Defoliation Effects on Sunflower (*Helianthus annuus* L.) Seed Yield and Oil Quality

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**Abstract:** The objective of the present study was to determine the influence of artificial defoliation on sunflower seed yield, oil content, and fatty acid composition. The research was carried out at Süleyman Demirel University, Isparta, Turkey, during 2002 and 2003. Six defoliation levels [0 (control), 5, 10, 15, 20 and 25 leaves per plant] were applied at the preflowering stage from bottom to top leaves. The results demonstrate a close relationship between yield reduction and the defoliation levels. The higher the defoliation level, the higher the yield reduction. Complete and partial leaf removal treatments reduced oil percentage of seed when compared with the undefoliated check. However, oleic acid and linoleic acid levels in seed were not significantly affected by defoliation treatments.

**Key Words:** *Helianthus annuus* L., leaf defoliation, yield, oil, fatty acids

Introduction

Defoliation in plants can be induced by natural causes, such as hailstorms, wind, insect attacks, and diseases, as well as accidental causes, such as the incorrect administration of herbicides or damage caused by farm machinery. There are several studies dealing with defoliation caused by different reasons in sunflower (1-6). All of these studies reported that a reduction in leaf area reduced sunflower seed yields. Sachstion (1) reported that sunflower yields were reduced between 22% and 30% when half of each leaf was removed at the flowering stage. Steer et al. (5) reported that complete and, to a lesser extent, partial defoliation at the anthesis stage of sunflowers decreased seed and oil yields. Schneiter et al. (4) found that yield was reduced the most by defoliation during flowering. According to Muro et al. (6), the preflowering stages, especially R3, were the most sensitive growth stages for defoliation effects in sunflower. They found that 100% defoliation of the leaf surface at the R3 stage caused 92% yield loss.

Sunflower is an important oilseed crop in Southwest Turkey. In this region, foliage loss from some leaf-devouring insects, leaf diseases, and hail result in important damage during some growing seasons in sunflower plants. The objective of this study was to determine sunflower seed yield and quality at different levels of artificial defoliation at the preflowering stage.

Materials and Methods

Field experiment

Seeds of the hybrid sunflower ‘AS-503’ were planted on May 10, 2002, and on May 9, 2003, in rows 70 cm apart at Süleyman Demirel University, Isparta, Turkey...
The farm soils were deep calcareous and had a clay-loam texture with a pH range from 7.5 to 7.8. Rows were furrow-irrigated for uniform emergence as needed during the growing seasons. Approximately 3 weeks after planting, stands were thinned to 4 plants per meter of row. Thinning provided a population density of 5.7 plants per square meter. Then 200 kg ha\(^{-1}\) 18:46:0 fertilizer was applied prior to planting and the crop was fertirrigated at a rate of 64 kg N ha\(^{-1}\). The plots received common cultural practices for the area where the experiments were conducted. The experimental design was a randomized complete block design with 3 replications. The plots were made up of 10 m rows with 40 plants each. Six defoliation levels, i.e. 0 (undefoliated check), 5, 10, 15, 20, and 25 leaves per plant from bottom to top, respectively, were applied prior to flowering on July 14, 2002, and July 21, 2003. The surface area of the leaves removed per plant (m\(^2\) plant\(^{-1}\)) was also measured (Table 1). Individual heads from the leaf removal treatments were harvested during the third week of August. Dry seeds from the heads were weighed for determining seed weight (g 1000 seed\(^{-1}\)) and seed yield (g plant\(^{-1}\)). To obtain percentage yield reduction, the following expression was used for each trial:

\[
\text{Yield reduction (\%)} = \left(\frac{\text{Check plot} - \text{Defoliated plot}}{\text{Check plot}}\right) \times 100
\]

**Oil extraction**

The seeds were oven-dried at 40 °C for 4 h, using a ventilated oven, to reduce moisture content to 5%. Then seeds were ground with a Waring Blender. Four grams of ground seeds were used to oil extract with petroleum ether for 6 h in a Soxhlet system (Büchi Universal Extraction System B-811, Germany) according to the AOCS method (7). The oil extract was evaporated by distillation at reduced pressure in a rotary evaporator at 40 °C until the solvent was totally removed.

**Analysis of fatty acids**

The oil extracted with hexane/isopropanol (3:2, v/v) from the test seeds was converted to its fatty acid methyl esters as described by Marquard (8). The methyl esters of the fatty acids (0.5 µl) were analyzed in a Hewlett-Packard 6890 series gas chromatograph (Perkin Elmer Auto System XL, USA) equipped with a flame ionizing detector (FID), and a fused silica capillary column (MN FFAP (50 m x 0.32 mm i.d.; film thickness = 0.25 µm)).

It was operated under the following conditions: oven temperature program, 120 °C for 1 min, raised to 240 °C at a rate of 6 °C/min and then kept at 240 °C for 15 min; injector and detector temperatures were 250 and 260 °C, respectively, carrier gas, helium, at flow rate of 40 ml/min; split ratio, 1/20 ml/min. Peak identification was performed by comparing the relative retention times with those of a commercial standard mixture of fatty acid methyl esters. The contents of palmitic (C16:0), stearic (C18:0), oleic (C18:1), and linoleic (C18:2) acids were determined by computing integrator on a percentage basis.

**Statistical analysis**

All data were subjected to an analysis of variance (ANOVA) test and treatment means were separated with Duncan’s multiple range test at 5% level in MSTAT-C (V. 2.1, Michigan State University, 1991).

**Results and Discussion**

Leaf area removed, percent leaf area reduction, seed yield, and percent yield reduction in both trial years are shown in Table 1. The average number of leaves for sunflowers was 25 per plant. Removal of leaves from sunflower plants caused a significant reduction in seed yield. Similar results were obtained in other studies dealing with defoliation (1-6).

When complete defoliation of sunflower plants occurred immediately prior to flowering, the yield was reduced by 37.9% in 2002 and by 42.8% in 2003. According to the data presented in Table 1, yield reduction in 2003 was higher than those occurring in 2002. The smallest amount of yield reduction occurred when 10, 15, and 20 leaves were removed from the plants in both trial years.

The oil percentage of sunflower seed was also influenced by defoliation treatments (Table 2). Complete and partial leaf removal treatments reduced oil percent of seeds in both seasons, but the seed oil percent in both years was not significantly affected by the defoliations of 5, 10, 15, and 20 leaves. It was interesting that the oil percent increased in the complete defoliations in 2002 and 2003. However, Johnson (2) reported that the oil percent was not as severely affected by partial defoliation treatments except when the top 12 leaves were removed from sunflower plants.
Fatty acid composition was not significantly affected by the defoliation treatments. Oil extracted from seeds in 2003 was rich in palmitic, stearic, and oleic acids (Table 2). Oleic and linoleic acid percentages of sunflower oil vary greatly, depending mainly upon temperature during seed development. Seed maturation during periods of high temperature results in oil with high and low concentrations of oleic and linoleic acids, respectively (9,10). Temperatures during the seed maturation in 2003 were generally higher than those in 2002 (Figure). Thus, higher temperatures in 2003 may have caused higher oleic acid and lower linoleic acid levels in comparison with 2002.

Complete and partial leaf removal treatments reduced the oil percentage of seed when compared with the undefoliated check in both years. Oleic acid and linoleic acid in seed oil were not significantly affected by defoliation treatments. Linoleic acid, the main fatty acid in sunflower oil, was higher in the defoliation treatments of 10, 15, and 20 leaves when compared with the undefoliated check in 2003.
Conclusions

Quantifying yield decreases resulting from defoliation in sunflower may play an important role in predicting yield or modeling the yield reduction, establishing thresholds for defoliation damage caused by biotic and abiotic agents.

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