WATER SATISFACTION ANALYSIS FOR DRYLAND MAIZE PRODUCTION IN FRANKFORT

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1. INTRODUCTION

Water deficiency during the growing period of summer crops is the main limiting factor for optimum crop production in most semi-arid areas of South Africa (Moeletsi et al., 2009). Water requirements of the crop depend mainly on the nature and stage of the crop and the atmospheric demand (Sharma, 2006). To assess crop performance based on water available to the crop during the growing season the water requirement satisfaction index (WRSI) was developed by the Food and Agriculture Organization (FAO) as documented in the FAO Plant and Protection Paper 73 (Jensen et al., 1990; Senay & Verdin, 2003). In this study, the water satisfaction for dryland maize production in Frankfort was investigated using the FAO WRSI to determine the optimum dates which minimizes crop failure due to water deficiency.

2. DATA AND METHODS

WRSI estimation requires rainfall, evapotranspiration (ET_o), soil water holding capacity, cultivar length and crop coefficients (K_c) (Jensen et al., 1990; Senay & Verdin, 2003; Instat, 2007; Moeletsi et al., 2009). Daily rainfall data from 1960 to 2004 and water holding capacity of the soil at Frankfort was obtained from the Agricultural Research Council-Institute for Soil, Climate and Water (ARC-ISCW) agroclimate databank. Missing daily rainfall records were estimated by the inverse distance method using up to five closest rainfall stations. Evapotranspiration data was estimated using the Hargreaves equation calibrated for the Frankfort area. Standard maize crop coefficients for the mid-season and late season were modified for local climate using the average wind speed and relative humidity (Allen et al., 1998).

The WRSI was determined on a dekadal basis (month is divided into 3 parts, 1st 10 days as dekad 1, 2nd 10 days as dekad 2 and the remaining days as dekad 3). The analysis was performed on short, medium and long season maize cultivars with 100-day (10 dekads), 120-day (12 dekads) and 140-day (14 dekads) growing periods respectively. WRSI values for different planting dates starting from the 1st dekad of September to the 3rd dekad of January were determined for all the cultivars. The WRSI water balance model operates on the dekadal steps in which the water stored cannot exceed the total water holding capacity after deducting potential evapotranspiration (PET=Kc*ETo) (Rafi & Ahmad, 2005; Instat, 2007). Water stored in the profile is added to dekadal rainfall in the following dekad. Excess water is taken as runoff or deep drainage. The WRSI values start from 100 and decrease dekadaly by the proportion of the water deficit over the seasonal potential evapotranspiration and it also decreases when the surplus water exceeds 100 mm.

3. RESULTS

The modified crop coefficients for the mid-season (late vegetative to grain-filling) and end of the growing period varied slightly from month to month with averages of 1.26 and 0.37 respectively. Fig. 1 shows the Kc values for all three maize cultivars when the planting dekad is in the 3rd dekad of November as an example. The Kc for the mid-season was 1.21 and at the end of the season was 0.34 for both the short and medium season varieties. The long season crop had Kc values for mid-season and end of the season of 1.20 and 0.35 respectively.

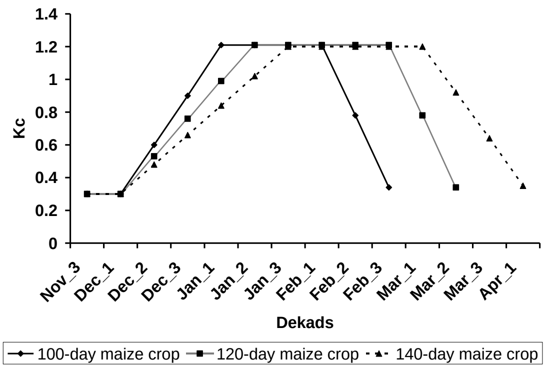

Fig. 1: Growing period crop coefficients for the 100, 120 and 140 day maize crop

Accumulated seasonal rainfall for the 100-day, 120-day and 140-day growing period at all the planting dates increased gradually from September and reached maximum values between the 2nd dekad of October to the 3rd dekad of November then decreased until the end of January. In contrast, accumulated PET decreased gradually from September until the end of January. For the short season variety, the WRSI at the end of the season is very low in September with values below 40, 50 and 60 for the 20th, 50th and 80th percentiles respectively (Fig. 2). High WRSI values were obtained from the 1st dekad of November to the end of January with the 20th percentile values around 50, 50th percentile values around 65 and 80th percentile values around 80 (Fig. 2).

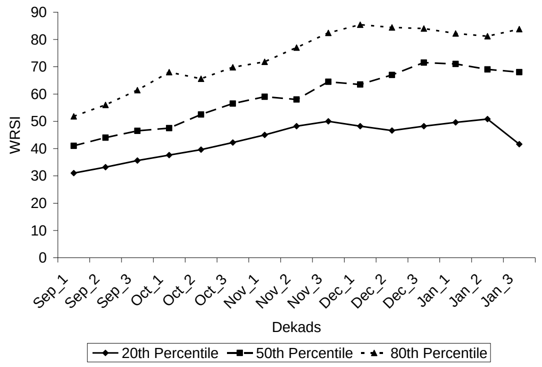

Fig. 2: WRSI values at 20th, 50th and 80th percentile for the short season maize crop

WRSI values at all the risk levels for the medium season variety increased gradually from the 1st dekad of September planting period until the 2nd dekad of November whereafter they flattened until the 3rd dekad of January planting period (Fig. 3). During the period from the 2nd dekad of November to the end of January the risk of crop failure due to water deficiency is relatively lower than in all the other planting periods for the 120-day maize crop.

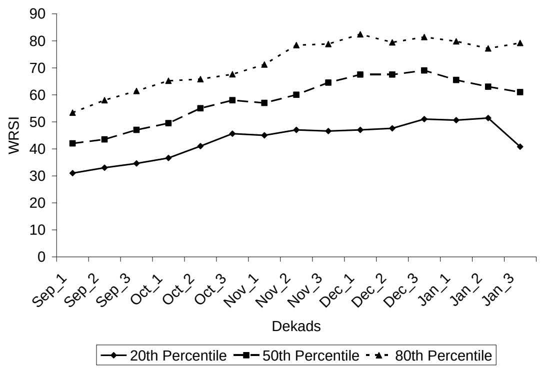

Fig. 3: WRSI values at 20th, 50th and 80th percentile for the medium season maize crop

For the long season maize crop the planting period before the 1st dekad of November and after the 1st dekad of January yielded relatively low WRSI values (Fig. 4). From September to November low WRSI values were caused by high cumulative atmospheric demand while after January planting period there was relatively low seasonal rainfall. The planting period which resulted in optimum maize water satisfaction was between the 2nd dekad of November and the 1st dekad of January.

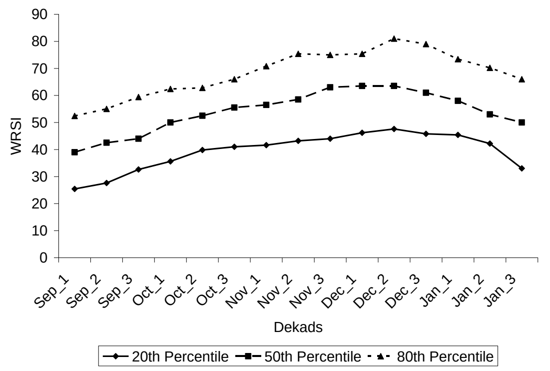

Fig. 4: WRSI values at 20th, 50th and 80th percentile for the long season maize crop

4. CONCLUSION

In Frankfort, recommended planting period based on soil water availability for the short and medium season maize crop varieties starts in November till end of January while for long-season crop the period extends from November to end of December.

5. REFERENCES

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