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Contingent crop planning for aberrant weather conditions in dryland agriculture

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Abstract
Unfavourable deviated weather from the normally expected one is called aberrant weather. Aberrant weather is a common feature of dryland agriculture. Crop production in dryland areas is mainly dependent upon rainfall, which is received during the south west monsoon. The rainfall is seasonal, erratic and highly variable with space & time. The deviations in rainfall pattern commonly met with include delayed onset, early withdrawal and intermediary dry spells during rainy season. Suitable manipulations in crop management practices are needed to minimize such adverse effects of abnormal rainfall. These management decision, constitute contingency planning. The major challenge in dryland agriculture is to minimize yearly variations in crop yields due to aberrant weather conditions and to stabilize production at a reasonably acceptable level.

Keywords: aberrant weather, monsoon, rainfall, crop, yield

Introduction
Dryland agriculture accounts for 63% of the country's arable land and provides 45% of the total agricultural production. However, the average crop productivity is quite low (one tonne/ha). Rain dependent *kharif* crops in arid and semi-arid regions are frequently subjected to aberrant weather conditions. Weather is the most variable factor in dryland crop production. It is the one, which can be least controlled. Besides uncertainties in rainwater availability, the swings in the onset, continuity and withdrawal pattern of monsoon and frequent dry spell make crop production a risky proposition. The only certainty about monsoon in these areas is uncertainty of temporal and spatial distribution of rainfall. The overall problem is very complex as the crops are subjected to wide range of soil-moisture conditions and to diverse interplay of environment factors. The high co-efficient of variation in the monsoon rainfall in areas located in zones of < 500 mm and 500-700 mm ranging from 50-55 and 40-50 per cent, respectively associated with scanty and ill distributed rainfall are the main crux of the drought problem in these areas (Joshi *et al.*, 1998) [3].
The major challenge in dryland agriculture is, therefore, to minimize yearly variations in crop yields due to aberrant weather conditions and to stabilize production at a reasonably acceptable level. The dryland crops usually face moisture stress of various intensities at one or more stages of crop growth during the season. Change in cropping calendars and pattern involving some alternative crops and varieties could be the immediate option. Introduction of cropping sequences, late or early-maturing crop varieties based on the available growing season, conservation of soil moisture through appropriate practices and efficient water-harvesting techniques are also important. A contingent crop production strategy has become a set of guidelines for managing weather aberrations in dryland cultivation. These approaches are useful conceptual tool to tailor various management practices for sustaining productivity of crops in drought situations. Contingency crop planning will necessitate greater attention. Long-term strategic approaches to efficiently conserve and utilize rain water on the one hand and in-season tactical approaches to mitigate the adverse effects of weather aberrations on the other are also needed.

Strategic approaches
Selection of crops and cropping systems
Choice of efficient crops and cropping systems are dependent on the available soil moisture and length of available growing season. In dryland areas, the length of growing season is

determined mainly by the moisture availability period that in turn depends on rainfall amounts and distribution, soil moisture storage properties and potential evapo-transpiration.
In most of the arid and semi-arid regions, crops and varieties grown are not efficient in moisture use. They are longer in duration than the water availability period and are invariably caught in moisture stress, resulting in low yields and some times complete crop failure. The guiding principle for selection of crops/ varieties should be that their growth rhythm is fit into the water availability period. For example, green gram and moth bean need 8 weeks of growing season, coinciding with 200 mm rainfall. Similarly, pearl millet/ cluster bean, sorghum and groundnut take 12, 16 and 18 weeks, respectively for their maturity and the corresponding mean length of growth season occurs when the rainfall is 300, 500 and 650 mm. The cropping systems varied from mono-cropping in shallow soils to double cropping in deep soils. The adoption of suitable crop calendar by matching critical pheno-phases with availability of water resources and atmospheric environment seems to improve transpiration efficiency of crops and economic yield. The mismatch between environment rhythm (especially the rainfall pattern) and the crop growth rhythm (critical pheno-phase for water needs) is the major cause of unsuitability of certain crops in the region.

Singh and Rao (1988) [4] suggested the following cropping system depending on the length of growing season available:

Length of growing period	Cropping systems to be adopted
< 75 days	Perennial vegetation, mixed cropping of short duration pulses, pearl millet
75-140 days	Mono-cropping of short duration pulses, pearl millet, sorghum, maize, castor, sesame, groundnut etc.
	Mono-cropping during post-rainy season with sorghum, chickpea, mustard
140-180 days	Intercropping
> 180 days	Double cropping with winter sorghum, chickpea, barley, lentil, mustard during post-rainy season

Yield reduction in continuous monoculture of crops such as sorghum, green gram etc. is often ascribed to allelo-pathic auto-toxicity. Alternate management systems such as crop rotation, mixed or intercropping and multi-cropping can enhance crop productivity by reducing auto-toxicity.
Mixed cropping of pearl millet with arid legumes is a common practice in arid and hyper-arid regions. This, not only provide an assurance against failure of one or the other crops due to vagaries of weather in dryland agriculture, but also enabled the farmers to enhance productivity through more efficient use of land, water and solar energy in vertical dimension.

Crop management approaches

Crop management practices include sowing crops immediately after onset of monsoon, establishment of seedling under sub-optimal conditions, maintaining adequate plant stands, nutrient management, tillage, improvement in plant characteristics, control of weeds, pests and diseases. Maintenance of adequate and uniform plant stand is very crucial for effective use of rain-water and other inputs. Use of high-quality seed improves the uniformity of crop establishment. Improved cultivars of different crops are available for cultivation in dryland, which are early and have high harvest index, and hence give higher grain yields than the local cultivators. Selection of cultivars resistant to pests and diseases and their timely control help in attaining high yield and water-use efficiency. Similarly, timely and efficient weed management is very necessary.

Diversified farming

A shift from sole cropping to a diversified farming system is highly benefited. Horticulture and agro-forestry need to be given more encouragement, whereas in the western part of the arid lands bigger emphasis is requisite on grassland or biomass development for the livestock, which becomes a major constituent of the individual farmer's economy.

Efficient rainwater management

Efficient rainwater management acts as insurance for the crop during the rainfall deficit periods. Storage of water in the soil and in natural or manmade structures and effective utilization of given quantity of water are important aspects of rainwater management. Management techniques that increase infiltration and soil water storage and decrease water loss by runoff, evaporation and water use by weeds increase the amount of water retained in the soil for subsequent use by crops. Maximizing infiltration and minimizing runoff can be achieved through a variety of *in situ* moisture conservation practices which include off- season deep tillage, mulching, addition of organic materials/pond sediments, inter row cultivation, ridge and furrow system of seeding, compartmental bunding and graded border strips (Jangir, 2004) [1].

1. Off-season deep tillage helps the rainwater to enter the soil profile more effectively and, in addition, helps in weed control. However, it is not suggested for aridisols (i.e., sandy soils of the desert regions) as this would accelerate wind erosion. Deep ploughing (i.e., up to 22 cm), once in two or three years, also helps to increase crop yield in soils with hard sub-soil below the plough layer. Deep tillage is also effective in controlling perennial weeds.
2. Mulching is yet another effective practice found useful in checking evaporative loss from soil, modifying soil thermal regime, checking growth of weeds and improving the availability of water and nutrients to the plants. Presence of crop residues stubbles / vegetative mulches/ dust mulching on soil surface reduce the runoff losses as well as soil surface sealing by reducing beating action of raindrops and thus, maintain high infiltration rates.
3. Addition of organic matter and pond sediments will reduce splash action of raindrops thereby evading crust formation, increasing microbial activity and water holding capacity.
4. Compartmental bunding: Making small ridge and furrow by *desi* plough or bund former across the field at an interval of 4-5 meters not only reduce runoff of excess rain water but also increases its percolation to deeper soil layers.
5. The inter-row water harvesting is practice suitable for light textured soils of the arid region, which increases soil moisture availability and conserve moisture by breaking its capillary movement. Significant yield advantages have been recorded with pearl millet crop by adopting these practices.

Tactical approaches

Since dry lands depend totally on unpredictable monsoon rains, the dry land technology should to be equipped with contingent crop plans to avoid total failure of crops. It is expected that under such weather aberrations, crop yields will not be normal, but the strategy will help to get some thing or to sustain. Under such situation, fodder for cattle becomes a problem. The contingent crop plans, therefore, should also give serious consideration for fodder production.

There are at least four important aberrations in the rainfall behaviour

1. Early or considerably delayed onset of monsoon
2. Breaks in monsoon rains
3. Uneven distribution of monsoon rains in space and time
4. Early withdrawal of monsoon

Early or considerably delayed onset of monsoon

Commencement of rains quite early is rare. Experience revealed that the normal crops can be planted as early as 15 days without any adverse effect. However, if pre-monsoon rains occur much before to the normal date (>15 days), cultivars with more elasticity should be planted. What causes concern is the delayed onset of monsoon. This type of aberration is very frequent in the drought prone area. The onset of rainfall may be delayed by a few days to even more than four weeks compared to the normal dates of sowing (Joshi and Kar, 2009) [2]. Under such situations, sowing of the crops gets delayed. Usual crops and their varieties some times need replacement due to two situations *viz*., on account of late arrival of monsoon, the length of growing season is considerably shortened, thus require the crops/ varieties of shorter duration and secondly, some crops get effected due to diseases e.g. downy mildew disease in late sown pearl millet. The practices transplanting have been tried to compensate the delay in sowing time. Some of the crops like pearl millet and finger millet can be grown in nurseries near the source of water (e.g. village pond), and seedlings can be transplanted after the receipt of rains. For example, sowing of pearl millet beyond third week of July gives poor yields in the arid zone, whereas legumes like cluster bean, green gram and moth bean give good yields under such conditions. Crops suitable for delayed monsoon conditions have been identified for different dry land agro-climatic regions (Venkateshwarlu *et al*., 1991) [5].

Breaks in monsoon rains

Breaks in the monsoon rains can be of different durations. Breaks of shorter duration like 5-7 days may not be a serious concern whereas, breaks of more than 15 days duration create situation of plant water stress leading to reduction of crop production. The stage of the crop growth at which break occurs decides the severity of damage. Germination and crop establishment is one of the most sensitive periods when moisture stress can have devastating effect on crop production. Poor germination and seedling mortality may result in low and erratic crop stand. If such situation occurs, gap filling by transplanting seedlings after the rains is an effective means of achieving the desired plant stand. In case of crops where transplanting is not possible, it is better to re-sow the crops after subsequent rains rather than having inadequate stand in the fields. Moisture stress during crop growth stages of high leaf area indices will have the maximum decrease in yield. Reduction in leaf area indices by thinning of the crop mitigates the ill effects of drought to a certain extent. For example, reduction of plant population by removing every third row was found to be advantageous to mitigate the moisture stress. Timely weed control and use of mulches may also be useful in extending the period of moisture availability by reducing wasteful loss of moisture. In region where crops usually face late season or terminal drought conditions, important options are selection of crops and cropping practices that lead to the completion of plant life cycle before the drought induced senescence. Selection of crops/ varieties with early anthesis ensures moisture availability during reproductive growth under terminal drought conditions. Therefore, indeterminate habit of crop growth is desired under dry land conditions. Further, drought may be more pronounced on soils with limited water holding capacity (usually shallow to medium deep soils) than with more water holding capacity (deep soils).

Uneven distribution of monsoon rains in space and time

Such situations are encountered almost every year in one or the other part of the country during southwest monsoon leading to drought. This situation affects the agricultural production giving instability to it. A combination of perennial crop component in agriculture can absorb shocks because of this situation. As such approach of Agro-forestry is important to impart stability.

Early withdrawal of monsoon

If monsoon terminates earlier than usual, it cuts the length of growing season. Normally crops in their maturity and those growing on shallow soils suffer heavily. Sowing of *rabi* crops may also get affected. It is, therefore, advisable to use short duration and early maturing varieties to face the situation.

Aberrant conditions and Agronomic management options

Rainfall situation	Agronomic management options
1. Early onset of monsoon	
	▪ Sow medium maturing composites of pearl millet if rains occur 15 days earlier than normal time. ▪ Use compaction device for combating crust formation
2. Delayed onset of monsoon	
A. Two weeks (15 July)	▪ Use early maturing cultivars of pearl millet or mixed cropping of pearl millet with pulses/ sesame ▪ Follow wider row spacing (60 cm) with low population ▪ Use compaction device for uniform germination ▪ Compartmental bunding in field ▪ Additional dose of 20 kg N under excessive rain during vegetative phase
B. Four weeks (July End)	▪ Extra Early varieties of pearl millet should be sown or transplanting of pearl millet seedlings or Grow short duration sole moth bean or cluster bean ▪ Follow wider row spacing (60 cm) with low population ▪ Use compaction device for combating crust formation

	▪ Compartmental bunding
C. Six weeks (2nd week of August)	▪ Grow fodder Pearl millet/Sorghum
3. Early season drought (Normal onset)	
A. Dry spell of 15-20 days after sowing	▪ Re-plant pearl millet in between the existing rows or relay cropping with short duration oilseed/ pulse crops ▪ Gap filling by transplanting with rains in pearl millet ▪ Intra row water harvesting for *in situ* soil moisture conservation ▪ Adoption of dust/ vegetative mulching
B. Mid season drought for 2 consecutive weeks	▪ Reduce plant population by 25% ▪ Create weed free environment & dust/ vegetative mulching ▪ Water harvesting tank for protective life saving irrigation at flowering.
4. Terminal drought (Early withdrawal of monsoon)	
	▪ Provide life saving protective irrigation. ▪ Skip N top dressing in coarse cereals ▪ Reduce plant population ▪ Adoption of dust/ vegetative mulching Mulching

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