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Agroclimatological assessment of intensity of proneness to and areal spread of crop droughts

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ABSTRACT. The comparative nature of and drawbacks to be avoided in assessment of crop droughts are pointed out. The methodology of Venkataraman (1979) for assessing the extent of crop transpiration deficits from monthly rainfall data, is detailed. Criteria derived from these deficits for assessment of (*i*) crop-drought intensity, (*ii*) degree of proneness to droughts and (*iii*) areal spread of droughts in a year are presented. The practical relevance and application of the study are mentioned.

1. Introduction

Under a given rainfall distribution the degree of manifestation of crop droughts vary widely due to variations in and inter-play of non-meteorological factors. Therefore, climatological assessments of crop droughts can only be comparative in time and space. However, models for such assessments must be rational and must relate to the sufficiency or otherwise of the rainfall to mature rainfed crops. Again, the drought assessments have to be made on a yearly basis over a very long period so that the frequencies of occurrence of various classes of crop drought intensities can be worked out. Therefore, methods based on the departures of rainfall from normal (Ramdas 1950) or computation of drought indices for the year as a whole (Thornthwaite 1948) and/or from mean monthly rainfall totals (Krishnan and Mukthar Singh 1972) are of little use. Computations relating to the extent of deviation of yearly drought indices from the mean (Subramanyan *et al.* 1965. Palmer 1965) is useful for comparative studies in time but not in space. In the light of the above Venkataraman (1979) has presented a two layer soil model for budgeting monthly totals of rainfall for assessing the extent of satiation of potential transpiration need of a reasonably parameterised crop. Brief details of the method and its application for assessing (*a*) the intensity of incidence and hence the intensity of proneness to crop droughts, and (*b*) areal spread of various classes of crop droughts are detailed below.

2. Method

(a) *Assessment of transpiration coefficient 'K'*

In the technique referred to above the transpiration coefficient '*K*' defined as the ratio of the amount of the assessed transpiratory consumption to the potential need, is first estimated for a ground-shading crop cover on a monthly basis. For the maturity period which lasts about a month, the transpiratory need is taken as 50 per cent of that relating to a full crop cover. The phase from sowing to the ground-covering state is spread over 2 months in the Kharif season. The soil moisture requirement for optimum crop development in this phase is shown to be and hence taken as equivalent to the monthly moisture need of a full cover. For computing *K*, monthly evaporative and transpiratory requirements are taken as $6x$ and $24x$ mm respectively where x is the daily rate of potential evapotranspiration 'PE'. This is based on the fact that for a full crop cover, potential evapotranspiration would consist of 20 per cent of evaporation and 80 per cent of transpiration (Hanks *et al.* 1969; Ritchie and Burnett 1971; Brun *et al.* 1972; Venkataraman *et al.* 1976, 1977). A reasonable value of available root zone moisture '*S*' is chosen. A maximum value of

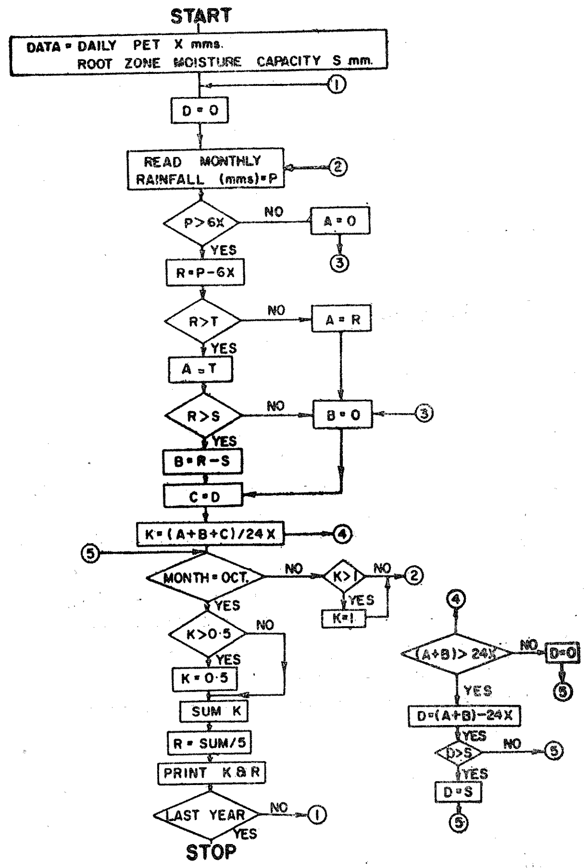

Fig. 1

transpiration 'T' for one filling of the soil zone to the capacity S is fixed up from considerations of soil type and level of evaporative demand. The effective rainfall 'R' is taken as monthly rainfall 'P' *minus* $6x$. When R is less than or equal to S the transpiration component 'A' would equal R or T whichever is less. When R is greater than S, the transpiratory component A would be limited to T and there would be an additional amount 'B' equal to R *minus* S available for transpiration. When $A+B$ exceed the maximum possible transpiration, *viz.*, $24x$, there would be a carryover of moisture 'D' to the next month equal to $(A+B—24x)$ or S whichever is less. The antecedent moisture storage 'C' for a current month would equal D of the previous month. K will be given by the ratio of $(A+B+C)$ to $24x$ subject to certain limiting values as indicated in Sec. 2(b). A sample calculation and the computerised procedure for computation of R, A, B, C, D and K from monthly values of rainfall P and for given values of X, S and T are given in Table 1 and Fig. 1 respectively.

TABLE 1

Solapur (Maharashtra State)

Storage : S=100 mm, PE : X=5 mm/day, T=85 mm

	Jun 1970	Jul 1970	Aug 1970	Sep 1970	Oct 1970
P	147.3	149.8	220.4	208.7	29.1
R	117.3	119.3	190.4	178.7	0
A	85.0	85.0	85.0	85.0	0
B	17.3	19.8	90.4	78.7	0
C	0	0	0	55.4	99.1
D	0	0	55.4	99.1	0
K	0.85	0.87	1.0	1.0	0.5

(b) *Assessment of crop drought intensity for dry land crops in India*

The Dry Farming Tract in India is defined as zone with mean annual precipitation between 40 and 100 cm (Swaminathan *et al.* 1970). In this tract, coming under the influence of the southwest monsoon, the rainy season is from June to September and the crop season extends a month further. The temperature and radiation regimes in the rainy season are equable and PE is about 5 mm/day [Rao *et al.* 1971 (a), 1971 (b); Venkataraman and Krishnamurthy 1973 (a), 1973 (b)]. The crop, sown with the onset of rain, covers the ground completely in August and September and matures in October. Unpublished lysimetric data on the evapotranspiration of crops indicate that a quantum of S equal to 100 mm and hence of 'T' equal to 85 mm would be quite reasonable. Venkataraman (1979) had used a subjective evaluation of the intra-seasonal march of the monthly K values to characterise drought intensities. However, for large scale evaluations an objective technique suitable for computer processing is required. This can be done as follows.

The values of K for the months June to October may be totalled with a limiting value of K=1.0 for the months June to September and K=0.5 for October. The former flows from the fact that K=1.0 is the maximum value for transpiratory consumption. The latter provision is necessary since higher moisture accretions during the month of maturity leading to values of K higher than 0.5 cannot contribute to crop-water balance.

The value of K so totalled can be averaged to get a value of crop drought index (CDI). From the above postulation the value of 0.7 of CDI would relate to a nonstressed crop. From considerations set out by Venkataraman (1979) it can be shown that crop survival would be difficult when CDI values go below 0.4. In light of the above the following criteria can be adopted for assessing the intensity of crop drought.

Value of CDI	*Crop Drought Intensity*
⩽0.4	Severe (S)
>0.4 but ⩽ 0.5	Moderately severe (MS)
>0.5 but ⩽ 0.6	Moderate (M)
>0.6 but < 0.7	Light (L)
⩾0.7	Nil (0)

(c) *Assessment of intensity of drought proneness*

For doing this the crop drought intensities have to be assessed on a yearly basis over a long series of years to work out the percentage frequency of occurrence of various classes of crop droughts. Once this is done the intensity to drought proneness can be arrived at as follows:

S. No.	Criteria	Degree of proneness to crop drought
1	S⩽50%	Chronic drought area
2	S<MS and S+MS⩾45% or	Severely drought prone
3	S⩽MS and S+MS⩾50%	
4	MS>M and S+MS+M⩾55% or	Moderately drought prone
5	MS⩽M and M+MS+S⩾60%	
6	M>L and M+L⩾45% or	Occasionally drought prone
7	M⩽L and MS+M+L⩾50% or	
8	M<L and S+MS+M+L⩾60%	
9	Remaining	Hardly drought prone

For arriving at the degree of drought proneness one should proceed step by step from criteria 1 to 10 and stop as and when a criteria comes to be satisfied.

(d) *Assessment of areal spread of drought*

The areal spread in a given year can be described as per the following criteria:

Percentage of stns. in area covered by a particular class of drought	Type of areal spread
⩾75%	Widespread
51 to 75%	Fairly widespread
26 to 50%	Scattered
⩽25%	Isolated

In this one should realise that as each class of drought can have 4 sub-classes of areal spread, in real time descriptions more than one combination may be required, *e.g.*, fairly widespread moderate drought with isolated severe droughts.

3. Scope

For undertaking long term projects for mitigation of distress due to crop droughts a comparative, meteorological assessment of the degrees of proneness to droughts of various areas in the dry farming tract would assist in according priorities and in selection of areas for development in a phased manner. For organising post-drought relief measures an assessment of the real spread of various classes of drought is of obvious value. These assessments, therefore, need to be taken up on regional basis and as a prelude to the drought prone areas programme.

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