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Agricultural droughts and crop planning — A case study for western Rajasthan

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सार — पश्चिमी राजस्थान के अर्धशुष्क, शुष्क और अतिशुष्क जलवायु वाले तीन स्थानों में खरीफ में पैदा होने वाली दालों एवं बाजरा की उपज में कृषि सूखे की बारंबारताओं को ज्ञात किया गया है । इन फसलों के लिए वास्तविक संभावित वाष्पोत्सर्जन के न्यूनत्तम आवश्यक मानों के आधार पर विभिन्न फसलों की ऋतुओं (1956–1975) के दौरान सूख की तीव्रताओं को ज्ञात किया गया है । इस अध्ययन से पता चलता है कि खरीफ में पैदा होने वाली दालें, बाजरा की अपेक्षा सूखे क प्रति ज्यादा संवेदनशील है । जोधपुर में जल्दी, सामान्य या देर से होने वाली बुवाई योग्य वर्षा की स्थिति में बाजरा की फसल पर सूखे की प्रभावशीलता को भी प्रस्तुत किया गया है ।

ABSTRACT. The frequencies of occurrence of agricultural droughts in respect of pearlmillet and kharif pulses were worked out for three stations in western Rajasthan representing semi-arid, arid and extremely arid types of climates. Based on the minimum required values of AE/PE for these crops, the intensities of drought during different cropping seasons (1956-1975) were worked out. The study brought out that kharif pulses are more susceptible to drought than pearlmillet. Also the vulnerability of pearlmillet to drought under early, normal and late receipt of sowing rains under Jodhpur conditions were presented.

1. Introduction

Knowledge of the frequency of occurrence of agricultural droughts of varying intensities is of fundamental importance in identifying the crops better suited in a given region. Besides, any information that can foretell the period during which the crop is vulnerable to drought depending upon the time of sowing is also of great help in evolving technology that can mitigate the drought intensity to some extent (Arnon 1972).

Not much literature is available in classifying agricultural droughts witr respect to field crops in India. in general and in arid regions, in particular. Some investigators attempted to classify agricultural droughts in India but they were not crop specific (Krishnan and Thanvi 1971, George and Krishnan 1969, George and Kalyanàsundaram 1969).

A proper analysis of agricultural droughts can be carried out only through a critical study of long-period climatological data, combined with crop yields. The analysis has to cover each crop separately because of the influence of climatic conditions on production vary from crop to crop depending upon the growth period and sensitive phenophases (Lockwood 1979, Sastri *et al.* 1981).

Keeping in view the above points, the present paper deals with the frequencies of occurrence of agricultural droughts of pearlmillet and kharif pulses which are the major rainfed crops grown in western Rajasthan at three regions, Sikar, Jodhpur and Barmer, representing semi-arid, arid and extremely arid type of climates. Drought vulnerability of the pearlmillet crop in Jodhpur region depending upon the period of sowing of the crop was also discussed.

2. Materials and methodology

The ratio of actual to potential evapotranspiration AE/PE known otherwise as the index of moisture adequacy (I_{MA}) indicates the rate at which moisture is available to the crop compared to its water demand and, therefore, is a better index of the adequacy of water availability to the crop. The weekly values of I_{MA} during crop growing season were worked out by computing weekly water balance using the book keeping procedure (Thornthwaite and Mather 1955). The potential evapotranspiration (PE) values required for the water balance computations were worked out by Penman's equation (Penman 1948) using the computational tables (Krishnan and Sastri 1978). The seasonal I_{MA} values for each of the cropping season were worked out by averaging the weekly I_{MA} values from the sowing to harvesting week. The grain yields of pearlmillet and kharif pulses for the period 1956-1975 were obtained from the Statistical Abstracts of Rajasthan State.

The minimum required values of I_{MA} in respect of pearlmillet and kharif pulses for getting average yields

were obtained from a graphical interpolation similar to that suggested earlier (Azzi 1956 as shown in Fig. 1). The yields would be above average if the I_{MA} value increases and *vice versa*.

The criterion adopted for classifying the drought intensities of pearlmillet and kharif pulses depending upon the minimum required values of I_{MA} during the growing season is as follows :

Departure of I_{MA} from the minimum values (percentage)	*Drought intensity*
Less than 10	Moderate
10-20	Large
20-30	Severe
Greater than 30	Disastrous

For analysing the drought vulnerability, the crop yields of pearlmillet for the years 1971 to 1980 recorded by the Dry Farming Research Unit at Jodhpur were considered. The average yield of pearlmillet for the years 1971 to 1980 was found to be 13.66 q/ha and the success or failure of the crop has been evaluated as per the criterion given below :

Yield (q/ha)	*Percentage of the average yield*	*Crop performance*
0.0-3.42	0-25	Failure
3.43-10.25	25-75	Partially successful
10.26 or above	75 or above	Success

Using the above criterion, crop yields and weekly rainfall distribution, it is formulated that :

(*i*) A 100 mm of rainfall during a week can support the crop for a period of four weeks inclusive of that week, even with *nil* or no rainfall during the subsequent three weeks.

(*ii*) A 50 mm of rainfall during a week can support the crop for two weeks inclusive of that week, even with no rainfall.

(*iii*) If drought conditions prevail for a period of 4 weeks or more upto maturity stage, it results in total failure of the crop.

(*iv*) Similarly drought conditions for 2 to 3 weeks upto maturity, result in partially successful crop.

Using the criteria for drought classification and the drought vulnerability, the crop production in western Rajasthan was critically examined.

3. Results and discussion

3.1. *Agricultural drought classification*

The minimum required value of AE/PE in respect of pearlmillet and kharif pulses for three representative regions of western Rajasthan obtained from graphical interpolation are as follows :

Region	*Pearlmillet*	*Kharif pulses*
Sikar (Semi-arid)	65	68
Jodhpur (Arid)	46	55
Barmer (Extremely arid)	39	55

The rainy season in western Rajasthan is restricted from 1 July to 5 September and as such the kharif pulses with a maturity period of 65-70 days have higher I_{MA} compared to pearlmillet with a maturity period of 90-100 days.

Based on the above mentioned minimum required values of the two crops, the droughts of various intensities were worked out for the period 1956 to 1975 as shown in Table 1.

It can be seen that in all the three regions, the kharif pulses experienced higher degree of drought compared to pearlmillet.

For example, in Sikar, 1958 was a moderate drought for pearlmillet while the intensity was "large" in respect of kharif pulses. Similarly, in Jodhpur, during the years 1958, 1968, 1972 and 1974, the drought intensity for kharif pulses was one degree higher than that of pearlmillet. Same is the case in Barmer during the years 1962, 1966 and 1967.

Thus, it is obvious that, though kharif pulses are of short duration and grown during the assured rainfall period, they are more susceptible to drought than pearlmillet, in case water stress occurs during the growing season.

This was further confirmed by analysing the coefficient of variation of grain yields of kharif pulses and pearlmillet. The C. V. of kharif pulses was 89.4 per cent while the same for pearlmillet was 69.6 per cent showing higher yield variation in kharif pulses than in pearlmillet.

3.2. *Drought vulnerability*

From the earlier analysis, it was found that the kharif pulses are more susceptible to drought than pearlmillet in western Rajasthan. However, due to mal-distribution of rainfall, the pearlmillet crop does suffer from drought conditions resulting in reduced yields. Hence, the drought vulnerability of pearlmillet was also studied to examine the production potential of this crop under different rainfall distribution patterns.

Applying the criterion of crop success/failure as mentioned earlier the chances of success, partially success or failure of the crop were evaluated for the years 1901 to 1980 (Table 2) considering that the sowing of the crop is possible during a week with 25 mm or more rainfall (Raman 1974).

TABLE 1

Agricultural drought intensities of pearlmillet and kharif pulses in west Rajasthan

Crop	Drought intensity	Regions Sikar	Jodhpur	Barmer
Pearlmillet	Moderate	1958	1958, 1962 & 1972	1962 & 1967
	Large	1965 & 1966	1968 & 1974	—
	Severe	1961	1960	1966
	Disastrous	—	1969	1968 & 1969
Kharif pulses	Moderate	—	1965 & 1966	1959
	Large	1958, 1965 & 1966	1958, 1963 & 1972	1957, 1962 & 1967
	Severe	—	1968 & 1974	1958
	Disastrous	1961	1969	1966, 1968 & 1969

TABLE 2

Drought vulnerability of pearlmillet crop sown during different standard weeks at Jodhpur (1901-1980)

Std. week	No. of years when sowing rains were received	Number of years when crop was			No. of occasions when the crop was partially successful or totally failure due to incidence of drought during week Nos.		
		Successful	Partially successful	Total failure	1-4	5-8	9-12
25	12	3	2	7	1	4	4
26	11	5	4	2	1	1	4
27	13	7	3	3	—	5	1
28	13	7	4	2	—	3	3
29	12	3	4	5	—	1	8
30	6	2	3	1	—	1	3
31	5	0	1	4	—	—	5
No. of years when sowing rains were not received	8	—	—	8	—	—	—

It can be observed from Table 2 that the sowing rains were not received in 8 out of 80 years suggesting that it will not be possible to sow the crop on the average once in ten years. Assuming that the sowing is taken up with the occurrence of the first spell of sowing rains, the number of years when the sowing rain occurred from 25th to 31st week are given week-wise along with the data on performance of the crop and the period during which droughts occurred with corresponding frequencies.

Some of the results reported in Table 2 are of great interest to the agriculturist as they bring out the following salient features :

(*i*) When the sowing is possible during 25th week (18-24 June) successful harvest can be had only in 3 out of 12 occasions with the chances of occurrence of drought being even during the grand growth and reproductive stages of growth.

(*ii*) When the sowing is possible during 26th week to 28th week (25 June-15 July), in 19 out of 37 occasions, successful harvest appears to be possible. Partial success or failure of the crop was observed due to occurrence of drought (a) during the reproductive stage in 4 out of 6 occasions when the crop was sown in 26th week, (b) during the grand growth stage in 5 out of 6 occasions when the crop was sown in 27th week and (c) during the grand growth and reproductive stages with even chance when the crop was sown during 28th week.

(*iii*) When the sowing is possible during 29th to 31st week (16 July-5 August) the partial success or failure of the crop was a resultant of drought which occurred in 16 out of 18 occasions during the reproductive stage of crop growth. The crop success appears to be possible only in 5 out of 18 occasions when sowing is done during 29 and 30 weeks and late sowing does not indicate any chances of raising a successful crop.

4. Conclusion

From the above analyses it was found that in western Rajasthan, kharif pulses are more susceptible to drought than pearlmillet. Even the pearlmillet crop is vulnerable to drought with 75 per cent probability either during grand growth or reproductive stages of crop growth when sown early during 25 standard week. The crop is vulnerable to drought with 70 per cent probability during reproductive stage when sown from 29th to 31st week.

Studies of the type discussed in the text will be extremely useful in crop planning in drought sensitive regions.

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