551.588.551.525.4 : 633.11

PHASIC DISTRIBUTION OF TOTAL HEAT UNITS IN WHEAT CULTIVARS IN INDIA

1. Accumulation of mean temperatures above a crop specific base value is called heat units (HU) and multiplication with the photoperiod is known as the photo-thermal units (PTU). The wheat crop has lent itself admirably to studies on its vegetative and reproductive durations in terms of the PTU. For practical purposes, heat units, which are easier to compute, give as good a measure of wheat development as the PTUs. In view of the envisaged increase in temperatures in the *rabi* season in the coming years on account of climate change, demand will arise for breeding of varieties with higher heat unit requirements in wheat growing regions. Evaluation of the pheno-thermal relations of the increasing number of new cultivars will be simplified, if the percentage accumulation of heat units in different phenological phases of wheat shows a similar distribution in the various zones.

2. For wheat cultivars, PTUs with a base temperature of 4.5° C for completion of the vegetative and maturity phases of wheat have been presented by Pande *et al*. (1974). The methodology and nomenclature used for delineation of the different stages of the crop do not appear to be uniform. Therefore, to carry out an examination of the above type, heat unit data for various sub-phases of growth of the wheat crop in various zones (Venkataraman and Rahi 1983*)* is the prime need. For wheat crop, the minimum (base) temperature varies growth-stage wise, of which the minimum was 3.3° C, considering all the growth stages of the crop (Kakde 1985, Kashyapi and Das 1999). Different authors have used different minimum (base) temperature for this computation. However, the data on heat units of different cultivars of wheat, accumulated above a base mean temperature of 3.3° C, for specified growth phases from sowing to harvest-maturity obtained from a number of evapotranspiration stations of India Meteorological Department (IMD), as presented by Kashyapi and Das (1999) have been analysed.

3. As a first step, the heat unit distributions at the IMD stations of Ludhiana and Jabalpur were compared with those presented by (a) Kaur *et al.* (2001) for the wheat crop at Punjab Agricultural University (PAU), Ludhiana and (b) Agarwal *et al.* (1999) for the wheat crop at Jawaharlal Nehru Krishi Vidyapeeth (JNKV), Jabalpur (Table 1). For the PAU and JNKV wheat crops, heat units had been accumulated above a base temperature of 5° C. In the range of 15 to 20° C mean temperature that prevails in the wheat belt in the *rabi* season, use of 3.3° C will utmost overestimate by 2% the distribution percentage based on 5° C. Thus, distribution percentage of heat units for various phases based on either 5° C or 3.3° C will not be affected.

The PAU wheat crop was of a longer duration (165 days) compared to 140 days duration of the IMD wheat crop. The heat unit accumulation of 2010 for the PAU crop was comparable with the value of 1930 for the IMD crop; while the distribution of percentage days were the same for the various growth stages from sowing to elongation; for the 2 crops there were differences in the distribution of heat units in the sub-stages of this phase. However, the percentage of heat units for the stages from sowing to elongation were about 40%. By reconciling the differences in nomenclature used for the sub-stages in the two papers, it was noticed that the percentage days and heat units accumulated in various phases were nearly the same for the two data sets. The JNKV crop had been sown on 3 different days. However, in the 2nd and 3rd sowings, the crops as stated by the authors, had been subjected to a temperature stress. So, data for the first sowing for the JNKV crop with a duration of 16 weeks and heat unit accumulation of 1858 was compared with the IMD crop with a duration of 19 weeks and heat unit accumulation of 2230. It was seen that the cumulative values of the distribution percentage was the same for both the crops from sowing to tillering, elongation, flowering and milk stages and dough to maturity stages.

From Table 1, the percentage distribution of stage-wise heat units were seen to show similar features for groups of stations *viz*, (a) Ludhiana and New Delhi, (b) Varanasi and Jabalpur, (c) Akola, Raipur and Jorhat, (d) Jodhpur and (e) Banswara and Bellary. Amongst the stations in groups a to d, some distinctly similar features and differences are seen. These distribution percentages with a plus or minus 1% tolerance are : (*i*) 13% in the phase from sowing to crown root initiation, (*ii*) 14% for the elongation, (*iii*) 11% for the flowering, (*iv*) 18% for the milk stage and (*v*) 13% for the dough stage. For Banswara and Bellary the differences were 16% for elongation, 16% for milk and 10% for dough stages. The combined percentage for the tillering and maturity stages was 32% at all the stations. The heat unit accumulations in the tillering phase were 15%, 17%, 19% and 21% of the total, for the a, b, c-d and e groups of stations, respectively. Thus, the increase or decrease in the accumulation percentage of the tillering phase was compensated by a corresponding decrease or increase in the phase from dough to harvest maturity.

4. To conclude, the features of similarity in the distribution, amongst the various crop stages of the total heat units, ranging from 1578 at Jorhat to 2349 at Akola is

TABLE 1

Growth stage-wise percentage distribution of heat units (HU), above a base of 3.3° C for wheat

Growth stage	Ludhiana		New Delhi		Varanasi		Jabalpur		Raipur		Akola		Jorhat		Jodhpur		Banaswara		Bellary	
	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total	HUs	% of total
Germination	82	4	83	4	98	5	97	4	98	5	102	4	73	5	102	5	104	5	119	6
Crown root initiation	155	8	161	8	148	7	202	9	156	8	205	9	115	7	176	9	162	9	173	8
Tillering	285	15	306	16	335	16	370	17	375	19	445	19	294	19	403	21	398	21	427	20
Elongation	247	13	254	13	268	12	307	14	292	14	340	14	236	15	263	13	297	16	342	17
Flowering	196	10	205	10	243	12	231	10	246	13	276	12	182	11	199	10	232	12	234	11
Milk	352	18	361	18	408	20	386	17	333	16	389	17	304	19	335	17	306	16	352	16
Dough	263	14	272	14	274	13	301	14	232	12	290	12	183	12	239	12	179	10	220	11
Maturity	353	18	333	17	312	15	337	15	260	13	302	13	191	12	252	13	210	11	231	12
Total	1933	100	1975	100	2085	100	2230	100	1991	100	2349	100	1578	100	1968	100	1889	100	2097	100

significant and gives rise to the expectation that the distribution percentage of the total heat units may be the same for all the cultivars in a homogeneous temperature zone. To ensure the above phenological data of only those sowing dates giving near maximal yields amongst the sowing date treatments, must be taken up for analysis (Venkataraman, 2004).

5. The authors are thankful to Shri S. K. Banerjee, the then DDGM (Agrimet) for providing the necessary facilities in preparation of the manuscript. They are also thankful to Mrs. S. Renuka Devi, S.A. for her assistance in preparation of the manuscript.

References

Agarwal, K. K., Shanker, U., Upadhyay, A. P. and Gupta, V. K., 1999, "Accumulated heat unit requirements for different phenophases of wheat (*Triticum aestivum)* cultivars as influenced by sowing dates of Jabalpur", *Journal of Agrometeorology*, **1**, 173-176.

Kakde, J. R., 1985, "Agricultural Climatology", Metropolitan Book Co. (P) Ltd., New Delhi, First Edn. (1985), 1-387.

Kashyapi, A. and Das, H. P., 1999, "Requirement of heat unit and agrometeorological indices in selected wheat growing zones", *Mausam*, **50**, 1, 63-70.

Kaur, G., Kler, D. S. and Singh, S., 2001, "Studies on heat unit requirement of wheat (*Triticum aestivum*) under different planting techniques at higher nitrogen nutrition", *Indian J. Environment and Ecoplanning*, **5**, 383-386.

Pande, H. K., Ravindranath, E. and Lahiri, S., 1974, "Optimum time of planting for wheat crop in acid lateritic zone", *Indian Journal of Agronomy*, **19**, 127-131.

Venkataraman, S., 2004, "Assessing degree-day requirements of phenological phases of kharif Pigeon pea", Under Publication in *Journal of Agrometeorology*.

Venkataraman, S. and Rahi, A. K., 1983, "Influence of temperature climatology on productivity of wheat crop in India", *Mausam*, **34**, 1, 81-84.

S. VENKATARAMAN*
A. KASHYAPI
H. P. DAS

India Meteorological Department, Pune, India
**59/19, Nav Sahyadri Society, Pune, India*
(*31 March 2003, Modified 30 June 2004*)