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***Short Communication***

# Thermal requirement of pearl millet varieties in Saurashtra region

**H. M. BHUVA and A. C. DETROJA**

*Pearl millet Research Station, Department of Agronomy,Junagadh Agricultural University, Jamnagar, Gujarat 361006*

*Corresponding author E-mail: hasmukhbhuva@gmail.com*

Pearl millet (*Pennisetum glaucum* L.) is a staple food grain crop of the arid and semi-arid regions of India. It is one of the important cereal crops globally after rice, wheat and maize(DES, 2016). InIndia, pearl millet occupies an area of 7.32 million hectares producing 9.18 million tones with productivity of 1255 kgha$^{-1}$. In Gujarat, it is cultivated over an area of 0.46 million hectares with a production and productivity of 0.77 million tones and 1677 kgha$^{-1}$ respectively (DES, 2016).Being a $C_4$ crop, it utilizes high temperature and solar radiation more efficiently. It can be very well fitted in cropping system with limited irrigation facilities. Under changing climate scenario, pearl millet being a drought-hardy crop will play an important role in food, feed and fodder security of the Indian population. Pearl millet development begins at a base temperature around 12ºC, an optimum temperature between 30-35 ºC and a lethal temperature around 45 ºC. The base temperature has been shown to be fairly constant regardless of the stage of development (Ong, 1983).The effect of temperature on the length of plant growth cycle, especially the grain filling phase is the most important factor in explaining the reduced yields at warmer temperatures (White and Reynolds, 2003).Temperature based agro-meteorological indices such as growing degree day (GDD), helio-thermo unit (HTU) and photo-thermal unit (PTU) can be quite useful in predicting growth and crop yield (Prakash *et al.,*2017).Therefore, an experiment was planned to determine the phenology and heat unit requirement of pearl millet varieties under different crop growing environment of Saurashtra region.

A field experiment was conducted during the summer seasons of 2011 to 2013, to find out the thermal requirement of pearl millet varieties at Pearl millet Research Station, Junagadh Agricultural University, Jamnagar (22º47' N, 70º07' E, 18.00 m above the mean sea level), Gujarat.The climate of this region is semi-arid and sub-tropical with fairly dry and hot summer. Treatments consisting of 3 sowing dates (15$^{th}$February, 2$^{nd}$ March and 17$^{th}$March) as main plot and 3 pearl millet varieties (GHB 558, GHB 538 and Proagro 9444) as subplot were replicated thrice in a split plot design. The sowing was done manually in rows at 60 cm spacing with 4-6 cm depth. The excess plants were thinned out at 20 days after sowing (DAS) keeping within row distance at 10 cm maintaining uniform plant stand. Recommended package and practices were followed for the crop. The gross and net plot size was 5.0 x 3.6 m and 4.0 x 2.4 m respectively. Irrigations were scheduled as and when required.

Weather data were collected from the agro-meteorological observatory Jamnagar. Agro-meteorological indices, viz.growing degree days (GDD), helio-thermal unit (HTU), photo-thermal unit (PTU),pheno-thermal index (PTI) and heat-use efficiency (HUE) were computed by adopting procedure laid out by Sahu *et al., (*2007).The equations are as under.

GDD (°C day) = $\sum(\text{Tmax} + \text{Tmin})/2) - \text{Tb}$

Where, Tmax: Daily maximum temp. (°C)

Tmin: Daily minimum temp. (°C)

Tb: base temp. taken as 12°C for pearl millet

HTU (°C day hrs) =GDD x BSS

Where, BSS: Bright sunshine hours

PTU (°C day hrs) = GDD x L

Where, L: Maximum possible day length hours

PTI (°C day$^{-1}$day) = Growing degree days/ No. of days taken between two pheno-phases

HUE (kg ha$^{-1}$ °C day$^{-1}$) = Grain yield/ Accumulated GDDs

Data were analyzed with analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984).Treatments were compared by computing the F-test. The significant differences between treatments were compared pare wise by critical difference at the 5 per cent level of probability.

### *Grain and biological yield*

Pearlmillet grain and biological yields were significantly impressed due to different sowing time and varieties (Table 1). Significantly the highest grain and biological yields were recorded with 15 February sowing

**Table 1:** Effect of sowing time and varieties on yield, days to flowering and maturity, growing degree days (GDD), helio-thermal unit (HTU), photo-thermal unit (PTU) pheno-thermal index(PTI) and heat use efficiency (HUE) of pearl millet(Pooled data of three years)

| Treatment | Grain yield ($kg ha^{-1}$) | Biological yield ($kg ha^{-1}$) | Days to flowering | Days to maturity | GDD (ºC day) | HTU (ºC day hrs) | PTU (ºC day hrs) | PTI (ºC day $day^{-1}$) | HUE ($kg ha^{-1}$ ºC $day^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| **Sowing date** | | | | | | | | | |
| 15th February | 4084 | 11476 | 55.9 | 98.5 | 2155 | 13793 | 16248 | 21.88 | 1.89 |
| 2nd March | 3716 | 10387 | 54.3 | 93.2 | 2072 | 13322 | 15706 | 22.23 | 1.79 |
| 17th March | 3137 | 9136 | 50.6 | 87.9 | 2006 | 12958 | 15303 | 22.82 | 1.56 |
| SEm± | 85 | 206 | 0.6 | 0.9 | 17 | 51 | 77 | 0.12 | 0.03 |
| CD (P=0.05) | 261 | 635 | 1.8 | 2.8 | 52 | 157 | 236 | 0.38 | 0.09 |
| **Varieties** | | | | | | | | | |
| GHB 558 | 3425 | 9621 | 52.6 | 93.1 | 2057 | 13121 | 15463 | 22.09 | 1.67 |
| GHB 538 | 3755 | 10125 | 52.0 | 89.3 | 1963 | 12680 | 15051 | 21.98 | 1.91 |
| Proagro 9444 | 3757 | 11253 | 56.2 | 97.2 | 2213 | 14275 | 16745 | 22.77 | 1.70 |
| SEm± | 81 | 194 | 0.5 | 0.8 | 16 | 47 | 72 | 0.11 | 0.03 |
| CD (P=0.05) | 232 | 556 | 1.4 | 2.3 | 46 | 136 | 206 | 0.32 | 0.09 |

which can be ascribed to favourable environmental conditions at all pheno-phases, which resulted in better development of yield attributing traits such as effective tillers, earhead length, earhead girth and test weight, than later sowing dates.The prolonged reproductive period of crop sown on 15thFebruary (42.6 days) over 2ndMarch (38.9 days) and 17th March (37.3 days) also ensured proper development of grain and consequently in achieving higher pearl millet grain yield.Sahu *et al.,* (2007) found that delayed sowing hastened the crop phonological development, thereby causing significant reduction in crop yields.Prakash *et al.,* (2017), Gupta *et al.,* (2017) and Palasaniya *et al.,* (2016) also reported the similar observation under delayed sowing. Higher temperature at flowering stage inhibited pollen germination and pollen-tube growth and resulted in poor seed setting and lower grain yield (Ram *et al.,* 2012).

The variety 'Proagro 9444' recorded the highest grain and biological yield which was statistically on par with 'GHB538' but was significantly higher than GHB 558 (Table 1).Maurya *et al.,* (2016) also observed differences in pearl millet grain yield while working in *kharif* season with different varieties. The higher grain yield with 'Proagro 9444' and 'GHB 538' was due to better expression of yield attributing characters which led towards an increase in grain yield. The interaction effect between dates of sowing and pearlmillet varieties was found to be non-significant.

***Days to flowering and maturity***

Sowing dates and different varieties had significant differences in days to 50 per cent flowering and maturity (Table 1). The crop sown on 15thFebruary took significantly higher number of days to 50 per cent flowering and maturity than that of 2nd March and 17th March dates of sowing.The late sown crop completed its life cycle at an accelerated pace, leading to shortening of days taken to flowering and maturity.The reproductive period was also shortened due to late sowing. In different varieties, 'GHB 538' and 'GHB 558' being statistically at par took significantly fewer number of days to 50 per cent flowering over 'Proagro 9444' while, significantly the minimum maturity days was noted with 'GHB 538'.

***Thermal units***

Growing degree days (GDD) were found to differ significantly at maturity due to dates of sowing (Table 1). Growing degree days required at maturity reduced with delayed sowing. Gupta *et al.,* (2017) also reported lower consumption of heat units under delayed sowing. The requirement of GDD was higher for normal growing condition than the late growing condition. This was due to longer period for all the phenological stages in the normal growing condition. Late sowing decreased the duration of phenology as compared to normal sowing due to fluctuated unfavourable high temperature during the growing period. So, the requirement of heat units decreased with late sowing. Variety 'GHB 538' recorded lowest GDD at maturity stage. Significantly the maximum GDD at maturity was recorded with 'Proagro 9444'.

The helio-thermal unit (HTU) and photothermal units (PTU) also showed similar trends as that of GDD (Table1). Whereas, photo thermal index (PTI) was found to have reverse trends ie. Significantly higher value of PTI was found in 17$^{th}$March sown crop at maturity.Among different varieties, PTI values in 'Proagro 9444' were significantly higher than 'GHB 558' and 'GHB 538' at harvest. It might be due to long duration of these varieties. However, 'GHB 558' and 'GHB 538' were recorded at par results of PTI at harvest (Table 1).

***Heat use efficiency (HUE)***

The 15$^{th}$ February sowing pearl millet crop recorded significantly the highest HUE (1.89 kg ha$^{-1}$ $^{o}$C day$^{-1}$), while lowest (1.56 kg ha$^{-1}$ $^{o}$C day$^{-1}$) was noted on 17$^{th}$March sown crop. Among the varieties, 'GHB 538' recorded significantly the maximum HUE (1.91 kg ha$^{-1}$ $^{o}$C day$^{-1}$) over 'Proagro 4999' (1.70 kg ha$^{-1}$ $^{o}$C day$^{-1}$) and 'GHB 558' (1.67 kg ha$^{-1}$ $^{o}$C day$^{-1}$).The higher heat use efficiency with variety 'GHB 538'was mainly due to its lowest heat unit required for maturity. These results are in agreement with the results of Gupta *et al.* (2017).

Thus it can be concluded that the early sown (15$^{th}$February) pearl millet recorded maximum calendar days, heat units and heat use efficiency at maturity which reduced significantly with subsequent delay in sowingtime. Pearl millet variety 'Proagro 9444' recorded the highest grain yield which was statistically comparable with 'GHB 538' and took the highest calendar days, heat units and heat use efficiency as compared to all other varieties.

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