

Diversification of rice-based cropping system with high-value crops for increased productivity and profitability

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As the world's population grows, so does the demand for food, putting pressure on the existing farming system to produce more. Crop diversification is an approach of fulfilling rising food demand by increasing the number of crops or substituting one or more crop with other in a cropping system. Crop diversification is intended to provide a wider choice in the crop production in a given area so as to expand production related activities on various crops while also minimizing risk. Due to prolonged adoption of existing rice-wheat cropping system, soil fertility and soil health is deteriorating which ultimately is affecting the sustainable food grain production. To meet the ever-increasing population's demand for cereal, pulses, and oilseeds, it was found that including oilseeds and pulses in a rice-based cropping sequence was more beneficial than cereal alone. Crop diversification can thus help to improve livelihoods, environmental stability, and financial prosperity.

Keywords: Crop diversification, Cropping system, Energetics, Productivity, Profitability, Rice-wheat

IN India, the rice-wheat is the most predominant cropping system. Despite the system's long-term stability, yield stagnation has been documented. The monotony of the system, as well as the exhaustive nature of the cereal—cereal crop sequence, are the main causes of production stagnation. Continuous rice cultivation especially under poor soil and crop management methods has resulted in soil fertility loss, multiple nutrient deficiency. Factor productivity also suffers due to declining soil quality. Crop diversification has been identified as a successful strategy for attaining the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, and the sensible use of land and water resources, as well as sustainable agriculture performance and environmental refinement. It allows farmers to make best possible use of available land, labour, water,

and other resources, minimize the risks of crop failures, yield losses, and market failures, and achieving faster or more consistent returns.

In India, marginal and small farmers account for more than 80% of the farming population, with only 32.5% of the total operational area. The income from a single season field crop is barely enough to sustain a small farmer's family need. As a result, cropping sequence must shift from a cereal-dominated system to a more productive and profitable cropping system with high-value crops. Considering rice is a staple diet in this region, we can either replace wheat or add other summer crops to the cropping sequence to intensify the system. Furthermore, including oilseed and vegetable crops will enhance the economic situations of small and marginal farmers by increasing the price and/or volume of their main and by-products.

Diversification options with high-value crops

Horizontal/vertical diversification is becoming more important in small-scale agricultural systems, with the potential to increase output and profitability by incorporating low water requiring, high-value crops into the existing rice-wheat cropping system. Small and marginal farmers will benefit from the inclusion of high value crops such as oilseeds, pulses, vegetables, and fodder crops due to better prices and/or volume of their main and by-products.

Due to weather patterns or social acceptability of the crops in the cropping system, different agro-climatic zones have varied cropping systems. Diversification of the existing cropping system also varies with the agro-climatic zone. The Zone wise distribution of alternate efficient cropping system is presented in Table 1.

Table 1. Zone wise distribution of alternate efficient cropping system

Zone	Prevalent cropping system	Alternate cropping system
Western Himalayan Region	Rice-wheat Maize-wheat	Rice-marigold-frenchbean Rice-potato-onion Rice-cabbage-onion Rice-pea-frenchbean Rice-radish-potato
Eastern Himalayan Zone	Rice-rice	Winter rice-toria-blackgram Winter rice-oat-greengram Winter rice-onion-cowpea
Upper Gangetic Plains Zone	Rice-wheat	<i>Dhaincha</i> (Sesbania)-potato-okra (lady's finger) Pearl millet-wheat-greengram
Middle Gangetic Plains Zone	Rice-wheat	Rice-potato-greengram Rice-onion
Lower Gangetic Plains Zone	Rice-rice	Winter rice-potato-jute Winter rice-potato-sesame Winter rice-mustard-summer rice
Trans Gangetic Plains Zone	Rice-wheat Pearlmillet-wheat	Maize-potato-greengram Groundnut-potato-pearlmillet
Western Plateau and Hill Zone	Soybean-wheat Sorghum-wheat	Soyabean-cabbage Soyabean-onion
Gujrat Plains and Hill Zone	Groundnut-wheat	Ground nut-potato-pearlmillet Castor-mustard-greengram
Western Plains and Ghats	Rice-rice	Rice-rice-okra (lady's finger) Rice-rice-sweet potato
East Coast and Ghat	Rice-rice	Rice-maize-cowpea Rice-groundnut-sesame
Western Dry Zone	Pearlmillet-wheat	Pearl millet-mustard Cluster bean-isabgol
Eastern Plateau and Hill Zone	Rice-fallow Rice-rice Rice-pulse	Rice-wheat-lentil Rice-potato-greengram
Central Plateau and Hill Zone	Soybean-wheat Fallow-wheat	Blackgram-mustard Soybean-onion
Island Zone	Rice-fallow	Coconut-ginger Coconut-clove Coconut-vegetables

(Source: IIFSR).



RICE



RICE



POTATO



BERSEEM



GREEN GRAM



MAIZE (F)

Rice-Potato-Green gram sequence

Rice-Berseem-Maize



RICE



MUSTARD



SUDAN GRASS (F)

Rice-Mustard-Sudan fodder



RICE



CABBAGE



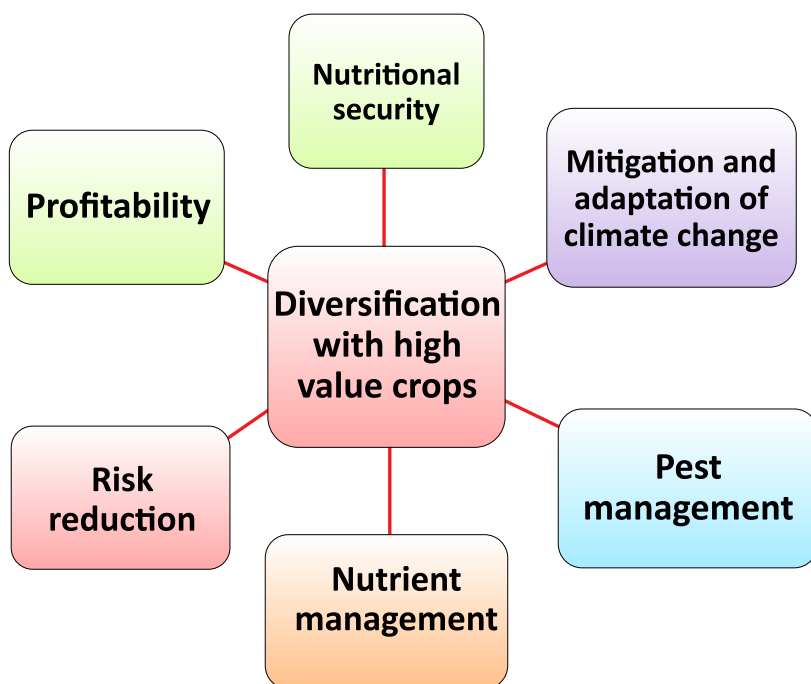
COWPEA (F)

Rice-Cabbage-Cowpea

Cropping system diversified with high-value crops (Author's field).

Productivity

The economic produce of different crops in different systems must be converted into rice equivalent yield (REY) for a more accurate comparison of cropping systems, taking into account the economic value of each crop and



Advantages of cropping system diversified with high value crops.

its market price. Addition of high-value vegetable crops in the cropping system enhances overall productivity of the system in terms of rice equivalent yield owing to the higher market price of the high-value crops as well as their higher production potential. In a field study at Varanasi, it was registered that high-value rice-potato-lady's finger gave highest system productivity followed by high-value rice-capsicum-vegetable cowpea, which was nearly 55%, 54% and 57%, 56% higher than conventional rice-wheat and rice-mustard system, respectively (Table 2). However, vegetable crops are harvested at higher moisture content and yield is measured in fresh weight basis that leads to higher yield and productivity.

Export import balance

High value crops are very export-friendly and have higher market prices as well as higher market demand. Hence, diversification of conventional cropping system with high value crops such as basmati rice, aromatic rice, spices, onion, cut flower and other vegetable crops are of greater importance. India is not sufficient enough in vegetable oil production, therefore diversifying some area for oilseed crops (mustard, soybean, ground nut etc.) can help India achieving self-sufficiency in vegetable oil production to some extent. However, the suitability of crops for diversification varies place-to-place due to soil, climatic conditions and according to the local preferences.

Table 2. Rice equivalent yield (REY) of different cropping systems

Treatment	REY of rainy crop (kg/ha)	REY of winter crop (kg/ha)	REY of Summer crop (kg/ha)	System REY (kg/ha/day)
Rice (rainy)-wheat (winter)	3579	4478	---	22.07
Rice (rainy)-mustard (winter)	3600	4097	---	21.09
High value aromatic rice (rainy)-potato (winter)-lady's finger (summer)	4263	7258	6519	49.42
High value aromatic rice (rainy)-capsicum (winter)-vegetable cowpea (summer)	4342	8371	4814	48.02

Employment generation and land use efficiency

Intensification of cropping systems enhances labour participation in the field, resulting in greater employment generation than conventional rice-based farming systems. Labour employment was maximum with high value rice-potato-lady's finger (357) followed by high value rice-capsicum-vegetable cowpea (305) (Table 3). In a field experiment, Karchoo *et al.* (2014) reported that rice-pea-lady's finger showed higher land use efficiency of 91% followed by rice-fenugreek (*methi*)-radish (89.65%) and rice-garlic-cowpea (86.6%) compared to 71% land use efficiency under traditional rice-wheat cropping system.

Profitability

High value crops are those with a higher market value than other traditional cereal crops. In a field study at Varanasi, cropping system with high-value rice-potato-lady's finger and high-value rice-capsicum-vegetable cowpea recorded 37% and 45% more system profitability over conventional rice-wheat cropping system (Table 3).

Table 3. System productivity and employment generation under different cropping system

Treatment	System profitability (₹/ha/day)	Labour employment
Rice-wheat-fallow	263.90	180
Rice-mustard-fallow	198.40	181
High-value rice-potato-lady's finger	424.63	357
High-value rice-capsicum-vegetable cowpea	485.22	305

Energetics

Because of rising energy costs, the era of low-cost energy is coming to an end, and energy conservation has become critical. If productivity is to be boosted in India, the availability of power on the farm must be increased. For timely and quality tillage, irrigation, harvesting, and threshing, more electricity is required. The Indian economy has

been harmed by the global energy crisis caused by fuel shortages and high petroleum prices. To alleviate the difficulty, non-renewable energy sources must be conserved, and existing conventional energy sources must be managed efficiently. Legumes need less energy than grains and oilseeds in the field. Alternative cropping systems must be designed so that, in addition to better production and profitability, they also behave as efficient energy converters. Although energy requirement of some high value crops are higher because of involvement of additional cultivation practices, but the energy output balances the energy input-output relationship.

Weed dynamics

Weed density and weed dry matter are affected by different cropping sequences. As the rice-based cropping system is diversified and intensified with multiple high-value crops, weed density and weed dry matter both decrease. Researchers found that weed density was significantly lower in rice-potato-greengram followed

by rice-berseem-cowpea and rice-cabbage-fodder cowpea. It has been observed that incorporating short-term leguminous crop or potato into the rice-wheat system efficiently controlled weeds without the use of herbicides or human weeding.

Risk management and nutritional security

Farm families in this country severely suffer from malnutrition and protein, mineral and vitamin deficiency. Therefore, intervention with high-value vegetable crops and other fortified crop varieties with higher nutrient content is an option for providing nutritional security to the farming community. Crop diversification is an effective strategy for dealing with any unfortunate crop failure. Having high-value crops in a system, on the other hand, not only reduces risk but also improve farmers' economic condition.

Nutrient management

Cereal based cropping systems are exhaustive in nature as they are the heavy feeder of nutrient. Hence, proper nutrient management is

crucial for getting maximum output of these cropping systems. Addition of leguminous vegetable crops enhances soil quality and enriches the soil with biological nitrogen fixation. Therefore, diversifying the traditional cropping systems with high-value leguminous vegetable crops have significant impact on increasing system productivity.

SUMMARY

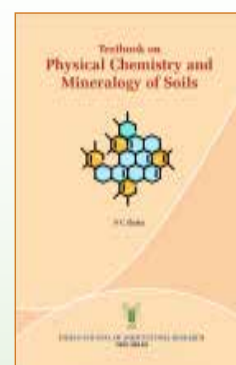
The concept of sustainable agriculture heavily relies on crop diversification. It is a transition from traditionally less profitable crops to more profitable ones. The large number of resource-poor small and marginal farmers in the rice-wheat cropping systems of the Indo-Gangetic plains may benefit much from diversifying their cropping system by engaging high-value crops. It not only improves the productivity and profitability of a system but also alters the monotony of rice-wheat system.

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