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# Effect of sowing dates on phenological development, yield and oil content of sunflower (*Helianthus annuus*) in a Mediterranean-type environment

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## ABSTRACT

The effect of sowing time on phenological development, seed yield and oil content of sunflower (*Helianthus annuus* L.) was studied under the restricted irrigation conditions in Hatay, Turkey (36° 39' N, 36° 40' E) in 1998 and 1999. Sunflower cultivars ('C 207' and 'Istranca') were sown at 2-week intervals from 1 March to 15 July, with 2 supplemental irrigations. Delaying in sowing shortened the period for emergence, head initiation, and total duration. Seed yield increased until 1 April and then decreased greatly with further delay in sowing both cultivars. The higher oil contents were also recorded with earlier-sown sunflower crop.

***Key words :*** Sowing date, Sunflower, Mediterranean

Sunflower is the most important oilseed crop in Turkey. The mediterranean region in Turkey is considered as cotton belt, where cotton - wheat rotations in irrigated areas, and wheat monoculture in non-irrigated areas is dominant. Since cotton production is a labour-intensive and wheat productivity is low, farmers are in search of suitable alternative crops for both irrigated and non-irrigated areas.

Sunflower could be grown effectively under both irrigated and non-irrigated areas in Mediaterranean-type environments (Gimeno *et al.*, 1989; Killi and Gencer, 1992). However, areas with no or limited irrigation are considered more favourable for sunflower cultivation than areas with irrigation. Under the Mediterranean climate evapotranspirative losses of water reach its peak during the summer months (June–August), which coincides with flowering and grain-filling stages. Gimeno *et al.* (1994) showed that planting of sunflower in the winter increased its seed and oil yields under the Mediterranean conditions in Spain, while Killi and Gencer (1992) recorded reduction in seed and oil yields in the Mediterranean region of Turkey due to

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delay in sowing of irrigated sunflower from April to June. With these views, this study was aimed to determine the effect of sowing dates on phenological development, yield and oil content of sunflower under limited irrigation under the Mediterranean conditions.

## MATERIALS AND METHODS

The experiment was carried out in 1998 and 1999 at experimental fields of the State Farm in Hatay, Turkey (36° 39' N, 36° 40' E). The soil was loamy clay, low in organic matter and slightly alkaline. The climate was typical Mediterrancean with mild winter temperatures and high temperatures during summer. Rainfall occurred between late autumn and spring. The mean temperatures during the experimental period ranged between 11.1°C (March) and 29.3°C (August) in 1998, and between 11.8°C (March) and 28.7°C (August) in 1999. Total rainfall during the crop season was 283.2 mm in 1998 and 165.4 mm in 1999. There was no rainfall after May in 1998 and after April in 1999.

Sunflower hybrids 'C 207' and 'Istranca' were sown at about 2-week intervals starting from 1 March to 15 July in a split-plot design with replications with sowing dates as main plots and cultivars as subplots. Seeds were sown in rows at 70 cm distance with pre-sowing irrigation. A 30 cm space between plants was maintained after emergence completion. The crop was fertilized with 75 kg N/ha and 100 kg $P_2O_5$/ha before planting, and an additional nitrogen dose at 75 kg/ha was applied at head-initiation stage. Weeds were controlled manually during the experiments. Two furrow-irrigations were applied at head initiation and grain-filling.

Time of emergence, head initiation and physiological maturity (heads yellow with bracts turning brown) were recorded when occurred at 50% of the plants. Then, number of days required to reach these growth stages and growing-degree day (GDD) summatations were calculated using a base temperature of 0°C (Garside, 1984). The 2 central rows measuring 1.4 m width and 6.0 m length were harvested at physiological maturity. Total oil content was determined by petroleum ether extraction in soxhlet.

## RESULTS AND DISCUSSION

### *Phenological development*

Days to emergence decreased from 23 to 6 and from 17 to 6 with delay in sowing in 1998 and 1999, respectively (Tables 1, 2). Increasing temperature associated with later dates was responsible for the shorter emergence periods because temperature is the most important factor affecting the germination of sunflower in soils with adequate water and aeration. Estimates of the minimum temperature for germination lie in the range 3 to 6 °C, optimum temperatures are close to 26 °C, and maximum temperature around 40 °C (Connor and Hall, 1997).

The growing degree day summations indicated that minimum values required for sunflower emergence was approximately 170 °C, although it could rise up to over 300 °C. However, the obtained values for different sowing dates also indicated that GDD might not be enough independently to decide emergence duration. The

emergence took a certain period in most sowings, despite they received enough GDD summations earlier. This can be attributed to the possible effects of soil temperature and moisture on emergence.

The period between emergence and head initiation noticeably shortened with delayed sowings until May, but inconsiderable fluctuations were observed with later sowings. Emergence and head-initiation periods greatly depend on temperature and photoperiod in addition to genetical constitutes of cultivars. Generally, lower temperatures and shorter days increase this period (Garside, 1984). Temperature increases toward summer months and reaches its peak during June-August in the Mediterranean-type environments. Day length also increases until late June. The emergence and head initiation period lies in spring months in earlier sowings, while this period occurred entirely during the summer months in later sowings after May. The summations of GDD during the emergence and head-initiation period indicated that the sunflower cultivars tested required over 1,000 °C GDD summation for head initiation after emergence under the Mediterranean conditions (Tables 1, 2). It also indicated that the plants required relatively higher GDD for that period in March sowings. This could be attributed to the effects of seasonal radiation on phenological development (Rawson *et al.*, 1984).

The period between head initiation and physiological maturity increased as the sowing delayed until May 15 with some fluctuations and decreased perceptibly after 15 May in both years (Tables 1, 2).

The GDD summations also showed similar trends with days summations for this period. This period could be greatly influenced by cultivar, temperature, radiation and water stress (Connor and Hall, 1997). Probably water stress had major effect on the head initiation and physiological maturity period. The earlier sowings might have removed more water due to spring rainfall and 2 supplemental irrigations and resulted in longer phenological period. Although pre-sowing irrigations were applied to plots sown after 15 May, the plants were subjected to earlier water stress due to increasing evapotranspirative losses and forced to rapid reproductive development. Consequently, total growing period was also reduced with delayed sowings until 15 July.

### *Seed yield*

The cultivar 'C 207' gave higher seed yield in most of the sowing dates. Seed yield increased with delay in sowing until 1 April and then decreased with further delay. Trends in seed yield of both cultivars under sowing dates followed the similar pattern. Poor seed-set and development caused by a combination of high temperature and water stress during head initiation and seed setting were the reasons for poor yields under delayed sowing. Sowing of sunflower in early spring increased the rainfall effectiveness by establishing the strong canopy and 2 supplemental irrigations applied during this stage increased the seed set and development. Reddy *et al.* (1998) reported that moisture stress during the grain-filling and flowering stages severely reduced the

seed yield of sunflower and supplemental irrigation during these stages improved seed yield in rainfed sunflower. Similar results from a Mediterranean-type environment in Spain were also reported by Gimeno *et al.* (1989).

### *Oil content*

The cultivar 'C 207' gave the highest oil content (40.2% in 1998 and 41.0% in 1999) in March 1 sowing (Table 4). Oil content of this cultivar decreased by 32% with delayed sowings. The oil content of 'Istranca',

**Table 1.** Phenological development of sunflower cultivars in relation with sowing dates in 1998

| Sowing date | Sowing to emergence | | Emergence to head initiation | | Head initiation to maturity | | Total duration | |
|---|---|---|---|---|---|---|---|---|
| | Days | GDD | Days | GDD | Days | GDD | Days | GDD |
| 1 March | 23 | 234 | 63 | 1,129 | 48 | 1,226 | 134 | 2,589 |
| 15 March | 18 | 184 | 62 | 1,191 | 53 | 1,463 | 133 | 2,838 |
| 1 April | 15 | 266 | 53 | 1,058 | 62 | 1,748 | 130 | 3,072 |
| 15 April | 10 | 276 | 57 | 1,154 | 53 | 1,508 | 120 | 2,938 |
| 1 May | 10 | 219 | 45 | 1,093 | 65 | 1,821 | 120 | 3,133 |
| 15 May | 13 | 260 | 40 | 1,044 | 67 | 1,923 | 120 | 3,227 |
| 1 June | 12 | 290 | 38 | 1,053 | 55 | 1,575 | 105 | 2,918 |
| 15 June | 9 | 242 | 39 | 1,110 | 45 | 1,289 | 93 | 2,641 |
| 1July | 6 | 172 | 42 | 1,223 | 40 | 1,080 | 88 | 2,475 |
| 15 July | 8 | 232 | 34 | 1,003 | 43 | 1,104 | 85 | 2,339 |

GDD, Growing degree-days

**Table 2.** Phenological development of sunflower cultivars in relation with sowing dates in 1999

| Sowing date | Sowing to emergence | | Emergence to head initiation | | Head initiation to maturity | | Total duration | |
|---|---|---|---|---|---|---|---|---|
| | Days | GDD | Days | GDD | Days | GDD | Days | GDD |
| 1 March | 17 | 206 | 70 | 1,270 | 56 | 1,498 | 143 | 2,974 |
| 15 March | 16 | 167 | 66 | 1,343 | 57 | 1,534 | 139 | 3,044 |
| 1 April | 15 | 217 | 52 | 1,158 | 62 | 1,691 | 129 | 3,066 |
| 15 April | 14 | 258 | 44 | 1,028 | 58 | 1,614 | 116 | 2,900 |
| 1 May | 14 | 300 | 40 | 1,010 | 66 | 1,868 | 120 | 3,178 |
| 15 May | 14 | 323 | 41 | 1,049 | 70 | 2,000 | 125 | 3,372 |
| 1 June | 7 | 177 | 40 | 1,089 | 53 | 1,487 | 100 | 2,753 |
| 15 June | 7 | 186 | 41 | 1,157 | 47 | 1,294 | 95 | 2,637 |
| 1July | 7 | 180 | 40 | 1,138 | 40 | 1,087 | 87 | 2,405 |
| 15 July | 6 | 175 | 40 | 1,176 | 39 | 992 | 85 | 2,343 |

GDD, Growing degree days

which had higher mean oil content, was less sensitive to delays in sowing, although its oil content also decreased with further delaying. 'Istranca' had oil content over 39% until 1 June (peaks were 43% in 1 April in 1998, and 41.4% in 15 March in 1999), and then decreased to around 36% in both years (Table 4). The higher oil

**Table 3.** Effects of sowing dates on seed yield of sunflower cultivars

| Sowing date | 1998 | | | 1999 | | |
|---|---|---|---|---|---|---|
| | 'C 207' | 'Istranca' | Mean | 'C 207' | 'Istranca' | Mean |
| 1 March | 3,579 | 3,431 | 3,505 | 3,854 | 3,577 | 3,716 |
| 15 March | 3,731 | 3,210 | 3,471 | 3,636 | 3,487 | 3,562 |
| 1 April | 3,835 | 3,627 | 3,731 | 3,911 | 3,921 | 3,916 |
| 15 April | 2,605 | 2,705 | 2,655 | 2,967 | 2,945 | 2,956 |
| 1 May | 2,320 | 2,956 | 2,683 | 2,329 | 2,763 | 2,546 |
| 15 May | 1,690 | 1,138 | 1,414 | 1,476 | 1,089 | 1,283 |
| 1 June | 1,127 | 648 | 888 | 1,138 | 1,017 | 1,078 |
| 15 June | 312 | 474 | 393 | 426 | 493 | 460 |
| 1 July | 297 | 370 | 334 | 388 | 367 | 378 |
| 15 July | 213 | 261 | 237 | 277 | 267 | 272 |
| Mean | 1,971 | 1,882 | 1,927 | 2,040 | 1,992 | 2,016 |
| CD (P=0.05) | | | 280.8 | | | 90.1 |
| | | | 75.6 | | | 37.3 |
| | | | 239.2 | | | 118.0 |

**Table 4.** Effects of sowing dates on oil contents of sunflower cultivars

| Sowing date | 1998 | | | 1999 | | |
|---|---|---|---|---|---|---|
| | 'C 207' | 'Istranca' | Mean | 'C 207' | 'Istranca' | Mean |
| 1 March | 40.2 | 40.1 | 40.2 | 41.0 | 40.8 | 40.9 |
| 15 March | 39.6 | 41.4 | 40.5 | 39.9 | 41.4 | 40.6 |
| 1 April | 38.7 | 43.0 | 41.1 | 38.7 | 40.4 | 39.6 |
| 15 April | 38.9 | 39.4 | 39.2 | 38.6 | 39.8 | 39.2 |
| 1 May | 37.8 | 40.1 | 38.9 | 37.8 | 39.9 | 38.9 |
| 15 May | 36.5 | 41.6 | 39.1 | 36.7 | 39.7 | 38.2 |
| 1 June | 35.2 | 39.5 | 37.4 | 35.8 | 39.3 | 37.6 |
| 15 June | 33.9 | 37.4 | 35.6 | 34.3 | 36.8 | 35.5 |
| 1 July | 33.3 | 36.4 | 34.9 | 33.6 | 36.1 | 34.8 |
| 15 July | 32.6 | 37.8 | 35.2 | 32.2 | 35.7 | 33.9 |
| Mean | 36.7 | 39.7 | 38.2 | 36.9 | 39.0 | 38.0 |
| CD (P=0.05) | | | 0.55 | | | 0.55 |
| | | | 0.38 | | | 0.29 |
| | | | 1.20 | | | 0.91 |

contents were obtained from earlier sowings. The lower oil content with late sowing might be due to unsuitable conditions for seed development as discussed earlier. Similar trends in oil content of sunflower planted during spring and summer were reported by Garside (1984) from Western Australia, and by Killi and Gencer (1992) from Turkey.

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