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Agricultural drought monitoring and management at sub district level in Telangana

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सार – मौसम या जलवायु को विशेष रूप से वर्षा आधारित पर्यावरण में खेती बाडी के लिए फसल की बेहतर योजना बनाने और फसल प्रणाली के लिए एक महत्वपूर्ण प्राकृतिक संसाधन और बुनियादी सूचना देने वाला माना जाता है। फसल की वृद्धि , विकास और पैदावार से संबंधित प्रत्येक पौधे की प्रक्रिया तथा प्रत्येक मौसम के और बेमौसम के फार्म प्रचालन मौसम पर निर्भर करते हैं। फसल वृद्धि विकास और पैदावार का स्तर तय करने में विभिन्न मौसम के तत्व, तापमान, विकिरण और वर्षा महत्वपूर्ण भूमिका निभाते हैं। वायुमंडलीय और मिटटी की नमी के लिए जिम्मेदार वर्षा महत्वपूर्ण मौसम कारकों में से एक है और इसलिए विशेष रूप से वर्षा आधारित कृषि के क्षेत्र में इसका अधिक कृषीय महत्व बढ़ जाता है।

ज्वार, मक्का, मूंगफली, मूंग, उडद और सूरजमुखी और पानी में उगाए जाने वाले चावल जैसी वर्षा आधारित फसले मुख्य रूप से सूख के कारण प्रभावित हो रहे हैं। सूखे की स्थितियां दक्षिण-पश्चिम मानसून की विफलता, दक्षिणी-पश्चिमी मानसून के आगमन में देरी और मानसून में व्यवधान की स्थिति या दक्षिणी-पश्चिमी मानसून के शुरूआत में ही समाप्त हो जाने के कारण होती है। भारत में वर्षा आधारित कृषि मानसून के आगमन और फसली विकास के मौसम के दौरान वर्षा वितरण पर निर्भर करता है। वर्षा की मात्रा और मानसून के प्रारम्भ होने का समय यह निर्णय करते है कि किस प्रकार की फसल बोई जाए। जून और जुलाई के महीने में मानसून बारिश के समय पर शुरू होने और अच्छी तरह से वितरण, वर्षा आधारित फसलों के क्षेत्र में आने वाले स्थानों का निर्णय करते है। दक्षिण पश्चिम मानसून वर्षा के शुरू होने और वितरण में किसी भी प्रकार का विचलन कृषि और उसकी निर्भर गतिविधियों पर बहुत बड़ा प्रभाव डालती है। मानसून और वर्षा के वितरण की प्रगति की करीब से निगरानी और वर्षा आधारित फसलों की बुआई पर इसके प्रभाव का जिला स्तर आवश्यक है जिससे असामान्य मौसमी स्थितियों के प्रभाव को कम करने के लिए (समय पर फसल प्रबंधनी नीति का सुझाव दिया है। इस शोध पत्र पर एम ए आई, डब्ल्यू आर एस आई आदि में राष्ट्रीय, राज्य और उप जिला (मंडल) के स्तर पर सूचनाओं का उपयोग करते हुए सूखे की निगरानी की गई। बुआई का अनुकूलतम समय, सामरिक सिंचाई, फसल कैलेंडर, आकस्मिक फसल योजना आदि पर सूखे के प्रभाव को कम करने के लिए प्रबंधन नीतियों पर चर्चा की गई। कृषक समुदाय के लाभ के लिए वास्तविक समय मौसम की जानकारी को सम्प्रेषित करने के लिए कृषि मौसम परामर्श प्रस्तुत किए गए।

ABSTRACT. The weather or climate is considered as an important natural resource and basic input for better planning of crop and cropping system in agriculture particularly rainfed environments. Every plant process, related with growth, development and yield of a crop and each of in-season and off-season farm operations depends on weather. Amongst the various weather elements, temperatures, radiation and rainfall play crucial role in deciding the crop growth, development and yield levels. Precipitation is one of the important weather factors being responsible for atmospheric and soil moisture and therefore has more agricultural importance, especially in rainfed agriculture.

Rainfed crops like jowar, maize, groundnut, greengram, blackgram and sunflower and one water-intensive crop like rice are mainly affected owing to drought. The drought conditions occur due to failure of South West Monsoon, delay in arrival of SW monsoon, and break monsoon conditions or early cessation of SW monsoon. Rainfed agriculture in India depends on onset of monsoon and the rainfall distribution during crop growth season. The amount of rainfall and the time of onset of monsoon decides the type of the crop to be grown. The timely onset and well distribution of monsoon rain in the month of June and July decides the area coverage of rainfed crops. Any deviation in the onset and distribution of southwest monsoon rainfall causes huge impact on agriculture and its dependent activities. Close monitoring of progress of monsoon and distribution of rainfall and its impact on sowing of rainfed crops is essential at sub district level to suggest time to time crop management strategies thereby to minimize the impact of aberrant seasonal conditions. In this paper a monitoring of drought at national, state and sub district (Mandal) level using indices like MAI, WRSI etc. were presented. Management strategies to reduce the impact of drought like optimum time of sowing, strategic irrigation, crop calendar, contingency crop planning etc. were discussed. Agromet advisories for communication of real time weather information for benefit of farming community were presented.

Key words – Drought, Telangana, WRSI, Extreme weather.

1. Introduction

Drought is a natural part of climate, although it may be erroneously considered as a rare and random event. Drought differs from aridity, which is restricted to low rainfall regions; it can occur in any climatic zone, but its characteristics vary significantly from one region to another. Drought does not automatically lead to a disaster. Disaster only occurs when there is a serious disruption of the functioning of a community or a society, which involves widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

Drought is caused by the delay in the onset of monsoon, failure of rain, and prolonged period of rainless days during the crop growing season. Thornthwaite (1948) characterized four types of drought such as permanent, seasonal, contingent and invisible. Broadly, droughts are characterized into 4 types, *i.e.*, meteorological, hydrological, agricultural and socio-economic. A year is considered as drought year, whenever, rainfall is less than 75 per cent of its normal. If the deficiency is more than 50 per cent of its normal, it is considered as severe drought. Shortage of rainfall coupled with its erratic distribution during rainy season causes severe water deficit conditions resulting in various intensities of droughts. Drought, seldom results in structural damage in contrast to floods, earthquake and cyclones. Because of this, the quantification of impact and the provision of relief are far more difficult tasks for drought, compared to other natural disasters.

In India, about 29% of the total geographical area is considered as drought prone, experiencing every second or third year a drought. In other words, on an average, every fifth year was a drought year, every 20th year was a severe drought year and every 40th year was severe devastating drought year. The IMD officially acknowledged that the year 2002 has been "the first ever all India drought year" since 1987. In view of the devastating effects of droughts on the economy of country, information about early warnings on possible occurrence of deficit rainfall conditions leading to droughts is required to take-up appropriate measures to mitigate the drought. The information about the onset of drought conditions in a timely and reliable manner is imperative to organize corrective steps for drought mitigation. There are ways to monitor drought which include the network system of stations, and use of remote sensing etc.

2. Drought monitoring

There are some approaches which help in monitoring of drought. The Palmer Index (1965) is most effective in determining long term drought - A matter of several months, so it can be applied to any part of the country to demonstrate relative drought or rainfall conditions. Whereas, the Crop Moisture Index (CMI) as modified by Palmer (1968) which responds more rapidly and can change considerably from week to week, so it more effective in calculating short - term abnormal dryness or wetness affecting agriculture. Drought severity index (DSI) considers the agricultural drought frequency and the severity based on Moisture availability index (MAI).

For assessment of crop yield during drought, monitoring stress through an index that takes into account the moisture deficiency during different growth stages, would be a very useful tool. Such an index with particular reference to growth stages of crops has been meagerly used in the country, for monitoring moisture stress at short intervals. Frere and Popov (1979) of FAO have developed a parameter known as "Water Requirement Satisfaction Index (WRSI)", which is expected to serve the purpose of monitoring moisture stress in rainfed crops. The Index of Moisture Adequacy (IMA) developed by Thornthwaite and Mather (1955) is another important index for assessing the moisture status in relation to water need at a place and can be used to monitor moisture stress. The magnitudes of these indices are yet to be specifically determined at each location and for each growth stage of crop species grown during the *kharif* season. Very meagre information is available on this aspect at present.

3. Drought monitoring in India

Drought has a number of short and long term effects on the ecosystem of the affected area. Agricultural production in India is highly dependent on rainfall; hence, drought has a direct effect on it. Drought reduces the country's food grains production in certain years by as much as 15-20 per cent of the yield of a normal year.

A well established drought monitoring system exists in India. India Meteorological Department (IMD)

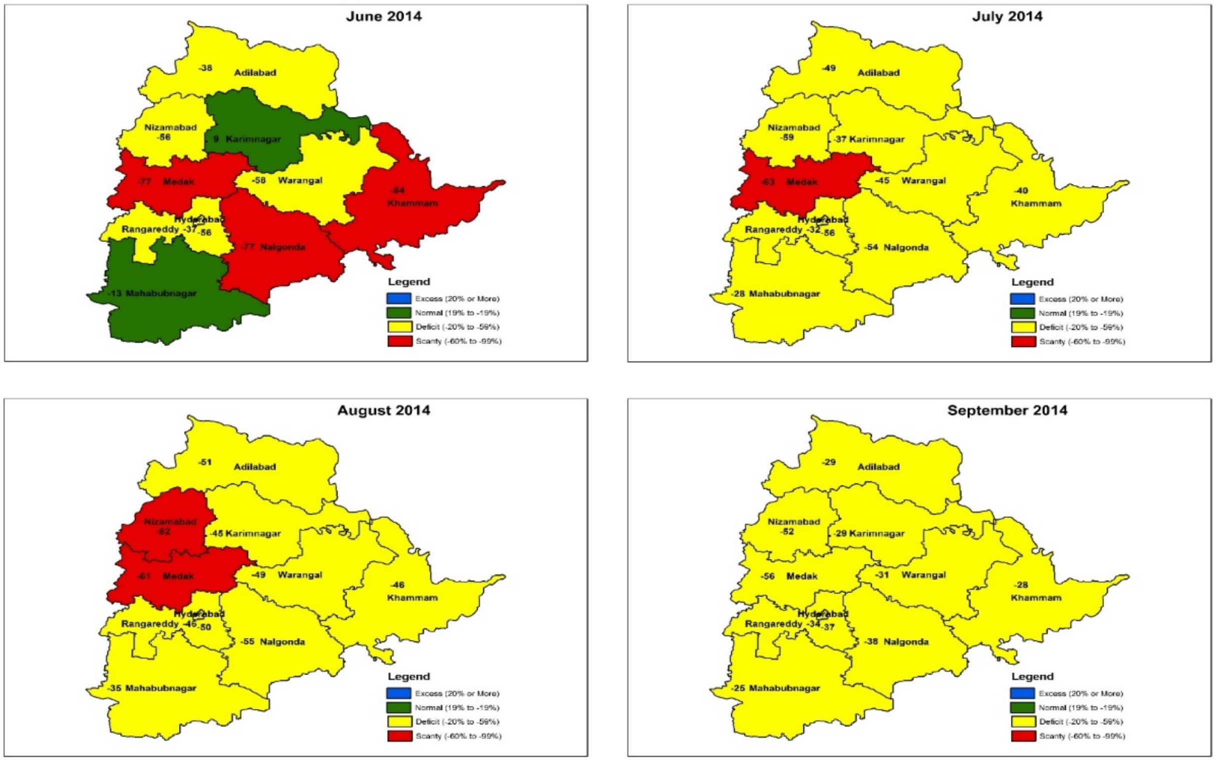

Fig. 1. Monthly rainfall deviation in different districts of Telangana during SWM 2014

and National Remote Sensing Centre (NRSC), Hyderabad have been monitoring drought over the country by the conventional way of rainfall monitoring and remote sensing methods respectively. IMD monitors both the meteorological drought and agricultural droughts. Meteorological drought over an area is defined as a situation when the monsoon seasonal (June-September) rainfall over the area is less than 75% of its long-term average value. It is further classified as 'moderate drought. If the rainfall deficit is 26-50% and 'severe drought' when the deficit exceeds 50% of the normal. Further, a year is considered as a 'drought year' when the area affected by moderate and severe drought either individually or together is 20-40% of the total area of the country and seasonal rainfall deficiency during southwest monsoon season for the country as a whole is at least 10% or more. When the spatial coverage of drought is more than 40% then it is called as all India severe drought year (www.imd.gov.in).

4. Drought monitoring at district level

Weekly or monthly rainfall monitoring at district or mandal level is done considering the rainfall deviation as per the criteria developed by the IMD. Accordingly the rainfall is considered as excess when deviation is +20% and above, normal $\pm$19%, deficit rainfall -19% to -59%, scanty rainfall -60% to -99% and No rainfall -100%.

Perusal of the Fig. 1 indicated that during month of June 2014 the districts of medak, Nalgonda and Khammam experienced scanty rainfal, whereas the districts of Adilabad, Nizamabad, Warangal and Ranga Reddy experienced deficit rainfall. During the month of July the district of Medak received scanty rainfall while remaining districts of the state received deficit rainfall. While in August, Medak and Nizamabad districts experienced scanty rainfall and other districts of the State received deficit rainfall. During month of September all the districts of the state experienced deficit rainfall.

Drought monitoring indices like Index of Moisture Adequacy (IMA) as suggested by Sastri *et al*. (1981) and Water Requirement Satisfaction Index (WRSI) as suggested by Frere and Popov (1979) were computed for monitoring crop condition of major crops in different centres of elangana. For drought monitoring, some of the indices like Index of moisture adequacy (IMA) and Water requirement satisfaction index (WRSI) are available and same were used in the study.

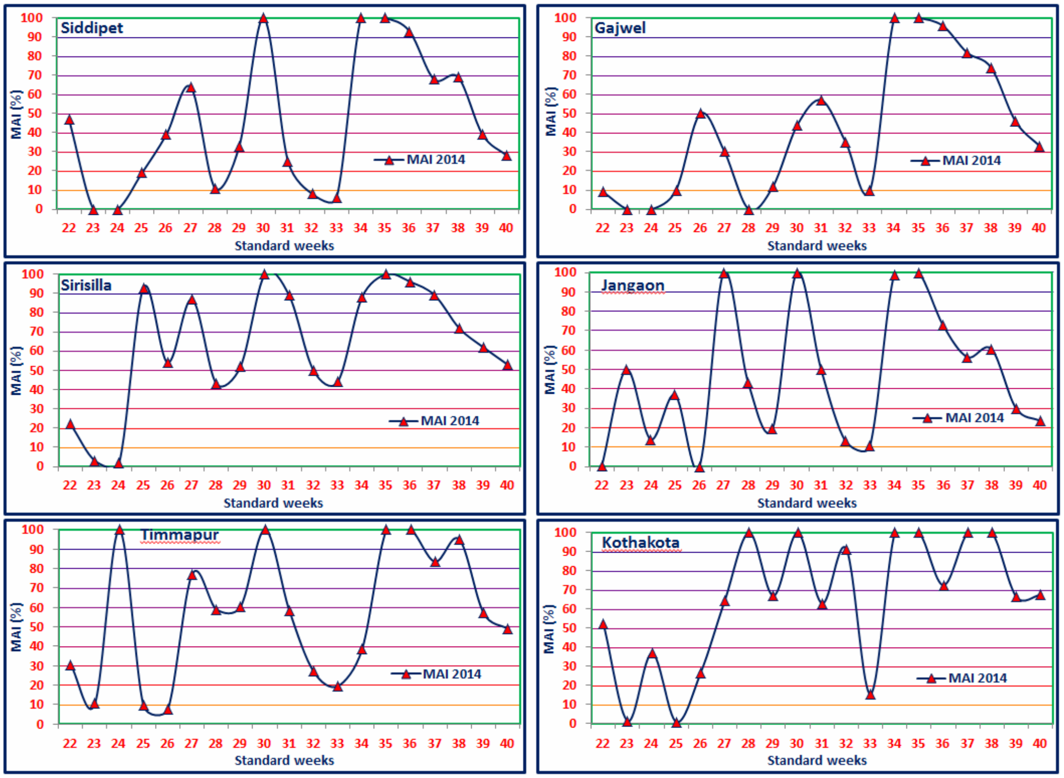

Fig. 2. Weekly Moisture Adequacy Index (MAI %) in different mandals of Telangana during SWM 2014

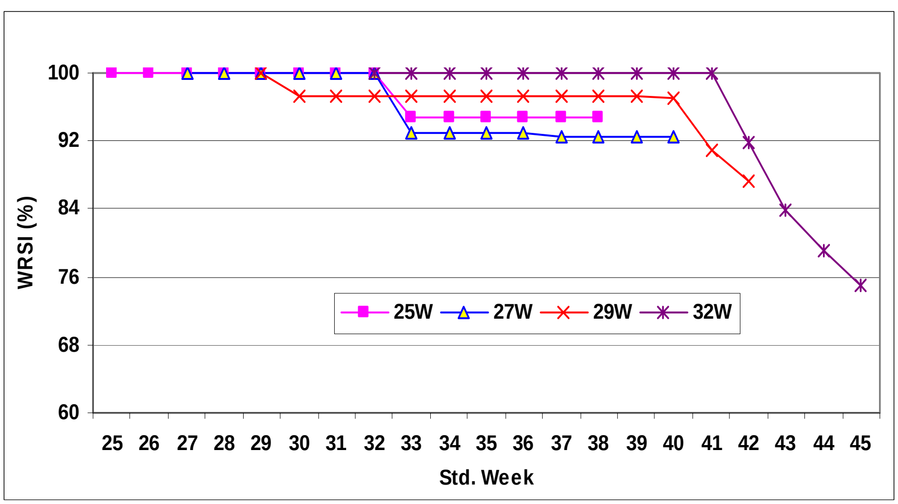

Fig. 3. Water requirement satisfaction Index (WRSI) of maize under different sowing weeks at Rajendranagar

5. Index of Moisture Adequacy (IMA)

Monitoring of drought using IMA during 2014 indicated that, all the centres, experienced moisture stress during *Kharif* 2014. At Siricilla of Karimnagar and Kothakota of Mahabubnagar district experienced moderate to severe moisture stress during *Kharif* 2014 compared to other centres (Fig. 2).

6. Water Requirement Satisfaction Index (WRSI)

Water Requirement Satisfaction Index (WRSI) at Rajendranagar indicated that, maize crop did not experience any stress both during emergence and vegetative phase while moderate stress experienced at flowering and yield formation phase when crop is sown on 25 Std. week (Fig. 3). Delay in sowing of crop resulted in

TABLE 1

Grain yield of maize as influenced by irrigation schedule

Irrigation schedule	Grain yield (t ha^{-1})
Irrigation as per crop water requirement	6.54
Skipping irrigation during vegetative phase	6.20
Skipping irrigation during reproductive phase	4.85
Rainfed	3.99

TABLE 2

Per cent increase in yield of maize due to irrigation over rainfed condition

Irrigation schedule	% Increase in yield over rainfed
Irrigation as per crop water requirement	26.3
Skipping irrigation during vegetative phase	21.2
Skipping irrigation during reproductive phase	14.6
Rainfed	0.0

increase in moisture stress during vegetative and reproductive phase (Reddy and Sreenivas, 2008).

7. Drought management strategies

The impact study of drought during different growth phases on grain yield of maize revealed that, among the irrigation schedules, significantly higher grain yield was recorded when irrigation was scheduled as per the crop water requirement and it was comparable when irrigation was scheduled as per the crop water requirement during reproductive phase by skipping irrigation during vegetative phase (Table 1). Significant reduction in grain yield was recorded when irrigation was scheduled during vegetative phase and skipping irrigation during reproductive phase. Significantly lower grain yield was obtained when crop was raised under rainfed conditions (Table 1).

The percentage increase in grain yield of maize was higher (26.3) when crop was irrigated as per its water requirement compared to rainfed crop (Table 2). Scheduling of irrigation during reproductive phase resulted in higher grain yield compared to irrigation during vegetative phase indicating that, between the crop phases the reproductive phase was highly sensitive compared to vegetative phase.

TABLE 3

Grain yield of maize as influenced by different dates of sowing

Date of sowing	Grain yield (kg ha^{-1})
22 June	8590
7 July	8420
22 July	7023

TABLE 4

Mitigation of drought in maize using drip irrigation

Irrigation schedule	Grain Yield (t/ha)	Effective rainfall (mm)	Irrigation water (mm)	Water productivity kg m^{-3}	Per cent increase in yield over rainfed
I_1	5.58	396.6	0.0	1.41	-
I_2	7.09	396.6	100.0	1.43	27.1
I_3	7.92	396.6	20.0	1.90	42.0

I_1 = Rainfed; I_2 = Ridge and furrow irrigation; I_3 = Drip irrigation

8. Optimum time of sowing

Sowing of the rainfed crops with onset of sowing rains is a pre requisite to minimize the impact of drought on yield of rainfed crops. Perusal of the data presented in Table 3 indicated that, significant increase in grain yield was recorded when crop sown on 7 July over 22 July and further delay in sowing decreased grain yield indicating that the timely sown crop escaped from terminal drought while crop sown late in the season was caught in late season moisture stress resulted in severe reduction in grain yield of maize.

The impact of drought on grain yield of maize can be minimized by adopting micro irrigation. Data presented in Table 4 indicated that, higher grain yield, water productivity were recorded with scheduling of irrigation through drip followed by irrigation at 0.8 IW/CPE ratio (Table 4). Lower grain yield and water productivity were obtained when crop was sown under rainfed conditions. Scheduling of irrigation as per crop water requirement through drip increased the yield by 12 per cent over surface irrigation and saving 80 mm of water. Under limited irrigation condition the yield of rainfed crops can be enhanced by providing supplemental irrigation at reproductive stage using micro irrigation.

9. Preparation of crop calendar

The Crop Calendar is a tool that provides timely information about seeds to promote local crop production.

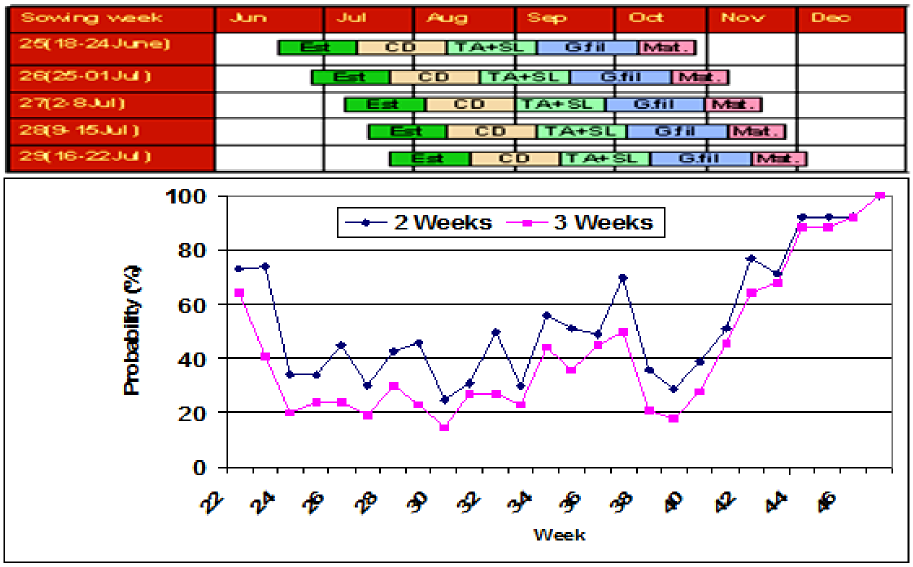

Fig. 4. Crop growth stages of maize and probability of consecutive 2 and 3 dry weeks at Rajendranagar

Fig. 5. The holistic view of weather based agro advisories

It contains information on planting, sowing and other important phenophases of crop including harvesting periods of locally adapted crops in specific agro-ecological zones (Reddy *et al*., 2009). This tool supports farmers and agriculture extension personnel in taking appropriate decisions on crops and their sowing period, respecting the agro-ecological dimension. It also provides a solid base for emergency planning of the rehabilitation of farming systems after disasters.

Developed crop calendar of maize for Ranga Reddy district of Telangana (Fig. 4) and was superimposed with probability of occurrence of two and three consecutive dry spells during crop season. The early sown maize crop

TABLE 5

District wise contingency crop planning

District	Soil type	Crops suggested upto 31 July	Crops suggested upto 15 August	Remarks
Medak	Light soils	Sunflower, Redgram, early duration Maize Castor, Fodder Jowar, Sesame + Redgram	Sunflower, Horsegram	-
	Medium to heavy soils	Redgram, Sunflower, Castor, early duration Maize	Redgram (Closer spacing), Sunflower	To go for normal rabi sowings from September onwards
Mahabubnagar	Light soils	Bajra, Ragi, Redgram, Groundnut, Castor	Bajra, Horsegram, Castor(closer spacing), Fodder Jowar	-
	Medium to heavy soils	Maize, Ragi, Sunflower	Sunflower, Castor	-
Nalgonda	Light soils	Redgram, Castor	Bajra, Ragi, Sunflower, Horsegram	
	Medium to heavy soils	Redgram, Sunflower	Sunflower	To go for normal rabi sowings from September onwards

escaping the probability of occurrence of two consecutive dry weeks during tasseling and silking when crop was sown during 25 STD (18-24 June) week which is more critical for moisture stress in maize. The delay in sowing of maize resulted in exposure of crop to severe moisture stress during sensitive moisture stages like tasseling and silking stages.

Normally, there are at least four important aberrations in the rainfall behavior, *viz*., (*i*) early commencement of the rains, or considerably delayed monsoon, (*ii*) intermittent "breaks" during the cropping season, (*iii*) variation in spatial and/or temporal aberrations, and iv) early cessation of rainfall or continued wet spells for longer period. These situations call for attention of agricultural scientists and planners to develop contingent measures to save the rainfed crops from varied monsoon aberrations. Further, there is a need to select crops and varieties matching the effective growing seasons in different agro climatic regions of the country. The high variability of rainfall (more precisely, the soil-water) is the single factor which influences the high fluctuations in the crop yields. Drought leads to moisture stress, which in turn effects crop production adversely. The district wise contingency crop plns were developed to manage the drought during crop season.

10. Contingent crop planning

District wise contingency planning are being prepared and disseminated during drought period to cope with adverse impact of prevailing situation (Table 5).

11. Agro advisories

Agro advisories issued twice a week based on medium range forecast and being disseminated to the farming community to reduce the impact of drought in crop production (Fig. 5). The agro advisory bulletin contains the information on past weather for five days, soil conditions, crop phenology and weather forecast valid for five days. Crop advisories include sowing, irrigation, pest and disease fore warning information, crop harvest etc. These advisories help the farming community to reduce the impact of drought by timely adopting appropriate crop management strategies.

12. Other coping options for management of drought for small holders

- Diversifying the livelihood sources
- Changing cropping patterns
- Planting more drought tolerant crops
- Increased share of non-agricultural activities
- Increased Agro-forestry practices
- Increased traditional coping strategies
- Improved on farm soil & water conservation
- Change to a mixed cropping pattern
- Access to information

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