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Water availability periods and soil moisture during extreme years of crop production at Solapur

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ABSTRACT. Analysis has been carried out to obtain different water availability periods during extreme rabi sorghum yields at Solapur. They are humid, moist and preparatory periods computed on the basis of weekly rainfall and potential evapotranspiration. It is observed that low yields occur due to shorter period of moist and humid type and are generally associated with higher positive aridity anomalies during sowing, tillering and flowering stages of the crop. Weekly water budgeting indicated that the soil moisture variations are significant in extreme years of crop output. Probabilities of different soil moisture ranges showed the possibility of shifting the sowing date backward for a better yield, which is supported by special field experiments conducted at Solapur.

1. Introduction

In India about 75 per cent of the total cropped area is rainfed, which contributes to about 40 per cent of the country's food production. The agricultural fortunes of these areas are closely linked with the availability of water, which controls the final crop production. The main reason for very low and highly unstable yields in these areas is the soil moisture stress during the active growth of the crop. Rainfall alone cannot decide the availability of soil moisture because the amount of water lost from soil or vegetation besides runoff and deep drainage is also important. The most important aspect is the amount and distribution of rainfall, in order to meet the combined demands by transpiration from plants and evaporation from soils. But the rainfall in these areas is inadequate and undependable with high variability. Irrigation from underground water or by diversion from other catchments is one solution to this problem, which is an expensive one. The other is to make the best use of ecological resources, particularly the available soil moisture.

George & K. Alda (1969) studied the water availability periods for one district of Bihar to assess the agricultural drought. They used the empirical formula suggested by Ramdas (1957) to compute the potential evapotranspiration and tried to explain the impact of water available periods on the low yields of the district. Ratnam and Joshi (1977) tried to understand the drought years at Dharwar by weekly water budgeting. Raman and Murthy (1971) using average monthly rainfall and potential evapotranspiration values attempted to suggest the cropping pattern in dry farming areas based on water availability periods. However, month is too long a period in life cycle of a crop and as such Murthy (1973) used shorter period analysis to obtain on weekly basis the water availability periods for four stations of Karnataka State. To compute these, he used the average weekly rainfall and interpolated (derived from monthly values computed by Rao *et al.* 1971) potential evapotranspiration values.

The crop yield vary significantly from year to year in dry-land farming areas. Thus any analysis using average data may not reflect the finer variations. The studies conducted so far by earlier workers mainly used the mean values only, and as such it is proposed in this paper to compute, on weekly basis, the water availability periods during extreme years of crop production at Solapur, in Maharashtra State.

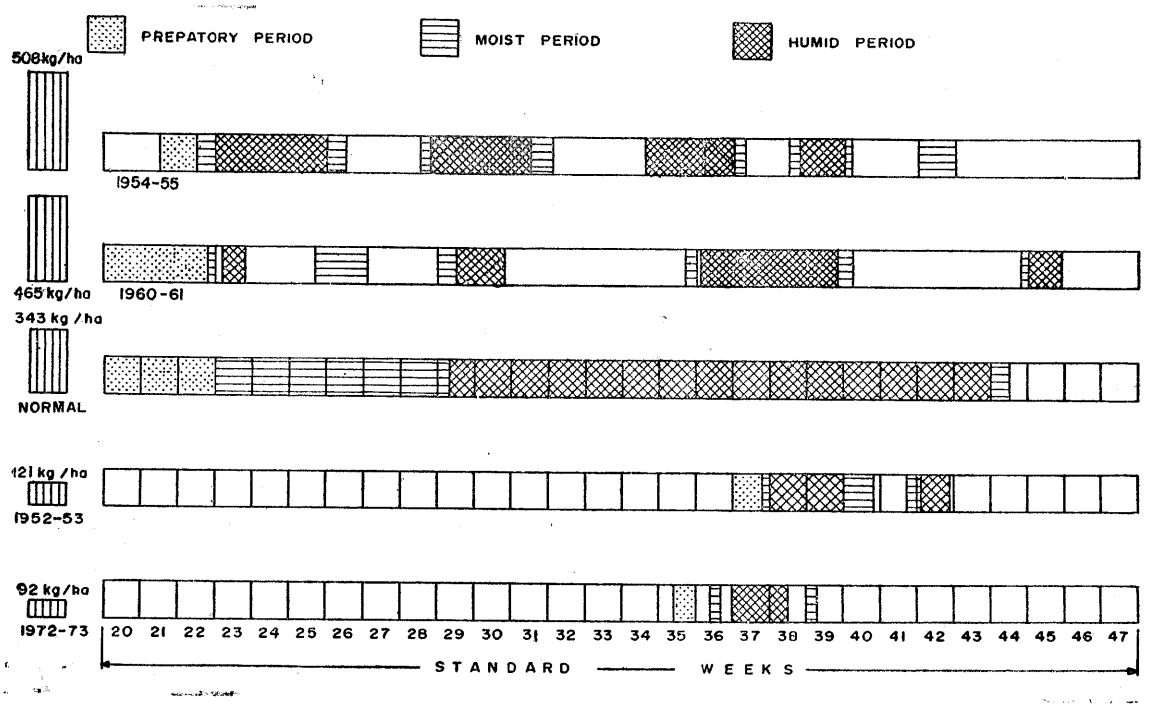

Fig. 1. Water availability periods for kharif season at Solapur

2. Data and method

Solapur receives annually 742 mm of rainfall and about 75 per cent of it occur during June to September and 18 per cent during October to November. Normal monthly potential evapotranspiration values are (Rao *et al.* 1971) always higher than the rainfall except in September.

Kharif crops in Solapur district account for 20 per cent and remaining 80 per cent are rabi crops, with sorghum as the major crop. The district's mean rabi sorghum yield during 1951—1976 is 343 kg/ha with some extreme years of crop production. During the years 1972-73, 1952-53, 1960-61 and 1954-55, the yields are 92, 121, 467 and 508 kg/ha respectively. The former two years are chosen as drought and latter two as good years of rabi yields respectively for the study. The parameters studied are water availability periods during kharif season, besides soil moisture storage, aridity anomalies and probability of available moisture during the rabi season.

3. Discussion of results

(a) *Water availability periods*

Water availability periods, as suggested by Cocheme and Franquin (1967), have been worked out. They are preparatory, moist and humid during the months from June to October.

Water availability periods are worked out for the normal period (1951 to 1976) besides for the above chosen years on weekly basis. It is observed that during the normal period, there are 102 days of humid, and 42 days of moist type. The total moist and humid periods are 144 days which agreed well with the earlier study of Raman & Murthy (1971). The total periods in case of drought years are 14 and 26 and in good years are 66 and 83 respectively.

The distribution of humid and moist periods is quite spread over, both in normal period and good years indicating that there is sufficient soil moisture available during the kharif season (Fig. 1). Thus the rabi crops of this area are solely grown on the moisture built up during the previous kharif season. It is observed that during the kharif season no substantial crops are grown at this place though there is good amount of moisture available. Of late, the State Government embarked a plan to raise kharif crops of shorter duration. Thus there is every possibility to raise suitable kharif crops in the district.

(b) *Soil moisture during rabi season*

Generally, rabi sorghum is sown (crop calendar, India Meteorological Department—Table 1) in 39th standard week and completes tillering by 49th week. About five weeks are needed for elongation and two weeks for flowering. Grain formation completes by 7th week of the subsequent year, and the crop is ready for harvest by

TABLE 1

The standard weeks

Week No.		Dates	Week No.		Dates
1	January	1-7	27	July	2-8
2		8-14	28		9-15
3		15-21	29		16-22
4		22-28	30		23-29
5		29-4	31		30-5
6	February	5-11	32	August	6-12
7		12-18	33		13-19
8		19-25	34		20-26
9		26-4*	35		27-2
10	March	5-11	36	September	3-9
11		12-18	37		10-16
12		19-25	38		17-23
13		26-1	39		24-30
14	April	2-8	40	October	1-7
15		9-15	41		8-14
16		16-22	42		15-21
17		23-29	43		22-28
18		30-6	44		29-4
19	May	7-13	45	November	5-11
20		14-20	46		12-18
21		21-27	47		19-25
22		28-3	48		26-2
23	June	4-10	49	December	3-9
24		11-17	50		10-16
25		18-24	51		17-25
26		25-1	52		24-34£

* In leap year the week No. 9 will be 26 February to 4 March, *i.e.*, 8 days instead of 7.
£ Last week will have 8 days, 24 to 31 December.

8th week. Thus the total duration of the crop is about 22 weeks.

Elements of climatic water balance are computed on weekly basis by standard book keeping method of Thornthwaite. The potential evapotranspiration values obtained by Thornthwaite formula are assumed to be sufficiently accurate in the present study, as the main aim is to compare the moistures during different years of crop yields. Rao *et al.* (1976) for moderately deep rooted crops in fine sandy loam soils considered the applicable soil moisture retention table as 150 mm. At Solapur, they used the field capacity as 150 mm in the computation of climatic water balance. The same value has been taken in the present study also. The normal weekly soil moisture storage as well as those during the extreme years under study are depicted in Fig. 2, with the phenological stages of the crop. It is seen that the sowing coincides with the peak soil moisture storage, which decreased quickly further with time. The normal values of soil moisture during the sowing and flowering stages are about 110 mm and 30 mm respectively.

In the drought years, the availability of soil moisture is quite low. During 1972-73 the maximum of about 20 mm occurred during 37th week, which became insignificant later. During 1952-53 it has reached a peak value of 110 mm, *i.e.*, almost the normal value, at the time of sowing, but the crops during this year also suffered heavily. The budget method is thus unable to explain the low yield during this year, but weekly rainfall indicated that there was completely no rain after the crucial 42nd week. Most probably the moisture shown in the budgeting procedure is not available to the crops after 42nd week. In good years, the soil reached the field capacity during sowing period. It remained above normal till the beginning of tillering stage. Later there were one or two good showers during tillering and elongation stages of the crop.

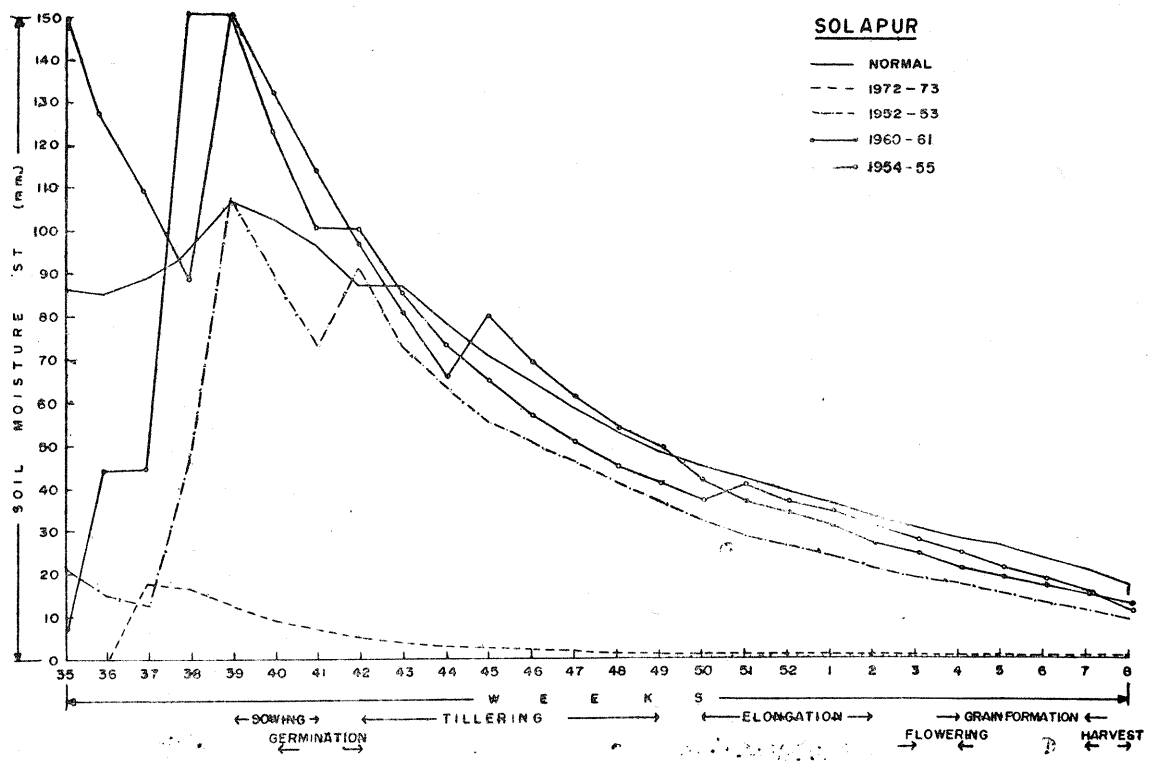

Fig. 2. Week by week soil moisture storage at Solapur

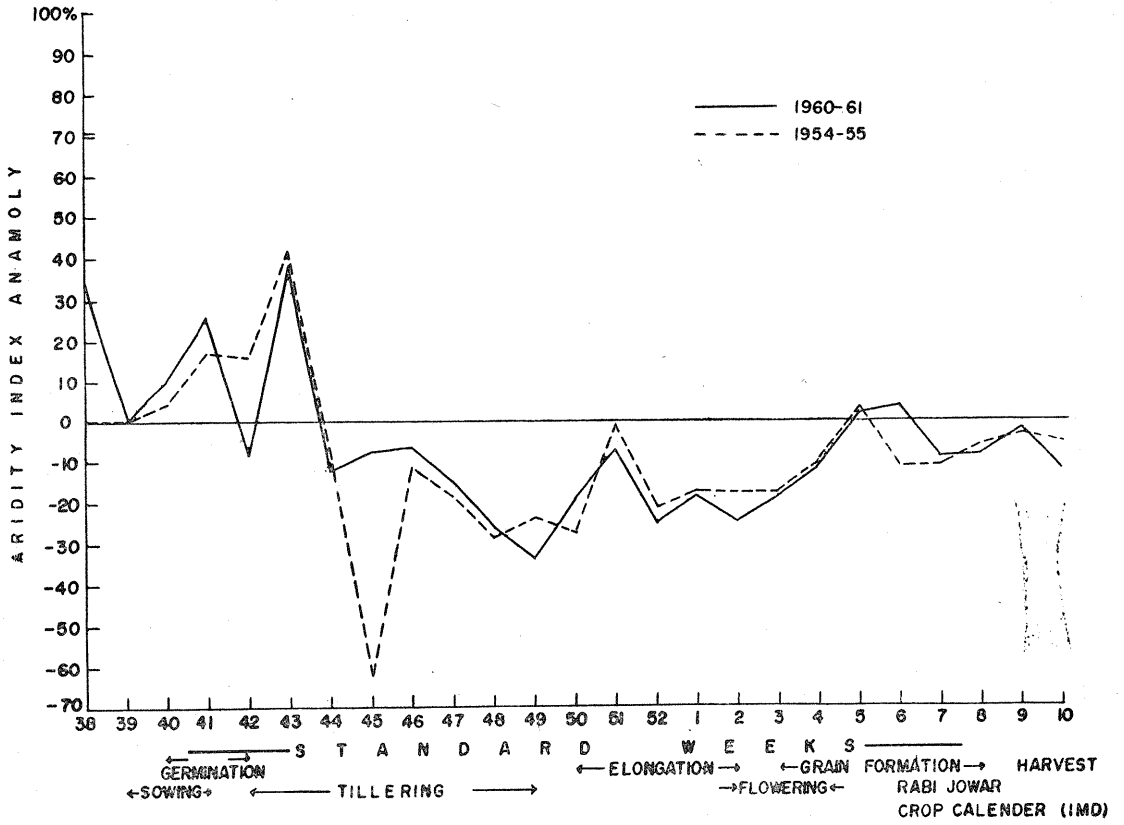

Fig. 3. Week by week aridity-index anomaly during good years at Solapur

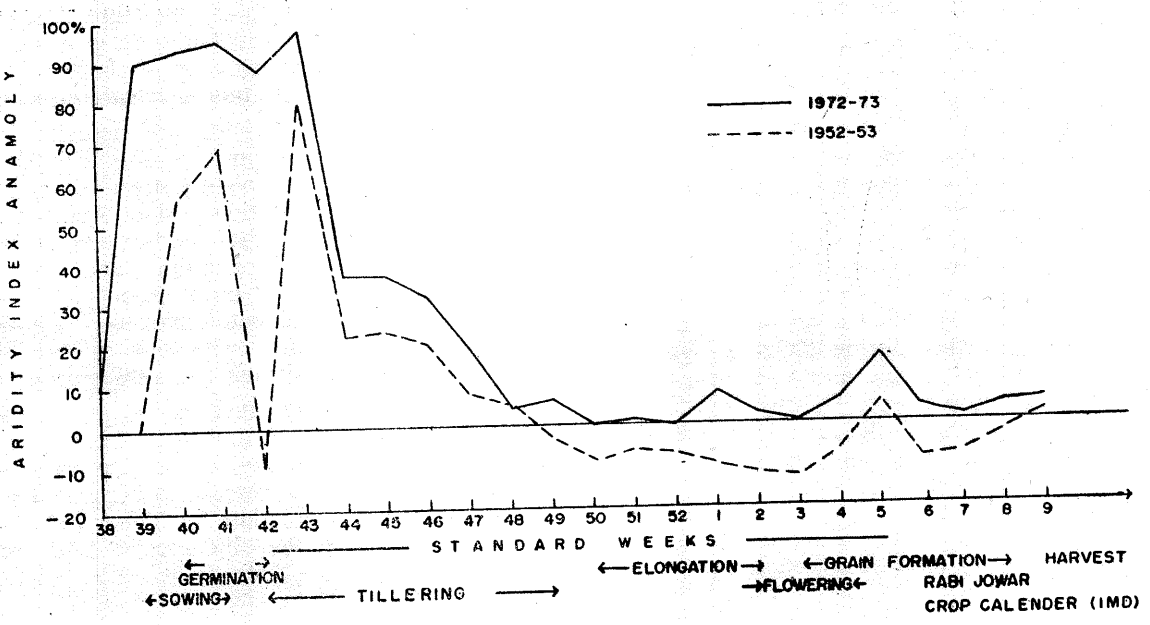

Fig. 4. Week by week aridity-index anomaly during drought years at Solapur

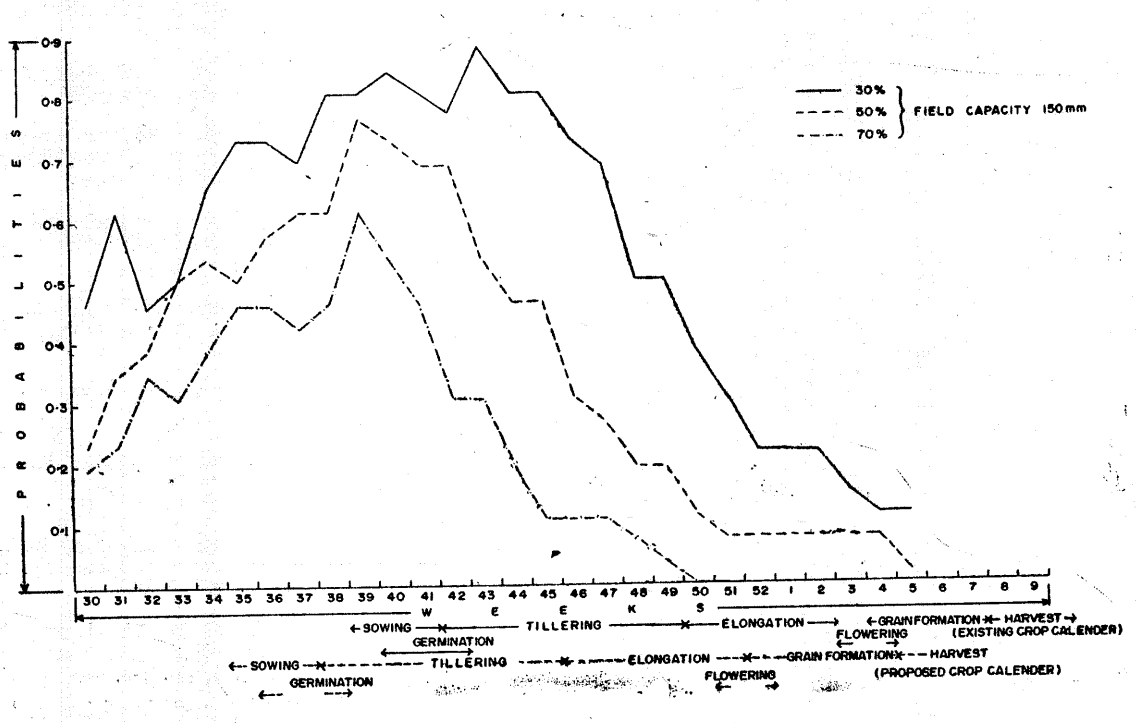

Fig. 5. Week by week probabilities of minimum assured soil moisture storage

(c) *Analysis of aridity index*

Aridity indices have been worked out and departures from normal are calculated. These anomalies were plotted in Fig. 3 and Fig. 4. In good years (Fig. 3), the values are negative throughout the crop life cycle except during the sowing and a part of tillering period. In the two drought years (Fig. 4), the anomaly patterns appear to be more or less similar. They touched a peak value of 100 in the middle of the tillering stage and thus the crop must have faced severe moisture stress. Among the two years, anomalies are higher during 1972-73 right from sowing to end of tillering and to some extent to the end of the crop season. During 1952-53 some moisture is available to the crop from 49th week onwards but crop must have been damaged by that time, due to lack of sufficient moisture in the earlier weeks.

(d) *Probability analysis of moisture*

The moisture content that is available, from 30th to 5th week of the subsequent year has been analysed to obtain the probability of minimum amount of assured moisture. The levels that are considered for this purpose are 30, 50 and 70 per cent of the field capacity, and are shown in Fig. 5. It is seen that there is sufficient moisture available to the crops even before the present day sowing. During 39th week, the assured amount of 70 per cent moisture is available with a probability of more than 0.6. Venkataraman *et al.* (1973) suggested that the amount of moisture required for commencement of sowing is about 75 mm (50 per cent of field capacity in this case), in the dry farming tracks of the country. It can be seen that the availability of 75 mm of moisture is right from 32nd week. From 32nd to 39th week, the field is being kept vacant by the farmers at present though there is sufficient moisture.

Suggestions were made (crop life saving research 1976) that it is possible to raise a good crop giving higher yields by shifting the sowing date backward by about 4 to 5 weeks. Early sowing during the special experiments conducted at Solapur in 1971 and 1972, increased the yield by about 70 per cent. Our analysis also suggest that it is quite possible to sow the crop well ahead of the present practice, *i.e.*, by 39th week, preferably by 35th week itself (Fig. 5), when the assured amount of 50 per cent soil moisture is available for sowing. This will help the crop to have sufficient moisture in the later active growth stages, such as tillering and elongation.

4. Conclusions

The present analysis has brought out the following results.

(i) Weekly mean soil moisture storage suggests the possibility of growing some suitable kharif crop of shorter duration without affecting later rabi crop.

(ii) Low rabi yields are associated with deficient kharif season rainfall and severe soil moisture stress during sowing and germination period. Another cause may be higher aridity values during tillering, elongation and flowering stages of the crop. Good yields occurred due to better moisture built-up by kharif rains, with one or two heavy showers during the rabi season.

(iii) Probability analysis of the minimum assured soil moisture storage suggests the possibility of sowing rabi jowar three to four weeks earlier than the present sowing date for higher yield, which is supported by special field experiments.

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