MOISTURE ADEQUACY
IN RELATION TO THE DISTRIBUTION
OF SOME CROPS IN INDIA

V.P. SUBRAHMANYAM, B. SUBBA RAO and A.R. SUBRAMANIAM

Department of Meteorology and Oceanography
Andhra University, Waltair, S. India

In a country like India where droughts are as severe as they are frequent, it is essential to know the water requirements of individual regions and the extent to which the normal water supply by precipitation is not able to meet those requirements. Thornthwaite proposed a book-keeping procedure (1) for the computation of the elements of water budget of a region by treating precipitation as income, potential evapotranspiration (PE) as expenditure and the moisture stored in the soil mantle as a kind of reserve for use in times of deficient precipitation. Of the three major elements of water balance, namely, Water Surplus, Water Deficiency, and Actual Evapotranspiration, water surplus is of interest to the hydrologist and water deficiency to the agriculturist while actual evapotranspiration is the concern of every field in which water balance plays any role. This is because the actual evapotranspiration (AE), by definition, is the actual amount of water lost to the atmosphere by evaporation and

Fig. 1 — Index of moisture adequacy(%)
transpiration under existing conditions of moisture availability. Thus it is almost impossible to measure it directly, but methods have been proposed for its indirect determination by the simultaneous recording of profiles of temperature, humidity and wind close to the ground. All such methods, however, make use of complicated equipment and the analysis of data too involves laborious procedures.

For obtaining estimates of AE in climatic studies, the book-keeping procedure suggested by Thornthwaite is again a very useful tool. The AE represents in a way the absolute amount of water that is actually available in the soil for use by vegetation; in places where there is adequate moisture, the AE will be high and may even equal the PE under conditions of saturated soil, while in dry areas, it will be proportionately smaller, in spite of large values of PE. Thus, if either AE or PE is considered independently, the suitability of a region for practical purposes cannot be clearly assessed. On the other hand, since PE, as water-need, represents the maximum amount of water evaporated and transpired under conditions of no water deficiency at any time, the ratio of AE to PE varies with the available moisture in the soil. This ratio, termed "index of moisture adequacy", thus provides a good indication of the moisture status of the soil in relation to the water-need, low percentage values of the index signifying poor moisture availability.

From the records of precipitation and computed data of potential evapotranspiration, the actual evapotranspirations were worked out for all the climatological stations in India according to the 1955 water balance scheme of Thornthwaite (5). Using the AE and PE values, the indices of moisture adequacy were computed as indicated above and the geographical distribution of this index over India is shown in figure 1.
The highest values of the index are found in north-east India and the south-western portion of the Peninsula; these are the areas of fairly heavy and prolonged precipitation and consequently they rarely experience moisture deficiencies, at least on an annual basis. The index which is higher than 80% in the north-east falls below 10% near Baluchistan in the west. In the Peninsula high values of the index are generally found along the west coast while in the Central Deccan, the values are less than 40% everywhere.

Fig. 3 — Rice: each dot represents 30,000 Acres

Since large values of the moisture adequacy index are due to the availability of abundant quantities of moisture in relation to water-need, in such regions intense agricultural operations throughout the year are either to be expected or may be recommended. On the other hand, in regions of low indices, agricultural activity is normally restricted only to the rainy season. A comparison of the moisture adequacy map with the map of vegetation types of India (Fig. 2) as prepared by Champion (3) shows
certain striking features: Wet ever-green and semi ever-green forests in regions with moisture adequacy indices in excess of 80% and desertic vegetation below 20%. Interestingly, the isopleth of 40% for the moisture adequacy index seems to bound semi-arid climates with thorn forests both in south and north India.

Fig. 4 — Wheat: each dot represents 20,000 Acres

Next, an attempt has been made to compare the moisture adequacy map with maps of distribution of some crops in India (4). About a third of the cultivated area in India is under rice which requires high temperatures and large amounts of water. Where irrigation facilities are either lacking or poor, it is, therefore, grown mainly in the south-west monsoon season when rainfall is usually abundant. Figure 3 shows the areas of rice cultivation not seriously influenced by supplemental irrigation. Intensive cultivation is found in the north-east and in the coastal belts of Peninsular India; it is significant that these regions are bounded by the isolines of 60% and 100% moisture adequacy index. In north and west India, however, its cultivation is limited either by the low thermal regime of climate, or inadequate amounts of precipitation.
While rice has high thermal and moisture needs, wheat (Fig. 4) requires low temperatures and has lower water-needs and is therefore grown primarily in north India. Though also raised over elevated regions in south India in the cool season, it is not a significant crop here. In the north, the small amounts of precipitation produced by the western disturbances in winter appear to be adequate for its cultivation. Comparison of figure 4 with the moisture adequacy map reveals that wheat-growing areas are generally surrounded by the 40% and 60% isolines of the index.

Jowar is an important millet crop which requires high temperatures and tolerates low amounts of moisture; excess water is considered to be even injurious to its cultivation. Its distribution presented in figure 5 shows that it is grown mainly in the interior plains of Peninsular and Central India where temperatures are high enough and moisture in the soil is quite low. Even here, as in case of wheat, the bounding lines of moisture adequacy index are 40% and 60%, but its high thermal requirements make it essentially a crop of south India.
An interesting conclusion that emerged from this study was that most of the agricultural crops in India do not seem to have favourable conditions of development below the 40% isolines of the moisture adequacy index, unless otherwise raised as irrigated crops. It would appear that in the reclamation of vast stretches of land for agricultural production, this index would be very useful for determining the suitable kinds of crops that may be grown with least hazard of damage from droughts. In the successful introduction of exotic tree plantations in silviculture, a careful study of the seasonal variation of this parameter may be of great practical utility. For, it is only when the changing water demands of the plantation through its vegetative cycle are matched by the seasonal fluctuations of moisture adequacy, that maximum development of the species may be expected. Thus, when systematically studied on a weekly or monthly basis, this index should provide valuable information on the liability to drought and therefore the climatic suitability of a region for agricultural or forest development. Results of these studies which are under active pursuit in these laboratories will be reported in due course.

REFERENCES