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EFFECT OF WEATHER PARAMETERS ON PROSO MILLET (*Panicum miliaceum* L.) CULTIVARS UNDER DIFFERENT SOWING WINDOWS

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ABSTRACT

A field experiment was conducted during *Kharif* season 2021 at Dryland Farm, S.V. Agricultural College, Tirupati, Andhra Pradesh, ANGRAU. To know the effect of weather parameters on proso millet crop under three dates of sowing i.e. first fortnight of June (D_1), second fortnight of June (D_2) and first fortnight of July (D_3) and three varieties *i.e.* CO 5 (V_1), TNAU 202 (V_2) and GPUP 8 (V_3) with three replications. Proso millet sown on I FN (* first fortnight) of June and variety GPUP 8 utilized more Growing Degree Days, Photothermal Units and Heat Use Efficiency compared to II FN of June and I FN of July. Among the three sowing windows crops sown in II FN of June (D_2) and cultivar, CO 5 (V_1) produced significantly higher straw yield, total dry matter, grain yield and monetary returns.

KEYWORDS: Growing Degree Days, Heat Use Efficiency, Monetary returns, Photothermal Units.

INTRODUCTION

Proso millet (*Panicum miliaceum)* also called as common millet, hog millet belongs to the Gramineae family, is a short duration crop and a significant minor millet, with high nutritional value and protein level of 11–12 per cent (Kalinova and Moudry, 2006). It adapts well to different soils and climatic conditions. The crop can thrive both on the plateau and at higher elevations. The chromosome number is 2n = 36. It is a self-pollinated crop; cross-pollination can occur up to 10 per cent. It is a short-day plant that will grow up to a height of 90 to 120 cm. The root system is adventitious. Profuse branching and tillering are found in Indian grown proso millet. Stems and leaves have slight hairs. The panicle is inflorescence.

As it is a C_4 crop, it utilizes water effectively and is drought-resistant. Because of its rapid maturity, the crop can withstand drought. Due to its short life span, it escapes from drought. The optimum base temperature is 10°C. Development of proso millet is linked with temperature using Growing Degree Days (GDD) (Tonapi *et al*., 2015).

The amount of land under millet cultivation is rapidly diminishing. The COVID-19 pandemic has shown the fragility and frailty of our current food system. A millet-based agricultural system is unavoidable due to its high nutritious value and ability to grow in a wide range of climatic conditions. Optimum sowing time and selection of improved cultivars play a remarkable role in exploiting the yield potential of crops under particular agro-climatic conditions. It governs the crop phenological development and the efficient conversion of biomass into economic yield.

Growing suitable varieties at an appropriate time is essential for ensuring optimum crop productivity. Temperature is an important environmental factor influencing the growth and development of crop plants. It influences crop phenology and yield (Bishnoi *et al*., 1995). Sowing of proso millet at an optimum time ensures a better harmony among soil, plant and atmospheric system. The variation in sowing time brings out varied plant environment interaction, which determines the efficiency of inherent physiological processes and ultimately the crop yield.

MATERIAL AND METHODS

This field experiment was carried out during *Kharif,* 2021 in Dryland Farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University which falls under the Southern Agro-climatic Zone of Andhra Pradesh and is geographically situated at 13.5 °N latitude, 79.5 °E longitude, with an altitude of 182.9 m above the mean sea level. Three dates of sowing *i.e.,* first fortnight of June (I FN) (D_1), second fortnight of June (II FN) (D_2) and first fortnight of July (I FN) (D_3) and three varieties *i.e.,* CO 5 (V_1), TNAU 202 (V_2)

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and GPUP 8 (V_3). The experiment was conducted in spilt plot design with three replications. The soil of the experimental plot was sandy loam in texture, neutral in pH, medium in organic carbon content, low in available nitrogen. The weekly mean maximum temperature during the crop growth period ranged from 30.82°C to 37.13°C, with an average of 33.98°C. The weekly mean minimum temperature during the crop period ranged from 22.07 °C to 26.53°C, with an average of 23.91°C. The weekly mean relative humidity during the crop growth period ranged from 52.5 to 80.0 per cent with an average of 69.77 per cent. During the crop growth period 997.36 mm of rainfall was received in 34 rainy days. Mean bright sunshine hours during the crop growth period ranged from 0.7 to 10.50 h day^{-1} with an average of 4.5 h day^{-1}. Seed rate at the rate of 10 kg ha^{-1} was taken by mixing with sand and were placed at 2 cm depth in an open furrow and covered thoroughly. The spacing adopted was 22.5 cm × 10 cm.

Data on weather parameters *viz.,* Temperature (Maximum and Minimum) (°C), Relative Humidity (%), Rainfall (mm), Evaporation (mm) and Bright sunshine hours (hours day^{-1}) are collected. Based on the above observations, the following Agrometeorological indices like Growing Degree Days (GDD), Photo Thermal Units (PTU) and Heat Use Efficiency (HUE) were computed during different phases of proso millet by adopting the procedure given by Rajput (1980). GDD was expressed in terms of °C day.

$$\text{GDD (°C)} = \sum\left(\frac{T_{max} + T_{min}}{2}\right) - T_b$$

where,

T_{max} = maximum temperature (°C)

T_{min} = minimum temperature (°C) and

T_b = Base temperature = 10°C (Narcico *et al.,* 1992).

The accumulated PTU was determined by the following formula (Monteith, 1984).

The unit of PTU is °C day hr.

$$\text{PTU} = \text{GDD} \times \text{Day length (hrs)}$$

where, day length refers to the maximum possible sunshine hours.

Heat Use Efficiency (HUE) for economic yield *i.e.,* grain yield, (kg ha^{-1}) was calculated using the following formula. The unit of it is kg ha^{-1}°C day^{-1}.

$$\text{HUE} = \frac{\text{Grain yield}}{\text{GDD}}$$

RESULTS AND DISCUSSION

The grain yield as influenced by dates of sowing varied significantly according to the statistical analysis. The variety sown during the II FN of June (D_2) gave significantly higher grain yield of 2059.3 kg ha^{-1}, followed by the I FN of June of 1581.7 kg ha^{-1}. However, the lowest grain yield was recorded in I FN of July (D_3) (1254.3 kg ha^{-1}) which is 39 per cent less compared with II FN of June (D_2) sowing.

The higher yield values in II FN of June (D_2) could be attributed to optimum environmental conditions for the growth and development of the crop which might enhance the accumulation of photosynthates from source to sink.

Sowing of proso millet on optimum date *i.e.,* II FN of June had resulted in better development of source in the form of dry matter accumulation which contributed to the higher grain yield and good seed set is favored by warm weather prevailed during its maturity. Similar results were reported by Maurya *et al.* (2016).

The higher straw yield of 2909.6 kg ha^{-1} was registered with CO 5 which was significantly superior to the other varieties. The next best was TNAU 202 (2661.1 kg ha^{-1}) and the lower straw yield of 2496.8 kg ha^{-1} was recorded by GPUP 8 and higher straw yield of 3044.5 kg ha^{-1} was obtained when sown during II FN of June and the least was observed in the crop sown on the I FN of July of 2442.2 kg ha^{-1}.

The delayed sowing may hasten the crop phenological development, thereby causing a significant reduction in crop yields. The I FN of July sown crops attained 50 percent flowering earlier than the others. The combined effect of all the growth and yield parameters resulted in increased above- ground biomass yield and grain yield in the II FN of June. Because early sowing increases the length of the growing period that plant might take advantage as favorable growing conditions and accumulates biomass as the highest yields generally result where the growing season is longest.

There was significant difference in total dry matter production with different dates of sowing. The crop

Table 1. Influence of staggered sowing on grain and straw yield, monetary returns and agro climatic indices of proso millet varieties

Treatments	Straw yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Gross returns	Net returns	GDD (°C)	PTU (°C^{-1} day^{-1} hr^{-1})	HUE (kg ha^{-1} °C^{-1} day^{-1}
Dates of Sowing (D)							
D_1 : I fortnight of June	2580.9	1581.7	56685	33165	1542	19281	7937
D_2 : II fortnight of June	3044.5	2059.3	73620	50100	1520	18740	7612
D_3 : I fortnight of July	2442.2	1254.3	45122	21602	1465	17907	7326
SEm ±	54.86	43.69	1208.17	714.98	14.98	261.76	104.40
CD(P = 0.05)	215.40	171.54	4743.88	2807.35	58.80	1027.81	409.92
Varieties (V)							
D_1 : I FN of June	2909.6	1989.0	71069	47549	1426	17635	7255
D_2 : II FN of June	2661.1	1575.3	56500	32980	1459	18097	7426
D_3 : I FN of July	2496.8	1331.7	47858	24338	1641	20197	8194
SEm ±	74.63	54.02	1172.79	799.97	20.21	280.06	117.01
CD(P = 0.05)	229.95	166.45	3613.72	2464.94	62.28	862.95	360.55

sown on the II FN of June recorded the highest dry matter accumulation of 452.3 g m^{-2} and the lowest value (376.1 g m^{-2}) was recorded in the I FN of July at harvest. Moreover, congenial climatic conditions during the first and second dates of sowing are reflected in higher dry matter accumulation. These findings were substantiated by those reported by Deshmukh *et al*. (2013).

The total dry matter production of plant^{-1} differed significantly by the different varieties at all the stages of crop growth as mentioned in the Table 2. The variety V_1 (CO 5) recorded significantly the highest dry matter (429.4 g m^{-2}) followed by V_2 (TNAU 202) and V_3 (GPUP 8) with 414.1 g m^{-2} and 397.3 g m^{-2} respectively. The superiority in dry matter accumulation of CO 5 variety over other two varieties might be due to a high source-sink relationship. The results were corroborative with the findings of Triveni *et al*. (2018) and Raundal and Vidya (2017). This might be due to the early sown crop may receive favorable climatic conditions in terms of temperature and other climatic parameters during various crop growth stages.

Gross returns were higher with the crop sown on the II FN of June (D_2) (73620 ₹ ha^{-1}) which was significantly higher than the crop sown on the I FN of June (D_1) (56685 ₹ ha^{-1}). The lowest was obtained in the last sown one (D_3) (45122 ₹ ha^{-1}) which is 39 per cent less than the highest one. The results were similar to the findings of Detroja *et al*. (2018).

Regarding the varieties tested, higher gross returns were realized with CO 5(V_1) (71069 ₹ ha^{-1}) which was significantly superior to the remaining other varieties. The next best variety was TNAU 202 (V_2) (56500 ₹ ha^{-1}) and the latter variety GPUP 8 (V_3) (47858 ₹ ha^{-1}) registered the lower returns. It might be due to the potential of different varieties.

The highest net returns were obtained with proso millet sown during II FN of June (D_2) (50100 ₹ ha^{-1}) followed by I FN of June (D_1) (33165 ₹ ha^{-1}), while the lower net returns was obtained under July I FN (D_3) (21602 ₹ ha^{-1}) sowing.

Table 2. Influence of staggered sowing on dry matter (g) of proso millet varieties

Treatments	Dry matter (g m^{-2})			
	20 DAS	**40 DAS**	**60 DAS**	**At Harvest**
Dates of sowing (D)				
D_1 : I fortnight of June	7.8	151.4	322.3	412.5
D_2 : II fortnight of June	8.1	176.6	368.4	452.3
D_3 : I fortnight of July	6.9	140.6	301.2	376.1
SEm ±	0.17	2.09	6.63	8.61
CD (P=0.05)	0.66	8.20	26.02	33.80
Varieties (V)				
D_1 : I FN of June	8.3	161.5	337.7	429.4
D_2 : II FN of June	7.3	156.9	331.2	414.1
D_3 : I FN of July	7.0	150.3	323.1	397.3
SEm ±	0.16	2.84	3.69	6.29
CD (P=0.05)	0.48	8.74	11.37	19.4

The optimum time of sowing and favorable weather conditions might have led to a proportionate increase in growth parameters like dry matter production, leaf area index, etc. These results corroborate the findings of Nigade *et al*. (2020)

The data presented in the Table 1 revealed that the GDD reported during I FN of June (D_1) was 1542 °C which was however comparable with II FN of June (D_2) of 1520 °C. The crop sown during I FN of July (D_3) recorded the lower number of growing degree days of 1465 °C throughout its life cycle. D_1 sown crop required more number of days to attain various growth stages. This is due to the existence of favorable conditions for crop growth and development. This is because the GDD which is the function of temperature in turn is a function of bright sunshine hours. The results are in close agreement with the findings of Londhe *et al.* (2020).

Among the different varieties of proso millet, the variety GPUP 8 registered the maximum number of growing degree days 1641°C. The mean heat unit requirement for the variety TNAU 202 was 1459°C. The minimum number of growing degree days was taken by the variety CO 5 (1426°C). The GPUP 8 exhibited the highest growing degree days as it is exposed to the sun for more period than the other two varieties.

The data presented in the Table 1 revealed that a significantly higher number of photothermal units reported during I FN of June (D_1) was 19281°C day hr which was followed by II FN of June (D_2) of 18740°C day hr. The crop sown during I FN of July (D_3) recorded the lower number of photothermal units of 17907°C day hr. This might be due to the presence of cloudiness, lower temperature and lower sunshine hours for more days under the timely sown condition in comparison to late sown crops. Similar results are reported by Chakravarty and Sastry (1983).

Among the different varieties of proso millet, the variety GPUP 8 registered the maximum number of photothermal units of 20197°C day hr. The photothermal units required for the variety TNAU 202 was 18097°C day hr. The minimum numbers were taken by the variety CO 5 (17635°C).

The data presented in the Table 1 revealed that a significantly highest heat use efficiency was reported during I FN of June (D_1) was 7937 kg ha^{-1} °C^{-1} day^{-1} which was followed by II FN of June (D_2) of 7612 kg ha^{-1} °C^{-1} day^{-1}. The crop sown during I FN of July (D_3) recorded a lower heat use efficiency of 7326 kg ha^{-1} °C^{-1} day^{-1}. HUE value decreased correspondingly with each delay in sowing. This is in conformity with results reported by Girijesh *et al*. (2011).

Generally higher HUE is attributed to the higher yield but slight variations are noted. As the temperature was optimum throughout the growing period, it utilized heat more efficiently and increased biological activity. In contrast, low temperature and higher duration hampered normal biological activities resulting in lower yield as well as lower HUE. A similar relationship was also expressed by Thavaprakaash *et al*. (2007).

Based on the investigation of suitable varieties and dates of sowing, it can be concluded that the June II FN sowed was found to be the optimum time of sowing for proso millet in the southern agro-climatic zone of Andhra Pradesh, with the highest grain yield across all the genotypes.

All the varieties shows decreased grain yield on the late dates of sowing. A greater reduction in yield at the third date of sowing in GPUP 8 (59.00%) compared with the CO 5 on the second date of sowing. Among the genotypes tested CO 5 (V_1) was found to be best followed by TNAU 202 (V_2).

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