



Performance of wheat (*Triticum aestivum*) varieties under different thermal regimes and N-levels

VIKAS GUPTA*, MEENAKSHI GUPTA, RAJEEV BHARAT, MAHENDER SINGH and
B C SHARMA

*Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha,
Jammu and Kashmir 180 009, India*

Received: 28 January 2019; Accepted: 14 January 2020

ABSTRACT

Present study was carried out during *rabi* 2015-16 and 2016-17 at SKUAST-Jammu to evaluate the performance of different varieties of wheat (*Triticum aestivum* L.) under thermal regimes and N-levels in terms of agrometeorological indices like accumulated growing degree days (AGDD), heliothermal units (AHTU), photothermal units (PTU), heat use efficiencies (HUE) of grain and biological yields. The treatments comprised of three wheat varieties (HD 2967, RSP 561 and WH 1105) planted in three sowing environments 25th October (early), 14th November and 4th December with three levels of nitrogen (100, 125 and 150 kg/ha) in split split plot design. Among the varieties, WH 1105 recorded significantly higher AGDD, AHTU, PTU and HUE than HD 2967 and RSP 561. Early sowing (25th October) of wheat also recorded higher AGDD, HTU, PTU and HUE values and grain and biological yield HUE than normal (14th November) and late sowing (4th December) environments. Delayed planting resulted in the reduction of accumulation of thermal indices along with HUE. Fifty kg higher nitrogen (150 kg/ha) than recommended dose (100 kg/ha) exhibited higher agrometeorological indices values along with higher HUEs. The relationship between grain and biological yield with AGDD and HUE was highly significant during both the years under experimentation.

Key words: AGDD, AHTU, APTU, HUE, Nitrogen, Sowing environment

Wheat (*Triticum aestivum* L.) is the second most important cereal crop in the world after rice and globally cultivated on an area of 224.72 mha with production and productivity of 734.62 MT and 3.27 t/ha, respectively (Anonymous 2016). In India, it is cultivated in about 30.60 mha with the production of 98.38 MT and productivity of 3.22 t/ha (Anonymous 2017). However, in J&K UT, it is 0.32 mha with production and productivity of 0.50 MT and 1.5 t/ha, respectively (Anonymous 2016a). Adequate growth and augmentation of crop could be obtained by adjusting the sowing environments which leads to better yield; as perfect sowing environment exploits the full genetic potential of a particular variety by providing optimum growth conditions such as temperature, light, humidity and rainfall. The research concerning the relationship between weather parameters and wheat yields is growing rapidly; exploit the role of temperature to determine yields (Tacka *et al.* 2015). Phenological development from sowing to maturity is related to accumulation of heat or temperature units above threshold or base temperature. Growing a suitable variety

at an appropriate time is essential for ensuring optimum productivity. The optimum sowing time and selection of improved varieties play a remarkable role in exploiting the yield potential of the crop under particular agro climatic condition. The accumulated temperature is considered as the principal factor affecting year-to-year variation in phenology. In general, increasing temperatures accelerate phenological development by reducing growth period. GDD also changes with growing stage and permits to estimate the exact time of occurring growth stage at particular location and ultimately effect the grain yield (Sourour *et al.* 2016).

Delay in sowing shortened the development phases of wheat which adversely affected the grain development and thus the grain yield (Suleiman *et al.* 2014). Hence, it becomes imperative to have knowledge of the exact duration of phenological stages in a particular crop-growing environment. Therefore, an experiment was conducted to determine the phenology and heat unit requirement of wheat varieties under different temperature regimes, nitrogen levels and post anthesis strategy.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2015-16 and 2016-17 at research farm of Agromet Research Centre, SKUAST-Jammu (Latitude 32°39' N, longitude 74°58' E

*Corresponding author e-mail: vikasadr@gmail.com

and altitude 332 m amsl). Three wheat varieties HD 2967, RSP 561 and WH 1105 were sown under three sowing environments 25th October (early), 14 November (normal) and 4th December (late) with three nitrogen levels (100, 125 and 150 kg/ha) and replicated thrice. The experiment was conducted in split split plot design. Half of the nitrogen along with full dose of phosphorus and potassium was applied at the time of sowing as basal dose. The remaining half of nitrogen was top dressed in two equal splits, i.e. at CRI stage and before booting of wheat crop. The recommended dose of P and K was 50:25 kg/ha for wheat crop (as per package and practices of SKUAST-J) and the sources for nitrogen, phosphorus and potassium were urea, diammonium phosphate and muriate of potash, respectively. The agrometeorological indices like accumulated heat units (HU) was calculated by the formula given by Nuttonson (1955). Whereas, Helio thermal units (HTU) and Photothermal units (PTU) were calculated with the formula given by Rajput 1980. The treatment-wise data recorded for different crop parameters were subjected to statistical analysis according to split split design as per the procedure outlined by Cochran and Cox (1963).

RESULTS AND DISCUSSION

Growing degree days: Relationship between duration of different growth stages and temperature could be well explained through GDD or heat units. The requirement of GDD in different phenophases varied with dates of sowing. The accumulated growing degree days (AGDD) taken from CRI to anthesis and CRI to maturity of wheat varieties for different temperature regimes (sowing environments) and nitrogen levels are given in Table 1. Among the varieties, WH 1105 accumulated maximum GDD values 1010.60 and 1663.22 followed by 994.63 and 1613.17, 990.87 and 1590.07°C in HD 2967 and RSP 561 varieties for attaining anthesis and physiological maturity, respectively. In different sowing environments, AGDD for attaining anthesis and physiological maturity for early sown (25th October) wheat crop was 1085.05 and 1733.18°C followed by normal (14th November) and late (4th December) sown wheat crop. Maximum GDD was accumulated by early sown wheat at anthesis and physiological maturity in comparison to the normal and late sowings. This clearly describes the effect of temperature on phenological stage. As wheat crop grown under various thermal regimes needed specific amount of GDD to enter from one phenophase to another. Early sowing resulted in absorbing sufficient GDD in relatively more time. While late sown crop experienced higher temperature during later stage in less time. Also the late sown wheat crop faces comparatively higher maximum, minimum and mean air temperature at the later stages of growth especially reproductive stages. Pandey *et al.* (2010), Kaur *et al.* (2016) and Gupta *et al.* (2017) also reported that the requirement of heat units decreased for different phenological stages with delay in sowing.

The wheat crop supplied with higher doses of nitrogen accumulated more growing degree days for accomplishing

Table 1 Variation in accumulated growing degree days, heliothermal units and photothermal units for anthesis and maturity of wheat varieties under thermal regimes and N levels

Treatment	AGDD (°C day)						AHTU (°C day hrs)						APTU (°C day hrs)					
	2015-16			2016-17			2015-16			2016-17			2015-16			2016-17		
	Anthesis	Maturity		Anthesis	Maturity		Anthesis	Maturity		Anthesis	Maturity		Anthesis	Maturity		Anthesis	Maturity	
Varities																		
V ₁ : HD 2967	994.63	1613.27		1060.83	1681.67		5059.06	8630.13		5035.70	9224.97		10325.01	17769.53		11002.02	18504.92	
V ₂ : RSP 561	980.87	1590.07		1046.66	1657.59		4977.72	8483.36		4927.39	9087.09		10178.78	17478.83		10835.52	18213.55	
V ₃ : WH 1105	1010.60	1663.22		1095.88	1774.89		5140.89	8817.42		5190.38	9977.00		10516.95	18407.68		11389.26	19694.10	
Sowing environments																		
D ₁ : 25 th October	1085.05	1733.18		1167.01	1806.48		5332.60	9151.39		5442.13	9928.27		11142.34	18719.34		11984.31	19493.49	
D ₂ : 14 th November	1005.93	1613.72		1076.27	1658.45		5177.39	8582.59		5087.11	9535.55		10406.78	17742.41		11128.24	18835.97	
D ₃ : 4 th December	895.12	1519.67		960.09	1649.23		4667.69	8196.93		4624.22	8825.24		9471.62	17194.29		10114.26	18083.11	
Nitrogen levels																		
N ₁ : 100 kg/ha	981.59	1582.46		1053.49	1651.09		4991.85	8393.32		4971.93	8980.15		10178.97	17373.31		10914.41	18126.53	
N ₂ : 125 kg/ha	995.29	1638.27		1067.84	1724.06		5056.73	8732.10		5051.77	9583.85		10341.12	18092.56		11075.97	19047.93	
N ₃ : 150 kg/ha	1009.21	1645.84		1082.04	1739.01		5129.09	8805.49		5129.76	9725.06		10500.65	18190.18		11236.42	19238.11	

the phenophases like anthesis and maturity. The wheat crop took more number of days to complete one stage to another in 150 kg N/ha treatment because by applying more fertilizers, vegetative phase of crop got enhanced. Kaur *et al.* (2016) also found the similar results.

Heliothermal units (HTU): The accumulated heliothermal units required to attain anthesis and physiological stages differed greatly among wheat varieties under different sowing environments and nitrogen levels (Table 1). Variety WH 1105 accumulated maximum HTU (5140.89 and 8817.42°C day hrs) to attain anthesis and physiological maturity, respectively than HD 2967 and RDP 561 varieties. Among sowing environments, wheat crop sown on 25th October accumulated highest HTU (5332.60 and 9151.39°C day hours) as compared to 14th November (5177.39 and 8582.59°C day hrs) and 4th December (4667.69 and 8196.93°C day hrs) for anthesis and maturity, respectively. This might be due to more duration of sunshine hrs on 25th October than 14th November and 4th December sown crop. Among nitrogen levels, highest HTU (5129.09 and 8805.49°C day hour) were acquired in 150 kg N/ha followed by 125 and 100 kg N/ha during both seasons of study. The higher values of HTU may be due to longer duration of wheat crop in 150 kg N/ha level as compared to lower levels. The findings confirmed the results of Kaur *et al.* (2016).

Photo thermal units: Variety WH 1105 required highest PTU to accomplish anthesis and maturity in comparison to other varieties (Table 1). However, early sown crop (25th October) required PTU 11142.34 and 18719.34 °C day hrs, for anthesis and maturity stages, respectively. However, later sowing environments needed lower APTU to accomplish the same phenological stages. APTU requirement for 100

Table 2 Heat use efficiency (kg/ha/°C day) of wheat varieties under different thermal regimes and N levels

Treatment	Heat use efficiency (kg/ha/°C day)			
	Grain		Biomass	
	2015-16	2016-17	2015-16	2016-17
<i>Varieties</i>				
V ₁ : HD 2967	2.57	2.61	6.62	5.94
V ₂ : RSP 561	2.50	2.57	6.76	5.97
V ₃ : WH 1105	2.74	2.59	6.88	6.10
<i>Sowing Environments</i>				
D ₁ : 25 th October	2.71	2.69	7.15	6.26
D ₂ : 14 th November	2.67	2.82	7.01	6.23
D ₃ : 4 th December	2.43	2.27	6.10	5.52
<i>Nitrogen levels</i>				
N ₁ : 100 kg/ha	2.50	2.53	6.61	5.82
N ₂ : 125 kg/ha	2.62	2.59	6.76	6.04
N ₃ : 150 kg/ha	2.69	2.65	6.90	6.16

kg N/ha was 10914.41 and 18126.53°C day hrs for anthesis and maturity stages, respectively; however the APTU was more in 125 and 150 kg N/ha. Similar findings were also reported by Kaur *et al.* (2016) and Gupta *et al.* (2017). The higher APTU value in early sown crop may be due to fact that crop took longer duration to reach phenological stages.

Heat use efficiency: Variety WH 1105 registered highest value of heat use efficiency in comparison to HD 2967 and RSP 561. Among the sowing environments, heat use efficiency (HUE) of grain and biological yield was found to be higher for earlier sown crop and it decreased with delay in sowing (Table 2). Subsequent delay in sowing

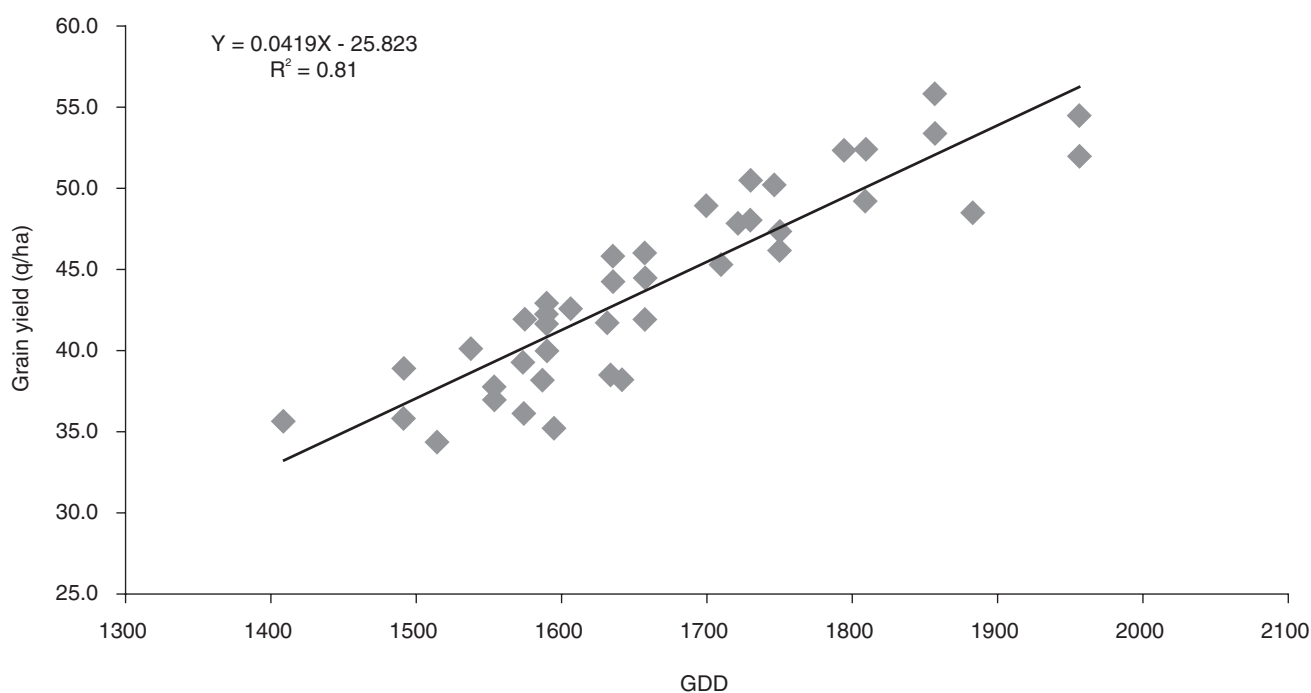


Fig 1 Relationship between grain yield and AGDD.

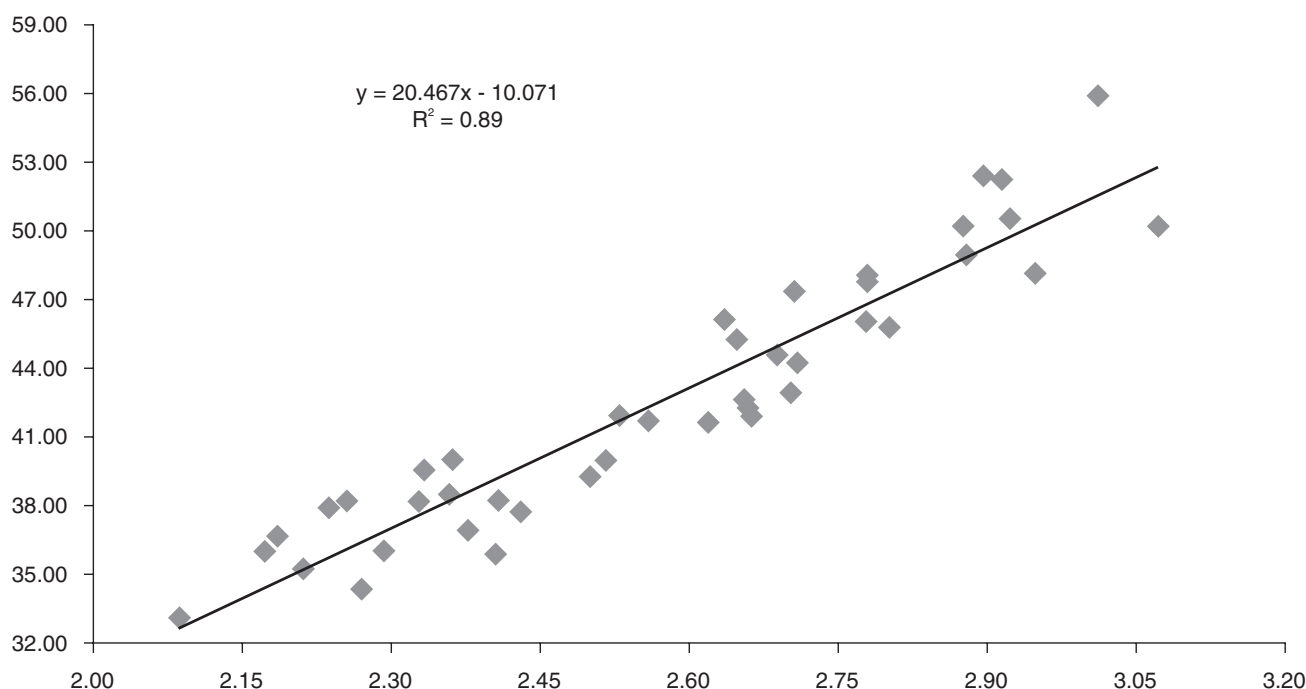


Fig 2 Relationship between grain yield and heat use efficiency.

resulted in decrease in the heat use efficiency. The early sown wheat crop seems to be essential for harnessing the good impact of prevailing weather conditions. Kumari *et al.* (2009) and Kaur *et al.* (2016) also reported that timely sown wheat crop exhibited maximum heat use efficiency. Among the nitrogen levels, the highest heat use efficiency was found in 150 kg N/ha grain as well as biological yield followed by 125 and 100 kg N/ha. The increase in nitrogen application significantly increased heat use efficiency of wheat crop. Mandic *et al.* (2015) and Pradhan *et al.* (2014) also reported that higher nitrogen application significantly resulted in higher radiation use efficiency.

Relationship of grain yield with agrometeorological indices

Grain yield and AGDD

The relationship between grain yield and accumulated growing degree days was calculated for both the *rabi* (Fig 1). A good linear relationship existed between grain yield and AGDD; which explained 81% variability. More the number of days taken by wheat crop to complete phenophase anthesis and maturity stages, the more will be grain yield. Kaur *et al.* (2016) also observed a highly significant relationship between grain yield and AGDD.

Grain yield and HUE

The relationship between grain yield and heat use efficiency for was calculated for both the *rabi* (Fig 2). A positive and linear relationship between grain yield and heat use efficiency was observed with 89% variability. Kaur *et al.* (2016) also observed a highly significant relationship between grain yield and HUE.

On the basis of two years study, it could be concluded

that wheat variety WH 1105 accumulated more GDD, AHTU and APTU sown on 25th October (early) in plains of Jammu region of J&K UT which was higher over timely and late sowings (14th November and 4th December). 25 kg more nitrogen than recommended dose could also be applied for higher accumulation of AGDD, AHTU, APTU and heat use efficiency. Because of very close relation between temperature and plant development, it is very important to derive exact information on the duration of anthesis and physiological maturity of wheat varieties under varying sowing environments and N levels.

REFERENCES

- Anonymous. 2016. The World Agriculture Production (July, 2016), United State Department of Agriculture (USDA).
- Anonymous. 2016a. Agricultural Statistics at a glance. Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics & Statistics, New Delhi.
- Anonymous. 2017. *Pocket Book of Agricultural Statistics*. Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics & Statistics, New Delhi.
- Cochran W G and Cox C M. 1963. Experimental Design. John Wiley and Sons, Inc New York.
- Gupta M, Sharma C Sharma R Gupta V and Khushu M K. 2017. Effect of sowing time on productivity and thermal utilization of mustard (*Brassica juncea*) under sub tropical irrigated conditions of Jammu. *Journal of Agrometeorology* 19(2): 137–41.
- Kaur H, Ram H Sikka R and Kaur H. 2016. Productivity, agronomic efficiency and quality of bread wheat (*Triticum aestivum* L.) cultivars in relation to nitrogen. *International Journal of Agriculture, Environment and Biotechnology* 9(1): 101–6.
- Kumari P, Wadood A Singh R S and Kumar R. 2009. Response

- of wheat crop to different hydrothermal regimes under the agroclimatic conditions of Jharkhand. *Journal of Agrometeorology* **11**: 85–8.
- Mandic V, Krnjajai V, Tomic Z, Bijelici Z, Simic A, Muslic D R and Gogic M. 2015. Nitrogen fertilizer influence on wheat yield and use efficiency under different environmental conditions. *Chilean Journal of Agricultural Research* **75**: 92–7.
- Nuttonson M Y. 1955. Wheat climate relationship and the use of phenology in ascertaining the thermal and photo thermal requirements of wheat. *Annals Crop Ecology*: 150
- Pandey I B, Pandey R K, Dwivedi D K and Singh R S. 2010. Phenology, heat unit requirement and yield of wheat varieties under different crop growing environment. *Indian Journal of Agricultural Sciences* **80**: 136–40.
- Pradhan S, Sehgal V K Sahoo R N Bandyopadhyay K K and Singh R. 2014. Yield, water, radiation and nitrogen use efficiencies of wheat (*Triticum aestivum*) as influenced by nitrogen levels in a semi-arid environment. *Indian Journal of Agronomy* **59**: 267–75.
- Rajput R P. 1980. “Response of soybean crop to climatic and soil environments”. Ph D Thesis, IARI, New Delhi, India.
- Sourour A, Afef O Nadia C H Mounir R and Mongi B Y. 2016. Relation between agro-meteorological indices, heading date and biological/grain yield of durum wheat genotypes. *Journal of Research of Agriculture and Animal Sciences* **3**: 1–6.
- Suleiman A A, Nganya J F and Ashraf M A. 2014. Effect of cultivar and sowing date on growth and yield of wheat (*Triticum aestivum* L.) in Khartoum, Sudan. *Journal of Forest Products and Industries* **3**: 198–203.
- Tacka J, Barkley B A and Lawton L N. 2015. Effect of warming temperatures on US wheat yields. *Proceedings National Academy of Sciences* **112**: 6931–6.