Fruit-cum-fodder-cum-crops-cum-animal production systems

The ideal fodder trees for intercropping are those that are readily available locally and have space between the fruit trees (citrus: sour lemon, mandarin orange, sweet orange/naval orange, plum, peach, pear, jack fruit, banana, guava and apple). Numerous crops, including millets (primarily finger millet and

foxtail millet), maize and diverse variety of legumes (cowpea, green gram, rice bean,) can be grown simultaneously or in succession even on the terrace risers and slopes of hills and mountains in India. For fodder crops, where it can produce vast amounts of feed to support sustained animal production, multiple cropping is especially crucial. Thus, the integration of fruit, fodder, animals, and crops is among the most crucial subsystems of multiple cropping in India.

10. Role of multiple cropping in soil improvement

Fertility of the soil may also get maintained by multiple cropping systems, if the cropping system includes suitable crops like legumes. For instance, intercropping legumes could speed up the nitrogen fixation process and improve the soil's nutritional status. Since on same piece of land different crops are growing at the same time would demand different nutrients, multiple cropping has an essential benefit of improving nutrient utilisation. By keeping raindrops from striking bare soil, intercropping reduces soil erosion. Cowpea is the best cover crop and helps to prevent soil erosion in intercroppings of maize and cowpea. Taller crops are said to act as a wind break for shorter crops. According to studies, intercropping helps to preserve soil and enhances soil quality in a variety of ways. Due to the lack of an intercrop, which causes a high rate of soil surface water evaporation, the in mono-cropping weight of brinjal and pods were low in intercropping of brinjal + groundnut (Prashaanth et al. 2009). Complex crop mixtures with a variety of crops sustain or enhance soil microbial diversity, a sign of sound soil health. Thousands of hyphae of fungi and millions of individual bacterial colonies may be present in one gramme of soil, which may contribute to the maintenance of soil health (Altieri, 1999).

Table 1 Limitations of different intercropping systems

Intercropping Systems	Limitations
Strip	Growing of annual crops with perennial crops causes problem of shading for annual crops
Row	Laborious harvesting caused by different growth habits of crops, limited yield by interspecific competition in improperly choose crops.
Relay	In sequential cropping the succeeding crops may yield lower than the normal crops
Mixed	Separate harvesting causes intensive labor

11. Role of Multiple cropping in protection of plant

A variety of effects can be caused by mixed crops and cover crops by creating residues containing glucosinolates, over soil pathogens, including suppressing parasitic plant nematodes and soil-borne illnesses like Pythium species. In the production of lettuce the suppression of root-knot nematode (*Meloidogyne hapla*) is known to be caused by Sudan grass (hort.cornell.edu/expo/proceedings/2012). Possibly the release of cyanogenic substances in the breakdown process of the Sudan grass residue cause this suppression. It has been documented that various insect pest-repelling intercrops cultivated beneath sugarcane or fruit orchards, such as garlic, coriander, fenugreek and onion increase pollinators in the field.

In comparison with mono-cropping systems, intercropping also have some limitation which are summarized in Table 1 (Maitra et al., 2020).

12. Conclusion

Numerous social and economic benefits of diverse cropping have been stated by eco-agriculture, including avoiding reliance on one crop, requiring less energy imports, and favouring wildlife. Over mono-cropping, multiple cropping systems show several benefits according to studies have been conducted by various researcher. These advantages include for small and marginal farmers specifically in terms of biological, physical, social, and economic resource mobilization in a sustainable way. Multiple cropping makes more efficient utilization of time and vertical space, as well as the capture of nutrients and solar energy in an effective way. With regard to management of crop, control on insect and pest, and the effective temporal and geographical relations usage, it is a sustainable farming method with low input. Crop combinations permit the complex mutualisms operation better and advantageous organism interactions. Additionally, multiple cropping may be helpful in ensuring the security of food in emerging countries' constantly expanding populations and lowering hunger. There is sufficient data to conclude that multiple cropping is preferable to mono or single cropping. Drought, floods, hail, hurricanes, and diseases may completely destroy sole harvests. The value and benefits of multiple cropping over mono or solitary cropping must be made more widely known. Farmers' organizations, both local, regional, and international, as well as public and corporate institutions, can actively participate in achieving this.

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Author contributions

Kamini Singh has drafted the main manuscript, L.S. Gangwar, Brahm Prakash, Om Prakash, Pallavi Yadav, Chandra Bhan and Shalu Rawat have edited and reviewed the manuscript and Dr. Om Prakash has supervised the work.

Conflict of interest

The authors declare that they have no known conflict of interest.

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