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***Short communication***

# Thermal time requirement and heat use efficiency in wheat crop in Bihar

**SUNIL KUMAR* and BIRENDRA KUMAR**

*Department of Agronomy*

*Bihar Agricultural University, Sabour, Bihar 284204, India*

**Corresponding author: iitsunil@gmail.com*

The sowing time of wheat is one of the most important factors that governs the crop phenological development and efficient conversion of biomass into economic yield. Normal sowing has longer growth duration which consequently provides an opportunity to accumulate more biomass as compared to late sowing and henceforth manifested in higher grain and biological yield (Singh and Pal, 2003). Whereas in case of delayed sowing, the wheat crop is exposed to sub-optimal temperature at establishment and supra-optimal temperature at reproductive phases that lead to forced maturity and reduction in grain yield (Sardana *et al.,* 1999).

The total heat and radiant energy available to any crop is never completely converted to dry matter and grain yield depends upon genetic factors, sowing time and crop type (Rao *et al.,* 1999). The concepts of heat growing degree days are based on the concept that real time to attain a phenological stage is linearly related to optimum temperature (Monteith, 1981). Influence of temperature on phenology and yield of crop plants can be studied under field condition through accumulated heat units system (Bishnoi *et al.,* 1995). Under North Indian condition, the maturity of wheat hastened due to gradual rise in ambient temperature under delayed sowing. Among the various inputs, water and fertilizer (nutrients) are two most important inputs which contribute to wheat productivity (Lenka *et al.,* 2009). Keeping this in view, an attempt was made to know the phenology and heat unit requirement of promising wheat variety under different irrigation condition under different crop growing environment in Bihar.

Field experiments were conducted during rabi (winter) 2010-2011 and 2011-2012 at the experimental farm of Bihar Agricultural University, Sabour, India ($25^0$ 24' N, latitude and$87^0$ 04'E, longitude at a height of 43 m above the mean sea level) with wheat (T. aestivum, L.) cultivar K-9107 (timely sown) & DBW-14 (late sown). The climate is subtropical humid with warm summer and dry winter. The soil is sandy loam in texture, neutral in reaction, low in available nitrogen, medium in phosphorous and available potassium.

The experiment was laid out in split plot design with date of sowing as the main plot and irrigation levels as sub plot factors, replicated three times. The net plot size was 5.0 x 2.0 m. The experiment was sown for nine dates of sowing- 15 November, 22 November, 29 November, 06 December (normal sowing date in the region) and 13 December, 20 December, 27 December, 03 January, 10 January (late sowing date in the region). All the cultural operations and plant protection measures were followed as per recommendations contained in package of practices for the crop.

Growing degree days (GDD) and heat use efficiency (HUE) were computed. The base temperature of 4.5 $^0$C was used for computation of GDD on daily basis (Leong and Ong, 1983). The agro-meteorological indices were computed using the daily meteorological data. The days to complete different phenological stages and the maturity stage were recorded. Heat use efficiency (HUE), which is a measure of amount of dry matter or grain yield produced per unit of GDD, was worked out as per procedures reported by Sahu *et al.* (2007).

The grain yields were differed significantly within different sowing dates under different irrigation conditions. The crop sown on November 15 recorded the highest grain yield which was due to higher yield attributes and GDD. The significant reduction in grain yield was recorded when sowing was delayed beyond November 15. It was significantly higher than other sowing dates. The higher value of yield in case of early sowing over delayed ones could be attributed to availability of optimum environmental conditions for growth and development of crop which might enhance accumulation of photosynthates from source to sink. The grain yield decreased continuously

**Table 1:** Effect of sowing time and irrigation on growing degree days (GDD), heat use efficiency (HUE) and grain yield at different phenophases (pooled data of two years)

| Treatments | GDD ($^0$Cday) | | HUE (kg $^0$Cday$^{-1}$) | | Grain yield(q ha$^{-1}$) |
|---|---|---|---|---|---|
| | Ear emergence | Maturity | Biomass | Grain | |
| **Sowing dates** | | | | | |
| Nov 15 | 1075.4 | 1738.9 | 5.45 | 2.62 | 45.83 |
| Nov 22 | 1045.8 | 1725.0 | 5.26 | 2.45 | 43.83 |
| Nov 29 | 1012.1 | 1706.4 | 5.05 | 2.36 | 40.87 |
| Dec 6 | 996.8 | 1693.2 | 4.98 | 2.20 | 39.49 |
| Dec 13 | 981.9 | 1675.8 | 4.81 | 2.13 | 38.74 |
| Dec 20 | 966.1 | 1661.5 | 4.32 | 2.04 | 35.83 |
| Dec 27 | 942.3 | 1646.2 | 4.27 | 1.81 | 33.12 |
| Jan 3 | 932.0 | 1633.3 | 4.22 | 1.75 | 28.70 |
| Jan 10 | 91 4.0 | 1606.0 | 4.05 | 1.70 | 28.67 |
| CD (5%) | 15.4* | 18.8* | 0.15* | 0.09* | 0.53* |
| SEm± | 5.14 | 6.27 | 0.07 | 0.04 | 0.17 |
| **Irrigation at** | | | | | |
| CRI | 995.4 | 1585.0 | 4.46 | 1.97 | 32.28 |
| CRI & flowering | 1092.4 | 1634.6 | 4.61 | 2.17 | 36.16 |
| CRI, boot & milking | 1109.9 | 1683.9 | 4.84 | 2.31 | 38.93 |
| CRI, tillering, boot & milking | 1144.5 | 1739.3 | 4.94 | 2.41 | 41.60 |
| CD (5 %) | NS | 15.9* | 0.04* | 0.02* | 0.45* |
| SEm± | 5.08 | 5.6 | 0.05 | 0.03 | 0.15 |

* Significant at 5% NS: Non Significant

for late sowing and with one to three irrigations at different stages. The greater reduction in yield of wheat crop under delayed sowing situation was attributed to decrease in season length might have an effect by reduction in its potential yield. Delayed sowing hastened the crop phonological development, thereby causing significant reduction in wheat yields (Singh and Pal, 2003).

Under different irrigation treatments, the highest grain yield was recorded in four irrigation (at CRI, tillering, boot & milking stage) applied crop, which was significantly higher than less no. of irrigated crop at different phenophases. The grain yield was lowest for one irrigation applied crop at CRI stage. Grain yield was significantly influenced by no. of irrigation and application of irrigation at different growth stages. Irrigation at CRI stage is life saving irrigation but irrigation at tillering, boot and milking stage, increases the yield attributes and more no. of grain filling.

The growing degree days (GDD) ranged from 914.0 to 1075.4 across the sowing dates for ear emergence stage and 1606.0 to 1738.9 across different no. of irrigation at different phenophases for maturity stage. The growing degree days were found to be significant both at ear emergence and maturity of different dates of sowing (Table 1). Significantly higher growing degree days from sowing to ear emergence and sowing to maturity were recorded in November 15 date of sowing. GDD required for ear emergence and maturity reduced with delayed sowing. The requirement of GDD was higher for normal growing condition than late growing condition. This was due to longer period for all phenological stages in the normal growing condition. Late sowing decreased the duration of phenological stages as compared to normal sowing due to fluctuated unfavorable high temperature during growing period.

GDD from sowing to maturity was significantly higher for four No. of irrigated crop than less no. of irrigation treatments. It shows that irrigation has significant effect on duration of the growth stages and GDD. But the result was non significant for sowing to ear emergence.

Crop sown on November 15 showed significantly higher heat use efficiency of 5.45 kg $^0$C day$^{-1}$ and 2.62 kg $^0$C day$^{-1}$ for biomass and grain (Table 1). The heat use efficiency was decreased with delay in sowing. Higher heat use efficiency in timely sowing could be attributed to the highest grain yield. As the temperature was optimum throughout the growing period crop utilized heat more efficiently and increased biological activity that confirms higher yield. Similar relationship was also expressed by Rajput *et al.* (1987), in different dates of sowing. The grain and biomass yield heat use efficiency differed significantly and found more in case of four no. of irrigated crop (4.94 kg $^0$C day$^{-1}$ and 2.41 kg $^0$C day$^{-1}$) compared to less no. of irrigated crop. It indicates that heat use efficiency (HUE) is influenced by no. of irrigation at different stages. It was due to more biomass production.

The crop sown on November 15 required maximum growing degree days, for ear emergence and maturity which was reduced significantly with subsequent delay in sowing time and recorded highest for November 15 and lowest for January 10 sown crop. Timely sown crop at November 15 recorded significantly higher grain and biomass yield. Crop with four no. of irrigation at CRI, tillering, boot and milking stage recoded highest yield (grain and biomass). It also took maximum GDD, and showed significantly higher heat use efficiency than crop with less no. of irrigation.

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