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Heat summation indices and wheat phenology in mid-hill rainfed region of Himachal Pradesh

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ABSTRACT

An investigation on various heat summation indices viz., accumulated degree-days (AGDD), accumulated helio thermal units (AHTU) and accumlated photo thermal units (APTU) in relation to phenology of wheat (*Triticum aestivaum* L. emend. Fiori & Paol) was carried our for five crop seasons for three different varieties viz., HPW-42, HPW-147 and HS-240 during 1999-2000 to 2003-2004 under rainfed conditions at CSK Himachal Pradesh Krishi Vishvadidylaya, Palampur. Itwas revealed that sowing to complete emergence and vegetative phases were difficult to predict under mind hill rainfed conditions as the coefficient of variation (C.V.) was observed to be the highest compared to other phenological stages. GDD are the best index to predict 50% grain filling and physiological maturity.

Key words: Wheat, Heat summation indices, Cumulative pan evaporation.

Wheat (*Triticum aestivum* L. emend. Fiori and Paol.) is one of the most important staple foods of India as well as Himachal Pradesh grown in diverse agro-climatic conditions from 11°N-35°N and 72° E-92°E. Wheat is thermo-sensitive long day crop extensively grown during *rabi* season in Himachal Pradesh. The duration, growth and yield are decided by the thermal and photoperiod conditions experienced by the crop during its life cycle. Information on crop phenology is ofen required for crop modeling. Growing degree-days approach is primarily used for estimating phenology of crop (Ritchie and Otter, 1985). Nuttonson (1953) reported that in many cases photo-thermal units were more stable than day degrees. Rao *et al* (1972) found that helo thermal units were good agro -climatic index to explain flowering behaviour of cowpea. McMaster and Smika (1988) reported that particular growth stage may be best predicted by one model or other using the growing degree days and photo thermal models. Sastry and Chakravarty (1982) reported the cumulative pan evaporation as the best index for predicting duration of the phase from sowing to anthesis in wheat crop. In Himachal Pradesh, research literature is meagre on energy summation indices for rainfed wheat under temperate wet conditions. Keepting this in view, an attempt was made to study the phenology of wheat crop in relation to various heat summation indices such as GDD, HTU and PTU and duration of phenophases.

MATERIALS AND METHODS

Five field experiments on wheat crop with three recommended varieties viz., HPW-42, HPW -147 and HS 240, under three sowing environments viz., early sowing (6 November), timely sowing (30 November) and late sowing (20 December) were conducted for *rabi* seasons of 1999 - 2000 to 2003 -2004 in randomized block design at university research farm at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental site is located at 1290m above mean sea level with 32°6'N and 76° 3'E. The crop was raised with all recommended agronomic and plant pprotection practices for this agro climatic region. Experiencing 10.6 to 20.8°C maximum and 5.0 to 17.9°C minimum temperatures during *rabi* season (November to May), it receives normal seasonal rainfall of 512 mm. The various phenological stages of the crop, viz., sowing, complete emergence, tillering, 50% heading, and physiological maturity were identified visually on randomly selected plants. Weather parameters were recorded at the agro-meteorological observatory located at 100 meters from the experimental farm. Growing degree days (GDD) or heat units were determined as per Nuttonson (1955)

$$GDD = [(T_{max} + T_{min})/2] - T_t$$

Where T_{max} = maximum temperature (°C), T_{min} = minimum temperature (°C) during a day and T_t = base or threshold temperature of 4.5°C (Peterson, 1965). The helio thermal units (HTU) is product of GDD and corresponding actual sunshine hours for that day were computed on daily basis. For PTU, the product of GDD and corresponding day length hours (for Palampur) was computed on daily basis. The three parameters were accumulated from sowing to each physiological stage. The days takne to each phenophases were counted and pooled together for all the seasons. For each index, data of each phenophases of the three varieties for five seasons were pooled and then the mean values, standard deviation and coefficient of variation were calculated.

RESULTS AND DISCUSSION

For the sake of simplification, various phenophases of wheat crop were divided into three broad groups viz., sowing to complete emergence, sowing to vegetative (tillering and heading), and sowing to reproductive phase (from 50% grain filling and physiological maturity).

Sowing to complete emergence:

A progressive decrease in growing degree-days was observed from normal to late sowing of crop in mid hill region of Himachal Pradesh (617 in early, 373 in normal and 201 in late sown). The C.V. (%) values were highest 52 in late sowing followed by normal 33 and early sowing 22 (Table 1). The similar trend was also noticed in helio-thermal and photo thermal units. The days taken to complete the sowing to emergence were higher for early sowing (67) compared to normal (46) and late sowing (29). The C.V. was 31% for early, 41% for normal and 52% for late sown crops.

Table 1: Mean, standard deviation (S.D.) and coefficient of variation (C.V.) in heat summation indices and the days taken to complete different phenophases

Phenophases/ heat units / days	Early			Normal			Late		
	Mean	S.D.	C.V.(%)	Mean	S.D.	C.V.(%)	Mean	S.D.	C.V.(%)
Sowing complete emergence									
GDD	617	136	22	373	125	33	201	104	52
HTU	4660	902	19	2737	1109	41	1452	787	54
PTU	6304	1453	23	3414	1318	35	2086	1096	53
PAN	164	39	24	104	44	43	64	38	59
Days	67	21	31	46	19	41	29	15	53
Sowing – tillering									
GDD	807	197	24	571	200	35	311	68	22
HTU	5758	1356	24	3909	1712	44	2539	1277	51
PTU	7942	2216	28	5538	2217	42	3041	1778	49
PAN	228	72	31	173	78	45	137	87	64
Days	94	25	26	74	23	31	54	17	32
Sowing – heading									
GDD	1428	185	13	1157	181	16	1009	158	16
HTU	10817	1523	14	8682	1680	19	1561	1403	19
PTU	16292	2464	15	13524	2413	18	12164	2084	17
PAN	432	73	17	426	193	45	343	96	28
Days	152	12	8	129	11	09	112	9	8
Sowing – 50%									
GDD	1615	120	7	1351	127	9	1223	134	11
HTU	12338	1128	9	10144	1132	11	9531	1138	12
PTU	18500	1983	11	16158	1681	10	1523	1744	12
PAN	488	666	14	432	70	16	409	95	23
Days	164	7	4	141	7	05	125	7	6
Sowing – physiological maturity									
GDD	2142	77	4	1894	89	5	1741	66	4
HTU	17162	1312	8	14958	1226	8	13923	848	6
PTU	26112	1077	4	23662	1227	5	23177	1876	8
PAN	664	40	6	602	43	7	571	43	8
Days	192	5	2	168	5	3	152	4	3

Sowing to vegetative phase:

All the three accumulated units decreased with delay in sowing from early (Nov 6) to late sowing of wheat (Dec 20). Taking into consideration the three groups, the C.V. was usually higher for all heat summation indices during sowing to tillering phase. Similar findings were also reported by Hundal *et al* (1997) under Punjab conditions. Days taken to tillering and heading in vegetative phase also decreased with delay in sowing. The C.V. values were lower, below 9% during sowing to heading phase indicating lower variations and good predictive value.

Sowing to reproductive phase:

Up to physiological maturity the early sowing availed the higher number, 2142 units of accumulated growing degree days. Ashwini Kumar (1982) and Hundal *et al* (1997) also reported similar findings. The early sown crop accumulated higher HTU and PTU compared to normal and late sown crops. The reduction in crop duration in late sown crop occurred because of higher temperature coinciding with grain development and resulting in forced maturity of the crop. The crop experienced 17162 helio thermal units from sowing to physiological maturity in early sowing, 14958 in normal and 13923 in late sowing of wheat. The C.V. for different indices was the lowest during reproductive phase compared to other phases of crop.

Comparison of three indices indicated higher C.V. for sowing to complete emergence and sowing to Tillering phases. The days taken to complete each phenophas also showed heigher C.V. This indicated that sowing to complete emergence and tillering phases of wheat may be difficult to predict under mid hill rainfed conditions of Himachal Pradesh. Early sowing showed the lowest C. V. compared to normal and late sowing. The C.V. in reproductive phase in all heat summation indices indicated that GDD yielded the lowest C.V. for reproductive phase under all three sowing conditions. The wheat crop took 192 days in early, 168 days in normal and 152 days in late sowing with very lower C.V. values ranging 2-6%. It can be inferred that reproductive and physiological maturity can be best predicted under rainfed conditions.

The crop took more time to complete emergence in early sowing compared to normal and late sowing. The days taken to attain reproductive phase from vegetative phase remained similar (12-13 days) in all the dates of sowing, Sen Gupta *et al* (1971) also reported that reduction in crop life duration of late sown wheat resulted not from a shortening of vegetative phase but through a reduction the reproductive phase in warm condition of West Bengal, however this was not found true at mid hill region of Himachal Pradesh. The variation in cumulative pan evaporation was also observed under different sowing environments. The early sown crop showed maximum cumulative pan evaporation (664

mm) followed by normal and late sown crops, requiring 62 and 93 mm less water compared to early sown crop respectively.

It is concluded that accumulated GDD can be used as the best index to predict grain filling and physiological maturity stage of wheat under rainfed mid hill conditions of Himachal Pradesh.

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