Mausam, (1984), 35,1, 75-80

551.58 : 631 (548)

Climatological approach to cropping pattern in Karnataka

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(*Received 2 July 1982*)

सार — सस्य-क्रम ऋतुओं के नमी सूचकांक के आधार पर कर्नाटक राज्य को चार कृषि-जलवायु क्षेत्रों मे बांटा गया है। वर्षा और वास्तविक वाष्पन-वाष्पोत्सर्जन पर विचार करके प्रत्येक क्षेत्र की फसल की उचित अवधि निकाली गई है। फसल पैदावार के दिनों में जलवायु की वाष्पोत्सर्जन मांग के संदर्भ में मृदा नमी की उपलब्धता को ध्यान में रखकर खरीफ और रबी की फसलों की बुवाई के लिए अनुकूल तारीखों के बारे में सुझाव दिया गया है। वर्तमान सस्यस्वरूप का वर्षा, मृदानमी, स्थलाकृति एवं मृदा के प्रकार के संदर्भ में विवेचन किया गया है। प्रत्येक क्षेत्र में सुरक्षित सस्यक्रम अवधि की गणना करके सस्य-स्वरूप में सुधार की संभावनाओं पर भी विचार किया गया है।

ABSTRACT. The State of Karnataka is divided into four agroclimatic zones, based on the moisture index during the cropping season. The suitable period for cropping in each zone was worked out by considering the rainfall and actual evapotranspiration (AET). Keeping in view the soil moisture availability in relation to the evaporative demand of the climate during the crop growing season, the optimum dates of sowing for kharif and rabi crops have been suggested. The existing cropping pattern in relation to rainfall, soil moisture, topography and soil type are discussed. The possibility of modifying the cropping pattern has been discussed in relation to the computed safe cropping period for each zone.

1. Introduction

Of all the climatological parameters, rainfall and temperature are the most important controlling factors of natural vegetation and agriculture. While rainfall supplies the water needed for vegetation, temperature along with other weather factors decides the evapotranspiration demands of the climate. Several leading climatologists (Koppen 1900, Thornthwaite 1948, Pennman 1948 and Subrahmanyam 1956) have tried with varying degree of success to prepare a balance sheet of moisture, considering rainfall and evapotranspiration and thus compute the moisture surplus or deficit for a region. The Thornthwaites concept of water balance has been widely accepted for climatological classification of a region. Following his technique, Subramaniam (1964) classified the Mysore State into six climatic regions and worked out the water budget. Brown and Cocheme (1969) have compared monthly mean evapotranspiration and the amount of rainfall to work out the water availability periods for safe cropping. Subrahmanyam (1965) compared Actual Evapotranspiration (AET) with Potential Evapotranspiration (PET) and computed what he termed as moisture adequacy index for successful crop growth. Krishnan (1971) in his study on water balance parameters and crop growth, had also compared PET with AET, which is more meaningful, as the computation of AET takes care of the amount of rainfall and available soil moisture which is a very important factor in crop planning (Suryanarayana and Kulkarni 1974). Ratnam *et al.* (1976) made an effort to divide the year into three different seasons in Karnataka and discussed the adequacy of moisture for crop growth.

Thornthwaite's concept assumes 300 mm as the available storage in the soil profile for working out the water budget, irrespective of the soil type. But, at least six major soil types occur in Karnataka and the assumption of uniform available moisture holding capacity (300 mm) may lead to, too much approximation. Consideration of different soil moisture holding capacities for various soils in classifying the climates may yield better results. In addition, from the agriculture point of view, the study of water balance and climates during the cropping season (May to November) is more important than the annual values. In this effort, an attempt was made to divide the Karnataka State into different agroclimatic zones using soil and climatic data during crop season and to discuss the existing cropping pattern and suitable modifications.

2. Material and methods

The mean monthly temperature and rainfall data for selected stations in Karnataka State were obtained from different agricultural research stations and India meteorological publications (Anonymous 1967). The 1/3 bar and 15 bar moisture content for composite

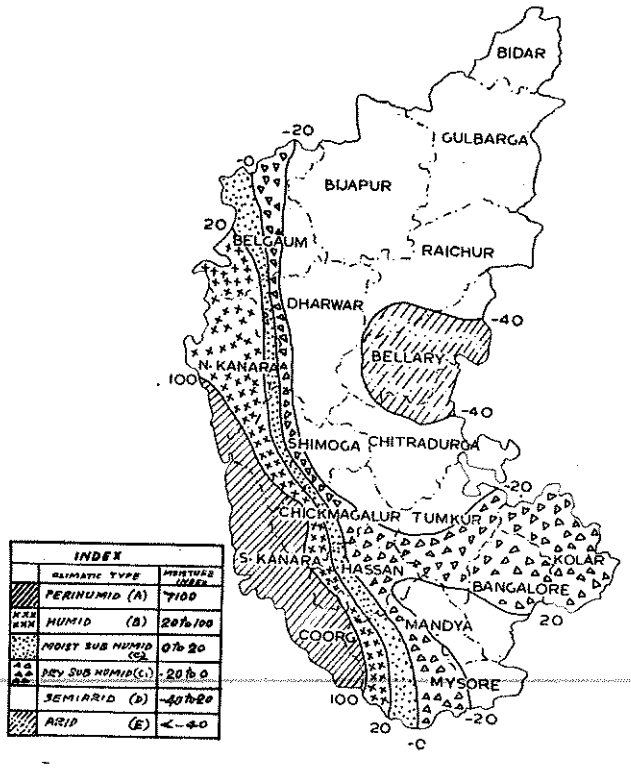

Fig. 1. Climatic classification of Karnataka

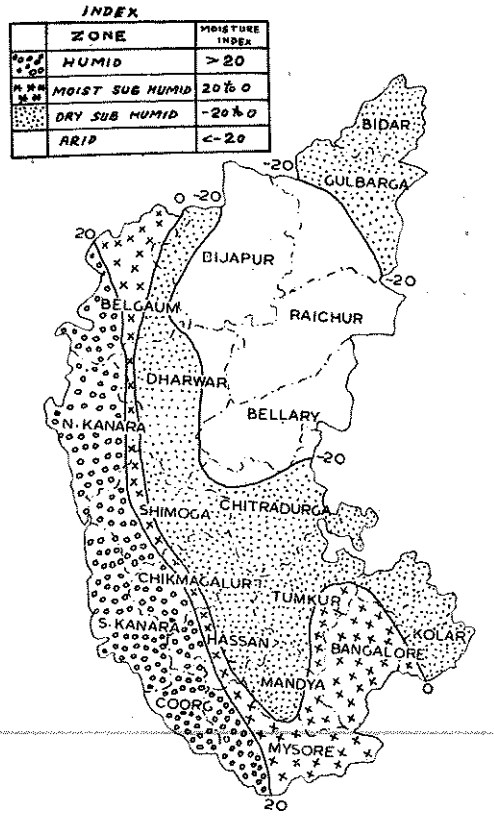

Fig. 2. Agroclimatic zones of Karnataka (Cropping season : May-Nov)

soil samples upto 100 cm depth from different stations were determined in the laboratory by using pressure plate extractor. The available moisture storage in the soil profile for different stations were calculated using the 1/3 bar and 15 bar moisture content and bulk density data of the different soils, as described by Dastane (1972).

The evaporative demand of the climate (PET) for al the stations was calculated by using Thornthwaite's formula (1948). Considering the available soil moisture, monthly rainfall and monthly PET of individual stations, the AET, the annual water surplus (W_S) and annual, water deficit (W_D) were computed by following Thornthwaite's water balance technique (1955). For all purposes in these computations, the field capacity was considered as the maximum amount of water held and wilting point as the minimum, since the soil moisture is not likely to go below wilting point during growth period.

Using W_S and W_D, the humidity index $\left(I_h = W_S/W_N \times 100\right)$ and the aridity index $\left(I_a = W_D/W_N \times 100\right)$ for each station were calculated, where W_N is the water need or PET. Combining these two indices, the moisture Index (I_m) for a place was calculated by using the equation $I_m=(I_h-0.6\ I_a)$ as given by Thornthwaite (1948).

Based on the concept of annual moisture index (Subramaniam 1964) the Karnataka State was divided into six climatic belts (Fig. 1). As it was felt that the classification based on the annual values may not be meaningful from the point of cropping and as the rainfall is mostly of monsoonal type, the State was divided into four agroclimatic zones, considering the rainfall and the moisture index for the crop season alone (Fig. 2). The area coming under each region was worked out by planimetering.

Following Krishnan's procedure (1971), suitable periods of cropping in relation to degree of moisture availability for the stations situated in different agroclimatic zones were worked out. The period during

TABLE 1

Moisture content of the soil of different stations of Karnataka

(at 1/3 and 15 bar atmosphere)

S. No.	Station	Moisture content(%) 1/3 bar	15 bar	Available water holding capacity (cm)
1	Annegeri	42.81	23.27	27.36
2	Bagalkot	35.32	19.29	22.45
3	Balehonnur	25.22	15.71	16.11
4	Bangalore	13.00	6.40	9.37
5	Belgaum	29.40	15.98	18.79
6	Bellary	34.68	16.50	24.91
7	Bidar	32.66	17.75	20.87
8	Bijapur	35.00	19.02	22.37
9	Chitradurga	34.24	16.22	25.23
10	Dharwar	36.68	18.00	26.15
11	Gadag	37.00	18.07	26.50
12	Gulbarga	34.60	18.80	22.12
13	Hagari	35.00	17.00	24.66
14	Hassan	24.00	13.09	15.37
15	Honnavar	17.12	8.85	12.00
16	Mandya	18.50	10.05	12.25
17	Mangalore	17.08	9.28	11.31
18	Mercara	15.09	8.20	9.65
19	Mysore	18.00	9.48	12.10
20	Raichur	28.81	15.66	18.15
21	Shimoga	20.02	10.88	12.80
22	Siruguppa	44.80	24.35	28.63

which the computed AET is in excess of 1/2 PET, is termed as moist period. It was assumed, during this period, the plants are not likely to suffer from moisture stress. The sub-humid period is the period during which the AET is greater than 1/4 PET and less than 1/2 PET. Occurrence of this period will be beneficial for the crop during the phases of low water requirement, *namely,* early or late stages of the crop. When PET/8 $<$ AET $<$ PET/4, the period is termed as semi-dry period, during which crops can be grown with supplementary irrigation. When AET $<$ PET/8 it is termed as dry period, during which even grasses may not be able to grow. The probable earliest date of sowing of kharif crop was assumed to be the day when rainfall received along with available soil moisture met half of the PET during the moist period following a sub-humid period and the probable date of sowing rabi crops was assumed to be the day when the soil moisture storage is sufficient to meet the full evapotranspiration demand of the climate. Based on these assumptions, the number of days in the moist period and the following sub-humid period were worked out for planning the crop pattern for each region and presented in Table 2.

3. Results and discussion

The climatic belts of Karnataka on the basis of water balance concept using the available moisture storage are shown in Fig. 1. Assuming that a moisture index of zero or less indicates a dry climate, about 1,41,06,918 ha out of the total geographical area of 1,89,24,722 ha or about 75 per cent of the total area comes under the dry belt. About 60 per cent of this area is under plough. But from agricultural point of view, the climate for the cropping season is more improtant than for the total year.

The rainfed agriculture, whether a kharif or rabi crop, depends on the rains received during June to October, whereas the kharif crops mature mostly on the rains received during their growth period, the rabi crops largely depend upon the stored soil moisture that is accumulated from the rains between June to October. Thus the success of either a kharif or rabi crop depends upon the rains received during this period. About 1,19,30,160 ha or about 63 per cent of the total geographical area (60 per cent of the cultivated area) can be classed as dry area from agriculture point of view (Fig. 2). In this region the rainfall is frequently inadequate to meet the evaporative demand of the atmosphere, thus resulting in a poor crop. According to Chang (1968), when the precipitation falls below 50 per cent of the PET, it is not possible to expect even a subnormal crop. Unfortunately in about 70 per cent of the total area in Karnataka, the ratio falls below 50 per cent (Fig. 3). In these areas, therefore, special practices of moisture conservation and new cropping methods are quite essential.

The assumption made in preparing a water budget does not make any provision for runoff before the soil moisture accretion takes place to its field capacity. It is very often repeated that about 20 to 40 per cent of the rain water in the dry regions is lost as runoff (Krishnamurthy 1969). If such a large quantity of

TABLE 2
Water availability periods and computed periods for sowing

	Moist period (No. of days)			Moist sub-humid/sub-humid, following the moist period	Computed period for sowing	
	Prior to June Sub-humid/moist	Kharif June-Sept.	Rabi Oct.-Dec.		Kharif	Rabi
I. Humid zone						
Belgaum	23	122	92	27	May I Week	—
Honnawar	36	122	67	34	May I Week	—
Mercara	89	122	92	59	May I Week	—
Balehonnur	69	122	92	80	May I Week	—
Mangalore	38	122	70	27	May I Week	—
II. Moist sub-humid						
Bangalore	34	122	92	56	May I Week	—
Hassan	42	122	92	109	April IV Week	—
Mysore	60	122	92	57	April III Week	—
III. Dry sub-humid						
Mandya	60	99	92	60	July I Week	—
Shimoga	14	122	92	74	May III Week	—
Chitradurga	86	78	59	14	June III Week	Sept. III Week
Dharwar	22	122	64	57	May III Week	Sept. III Week
Annigeri	32	122	51	65	—	Sept. I Week
Gadag	47	120	46	25	June III Week	Sept. I Week
Bidar	15	120	92	49	June I Week	Oct. II Week
Gulbarga	—	116	34	36	June III Week	Sept. I Week
IV. Dry region						
Bellary	—	42	46	21	—	Oct. II Week
Hagari	—	40	35	8	—	Oct. II Week
Siruguppa	40	111	33	13	July II Week	Sept. I Week
Raichur	21	113	33	36	June II Week	Sept. I Week
Bijapur	42	92	41	32	June III Week	Sept. I Week
Bagalkot	—	86	37	39	—	Sept. I Week

water is allowed to be lost, the water available for evapotranspiration falls down further. Therefore, all water conservation methods should be taken up before formulating a cropping pattern based on the availability of rain water. The suggestions made in this paper presume that these pre-requisites are not met with.

From agroclimatic point of view the Karnataka State can be divided into four different regions (Fig. 2) based on the moisture index for cropping season alone.

Moisture Index Im (Percentage)	*Agroclimatic zone*
More than 20	Humid (includes Perhumid)
20 to 0	Moist sub-humid
0 to—20	Dry sub-humid
and less than—20	Dry

3.1. *The cropping pattern for different agroclimatic zones*

The success of a crop in dry-land agriculture depends on its sowing at a time when soil moisture

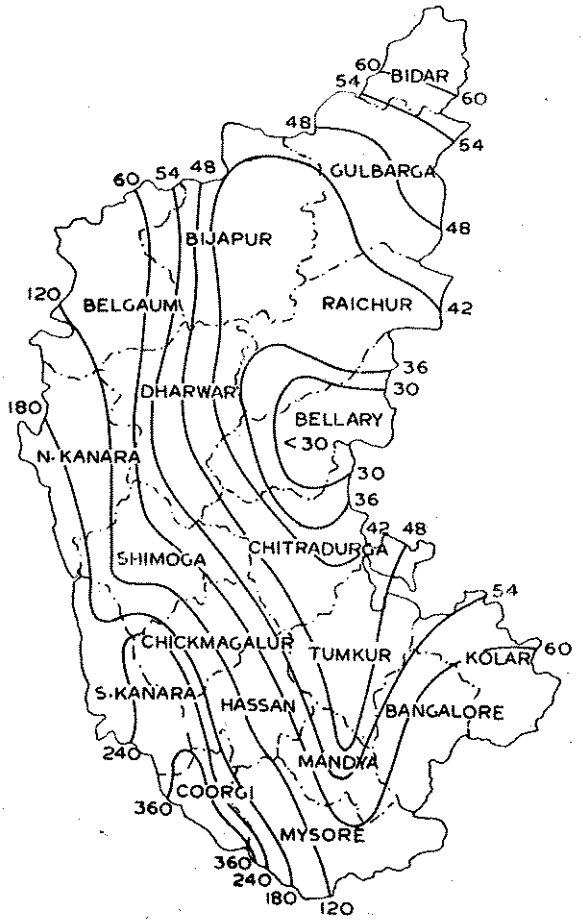

Fig. 3. Index of moisture adequacy (ER/PE) for cropping season

is adequate and on providing a sufficiently long moist period for successful completion of its life cycle. The number of days of moist period during kharif (June to September), rabi (October to December) seasons and optimum period of sowing for kharif and rabi for the various regions of the State are given in Table 2. The analysis of the Table reveals that the length of moist period and subsequent sub-humid period are usually more than 150 days in most of the stations except a few places like Bellary, Hagari and Bijapur. However, one needs to remember that these long moist or moist sub-humid periods are interspread with breaks of more than 15 to 20 days affecting the crop growth very seriously. Further, many locations provide an opportunity for sowing in May which is not so common with the farmers at present. The main reason for this appears to be the scarcity of rainfall and breaks in June and July especially in Zone-II. However, this can be overcome by selecting suitable crops which can withstand long spells of dry periods. Based on this data, the existing cropping pattern and possible modifications are given below for each zone.

3.2. *Perhumid and humid zone* ($Im > 20$)

In this zone, the moist period ranges from 189 to 214 days (June-December) followed by sub-humid period ranging from 27 to 80 days. The rains set in over most of the portion of this zone during May. Because of heavy rainfall and its high intensity, there is no moisture deficiency, but there is a problem of excess moisture in this zone. Paddy is the crop of the kharif season. The ghat portions are occupied by plantation crops. There is not much scope to diversify the type of cropping in this zone, particularly during the kharif season. After the cessation of heavy rains, it may be possible to grow crops on the residual moisture from the end of October to the end of moist sub-humid period. This period ranges from 67 to 89 days except in Mercara and Balehonnur where it could be extended upto 120 days or more. In the locations where this period is of about 2 to 3 months duration, suitable short duration pulse crops like black-gram, french beans and a number of vegetables or fodder crops can be grown. At present, these lands mostly remain fallow after the harvest of the paddy crop. In these areas having more extended moist and moist sub-humid period, the type of crop to be grown will depend mostly on the topographical situation and soil depth. Intensification of plantation crops, horticultural crops and forage crops could increase the productivity of these areas.

3.3. *Moist sub-humid zone* ($Im = 20$ to 0)

A reference to the Table 2 reveals that, in this zone, moist period is about 214 days duration from June to December followed by sub-humid period ranging from 56 to 109 days. The soils of this region are mostly red soils with light texture and low water-holding capacity, thus there is very little carry over of stored moisture for the succeeding period.

In parts of Mysore and Hassan where early rains occur and the sowings could be taken up by the middle of April, the advantage of taking short duration crops in sub-humid periods needed due emphasis. In this zone, growing at least two crops of about 120 days duration can be thought of. In areas receiving early rains, a regular crop of 120 days can be sown by April end, following a catch crop of 60 to 75 days. Alternatively, a catch crop of 60 to 75 days can be followed by a regular crop of 120 days in kharif season. Some such cropping pattern like hybrid Jowar followed by horse-gram is already in practice in this region. The studies conducted at the Dryland Research Centre at Bangalore have conclusively proved that sowing cowpea in May, to be followed by a regular crop of finger millet is a feasible practice (Anonymous 1976). In the portions of Belgaum district where a single crop of long duration sorghum is being grown at present, it could be replaced by hybrid sorghum followed by pulses. In this zone, hybrid maize has also a good potential and the area can be extended to soils that are freely drained.

3.4. *Dry sub-humid zone* (I_m = 0 *to*—20)

The soils in the southern districts of this zone are mostly red sandy and red loams while towards north, they are heavier in texture and range from medium to deep black and mixed red and black. Kharif cropping is predominant in areas having lighter texture soils while rabi cropping is predominent in areas having heavier soils.

A reference to the Table 2 reveals that the moist period for cropping ranges from 137 to 186 days from June to December except in parts of Shimoga and Bidar, where it will extend upto 214 days. The period of sowing for kharif crop may range from third week of May in Dharwar and Shimoga regions to the first week of July in Mandya. A four month crop or a catch crop of 2 to 2½ months followed by a short duration kharif crop or a kharif crop followed by overlap cropping with a pulse or mixture of pulse or oil seeds having longer duration with the main crop are possible in this zone. The important cropping practices that can be considered are ragi or cotton following a catch crop of green-gram, black-gram or cowpea or a crop of kharif sorghum or groundnut followed by bengal gram or rabi sorghum can be practiced in relatively heavier soils. Mixing of pulse crop like red gram or field beans in the crops of sorghum or ragi which is the existing practice appears to be sound. Hybrid sorghum with overlap cropping of a pulse like horse-gram is also becoming popular.

In relatively heavy textured soils, rabi cropping is predominant. The probable time of sowing rabi crop, is the first week of September. From the table it can be seen that the rabi crop can get moist period ranging from 101 days to 142. The existing long duration varieties of crops, therefore, appears to be less efficient for these areas. Adopting a variety of crop that could mature within 105 to 120 days after sowing at the appropriate time is likely to cause a major break through in productivity of these areas.

3.5. *Dry zone* : (I_m <— 20)

The moist period in this zone ranges from 75 to 146 days from June to December. As in the dry sub-humid zone, the kharif cropping is predominent in areas with relatively lighter soils and rabi cropping in soils with heavier texture. In view of the short moist period, only one main crop with mixtures of oil seeds and pulses which can take advantage of the stored moisture during the following moist sub-humid period appears to be reasonable. The date of sowing of kharif crop could be from middle of June to middle of July. In heavier soils, the dates of sowing could be from first week of September in Bijapur and Raichur areas to middle of October in Bellary region. While the rabi crop will get about 100 days as moist and sub-humid period in the areas of Bijapur and Raichur districts, it is likely to get only about 67 days in Bellary district. It is interesting to note that September sowing has been found to be favourable in areas where normal sowing are in October at present, as per the observations at the Dryland Agriculture Centre, Bijapur. The peculiar nature of black soils leading to development of cracks and rapid evaporation of soil moisture sets a limitation on the extension of cropping period beyond moist sub-humid period. Adoption of varieties and the crops with duration of about 90 to 100 days and sowing early in September appear to be suited under this situation. Suitable crops and practices have to be evolved considering the limitations of the growth period in this zone.

Acknowledgement

The authors are highly thankful to Prof. V. P. Subrahmanyam, Professor of Meteorology, Andhra University, Waltair for his critical review of the manuscript.

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