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Probabilities of moisture adequacy index (I_{ma}) for crop planning in Maharashtra

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सार — फसल आयोजना के लिए महाराष्ट्र के विभिन्न कृषि जलवायुवी स्थलों में उपलब्ध मृदा-आर्द्रता को, आर्द्रता पर्याप्तता सूचकांक I_{ma} की अभिकलित संभावनाओं से निर्धारित किया गया है। I_{ma} के वितरण के लिए बीटा फलन द्वारा I_{ma} की प्रायिकताओं को प्राप्त किया गया है इस प्रकार प्राप्त I_{ma} की प्रायिकताओं की उस क्षेत्र में फसलों में नमी की पर्याप्तता के लिए जांची गयी और जिस अवधि में संपूरक सिंचाई की आवश्यकता थी, उसका पता लगाया गया।

ABSTRACT. For crop planning, the soil moisture availability in different agroclimatic locations of Maharashtra is assessed from the computed probabilities of moisture adequacy index (I_{ma}). The probabilities of I_{ma} are obtained by adopting Beta function to the distribution of I_{ma}. The I_{ma} probabilities thus obtained are examined for the moisture adequacy of crops in the region and the periods which need supplemental irrigation are identified.

1. Introduction

The moisture adequacy index, I_{ma} is defined as the ratio of actual evapotranspiration (AE) to potential evapotranspiration (PE) (Subrahmanyam *et al.* 1963) and thus indicates the moisture status at a place. Since soil moisture availability is a major limiting factor for crop production in tropical regions like Maharashtra, the index values for the region will be useful in crop planning.

Subrahmanyam *et al.* (1963 have reported that there is a close relationship between I_{ma} values and the type of crop and its distribution in the Indian region.

Yao (1969, 1974) coined I_{ma} as R-index and pointed out that the behaviour of R-index distribution frequency follows that of Beta distribution frequency. He also suggested that I_{ma} probabilities can be used to solve problems of agricultural landuse capability, longterm agricultural planning, irrigation project design and agricultural drought.

Bishnoi (1980) has reported that the monthly probabilities of I_{ma} in Punjab and Haryana. Such I_{ma} probabilities will be helpful for other regions also in crop planning especially if they are computed for shorter periods since the physiological stages of many crops have lesser duration than a month.

In this paper, the weekly I_{ma} probabilities at selected locations in Maharashtra are computed and discussed for crop planning.

2. Methodology

The I_{ma} values are obtained from the computed weekly AE and PE at Karjat (per-humid), Niphad, Pune, Padegaon, Jalgoan, Sholapur, Akola and Parbhani (semi-arid) and Nagpur (dry sub-humid) stations.

The PE on yearwise and for weekly periods during 1946-76 at the selected locations computed by Sambasiva Rao (1983) using a modified Penman's formula (Rao 1971, Brown and Cocheme 1973) are used in the present study. Since, the field measurements on AE are not available, the AE computed by Sambasiva Rao (1983) using the soil water budgeting procedure of Thornthwaite and Mather (1957) for the corresponding period at these locations are used in this study.

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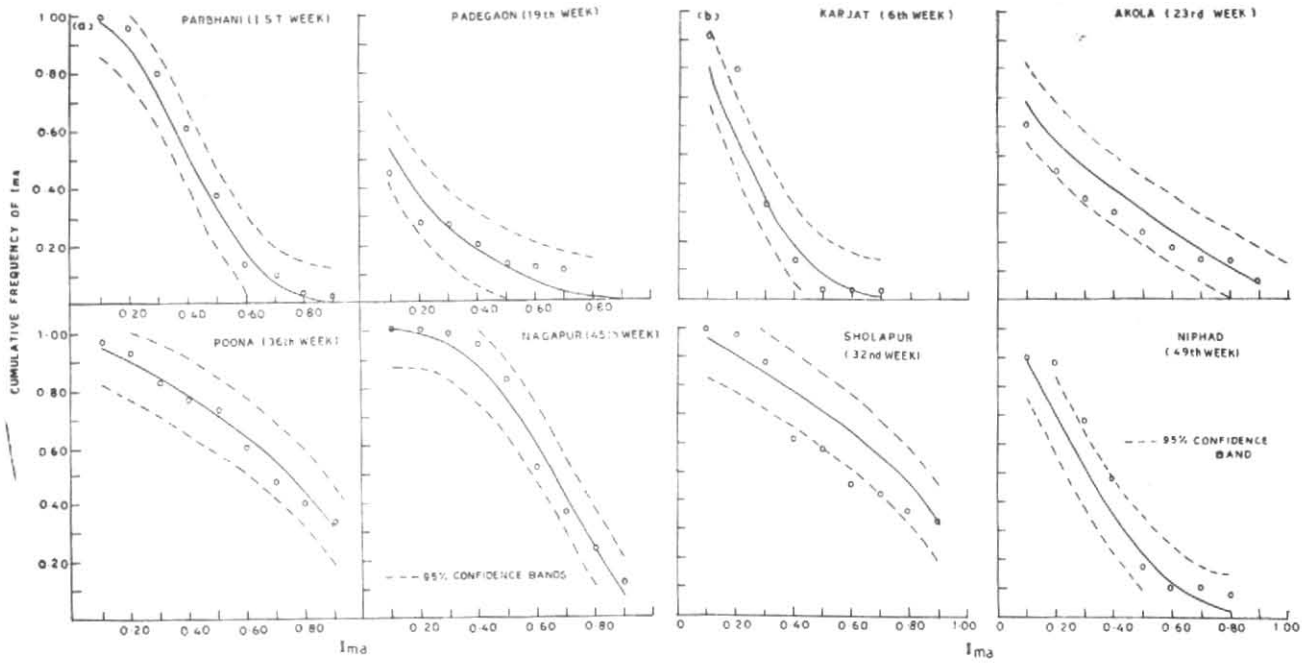

Fig. 1. Cumulative frequency of I_{ma} and the Beta distribution curves with 95 per cent confidence bands

The I_{ma} probabilities are fitted by adopting a Beta function to the frequency distribution of I_{ma}. The goodness of fit of the distribution is obtained using a K-S test. Following the methodology suggested by Yao (1969, 1974) and Ravelo and Decker (1979) and using the computed tables of Pearson (1948), the shape parameters of the probability distribution curves, probabilities of higher than the I_{ma} values in the range 0.20 to 0.90 and the I_{ma} values for the given probability level between 0.20 and 0.90 are computed for the selected stations and discussed for crop planning.

3. Results and discussion

(a) *The Kolmogorov-Smirov goodness of fit test*

The absolute maximum difference between the observed and theoretical frequency distribution of I_{ma} obtained by adopting Beta function are tested at 0.15 level of significance (Birnbaum 1952 and Fellar 1967) using the Kolmogorov-Smirov (K-S) test for goodness of fit.

Out of the 108 sample curves tested, 95 per cent of them are following the Beta distribution with minimum absolute difference between the two curves (Fig. 1a) when the I_{ma} ranges between 0.30 and 0.80. The percentage of I_{ma} that followed the fitted values decreased to 45 per cent for I_{ma} 0.20 and 0.90 and to 21 per cent for I_{ma} 0.0 and 1.0. Few cases where frequency of I_{ma} does not followed Beta distribution are shown in Fig. 1(b). However, I_{ma} below 0.30 and above 0.80 represent extreme moisture conditions and are of little value in agricultural planning.

(b) *Moisture adequacy and crop planning*

The weekly probabilities of higher than the indicated I_{ma} between 0.20 and 0.90 and the I_{ma} for a given probability level between 0.20 and 0.90 are found for Karjat, Pune, Jalgaon, Parbhani and Nagpur.

For water management or for identifying a suitable cropping pattern in a location, the probabilities of I_{ma} at lowest allowable moisture levels for different crops should be known.

The ratio of evapotranspiration to pan evaporation (ET/Epan) is similar to the ratio of AE to PE (I_{ma}). The ET/Epan values available for different crops can be taken as a limit for evapotranspiration requirement. Under tropical conditions, the ET/Epan ratios for kharif rice are 0.90 at transplanting and is equal to or above 1.00 during the remaining period (Subba Rao *et al.* 1976). The ET/Epan for rabi wheat at Pune and Akola were 0.40-0.70 at crown initiation, 0.4-1.2 at tillering, 1.2-1.25 at jointing to flowering

and 0.1-0.2 at maturity (Venkataraman *et al.* 1976). The ET/Epan for kharif jowar at Akola varies from 0.45 at seedling to 1.15 at reproductive stage and then further declines by grain formation stage (Sarker *et al.* 1976). The above are some of ET/Epan values taken for examination of I_{ma} probabilities.

For achieving optimum I_{ma}, the kharif rice sown in 25th week at Karjat has probabilities of 0.74-1.00 during vegetative stage (from seed germination to panicle initiation), > 0.99 during reproductive stage (from panicle initiation to flowering) and 0.43-0.83 during ripening stage. Similarly, for achieving optimum I_{ma}, the kharif rice sown in 25th week at Nagpur has probabilities of 0.55 during seedling, 0.74-0.67 during vegetative, 0.67— $>$ 0.99 during reproductive and 0.28-0.71 at ripening stages. The initial soil moisture stress for the crop can be avoided by sowing the crop in 28th week and thereby increasing I_{ma} probabilities to 0.74.

To meet the crop water requirement, the rabi wheat sown in 42nd week at Niphad has probabilities of 0.60-0.52 at crown root initiation, 0.01-0.20 at tillering and jointing, $<$ 0.01 at flowering and 0.46-0.68 till maturity. The higher probabilities obtained during the late season period are due to less moisture required during that stage. The corresponding probabilities for achieving the optimum I_{ma} for a rabi wheat sown in 42nd week at Parbhani are 0.65-0.71, 0.03-0.15, $<$ 0.01-0.02 and 0.36-0.46 respectively.

For a kharif jowar sown in 23rd week at Sholapur, the probabilities of I_{ma} being higher than the requirement are 0.50-0.71 during seedling, 0.11-0.30 during vegetative, 0.21-0.32 at reproductive and 0.21-0.40 during ripening stages. The probabilities for the corresponding stages of kharif jowar sown in 24th week at Akola are 0.50, 0.30-0.45, 0.32-0.52 and 0.46-0.51 respectively.

The above are few examples discussed for the probabilities of moisture adequacy at various growth stages of crops of the region.

For a given crop and its variety, the potential yield at a place depends upon on the extent the soil moisture meets PE. Crop yields have been shown to increase linearly with AE until PE has attained (deWit 1958, Hanks 1974, Musick and Dusek 1980, Tanner 1981). Therefore, the probabilities of I_{ma} that satisfy AE will also show the probabilities of achieving potential crop yields.

From the above discussion, it can also be referred that the lesser the probability for achieving required I_{ma} of a crop, the higher the probability to supplement moisture through irrigation.

4. Summary and conclusions

The weekly probabilities of moisture adequacy index (I_{ma}) at selected locations of Maharashtra are obtained by adopting Beta function to the distribution of I_{ma} The theoretical frequency is closely following with that of actual frequency of I_{ma} within the range 0.30 to 0.80 at 0.15 level of significance. The probabilities of I_{ma} satisfying the evapotranspirational requirement of some crops in the region are examined. The computed probabilities can be used in scheduling timely irrigation and hence thereby to achieve potential yield under a given soil and climatic environment.

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