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A Climatic Method for Optimizing Cropping Patterns in Arid Kutch Region

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Abstract A climatic method is described for optimizing cropping patterns on the basis of mean length of the growing season as related to the distribution of annual rainfall. Application of the method for Bhuj region in the Kutch district reveals that, for optimized and sustainable production, about 32% of the total agricultural land should be covered by grasses or silvipastoral system compared to only 11% area under grasses at present. The method of optimizing the area allocation for the different crops that can provide sustainable production from a given farm area is also discussed.

Key words Climatic method, Rainfall distribution, Growing season, Optimizing cropping pattern, Sustainable production

Farmers of Kutch region are continuing to grow crops like groundnut, sorghum, pearl millet, green gram and other short duration pulses inspite of low rainfall and high evaporative demand which is limiting crop production in the region. Also the area allocated under grasses at present is small which also hampers development of animal husbandry in the area as a result of which the over all production from the region is low (Singh *et al.* 1990). The exisiting cropping patterns are traditional and subsistence oriented, leading to indiscriminate use of agricultural lands and low economic returns (Mann & Singh 1977). For sound economy of the region it is necessary to optimize the cropping pattern in synchronisation with the variation in agroclimatic conditions of the region. Therefore, in the present papper an analysis is made based on the agroclimatic method developed earlier (Ramman Rao *et al.* 1983) for optimizing the cropping pattern under arid situations, assuming the Bhuj station as representative of the Kutch region.

Materials and Methods

Daily rainfall data of Bhuj (Kutch) for the period 1901-1989 were used in this study. Water budgeting is worked out (Thornthwaite & Mather 1955) to assess weekly ratio of actual evapotranspiration (AE) to potential evapotranspiration (PE) for all the years, using normal potential evapotranspiration values computed fom Penmen's formula (Rao *et al.* 1971). Commencement and duration of crop growing season under rainfed farming was computed as per Ramana Rao *et al.* (1983) and Singh *et al.* (1991b) assuming that the crop can withstand moisture stress (AE/PE less than 0.25) for a maximum of three consecutive weeks within the growing season.

The annual rainfall occured at Bhuj (Kutch) was maximum 1311.4mm) during 1959 and minimum (5.0 mm) during 1987. Therefore, the individual years were grouped according to the annual rainfall ranging from 0-100, 101-200, 201-300, 301-400 mm and so on. The mean length of the growing seson were worked out from the individual year water balances for the years falling in the above different ranges of rainfall. Also the probabilities of occurrence of different amounts of annual rainfall have been computed for Bhuj location through Log Pearson Type III distribution (Fig. 1) as described earlier (Singh *et al.* 1991 a).

Results and Discussion

The normal monthly values of rainfall, number of rainy days and potential evapotranspiration at Bhuj are given in table 1. The peak rainy season occurs during the months of July and August and throughout the year under normal conditions the rainfall does not meet the water demand of the region. The water demand is highest during peak

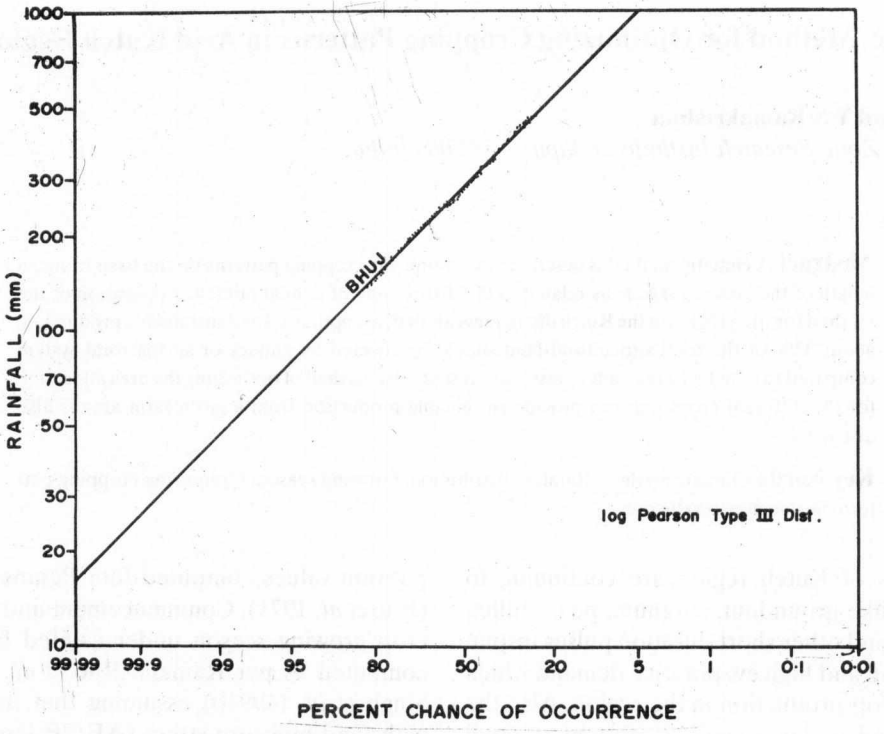

Fig 1 Probability of occurrence of different amount of annual rainfall at Bhuj (Kutch)

summer. The coefficient of variation (CV) of annual rainfall also varies from 54 to 80% accross the Kutch region with 66% at Bhuj location.

Table 1 *Normal monthly rainfall, number of rainy days and potential evapotranspiration at Bhuj*

Month	Normal rainfall (mm)	No. of rainy days	Normal potential evapotranspiration (mm)
January	2.2	0.3	92.9
February	3.7	0.3	109.9
March	2.5	0.2	162.8
April	0.8	0.1	209.4
May	5.2	0.2	266.0
June	29.4	1.5	226.0
July	145.1	5.6	168.0
August	96.3	4.1	153.8
September	43.5	2.1	160.2
October	9.4	0.4	158.0
November	4.8	0.3	107.5
December	0.8	0.1	81.5
Annual	342.4	15.2	1897.1

The probability of occurrence of different amounts of rainfall and the corresponding length of the growing season as related to the annual rainfall at Bhuj are shown in fig. 2. Green gram and moth bean, the major pulse crops of the region, are of about 60 days duration, and these crops will be completing the flowering and reproductive stage by 8 weeks after sowing, thereby requiring atleast 8 weeks of growing season. From fig. 2, it can be seen that the mean length of growing season of 8 weeks occurs when the annual rainfall is about 200 mm. The probability of occurrence of 200 mm rainfall is about 68%. Amongst the cereal crops, pearl millet of 85-90 days duration is extensively grown. As the crop completes the flowering, reproductive and physiological maturity stages by 12 weeks after sowing, the mean length of the growing season of 12 weeks occurs when the annual rainfall is about 300 mm. The probablility of occurrence of 300 mm is about 45%. Similarly sorghum and groundnut takes 16 and 18 weeks, respectively for their physiological maturity. The mean length of growing season of 16 and 18 weeks occurs when the annual

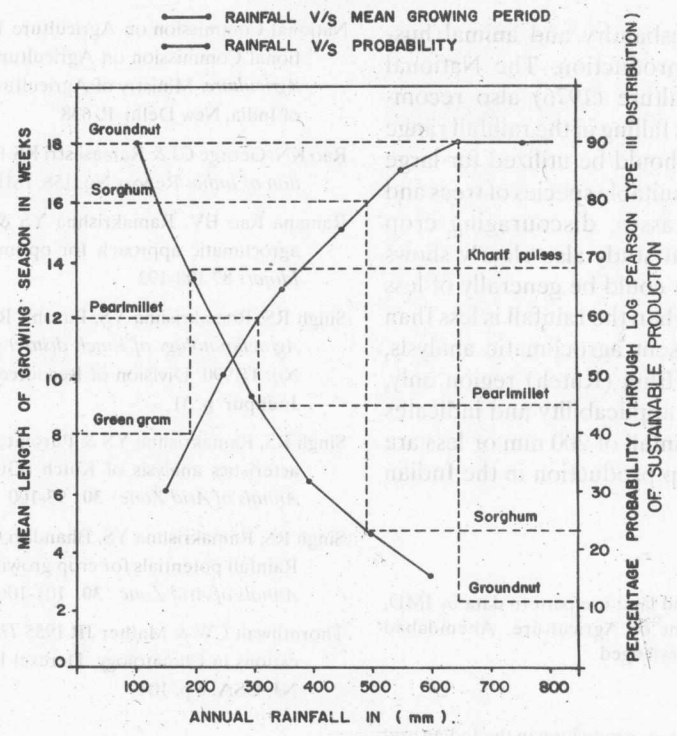

Fig 2 Rainfall, its probability of occurrence and length of the growing season at Bhuj (Kutch)

rainfall is about 500 mm and 640 mm respectively. The probability of occurrence of 500 mm is about 23% and for 640 is about 11%.

For deciding the cropping patterns under these circumstances, based on the agroclimatic data it can be seen that the available growing season will be less than 8 weeks duration in 32% of occassions. Therefore, it is appropriate that 32% of the agricultural land should be under pastures or silvipastoral systems, which are of low water requirement and perennial in nature to provide sustained production even under low rainfall years. Thus the risk involved in crop production can be compensanted through annimal husbandry. In the remaining 68% of the occassion, a growing season of more than 8 weeks can be expected and the chances of a growing season exceeding 12 weeks is 45%. Therefore the pearl millet and other long duration crops including sorghum, groundnut, cotton and others can be grown in maximum area up to 45% of the total rainfed agricultural area of the region, so as to increase the probability of success in crop growth and sustainability in production from the given region.

From the above climatic analysis it can be concluded that in order to minimize the risk in crop production and for a stablilized economy, 32 % of the agricultural land should be under grasses, contrary to only 11% of the area under grasses in the existing cropping pattern. Though the area under short duration pulses is only 18% as per this study, its cultivation should be increased to at least 23% of the total agricultural land keeping in view that a maximum area up to 45% can be covered by pearl millet and other long duration crops and 32% under pastures and grasses which are of lower water requirement. Therefore, there is a great need to increase the cultivated area by at least 5 % under short duration *kharif* pulses to stabilize the economy of the area.

These findings are according to the recommendations of the National Commision on Agriculture (1976), suggesting that the regions with annual rainfall ranging from 300 to 400 mm should have an

intergration of crop husbandry and animal husbandry for stabilized production. The National Commission on Agriculture (1976) also recommended that the regions falling in the rainfall range of 300 mm and below should be utilized for large scale afforestation with suitable species of trees and adapted species of grasses, discouraging crop production. The present study also clearly shows that the gorwing season could be generally of less than 8 weeks duration when the rainfall is less than 200 mm. Thus the present agroclimatic analysis, though carried out for Bhuj (Kutch) region only, holds good for a wider applicability and indicates that the regions with rainfall of 200 mm or less are not suitable for any crop production in the Indian desert.

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