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Short Communication

Thermal requirement of sunflower plant types under three dates of spring planting

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The occurrence of different phenological events during growing season of any crop and the effect of temperature on plant growth can be inferred using accumulated heat units or growing degree days (GDD). Degree days required for a crop to progress from one stage to the other was worked out by several workers in the past. Real time to attain a given development event is approximately linearly related to temperature in the range between a base (Tb) and optimum temperature (Monteith, 1981).

The concept of heat units has been applied to correlate the phenological development of different crops to predict maturity and seed yield (Keitzar and Singh, 1981; Swan *et al.*, 1987). However, the interaction between phenology and ambient temperature in sunflower has not been attempted. Hence, the present study was conducted to understand phenological development in relation to growing environement of sunflower genotypes under field condition in Jabalpur, Madhya Pradesh.

The field experiment was carried out at Jabalpur (23°09" N.79°50" E at altitude of 411 m) during the spring season of 1998 on predominantly vertisols. The treatments consisted of 3 planting dates [(10 Feb (D_1), 23 Feb (D_2) and 23 March (D_3)] and 6 genotypes [PSS -55 (V_1), PV-799 (V_2) IV 81 (V_3), IV 72 (V_4), 310411 (V_5) and modern - 1 (V_6)]. The treatments were replicated thrice in split plot design, and crop was raised using recommended agronomic package for spring season.

The number of days required for capitulam formation (S_1), flowering (S_2), grain filling (S_3) and maturity (S_4) were recorded when 50% of plants in that particular plot reached the specific growth stage. The growing degree days were computed by substracting base temperature of 5°C from daily mean temperature as suggested by Nuttonson (1955). The heliothermal units (HTU) are the product of GDD and actual sunshine hours (Rajput, 1980) whereas photothermal units (PTU) are the product of GDD and photoperiod. The heat use efficiency and the phenothermal index were also computed as suggested by Rajput (1980).

On the basis of dates of planting the number of days taken for maturity were maximum in D_1 (106 days) followed by D_2 (104 days) and lowest in D_3 (85 days). Buttar and Uppal (1998) reported that later sowing shortened the crop growth period. Number of days from sowing to flowering (50%) decreased as sowing dates were delayed (Goksay *et. al.* 1998). Among the 6 plant types the number of days taken for maturity were higher for V_1 and V_6 in D_1 sowing (Table 1), whereas different plant types did not differ in the their response to duration (days) in D_2 and D_3 planting. For different planting dates GDD

Table 1: Heat unit requirement from sowing to capitulam formation, flowering, grain filling and maturity in sunflower.

	Capitulam formation				Flowering				Grain filling				Maturity			
Treatment	Duration	GDD	HTU	PTU	Duration	GDD	HTU	PTU	Duration	GDD	HTU	PTU	Duration	GDD	HTU	PTU
D_1V_1 - PSS-55	38	607	5534	7400	48	800	7268	9890	79	1522	15709	19702	110	2443	26563	31742
D_1V_2 - PV-799	41	669	6106	8313	51	855	7825	10599	79	1522	15709	19702	105	2236	24738	29157
D_1V_3 - IV -81	39	626	5722	7714	52	876	8024	10988	74	1397	14860	18120	105	2236	24738	29157
D_1V_4 - IV -72	38	607	5534	7404	48	800	7263	9890	79	1522	15709	19702	105	2236	24738	29157
D_1V_5 - 310411	38	607	5534	7404	50	835	7626	10335	72	1344	14334	17456	102	2148	23812	27899
D_1V_6 - Modern-1	38	607	5534	7404	54	924	8428	11462	79	1522	15709	19702	110	2431	26563	31472
Mean	**38**	**620**	**5660**	**7607**	**50**	**831**	**7739**	**1051**	**77**	**1477**	**15338**	**19064**	**106**	**2288**	**25192**	**29809**
D_2V_1 - PSS-55	36	625	5626	7968	56	1058	11563	14139	76	1592	18606	20629	103	2403	26248	31808
D_2V_2 - PV-799	39	691	6223	8820	58	1107	12068	14759	78	1641	19097	21700	105	2466	26692	32649
D_2V_3 - IV -81	37	644	5825	8232	55	1036	11336	13868	76	1592	18606	20692	105	2466	26692	32649
D_2V_4 - IV -72	46	624	5826	7668	56	1058	11563	14139	79	1666	19369	22048	105	2466	26692	32649
D_2V_5 - 310411	36	624	5625	7968	56	1058	11563	14139	76	1592	18606	20692	103	2403	26284	31808
D_2V_6 - Modern#1	37	644	5625	7968	57	1081	11810	14434	78	1641	19097	21700	103	2403	26284	31808
Mean	**36**	**642**	**5791**	**8198**	**56**	**1066**	**11650**	**14246**	**77**	**1620**	**18896**	**21254**	**104**	**2434**	**26488**	**32228**
D_3V_1 - PSS-55	39	897	10074	11999	50	1197	15203	16003	70	1812	20984	24152	85	2172	23848	28282
D_3V_2 - PV-799	38	870	9792	11638	49	1170	14927	15640	67	1692	19794	22551	85	2172	23848	28282
D_3V_3 - IV -81	35	815	9262	10927	51	1225	15651	16372	80	1755	20392	23325	85	2172	23848	28282
D_3V_4 - IV -72	37	843	9534	11281	48	1144	14655	15292	70	1812	20392	23325	85	2172	23848	28282
D_3V_5 - 310411	38	870	9792	11638	50	1197	15003	16003	70	1812	20392	23325	85	2172	23848	28282
D_3V_6 - Modern-1	35	815	9267	10927	51	1225	15651	16373	70	1812	20392	23325	85	2172	23848	28282
Mean	**37**	**851**	**9621**	**11401**	**49**	**1193**	**15148**	**15947**	**69**	**1781**	**20391**	**23339**	**85**	**2172**	**23848**	**28282**

D_1 10th Feb. D_2 23rd Feb. D_3 23rd March Sowing, GDD - Growing degree days; HTU - Helio thermal units; PTU - Photo thermal units.

Table 2: Seed yield (kg ha^{-1}) of sunflower plant types as influenced by time of planting.

Varieties	Sowing dates			
	D_1(10th Feb.)	D_2 (23rd Feb)	D_3 (23rd March)	Mean
V_1 (PSS-55)	1950	1958	729	1545.6
V_2 (PV-799)	2042	1554	750	1448.6
V_3 (IV 81)	2604	1625	792	1673.6
V_4 (IV 72)	2126	1554	833	1504.6
V_5 (310411)	2125	1842	833	1633.3
V_6 (Modern -1)	1875	1542	667	1361.3

from planting to maturity ranged between 2172 to 2466. GDD was higher in D_2 and D_1 planting than D_3 and its mean value was 2435, 2288 and 2172 respectively. However, different genotypes were similar in GDD requirments. For attaining maturity, 23rd February (D_2) planting required the maximum number of HTU (26488) followed by D_1 (25192) and D_3 (23848). The variations in different cultivars for HTU were insignificant. The maximum possible energy summation index for the three sowing dates and 6 plant types ranged between 28282 to 32649 growing degree-day hours. The maximum PTU was in D_2 planting and minimum was in D_3 planting, whereas, varieties did not differ significantly.

All plant types produced maximum average seed yield (2120.3 kg ha^{-1}) by sowing on February 10th which was significantly reduced by delayed sowing on February 23rd (1965.8 kg ha^{-1}) and March 5th (767.3 kg ha^{-1}). Genotypes IV-81 produced significantly higher seed yield (1673.6 kg ha^{-1}) than others, while Modern 1 produced the lowest seed yield (1361.3 kg ha^{-1}) irrespective of dates of sowing (Table 2). Goksay *et al.* (1998) also observed that seed yield and yield components decreased significantly with later sowing date. Legha and Giri (1999) also revealed that crop sown in 2nd week of February recorded better yield attributes and seed yield.

Heat use efficiency (HUE) was calculated based on the growing degree days accumulated to produce unit amount of grain yield. The D_3 planting has shown the highest HUE ranging from 3.25 to 2.74 for different plant types and lowest HUE was in D_1 planting and it ranges between 0.85 to 1.25.

The heat units accumulated per growth day between two phenological stages were computed with the view to express the relationship of the duration between phenological stages to the prevailing ambient temperature and their adjustment under field conditions in a single parameter. The phenothermal index is expressed as degree days per growth day. From Table 3 it is clear that during capitulam to flowering stages the index fluctuated ± 2 with normal dates of sowing with mean value of 22.6. The indices in the different stages from flowering to maturity gradually increased from a mean value of 27.2. The indices for the entire crop span showed variation (21.1 to 25.6) between the different sowing dates. Goynet *et al.* (1989) also observed

Table 3: Phenothermal index.

Date of sowing and varieties	Phenological Stage			
	Sowing to maturity	Capitulam formation to flowering	Flowering to grain filling	Grain filling to maturity
10th February				
PSS - 55	22.20	19.3	23.3	29.7
PV - 799	21.29	18.6	23.8	27.5
IV -81	21.29	19.2	23.7	27.0
IV - 72	21.29	19.3	23.2	27.5
310411	21.00	19.0	23.1	26.8
Modern -1	21.05	19.2	23.9	23.3
Mean	**21.05**	**19.2**	**23.5**	**27.9**
23rd February				
PSS - 55	23.4	21.6	26.7	30.0
PV - 799	23.5	21.9	26.7	30.6
IV -81	23.5	21.8	26.5	30.1
IV - 72	23.5	21.6	26.4	30.8
310411	23.5	21.6	26.7	30.0
Modern -1	23.5	21.8	26.7	30.5
Mean	**23.4**	**21.7**	**26.6**	**30.3**
23rd February				
PSS - 55	25.6	27.3	30.7	24.0
PV - 799	25.6	27.3	29.0	26.7
IV -81	25.6	2.6	30.9	24.8
IV - 72	25.6	27.4	30.4	24.4
310411	25.6	27.3	30.7	24.0
Modern -1	25.6	25.6	30.9	24.0
Mean	**25.6**	**27.0**	**30.4**	**24.6**
Over all mean	**23.3**	**22.6**	**26.8**	**27.6**

that the photoperiod at vegetative emergence for most sites ranges from 14.5 to 16.2.

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