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# Potential of Opportunity Double Cropping with Short Duration Legumes in the *Rabi* Sorghum Areas of India

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**ABSTRACT :** In *rabi* sorghum growing region of India the soils are kept cultivated fallow during rainy season and sorghum is grown during post-rainy season. The fallow soils are exposed to run-off led soil erosion during rainy season and thus get degraded overtime. There is scope for double cropping with short duration legumes in some years provided soil water availability is to provide sufficient length of growing season (LGS) for two crops. The historical weather data was analysed for LGS by using soil water balance approach. In this study, LGS is characterized for 11 spatially well districted locations in the *rabi* sorghum region of India. The results show that locations in the decreasing order for suitability of opportunity double cropping on deeper soils (available water holding capacity = 200 mm) are Parbhani, Pune, Aurangabad, Nanded, Akola, Solapur, Gulbarga, Beed and Osmanabad. At Parbhani opportunity double cropping would be successful for 55 % at least half the years, whereas at Osmanabad it would be successful for 25 % of the years on an average. Bellary and Bijapur are not suitable for double cropping with short duration legumes. The potential for double cropping at a location is greater if soils have high water holding capacity and rainy season starts early.

Geographically *rabi* sorghum area covers much of the western deccan plateau of India, comprising mostly of western Maharastra and some parts of Karnataka. Annual rainfall in this region is low to medium (600-750 mm), highly variable in time and space and uncertain for successful cropping during season. Average LGS in the ecoregion ranges from 90 to 120 days. However, because of variability of soils and rainfall distribution a number of sub-regions with different potential for cropping because of different soil types and year-to-year variability in rainfall can be delineated. The soils in the ecoregion are mainly Vertisols and Vertic Inceptisols interspersed with some Alfisols. Cropping systems are predominantly *rabi* sorghum based on Vertsols and *kharif* pearlmillet-based on Vertic Inceptisols. The *rabi* sorghum system is dominant mainly due to the risk of failure of rainy season crop as this region is on a 'rain shadow' of south west monsoon. The *rabi* crop is grown on stored soil moisture. Other crops grown to a lesser extent are groundnut, pigeonpea, sunflower, safflower and chickpea.

The crop yields in this region are low primarily due to poor soil and water management, use of low yielding land races, inadequate nutrient management, severe water limitations during the post- rainy season, and low adoption of IPM methods. Crop production in this region can be increased and sustained through improved soil and water management during rainy and post-rainy seasons coupled with introduction of improved cultivars of crops and appropriate nutrient management. Field studies conducted in Solapur showed that under favourable rainfall situation sequence or double cropping has increased cropping intensity on medium deep black soils. Short duration legumes such as cowpea, mungbean,

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blackgram and soybean can be sown as opportunity crops under favourable moisture condition during rainy season followed by conventional post-rainy season sorghum on Vertisols. These crop sequences are superior to monocropping with *rabi* sorghum because short duration legumes provide the soil adequate vegetative cover during rainy season and reduces soil erosion. They also reduce N fertilizer need for *rabi* sorghum due to residual N benefits through biological N fixation (BNF) from legume crops. Thus this system improves soil fertility, rainfall use efficiency and minimises land degradation. This paper characterizes LGS of *rabi* sorghum in terms of start and end of season by using soil water balance approach in order to identify locations where opportunity based double cropping could be successful.

## MATERIALS AND METHODS

Long term weekly rainfall data of last 40 years were collected from India Meteorological Department (IMD), Pune for 11 locations in *rabi* sorghum region for soil water balance analysis. The selected locations are Akola (1938-80), Aurangabad (1926-66), Beed (1926-66), Bellary (1945-84), Bijapur (1945-84), Gulbarga (1930-69), Nanded (1929-82), Osmanabad (1926-69), Parbhani (1944-83), Pune (1941-80) and Solapur (1943-82). Monthly values of Penman potential evapotranspiration (PE) for these sites have been reported by Rao *et al.*, (1971). These values were linearly interpolated to estimate weekly PE for these locations. Soil water balance analysis was performed using WATBAL model of Keig and McAlpine (1974). This model is not crop specific as it assumes complete crop cover during the season. It operates on weekly basis and requires inputs of weekly rainfall, weekly PE and maximum available water holding capacity (AWHC) of soil. The model calculates soil water storage at the end of each week as the sum of soil water storages at the end of previous week plus the rainfall during the week minus soil water loss as actual evapotranspiration (AE) during the week. AE during the week is calculated as the ratio of AE/PE multiplied PE. The ratio AE/PE was taken as 1.0 as soil water storage varies from X % to 0.0 %. The values of X varies with AWHC of the soil and calculated as X = 22 + 0.16 * AWHC as desired by Keig and McAlpine (1974). Because of the variability of soils found in the region, water balance analysis was performed for 50, 100, 150 and 200 mm available soil water storage capacity for each location. The weekly outputs of the WATBAL were ratio of rainfall to PE (R/PE), ratio of actual evapotranspiration tp PE or moisture adequacy index (AE/PE), available soil moisture status (SMOS) and water surplus (SURPLUS) as runoff and deep drainage. R/PE and AE/PE were used to characterise the start and end of seasons for each soil type and year of simulation. The model also produced output on the mean values of these variables simulated over years to have an average picture of the water balance components. Each season was characterized by the following criteria.

**1. Start of growing season (SGS)** : After mid-May (MW 20) the season was considered to have started during a week if R/PE of that week was 50 and the consecutive 3 weeks had AE/PE > 0.50 to ensure continuity in water availability to crops after the season has started. If this condition was not met for a week then the program checked for the subsequent week and so on.

**2. End of growing season (EGS)** : After 1st week of September (MW 36) the season was considered to have ended during the week if the AE/PE < 0.25. In case SGS was on or after

MW 36 then the searching for the end of the season week was done from the week marked as the start of the season.

**3. Length of growing season (LGS)** : This represents the water availability period and is calculated for each year as the week of end of season minus week of start of season plus one as LGS = EGS - SGS + 1.

To calculate total seasonal rainfall for a year the rainfall amounts from SGS to EGS were summed. After the estimate of SGS, EGS, LGS and the seasonal rainfall for each year for a given location, mean, range and coefficient of variation were calculated. Cumulative probabilities for each parameter were also calculated from their frequency distribution to estimate the probabilities associated with each value of a given parameter.

## RESULTS AND DISCUSSION

**Start of growing season**: Although the onset of monsoon at a given location determines its SGS, the soil type can also have some effect on actual date of sowing of crops because of the differences in depth of wetting by rainfall or workability of soil. Therefore, the SGS has been presented for the two water holding capacity soils (50 and 200 mm) considering the ratio of R/PE and ability of soil to supply water for the next 4 weeks (Table 1). Coeffiecient of variability (CV) in the start of season ranged from 7 to 23% across locations. Locations with low CV (7-10%) are Aurangabad, Akola,Nanded, Osmanbad and Parbhani. The highest CV for SGS is Bellary and Bijapur (19-23%). Mean value for SGS ranged from MW 23 to 25 across locatons, except for Bellary where the mean date for SGS was MW 28 to 30 MW on two soil types. At none of the locations SGS commenced earlier than MW 20. However, the delay in SGS could be as late as MW 36, except Bellary and Bijapur where SGS could commence as late as MW 47 on a shallow soil. In 75 % of years the SGS started in MW 26 or earlier at most locations, except for Bellary and Bijapur.

**End of growing season**: EGS is primarily determined by the end of rainy period and further modified by the available water holding capacity (AWHC) of soil. That is, LGS is no longer on soils with high water holding capacity than soils that are shallow. With each 50 mm increase in the AWHC of soil the length of growing season increased on average by 1-2 weeks depending upon the location and seasonal rainfall (Table 2). Variabilty in EGS on a given soil for location was much less than the variability in SGS: it ranged 5 to 11% across locations and soil types. The lowest variability in EGS was for Solapur (6%) and Gulbarga (5-7%). The locations with highest variability in EGS were AKOLA (8-10%) and Bijapur (8-11%). Probability analysis showed that the season could extend beyond the month of January at most of the locations on deeper soils in about quarter of the years (Table 2).

**Growing season rainfall**: Bellary and Bijapur received least rainfall during growing season compared to others and it was highly variable over years (CV=43%) (Table 3). At other locations rainfall during growing season was high and CV in seasonal rainfall ranged from 22 to 31%. Aurangabad had lowest variability in seasonal rainfall (CV=22%). The higher values of minimum seasonal rainfall were for Parbhani (489 mm), Osmanbad (540 mm) and Aurangabad (470 mm). Greater mean seasonal rainfall and low CV indicate greater dependability for soil water availability, however the potential for double cropping will depend upon the LGS as well as on amount and distribution of rainfall.

**Table 1. Start of growing season at various locations in the *rabi* sorghum areas**

| Location | AWHC* (mm) | Start of season | | | | |
|---|---|---|---|---|---|---|
| | | Earliest | Latest | Mean | CV % | At 75% probability |
| | | ---------- Standard meteorological week---------- | | | | |
| Nanded | 50 | 20 | 27 | 24 | 7 | ≤ 25 |
| | 200 | 20 | 27 | 24 | 7 | ≤ 25 |
| Parbhani | 50 | 21 | 33 | 24 | 9 | ≤ 25 |
| | 200 | 21 | 33 | 24 | 9 | ≤ 25 |
| Osmanbad | 50 | 20 | 30 | 23 | 8 | ≤ 25 |
| | 200 | 20 | 34 | 24 | 10 | ≤ 25 |
| Akola | 50 | 22 | 28 | 24 | 7 | ≤ 26 |
| | 200 | 22 | 28 | 25 | 7 | ≤ 26 |
| Aurangabad | 50 | 20 | 27 | 24 | 6 | ≤ 24 |
| | 200 | 20 | 27 | 24 | 6 | ≤ 24 |
| Gulbarga | 50 | 21 | 37 | 25 | 15 | ≤ 25 |
| | 200 | 21 | 34 | 24 | 12 | ≤ 25 |
| Beed | 50 | 20 | 36 | 24 | 12 | ≤ 24 |
| | 200 | 20 | 36 | 24 | 13 | ≤ 25 |
| Solapur | 50 | 20 | 36 | 24 | 15 | ≤ 25 |
| | 200 | 20 | 32 | 23 | 12 | ≤ 24 |
| Pune | 50 | 20 | 28 | 24 | 10 | ≤ 26 |
| | 200 | 20 | 28 | 24 | 10 | ≤ 26 |
| Bellary | 50 | 20 | 47 | 30 | 23 | ≤ 35 |
| | 200 | 20 | 39 | 28 | 22 | ≤ 34 |
| Bijapur | 50 | 20 | 36 | 25 | 19 | ≤ 29 |
| | 200 | 20 | 39 | 25 | 19 | ≤ 29 |

*Available water holding capacity

**Table 2. End of growing season at various locations in the *rabi* sorghum areas**

| Location | AWHC (mm) | End of season | | | | |
|---|---|---|---|---|---|---|
| | | Earliest | Latest | Mean | CV % | At 75% probabilty |
| | | ---------- Standard meteorological week---------- | | | | |
| Nanded | 50 | 37 | 50 | 43 | 7 | ≤ 44 |
| | 100 | 37 | 52 | 45 | 7 | ≤ 47 |
| | 150 | 38 | 5 | 47 | 7 | ≤ 49 |
| | 200 | 38 | 9 | 50 | 8 | ≤ 52 |
| Parbhani | 50 | 38 | 51 | 43 | 6 | ≤ 44 |
| | 100 | 40 | 4 | 45 | 7 | ≤ 47 |
| | 150 | 42 | 10 | 48 | 8 | ≤ 49 |
| | 200 | 44 | 10 | 50 | 7 | ≤ 52 |
| Osmanbad | 50 | 38 | 52 | 44 | 8 | ≤ 46 |
| | 100 | 40 | 52 | 45 | 7 | ≤ 46 |
| | 150 | 42 | 52 | 46 | 6 | ≤ 47 |
| | 200 | 43 | 1 | 47 | 6 | ≤ 48 |
| Akola | 50 | 36 | 52 | 42 | 8 | ≤ 43 |
| | 100 | 39 | 3 | 44 | 9 | ≤ 46 |
| | 150 | 40 | 11 | 47 | 10 | ≤ 48 |
| | 200 | 41 | 11 | 49 | 10 | ≤ 1 |
| Aurangabad | 50 | 37 | 51 | 43 | 8 | ≤ 44 |
| | 100 | 39 | 1 | 45 | 8 | ≤ 47 |
| | 150 | 41 | 3 | 47 | 7 | ≤ 49 |
| | 200 | 42 | 9 | 49 | 8 | ≤ 51 |
| Gulbarga | 50 | 39 | 51 | 45 | 6 | ≤ 46 |
| | 100 | 40 | 1 | 46 | 5 | ≤ 47 |
| | 150 | 41 | 1 | 47 | 5 | ≤ 48 |
| | 200 | 41 | 1 | 48 | 7 | ≤ 50 |
| Beed | 50 | 39 | 1 | 45 | 8 | ≤ 46 |
| | 100 | 41 | 2 | 47 | 7 | ≤ 49 |
| | 150 | 41 | 11 | 49 | 8 | ≤ 52 |
| | 200 | 41 | 11 | 51 | 8 | ≤ 2 |
| Solapur | 50 | 36 | 50 | 44 | 6 | ≤ 45 |
| | 100 | 39 | 51 | 46 | 6 | ≤ 47 |
| | 150 | 40 | 52 | 47 | 6 | ≤ 49 |
| | 200 | 40 | 2 | 48 | 6 | ≤ 51 |
| Pune | 50 | 37 | 50 | 44 | 7 | ≤ 46 |
| | 100 | 39 | 2 | 47 | 8 | ≤ 48 |
| | 150 | 41 | 4 | 49 | 8 | ≤ 51 |
| | 200 | 42 | 6 | 50 | 8 | ≤ 1 |
| Bellary | 50 | 40 | 5 | 46 | 7 | ≤ 48 |
| | 100 | 41 | 2 | 48 | 6 | ≤ 49 |
| | 150 | 42 | 4 | 49 | 7 | ≤ 52 |
| | 200 | 43 | 5 | 50 | 7 | ≤ 1 |
| Bijapur | 50 | 36 | 51 | 45 | 8 | ≤ 47 |
| | 100 | 36 | 1 | 47 | 8 | ≤ 49 |
| | 150 | 36 | 3 | 48 | 9 | ≤ 51 |
| | 200 | 36 | 9 | 49 | 11 | ≤ 52 |

**Soil water availability** : Changes in soil water availability for 11 locations are given for 200 mm AWHC soil only. In relatively high rainfall environments the accretion of soil water was much faster at Aurangabad, Pune, Akola, Nanded and Parbhani as compared to Beed, Gulbarga, Solapur and Osmanabad. Peak soil moisture retention and water retentions during depletion phase were also greater where the accretion of soil moisture was faster. At low rainfall locations (Bellary and Bijapur) the accretion of soil moisture, peak water retention, and water retention during the depletion phase were all low indicating inadequate soil moisture availability and a lower potential for opportunity double cropping.

**Moisture Adequacy Index (MADI)**: MADI is defined as the ratio of AE to PE. It is an index of water adequacy in relation to potential demand by crops. Therefore, in the rainfed farming systems the distribution of MADI defines the quality of LGS for the success of a cropping system. For each location MADI is computed for 20 mm AWHC soil. During rainy season MADIs for Aurangabad, Pune, Akola, Nanded and Parbhani were higher than those for Beed, Gulbarga, Solapur and Osmanabad in high rainfall environment. In low rainfall environment of Bijapur, the MADI was better than Bellary. The analysis indicated that Aurangabad, Pune, Akola, Nanded and Parbhani are better suited for opportunity double cropping compared to intermediate Solapur, Gulbarga, Beed and Osmanabad ; and least suited Bijapur and Bellary.

**Length of growing season (LGS)** : In rainfed agriculture LGS is determined by amount and distribution of rainfall and soils AWHC. LGS is usually longer if the soils have greater AWHC. On soils with 50 mm AWHC the mean LGS ranged from 120 to 153 days across locations ; whereas on soils with 200 mm AWHC the mean LGS ranged from 157 to 194 days across locations (Table 4). Normally a short duration legume (mungbean, blackgram and cowpea) followed by *rabi* sorghum would require in toto about 190 days of growing period ; that is about 6-65 days for legume crop, about 120 days for *rabi* sorghum, with about 10 days as turn-around time between harvesting of *kharif* legume and sowing of *rabi* sorghum. Based on LGS opportunity double cropping is possible at Beed, Parbhani, Pune and Nanded in most years on a deep black soil (AWHC = 200 mm). At other locations it would not be possible in any soil. As soybean-*rabi* sorghum would require about 220 days of growing season (95 days for soybean + 5 days of turn around time + 120 days for *rabi* sorghum). It may not be possible to grow this sequence at any location if we consider mean LGS. However, soybean may be grown as a forage and harvested before *rabi* sets-in for sowing sorghum.

As there is a significant year-to-year variability in rainfall at these locations, LGS also varies accordingly as indicated by CV and range of LGS for a location (Table 4). Therefore, it would be possible to grow two crops in some years when right opportunity at a given location exists. LGS of at least 190 days on a deep soil according to probability analysis is 50-60 % for Beed, Parbhani and Pune ; 40-50 % for Aurangabad and Nanded ; and < 40 % for Akola, Solapur, Bijapur, Gulbarga, Bellary and Osmanabad. Therefore the locations in decreasing order of suitability for opportunity double cropping on 200 mm AWHC soils are : Parbhani > Pune > Aurangabad > Nanded > Akola > Solapur > Gulbarga > Osmanabad > Beed. Bijapur and Bellary would not be suitable for double cropping because of very low AE/PE during season. At all locations the chances of double cropping would further decrease with a decrease in AWHC of soil.

**Table 3. Amount and variabilty of rainfall during growing season (as determined for 200 mm AWHC soil) at various locations in *rabi* sorghum areas**

| Location | Seasonal rainfall (mm) | | | |
|---|---|---|---|---|
| | Minimum | Maximum | Mean | CV% |
| Nanded | 300 | 1377 | 877 | 28 |
| Parbhani | 489 | 1562 | 862 | 31 |
| Osmanbad | 540 | 1239 | 802 | 25 |
| Akola | 341 | 1366 | 779 | 27 |
| Aurangabad | 470 | 1059 | 732 | 22 |
| Gulbarga | 222 | 1144 | 700 | 28 |
| Beed | 274 | 1121 | 687 | 30 |
| Solapur | 229 | 1178 | 693 | 29 |
| Pune | 295 | 1100 | 650 | 26 |
| Bellary | 142 | 830 | 436 | 43 |
| Bijapur | 155 | 1072 | 551 | 43 |

**Table 4. Length of growing season on soils of different available water holding capacities (AWHC) at various locations in the rabi sorghum areas**

| Location | AWHC (mm) | Length of growing season (days) | | | |
|---|---|---|---|---|---|
| | | Minimum | Maximum | Mean | CV% |
| Nanded | 50 | 91 | 196 | 140 | 16 |
| | 100 | 91 | 210 | 156 | 15 |
| | 150 | 98 | 245 | 171 | 15 |
| | 200 | 98 | 273 | 189 | 17 |
| Parbhani | 50 | 84 | 203 | 138 | 19 |
| | 100 | 105 | 231 | 155 | 18 |
| | 150 | 119 | 266 | 174 | 17 |
| | 200 | 140 | 266 | 192 | 15 |
| Osmanbad | 50 | 98 | 231 | 151 | 20 |
| | 100 | 112 | 231 | 156 | 17 |
| | 150 | 98 | 231 | 163 | 16 |
| | 200 | 112 | 231 | 171 | 15 |
| Akola | 50 | 77 | 189 | 127 | 21 |
| | 100 | 84 | 231 | 142 | 21 |
| | 150 | 98 | 280 | 160 | 23 |
| | 200 | 105 | 280 | 180 | 21 |
| Aurangabad | 50 | 98 | 203 | 146 | 18 |
| | 100 | 112 | 217 | 158 | 17 |
| | 150 | 126 | 231 | 172 | 15 |
| | 200 | 140 | 273 | 183 | 15 |
| Gulbarga | 50 | 35 | 217 | 148 | 26 |
| | 100 | 49 | 231 | 156 | 19 |
| | 150 | 56 | 231 | 164 | 18 |
| | 200 | 56 | 238 | 173 | 19 |

(Table 4 continued)

| | | | | | |
|---|---|---|---|---|---|
| Beed | 50 | 77 | 224 | 153 | 20 |
| | 100 | 105 | 231 | 167 | 18 |
| | 150 | 98 | 294 | 181 | 22 |
| | 200 | 112 | 294 | 194 | 20 |
| Solapur | 50 | 63 | 217 | 148 | 23 |
| | 100 | 63 | 203 | 158 | 20 |
| | 150 | 63 | 210 | 172 | 17 |
| | 200 | 112 | 217 | 182 | 14 |
| Pune | 50 | 91 | 210 | 148 | 22 |
| | 100 | 98 | 217 | 166 | 19 |
| | 150 | 112 | 238 | 180 | 17 |
| | 200 | 126 | 252 | 191 | 17 |
| Bellary | 50 | 28 | 217 | 120 | 46 |
| | 100 | 42 | 238 | 136 | 39 |
| | 150 | 42 | 252 | 150 | 34 |
| | 200 | 42 | 259 | 157 | 35 |
| Bijapur | 50 | 70 | 210 | 146 | 29 |
| | 100 | 70 | 217 | 156 | 28 |
| | 150 | 70 | 231 | 164 | 28 |
| | 200 | 70 | 287 | 173 | 30 |

**Table 5. Probability (%) of specified length of growing season on various water holding capacity soils at different locations**

| Location | AWHC (mm) | Length of growing season (days) | | | | |
|---|---|---|---|---|---|---|
| | | ≥ 180 | ≥ 190 | ≥ 200 | ≥ 210 | ≥ 220 |
| Nanded | 50 | 5 | -- | -- | -- | -- |
| | 100 | 13 | 3 | -- | -- | -- |
| | 150 | 40 | 18 | 7 | -- | -- |
| | 200 | 63 | 43 | 30 | 25 | 10 |
| Parbhani | 50 | 5 | -- | -- | -- | -- |
| | 100 | 18 | 13 | 5 | 3 | -- |
| | 150 | 35 | 28 | 20 | 8 | 5 |
| | 200 | 68 | 55 | 36 | 28 | 16 |
| Osmanbad | 50 | 15 | 13 | 8 | 5 | -- |
| | 100 | 15 | 13 | 5 | 3 | -- |
| | 150 | 25 | 15 | 13 | 3 | -- |
| | 200 | 33 | 25 | 13 | 10 | 3 |
| Akola | 50 | 5 | -- | -- | -- | -- |
| | 100 | 13 | 4 | -- | -- | -- |
| | 150 | 28 | 23 | 14 | 8 | 4 |
| | 200 | 53 | 38 | 35 | 33 | 9 |
| Aurangabad | 50 | 13 | 10 | 3 | -- | -- |
| | 100 | 20 | 15 | 10 | 3 | -- |
| | 150 | 35 | 26 | 14 | 10 | 3 |
| | 200 | 50 | 45 | 29 | 20 | 3 |

(Table 5 continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| Gulbarga | 50 | 15 | 10 | 3 | -- | -- |
| | 100 | 14 | 8 | 5 | -- | -- |
| | 150 | 25 | 18 | 7 | 3 | -- |
| | 200 | 43 | 33 | 13 | 5 | -- |
| Beed | 50 | 24 | 12 | 4 | -- | -- |
| | 100 | 33 | 23 | 10 | 5 | -- |
| | 150 | 48 | 45 | 28 | 18 | 14 |
| | 200 | 68 | 58 | 45 | 40 | 20 |
| Solapur | 50 | 10 | 3 | -- | -- | -- |
| | 100 | 36 | 15 | 3 | -- | -- |
| | 150 | 46 | 25 | 14 | -- | -- |
| | 200 | 58 | 38 | 22 | 18 | -- |
| Pune | 50 | 20 | 12 | 3 | -- | -- |
| | 100 | 39 | 33 | 17 | 5 | -- |
| | 150 | 56 | 45 | 31 | 20 | 5 |
| | 200 | 64 | 55 | 44 | 35 | 22 |
| Bellary | 50 | 19 | 10 | 6 | 3 | -- |
| | 100 | 30 | 20 | 11 | 8 | 3 |
| | 150 | 30 | 26 | 23 | 16 | 8 |
| | 200 | 35 | 31 | 27 | 25 | 15 |
| Bijapur | 50 | 16 | 15 | 5 | -- | -- |
| | 100 | 35 | 25 | 16 | 9 | -- |
| | 150 | 36 | 33 | 28 | 23 | 10 |
| | 200 | 44 | 38 | 30 | 28 | 23 |

**Relationship of LGS and seasonal rainfall to SGS** : The locations that exhibit greater variability in SGS and have low to medium rainfall show better relationship for LGP and seasonal rainfall with SGS. Such locations are Bellary, Bijapur, Beed, Gulbarga, Osmanabad and Solapur where both LGS and seasonal rainfall decreased with delay in the onset of season. Generally the relation of SGS was better with LGS than with seasonal rainfall. This shows that when season starts early the potential of the Environment for double cropping is greater than when it starts late. At other locations (Akola, Aurangabad, Nanded, Solapur, Parbhani and Pune) LGS was not related with SGS indicating that the potential of the season for double cropping could still be there even if monsoons set in late.

## REFERENCES

Keig, G. and McAlpine, JR. 1974. WATBAL : A computer system for the estimation and analysis of soil moisture regimes from simple climatic data. Second Edition, Tech. Memo. 74/7 CSIRO, Australian Division of Land Research : p45.

Rao, K.N., George, C.J. and Ramasastri, K.S. 1971. Potential evapotranspiration over India. Science Reporter No. 136, IMD, Pune, India.