

Crop intensification

in rainfed regions

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Farmers around the world are challenged to produce more food per hectare with less water and agrochemical inputs due to the world's rising population, climate change and constraints on soil and water availability and quality. The ideas and methods of the system of crop intensification are improving overall agricultural production and are now being extended/adapted to many other crops: cotton, soybean, rice, wheat, maize, finger millet, sugarcane, mustard, legumes, vegetables and even spices. Various farmer centred sequential/double cropping systems in rainfed regions of country can contribute to agricultural sustainability with higher productivity. The All India Coordinated Research Project for Dryland Agriculture is having research centres across the country, which have made an extensive research on sequential/double cropping systems with an aim for better utilization of land, water and higher incomes to the farm families over the year through promotion and implementation of these systems in different states across the rainfed regions of the country.

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IN general, cropping systems of rainfed and dry areas display larger diversity than irrigated areas due to higher risks involved in extensive cultivation of a particular crop, and thus are over-crowded with inter/mixed cropping practices. Rainfed farming is rarely practiced as a single crop or livestock system rather mixed farming and diversity are its main features. Contrary to this, only few cropping systems are followed in areas with assured irrigation. These systems have sizable coverage and significantly contribute to national food security. However, besides areas under mono-cropping due to moisture or thermal limitations, only 30 cropping systems are prevalent in the country.

Majority of India's cereals, food legumes, minor millets, and livestock are produced through a number of various types of rainfed agricultural systems. Crop intensification in rainfed agriculture is essential for addressing the issues like food and nutritional security and in the context of climate change. To feed the growing population, future of agriculture needs to be more productive and stable while minimizing the environmental impacts. In this changing climate scenario with monsoon vagaries, greater potential exists

in harvesting the rainwater and utilizing the harvested farm water for protective irrigation to crops and making the double cropping system more remunerative. The sustainable intensification of rainfed agriculture is thus, more than the provision of irrigation and needs critical engagement with changing agrarian livelihoods, dynamic natural resources base and changing rural aspirations that collectively mediate dryland agriculture. Climate change is likely to impact all aspects of crop production, affecting plant growth, development and crop yields. Sequential cropping is an emerging solution towards the climate change which allows farmers to make the most efficient use of limited space in order to maximize yield potential and lower the risk of crop failure.

Essentials of double cropping

The double cropping system aims to make optimum use of land through the production of an extra crop being cultivated in winter (*rabi*) after rainy (*kharif*) season. In general, double cropping becomes feasible when there is on time onset of monsoon rains which help to successfully establish the first crop, then remain persist

for an extended period of time to allow the planting and maturation of the second crop. To develop feasible and sustainable double cropping systems, production factors such as length of growing season, cropping sequence, crop compatibility, biological complementarity, and planting time must be considered. Sequence/double cropping necessitates more thorough planning, which includes choosing hybrids or cultivars that will mature early enough to allow for next season field operations and the establishment of the winter (*rabi*) season crops. Reliable legumes or cereal crops with short growing periods like chickpea and wheat should be preferred to be planted in the post-rain season (September/October) relying on residual moisture in major soil types of rainfed regions of India. Use of early maturing cultivars of main crop in *kharif* facilitates timely planting of succeeding winter crops to ensure optimum production as irrigation is the dominant constraint during *rabi* for rainfed regions. It is necessary to look for best combination and compatibility of crops and inclusion of legumes in double cropping systems which helps to fix and incorporate nitrogen into the soil, and improves soil structure, avoiding the formation of hardpan and promoting better aeration with soil sustainability.

Traditionally, double cropping including relay cropping was practiced in rainfed regions with sufficient rains (usually >750 mm) and good soil moisture holding capacity (>150 mm). However, some more areas could be brought under double cropping through adoption of available dryland technologies, viz. rainwater management, choices of crops, short duration varieties and agronomic practices. Out of the two crops, one could be short durations (usually legumes) and another, medium duration (usually cereals) for optimum use of

available growing season. For example, a second crop could be successfully grown in high rainfall regions of Odisha, Eastern Uttar Pradesh and Madhya Pradesh by replacing medium to long duration (>120 days) rice variety with short duration (<100 days) rice variety; while another crop of chickpea or safflower could be taken in Malwa (MP) and Vidarbha (Maharashtra) regions by substituting sorghum variety of 140–150 days with 90–100 days cultivars. Similarly, relaying a short duration and fast-growing crop in standing principle crop provides good opportunity for efficient use of growing period. For e.g. relay cropping of castor bean in 40–45 days old green gram crop is practiced in about 35000 ha area of North Gujarat.

Double-cropping can be an excellent option for farmers to increase productivity which can intensify production using the same units of land. Although, more than 250 double cropping systems are adopted in the country, the major contribution to food basket remains with the few cereal based systems such as rice-wheat, rice-rice, rice-gram, rice-sorghum, maize-wheat, maize-gram and sugarcane-wheat due to their extent of cultivation. Growing soybean in a double-cropping system is becoming a common practice in different states of India. Growing two cash crops on the same land in the same crop year, such as soybean with grains like wheat, barley, or other winter crops, can boost farm income. In order to achieve the targeted food production of 450–500 MT in 2050, double cropping systems will play a vital role in enhancing the land use efficiency as per capita availability of agriculture land is decreasing at a faster rate (0.48 ha in 1951 to 0.14 ha in 2001) (Table 1).

Table 1. Suggested double cropping systems in various rainfed agro ecologies

State	Agroclimatic zone/AICRPDA centre/Climate/Soil type	Major rainfed crop based production system	Double cropping system	Recommendation domain
Andhra Pradesh	Scarcity zone of Andhra Pradesh/Ananthapuramu/ Semi-arid/Arid (Hot)/Alfisols	Groundnut	Groundnut-horsegram/fodder sorghum	Ananthapuramu, Kurnool, Y.S.R. Kadapa and Chittoor districts
Jammu	Low Altitude Sub-Tropical zone/Rakh Dhiansar/Semi-arid (Moist dry)/Inceptisols	Maize	Maize-wheat/gobhi sarson/rapeseed/ chickpea/lentil/pea; Pearl millet wheat; Blackgram-wheat/ rapeseed	Jammu, Samba, Kathua, Udhampur and Rajouri districts
Jharkhand	Western Plateau zone/ Chianki/Sub-humid (Hot moist)/Inceptisols	Rice	Rice-wheat/chickpea/ lentil/linseed/safflower	Palamu, Garhwa, Latehar, Chatra, Lohardaga, Gumla and Simdega districts
Karnataka	Eastern, Southern and Central Dry zones/ Bengaluru/Semi-arid (Hot moist)/Alfisols	Finger millet	Field bean-finger millet; Cowpea-finger millet	Mysore, Tumkur, Kolar, Ramanagara, Bengaluru (Rural and Urban), Chamarajanagar, Hassan, Chikkaballapur and Mandya districts
	Northern Dry zone/ Vijayapura/ Semi-arid (Hot dry)/Vertisols	<i>Rabi</i> sorghum	Greengram-sunflower/ <i>Rabi</i> sorghum/ chickpea/safflower; Onion- <i>rabi</i> sorghum/chickpea	Vijayapura, Bagalkote, Gadag, Bellary, Koppal, parts of Dharwad, Belagavi and Raichur districts
Maharashtra	Central Maharashtra Plateau zone/Akola/Semi-arid (Hot moist)/Vertisols	Cotton	Soybean-chickpea/wheat; Green gram/Black gram-chickpea/safflower; Cotton + soybean (4:10)- safflower	Akola, Washim, Buldana, Yavatmal, Amravati, Wardha and of Nagpur districts
	Central Maharashtra Plateau zone/Parbhani/Semi-arid (Hot moist)/Vertisols	Cotton	Green gram- <i>rabi</i> sorghum; Soybean-chickpea/linseed; Sorghum-safflower	Parbhani, Hingoli, Nanded, Beed, Latur Osmanabad, Aurangabad and Jalna districts

State	Agroclimatic zone/AICRPDA centre/Climate/Soil type	Major rainfed crop based production system	Double cropping system	Recommendation domain
Madhya Pradesh	Scarcity zone/Solapur/ Semi-arid (hot dry)/Vertisols	<i>Rabi</i> Sorghum	Blackgram- <i>rabi</i> sorghum/chickpea/ safflower; Greengram- <i>rabi</i> sorghum/ safflower; Cowpea (fodder)- <i>rabi</i> sorghum/chickpea/safflower; Pearlmillet/sunflower-chickpea; Sorghum (fodder)-chickpea/safflower	Solapur, Ahmednager, Sangli, Pune, Dhule, Jalgoan, Nandurbar, Satara districts
	Malwa zone/Indore/Semi- arid (hot moist)/Vertisols	Soybean	Soybean-chickpea/safflower; Maize-chickpea/safflower	Mandsaur, Ratlam, Ujjain, Rajgarh, Shajapur, Indore, Dewas, Dhar, Jhabua and Sehore districts
	Keymore Plateau and Satpura Hill zone/Rewa/ Sub-humid (hot dry)/ Vertisols	Soybean	Rice-wheat/chickpea/lentil; Soybean-wheat/chickpea	Rewa, Sidhi, Singroli, Satna, Panna, Katni, Jabalpur and Seoni districts
Odisha	Northeastern Ghat zone/ Phulbani Sub-humid (hot moist)/ Inceptisols	Rice	Upland rice-greengram/horsegram; Maize-potato/horsegram/mustard	Kandhamal, Gajapati, Rayagada, Ganjam, and part Koraput districts
Punjab	Kandi region/Ballowal Saunkhri/Sub-humid (hot dry)/Inceptisols	Maize	Maize-wheat/mustard/taramira/ chickpea; Ash gourd-taramira/wheat; Pearlmillet-wheat/barley/chickpea; Sunhemp (green manure)-wheat + chickpea; Cowpea (fodder)-wheat + chickpea	Roopnagar, Hoshiarpur, Shaheed Bhagat Singh Nagar, Pathankot, Sahibzada Ajit Singh Nagar districts
Rajasthan	Southern zone /Arjia/Semi-arid (hot dry)/ Vertisols	Maize	Maize-chickpea; Sorghum-mustard; Sorghum + cowpea (green fodder)- taramira; Maize-chickpea + mustard; Blackgram/greengram/cowpea/ sorghum fodder-mustard	Bhilwara, Chittaurgarh, Rajsamand, Udaipur and part of Sirohi districts
Uttar Pradesh	South-western semi-arid zone/Agra/Semi-arid (hot dry)/Inceptisols	Pearl millet	Greengram/blackgram (green manuring after first picking)-mustard; Pearlmillet + cowpea (fodder)- mustard; Green manuring in <i>kharif</i> (Sesbania)- mustard	Agra, Mathura, Mainpuri, Aligarh, Hathras, Firozabad, Etah and Kanshiram Nagar districts
	North-eastern Plain zone /Faizabad/Sub-humid (hot dry)/Inceptisols	Rice	Blackgram-chickpea; Maize-chickpea; Maize + cowpea-lentil; Blackgram-mustard; Greengram-chickpea	Faizabad, Sultanpur, Basti, Gonda, Ambedkarnagar districts
	Eastern plain and Vindhayan zone /Varanasi/Sub-humid (hot dry)/Inceptisols	Rice	Rice-lentil/rapeseed mustard/ chickpea; Pearlmillet-lentil/rapeseed mustard/ chickpea; Sesame-lentil/rapeseed mustard/ chickpea	Varanasi, Chandauli, Sant Ravidas Nagar, Jaunpur, Ghazipur, Mirzapur and Sonbhadra districts

Vertisols of Western Vidarbha, Maharashtra



Cotton + soybean (4:10)-safflower



Maize-chickpea system

Triple Cropping Systems

In high rainfall zones such as Northeast region, there is a scope for runoff rainwater harvesting and efficient utilization for enhancing the crop intensity with maize and Ahu rice based triple cropping systems (Table 2).

Table 2. Suggested triple cropping system for North Bank Plains zone of Assam

State	Agroclimatic zone/ AICRPDA centre/ Climate/Soil type	Rainfed crop based production system	Triple cropping system	Recommendation domain
Assam	North Bank Plains zone/ Biswanath Chariali/ Humid (hot)/ Alfisols	Rice based production system	Maize-toria-greengram/blackgram; Maize-linseed-greengram/blackgram; Maize-buckwheat-greengram/blackgram; Maize-niger-greengram/blackgram; Maize-rajmah-greengram/blackgram; Maize-potato-greengram/blackgram; Direct seeded Ahu rice-greengram-toria/rajmah/potato	Dhemaji, Lakhimpur, Biswanath, Sonitpur, Darrang and Udalguri districts



Maize + greengram (1:1)-potato-blackgram

SUMMARY

In rainfed areas, there is untapped potential for crop intensification with double, relay or triple cropping in various bimodal and high rainfall zones. However, this is possible only with rainwater harvesting in farm ponds/percolation tanks/other rainwater harvesting structures and efficient utilization through micro-irrigation systems. This preparedness will enable to adjust sowing windows for double cropping, taking up normal sowings and critical/lifesaving irrigation to mitigate dry spells during *kharif* season, pre-sowing/supplemental

irrigation for early/*rabi* cropping and to enhance overall resource use efficiency, system productivity and profitability. Further, crop intensification in rainfed areas shall lead to climate adaptation, doubling farmers' income, livelihood security of small farm holders and also contribute towards food and nutritional security at household level.

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