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***Strategy paper***

# Horticulture opportunities in rainfed areas

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## Introduction

Horticulture provides tremendous opportunities with high growth potential for enhancing nutrition, employment, income and livelihood securities. Food prices during 2009 a drought year have inflated by 20% mainly due to failure of vegetable crops and lesser yield from orchards in the predominantly rain dependent Himalayan region. The rainfed area covers about 60 per cent of the net sown area of India and this percentage could be 80-90% in some of the horticultural states like J&K, Himachal Pradesh, *etc*. Rainfed areas are under-invested, poverty ridden, risky, uncertain, distress prone, far more dependence on natural resources and suffer most due to wrath of climatic changes. Matured fruit trees with very extensive and deep root system can explore soil moisture massively and are risk moderating safety nets against uncertainties of rainfall. Most of the hilly and western coasts already have very ancient and traditional orchards for harnessing rainwater and social capital in the undulating topographies where irrigation opportunities are very limited. Conservation and management of natural resources, particularly rainfall as an entry point, assumes greater importance in improving overall horticulture productivity. Therefore, need based and market led diversification and farming systems are being emphasised for inclusive development of rainfed areas.

Horticulture plays a significant role in diversification, risk moderation, value addition and enhancing farm income in rainfed areas. Diversification of low productive land use to alternate land use is more beneficial and sustainable production system. Hardy horticultural fruit crops provide better choice in these areas because of their perennial nature, synchronization of fruit development with rains (as in *aonla*) and deep root system, which can utilize the moisture from deeper soil layers and better adoptability in the waste lands where spot reclamation will be less expensive. As the result of a number of Government Policies/ Programmes and support over the years, horticulture has emerged as a viable option for crop diversification. It offers a wide range of opportunities for choice of crops (fruits, vegetables, flowers crops, spices, medicinal/aromatic, plantations, bamboo), better land use, reduced pressure on natural resources, improved productivity, risk minimization, agro-industries opportunities, better economic returns and nutritional security. It has played an important role in the national economy and contributed around 28% of the GDP in agriculture from about 13.08% of the land (Anon, 1). The demand for horticulture and livestock during the 11$^{th}$ Plan is projected to grow at 4 to 6% against 2 to 2.5% for food grains. Diversification towards horticulture and livestock will therefore assume greater significance for achieving 4% agricultural growth.

The traditional areas of horticulture are shrinking due to urbanization, industrialization and land degradation. The recent awareness regarding potentials of the ecologically fragile rainfed areas for production of horticulture has opened up large scope for providing economic sustenance. Vertical growth in terms of productivity, diversification, farming systems, off-season production and cost effective cultivation would play important role due to limited horizontal expansion.

## Economic Competitiveness

Agricultural productivity of most of the districts in the country has recently been compiled by Chand *et.al.* (4) and a part of it is reproduced in Table 1.

Average per hectare per annum productivity was lowest (about Rs. 3,000) in the hot desert of Barmer and highest (Rs. 1,50,000) in the cold desert of Lahaul and Spiti (H.P.) with 50 times variation. The highly productive districts of Lahaul and Spiti, Simla, Howrah, Kullu, Nilgiris and Kinnaur are basically fruits or vegetables producing regions and most of them are rainfed or snow melt dependent irrigation. It is therefore evident that rainfed regions provide very diverse opportunities to improve productivity, production, farm income and reduce poverty.

## Extent and Distribution

About 80% of apples, stone and other temperate fruits in the Himalayas are generally rainfed. Mangoes, wild bananas, pineapple and other plantation crops in the north-east regions are thriving without committed

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**Table 1.** Districts arranged in the ascending order each of lowest and highest 5 districts in terms of 2003-2005 average productivity.

| State | District | Ave. prodn./ ha/annum | Ave. prodn./ worker | NIA (%) | Rainfall (mm) |
|---|---|---|---|---|---|
| Rajasthan | Barmer | 2,909 | 6,836 | 7 | 265.7 |
| Rajasthan | Jaisalmer | 3,317 | 13,403 | 12 | 185.5 |
| Rajasthan | Churu | 4,770 | 8,379 | 4 | 354.7 |
| Madhya Pradesh | Anuppur | 6,491 | NA | 2 | 910.0 |
| Rajasthan | Jodhpur | 6,616 | 12,975 | 11 | 313.7 |
| Tamil Nadu | The Nilgiris | 98,679 | 12,5,222 | NA | 1695.7 |
| Himachal Pradesh | Kulu | 10,2,052 | 21,721 | 8 | 900.4 |
| West Bengal | Howrah | 11,4,815 | 45,369 | 91 | 1501.0 |
| Himachal Pradesh | Simla | 13,5,950 | 37,116 | 31 | 957.2 |
| Himachal Pradesh | Lahaul & Spiti | 15,0,453 | 39,684 | 91 | 483.4 |

irrigation. Konkan region is known for the production of mangoes and others. Similarly, cashew nut is very hardy and tolerant to the variations in rainfall and is spreading very fast even in the rugged coastal regions. About 80% of mangoes in the plains of north, central and southern plateaus of Karnataka are rainfed except during the initial establishment period of 4-5 years. Arid horticulture of *ber, aonla,* pomegranate, fig., *etc.* has very high potential of diversifying income, even in the very scarce and limited rainfall regions.

## Promotion of Horticulture through Employment Guarantee

Employment guarantee resources for raising horticulture is a very successful story of EGS (Employment Guarantee Scheme) of Maharashtra state. Farmers could employ themselves or hire other wage seekers for digging of pits, plantation, raising of fruit trees and reimbursed ssubsequently on the basis of establishment of plants. Labour norms for various fruit cultures were fixed so as to avoid any mis-utilisation in the implementation of the scheme. Reimbursement was made to the orchard owners on the basis of survival of fruit plants after two and three years. This innovative system of reimbursing was really a significant policy decision to ensure establishment and spread of horticulture in Maharashtra. As a result of this the state having 83% rainfed area is coming up as an important exporter of fruits to earn foreign exchange and livelihood even by the small holders. Implementation of the NREGS with financial allocation of Rs. 39,000 crores provides very good opportunities for creating assets which will ultimately reduce unemployment level and take off burden on the planned resources in the future. Recently, Andhra Pradesh took a lead in converging National Horticulture Mission resources with NREGS and micro-irrigation scheme.

## Rootstocks

Drought tolerant and hardy species could be deployed especially in the low rainfall regions for reducing vulnerability to droughts, long dry spells during rainy season, heat or cold waves and other uncertainties which are progressively increasing due to climatic changes. Budding of indigenously growing wild *ber* (Mallaha), *manilkara sherandra, etc.* with improved material was very successful in the Bundelkhand and other regions. Wild growing *amla* and custard apple is another potential for improving the hardy wild species by top-working. There could be many more possibilities in other fruit species and regions which need to be reviewed and published if not done already.

## Rainwater Harvesting

Micro level re-configuration of the land surface so as to induce run-off and direct to the tree was demonstrated in Jodhpur and Agra. Plastic lining of the re-configured slope could further enhance harvesting to establish fruit trees especially in the initial sensitive phase of tree growth.

## Watershed Management

An integrated watershed of 370 ha was developed in 1975-76 at Fakahot above Rishikesh in Uttaranchal. Cultivation of coarse cereals was most important traditional practice under rainfed condition. Farmers did not want to put best terraced land under horticulture and allowed plantation of mangoes, citrus, *etc.* in the ravine beds wastelands locally called Gadera. Income dynamics of diversification of different commodities have been monitored and are given in Fig. 1.

It is evident that income from the traditional coarse cereals came down, fine cereals increased initially and then stabilised. However, income from the livestock and all sectors is still rising. Income from horticulture (cash crop) has overtaken all other sectors tremendously inspite of the fact that fruits were planted in the wastelands due to initial low priority of the farmers.

## Horticulture-Based Farming Systems in Rainfed Areas

Horticulture based farming system comprises of integration of different components, *viz.* crop production, livestock, poultry, vegetable gardening along with horticulture to diversify risks and ensure flow of cash throughout the year. Combination of deep and shallow rooted trees/crops also ensures proper utilization of conserved soil moisture. It is important to emphasize that each agro-ecological region has different species, permutations and combinations of horticultural crops and other related enterprises, which can be integrated suitably.

### Arid-Ecosystem

The rainfed arid zone is characterized by high temperature and low and highly variable precipitation which limit the scope for high productivity. However, these conditions greatly favour development of high quality production in number of fruits such as date palm, *ber*, pomegranate, citrus, fig (*anjir*) *aonla, bael*, grapes, guava and in vegetables such as cucurbitaceous crops, spices and some medicinal plants. *Ber* fruit comes into local market at an early date and fetch very high price outside the region if marketed properly. *Khejri* is a multipurpose tree for vegetable (*sangri*), fodder and fuel wood. It has very extensive lateral and deep tap root system to mine soil moisture and can survive without rains for 6-8 years. In arid ecosystem of western plains where the rainfall is very low and the climate is very fragile, some drought hardy fruit crops like *ber, kajoor, ker, khejri, etc*. can be the major component of farming system and the drought hardy legumes like *guar* (cluster bean) and moth bean, coarse cereals like *bajra,* pasture grasses like *Stylosanthes* and *Cencrus* can be the subsidiary component for animal rearing and sustaining the livelihood. Seed spices, *mehendi* and several other herbal products are very unique commodities of dryland. The fodder from *ber, khejri, ker*, *etc*. can also be used as feed for small ruminant and the pastures legumes and grasses can be allowed for open grazing by cattle and other animals. Pruning, trimming, *etc*. provide enough fuel wood especially in *ber.* In arid region, considerable area has come up under fruits like *aonla, ber,* pomegranate, fig and *phalsa* in different parts of the country, which had negligible spread in the past.

### Cold Arid Ecosystem

It receives precipitation in the form of snow during winter season and provide very unique opportunities. Snow harvesting and its melting can provide irrigation to raise productivity as in Lahaul and Spiti of Himachal Pradesh. Formation of rings around the tree retains precipitation very effectively. Deep hoeing is done to improve penetration or infiltration of water. Mulching during non-rainy season is very effective in improving rain water efficiency. It is spreading in Kinnaur district.

In order to maintain the soil health and improve the moisture regime near root zone of perennial crops, land treatment for *in-situ* water harvesting, moisture conservation and use of compost generated in the system can be utilized.

### Sub-Humid Ecosystem

In sub-humid ecosystem of eastern plateau, central India which receives over 1,100 mm annual rainfall with red lateritic soil, the tropical and sub-tropical fruits like mango, litchi, *aonla*, jackfruit can be the major component of the system. This can be supported with dwarf statured fruit crops like guava, pomegranate, lime, *etc*. and fast growing agro-forestry trees like *Gmelina, Leuceana* as component crops. Cashew nut is very hardy and moisture stress tolerant fruit with great commercial and employment potential. After initial establishment they can be managed without intensive irrigation. By utilizing the rains during prolonged rainy season (June-October), coarse cereals like ragi and short duration upland paddy, pulses like black gram and ground nut, oil seeds like niger and sesamum, grass, species like *Stylosanthes* and *Dinanath* grass, and vegetables like cowpea and French bean can make the subsidiary components of the system. The rearing of cattle and small ruminants and backyard poultry can very well be integrated into the system. Fodder from jackfruit can be used for sheep and goats in the system. Water harvesting structures, ponds/tanks, check dams and groundwater recharge through sub-surface *bandharas, etc*. along with small *Jalkundas*/*dobas* to support horticulture plantations will be ideal together with contour trenching, micro-catchments, bio-engineering measures (*i.e.,* combination of low-cost engineering measures and value-added horticulture, grasses), half-moon terrace and mulching to stabilise rainfed horticulture.

### Humid Ecosystem

In humid and hot humid eastern coastal region and in NEH region, pineapple, tuber crops, turmeric, ginger, black pepper, cardamum can be integrated with mango, coconut and arecanut. The bi-products from horticulture can be used for rearing pig, poultry, dairy in the system.

In these areas, multiple use of water can also be promoted for enhanced productivity of water and higher return from the system. Similarly, in other conditions also, the different components of the horticulture, crop, animal (both the big and small), birds, pigs, *etc*. can be integrated, based on the available natural resources and diversities. These areas have ample potential for conserving soil and moisture through staggered contour trenching, mulching for *in-situ* conservation and water harvesting systems including spring flow harvesting and sub-surface collection wells in the valleys and near gullies/drainage lines. Micro-irrigation including bamboo drip system for efficient use of harvested water has shown good response in the NEH region.

## Some Fruit Crop Based Farming Systems

In east coast eco-system of Khorda (Old Puri district), mango based horti-system has been demonstrated at Central Horticultural Experiment Station (IIHR), Bhubaneswar. Okra, cow pea, cluster bean, ridge gourd, onion and radish during rainy season; tomato, chilli, French bean, amaranth, cow pea and *Dolichos* bean during winter season; and water melon, bottle gourd, cow pea, ridge gourd, bitter gourd, okra and amaranth during summer season could be grown successfully in the young mango orchard. The soil fertility of the orchard was improved significantly due to inter-cropping of vegetables. Short statured and short duration fruit crops as filler crop in the mango and coconut orchard were also found to enhance the total income from the land over period of time. For establishment of mango plants under rainfed conditions, horticultural techniques such as *in-situ* grafting or budding, water harvesting (both *in-situ* and *ex-situ*) and moisture conservation, initial frame working of plants were practised. Cashewnut is also a hardy crop having tolerance to moisture and various soil stresses.

In plateau region of Chotanagpur, Jharkhand fruit crop-based multi-tier system has been developed and standardized (Nath *et al.*, 10). The system comprises of taller fruit plants like mango, litchi, *aonla*, jackfruit as main crop, guava, lime, papaya and *gamhar* (timber species) as filler crop and various kinds of legumes cereals, oil seeds, grasses, pasture legumes as intercrop. It has been observed that in the initial year of system establishment 60-70% of land remains available for inter crops which minimizes the risk of sole cropping in the uplands. The *in-situ* moisture conservation including mulching and rainwater harvesting system of *Doba/ Julkunda* stabilises the growth.

The strip cultivation along contours or crescent bunding on slopes, fodder cultivation on steep slope and fruit crops like mango and sapota with inter-crops in initial stages on gentle slopes; disposal of excess run-off water through grassed waterways into lined farm ponds to be used for irrigation and fishery is a good model in rainfed coastal eco-system. Crop sequences and combinations involving different components of farming effectively improve the production per unit area and provide a buffer against risk of crop loss and price fluctuations. Mango and cashew-based systems with contour trenches, *jalkunda*, *in-situ* moisture conservation and bio-engineering measures have been successfully demonstrated in the rainfed areas.

## Improved Micro Site Conditions for Degraded Soils

The soil of dry lands are generally characterized with low level of organic matter, weak to moderate profile development, gravelness, salinity or alkalinity, coarse to medium texture with shallow soil depth, poor fertility status and biological activity. Better survival and establishment of fruit trees in rainfed and dry lands requires proper micro-site improvement in the pits apart from providing life saving water during summer in the initial years. Micro-site improvement consists of soil profile modification by way of increasing volume of pit with good rooting medium for the better establishment of fruit plants under adverse growing condition.

Improved micro-site conditions through pits filled with original sieved soils with pond silt + FYM recorded better survival per cent and growth performance of grafted mango and tamarind under degraded gravely soils in dry lands of Salaiyur Watershed in Coimbatore district (Madhu *et al.*, 6). Mechanical pitting by JCB was fond to be better than manual pitting in addition to micro-site (pits) improvement through gravel-free soil mixed with pond silt + FYM for better survival per cent and growth performance of fruit seedlings under dry land condition. In mechanical pitting by JCB, greater pits size, loosened sidewalls of the pits, improved soil moisture holding capacity and cracks / fractures for easy / better penetration of roots resulted in better growth performance. Studies at CRIDA, Hyderabad have also indicated that ring weeding and *in-situ* moisture condition besides microsite improvement are essential to improve the survival of fruit tree seedlings in dry-lands.

*Aonla* plantation in sodic soils in pits filled with soil, gypsum and FYM was very successful in UP and other places. Excavation of pits in gravelly soil and their filling with sieved soil plus FYM, *etc*. supported very good establishment and growth of fruit trees in Shivalik and lower Himalayas.

## Rainwater Harvesting and Water Management for Horticulture Development

Rain water, in its any form receives highest priority as the most limiting production factor in rainfed horticulture. Therefore, conservation and management of rainwater in the form of *in-situ* soil moisture, *ex-situ* rainwater harvesting as surface and sub-surface storages and its efficient use assume highest importance for stabilizing horticulture production and enhancing livelihoods in rainfed areas. Water harvesting and integrated watershed management have shown promising response and offer great potential for promoting horticulture in rainfed areas.

*In-situ* moisture conservation can be achieved by increasing infiltration with the profile modifications, mulching, keeping soil surface rough, contour trenching, inter-terrace land treatments, *etc*. Different *in-situ* rainwater conservation measures are trenching, narrow orchard terraces, catch pit, V-ditch, *jalkunda*, micro-catchments, pits with crescent bunds, *etc*. The *ex-situ* rainwater harvesting technologies include roof top water harvesting, dug out ponds, wells, storage tanks, *nala* bunding, gully control structure/ check dams/ *bandharas* (weirs), water harvesting dams, percolation tanks/ ponds, sub-surface dams/ barriers, *etc.*

The *in-situ* run-off harvesting through micro-catchments and half moon terraces are most suited to the fruit crop. Run-off can be used for growing trees in such a way that each tree or a group of trees has its own micro-catchment area. The layout of micro-catchment in relation to the location of tree would depend upon the topography of the area. The optimum size of a micro-catchment has been worked out for some fruit crops (Moore *et al*., 7). The highest *ber* yields were obtained when 0.5 and 5 per cent slopes had 8.5 and 7 m length of run and 72 and 54 $m^2$ catchments area per tree respectively in Jodhpur (Sharma *et al*., 9). Arora and Mohan (*3*) standardised V-shaped micro-catchment with grass mulching to enhance productivity of lemon, sweet orange and plum in Doon Valley. The hilly, rocky and degraded lands can generate run-off for raising fruit trees.

Run-off water can also be stored in tanks, check dams, ponds, *etc.* during the rains and the same can be utilised for tree establishment and/ or at the time when fruit trees show moisture stress during dry months. Use of lined tanks for the establishment of orchards are also recommended. Besides this, direct rainfall storage through small sized 3-4 $m^3$ poly lined *jalkundas* in *Dapoli* and *Dobas* in Jharkhand for horticulture development have shown great promise.

## Drip Irrigation

Drip irrigation is one of the most efficient irrigation methods for orchard and plantation crops where it saves 30-70 per cent irrigation water and increases yield by 25-80 per cent. Evidences from drip irrigation trials have clearly indicated the advantages like water saving, higher productivity, limited weed growth, better management of assets, off-season maturity, better fruit quality and reduced incidence of insects, pests and disease. However, due to its high initial cost, expansion of drip has been limited. Development of horticulture through plasticulture applications and now through a centrally sponsored scheme of micro irrigation, the Government initiated scheme for subsidising cost of drip irrigation.

## Fertigation

Through fertigation, both fertilizers and water are delivered to the root system of the growing crops with the help of micro-irrigation systems. Fertigation ensures higher and quality yield along with saving in fertilizer, time and labour. Few progressive farmers are growing high value fruit crops of grapes, pomegranate and banana using fertigation. One of the main reasons for slow adoption of fertigation is the non-availability of totally water soluble fertilizers at affordable cost.

## Mulching

Mulching prevents the loss of moisture by evaporation. Various organic (straw, hay, organic manure, tree leaves) and inorganic mulches (black alkathene) are available. To conserve the moisture loss from the surface of plant and soil, use of mulches, cover crops and antitranspirants have been used. This is a very common practice in Kerala especially in mixed systems of coconut, banana, black pepper, *etc*. Black polythene (400 gauge) has been found effective mulch material in *ber*, pomegranate, date palm and *aonla* orchards. Some local weeds like *bui Aerva tomentosa, sarkanda* (*Saccharum munja*), etc. are effective live mulch materials. Antitranspirants like 10% kaolin and $10^3$M PMA (Phenyl mercuric acetate) have been found effective to check moisture losses from plant surface resulting in increased fruit production in pomegranate. By proper and timely mulching, the evaporation loss from the soil and through weeds can be minimised. Besides increasing yield and fruit quality, the organic mulches are also helpful in improving the physical conditions of the soil.

## High Density Plantations

High density planting has been a success story in India in many fruit crops like banana, pine apple, papaya, citrus, cashew, mango, *etc*. High density

orchards not only provide higher yield and net economic returns per unit area in the initial years, but also facilitate more efficient use of inputs and easy harvest. Technologies for high density planting in different fruit crops have been standardized. This should be supported with site specific soil moisture conservation and water harvesting practices, along with micro-irrigation and fertigation.

## Organic Farming and Primary Producers Companies

In the last few years, organic farming especially combined with eco-tourism in our country (Goa) has attracted many tourists and growers across the country and many growers have experimented successfully with grape, mango, sapota, banana, papaya and spices. Large scale investment in this sector will overcome the marketing constraints of these produce and hence, will be a highly remunerative venture.

There is a demand of about 4,000 tonnes of organically produced cocoa by Switzerland since their traditional suppliers of Africa are not satisfying phyto-sanitary conditions. Primary producers companies registered under amended (2002), Companies Act of 1956 are able to aggregate inputs, credit, output, processing, branding and process certification to harness sufficient benefits. The primary producing share holders received 20-25% high prices through entrepreneurship of their company

## Convergence

Advantage of harmonization and rationalization by converging with different programmes like National Horticulture Mission (NHM) and Integrated Watershed Development Programmes (IWMP), NREGS, Artificial Ground Water Recharge, Renovation of Water Bodies, *etc.* should be utilised for creating local level micro-water harvesting systems and resources from schemes like Micro Irrigation of Agriculture Ministry and similar scheme of Ministry of Water Resources could be used for providing micro irrigation and fertigation to the fruit trees. For example natural resource base or productive asset created by NREGS could be converged with horticulture related production system components of NHM and/ or IWMP and similarly Artificial Ground Water Recharge converged with Micro Irrigation, IWMP or NHM for productive and efficient utilisation of created water resources.

## Interventions for Various Rainfall Situations

Late/early arrival or withdrawal, long dry spells, high rainfall events, heat or cold waves are quite common and rainfall abnormalities are increasing due to climatic changes.

### Rainfall deficit

*Fruit Crops*

- *In-situ* grafting, budding, drip or pitcher irrigation, mulching and urea spray.
- Inter-cropping of drought tolerant and short duration crops like ragi, cowpea, horsgram, groundnut, sesamum, *etc*. in the inter-space of fruit trees.
- To a certain extent we can change or modify the active growing season of the crops with different physical (pruning) and chemical (growth regulators) means and harmonize the growth pattern according to the availability of water.
- Supplemental irrigation during critical stages like fruit setting, fruit development, *etc*. in order to check the fruit drop and better fruit development.

*Vegetables*

- Switching over from direct seeding to transplanted crop will make up for 3-4 weeks delay in the onset of monsoon.
- Recommended varieties for rainfed situation such as Arka Meghali (tomato), Arka Lohit (chillies), Arka Kalyan (onion).
- Mulching with crop residues and other organic biomass to conserve water.
- If dry spell is more than 7 days life saving irrigation can be given by rainwater harvesting.
- Various types of anti-transpirants, *viz*. metabolic inhibitors, film forming chemicals like wax and radiation reflecting like kaolin may cut down water needs. Kaolin clay has been tried in dryland and chilli, whenever mid-season drought occurred. Phenyl mercuric acetate (30 ppm) and kaolin 5% can be used in tomato and onion for the purpose.
- Fertilizer response is difficult under drought, foliar spray of fertilizers with higher potash content like multi nutrient K (12:43, N:K) water soluble fertilizer @ 0.5% are recommended.
- To facilitate *in-situ* moisture conservation, ridges and furrow method of planting with tied ridges every 15-20 m length is suggested.
- In capsicum, cauliflower and okra by adopting alternate furrow irrigation or wide space furrow irrigation system, 35 to 40 % of irrigation water can be saved without adverse effect on the yield.
- Enrichment of FYM with bio-fertilizers like *Azospirillum, Azobacter* and PSB can improve the soil fertility at low moisture levels.
- Micro-irrigation is one of the very important strategies in reducing the impact of drought.

- In the areas becoming drought prone, the fruit crops like mango, sapota, jack, and semi-arid crops like *ber,* pomegranate, *aonla,* annona, *phalsa, etc.* may be taken up for future planting.
- Fruit based cropping systems such as mango-chilli, mango-leguminous vegetables, *etc*. such cluster beans, cowpea, dolichos can be employed for better land utilization and higher productivity under water stress conditions.

*Above normal rainfall*

- Flushing out water by providing suitable drainage.
- Raised bed cultivation of vegetables.
- Foliar nutrition of urea and micronutrient mixture so as to meet immediate nutrient requirement.
- Disease resistant varieties like Arka Ananya (tomato), Arka Anand (brinjal), *etc.*
- To reduce run-off and enhance rainwater infiltration, inter-cropping of legumes is recommended in fruit crops.
- Water guzzling fruit crops like banana may be preferred.
- Application of adequate quantities of FYM and crop residues to improve soil structure and water holding capacity is suggested. Short duration green manure crops like sun hemp can be grown as catch crops in dry lands.
- Application of tank silt during summer improves the soil texture and its water holding capacity.
- In a sloppy terrain contour bunding to check the soil and water erosion.
- Soil moisture conservation through mulching either with black polyethylene or locally available mulches, growing cover crops or inter-culturing in the orchards to check soil erosion and run-off of rain water are advisable.
- Rain water harvesting is an important technique which might comprise *in-situ* water harvesting by opening small trenches, contour bunding, 180°C crescent bunding, *etc.,* or collecting the rain water in the lower regions of the farm and recycling it by providing critical irrigations to crops through micro-irrigation systems. Improvement and popularization of traditional rain water harvesting systems, water conservation and efficient utilization play a major role in judicious water use where it is a limiting factor.

## Vegetable Varieties Suitable for Rainfed Cultivation

Some of the vegetable varieties suitable for growing in rainfed conditions are; tomato - Arka Meghali; onion - Arka Kalyan; cowpea - Arka Garima, Arka Samrudhi and Arka Suman; dolichos - Arka Jay and Arka Vijay.

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