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Assessment of moisture stress using water requirement satisfaction index in *kharif* maize

G. JAYASREE, D. LINGAIAH, D. RAJI REDDY and S.B.S. NARASIMHA RAO
Agromet-cell, Agricultural Research Institute,
Acharya NG Ranga Agril.University, Hyderabad-500 030
Email : gyayasree2001@yahoo.com

ABSTRACT

A field experiment was conducted to study the impact of moisture stress at different growth phases in maize using Water Requirement Satisfaction Index (WRSI) during *kharif* 2004 at Agricultural Research Institute (ARI) farm, ANGRAU, Rajendranagar. The experiment was laid out in RBD (Factorial) with four dates of sowing starting from onset of monsoon at 15 days interval and four "irrigation schedules" *viz*. irrigation as per water requirement, skipping of irrigation at vegetative, flowering stages and rainfed.. Reduced yields were recorded when irrigation was withdrawn during reproductive phase. A significant positive correlation between WRSI and yield was observed (r = 0.79). Higher WUE was observed with skipping of irrigation at vegetative stage and in rainfed treatments.

Key words: Water Requirement Satisfaction Index (WRSI), AET, WUE and yield

Maize is an important cereal crop and in recent years it is replacing other rainfed crops in the Telangana region of Andhra Pradesh during *kharif* season. The crop experiences dry spells at one or other stages during crop growth due to erratic distribution of rainfall. However its grain yield is quite unpredictable due to changing rainfall situation and distribution of dry spells during crop growth season. Amongst various inputs required for precision crop management, information on seasonally variable conditions especially soil moisture availability and its interactions with the meteorological parameters and crop pheno-phases plays a crucial role. Study of moisture deficiency during different growth phases and its impact on yield will enable the forecast of rainfed crop yield. The WRSI indicates the extent to which the water demand of crop during the period has been met cumulatively during the crop growth period. This in turn gives an idea on the stress undergone by the crop at any stage of its life cycle. The WRSI model can be effectively used for crop monitoring and yield forecasting in the semi-arid region (More *et al*., 1991 and Pote, 1999). Several workers (Victor *et al*., 1988; Sahu *et al*., 1994 and Ramana *et al*., 1998) studied drought or moisture stress occurrence in relation to yield through water balance methods. Yet there is a need to develop different threshold values of WRSI or aridity index locally for different crop species to represent local soil and crop conditions. Close relationship was observed between WRSI and bajra yield (Victor *et al.*,1988) and Groundnut yield (Raji Reddy *et al.*, 2003). Hence, the present study was carried out to assess moisture stress in terms of WRSI in *Kharif* maize and its relationship with the yield.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Institute (ARI) farm, ANGRAU, Rajendranagar during the *Kharif* 2004. The actual site of experiment is located adjacent to the meteorological observatory. To ensure that the crop was subjected to stress, staggered sowing was done on four dates at an interval of fifteen days. The experiment was laid out in RBD (factorial) with three replications and the treatments are as follows.

Irrigation regimes

I_1 - Irrigation as per local recommendation
I_2 - Skipping irrigation at vegetative stage
I_3 - Skipping irrigation at reproductive stage
I_4 - Rainfed

Dates of sowing

D_1 - 11 .06. 2004 (onset of monsoon)
D_2 - 02. 07. 2004
D_3 - 18 .07.2004
D_4 - 03. 08.2004

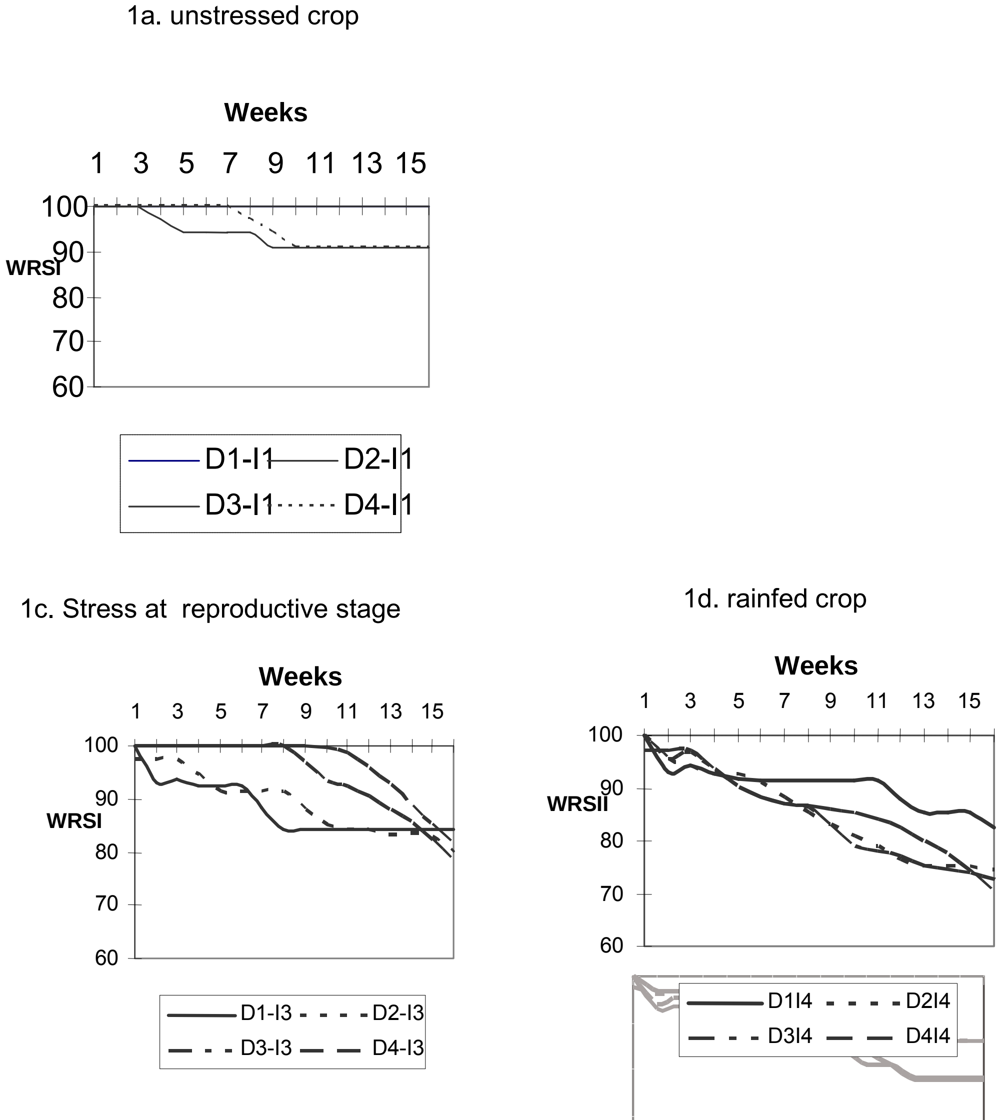
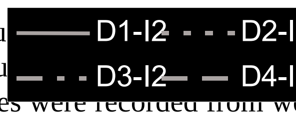


Fig. 1 : Weekly WRSI pattern under different dates of sowing and skipped irrigation treatments

Maize variety DHM-103 was grown with spacing of 60 x 20 cm. A uniform dose of fertilizer 120, 50 and 40 kg ha^{-1} N, P_2O_5 and K_2O was applied. The soil is sandy clay loam with water holding capacity of 16% at 0.33 bars and 6% at 15 bars and bulk density 1.57g/cc at surface in 0-15 cm layer, 1.63 at 15-30 cm layer and 1.70 at 30-45 cm layer. The soil is neutral in reaction with a pH of 7.4.

The WRSI, which is a measure of quantification of stress was computed for all the treatments using FAO water balance technique (Frere and Popov,1979). The



Actu [illegible] (AET) was computed throu [illegible] ethod. In addition, AET values were recorded from weighing lysimeter in one of the rainfed treatments. The weekly crop water requirement was computed using AET values. The profile soil moisture in all the treatments was measured with Time Domain Reflectometer (TDR) at weekly intervals. Weekly pan evaporation data was taken as PET (Bhattacharya, 1998). The crop coefficient was assessed using line quantum sensor that was placed below canopy at ground level. Total crop water requirement (WR) was calculated by adding the weekly

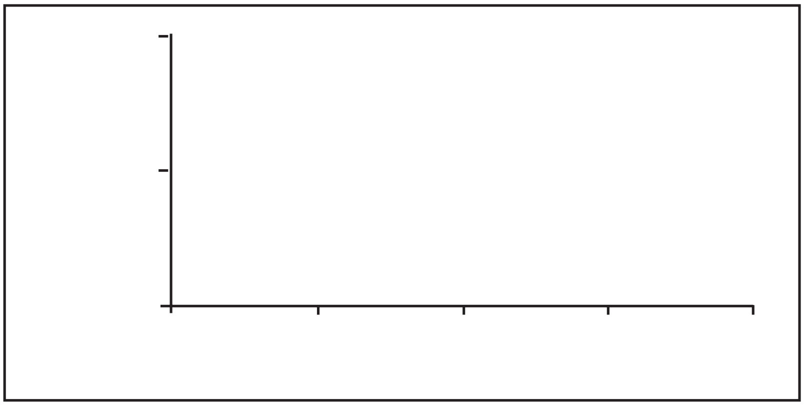


Fig.2: Relationship between WRSI and grain yield of maize

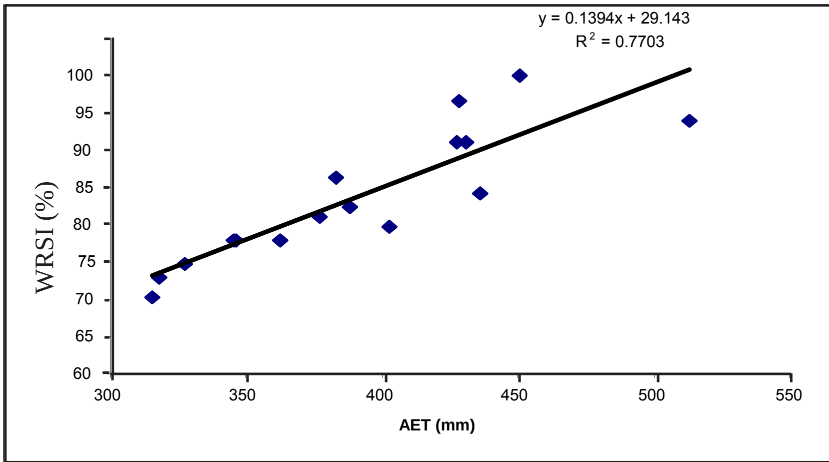


Fig.3: Relationship between water requirement satisfaction index (WRSI) and actual evapotranspiration (AET)

values.

RESULTS AND DISCUSSION

Typical pattern of WRSI, along with growth phases for different irrigation treatments is shown in Fig.1a to 1d. The WRSI for unstressed crop (Fig.1a) started decrease only either in vegetative or reproductive stage. In the case of rainfed crop (Fig.1d), the WRSI started decreasing right from the emergence and remained constant over a period only for the first date of sowing due to sufficient rainfall occurrence during this period. In all treatments the index decreased constantly and reached around 70 at the end of growing season. The variation in WRSI for I_2 (skipping irrigation at vegetative stage) treatment ranged from 96.5 to 78.(Fig.1b). Due to sufficient amount of rainfall during first date of sowing, the index has not decreased much. For D_2 treatment it decreased to 86. In third and fourth dates of sowing (D_3 and D_4) the crop experienced more stress at vegetative stage and hence WRSI decreased to 78%. During third date of sowing (D_3) even though the WRSI was lower for I_2 (78%) than I_3 (81%) the yield was inversely related. This anomaly might be due to higher degree of sensitivity of the crop to stress at reproductive stage than in vegetative stage, which is reflected in grain yield.

In the present study, significant positive correlation was observed between WRSI and grain yield (r = 0.79). The decrease in grain yield was noticed proportionately with the decrease in WRSI indicating the effect of moisture stress.(Fig.2). Reduced yields were recorded when irrigation was withdrawn during

Table 1: Grain yield of maize (kg ha^{-1}) and WRSI, AET grain yield and WUE in maize as influenced by dates of sowing and irrigation treatments

Treatment	WRSI (%)	∑AET (mm)	Grain yield (kg ha^{-1})	WUE (kgha^{-1}mm^{-1})
D_1I_1	94.0	513.5	4190	8.16
D_1I_2	96.5	428.8	3910	9.11
D_1I_3	84.3	436.4	3700	8.47
D_1I_4	82.5	388.1	3440	8.86
D_2I_1	100	450.7	3930	8.17
D_2I_2	86.2	383.1	3710	9.84
D_2I_3	79.8	402.4	3310	8.22
D_2I_4	74.7	327.0	3250	10.00
D_3I_1	91.0	427.9	3130	7.30
D_3I_2	78.0	345.0	3940	8.52
D_3I_3	81.0	377.0	2870	7.60
D_3I_4	73.0	318.0	2660	8.36
D_4I_1	91.0	431.0	3090	7.19
D_4I_2	78.0	346.0	2910	8.40
D_4I_3	78.0	362.8	2860	7.87
D_4I_4	70.2	315.2	2460	7.80

reproductive phase.

By employing regression technique, a linear regression model was developed based on the values of WRSI to predict maize grain yield. The model is as follows.

$$Y=44.868x - 469.43 \quad (R^2=0.61)$$

Where,

Y= Yield in (kg ha^{-1}),

x= Water Requirement Satisfaction Index (WRSI) %

Water use efficiency (WUE)

The AET values of maize under different dates of sowing and skipped irrigation treatments ranged between 513.5 to 315.2 mm. The highest amount of water was used by fully irrigated treatment in first date of sowing (D_1I_1). In the present study, the AET is closely related to the WRSI (Fig.3). The water use efficiency (WUE) was calculated by dividing the grain yield with "AET. It ranged between 7.19 and 10.0 (Table 1). The lowest WUE was observed in fully irrigated treatment (I_1) and was higher under D_1 and D_2 sowings. Further it was higher where irrigation was withdrawn at vegetative stage (I_2) and in rainfed treatment (I_4) .

CONCLUSIONS

Late sowing of maize (D_4) and skipped irrigation treatment (I_3) at reproductive stage and Rainfed(I_3) treatments reduced the yield as well as WRSI significantly. Further the WRSI has proved to be a valuable tool for understanding the grain yield reductions and Water Use Efficiency of maize crop under different irrigation schedules.

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