EFFECT OF LEAF REMOVAL ON SUNFLOWER YIELD AND YIELD COMPONENTS AND SOME QUALITY CHARACTERS

Tahsin KARADOĞAN İlknur AKGÜN Nüket ALTINDAL[*]

Süleyman Demirel University, Faculty of Agriculture, Dept. of Field Crops, 32260, Isparta, Turkey.
[*]Corresponding Author: nuket@ziraat.sdu.edu.tr

ABSTRACT

The experiment was conducted to determine the effects of the ratio of leaf removal from bottom of plants (0, 4, 8 and 12 leaves / plant) shortly before flowering on yield components and some quality characters of sunflower ecotypes (Amasya, Uşak, Kırşehir, Erzurum, Iğdır-2, Çorum-2, Edirne -1, Çorum-1, Line-1 ve Iğdır-1).

Based on the results, seed setting, seed yield, kernel ratio, crude oil and crude protein content of seeds crude oil yield and crude protein yield changed with different degrees of leaf removal. Head diameter, seed setting, seed yield, 1000 seed weight, kernel ratio, crude oil, crude protein content, crude oil yield and crude protein yield varied with degree of leaf defoliation of some ecotypes while those characters were not affected by defoliation in some ecotypes.

Keywords: *Sunflower, leaf removal, yield, yield components, Quality*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is grown for its edible oil and for use as snack. The main objective in crop production is to obtain high yield and high quality. Achievement of this goal requires the use of appropriate cultivars for any region, high quality seed and application of proper management practices (Majid and Schnettier, 1988; Karadoğan et al., 1998).

Sunflower has long been used for plant physiological investigations, particularly in the seedling stage (Pereira, 1978). Lately importance is given to experiments of the whole plant and the relationship between the leaf parts of individual plant and yield has become an important subject (Johnson, 1972; Pereira, 1978; Schneiter et al., 1987; Sadras et al., 2000). Leaves are vitally essential organs in most plants. Photosynthesis is a major process affecting crop growth rates and is affected by either the number or the area of the leaves. Since the productivity of a plant depends on the efficiency of its photosynthetic processes and therefore on the extent of its photosynthetic surface, the growth and development of leaves have a profound impact on the yield of the plant. In addition, leaves also play a vital part in controlling water loss incurred by plants.

Prior experiments related leaf removal shown that the effects of leaf removal on sunflower yield and yield components change according to the number of removed leaves (Sackston, 1959), removal time (Schneiter et al., 1987)and the position of the removed leaf (Johnson, 1972). It is also reported that reactions of cultivars are different from each other (Pereira, 1978).

Experiments about artificial leaf removal have been conducted on other plants, such as; sugarcane (Singh and Singh, 1984), peanut (Jones et al., 1982), chickpea (Pandey, 1984), sorghum (Rajewski et al., 1991), soyabean (Diogo et al., 1997) and it is stated that leaf removal is effective on yield.

Because of drought, hail, insect and disease damage or as a result of senescence, leaf area in the field decreases. Although lower leaves don't make significant contribution to photosynthesis because of exposure to shadow they cause water loss by respiration. Some parts of our country leaves of sunflower are removed in different depths especially during the periods after flowering. But the effect of leaf removal on plant growth is not known.

In this experiment, the effects of leaf removal in different numbers in different ecotypes during the beginning of flowering on sunflower yield and yield components were studied.

MATERIALS AND METHODS

A field experiment was carried out at Atatürk University Research Farm, Erzurum, Eastern Anatolia, Turkey (39°55'N, 41°16'E, altitude 1950 m). The experiment was conducted using 10 sunflower ecotypes (Amasya, Uşak, Kırşehir, Erzurum, Iğdır-2, Çorum-2, Edirne -1, Çorum-1, Line-1ve Iğdır-1) and information about those ecotypes is given in Table 1.

The experimental area had clay, neutral characteristics. Soil was rich for potassium, poor for nitrogen and organic material, and had medium level for phosphorus. The climatical parameters were similar to average temperature during growth period was 14.8 C, precipitation was 174.1 mm and relative humidity was 57.6 %.

Table 1. Sunflower ecotypes used in the experiment

Ecotypes	**Collection Site**	**Maturity**
Amasya	Suluova-Amasya	Late
Uşak	Banaz- Uşak	Late
Kırşehir	Oluklu Kırşehir	Late
Erzurum	Pasinler	Early-middle
Iğdır-2	Çalpalan -Iğdır	Early-middle
Çorum-2	Sungurlu-Çorum	Late
Edirne -1	Hatip -Edirne	Late
Çorum-1	Alaca-Çorum	Late
Line-1	Atatürk Univ. Agricultural Faculty	Early-middle
Iğdır-1	Enginalan -Iğdır	Late

The experiment was arranged as a factorial design with 3 replications in the to randomized complete blocks design. Sunflower ecotypes were treated as first factor and leaf removal level (from bottom 0, 4, 8, 12 numbers leaves/plant) were considered as second factor. Distance between rows was 70 cm; plant distance within rows was 40 cm. Each row had 12 plants, each plot had 4 rows. During sowing 8.5 kg/da N and 9 kg/da P_2O_5 were applied (Öden, 1991) and throughout the plant growth agronomic practices were done. The experimental area was irrigated when the available moisture reached 20% of field capacity.

As soon as flowering head was seen in every plot by beginning from the bottom 0, 4, 8, 12 leaves were removed from each plant from each plot by cutting with a knife.

During harvest time, the plants which are in the two middle rows (total 24 plants) were collected and taken to the laboratory and yield components were determined after the heads had been threshed and the seeds had been dried to a moisture content of about 7%.

Measurements

The following parameters were studied; head size (cm), seed setting (seed setting (%) = 100- (r^2 / R^2) x 100 ; R= head diameter and r= diameter of central circle), seed yield (kg/da), 1000-seed weight (g), kernel ratio (kernel ratio (%): [Kernel weight (g)/grain weight (g)] x 100), crude protein content (%), crude protein yield (kg/da), crude oil content (%) and crude oil yield (kg/da) according to Günel, (1972) and Karadoğan and Özgödek, (1994). Data was analyzed by the analysis of variance using the MSTATC computer package program. When analysis of variance showed significant treatment effect, the least significance difference (LDS) test was applied to make comparisons among the means at the 0.05 level of significance.

RESULTS

Head size

Although there was an increase in the head diameter parallel to the increase in the number of leaf removed, this effect was statistically insignificant (Table 2).
Head diameter due to the quantity of leaf removed showed significant changes depending on ecotypes ($p<0.01$). Head diameters decreased with leaf removal in Iğdır-2, Line-1, Çorum-1and Edirne-1 and head diameters increased in Uşak, Kırşehir, Iğdır-1 and Erzurum. No changes was observed for head diameters for other two ecotypes (Figure 1). Leaf removal x ecotype interaction was found to be significant ($p< 0.01$).

Table 2. Effects of leaf removal on head diameter, seed setting, seed yield and 1000-grain weight of sunflower

Number of removed leaves	**Head diameter (cm)**	**Seed setting (%)**	**Seed yield (kg/da)**	**1000-Grain weight (g)**
0	17.8	98.40 ab	227.95 b	123.27
4	17.9	98.17 b	250.12 a	123.77
8	18.0	98.90 a	270.20 a	125.73
12	18.2	98.51 ab	266.56 a	123.80
LSD	ns(1)	0.5042	21.69	ns

1/ insignificant.

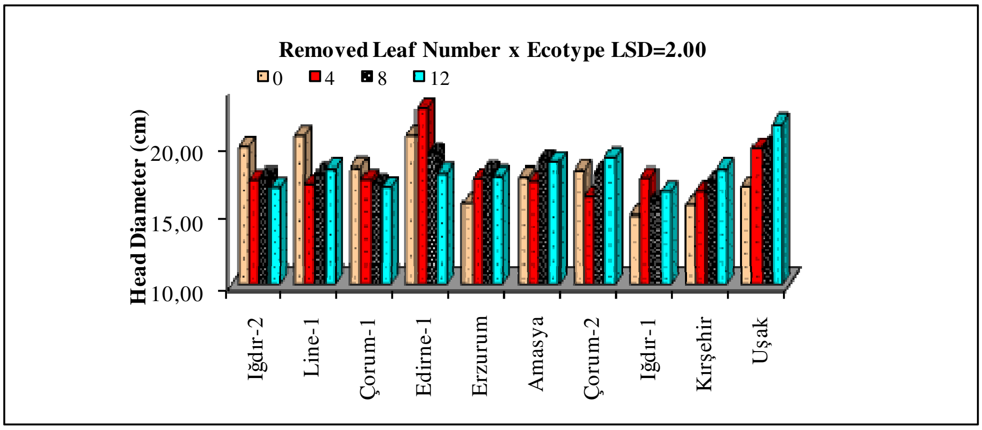

Figure 1. Change of head diameter of sunflower in accordance with number of removed leaves

Seed setting

With the number of removed leaves, seed setting of the heads showed a considerable change and in the case of removal of 8 leaves from the plant, seed setting occurred at the highest level. Removal of 12 leaves did not increase seed setting significantly compared to removal 8 leaves (Table 2). The effect of leaf removal on seed setting also showed a considerable variation according to ecotypes ($p<0.01$). This variation was observed in the form of a decrease in leaf removal and seed setting in Çorum-1, Line-1, Amasya and Iğdır-1 ecotypes whereas in Kırşehir, Uşak and Edirne-1 ecotypes showed increased seed setting (Figure 2). In other ecotypes, the effect of leaf removal on seed setting was insignificant. The ecotype x leaf removal interaction was found to be significant ($p< 0.01$).

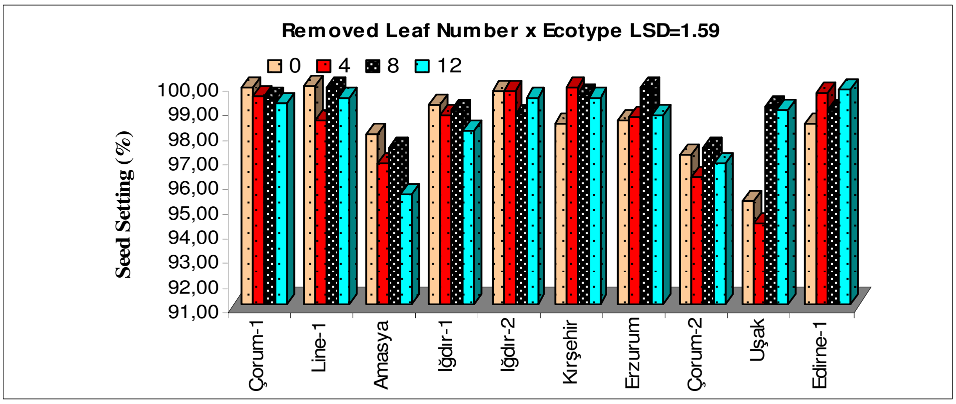

Figure 2. Change of seed setting of sunflower ecotypes with number of removed leaves

Seed yield

Generally, with the removed leaves, the seed yield was increased ($p< 0.01$) and the seed yield of the plants without leaf removal found to be lower than plants leaf removal (Table 2). Leaf removal effect showed significant variations with the ecotypes ($p< 0.01$). With the removal of 8 leaves from Edirne-1, Amasya, Uşak, and Erzurum ecotypes, the highest seed yield was obtained.

Seed yield was the highest when 12 leaves were removed from Line-1, Iğdır-2, Çorum-2, Iğdır-1 and when 4 leaves were removed from Çorum-1 ecotype (Figure 3). The ecotype x leaf removal interaction was statistically insignificant.

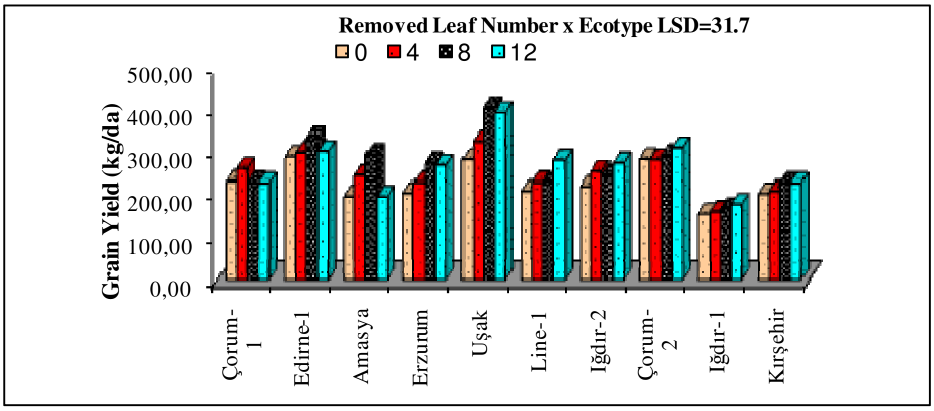

Figure 3. Change of seed yield of sunflower ecotypes with number of removed leaves

1000-Seed weight

Statistically, the effect of leaf removal on 1000-seed weight was insignificant. However, removal of 8 leaves from the bottom of the plants, 1000-seed weight increased (Table 2). Effects of leaf removal on 1000-seed weight showed variations with the ecotypes ($p<0.01$). Parallel to the number of the leaves removed, 1000-seed weight showed decrease in Line-1, Kırşehir and Çorum-1 ecotypes; whereas an increase was observed in other ecotypes (Figure 4).

When 8 leaves were removed from the bottom from Amasya ecotype and 4 leaves were removed from Edirne-1 ecotype, 1000-seed weight reached the highest value. 1000-seed weight of other ecotypes didn't change as to the leaf removal and the interaction was insignificant.

Kernel ratio

In the ecotypes studied, kernel ratio showed considerable variation and the highest ratio (56.05 %) was obtained by removing 8 leaves. The changes in other leaf removal practices were not found to be significant. The lowest kernel ratio (54.10 %) was obtained from the plants with no leaf removal (Table 3). Change in kernel ratio, also showed changes due to the ecotypes ($p< 0.01$). While a loss in kernel ratio by high leaf removal was observed in Edirne-1, Uşak and Iğdır-2 ecotypes; a rise was observed in others (Figure 5). Reactions of different ecotypes to leaf removal practices were different from one another and interaction was statistically significant ($p< 0.01$).

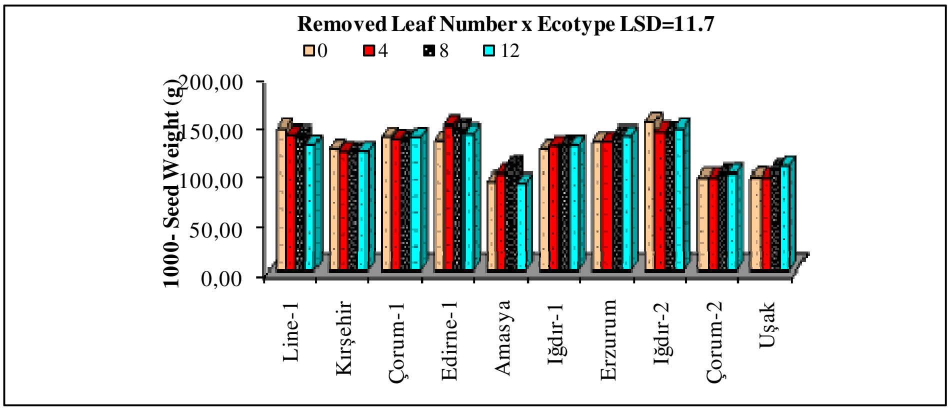

Figure 4. Change of 1000 seed weight of sunflower ecotypes with number of removed leaves

Table 3. Effects of leaf removal from sunflowers on kernel ratio, crude oil, crude protein content, crude protein yield and crude oil yield

Number of removed leaves	**Kernel ratio (%)**	**Crude protein content (%)**	**Crude protein yield (kg/da)**	**Crude oil content (%)**	**Crude oil yield (kg/da)**
0	54.10 b	21.15 b	49.25 b	19.40 a	44.11 c
4	55.43 ab	21.68 ab	54.69 ab	19.20 a	48.04 bc
8	56.05 a	22.38 a	60.94 a	19.23a	53.20 a
12	54.90 ab	22.33 a	59.84 a	18.34 b	49.23 ab
LSD	1.414	1.055	6.179	0.5142	4.437

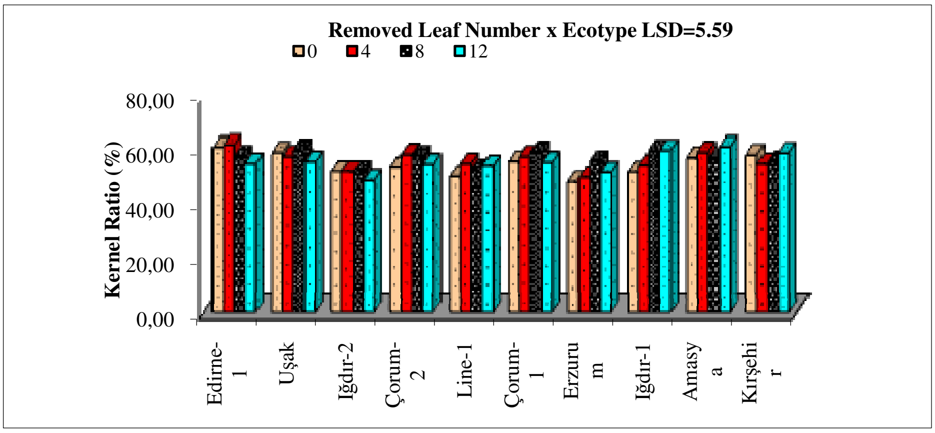

Figure 5. Change of kernel ratio of sunflower with number of removed leaves

Crude protein content

With an increase in the average number of leaf removed there was an increase in the crude protein content of seeds ($p< 0.01$). When compared to the plants without leaf removal, crude protein content in seeds of plants with 8 and 12 leaves removed were high (Table 3).

Crude protein content showed significant differences among the studied ecotypes ($p< 0.01$). While there were decreases in crude protein content in Kırşehir, Iğdır-2, Amasya and Iğdır-1 with number of removed leaves, there were increases in other ecotypes (Figure 6). When 4 leaves removed from Edirne-1 ecotype and 8 leaves from Çorum-2 ecotype, crude protein ratio was highest and the interaction between removal x ecotype was statistically significant ($p<0.01$).

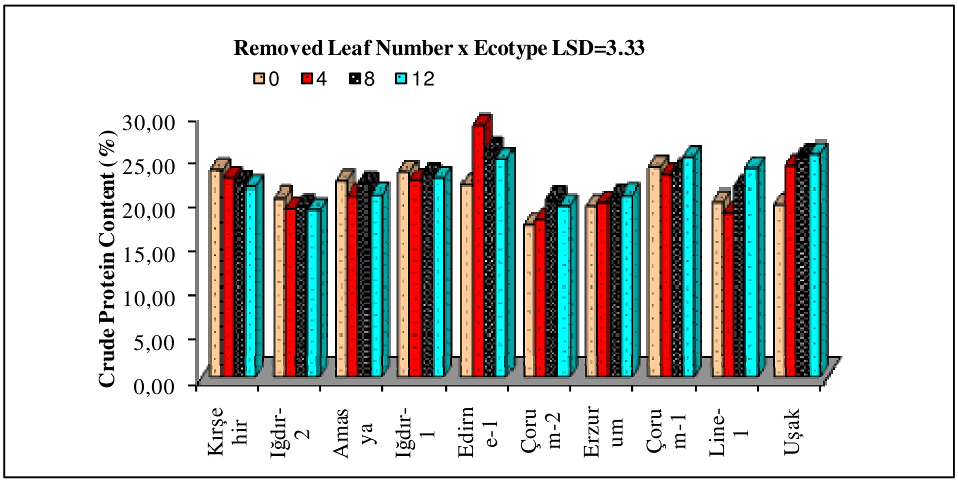

Figure 6. Change of crude protein content of sunflower ecotypes with number of removed leaves

Crude protein yield

The effect of leaf removal on the crude protein yield was significant ($p< 0.01$). Average crude protein yield of plants without leaf removal was lower (49,25 kg/da) than those plants whose leaves removed (4, 8 and 12). Difference between leaf removal treatment on crude protein yield was insignificant.

There were differences in the effect of leaf removal on crude protein yield for ecotypes ($p< 0.01$) and except for Iğdır -1 leaf removal increased crude protein in yield other entries. While the effect of leaf removal on crude protein yield in Çorum-1, Iğdır-2, Çorum-2, and Kırşehir ecotypes was insignificant, in Edirne-1, Uşak, Erzurum and Amasya ecotypes, 8 leaves removal and in Line-1 12 leaves removal gave the highest crude protein yield (Figure 7). Ecotype x leaf removal interaction was significant ($p< 0.01$).

Crude oil content

Crude oil content decreased along with the number of removed leaves. Decrease in oil content was insignificant until 8 leaves. When 12 leaves were removed (Figure 8), crude oil ratio decreased considerably when compared to other treatments (0, 4 and 8 removed leaves ,Table 3).

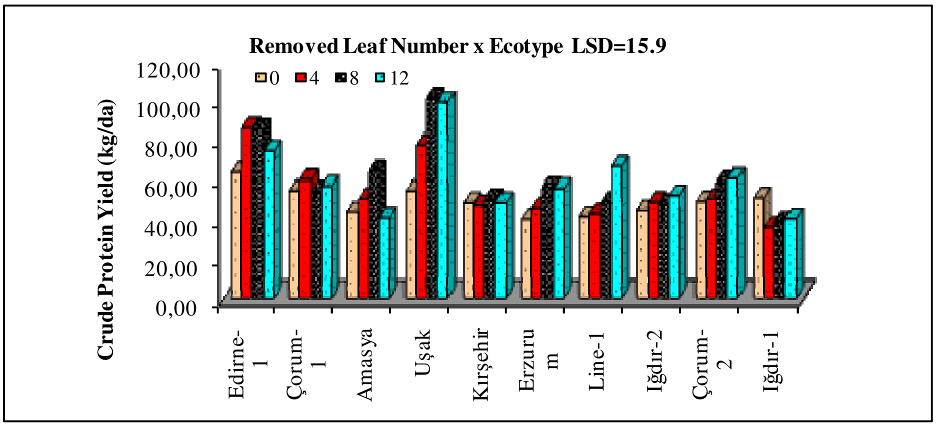

Figure 7. Change of crude protein yield of sunflower ecotypes with number of removed leaves

The effect of leaf removal on crude oil proportion showed a considerable change among ecotypes ($p< 0.01$). While crude oil proportion with removed leaves in Edirne-1, Erzurum, Amasya, Çorum-1, Uşak and Çorum-2 ecotypes was not showed a considerable change , in Iğdır-1, Kırşehir, Iğdır-2 and Line-1ecotypes, the crude oil proportions of seed, the plants of which are not removed off, have been higher. In the other ecotypes when 4 or 8 leaves are removed off, crude oil proportion has been found to be higher. Ecotype x treatment interaction was statistically significant ($p< 0.01$).

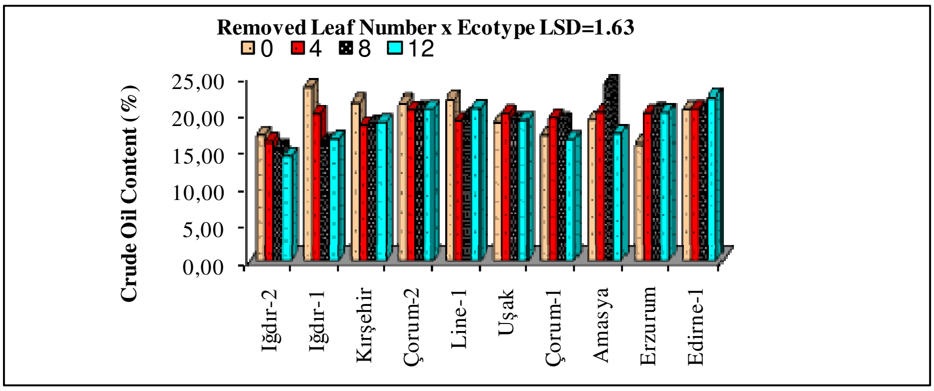

Figure 8. Change of crude oil content of sunflower ecotypes with number of removed leaves

Crude oil yield

Crude oil yield varied depending on the number of leaves removal and the highest value was obtained from the 8-leaf removal treatment (53.20 kg/da). The lowest crude oil yield (44. 11 kg/da) was obtained from the control plots (Table 3).

The change in crude oil yield of sunflower ecotypes related with the amount of the leaves that are removed off. Interaction between ecotype and removed leaf number from plants was significant ($p<0.01$). In all ecotypes, except Iğdır- 1, leaf removal practice has increased crude oil yield (Figure 9).

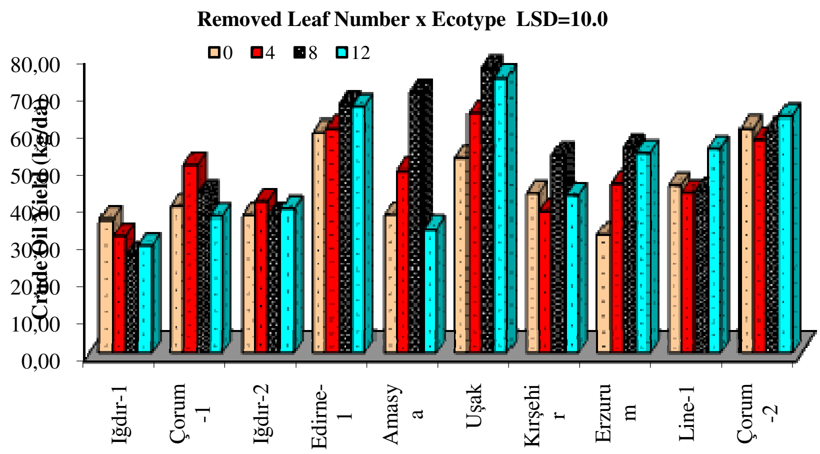

Figure 9. Change of crude oil yield of sunflower ecotypes with number of removed leaves

DISCUSSION

The results indicated that leaf removal from bottom of plants had significant effect on the seed setting, seed yield, kernel ratio, crude protein and crude oil contents and crude protein and crude oil yields per decare. While leaf removal practice has insignificant effect on the head size and 1000-seed weight, average number of removed leaves in the plants were found to be higher as compared to control plants. Effects of leaf removal treatment were highly dependent on genotypes used (Figure 1, 2, 3, 4, 5, 6, 7, 8 and 9). This ecotype x treatment interaction could be due to the height of ecotypes, branch and leaf numbers (Karadoğan and Özgödek, 1994) leaves' angels to the stem and the differences in leaf area. Shulgin and Klimov (1974) investigated physiological properties of semi-dwraf and standard height sunflowers. They found that the semi-dwraf forms were characterized by a better distribution of assimilates throughout the organs and a more active photosynthetic apparatus. Especially, the effect of leaf removal on the examined traits could be more apparent in the ecotypes with a high leaf number and with leaves straight to the plant's stem (like Amasya, Kırşehir, Uşak, Edirne). In fact, lower leaves do not participate in photosynthesis due to being shaded by upper leaves, they cause a positive increase in the examined traits.

In the earlier studies about the subject, it has been showed that leaf removal affects, head size, seed yield, 1000-grain weight, kernel rate, crude oil rate and oil yield (Johnson, 1972; Schneiter et al., 1987). Pereira (1978) reported yield of the late cultivars less adversely affected than the early cultivars. In addition, timing the in removal of sunflower leaves has significant effect on yield and yield components of yield. Defoliation was not suitable at the flowering stage compared to seedling and maturing stages (Stackston, 1959).

Leaf removal at various times of sunflower genotypes had significant effects on reducing time to first anthesis (12 to 13 %), on reducing total floret number (16 to 17 %) and on vastly increasing receptacle area (Kim, 1990).

Based on the results obtained in this study, it could be a clear cut statement is impossible about the effect of leaf removal on yield, components of yield and quality related to varieties. But average of 8 leaves removal might increase yield and quality.

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