

Increasing crop productivity in dryland/rainfed areas for achieving the sustainability goal of zero hunger

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Out of 143 million hectares (mha) of cultivated area in India, only 33% falls under irrigated, leaving the remaining 67% as rainfed. Drylands are characterized by intense moisture deficit, high evaporation rate, exceptionally high day temperature during summer, low humidity and high run-off and soil erosion. As water is the indispensable factor in crop production so inadequacy and uncertainty of rainfall often causes partial or complete failure of the crops leading to period of scarcities and famines. Advancement and adoption of moisture conservation technologies by the farmers may improve dryland crop productivity, farm income along with upliftment in their livelihood. Furthermore, harnessing every inch of rainfed lands by following highly efficient technologies is also need of the hour to feed the ever-increasing population.

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SINCE the further expansion of irrigated area is limited due to growing competition for water and high investment cost, the dryland agriculture keeps immense potential in increasing crop productivity and farm income. So, it can be said that second green revolution in Indian agriculture can take place in rainfed/dryland areas. Even after full utilization of water resources for irrigation, half of the cultivated area remains rainfed. Rainfed cultivation comprises of about 80% of total croplands in the world that not only produce most of the world's cereal grains but also generate livelihood in rural areas. However, scarcity of moisture in rainfed areas is a major challenge in global agriculture.

Ideas to conserve soil moisture

Construction of bunds and tanks: Contour bunding, basin tillage, check dams, percolation tanks, ex-situ water harvesting.

Improve infiltration: *In situ* water collection, ridge and furrow system, deep cultivation, incorporation of organic matter to improve water holding capacity of soil.

Control of runoff: Through land shaping, land levelling, other land configuration practices like growing of vegetative barrier, bunding, ridge and furrow system against slope.

Argo-techniques to conserve soil moisture

Crop management practices: Selection of crop varieties, timely sowing, seed rate (25% more), fertilizer (half of normal dose), seed hardening (with KNO_3), weed control, optimum plant population, life-saving irrigation, timely harvesting of rainy (*kharif*) season crops.

Soil management practices: Addition of crop residue and organic

matter, mid-way correction, use of polymers, deep summer ploughing.

Use of mulches: Mulch is any material applied on soil surface to check evaporation, improve soil water and moderation of temperature, reduction in soil salinity, weed control, and improvement of soil structure.

Use of anti-transpirants: The objective of anti-transpirant is to reduce the rate of transpiration with no or little effect on photosynthesis. They induce plant to offer more resistance to loss of water vapour through stomata closing but relatively lower resistance to CO_2 entry.

Wind breaks: The wind breaks have found their utility in reducing transpiration losses under field conditions. It has been seen that yield of grain crops increased by 20–30% and grasses by 100–200% in sheltered zone.

Contingent crop production

Aberrant weather is a common and frequent phenomenon in dryland agriculture. The rainfall is seasonal, erratic and highly



Furrow planting of crops



Use of mulch material in field crops

variable in space and time. The two important and more commonly observed vagaries of monsoon are:

Delayed onset of monsoon: Delay in south-west monsoon by 3–4 weeks than normal results in yield loss because of reduced growth. In this situation, only two options can be followed for getting relatively higher yield i.e. transplanting and alternate crop/variety. For transplanting, nursery has to be raised at a place where water is available so that transplanting can be done with onset of rain. This is a sure way of compensating delay in sowing. While, certain crops are more efficient either due to their short-duration or capacity to produce better yield under unfavourable moisture regimes, when sown late in season. For e.g. cereal crop in general is less tolerant to drought condition than legumes or oilseed crops. Also, it is now well established that castor variety Varuna produces more yield in red soils of Telangana region

as compared to pigeonpea under late sown conditions. In western Rajasthan, short-duration crops like green gram and cowpea have been found to perform better than pearl millet under late sown conditions.

Break in monsoon/early withdrawal: The water requirement of crop depends upon solar radiation intercepted by crop canopy. For e.g. if drought conditions occur 40–50 DAS, the leaf area development will be maximum leading to fast depletion of soil moisture. Therefore, reduction in LAI by either pruning or ratooning of crop mitigates adverse effect of drought to a certain extent. Ratooning of a drought affected sorghum crop with subsequent rain gave 8 q/ha of grain yields over 2 q/ha without ratooning. For e.g. in Kandi areas of Punjab, mulching with Bersooti is useful for maize crop, and maize stover/stalk is useful for retaining more moisture for succeeding winter (*rabi*) season crop.

Good agricultural practices to get higher yield under rainfed conditions

Rainwater management

The broad bed and furrow (BBF) system of the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) for managing rain water in Vertisols made it possible to increase crop yields 4–5 times as compared to normal practice. Alternatively, application of compost and farmyard manure as well as raising legumes will add the organic matter to the soil and increase the water holding capacity.

Crop substitution

Alternate crop strategies have been worked out for important regions of the country i.e. Vertisols, Alfisols, Entisols, Submontane and Sierozemic soils. Studies revealed that under normal monsoon, short-duration upland rice, maize, pearl millet, blackgram, greengram, sesame, pigeonpea etc. should be



Bed planting of crops

taken up on the basis of needs. These crops should be followed by chickpea, lentil, barley, mustard, safflower, linseed on residual moisture during winter (*rabi*) season. If monsoon sets in as late as second week of July, short-duration upland rice (variety - NDR-97 and NDR-118) may be included. If the rains are delayed beyond the period but start somewhere in last week of July or first week of August and growing season is reduced to 60–70 days, then cultivation of hybrid pearl millet (NHB 3,4; BJ 104), blackgram (Type 9), greengram (var. Jagriti and Jyoti) may be included in place of T-44 and K-851. In other dryland regions, alternative efficient crops can profitably substitute the traditional ones (Table 1).

Efficient cropping system

Besides putting various measures to increase the productivity levels of dryland crops, cropping intensities of these areas could be increased by the practice of multi-cropping. The cropping intensity would depend on the length of growing season which in turn depends upon rainfall pattern and moisture storage capacity of the soil. For e.g. in Indore region, (receiving 1000 mm annual rainfall) only single crop can be taken on shallow soils, inter-cropping in medium depth soils and double cropping on deep soils. Similar crop combinations have been identified for different regions of the country.

Fertilizer application

Soils of drylands in the country are not only thirsty but also hungry, because these soils are severely eroded horizontally as well as vertically. Whenever efforts are made towards bunding and levelling of the fields in dryland areas, it is the surface soil which is removed. The resultant effect is that the fields are rendered shallow in depth and completely deprived of plant nutrients. Since soil moisture is limiting in drylands, the availability of nutrients becomes limited, attempt should always be made to apply fertilizers in furrows below the seed. The recent findings have

Table 1. Relative yield of traditional and efficient crops in dryland areas

Region	Traditional	Yield (q/ha)	Efficient crops	Yield (q/ha)
Bellary	Cotton	2.0	Sorghum	26.7
Varanasi	Wheat	8.6	Chickpea	28.5
Ranchi	Upland Rice	28.8	Maize	33.6
Indore	Green gram,	11.8	Soybean	33.3
	Wheat	11.0	Safflower	24.2
Agra	Wheat	10.3	Mustard	20.4
Hisar	Wheat	3.0	Taramira	16.0
Udaipur	Maize	18.0	Hybrid sorghum	29.0

Source: [www/agropedia.iitk.ac.in/node/2609](http://www.agropedia.iitk.ac.in/node/2609)

shown that use of fertilizer is not only helpful in providing nutrients to crop but is also helpful in efficient use of profile soil moisture.

Alternate land use system (ALUS)

All drylands are not suitable for crop production. Some lands may be suitable for range/pasture management, while others for tree farming, ley farming, dryland horticulture, agro-forestry systems including alley cropping. All these systems which are alternatives to crop production are called as alternate land use systems. This system not only helps in generating much needed off-season employment in monocrop dryland but also minimizes risk, utilizes off-season rains which may otherwise go waste as runoff, prevents degradation of soils and restores balance in the ecosystem. Scientists working in the areas of dryland have developed many alternate lands use systems as:

Alley cropping: Alley cropping is a system in which food crops are grown in alleys formed by hedge rows of trees or shrubs. The essential feature of the system is that hedge rows are cut back at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops. For e.g. fast growing leguminous trees such as *Leucaena leucocephala* or *Gliricidia* spp. are planted in rows. Arable crops like maize, rice, pearl millet, legumes, oilseeds are planted in the alleys formed by the two rows of trees.

Agri-horticultural system: Suitable example of agri-horti-system is growing of cowpea/

greengram/horse gram in inter-space of ber (*Ziziphus mauritiana*) at 6 m × 6 m spacing at Hyderabad. Phalsa (*Grewia asiatica*) may be planted in between two ber plants in a row with a view to intensify the system. A well-managed dryland orchard of ber should give 50 kg fruits per tree/year. There should be 250 plants/ha for optimized production. The grower income would touch around ₹50,000/ha (250 × 50 × 4), assuming that 1 kg ber fetches ₹4. One could get an additional income of ₹800–1000 from greengram/cowpea (2.5–3.0 q/ha).

Silvi-pastoral system: This system is suited to marginal drylands and is most preferable where the fodder shortages are experienced frequently. The system essentially consists of a top feed tree species carrying grasses on legumes as understorey crops.

Mechanization

In order to take full advantage of annual precipitation in dryland agriculture, higher doses of energy input are essential. Farmers in drylands have been using traditional and outdated farm equipment's which not only perform poorly but also demand a lot of energy and time and post-harvest operations. Farm implements can help in *in situ* conservation of rain water. Deep tillage has resulted in 10% yield increase in sorghum and 9% yield increase in case of castor. For *in situ* moisture conservation, land has to be opened so that it can cause hurdle to flow of rain water. Location specific seeders have been developed for dryland areas and these have shown good prospects and promises.

Table 2. IFS models for arid and semi-arid regions of India

Region	IFS Model
Semi-arid Vertic-Inceptisols of Tamil Nadu	Crop + poultry (20) + goat (4) + sheep (6) + dairy (1)
Tungbhadra project area of Karnataka	Crop (0.74 ha) + horticulture (0.18 ha) + fodder crop (0.02 ha) + livestock (2 cow, 1 buffalo, 14 goat) + vermicompost units (4) + compost unit (1) + <i>Azolla</i> unit (1)
Semi-arid Gujarat	Crops: pearl millet – wheat (0.44 ha), mustard – pearl millet (0.22 ha), cotton – fodder sorghum (1 ha) + horticulture: papaya (0.04 ha) + dairy buffalo (6)
Semi-arid irrigated Punjab	For 2 ha land: crop (1.14 ha) + dairy (0.22) + fishery (0.56) + piggy (0.24)
Arid Rajasthan	IFS for 7 ha land: Agroforestry (<i>Prosopis cineraria</i> + crop), agroforestry (<i>Hardwickia binata</i> + crop), agri-horti (<i>Ziziphus mauritiana</i> + crops), hortipasture (<i>Ziziphus mauritiana</i> + grass), silvipasture (<i>Colophospermum mopane</i> + grass) with six adult cattle unit (4 cow, 8 bucks and 4 rams)

Table 3. Income generated from the components of IFS model at ZAHRS, Shimoga

Component technology	Income after intervention (₹) (estimated)
Sapota – 180 plants; regular irrigation introduced	72,000/year, potential
Grass on bunds – 1200 m; 6 cuttings/year	9000/year
Multipurpose trees on bunds (45 trees)	Many indirect benefits + 10,000/year
Kitchen garden	45,000/year + nutritional security of the family
Apiculture – 3 boxes	2,400/year
Poultry; Girirani – 50 birds	30,000/year + family consumption
Composting; 3 vats/pits	18,000/year
Vermi-composting	9,000/year
Gobar gas	6,000/year
Nursery – Sapota grafts	4,000/year at present, 80,000/year is the potential
Field crops	10,000/year
Lucerne	6,000/year
Jack trees; 40 (newly planted).	40,000/year
Teak plants 15-year-old (90 trees)	90,000 potentials at present
Fisheries 800 m ² area tank with water year round	55,000/year
Intercrop of drumstick, curry leaf, papaya etc	5,000/ year
Two Cows (HF Breed)	78,250/ year
Total of the potential created now	4,89,650/year

Adoption of suitable integrated farming systems for arid/semi-arid regions

It has been conclusively established that IFS involving integration of different enterprises (crop, livestock, horticulture, forestry, poultry and fish) enhanced productivity, profitability, resource use efficiency, generated more employment and minimized resources degradation and risks. IFS, therefore, could be a key form of farming intensification needed for achieving future food security and environmental sustainability in arid and semi-arid regions (Table 2 and 3).

SUMMARY

Scarcity of moisture in dryland/rainfed areas is a major challenge in achieving their potential productivity. Approximately, 91% coarse grains, 91% pulses, 80% oilseeds, 60% cotton, 50% rice, and 19% wheat in India is produced from rainfed lands, of which 43% share through drylands. Advancement and adoption of moisture conservation technologies by the farmers may increase farm income along with upliftment in livelihood of the farmers. Furthermore, harnessing every inch of rainfed lands by following highly efficient technologies is also need of the hour to feed the ever-increasing population. Also, development and adoption of suitable integrated farming system models in arid and semi-arid regions of the country plays critical role in resource utilization, in creation of new avenues of farm income as well as in decreased dependence of farming community on synthetic growth factors.

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Mulching and inline drippers enhance irrigation use efficiency in oil palm

The technique of using plastic mulches in oil palm basins was standardised. Plastic mulching was effective in enhancing water-use efficiency as it recorded almost comparable yields with microjet irrigation (normal practice) when irrigated at 25% deficit irrigation in combination with normal drip and inline drip methods. Plastic mulching is effective in saving 25% water under deficit water conditions.

Source : ICAR Annual Report 2021-22