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AGROCLIMATOLOGICAL CHARACTERISTICS OF CHICKPEA AND GROUNDNUT GROWING AREAS IN INDIA

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CHICKPEA

Chickpea is grown in a wide range of agroclimatic environments (Sinha 1977), and their yield potential exceeds 4 t ha^{-1} (Nene 1986). However, the yields achieved by farmers are quite low and variable.

Based on chickpea production data (FAO 1982), there are 37 chickpea growing countries. The total chickpea production in the world for 1982 was 6.2 million t. India produced 74% of the world production.

Chickpea is usually grown after the rainy season on stored soil moisture, during winter in the tropics and in the spring in temperate and mediterranean regions. Chickpea has been recently grown in temperate and mediterranean regions as a winter crop when rainfall was well distributed during the growing period (Saxena 1984).

TWO CONTRASTING ENVIRONMENTS:

Precipitation and evapotranspiration, maximum and minimum temperatures, and photoperiod for two contrasting environments Hisar (29° 10'N) and Hyderabad (17° 32'N) have been presented in detail by Saxena (1984).

At Hisar, where the maximum temperature declines from 35°C to 20°C

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and the minimum from 17°C to 5°C between sowing in October and flowering in January, pod set begins when minimum temperatures become higher than 8°C in February. The rapid rise in maximum/minimum temperatures (from 25/8 to 37/20°C) and in evaporation (from 1-2 mm day^{-1} in December and January to 4-5 mm day^{-1} in late March and early April) hastens senescence and forces maturity. Growth duration is long, usually from 150 to 160 days. The daylength decreases from 11 h 16 min to 10 h 10 min between sowing and flowering and increases to 11 h 44 min at maturity. On average 370 mm rainfall is received before sowing and 80 to 90 mm during crop growth.

At Hyderabad, the crop is sown at about the same time as at Hisar but the seasonal variation in mean maximum and minimum temperatures and in daylength are relatively small compared with Hisar. Maximum temperature declines from 30 to 28°C and minimum from 20 to 13°C. Maximum/minimum temperatures and evaporation increase in late January and at maturity maximum/minimum temperatures are around 32/16°C. The growth duration is short, usually about 100 days. Daylength decreases from 11 h 34 min at sowing to 11 h 09 min at flowering and then increases to 11 h 24 min at maturity. On average 600 mm rainfall is received before sowing and another 40 to 100 mm during crop growth.

DISTRIBUTION:

Fig. 1 shows that the states of Madhya Pradesh, Rajasthan and Uttar Pradesh contributed 70% chickpea production in India (Bose 1981). Easter and Abel (1973) demarcated the chickpea growing regions into 'core' and 'satellite' districts. A core district was one that had at least 5% of total cropped area under chickpea and contributed at least

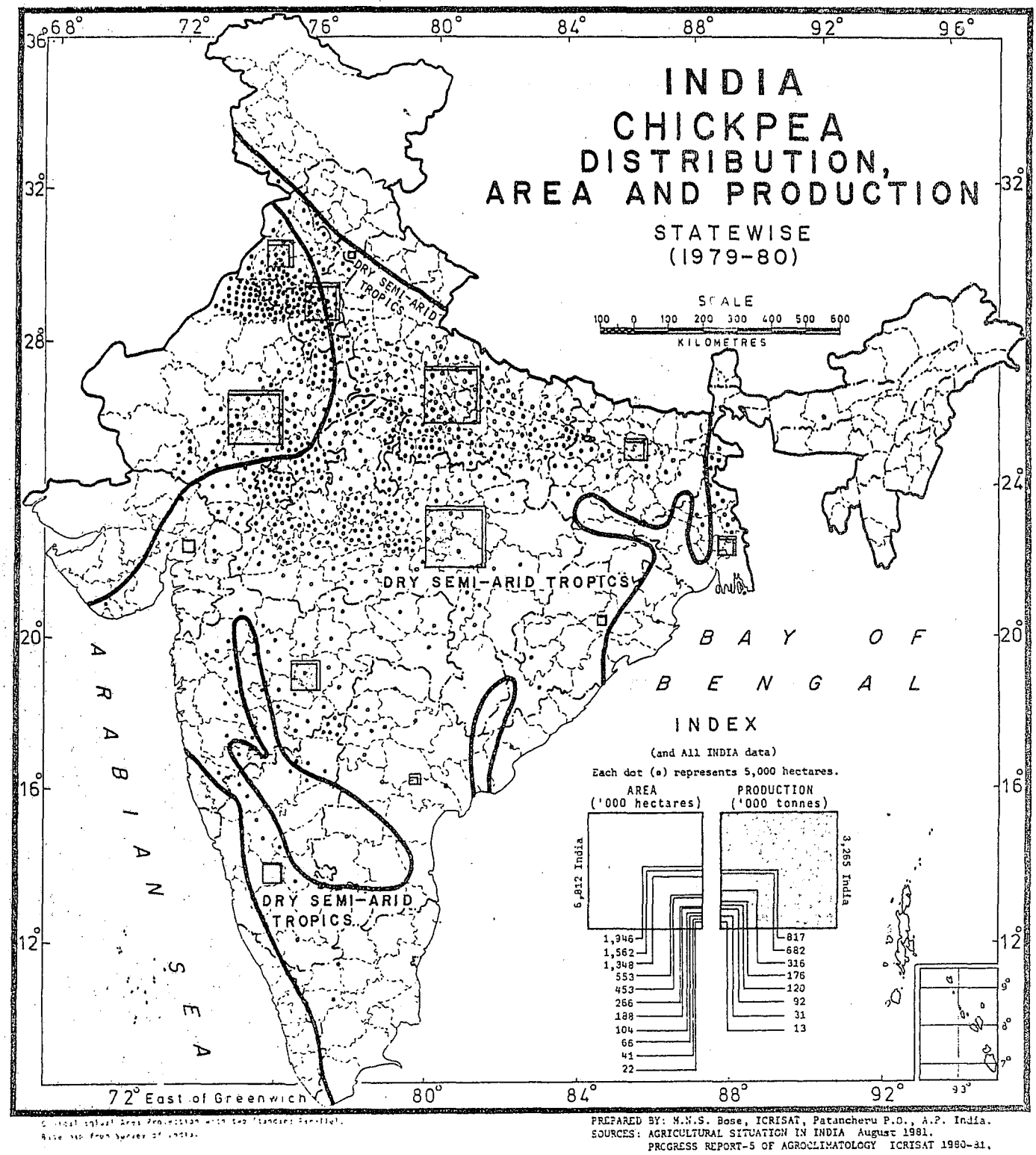


Fig. 1. Distribution, area and production of chickpea in India.

1% to total national production. A satellite district was one that had less than 5% but at least 2% of gross cropped area under chickpea and produced at least 0.5% of the national level.

The air temperature isotherms for October, January and April are superimposed on the maps of chickpea growing regions and these are shown in Fig. 2. In October, when chickpea is usually sown, the mean daily maximum temperature ranges between 32.5 and 35.0°C while the mean daily minimum temperature ranges between 20.0 and 22.5°C. In January, when flowering usually begins, the mean daily minimum temperature ranges from as low as 7.5°C to 15.0 C; the mean daily maximum temperature ranges between 22.5 C and 30.0°C. As pod filling begins the temperature starts rising and by the time chickpeas are harvested the air temperatures go very high. For example, in April, the mean daily minimum temperature ranges between 20.0 and 25.0°C and the mean daily maximum temperature ranges between 37.5 and 40.0°C.

Soils:

The benchmark soils map of India (Murthy et al. 1982) is superimposed on the chickpea growing areas of India and the soils in chickpea growing regions are shown in Fig. 3. The soils are Alfisols, Inceptisols, Entisols and Vertisols.

The Alfisols are usually neutral to slightly acidic in reaction (pH 6.5 - 7.0), are relatively shallow (<1m deep) and have less clay content. These soils are usually sandy loam in texture and can retain less than 100 mm available water. The Entisols are deep loams, slightly alkaline (pH 7.5 - 8.5), with about 150 to 200 mm available water storage capacity in about 2m soil depth. The Inceptisols are mineral

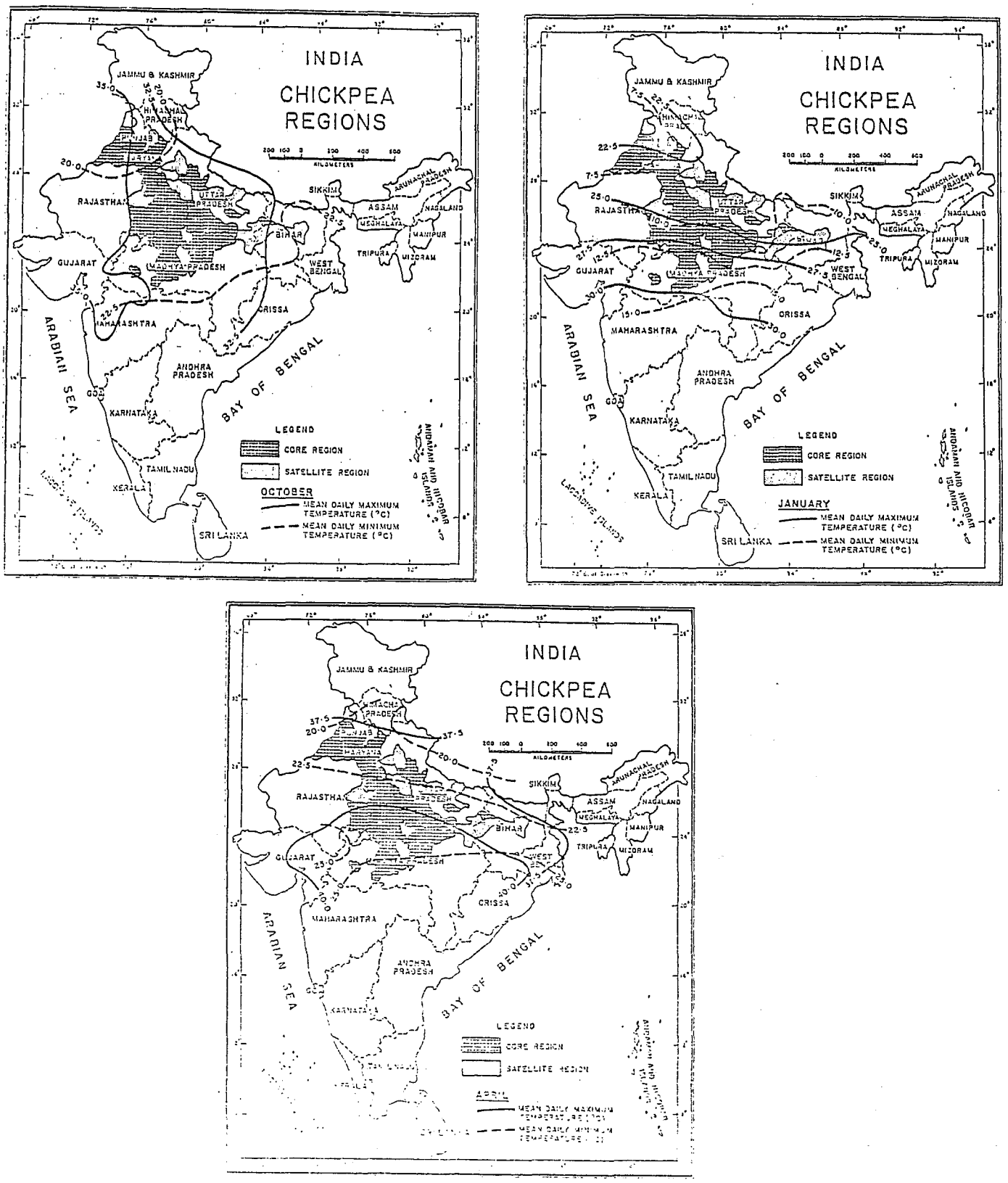


Fig. 2. Mean daily maximum and minimum air temperature (°C) for October, January and April in chickpea growing regions of India.

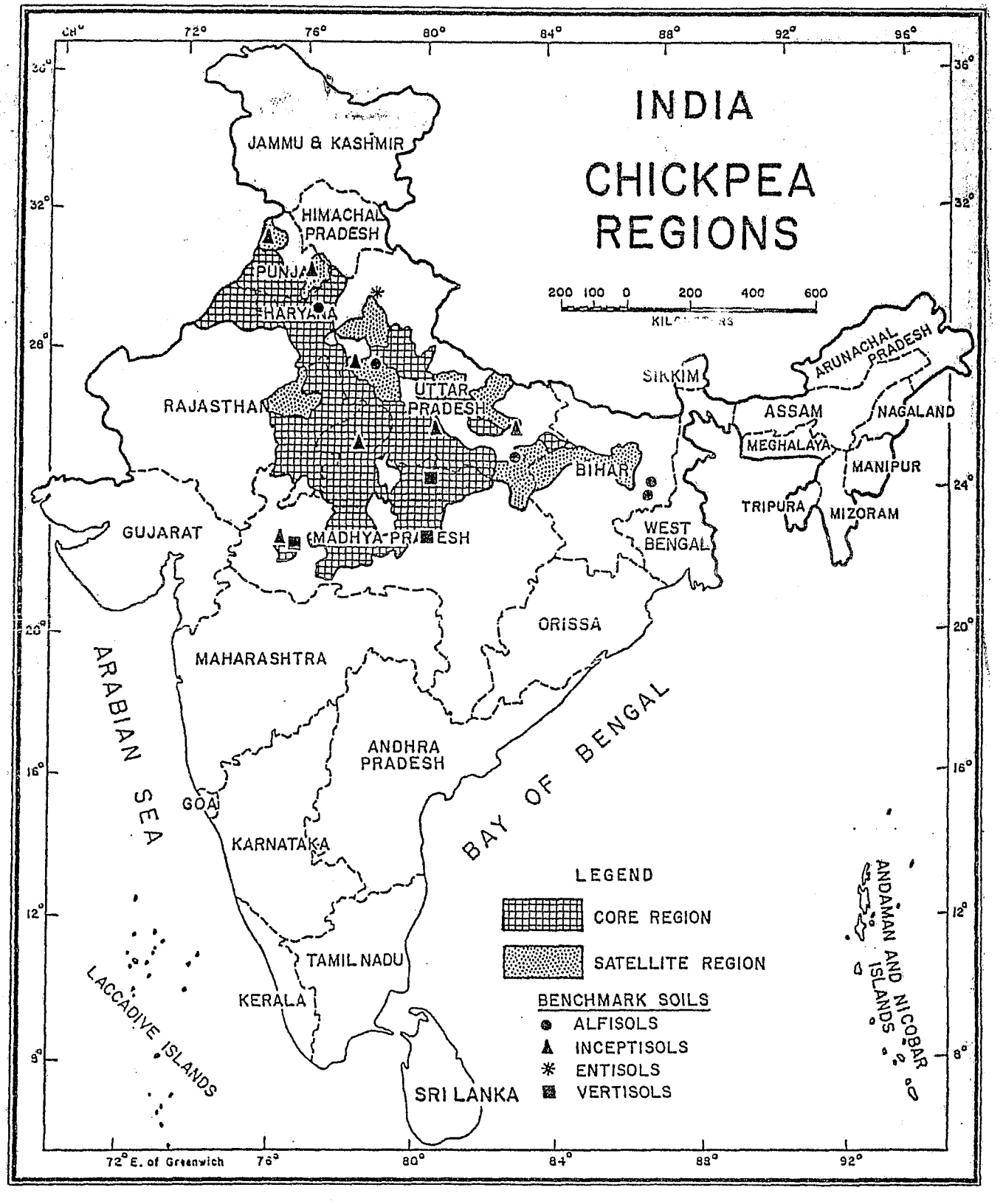


Fig. 3. Benchmark soils in chickpea growing regions of India.

soils which are more highly developed than the Entisols. The clay content in the surface soil ranges from 30 - 50%, pH 7.5 - 8.0; the soils are usually less than one meter deep. The available water holding capacity is less than 150 mm. The Vertisols are characterised by 40 to 60% clay in the surface soil horizons, pH of about 8, and they can store between 150 and 300 mm available water in 1.5 - 2 m soil depth.

Soil water:

Chickpea is able to extract moisture from deeper layers of the soil profile. An adequate supply of soil moisture at the time of sowing and winter rains of the order of 60 to 80 mm (in the Indian subcontinent) are essential for a successful chickpea crop (Singh and Das 1986). It is difficult to measure soil water at the time of sowing for various locations, thus a soil water balance model can be used to provide some estimate of soil water. The soil water balance model developed by Ritchie (1972) was used to simulate soil water for ICRISAT Center and Hisar (Fig. 4). The available water holding capacity of a medium-deep Vertisol at Patancheru and for an Entisol at Hisar is 150 mm. The normal rainfall from June to October is 653 mm for Patancheru and 366 mm for Hisar. Sowings of chickpea were assumed on 15 October at Patancheru and on 1 November at Hisar. Historical weather data for 1901-70 for Patancheru and 1951-82 for Hisar were used to compute cumulative probability of simulated available soil water at sowing for these two locations. For Patancheru, simulation of soil water was done for both rainy season fallow and rainy season sorghum. For Hisar, simulation of soil water was done for rainy season fallow. Fig. 4 shows that for Patancheru in 70% of the years there is at least 120 mm available water under rainy fallow condition and 80 mm under rainy season sorghum.

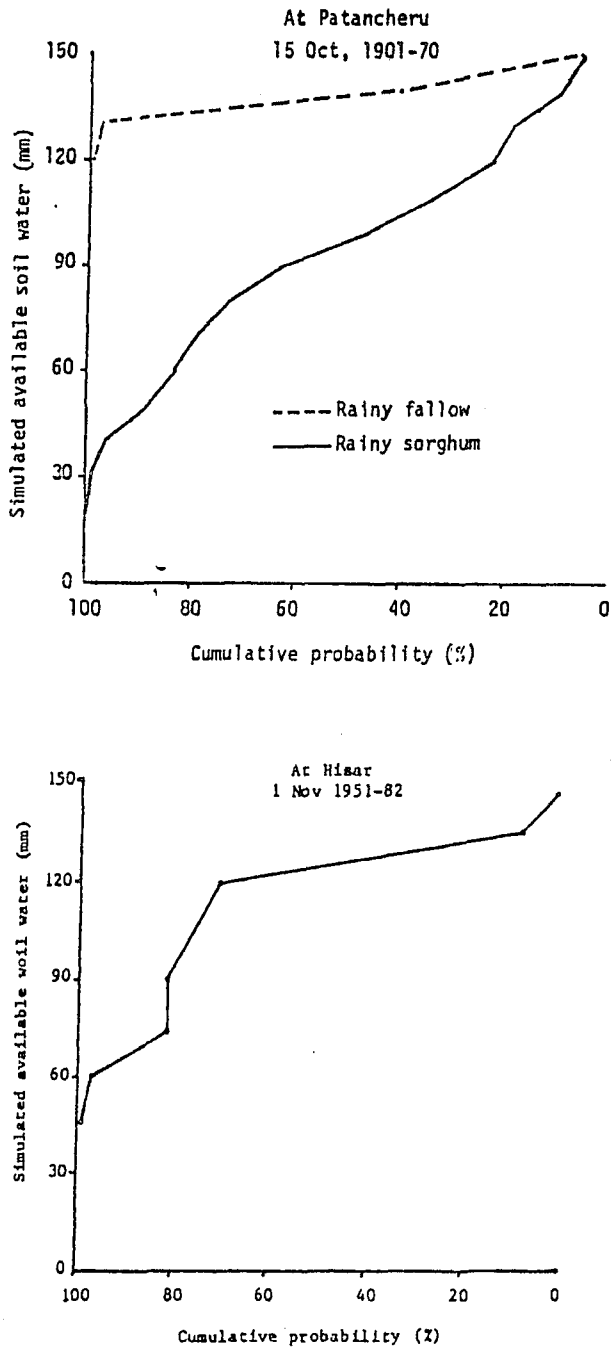


Fig. 4. Cumulative probability of simulated available soil water.

Considering that the normal rainfall and potential evaporation (PE) are 42 and 442 mm, respectively, from November to February at Patancheru, it is apparent that to achieve a reasonably good chickpea yield after rainy sorghum in a medium-deep Vertisol, supplemental irrigations are required. At Hisar, the simulated available soil water after rainy season fallow was more than 120 mm in 70% of the years. The normal rainfall and PE from November to February is 64 mm and 235 mm and thus good yields of chickpea are expected at Hisar without supplemental irrigation.

The information on simulated soil water at sowing is important but the simulated daily/weekly soil water balance during the growing season would help us to understand whether the crop suffers from water deficits at any growth stage. Additional information on canopy development would be required to calculate the evapotranspiration component of daily soil water balance.

Grain yield:

Chickpea grain yield could be simulated on the basis of stored available soil water plus winter rains (Singh and Das 1986). Singh and Bhushan (1979) reported the following regression equation from their experimental results of 1972-73 to 1975-76 at Dehradun using cv H 208, and the experimental yield ranged between 800 and 3,000 kg ha^{-1}

$$Y = 13.1\ X - 456,$$

Where Y = Chickpea yield (kg ha^{-1})

X = Water use (mm), i.e. soil water at sowing plus growing season rainfall.

We have used this relationship to compute cumulative probability of chickpea yield for Hisar (Fig. 5). Sowing date was assumed to be 1 November and historical weather data for 1951-82 were used. Phosphorus requirements to achieve these yields were also simulated assuming that 5 kg of phosphorus is required to produce 1 t of chickpea grain yield (Saxena 1984). In 70% of the years, simulated chickpea grain yields were at least 1.5 t ha^{-1} and simulated phosphorus requirements were 7.5 kg ha^{-1} (Fig. 5). The simulated yields were compared with the actual yields quoted in the estimates of area and production reports. Two points were noteworthy: (i) farmers are achieving less than 1 t ha^{-1} chickpea yield in 80% of the years; (ii) the simulated maximum yield (2800 kg ha^{-1}) was similar to the experimental yield as reported by Singh and Bhushan (1979), however, this was much higher than the actual maximum yield of 1800 kg ha^{-1} obtained by farmers. This yield gap could be reduced if proper management such as timely planting, fertiliser application, and plant protection are undertaken.

The water use efficiency (WUE) of unfertilised chickpea crops grown on stored soil water at ICRISAT Center, Patancheru is between 7.6 and 9.2 kg grain ha^{-1} mm^{-1} (Saxena 1984). We have used the WUE value of 8.0 kg of grain ha^{-1} mm^{-1} to compute cumulative probability of chickpea yield for Patancheru under both rainy season fallow and rainy season sorghum (Fig. 5). Historical weather data for 1901-70 were used and sowing date was assumed to be 15 October. The maximum yields under both rainy fallow and rainy sorghum were about 3.0 t ha^{-1}. Percent of maximum yield was computed by dividing individual year simulated value by the maximum simulated yield. In 70% of the years, at least 40% of the maximum yield was simulated under rainy fallow and 35% of the

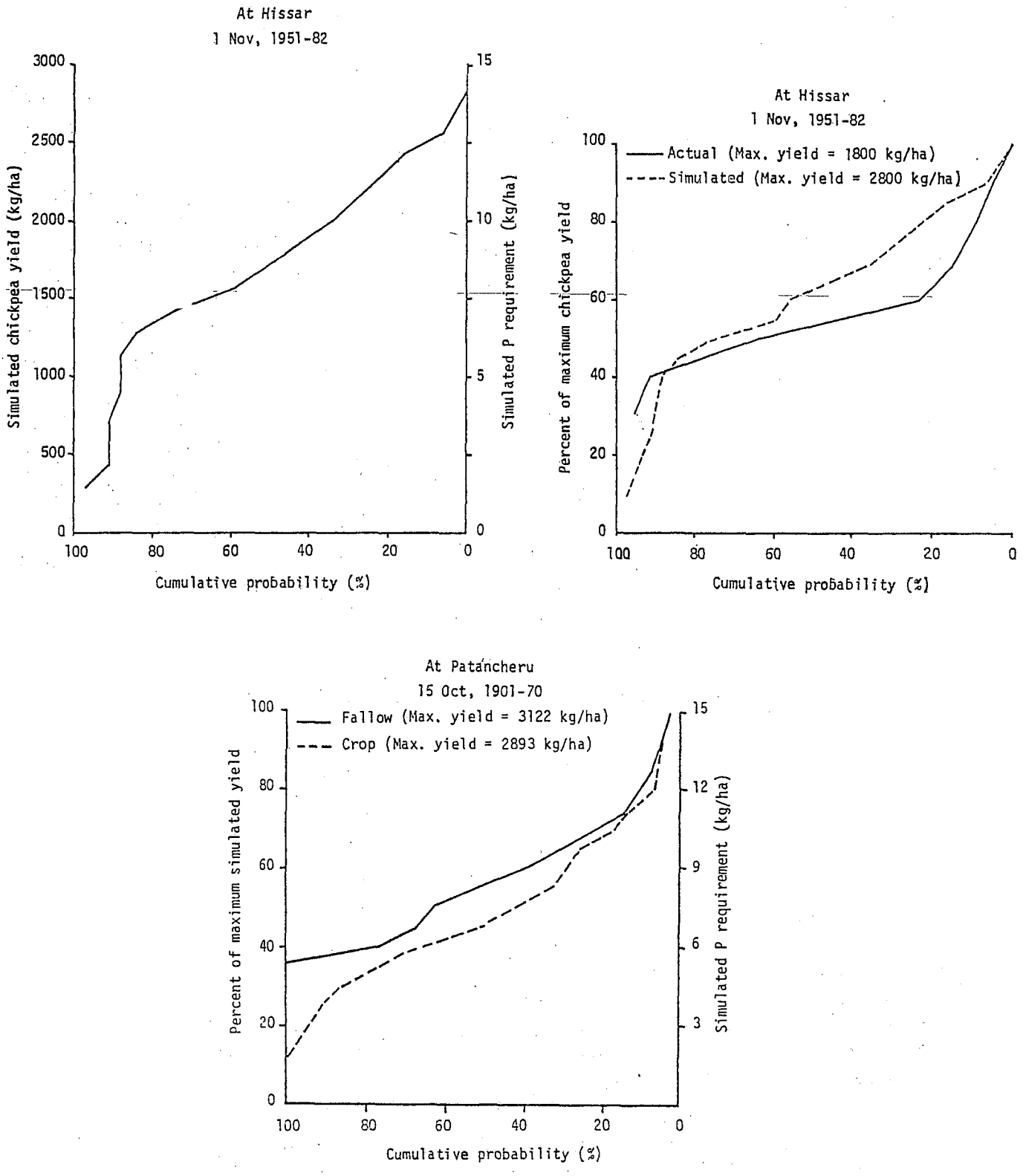


Fig. 5. Cumulative probability (%) of simulated chickpea yield and simulated P-requirements for Hisar and ICRISAT Center, Patancheru. Sowing dates assumed for Hisar, 1 November, and for Patancheru, 15 October.

maximum yield under rainy sorghum. Phosphorus requirements for achieving these yield levels were also simulated (Fig. 5).

Using the WUE value of 8.0 kg grain ha^{-1} mm^{-1}, chickpea yields were also simulated from 1974-75 to 1982-83 for ICRISAT Center, Patancheru. Simulated yields were compared with the actual yield as documented in ICRISAT Annual Reports for these years (Table 1). Simulated values were within ± 20% of the actual yield data for 50% of the years. The lowest chickpea yields were simulated for 1976-77 and 1980-81 under the rainy season sorghum. These are due to low winter rainfall. Rainfall from November to February was 30 mm in 1976-77 and 24 mm in 1976-77 and 1980-81.

GROUNDNUT

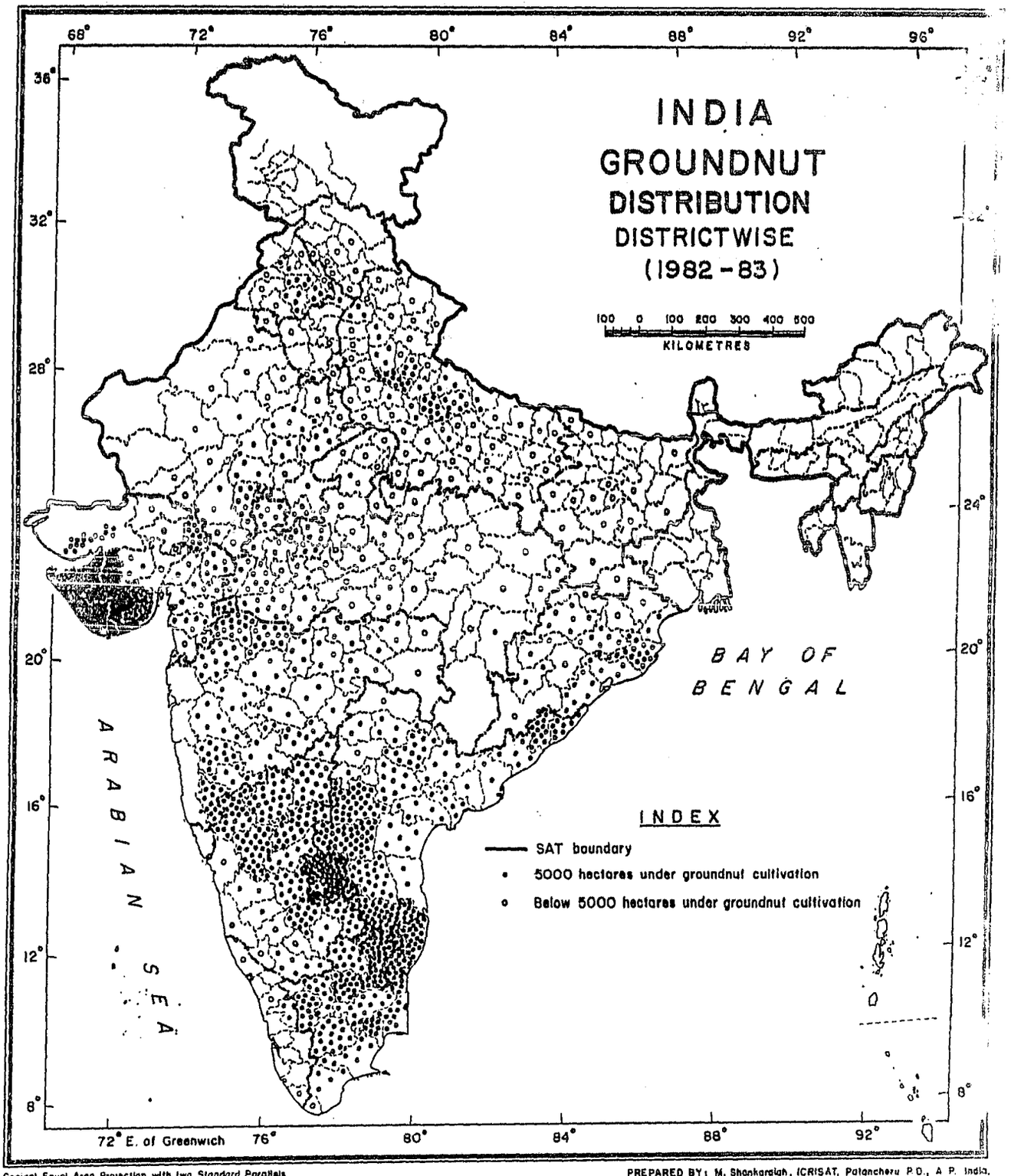
Groundnut is grown primarily in rainfed dryland conditions. According to FAO (1982), there are 90 groundnut growing countries in the world. The area under groundnut was 18.8 million ha; and 19.9 million t of groundnuts in shell were harvested in 1980-82. Over 7 million ha of groundnuts are cultivated annually in India (Fig. 6) with the total production of about 6 million t (Fig. 7).

In India, groundnuts are cultivated on Ustic Alfisols, Oxisols, and Usterts (the dry Vertic soils), from 7-30° N (Fig. 8). The major groundnut-producing areas are located in western India. The crop is raised primarily under rainfed dryland conditions. In northern India (20 N) groundnuts are sown with the onset of the rainy season in late June or July and harvested in October. In the eastern coast of southern India, where the rainfall is bimodal, two crops are raised per year. The second crop is raised with some supplemental irrigation. The first

Table 1. Observed and simulated chickpea yield at ICRISAT Center, Patancheru, under residual moisture for 1974-75 to 1982-83.

Year	Chickpea yield (kg ha^{-1}) at Patancheru under residual moisture		
	Observed	Simulated	
		Rainy fallow	Rainy sorghum
1974-75	2596	3024	2928
1975-76	1878*	2248	2176
1976-77	2654*	1258	578
1977-78	1963	1805	1238
1978-79	1342	1715	1459
1979-80	1015	1743	1447
1980-81	1499	1265	658
1981-82	1250	1232	1104
1982-83	2460	1636	1268

*Cultivar other than Annigeri



Conical Equal Area Projection with two Standard Parallels
Base map from Census of India

PREPARED BY: M. Shankaraiah, ICRISAT, Patancheru P.O., A.P. India.
SOURCE: AGRICULTURAL SITUATION IN INDIA February 1984.

Fig. 6. Groundnut growing areas in India.

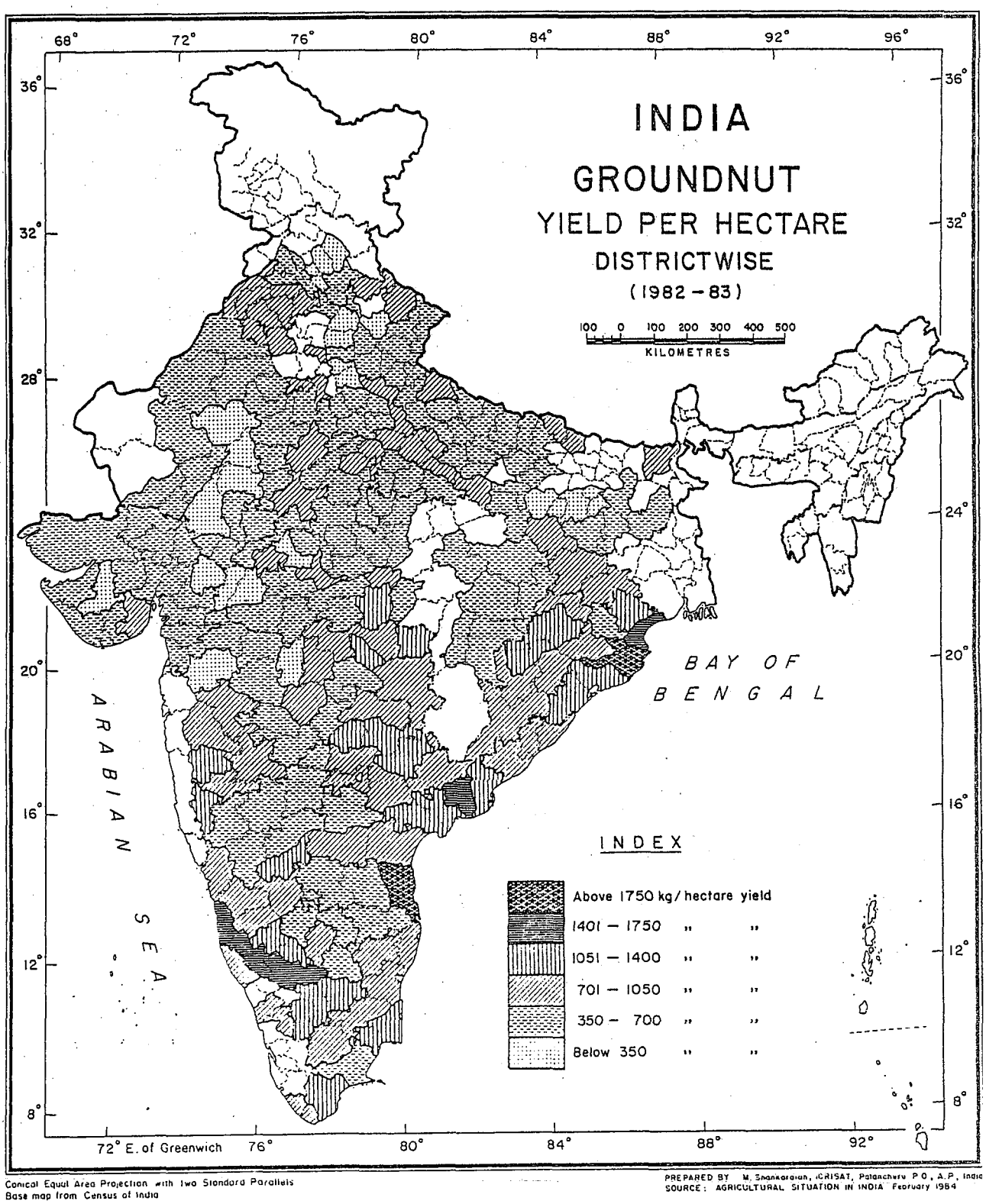


Fig. 7. Groundnut yields in India.

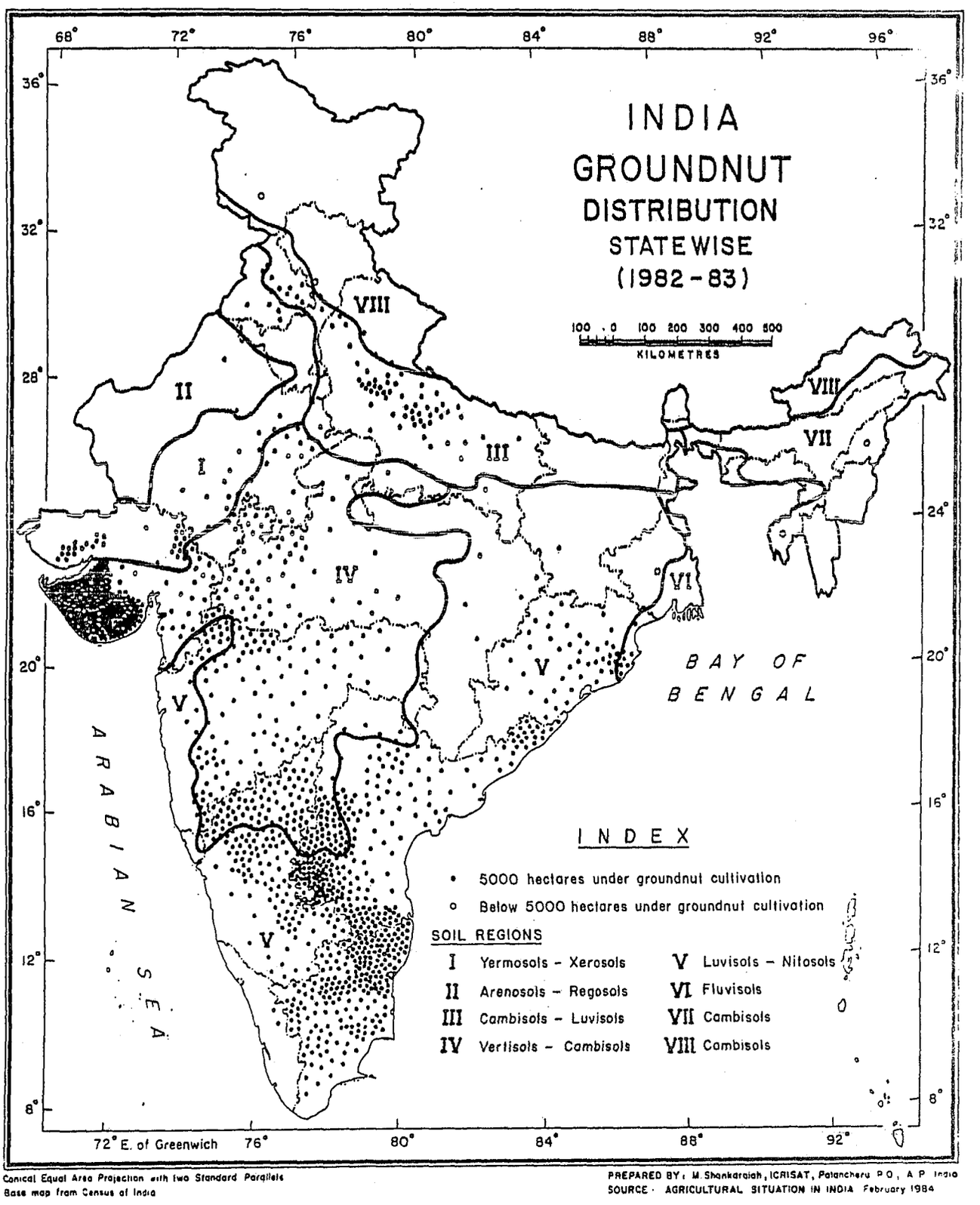
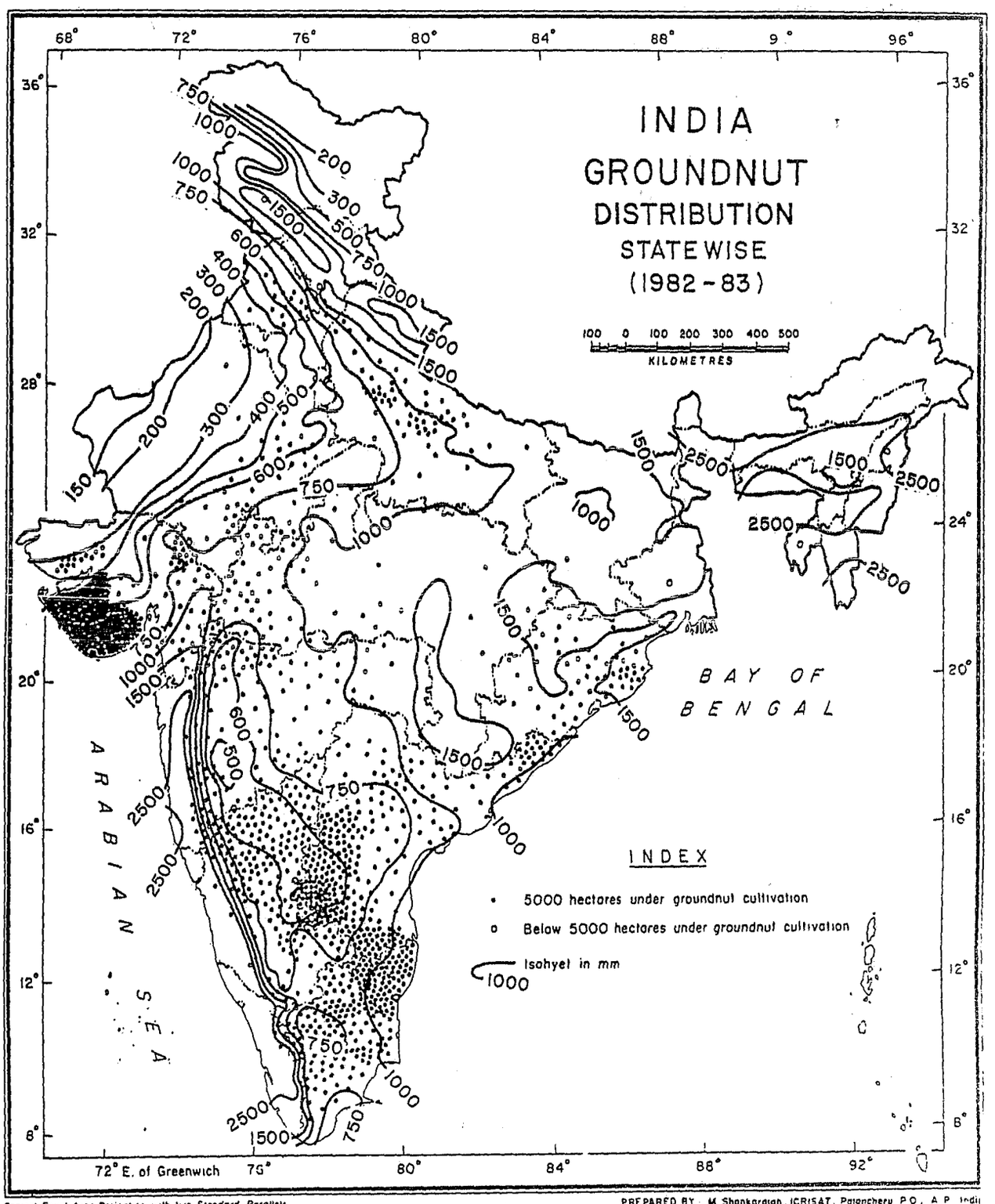


Fig. 8. Soil regions in groundnut growing areas in India.

cropping season is from June to September or October, and the second from October/November through February. Fig. 9 shows the isohyets of annual rainfall in groundnut growing areas. Mean daily maximum temperatures in July range between 30 to 35°C (Fig. 10). The average temperature during the growing season is 27°C, with total sunshine hours per annum in the groundnut-growing areas varying between 2381 and 2900 from south to north.

The groundnut-growing areas in the SAT have short (75-110 d) growing seasons (Fig. 11) and are characterized by intermittant drought periods. The probability estimates of moisture adequacy for a few selected locations in relation to crop-water needs were examined. This study showed that the amount of soil moisture in the surface soils is fairly restricted at the time of seed formation and maturity, thus leading to pod development and harvesting problems.

The moisture environment for these locations has been assessed by calculating the moisture availability index (MAI) at different probability levels. The amount of expected rainfall has been calculated using an incomplete gamma statistical procedure (WMO, 1971). The potential evapotranspiration was calculated following modified Penman's procedure (Rao et al. 1971). Values of MAI less than 0.33 reflect a moisture environment insufficient for active plant growth, while values between 0.34-0.99 show adequate rainfall to meet plant water needs. Values of MAI above 1.00 show that water is present in excessive amounts (Hargreaves 1971). The values of MAI and the length of the growing season obtained at different probability levels for Ahmedabad and Madras are discussed below.



Conical Equal Area Projection with two Standard Parallels
Base map from Census of India

PREPARED BY M. Shankaraiah, ICRISAT, Patancheru P.O., A.P. India
SOURCE AGRICULTURAL SITUATION IN INDIA February 1984

Fig. 9. Annual rainfall in groundnut growing areas in India.

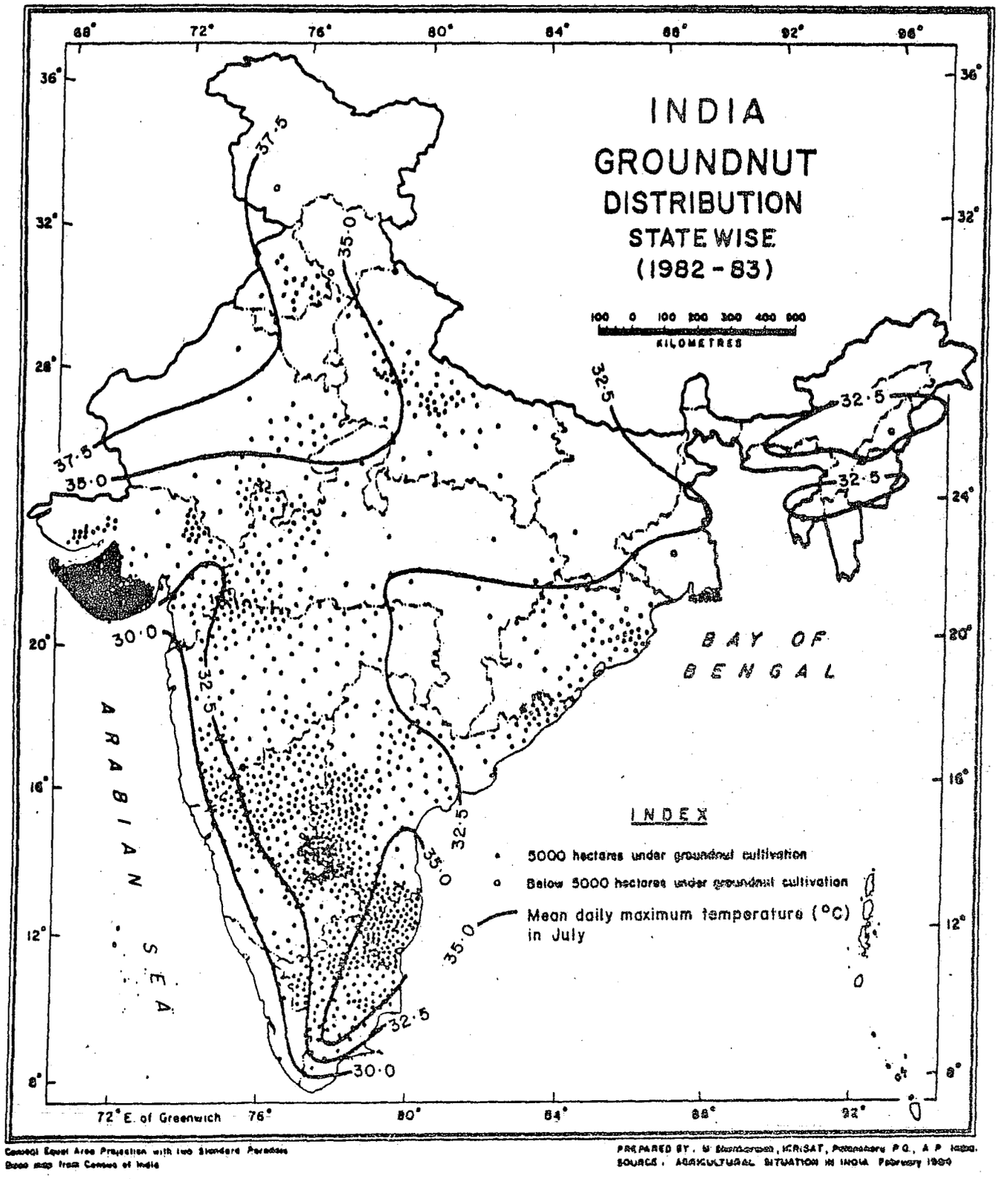


Fig. 10. Mean daily maximum temperatures (°C) in July in groundnut growing areas in India.

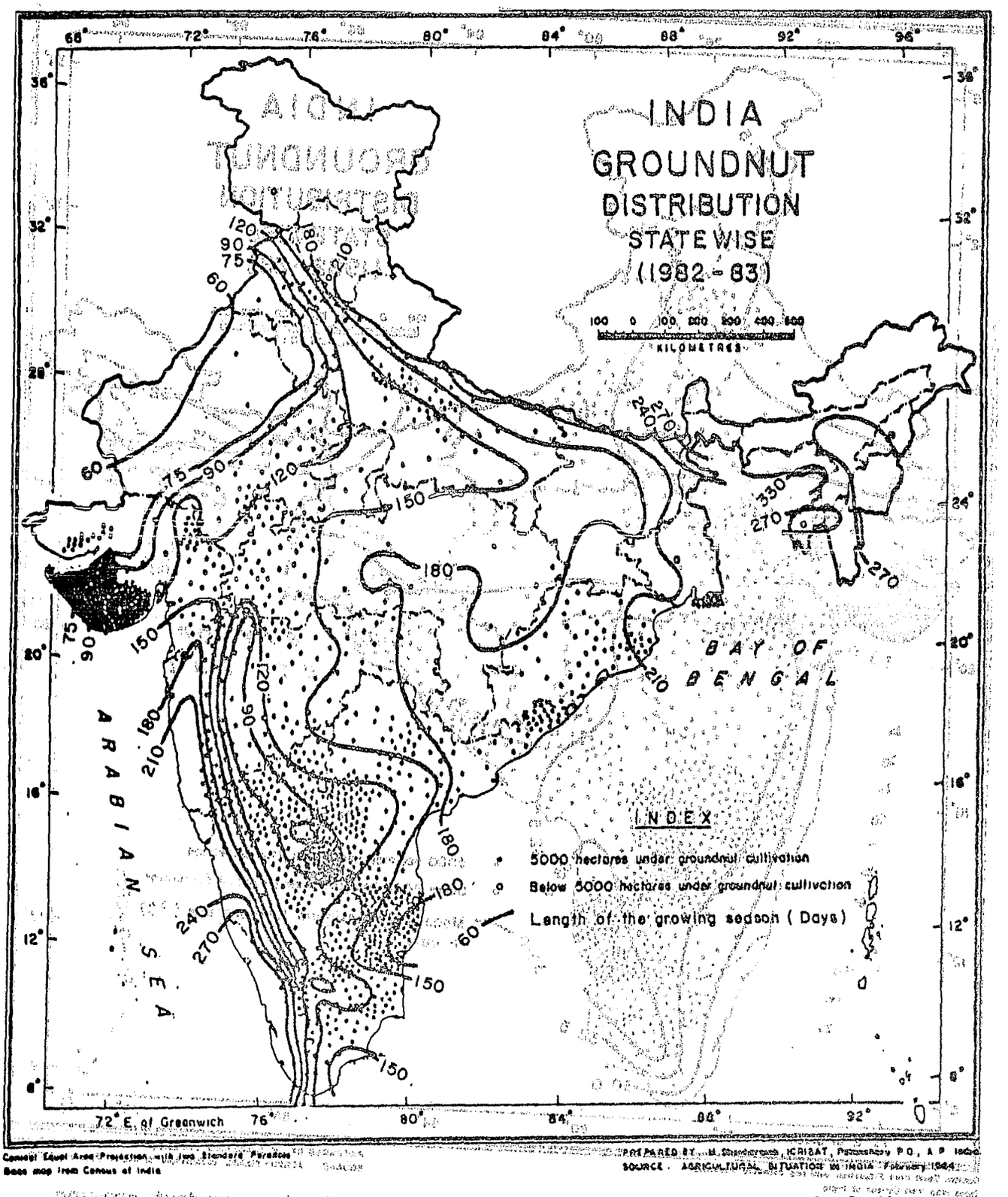


Fig. 11. Length of the growing season in groundnut growing areas in India.

Ahmedabad:

In this north Indian groundnut growing location, the crop is grown during the southwest monsoon rainy season. Average length of the growing season is 135 d. In 2 out of every 10 years, the growing season is likely to be highly restricted (< 50 d). October has very low MAI values (Table 2). Since the crop is grown on Vertic soils in this region, harvesting groundnut may present serious problems in most years. Water conservation would be an important aspect of improved dryland groundnut production of this area.

Madras:

This southern Indian coastal location receives rainfall from both the southwest and northeast monsoons. Two growing seasons are utilized for raising groundnuts -- the first from June to October and the second from October to January or February. However, two groundnut crops are rarely grown sequentially on the same dryland field. The data on MAI (Table 3) show that a 120-day crop could be raised in 8 years out of 10 in this area. The average growing season there is 180 d. Groundnuts are raised on Alfisols and Oxisols in this region. These soils have low AWC (< 50 mm). Soil and water management would be an important component of the improved groundnut-management systems in this region.

Table 2. Moisture availability index and growing season in Ahmedabad.

24° 04'N 72° 38'E Soils: Ustert AWC* 150 mm

Annual rainfall: 804 mm Data: 1931-60

Probability (%)	Moisture availability index					Growing season (days)
	Jun	Jul	Aug	Sep	Oct	
80	0.10	1.03	0.74	0.18	0	50
Mean	0.43	2.41	1.78	1.12	0.01	135
40	0.46	2.46	1.82	1.22	0.01	>135

*AWC = Available water holding capacity of the soil

Table 3. Moisture availability index and growing season in Madras.

13° 00'N 80° 11'E Soils: Ustalf AWC 50 mm

Annual rainfall: 1233 mm Data: 1931-60

Probability (%)	Moisture availability index							Growing season (days)
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
80	0.12	0.27	0.44	0.47	1.10	1.28	0.18	120
Mean	0.28	0.52	0.80	0.89	2.12	2.85	1.18	180
40	0.29	0.54	0.90	0.95	2.03	3.17	1.50	>187

ACKNOWLEDGEMENTS:

The following two papers were used to prepare this note:

(i) Huda, A.K.S., and Virmani, S.M. 1986. Agroclimatic Environment of Chickpea and Pigeonpea. Proceedings of the Workshop on Adaptations of Chickpea and Pigeonpea for Tolerance to Physical Stress, 19-21 Dec 1984, ICRISAT, Patancheru, Andhra Pradesh, India (in preparation).

(ii) Virmani, S.M., and Singh, Piara. 1986. Agroclimatological Characteristics of the Groundnut Growing Regions in the Semi-Arid Tropics. Proceedings of the International Symposium on Agrometeorology of Groundnut, 21-26 Aug 1985, Niamey, Niger. ICRISAT, Patancheru, Andhra Pradesh, India (in press).

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