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RESEARCH ARTICLE

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Effect of Weather Indices under Different Sowing Windows on Grain Yield of Sorghum

Y. Sindhu[1], R. Karthikeyan[1], S.D. Sivakumar[2],
M. Djanaguiraman[3], M. Thirunavukkarasu[1], K. Boomiraj[4]

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ABSTRACT

Background: Sorghum (*Sorghum bicolor*) is one of the major staple cereal crops after rice and wheat. Photoperiod (day length) sensitivity has been shown to affect the duration of plant's vegetative phase based on sowing dates. Optimum sowing date is one of the most important factors that play an important part in yield.

Methods: A field experiment was carried out during the summer season of 2022. in the Eastern block farm, field No:-37F of Tamil Nadu Agricultural University (TNAU), Coimbatore in sandy loam soil to study the phenological behaviour of sorghum (var. CO-32) as influenced by sowing window (D_1- First fortnight of February, D_2- First fortnight of March and D_3- First fortnight of April) by analysing the Helio-thermal units (HTU), Photo-thermal units (PTU) and growing degree days (GDD) and to evaluate the performance of sorghum CO-32 cultivar. The experiment was laid out in strip plot design.

Result: Among the different sowing windows, highest grain yield was recorded when sowing was done in I FN of April (2585 kg/ha) followed by I FN of March (2459 kg/ha). The attainment of phenophases was found early in February sowing. It was observed that accumulated heat units increased by 114 and 142.2°C days, respectively in March I FN and April I FN sown crop compared to February I FN sown crop. Among the sowing windows maximum photo thermal units were accumulated by April I FN sown crop (26787.2°C day hrs) followed by March I FN (25797.1°C day hrs) and February I FN (24459.8°C day hrs) sown crop, respectively.

Key words: GDD, Grain yield, HTU, PTU, Sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor*) ranks fifth among the important crops in the world after wheat, rice, maize and barley and is one of the main staple foods of world's poorest and most food insecured people across the semiarid tropics. In India sorghum is grown in an area of 4.3 million ha with the production of 4.8 million tonnes and productivity of 1099 kg/ha (MoA and FW, 2021).

The sorghum crop is characterized by its tolerance to the environmental conditions that are not suitable to produce other summer crops (maize and soybeans), especially towards heat, drought and soil salinity, hence, called as Camel Crop (Lamessa *et al.*, 2016). In India, sorghum is cultivated during both monsoon (rainy) and winter (post rainy) seasons, mainly as a rainfed crop.

Since sorghum is grown as a rainfed crop, the climatic factors play a significant role in its productivity. With the threat of climate change looming large on the crop productivity, the tropics are the most vulnerable areas of the world, especially the semi-arid areas where higher temperatures and more variable rainfall might have significant negative effects (Parry *et al.*, 2004). So, sowing window play an important role for achieving optimum yield and to enable the crop to avoid environmental stresses at critical growth stages.

The important meteorological variables associated with agricultural production are solar radiation, precipitation and air temperature (Hoogenboom, 2000).An estimation of the harvest date and the stage of crop production can be given with the knowledge of accumulated GDD. A minor change in temperature will adversely affect the phenophase duration. The present investigation was carried out to generate location specific information on duration of phenophases in sorghum variety CO-32.

[1]Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
[2]Institute of Agriculture, Kumulur-621 712, Tamil Nadu, India.
[3]Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
[4]Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.

Corresponding Author: R. Karthikeyan, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India. Email: agrikarthi@yahoo.co.in

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MATERIALS AND METHODS

The experiment was conducted in the Eastern block farm of Tamil Nadu Agricultural University, Coimbatore. The experimental site is at an altitude of 420.7 m above mean sea level and is situated at 11°N latitude and 76°57′E longitude. The soil of experimental field is sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potassium. The sorghum variety Co-32 in the experiment was released from TNAU during the year 2020.The varietal characters are presented in Table 1.

The field trail was conducted in summer season of 2022. The experiment was laid out in strip plot design with three different sowing windows (D_1 - First fortnight of February, D_2 - First fortnight of March and D_3 - First fortnight of April) as Factor A and six different crop geometries as factor B (S_1 - 45 × 15 cm, S_2 - 45 × 10 cm, S_3 - 45 × 5 cm, S_4 - 30 × 15 cm, S_5 - 30 × 10 cm and S_6 - 30 × 5 cm) and replicated thrice. All necessary package of practices were followed during the crop growing season. Daily maximum and minimum temperature, rainfall, relative humidity, wind speed, bright sunshine hours during the cropping season were retrieved from Agromet observatory of the Agro Climate Research Centre, Coimbatore. The weather graph of growing season was presented in Fig 1. The data was converted into standard meteorological weeks (D_1-6th SMW TO 21st SMW, D_2-10th SMW to 25th SMW and D_3- 14th SMW TO 26th SMW). Using this daily weather data, weather indices such as Helio-thermal units (HTU), Photo thermal units (PTU) and growing degree days (GDD) were calculated based on air temperature and used to describe changes in phenological behaviour and growth parameters (Paul *et al.,* 2000; Girijesh *et al.,* 2011; Prakash *et al.,* 2015).The temperature based weather indices provide a reliable prediction for crop development and yield. A minimum temperature of 19°C to 25.2°C, maximum temperature of 31°C to 36.5°C, bright sunshine hours upto 10.3 hrs and a rainfall of 148.4 mm have been recorded during the growing season. The occurrence of different phenophases of the crop has been recorded when the crop reached the respective stages *i.e.,* P_1= Sowing to emergence, P_2= Emergence to booting stage, P_3= Emergence to 50% flowering, P_4= 50% flowering to maturity and P_5= Booting to 50% floweringP_6= Emergence to maturity. The weather indices were calculated using the following formulae.

Growing degree days

GDD is the difference between the mean temperature of the day and base temperature. It is one of the best weather indices for assessing the development of crop. Base temperature of 10°C has been used to compute GDD on daily basis for sorghum (Kumar *et al*., 2008).

$$\text{Growing degree days (°C days)} = \sum_{i=1}^{n} \frac{\text{Tmax} + \text{Tmin}}{2} - \text{Tb}$$

Tmax= Maximum temperature.
Tmin= Minimum temperature.
Tb= Base temperature.

Helio-thermal units (HTU)

Helio thermal units (°C day hrs) = GDD × Sunshine hours (Rajput, 1980).

Photo-thermal units (PTU)

Photothermal Units (°C day hrs) = GDD × Day length (Major *et al*., 1975).

RESULTS AND DISCUSSION

Phenological phases

The results pertaining to phenophase attainment are presented in the Table 2. Time of sowing has influence on number of days required to attain a particular phenophase. The mean phenological duration from plant emergence to 50% flowering (P_3) was 59 days for April I FN sown crop (D_3) followed by March I FN and February I FN sown crop accounting 56.3 and 54.6 days, respectively. Similarly, number of days to attain physiological maturity from the time of emergence was 105 days for April I FN sown crop 102 days for March I FN sown crop and 100 days for February I FN sown crop. Whereas from 50% percent flowering to maturity it was in reverse order *i.e*. 41.6 days, 46.9 days and 47.5 days, respectively. This might be because sowing time determines time available for vegetative phase before onset of flowering, which is mainly influenced by the photoperiod.

Growing degree days, Helio-thermal units and Photo-thermal units

The agro meteorological indices of GDD, HTU and PTU accumulated during different phenophases of sorghum are presented in Table 3. The total accumulated GDD and HTU during emergence to 50% flowering were 981.8°C days and 7393.8°C day' hrs under Feb I FN sowing, 1106.7°C days and 8192.2°C day hrs under March I FN sowing and 1224.5°C days and 8672.8°C days hrs during April I FN sowing, respectively. The sorghum crop sown during April I FN accumulated more GDD (2079.8°C days) to reach maturity followed by March I FN and February I FN (2051.6 and 1937.6°C days) sown crops, respectively. Fifteen days delay in sowing from February (early sown) to March and April (timely sown) increased the accumulated heat units by 114°C and 142.2°C days in March I FN and April I FN sown crop compared to February I FN sown crop. Also, longer phenophasic days accumulated a higher amount of GDD during early sowing in baby corn, which might be attributed to variation in temperature prevailed under different sowing dates, as stated by Dar *et al.* (2018), Prakash *et al*. (2017)

Table 1: Varietal characteristics of sorghum cultivar Co-32.

Characteristics	
Duration (days)	105-110 days
Grain colour	Creamy white
Grain yield (Rainfed condition)	2445 kg/ha
Grain yield (Irrigated condition)	2911 kg/ha
Dry fodder yield (Rainfed condition)	6490 kg/ha
Dry fodder yield (Irrigated condition)	11710 kg/ha

Accumulated Helio-thermal units are less in April I FN sown crop (12270.7°C day hrs) compared to February I FN and March I FN sown crop but there might be optimum light intensity though the duration of light intensity is less which led to higher grain yield of April sown crop compared to other two sowings.

Accumulated photothermal units, among all the phenophases that are taken under observation during reproductive stage we can observe maximum photo thermal units *i.e* P_3 phenological stage in all the three sowing windows. Among the sowing windows April I FN sown crop has accumulated maximum photo-thermal units (26787.2°C day hrs) followed by March I FN (25797.1°C day hrs) and February I FN (24459.8°C day hrs) sown crop respectively. The maximum PTU accumulation (°C day hrs) for attaining maturity also followed similar trend as that of

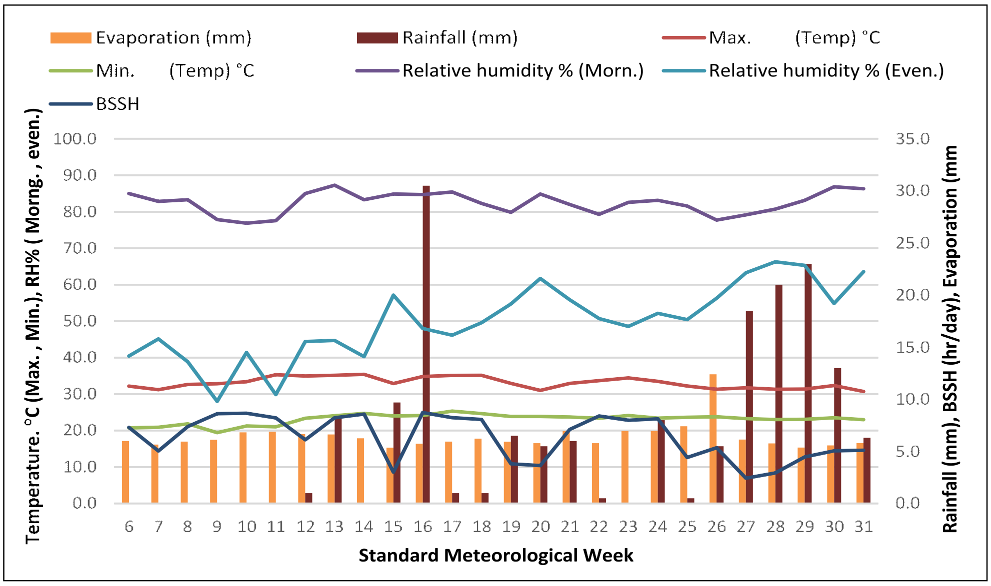

Fig 1: Standard meteorological data recorded during the crop growing season.

Table 2: Effect of sowing windows on duration of different phenophases of sorghum.

Phenophases	No of days taken to reach each phenophase		
	D_1	D_2	D_3
P_1- Sowing to emergence	4.8	6	7.1
P_2- Emergence to booting stage	47.7	48.3	51
P_3- Emergence to 50% flowering	54.6	56.3	59
P_4- 50 % flowering to maturity	47.5	46.9	41.6
P_5-Booting to 50% flowering	8.2	9.2	10.7
P_6- Emergence to maturity	100	102	105

D_1- I FN of February, D_2- I FN of March, D_3- I FN of April.

Table 3: Effect of sowing window on accumulated GDD, HTU and PTU during different phenophases of sorghum cv. CO-32.

S. no	GDD (°C days)			HTU (°C day hrs)			PTU (°C day hrs)		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
P_1	81.8	120.0	152.2	510.6	1052.6	728.0	948.3	1439.4	1901.9
P_2	866.1	949.7	979.4	6469.5	6971.5	6726.1	10288.8	11690.6	12451.4
P_3	981.8	1125.7	1224.6	7393.8	8325.2	8672.8	11721.7	13943.4	15638.4
P_4	927.1	896.9	738.6	5868.9	5552.4	3017.4	11725.8	11329.2	9699.9
P_5	180.0	195.3	209.4	1462.6	1374.9	1714.1	2250.0	2499.2	2722.2
P_6	1871.4	1948.3	1944.9	12880.4	13567.8	11549.6	22967.5	24558.1	25101.0
Total	1937.6	2051.6	2079.8	13559.2	14453.4	12270.7	24459.8	25797.1	26787.2

P_1= Sowing to emergence, P_2= Emergence to booting stage, P_3= Emergence to 50% flowering, P_4= 50% flowering to maturity and P_5= Booting to 50% flowering P_6= Emergence to maturity. D_1- I FN of February, D_2- I FN of March, D_3- I FN of April.

Table 4: Grain yield as affected by sowing window.

Treatment sowing window	Grain yield (kg/ha)
D_1 - First fortnight of February	2338.00
D_2 - First fortnight of March	2459.27
D_3 - First fortnight of April	2585.38
SEd	36.96
CD (P= 0.05).	102.61

Table 5: Leaf Area Index at different crop growth stages as affected by sowing window.

Treatment	Leaf area index		
sowing window	30 DAS	60 DAS	90 DAS
D_1- First FN of February	2.35	7.29	6.63
D_2- First FN of March	2.61	8.36	7.80
D_3- First FN of April	2.70	9.77	8.16
SEd	0.04	0.21	0.31
CD (P= 0.05)	0.11	0.58	0.88

reproductive stage. Similar findings were reported by Pathania *et al*., (2019).

Grain yield

The grain yield of sorghum cultivar CO-32 was significantly influenced by the sowing time. The data regarding grain yield are presented in the Table 4. Grain yield was significantly higher in Aprils I FN sown crop (2585 kg/ha) and which was 10 percent increase over February I FN sowing. The second highest yield was observed in March I FN (2459 kg/ha) sown crop followed by February I FN (2338 kg/ha) sown crop. Grain yield was higher in April I FN sown crop because of better growth and yield attributes which lead to higher yield. Similar findings were reported by Thavaprakash *et al.* (2007). Low grain yield recorded in February I FN sown crop might be due to lack of accumulation of adequate the photosynthates owing poor vegetative growth (Mishra *et al*., 2017). Azrag and Dagash (2015) reported that sowing date had greater effect on yield.

Leaf area index

Data pertaining to leaf area index was presented in Table 5. Date of planting had significant influence on leaf area index. At all the stages of observation *i.e*. 30 DAS, 60 DAS and 90 DAS leaf area index was significantly higher when the crop is sown during I FN of April followed by March I FN sown crop and February I FN sown crop. This might be due to cooler temperature prevailed during the vegetative stage in February sown crop probably reduced the LAI (Nishad, 2017).

CONCLUSION

From the above study, it may be concluded that CO-32 sorghum variety recorded highest yield (2585 kg/ha) when the crop was sown during I FN of April because of optimum temperature, uniform rainfall throughout the growing season, it was followed by March I FN sown and February I FN sown crop. Heat Units and photo thermal units were also highest for April I FN sown crop which led to better yield. It also indicated that change in the microclimate because of different sowing windows reflected in the phenological stage of the crop.

Conflict of interest: None.

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