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_3), PV-799 (V_2) IV 81 (V_3), IV 72 (V_3), 310411 (V_3) 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 (S₁), flowering (S₂), grain filling (S₃) and maturity (S₄) 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 D₁ (106 days) followed by D₂ (104 days) and lowest in D₃ (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 V₁ and V₆ in D₁ sowing (Table 1), whereas different plant types did not differ in the their response to duration (days) in D₂ and D₃ planting. For different planting dates GDD

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

| | Ca | pitulan | Capitulam formation | tion | | How | Howering | | | Grain | Grain filling | 22 | | Ma | Maturity | |
|--|------|---------|---------------------|-------|------|------|----------|-------|------|-------|---------------|-------|----------|------|----------|-------|
| Treatment | Dura | GDD | пти | PTU | Dura | GDD | D.LH | PTU | Dura | GDD | нтп | PTU | Dura | CDD | нти | PTU |
| D,V, - PSS-55 | 38 | 109 | 5534 | 7400 | 48 | 800 | 7268 | 9890 | 79 | 1522 | 15709 | 19702 | 110 | 2443 | 26563 | 31742 |
| D,V - PV-799 | 4 | 699 | 9019 | 8313 | 35 | 855 | 7825 | 10599 | 79 | 1522 | 15709 | 19702 | 105 | 2236 | 24738 | 29157 |
| D,V IV -81 | 39 | 626 | 5722 | 7714 | 52 | 876 | 8024 | 88601 | 74 | 1397 | 14860 | 18120 | 105 | 2236 | 24738 | 29157 |
| D, V, - IV -72 | 86 | 209 | 5534 | 7404 | 48 | 800 | 7263 | 0686 | 79 | 1522 | 15709 | 19702 | 105 | 2236 | 24738 | 29157 |
| D,V 310411 | 38 | 607 | 5534 | 7404 | - 50 | 835 | 7626 | 10335 | 72 | 1344 | 14334 | 17456 | 102 | 2148 | 23812 | 27899 |
| D ₁ V _n - Modern-1 | 38 | 209 | 5534 | 7404 | 54 | 924 | 8428 | 11462 | 79 | 1522 | 15709 | 19702 | 110 | 2431 | 26563 | 31472 |
| Mean | 38 | 620 | 9995 | 7607 | 20 | 831 | 7739 | 1051 | 77 | 1477 | 15338 | 19064 | 106 | 2288 | 25192 | 29809 |
| D,V, - PSS-55 | 36 | 625 | 5626 | 7968 | . 56 | 1058 | 11563 | 14139 | 76 | 1592 | 18606 | 20629 | 103 | 2403 | 26248 | 31808 |
| D ₂ V ₂ - PV-799 | 39 | 169 | 6223 | 8820 | 58 | 1107 | 12068 | 14759 | 78 | 1641 | 19097 | 21700 | 105 | 2466 | 26992 | 32649 |
| D,V, - IV -81 | 37 | 644 | 5825 | 8232 | 55 | 1036 | 11336 | 13868 | 76 | 1592 | 18606 | 20692 | 105 | 2466 | 26992 | 32649 |
| D, V, - IV +72 | 46 | 624 | 5826 | 7668 | 99 | 1058 | 11563 | 14139 | 79 | 1666 | 19369 | 22048 | 105 | 2466 | 26992 | 32649 |
| D ₂ V ₅ - 310411 | 36 | 624 | 5625 | 2962 | 99 | 1058 | 11563 | 14139 | 16 | 1592 | 18606 | 20692 | 103 | 2403 | 26284 | 31808 |
| D ₁ V ₄ - Modern4 | . 32 | 3 | 5625 | 7968 | 57 | 1081 | 11810 | 14434 | 78 | 1641 | 19097 | 21700 | 103 | 2403 | 26284 | 31808 |
| Mean | 36 | 642 | 5791 | 8198 | 99 | 1066 | 11650 | 14246 | 77 | 1620 | 18896 | 21254 | 104 | 2434 | 26488 | 32228 |
| D,V, - PSS-55 | 36 | 897 | 10074 | 11999 | 20 | 1197 | 15203 | 16003 | 70 | 1812 | 20984 | 24152 | 85 | 2712 | 23848 | 28282 |
| D,V2 - PV-799 | 38 | 870 | 9792 | 11638 | 46 | 1170 | 14927 | 15640 | 29 | 1692 | 19794 | 22551 | %1 00 | 2172 | 23848 | 28282 |
| D,V, - IV -81 | 35 | 815 | 9262 | 10927 | 3 | 1225 | 15651 | 16372 | 80 | 1755 | 20392 | 23325 | 58 | 2172 | 23848 | 28282 |
| D, V 1V -72 | 37 | 843 | 9534 | 11281 | 48 | 1144 | 14655 | 15292 | 70 | 1812 | 20392 | 23325 | × × | 2172 | 23848 | 28282 |
| D,V, - 310411 | 38 | 870 | 9792 | 11638 | 20 | 1197 | 15003 | 16003 | 70 | 1812 | 20392 | 23325 | SS | 2172 | 23848 | 28282 |
| D,V, - Modem-1 | 35 | 818 | 9267 | 10927 | 51 | 1225 | 15651 | 16373 | 92 | 1812 | 20392 | 23325 | \$8 | 2172 | 23848 | 28282 |
| Mean | 37 | 851 | 9621 | 11401 | 46 | 1193 | 15148 | 15947 | 69 | 1781 | 20391 | 23339 | 88 | 2172 | 23848 | 28282 |

D, 10th Feb. D, 23th Feb. D, 23th 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.

| | Sowing dates | | | | | |
|---------------|----------------------------|---------------------------|---|--------|--|--|
| Varieties | D _i (10th Feb.) | D ₂ (23rd Feb) | D ₃ (23 rd March) | Mean | | |
| V. (PSS-55) | 1950 | 1958 | 729 | 1545.6 | | |
| V, (PV-799) | 2042 | 1554 | 750 | 1448.6 | | |
| V, (IV 81) | 2604 | 1625 | 792 | 1673.6 | | |
| V, (IV 72) | 2126 | 1554 | 833 | 1504.6 | | |
| V, (310411) | 2125 | 1842 | 833 | 1633.3 | | |
| V (Modern -1) | 1875 | 1542 | 667 | 1361.3 | | |

from planting to maturity ranged between 2172 to 2466. GDD was higher in D₂ and D₁ planting than D₃ and its mean value was 2435, 2288 and 2172 respectively. However, different genotypes were similar in GDD requirments. For attaining maturity, 23rd February (D₂) planting required the maximum number of HTÜ (26488) followed by D₁ (25192) and D₃ (23848). The variations in different cultivars for HTÜ were insignificant. The maximum possible energy summation index for the three sowing dates and 6 plant types ranged between 28282 to 32649 growing degreeday hours. The maximum PTÜ was in D₂ planting and minimum was in D₃ planting, whereas, varieties did not differ significantly.

167

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 D₃ planting has shown the highest HUE ranging from 3.25 to 2.74 for different plant types and lowest HUE was in D₁ 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.

| | | Phenological | Stage | |
|------------------------------|--------------------|--|----------------------------|------------------------------|
| Date of sowing and varieties | 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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