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# Thermal unit requirement for leaf growth and phenological development in sunflower

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## ABSTRACT

Thermal requirement of sunflower phenological development and leaf area expansion, the key factors influencing yield of sunflower, were estimated in a field experiment at Hyderabad with four sowing dates. The phenological development was recorded based on the leaf appearance. The GDD requirement for different phenological stages in different sowings varied more during grain filling period than the vegetative period. Maximum canopy size coincided with the 50% flowering stage. Growth rates being phenology based, while screening the germplasm for any given trait it is important to ensure that the comparisons are made at corresponding phenological stages under similar environments. Even if the leaf expansion rates are taken as one of the selection criteria for crop improvement in sunflower, phenology based comparisons are recommended.

*Key words :* Sunflower, phenology, growing degree days (GDD), leaf growth

Temperature influences the growth and development of crops. Thermal requirement of sunflower phenology was studied earlier by Villalobos *et al.*, 1992. The phenological development and leaf area expansion are identified as the key factors influencing yield of sunflower (Conner and Sadras 1992; Sadras and Villalobos, 1994) as in case of other crop species (Passioura *et al.*, 1993). Hence, understanding of leaf expansion and phenological development, two major determinants of phenotypic plasticity, is important for development of cultivars suitable for different environments (Sadras and Trapani, 1999). Among the weather parameters temperature is the most influential factor for crop growth. Present study was aimed to estimate the thermal requirement for various phenological stages of sunflower and the leaf area growth under different sowing times.

## MATERIALS AND METHODS

Sunflower crop was raised on the red-sandy loam soils of the research farm of the Plant Gene Ltd., Medchal, Hyderabad. Seeds were sown on 16$^{th}$, 20$^{th}$, 24$^{th}$ June and 1$^{st}$ July 1994, for comparing the phenological development and thermal requirement. Inter- and intra- row spacings

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Table 1 : Growing Degree Days (GDD) and days required for phenological stages in sunflower

| Parameter / Phenological stage | Growing Degree Days | | | |
|---|---|---|---|---|
| Julian day of sowing | 167 | 170 | 175 | 182 |
| GDD from sowing to germination | 140 (6)[a] | 141 (6) | 229 (10) | 195 (9) |
| GDD from germination to | -[b] | - | 111 (5) | 81 (4) |
| 2-leaf stage | 342 (15) | 294 (13) | - | 263 (12) |
| 6-leaf stage | - | - | 257 (12) | - |
| 7-leaf stage | 386 (17) | 462 (21) | - | - |
| 8-leaf stage | 466 (21) | - | - | 438 (20) |
| 9-leaf stage | 488 (22) | - | 394 (18) | 503 (23) |
| 10-leaf stage | 488 (22) | - | - | - |
| 11-leaf stage | 533 (24) | 599 (27) | 570 (26) | - |
| 12-leaf stage | - | - | 634 (29) | - |
| 14-leaf stage | - | 775 (35) | - | 875 (40) |
| 17-leaf stage | - | 818 (37) | - | - |
| 18-leaf stage | 669 (30) | - | - | - |
| 19-leaf stage | - | 1061 (48) | 1007 (46) | - |
| 24-leaf stage | 845 (38) | - | - | - |
| 25-leaf stage | 910 (41) | 1212 (55) | 1093 (50) | - |
| 26-leaf stage | 1132 (51) | - | - | - |
| 30-leaf stage | 1070 (49) | 1148 (52) | 1051 (48) | 1214 (56) |
| 10% star bud stage | 1132 (51) | 1191 (54) | 1115 (51) | - |
| 50% star bud stage | 1218 (55) | 1298 (59) | 1258 (58) | 1323 (61) |
| 10% flowering | 1261 (57) | 1362 (62) | 1302 (60) | 1369 (63) |
| 50% flowering | 1970 (90) | 1961 (90) | 1865 (86) | 1755 (80) |
| Harvest | | | | |

a- Values in parenthesis indicate days required; b – no observation

were kept at 60 and 20 cm, respectively and plant population was maintained at 65,000 plants/ha. The plot size was 2,500 $m^2$. All recommended crop management practices were followed uniformly. The phenological development was recorded based on the leaf appearance (Robinson, 1971; Schneiter and Miller, 1981). Dates were recorded when 75% of the plants attained a particular phase. Number of dead leaves was taken into account while recording the phonological development and leaf area. Area of individual leaf and the number of leaves present on the plants were recorded. Daily weather data was collected from the nearby weather station and the thermal unit requirement for phenological stages was computed as GDD with 4 °C as

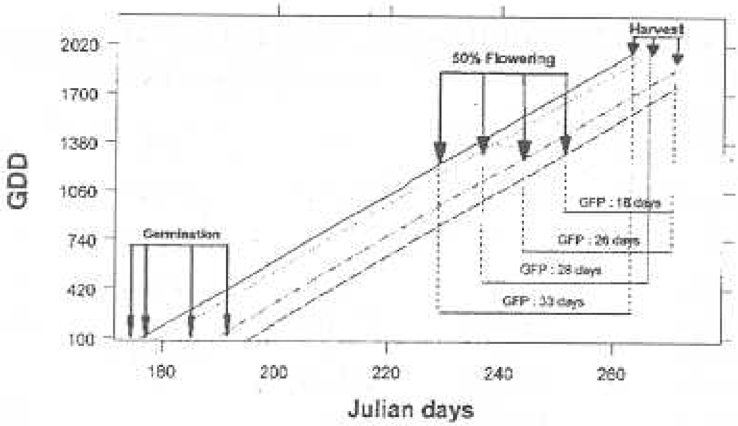


Fig. 1: Growing degree days (GDD) requirement for different phenological stages of sunflower grown at four sowing dates (GFP- Grain filling period)

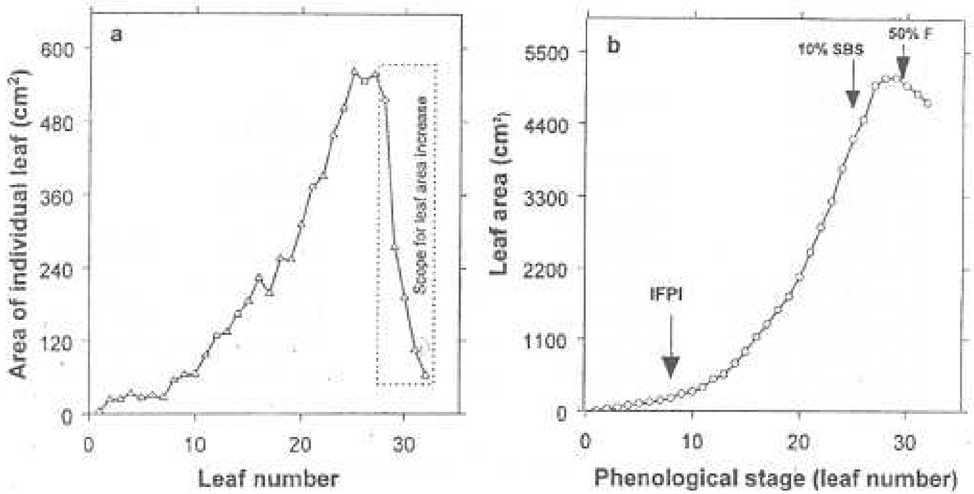


Fig. 2: (a) Area of individual leaf in sunflower canopy (leaf number indicates position of leaf from germination) and (b) Net canopy area at different phenological stages based on leaf number in sunflower (IFPI-Inflorescence primordial initiation; SBS-Star bud stage; F- Flowering)

base temperature (Villalobos *et al.*, 1996).

## RESULTS AND DISCUSSION

The crop growth varied between early sown and late sown crops. Days taken for germination ranged from 6 in early sown crop to 10 days in late sown crop (Table 1). Similarly, more days were taken for 10 percent star-bud stage and 50 percent flowering in late sown crop.

The thermal requirement for phenological stages, which were based on leaf appearance, is given in Table 1. Data indicate differences in requirement for GDD for different phonological stages due to change in sowing date. Differences were more during grain filling period (GFP) than in the vegetative period. Rate of appearance and growth of leaf (area) are the parameters, which mainly varied, and these are the major contributors for variations in source size in sunflower. Different sowing dates did not influence the GDD requirement during vegetative period in sunflower (fig 1). Late sown crop has less grain-filling period as evident from the figure, a possible cause for reduced yields in late sown crop. Late sown crop had longer vegetative period, attributable mainly due to decrease in temperature in corresponding periods.

The GDD requirement for early sown crop was more compared to the late sown one. During most of the growth under different sowings, crop growth was simultaneous but with different phenological phases. Hence, it can be safely assumed that variations in accumulated GDD for early and late sowing crops from emergence to head-visible and emergence to first anther period were due to variations in GDD/day but not due to photoperiods. The results also indicate that in early sown crop, the initial crop growth coincided with higher temperature regimes (38/25 °C). This probably hastened the leaf emergence and occurrence of phenological stages.

Growth of each leaf indicated that 25$^{th}$, 26$^{th}$ and 27$^{th}$ leaves had maximum area at full expansion (Fig. 2a). At full expansion, area of individual leaf increased till 25$^{th}$ leaf and decreased rapidly after 28$^{th}$ leaf. Selection for broader leaves for last five to six leaves will be of great importance in increasing the leaf area during grain-filling period for increased light harvesting to improve the yields. Net leaf area/plant increased till 28$^{th}$ leaf stage, which coincided with flowering time. The net leaf area drastically declined during grain filling period (Fig 2b). The 10% star bud stage coincides with 25$^{th}$ leaf emergence. Maximum canopy size coincided with the 50% flowering stage of crop. Analysis of canopy development in relation to number of days from emergence or GDD requirement from germination followed same pattern (fig 3 a & b). Further analysis of net leaf expansion rates indicate presence of three distinct phases in sunflower i) early slow leaf expansion stage ii) fast leaf expansion phase from 12$^{th}$ to 25$^{th}$ leaf stage and iii) growth phases with medium rate of leaf expansion (fig 4). Since the leaf area, that is photosynthetically active, is reduced drastically during grain filling period, selection of genotypes with broader upper leaves may provide adequate source size for developing grains, the sink. Proximity of these leaves to the sink also prove advantageous for translocation of photosynthates to sinks.

The results indicate that the growth rates are phenology based, which in turn is influenced by the temperature regimes.

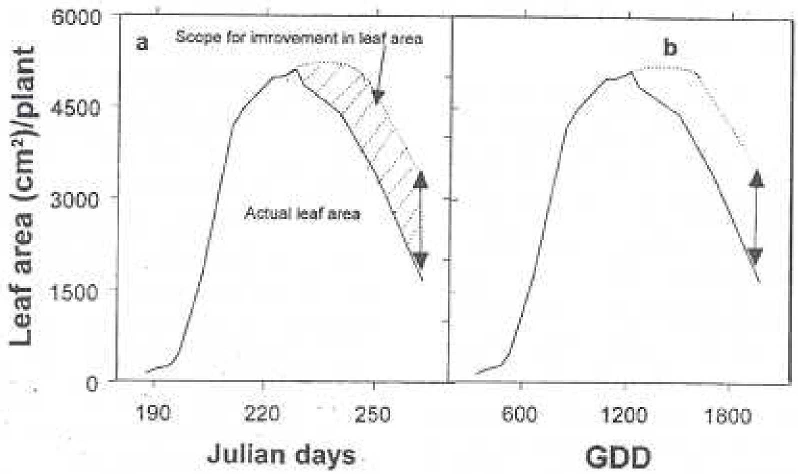


Fig.3: (a) Leaf area in sunflower plotted against the Julian days and (b) GDD accumulated during growth season.

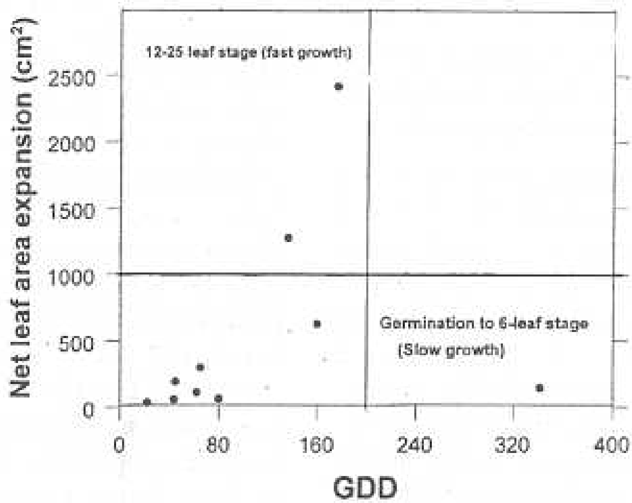


Fig. 4: Growing degree days (GDD) and net leaf expansion in sunflower at different phenological stages.

Since it was reported that the physiological parameters like NR activity, nitrogen accumulation are phenology sensitive (Naresh Kumar and Singh, 2002), it is important to ensure, while screening the germplasm for any given trait, that the comparisons are made at comparable phenological stages under similar environments. Further, the results indicate that the leaf expansion rates, if taken as one of the selection criteria for crop improvement in sunflower, it should be ensured that comparisons are made based on phenology for meaningful conclusions.

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