

Alternate cropping systems for food and nutritional security in eastern India

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There is an urgent need for identification of the eco-friendly/cleaner production system that is more productive and profitable, efficient user of energy, water and carbon-based inputs, and environmentally safer. In India, there are more than 80 pre-dominant cropping production systems. Continuous growing of the existing pre-dominant cropping system has resulted in stagnation or decline in crop productivity, particularly in rice-wheat system in the Indo-Gangetic Plains. Excess use of inorganic fertilizers along with frequent use of pesticides and climate change have adversely impacted the soil health, productivity and thereby livelihood and nutritional security of small and marginal farmers. Hence, there is a need to develop the site specific an alternate cropping system for efficient utilization of available resources and to maintain stability in agricultural production systems for a longer period, and get a higher profit. This will support for the crop modeling, policymakers, government planners, researchers and producers to achieve the sustainable development goals in Indo-Gangetic Plains and similar agro-climatic conditions of south Asia.

Keywords: Alternative cropping system, Climate resilient cropping, System productivity

India is the vast and diversified country with a total geographical area of 328.7 m ha, out of which ~141.3 m ha is net sown area. Production of all food grains increased from 50.8 million tonnes in 1950–1951 to 316.1 million tonnes in 2021–2022 on a country scale. The country produces large diversity of crop at a higher rate than any other country due to its diversified climatic conditions. Food grains (rice, wheat, maize, millets, pulses), cash crops (cotton, jute, sugarcane, tobacco, oilseeds), plantation crop (tea, coffee, coconut, rubber) and horticultural crops (fruits, vegetables) are the 4 main groups into which the crops grown in India can be grouped.

Cropping systems

Order in which crops are grown on a piece of land over a specified period is known as cropping system. By using an effective soil management technique, land productivity can be maintained or

even boosted. Cropping systems continue to be dynamic in both time and space, making it challenging to estimate their distribution over a broad area using conventional production methods. More than 250 double cropping systems are reportedly in use across nation. Thirty significant cropping systems have been identified for irrigated

agro-ecosystem based on rationale for spreading crops across the districts in country. Among these, rice-wheat (10.5 m ha), rice-rice (5.9 m ha), and cropping systems based on coarse grains are key contributors to the nation's food production (10.8 m ha). Together, rice and wheat provide ~65% of total food grains, compared to 40% for rice-wheat

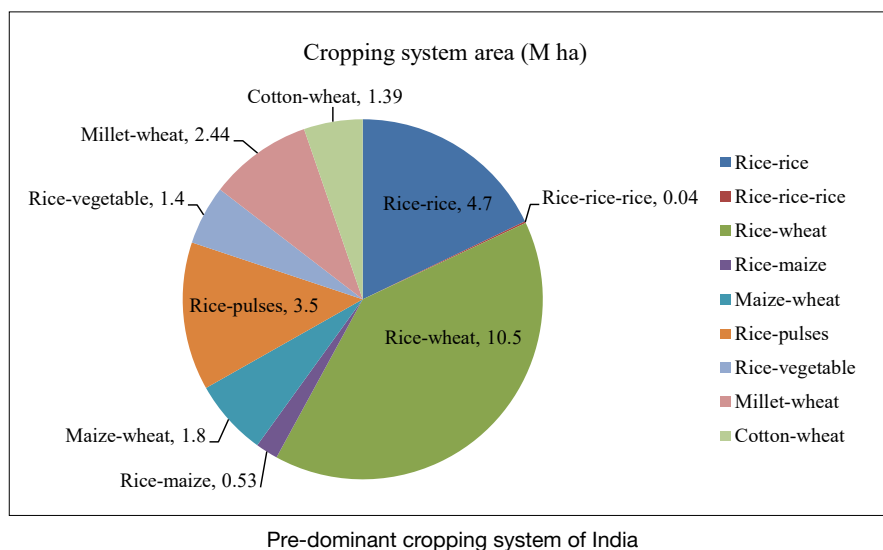


Table 1. Alternate crops/cropping diversification under irrigated ecosystem of the India

Kharif alternate crop (Rice)	Rabi alternate crop (Wheat)	Summer alternate crop (Mung)	States
Maize, mung, soybean, urdbean	Mustard, lentil, coriander, field pea, cowpea, potato	Dual purpose cowpea, cluster bean (fodder)	Punjab, Delhi
Arhar/mung/urd	Mustard, toria, lentil, french bean, chickpea, potato	Cowpea (dual purpose), lady finger	Uttar Pradesh
Arhar, toria, urd, mustard	Maize, sorghum fodder, cabbage, tomato, toria, lentil, rajma, coriander, cowpea, chickpea	Urd, onion, cucumber, tomato, cowpea, lady finger, cluster bean (fodder), bitter gourd, bottle gourd	Bihar, Jharkhand
Maize (green cob), arhar, french bean	Mustard, toria, broccoli, radish, cauliflower, potato	Cowpea (dual purpose), french bean, squash, garlic, potato	Uttarakhand, Himanchal Pradesh
Jute, mesta	Potato, rapeseed	Sesame	West Bengal
Soybean	Chickpea, berseem, mustard, toria	Onion, linseed	Madhya Pradesh

system alone. Soil types and climatic factors are taken into the account, when determining cropping systems of given region, which in turn determines entire agro-ecological setting for nourishment and suitability of a crop for cultivation. When choosing a particular cropping system, farmers should be guided by prospective productivity and financial gains. The judgments regarding selection of a specific crop/cropping systems are further narrowed down by several different micro level factors.

Identification of efficient cropping systems

Sustainability of agriculture is threatened by post-green revolution emergence of some second-generation problems i.e. over-mining of soil nutrients, decline in factor productivity, reduction in profitability, lowering of groundwater, soil salinization and resurgence of pest-diseases including weeds, diseases, and insects in majority of intensively cultivated cereal-based production systems. To overcome these problems, different cropping systems and resource management techniques were adopted by duly taking care of region-specific needs of crops and their cultivars. Various innovative alternative cropping systems have been identified and are listed in the Table 1. Sequential/intercropping systems were both included in suggested multiple cropping system, along with several variant i.e. mixed cropping, relay cropping, alley cropping, parallel-multiple cropping, multi-story cropping. Sequential cropping

with inclusion of non-conventional crops, short duration crop/cultivars and intensive input management practices are being observed as key factors in increasing the productivity of systems all over the country.

Thus, adoption of proper diversification, improved production techniques offer a scope of achieving the better net income. Presently, an efficient alternative cropping systems have successfully been developed for different agro-climatic zones of the country to get

the high productivity. The present mean productivity of most suited prevailing systems stood at 9.2 tonnes/ha across location, which can be increased further up to the extent of 22.4 tonnes/ha via demo of high productive systems.

Weed management

Crops, develop fast canopy and possess allelopathic properties generally impose an adverse impact on weeds infestation, therefore, can be adopted as weed management



Crop diversification view during *kharif* at ICAR Research Complex for Eastern Region, Patna



Crop diversification view during *rabi* at ICAR Research Complex for Eastern Region, Patna



Crop diversification view during summer at ICAR Research Complex for Eastern Region, Patna

tool. As per various estimates, in rice-rice cropping system, ~31.5% reduction in system productivity was seen due to uncontrolled weed infestation. It was observed that growing of summer cowpea in soybean-wheat system was effective in reducing the weed load; therefore, this practice is profitable in increasing net income from system. Intercropping of Dhaincha + Direct seeded rice resulted in concurrent rise in weed smothering efficiency, system observed 62% lower weed density compared to solitary rice. DSR and wheat can both be grown in tillage for increased weed control and productivity of rice-wheat combination under irrigated conditions. To reduce weed infestation, release nutrients and boost productivity of sunflower-bell pepper sequence, FYM @10 t/ha can be applied prior to ploughing with irrigation up to field capacity. Best cultural weed control methods include using cover crops, intercrops and relay crops.

Water management

Irrigation is a tool that is utilized to intensify crops. 'More crops and profit per drop of water' approach for sustainable crop intensification, can only be accomplished by proper designing of cropping systems. Through, use of intercropping systems with maize + tomato + garden pea + french bean, water productivity can be raised to 59.7 kg/ha cm of water. The goal of complementary intensive intercropping systems is to raise crops that differ in terms of

morphology and physiology over course of an agricultural year in successive intercropping system that are complimentary to one another and succeeding association.

Nutrient management

Planning for nutrient-management gives us a comprehensive way to calculate quantities of nutrients required for best plant growth. A nutrient-management plan should be developed for every nutrient application operation that pertains to land, and it should be designed by a person with a strong understanding of plant and soil sciences. It's crucial to keep in mind that for healthy growth and development, plants must absorb nutrients from soil through their roots. To enable best possible plant

growth, nutrients must be provided to soil if soil testing shows a requirement for them. However, if too much fertilizer is applied to field, surplus nutrients may leak out of soils and lead to contaminate underground water. Thus, objective of an effective nutrient-management is to maximize the plant health by properly addressing to environmental factors.

Economic analysis of cropping systems

Most crucial stage for achieving sustainable production is delineation of agro-climatic zones based on factors i.e. soil, water, rainfall and temperature. A short-term experiment was carried out on crop diversification to maximize crop productivity and profitability (Table 2). Results revealed that productivity in rice equivalent yield (REY) was realised the maximum with maize cob-pigeonpea (ZT) (22.4 t/ha) and lowest (5.81 t/ha) with finger millet-toria (ZT) system. Correspondingly, net profits were also noted highest with maize cob-pigeonpea (ZT) and sorghum (fodder)-mustard (ZT)-urd (ZT) (₹262902/ha and ₹182004/ha, respectively).

Way forward

The dominant rice-wheat cropping system is intensively cultivating in the Indo-Gangetic Plains zone of South Asia. It is an

Table 2. System productivity (SREY) of diversified cropping systems and economic returns under different agro-climatic regions of eastern India

Diversified cropping system	Rice equivalent yield (t/ha)			SREY (t/ha)	System net returns (₹/ha)
	Kharif	Rabi	Summer		
TPR-wheat-mungbean (FP)	4.85	5.78	4.35	14.98	104926
CTDSR - wheat (ZT)-mungbean (ZT)	5.35	6.13	3.63	15.12	123006
Soybean-maize (ZT)	3.65	9.66	0.00	13.31	129731
CTDSR-mustard (ZT)-urdbean (ZT)	5.26	7.30	3.83	16.40	135902
Foxtail millet-lentil (ZT)-fallow	1.43	5.65	0.00	7.08	73561
Pearl millet-chickpea (ZT)-fallow	4.04	6.87	0.00	10.91	121391
Finger millet-toria (ZT)-fallow	2.01	3.80	0.00	5.81	35882
Jowar (Grain)-chickpea (ZT)-fallow	4.51	7.18	0.00	11.69	136507
Maize cob-Pigeon pea (ZT)	12.49	9.88	0.00	22.37	262902
Sorghum (Fod.)-mustard (ZT)-urd (ZT)	9.72	6.27	2.54	18.53	182004
TPR-wheat-mungbean (FP)	4.85	5.78	4.35	14.98	104926

ZT, zero tillage; CT, conventional tillage; FP, farmer's practices; DSR, direct seeded rice; SREY, system REY.

energy and C-intensive zone for rice-based cropping systems, hence, there is an urgent need to design more efficient production systems, which are more productive, climate resilient, C-and energy-efficient and environmentally sustainable. Although the millet-based production systems have been proved to be highly efficient in terms of system productivity and profitability but their adoption and substitution for rice-wheat cropping system is a difficult task in eastern IGP due to fact that rice and wheat have become a major food staple. Being rich in nutrients and dietary fibres, millets need to be promoted as nutri-cereals in the diets of rural poor. The government policies should be changed in favour of millet-based production systems for wider adoption. Hence, the existing rice-wheat cropping system may be diversified with the substitution

of climate-resilient millet-based production systems, which are more productive, resource use-efficient, energy-cum-carbon-efficient and low emitter of GHGs.

SUMMARY

Thus, there is need of climate resilient and better remunerative cropping systems to be developed for making country self-sufficient in food and nutrition on available limited farm resources, viz. land, labour, capital and infrastructure. Crop productivity of prominent cropping systems can be increased by many times by adoption of alternative productive and profitable cropping systems. This can be done by inclusion of new crops in prevailing cropping systems of different agro-climatic zone. New identified efficient cropping system revealed to add the additional productivity and profitability to

farmers for which short-duration cash/catch crops can be integrated easily with long-duration crops in between two crops and seasons. For eastern India particularly, rice/wheat can be diversified by using the suitable crops/varieties like soybean, maize for cob/fodder, fodder jowar, major millets like jowar/bajra in *kharif* season and maize, arhar, and mustard during *rabi* in cropping systems for sustainable agriculture. Thus, novel selected crops were found more suitable to prevailing the climate, soil, irrigation, market, input supply, labour availability and better farmers' perception to adopt them. Therefore, developed climate resilient cropping systems need to showcase in farmer's field to break the traditional systems, which are vulnerable to the climate variability.

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HANDBOOK OF INTEGRATED PEST MANAGEMENT

To reverse the loss of environmental resources and also to reduce biodiversity loss, the Government of India has Integrated Pest Management (IPM) as part of the National Agricultural Policy. Integrated Pest Management emphasizes the growth of a health crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM is not new – mechanical, cultural and biological tactics were used by farmers for hundreds of years before chemical pesticides became available. Besides, there are IPM techniques that have been developed more recently and are effective in suppressing pests without adversely affecting the environment.



The task of spreading the message of IPM across is tough due to poor awareness about the subject among people in line-departments as also among the farmers. The information on integrated pest management as a whole is scattered. This *Handbook* comprehensively deals with all the aspects of integrated pest management in field crops, horticultural crops under traditional, protected systems. Information on basic strategies and tactics of different methods of management including mass production of biocontrol agents, IPM policy and pesticide registration is provided in comprehensive form.

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TECHNICAL SPECIFICATIONS

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