October 1996

Moisture Deficit Index Evaluated for Dry Regions of India

K. K. Nathan
Water Technology Centre, New Delhi, India

S. K. Sinha
Water Technology Centre, New Delhi, India

Moisture Deficit Index Evaluated for Dry Regions of India

K. K. Nathan and S. K. Sinha
Water Technology Centre
New Delhi, India

In India, about 70% of the cultivable land is rainfed. This includes areas where crops are rarely affected by drought and areas where crops experience moisture stress and often fail. The regions with the latter characteristics are often called *dryland areas* and the agriculture so practiced there is known as *dryland agriculture*. About 35% of the total cultivable land belongs in this category. To determine the magnitude of water deficiency in these regions, the moisture deficit index (MDI) has been evaluated for dryland stations in India. The MDI is usually determined on the basis of annual precipitation and annual potential evapotranspiration, as adapted by Thornthwaite and Mather in 1955. This does not reflect the true nature of MDI for the purpose of crop production, although it does give information regarding the degree of aridity. Since this index sometimes is used as a criterion for crop planning, it would appear more appropriate for it to be based on precipitation and PET during the crop growth period. In this article, the monthly MDI for dryland stations in India based on normal data has been worked out. We have also discussed its implications for crop production in relation to other meteorological factors.

Fifty years of normal precipitation data (1901–50), both monthly and annual, were obtained from the India Meteorological Department. The normal monthly and annual PET (also obtained from the India Meteorological Department) were computed using the Penman method. The following formula (Thornthwaite) was used to calculate the MDI.

$$\frac{P\text{-}PET}{PET} \times 100$$

P = Precipitation (in millimeters)
PET = Potential evapotranspiration (in millimeters)

Sowing and harvesting dates of some of the kharif crops were obtained from the Indian Council of Agriculture Research (ICAR) Annual Progress Report, 1973–74, for some dryland stations in India.

Among 19 dry-region centers, only Dehradun had a positive moisture index. The index ranged from -16.0 at Ranchi to -80.1 at Jodhpur. This is based on annual PET and precipitation (Table 1). Indeed, if PET is more than precipitation, the plants must experience moisture stress, and unless they receive irrigation, they may not grow and produce yields. But crops do grow in all the regions for which data is given (Table 2).

Two points must be borne in mind. First, crops do not grow year round, but PET is taken into account on an annual basis. Second, in crop production, evapotranspiration is not expected to become equal to PET until a full canopy has been developed. This normally takes half the crop growth period. If these factors are not taken into consideration, a proper assessment of crop planning may be difficult.

In India, the kharif crops (rainy season crops) are sown immediately after the arrival of monsoon rains in the dry regions. Therefore, the period from the first showers to harvest time constitutes the growth and maturity period of the crop. For all the crops, this period ranges from 80 days to 120 days, with the exception of pigeon peas or *Cajanus cajan* (Table 2).

Stn. No.	Stations	*Annual precip.(mm)	*Annual PET(mm)	*Moisture Index(%)
1.	Ludhiana	680.1	1359.9	-50.0
2.	Dehradun	2048.1	1152.4	+77.7
3.	Hissar	428.4	1615.6	-73.5
4.	New Delhi	660.1	1658.7	-60.2
5.	Jodhpur	366.0	1843.0	-80.1
6.	Udaipur	638.1	1381.2	-53.8
7.	Agra	679.0	1467.2	-53.7
8.	Jhansi	917.6	1516.0	-39.5
9.	Varanasi	1076.0	1525.2	-29.5
10.	Ranchi	1512.7	1304.0	-16.0
11.	Hyderabad	772.2	1756.8	-56.0
12.	Anantpur	583.0	1857.1	-68.6
13.	Bangalore	888.9	1500.5	-40.8
14.	Bellary	519.9	1738.1	-70.1
15.	Akola	596.7	1729.7	-65.5
16.	Bijapur	520.5	1650.1	-68.5
17.	Sholapur	677.7	1801.7	-62.4
18.	Rajkot	594.3	2144.6	-72.3
19.	Indore	929.1	1813.2	-48.8

*Computation is based on normal data

Table 1. Annual precipitation, annual potential evapotranspiration (PET), and moisture index for different dryland stations in India.

Station Number	Station	*Approximate period of:* Sowing	Harvesting	Crop	Approximate duration
1.	Ludhiana	July 4	Oct 10	Pearl Millet	93
2.	Dehradun	June 27	Oct 5	Maize	100
3.	Hissar	May 30	Oct 4	Sorghum	125
		June 3	Sept 3	Greengram	90
4.	Agra	Aug 17	Oct 20	Sorghum	66
		Aug 17	Nov 10	Cowpea	83
5.	Varanasi	Aug 12	Oct 23	Pearl Millet	72
		July 8	Sept 6	Blackgram	58
6.	Anantpur	July 29	Nov 2	Pearl Millet	94
7.	Bellary	Sept 9	Nov 30	Sorghum	80
8.	Akola	June 25	Oct 19	Sorghum	113
		Aug 5	Nov 21	Pearl Millet	107
9.	Bijapur	June 30	Nov 27	Greengram	147
		June 30	Oct 30	Pearl Millet	118
		July 9	Sept 17	Blackgram	68
		July 4	Sept 5	Greengram	61
10.	Sholapur	June 30	Sept 28	Pearl Millet	88
		July 5	Sept 22	Greengram	78
11.	Rajkot	July 4	Sept 29	Sorghum	86
			Sept 23	Greengram	80
			Sept 20	Maize	76
12.	Anand	June 29	Oct 6	Pearl Millet	97
		June 29	Sept 9	Greengram	70

Table 2. Approximate period of sowing and harvesting of different crops in some dryland stations during kharif (rainy) reason.

From Table 2, it is clear that in most of the country, sowing occurs in the last week of June or the first week of July. The crops usually are harvested in October. A study of MDI during this period would be important in classifying the different regions.

The MDI for the 19 dryland stations are depicted, on a monthly basis, in Figures 1 and 2. At six centers—Hissar, Jodhpur, Anantpur, Bellary, Bijapur, and Sholapur—the moisture index was negative in July. The MDI at these places ranged from -21.6% to -73.9%, indicating that the available moisture may be enough for sowing and subsequently for the establishment of the crop but not necessarily for optimal growth if there was full crop canopy.

In August, nine centers had negative moisture indexes; in September, eight centers had negative indexes. Seven centers, including Dehradun, Agra,

*This article appeared in the October 1996 issue of **Drought Network News**.*

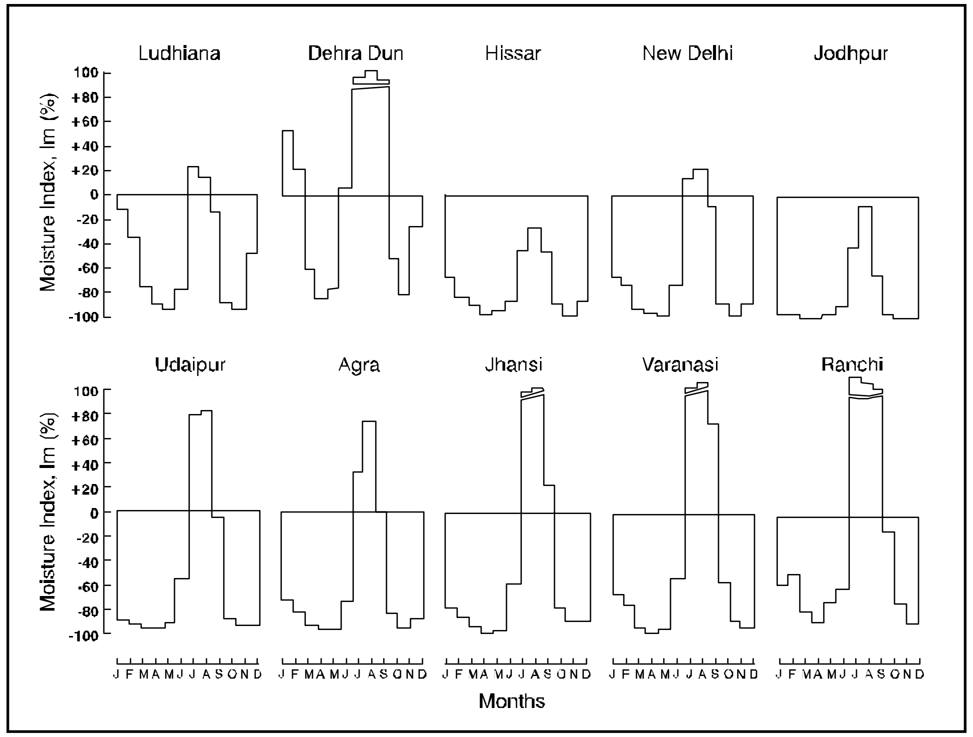

Figure 1. MDI for dryland stations, on a monthly basis.

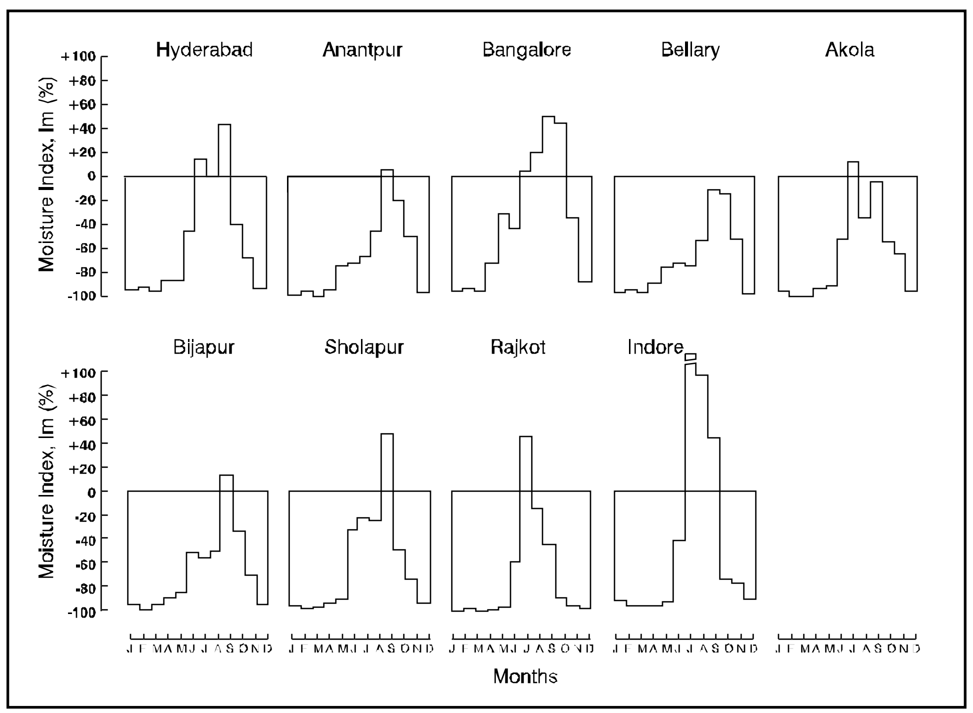

Figure 2. MDI for dryland stations, on a monthly basis.

Jhansi, Varanasi, Ranchi, Bangalore and Indore, had excess moisture index during July, August, and September (Figures 1 and 2). There is a distinct possibility of growing a second crop at these places provided a small amount of water is available as supplemental irrigation. The Hissar station (Figure 1) showed a negative moisture index from July to September, but it was less than -50%. Since crop production does occur at this place, we consider this the lower limit of the deficit moisture index in relation to crop growth.

Therefore, from the point of view of crop production, the moisture index for the period of crop growth provides a better picture than the moisture index from the annual data. This information can be helpful in predicting whether a particular dry region would be suitable for a single or double crop. However, the number that we need to know is the moisture index at which the crop would be wilting, particularly in drought or dry regions.

*This article appeared in the October 1996 issue of **Drought Network News**.*