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# Water Availability Pattern and Water Requirement of Kharif Crops in Saurashtra Region, Gujarat

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**Abstract** Climatic water balance on weekly basis for individual years in respect of three main agricultural research stations in Saurashtra region was evaluated and periods of water deficits and soil moisture recharge were worked out. Aridity index with reference to crop phenophases was determined and the reference crop ET, water requirement, water requirement satisfaction index (WRSI) in each of the phenophases for the important Kharif crops, pearlmillet (*Pennisetum typhoides*), sorghum (*sorghum vulgare*), Groundnut (*Arachis hypogaea*) and Cotton (*Gossypium hirsutum*) were evaluated. In general, analysis showed that the Junagadh has large surplus while the Jamnagar and Rajkot showed mid-seasonal moisture deficit with no water surplus during any week in the growing season. In case of Junagadh, for the four crops studied, the coefficient of variation in water requirements at individual growth stages of crops are also discussed.

**Key words** Water requirement, Water requirement satisfaction index, Crop water deficit index.

Monthly rainfall distribution and probability studies for Junagadh, Bhavnagar, Amreli, Rajkot and Jamnagar districts of Saurashtra region of Gujarat and average weekly water balance studies for Junagadh were made by Shekh (1989). Satisfactory production of kharif crops can be obtained only when crop water requirements are met and match the weekly water availability pattern in relation to crop phenology. Therefore, the present paper deals with the weekly water availability pattern and water requirement of kharif crops in Saurashtra region.

## Materials and Methods

Daily meteorological data recorded at agrometeorological observatories in respect of three main Agricultural Research Stations, Junagadh (1957-89), Rajkot (1971-89) and Jamnagar (1976-1989) were utilized for this study. The daily average of different weather parameters were used to compute weekly values for actual crop growth periods to derive further estimates of water balances parameters and water requirement of crops.

Climatic water balance on weekly basis for individual year was calculated by using the procedure developed by Thornthwaite and Mather (1957). Reference crop evapotranspiration (ETO) was estimated by using the modified Radiation method (Doorenbos & Pruitt 1979). Water requirement of crops were calculated by using the crop coefficients suggested by Doorenbos and Kassam (1979). Water requirement satisfaction index (WRSI) was calculated using the crop water balance method adopted by Frere and Popov (1979).

The water holding capacity of the soil at different stations was taken as 150 mm for Jamnagar and Rajkot, and 200 mm for Junagadh. The length of growing period for pearlmillet, sorghum, groundnut and cotton is considered as 13,14,16 and 22 weeks respectively.

## Results and Discussio

### *Water availibility*

A threshold of 25 mm of rain collected over a single week as suggested by FAO (1986) was considered

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to identify a sowing week at the different stations. Accordingly the mean sowing week for kharif crops was found to be the 25th week (June 18-24) in the Saurashtra region both from initial quantum of rainfall and higher probability.

The choice of the starting period for accumulation of crop season rainfall was based on the method proposed by Frere and Popov (1979) namely the week at the beginning of the monsoon season when rainfall exceeded the estimated water requirement of the particular crop under consideration. The total amount of precipitation received during the crop growing period for each crop at these locations varied from 460 to 765 mm.

*Climatic water balance :* Average weekly water balance for the kharif season (22nd to 44th week) for the stations under study are presented in figures 1a to 1c in the form of climograms. It is seen from the figures that at Jamnagar the soil moisture recharge occurs only for about 5 to 6 weeks in two spells with moisture deficit occurring in between the two recharge periods. Even during the active monsson season the crops need to be supported by moisture stored in the soil. After the 35th week, the deficit shows a gradual increase till the 44th week. However during this period also about 10 mm of moisture per week is available from the soil to support the crop during the grain filling and maturity phase.

At Junagadh, where variability of rainfall is high with a seasonal rainfall of 910 mm, water surplus is observed for a period of eight weeks (29 to 36th week). Moisture deficit starts from the 39th week onwards but evapotranspiration demand is met from the stored soil moisture, of the order of, 20 mm per week for the remaining period of crop. The Rajkot, located in north Saurashtra agro-climatic zone shows a similar pattern with that of Jamnagar with soil moisture recharge occurring in two spells for about five weeks with a small soil moisture deficit in between. After the 36th week, the rainfall received does not fully meet the evapotranspiration demand. The moisture deficit is met to some extent by utilization of moisture stored in the soil till the end of season. In general, this analysis shows that the Junagadh has large surplus where as the Jamnagar and Rajkot show mid season moisture deficit with no water surplus in any week during the growing season. However in individual years the water availability pattern would be different at different locations.

*Crop water*

*Crop Water deficit index (CWDI) :* The concept of crop water deficit index is used to classify the drought years. The aridity index for kharif season was computed by using the values of AET and PET from the climatic water balance (Thornthwaite & Mather 1957). The weekly values

**Table 1** *Limits of crop water deficit index (CWDI) for drought categorization.*

| Drought intensity | Pearlmillet | Sorghum | Groundnut | Cotton |
|---|---|---|---|---|
| | | **Jamnagar** | | |
| No drought | < 571 | < 700 | < 869 | < 1403 |
| Mild | 572-727 | 701-866 | 870-1060 | 1404-1632 |
| Moderate | 728-882 | 867-1032 | 1061-1251 | 1633-1861 |
| Severve | > 883 | > 1032 | > 1252 | > 1682 |
| | | **Junagadh** | | |
| No drought | < 150 | < 162 | < 234 | < 514 |
| Mild | 151-272 | 163-297 | 235-391 | 516-728 |
| Moderate | 273-395 | 298-432 | 392-547 | 729-941 |
| Severe | > 396 | > 433 | > 548 | > 942 |
| | | **Rajkot** | | |
| No drought | 403 | < 447 | < 418 | < 1053 |
| Mild | 404-528 | 448-589 | 419-600 | 1054-1291 |
| Moderate | 529-653 | 590-731 | 601-782 | 1292-1528 |
| Severe | > 654 | > 732 | > 782 | > 1529 |

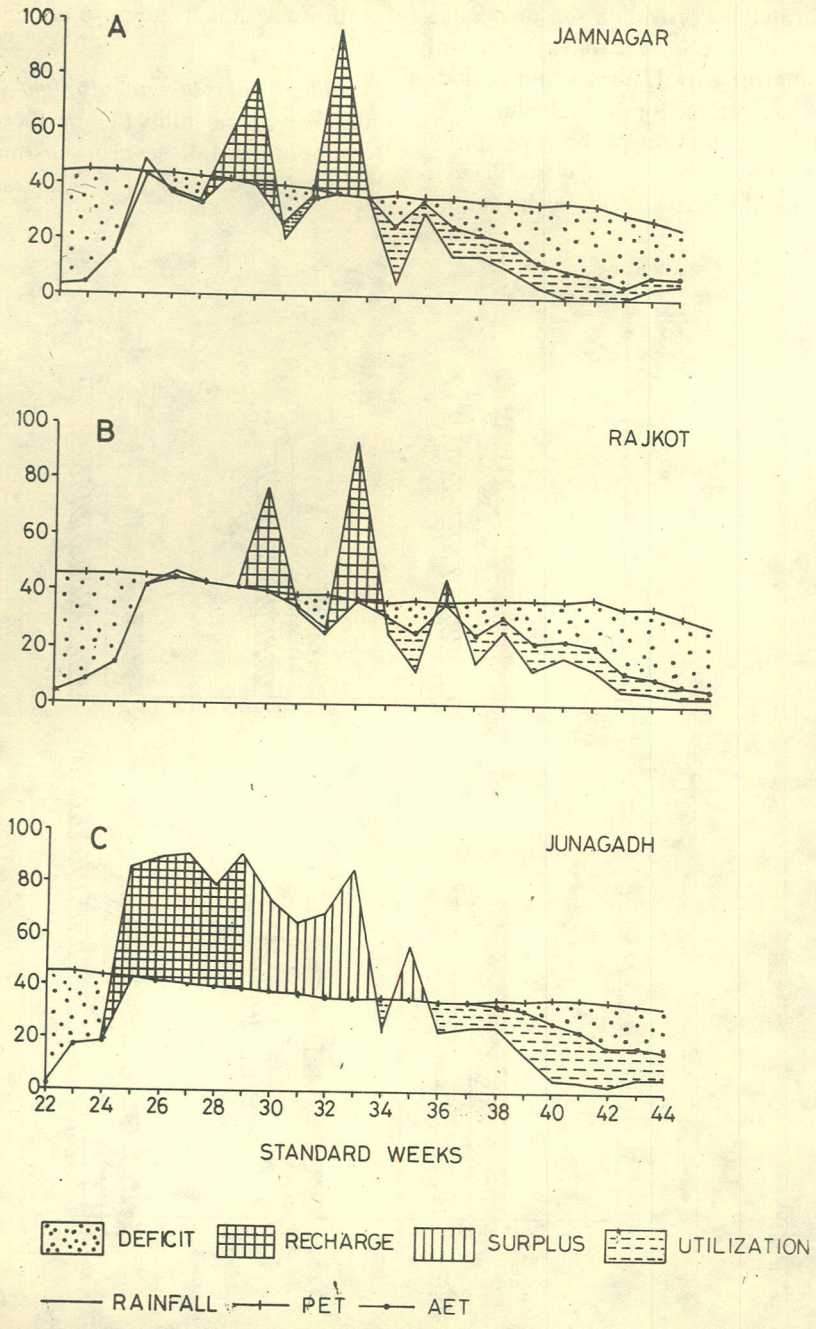


**Fig. 1** Climatic water balance for kharif season inSaurashtra.

were then accumulated for the growth period of each crop separately to provide a seasonal value. Thus, This index reflects climatic water deficit with reference to the crop growth phases and periods. The values thus, are derived for the individual crops at each station. The amplitude of the departure of standard deviation from the median was utilized to categorise individual Kharif seasons by the method of Subrahmanyam and Sastry (1969). The limits of crop water deficit index so obtained are given in Table 1.

*Probability of seasonal drought in crops* : The cumulative probability (Thom 1966) of occurrence of moderate and severe seasonal drought are depicted in the form of bar diagrams (Fig.2). The

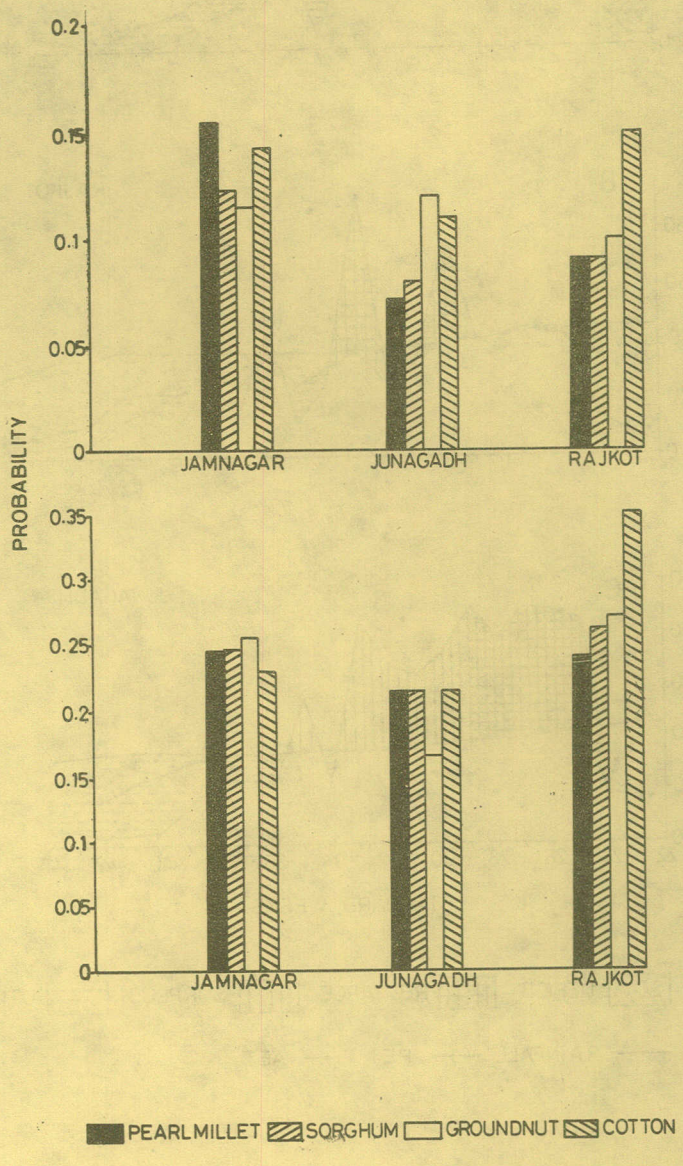


**Fig 2** Probability of occurrence of mderate (A), and severe (B) seasonal drought in Saurashtra region

probability of occurrence of moderate seasonal drought is lowest at Junagadh. Compared to pearlmillet and sorghum, cotton and groundnut crops have relatively higher probability of occurrence of moderate drought at Junagadh. At Rajkot, cotton crop is more vulnerable to moderate drought condition compared to the other three crops. At Jamnagar, the probability of occurrence of moderate drought for groundnut and sorghum is lower than in case of the pearlmillet and cotton. On the contrary, severe seasonal drought has higher probability at all the stations than that of moderate drought occurrence. The probability of severe seasonal drought is the lowest at Junagadh compared to other two stations in this region. It is interesting to find that the probability of the drought is the lowest for groundnut crop at Junagadh.

*Water requirement of Kharif crops* : The mean phenophasic water requirements of kharif crops for the region are presented in Table 2. It is seen that water requirement of all the crops are considerably less at Junagadh in comparision to the values at Jamnagar and Rajkot (Table 2). This is owing to the fact that the climatic demand at the later two stations was higher as indicated by the high rate of seasonal and daily reference crop ET. Again these two stations are comparatively dry and the growing season is short. The water requirement of pearlmillet, Sorghum, groundnut and cotton are 292, 329, 347 and 603 mm respectively at Junagadh which is a surplus station.

*Water requirement satisfaction index (WRSI):-* The unit of WRSI is the percent ratio of water deficit (WD) and total seasonal water requirement. This index at the end of the season in respect of a crop is an indicator of the effect of moisture deficit on yield (Frere & Popov 1979). The weekly pattern of WRSI for kharif crops at Jamnagar is shown in fig.3.

It can be seen that for the relatively shorter duration crops (pearlmillet and sorghum) under mild and moderate drought conditions there is a decrease in WRSI starting in the 6th or 7th week after sowing. However, for the long duration crops (groundnut and cotton) under similar conditions of drought the decline starts around 9th week after sowing. In case of severe drought conditions a drastic decrease in WRSI is noticed between 2 to 3 weeks after sowing. Late planting due to late onset of monsoon superimposed by drought conditions such as that observed in 1985 at Jamnagar, results in a lower WRSI value at the end of the season as compared to the severe drought year (1986). Similar observations were also reported by Stern and Coe (1982) in case of sorghum crop for the Hyderabad region.

*Relationship of CWDI and WRSI with yield of crops :* The relationship of WRSI and CWDI with yield was examined through correlation studies (Table 3). The results show that the yields of groundnut and pearlmillet are positively and significantly correlated with WRSI at all the stations. The yields of these crops are negatively correlated with the CWDI. Since the results show significant

**Table 2** *Mean Phenophasic water requirment of major kharif crops in Saurashtra region..*

| Station | Pearlmillet | | | | Sorghum | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV* | I | II | III | IV | V |
| Jamnagar | 43 | 109 | 66 | 114 | 43 | 97 | 130 | 125 | – |
| Junagadh | 38 | 96 | 60 | 98 | 38 | 67 | 117 | 107 | – |
| Rajkot | 43 | 109 | 64 | 112 | 43 | 77 | 128 | 122 | – |

| | Groundnut | | | | Cotton | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jamnagar | 82 | 103 | 103 | 106 | 29 | 89 | 377 | 141 | 30 |
| Junagadh | 72 | 94 | 86 | 95 | 26 | 77 | 329 | 139 | 32 |
| Rajkot | 82 | 102 | 98 | 104 | 30 | 87 | 369 | 145 | 31 |

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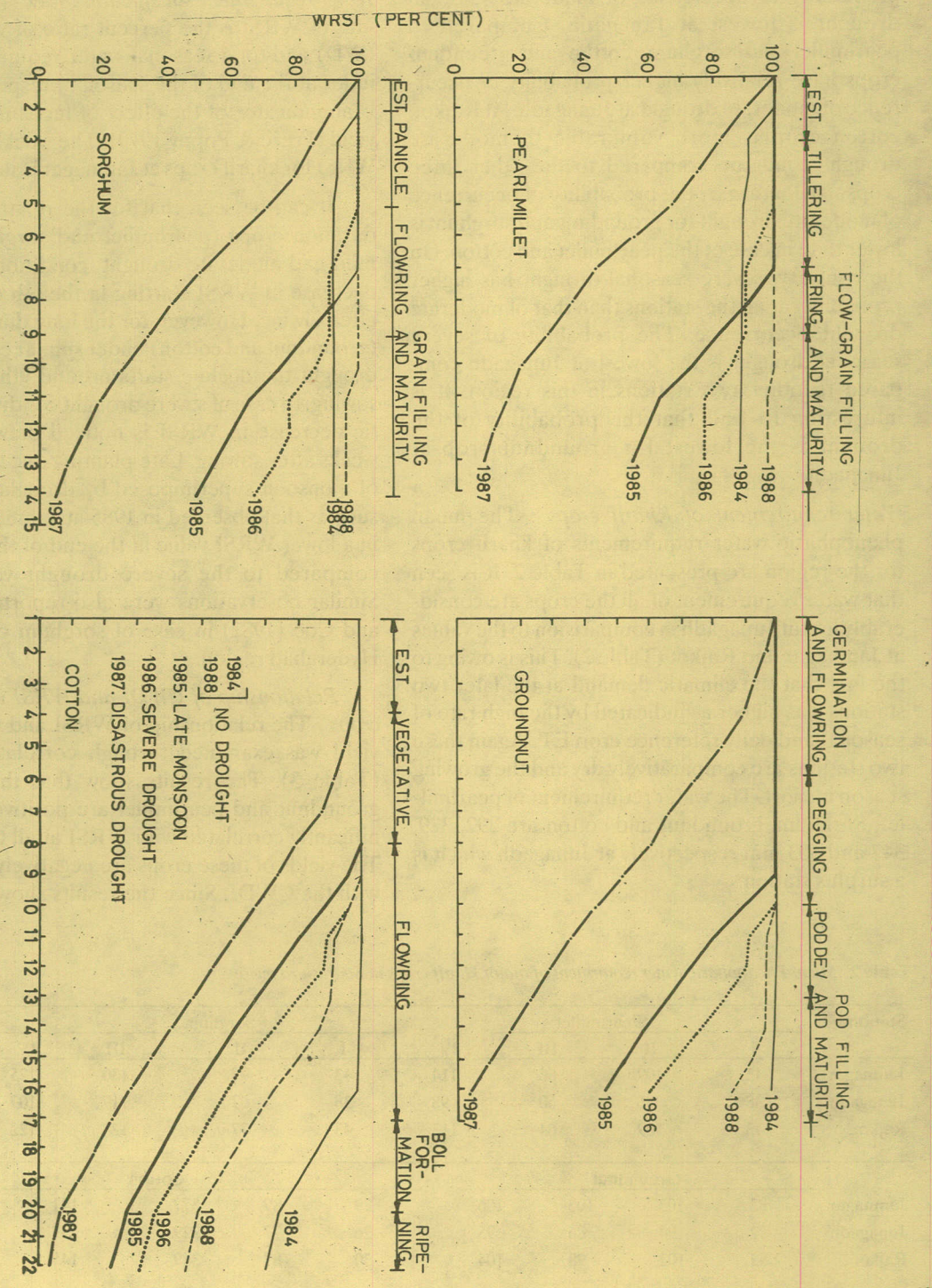


Fig. 3 Weely WRSI pattern in the different kharif seasons with reference to growth phases of four crops at Jamnagar

**Table 3** *Corelation of WRSI and CWDI with yield of crops at different statin*

| Station | WRSI | | CWDI | |
|---|---|---|---|---|
| | Pearmillet | Groundnut | Pearlmillet | Groundnut |
| Jamnagar | .883** | .716* | -.986* | -.951* |
| Junagadh | .530* | .823** | -.545* | -.690* |
| Rajkot | .915** | .934** | -.785 | -.671* |

* Significant at 5% level, ** Significant at 1% level.

correlations between yield, CWDI and WRSI, it would be useful to monitor CWDI and WRSI at the different stations for an assessment of yield potential in any given kharif season on a weekly basis from the start of sowing week.

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