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RESEARCH ARTICLE

Optimizing the Best Sowing Week by Employing Water Requirement Satisfaction Index for Maize and Sorghum for Selected Districts of Tamil Nadu

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ABSTRACT

Water Requirement Satisfaction Index (WRSI) is an indicator of crop performance based on the availability of soil moisture to crop needs to meet PET demand during a growing season. An attempt was made to identify the best sowing week for the selected districts of Tamil Nadu at Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore for maize and sorghum using WRSI under dryland situation. The data of weekly rainfall and potential evapotranspiration for Dindigul, Theni and Namakkal districts were collected from the respective stations for a period of 30 years (1981 to 2010). The existing sowing window was obtained from the farmers with discussion for dryland conditions. Crop coefficients (Kc) values for the maize and sorghum crops for different crop growth stages were collected from Food and Agricultural Organization (FAO)-Bulletin-56. From the study, it was found out that for sorghum and maize, the elasticity of the identified optimum sowing week was expanded from 35th Meteorological Standard Week (MSW) to 39th standard week for Dindigul Theni and Namakkal districts

Keywords: *WRSI, maize, sorghum, Meteorological Standard Week*

INTRODUCTION

India ranks first in rain-fed agriculture globally in the area. Rain-fed agriculture occupies 67 per cent of the net sown area and contributes 44 per cent of total food grain production. Ninety-five per cent of the area comes under coarse cereals, 91 per cent under pulses and 80 per cent under oilseeds (Srinivas Rao *et al*., 2015). Out of 7 m ha of the net cultivable area in Tamil Nadu around 3.1 m ha area is under dryland / rain fed agriculture.

Rainfall is the single most critical agro-meteorological variables in influencing crop production. Agriculture ensuring food security of India is crucially dependent on the timely availability of the adequate amount of soil moisture under a given climate and weather. Climate change threatens dryland/rainfed crop production. One strategy under which the farmers could use to maintain or increase crop yield in the face of a changing climate is to adjust sowing and planting dates. Sowing date showed significant interaction with accessions for all physiological and yield traits.

A close relationship was observed between moisture stress, expressed as WRSI and bajra as reported (Yogeswara Rao *et al*., 1988). WRSI is also directly related to economic yield. By employing the regression technique, a linear regression model based on WRSI was developed to predict groundnut pod yield (Raji Reddy *et al*., 2003). Assessment of crop yield potential in any given *Kharif* season on weekly basis from the start of sowing week can be done by employing WRSI(Sahu and Sastri, 1992). The correlation and regression studies revealed that the crop WRSI, soil moisture content, AET and rainfall have a significant positive correlation during the pod development phase and during the entire groundnut crop duration (Guled *et al*., 2013).

MATERIAL AND METHODS

The data on weekly rainfall and potential evapotranspiration were collected from the respective station for a period of 30 years (1981 to 2010). Existing sowing week was obtained from the farmer's discussion for rainfed conditions. Crop coefficient (Kc) for the studied crops at different growth stages were collected from Food and Agricultural Organization (FAO) - Bulletin-56, (1998).

Water Requirement Satisfaction Index (WRSI) is an indicator of crop performance based on the availability of soil moisture to its crop during a growing season. FAO studies had shown that WRSI

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could be related to crop production using a linear yield-reduction function specific to a crop. Among the various meteorological parameters, rainfall played a significant role in determining sowing time for dryland crops. Frere and Popov (1979) developed a simple crop water balance model to estimate the water availability to the crop using rainfall, ET and WHC of soil as inputs. WRSI indicated the extent to which the water requirement of a given crop had been satisfied cumulatively at any growth stage (Mukhala, 2002).

The best sowing window for the selected crops (maize and sorghum) was worked out by using a water balance model (Frere and Popov, 1979). The detailed procedure for the computation of WRSI, as given by Frere and Popov, (1979) was used in the Microsoft excel spreadsheet 2010 since the software was not available on demand. WRSI was worked out for Theni, Dindigul and Namakkal as these districts were identified as Most Efficient Cropping Zone (MECZ) for maize and sorghum.

Steps to compute WRSI are detailed as below.

Crop Water Requirement (WR)

The crop water requirement was computed by multiplying the total value of PET for each phenological stage with Kc value. To calculate the total water requirement of the season from sowing to harvest, the values were summed up. This is based on the model used.

Water Use (WU)

The water use was obtained by comparing the rainfall and water requirement of the crop. When the precipitation was less than water requirement, the observed precipitation was considered as water use.

Soil Moisture Requirement (SMR)

The individual weekly amount of precipitation was subtracted from the same week water requirement to arrive soil moisture.If the resultant value of precipitation –water requirement was positive, then the consecutive week values were added to arrive soil moisture requirement. When the resultant value was negative, it is denoted as zero.

Surplus and Deficit (S&D)

Surplus refers to the water more than storage in the soil, while deficit refers to any quantity of water below the water retention capacity of the soil. The value of water deficit was very important for the calculation of the Water Requirement Satisfaction Index

Water Requirement Satisfaction Index (WRSI)

WRSI was computed as follows

$$\text{WRSI} \quad \frac{\text{Deficit (mm)}}{\text{Total water requirement (mm)}}$$

The criterion proposed by Rajavel *et al*., (2012) was adopted to categorize the WRSI.

WRSI (%)	Description
95-100	Good
80-94	Average
50-79	Poor
< 50	Failure

WRSI was worked out for the farmer's sowing window (37th standard week), two weeks prior (35th standard week), and two weeks later (39th standard week) for maize and sorghum crop. This exercise was carried out to validate the farmer's sowing window.

RESULTS AND DISCUSSION

Maize and Sorghum- Dindigul and Theni districts

Dindigul district was identified as Most Efficient Cropping Zone (MECZ) for maize and sorghum. Farmer's preference to take up sowing for maize and sorghum was 37th meteorological standard week (Sep 10-16) and the crop duration got terminated at 52nd meteorological standard week (Dec 24-31).

Table 1. Computation of WRSI for maize and sorghum - Dindigul district(Total of sowing to harvest for each sowing window)

MSW	Sowing rain	MHW	PPT(mm)	PET(mm)	KCR	WR(PET*KCR)	WU	SPL	DEF	WRSI
37	25.0	52	415.0	404.2	0.2-0.7	206.5	201.9	59.0	0.0	100
35	25.0	50	426.0	405.0	0.2-0.7	209.4	206.1	66.3	0.0	100
39	41.6	02	371.8	408.2	0.2-0.7	206.6	200.0	17.6	0.0	100

WRSI computed a value for all the chosen sowing week like two weeks advanced (35th meteorological standard week -Aug 27- Sep 2) and later sowing (39th meteorological standard week -Sep 24-30) with respect to farmer's choice was 100 per cent. The result inferred that two weeks advanced sowing (35th meteorological standard week -Aug 27- Sep 2) for Dindigul and two weeks delayed sowing (39th meteorological standard week -Sep 24-30) for Theni district could be chosen by the farmers in the respective district because a threshold level of 25 mm of rainfall collected over a single week as suggested by FAO (1986) and was considered to identify a sowing week (Table 1&2).

The study indicated that in all the chosen sowing weeks, precipitation was more than potential evapotranspiration, which led to soil moisture surplus. Soil moisture surplus occurred when there was more water available than the actual evapotranspiration. The surplus water first reached the field capacity and then the excess water, if any, added to groundwater recharge (Bakundukize *et al*., 2011). In all the selected sowing week, soil moisture surplus reached after 10 weeks of sowing for both the districts. The surplus water may be stored in farm ponds and utilized to grow short duration pulse crops suited to that area along with one or two supplemental irrigations.

Table 2. Computation of WRSI for maize and sorghum -Theni district (Total of sowing to harvest for each sowing window)

MSW	Sowing rain	MHW	PPT(mm)	PET(mm)	KCR	WR(PET*KCR)	WU	SPL	DEF	WRSI
37	14.0	50	419.0	368.7	0.2-0.7	188.0	179.1	83.0	0.0	100
35	8.7	50	422.2	365.3	0.2-0.7	188.3	187.0	84.0	2.0	100
39	25.6	02	398.4	376.5	0.2-0.7	190.0	176.2	71.7	0.0	100

FAO studies (Doorenbos and Pruitt, 1977) had shown that WRSI could be meaningfully related to crop production in semi-arid regions, using a linear-yield reduction function specific to a crop. Awoke (1991) also studied WRSI for maize production in central Ethiopia and found useful relationships between maize yield and WRSI.

Table 3. Computation of WRSI for sorghum – Namakkal district(Total of sowing to harvest for each sowing window)

MSW	Sowing rain	MHW	PPT(mm)	PET(mm)	KCR	WR(PET*KCR)	WU	SPL	DEF	WRSI
37	24.1	52	268.1	444.0	0.2-0.7	227.2	199.4	0.0	0.0	100
35	9.8	50	287.0	446.1	0.2-0.7	231.1	207.7	0.0	2.5	100
39	16.8	02	229.7	446.8	0.2-0.7	226.6	177.8	0.0	0.0	100

Note: MSW- Meteorological Sowing week; MHW- Meteorological Harvest week; PPT- Precipitation; PET- Potential Evapotranspiration; KCR- Crop Coefficient; WR-Water Requirement; WU- Water Use; SPL- Surplus; DEF-Deficit; WRSI- Water Requirement Satisfaction Index

Sorghum –Namakkal district

Namakkal district was identified as MECZ for sorghum and the farmers sowing week was 37th meteorological standard week (Sep 10-16) and the crop duration got terminated at 52nd meteorological standard week (Dec 24-31). Two weeks advanced (35th meteorological standard week -Aug 27- Sep 2) and later sowing (39th meteorological standard week -Sep 17-23) with respect to farmer's choice also registered 100 per cent WRSI (Table 3). Interestingly, in all the chosen sowing weeks, precipitation was lower to 60, 64, and 51 per cent of potential evaporation, respectively. Even then, 100 per cent WRSI was possible because precipitation exceeded water requirements in most of the weeks except vice versa in a few weeks. Since precipitation was lower than potential evaporation, the difference in precipitation and water requirement gone to soil moisture recharge which resulted in no deficit or surplus. A threshold of 25 mm of rainfall collected over a single week, as suggested by FAO (1986) was considered and hence the 37th meteorological standard week (Sep 10-16) may be chosen by the farmer in Namakkal district for sowing.

CONCLUSION

Water Requirement Satisfaction Index (WRSI) is an indicator of crop performance based on the availability of soil moisture to its crop during a growing season. Dindigul district was identified as Most Efficient Cropping Zone (MECZ) for maize and sorghum while Namakkal district was identified as MECZ for sorghum alone. Farmer's preference to take up sowing for maize and sorghum was 37th meteorological standard week (Sep 10-16) in all the selected districts. From the study, it was found out that for sorghum and maize, the identified optimum sowing week was 35th Meteorological Standard Week(MSW) (Aug27- Sep 2) for Dindigul and 39th MSW (Sep 24 - 30) for Theni and 37th MSW(Sep 10-16) for Namakkal districts respectively.

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