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# Simulation of Leaf Damage by Artificial Defoliation and its Effect On Sunflower (*Helianthus annuus* L.) Performance

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**Abstract:** The removal of upper 2/3 and ½ leaves caused a yield reduction of 29 and 55.8 percent in 1992 and 37 and 44.8 percent in 1993, respectively. During 1992, about 1 percent yield decline was observed when the lower 1/3 leaves were removed and 6 percent yield declined with the removal of the lower ½ leaves, while in 1993, the yield reduction was 26.7 and 39.2 percent due to removal of lower 1/3 and ½ leaves, respectively. This indicated that upper leaves (source) contribute more towards sink (seed yield) as compared to the lower ones. Correspondingly, the results indicated that insects and pests feeding on the upper portion of the sunflower plant can cause more reduction in seed yield than the lower leaves.

**Key words:** Sunflower *(Helianthus annuus* L.), artificial defoliation, leaf damage, simulation, performance, seed yield, source and sink relationship, Pakistan

## Introduction

Defoliation has been used on a wide number of crop species. In soybean *(Glycine max* L.), for example, it was shown to reduce the yield considerably particularly if it occurs during the final stages of development (Malone and Caviness, 1985; Goli and Weaver, 1986) and when the pods begins to develop (Fehr *et al*., 1971; 1977; 1981). After defoliation, a decrease in grain yield as well as a drop in dry weight was observed in maize *(Zea mays* L.) (Hanway, 1969; Vasilas and Seif, 1985). Total defoliation before flowering in sunflower caused about 93 percent reduction in seed yield (Johnson, 1972). Defoliation during flowering may either block achene production altogether or enormously reduce achene size and oil content. A progressive increase in the percentage of defoliation corresponds to a progressive decrease in yield.

The dimension of the effect of artificial defoliation in sunflower depends on the phenological stage at which it is carried out and which leaves are removed. With regard to the phenological stage, defoliation has its most marked effects on seed yield just before flowering and during flowering (Sackston, 1959), but effects are far less notable when carried out during later stages of development (Rodrigues, 1978). As far as the portion of plant defoliated is concerned, it can be said that the more apical it is, the greater is its effect on yield. Yield increases if among the remaining leaves there is a high percentage of young ones (Rodrigues, 1978). This may be due to their greater capacity to transport assimilates to the flowers (McWilliam *et al*., 1974). Stickler and Pauli (1961) reported that grain sorghum *(Sorghum bicolor* L.) yields were reduced more from removing approximately one half of the upper portion of the plants than the removal of an equal proportion of leaves from the lower portion.

## Materials and Methods

Sunflower hybrid, NK-212, was planted on 2nd March 1992 and 7th February 1993 at National Agricultural Research Centre (NARC), Islamabad, Pakistan to assess the impact of various level of simulated leaf damages caused by insects, hail, foliage diseases and source and sink relationship. A randomized complete block design (RCBD) with four replications was used. A plot size, having four rows of 5 m length, spaced 75 cm apart was used. Plant to plant distance of 25 cm within rows was maintained in each plot. A uniform fertilizer dose of 60 N and 60 $P_2O_5$ (kg $ha^{-1}$) was applied to each treatment at the time of sowing in both experiments, while 60 N (kg $ha^{-1}$) was given at the time of first irrigation, when the plants attained 35-45 cm height. Planting was done by dibbler, putting three seeds per hill at a depth of 3-5 cm in the soil. After germination, hills were thinned to one seedling per hill. The crop was thinned to one plant per hill at 2-4 leaf stage. Two hoeings were done to eradicate the weeds. Earthing up was done manually after the second irrigation to prevent the crop from lodging. The following ten defoliation treatments were applied at the time of flower initiation.

Leaves were clipped (removed) from their point of attachment to the petioles in all the 4 rows of each plot but the data were recorded from the two central rows. Plant height (PH), head diameter (DH), seed yield (SY), 100-achene weight (100-AW) and oil content (OC) were recorded. Plant height was measured from ground level to the receptacle of the flower as an average of 10 plants selected randomly from the two central rows of each plot at physiological maturity stage. Head diameter was also measured from the same randomly selected, 10 plants. The central two rows from each plot were harvested for recording seed yield, oil content and 100-AW. After recording the seed yield, samples of 120 to 150 gm seed were collected in Kraft paper bags for determining the moisture content of seed at harvest using the following formula:

$$\text{MC (\%)} = \frac{\text{Fresh wt. (g) at harvest - dry wt.(g) of the seed taken after drying in oven at } 70^{\circ}\text{C for 120 hours}}{\text{Fresh wt. (g) at harvest}} \times 100$$

Hundred seed weight was taken as an average of three samples from each plot. Oil content was determined by using Nuclear Magnetic Resonance (NMR), Model Oxford 4000. The data collected were subjected to analysis of variance (Steel and Torrie, 1980), using Mstat-C software of micro computers. Duncan's Multiple Rang Test (Duncan, 1955) was used for separating the treatment means.

## Results and Discussion

The defoliation treatments affected seed yield, plant height, head diameter and oil content highly significantly during both the years. Treatment × year interaction was also highly significant. During 1992, when all the leaves were left intact maximum yield of 3511 kg $ha^{-1}$ was obtained, followed by T2 (removal of lower 1/3 leaves) and T3 (removal of lower 1/2 leaves) with 3483 and 3287 kg $ha^{-1}$ yield, respectively. Seed yield of T2 and T3 were not significantly different from T1 (Table 1). These results indicated that the removal of lower 1/3 or 1/2 leaves did not reduce yield significantly. Contrarily, the maximum reduction in

Table 1: Simulation of leaf damage by artificial defoliation and its effect on sunflower performance during, 1992

| Defoliation treatment | PH (cm) | HD (cm) | Yield (kg ha$^{-1}$) | 100-AW (gm) | OC (%) |
|---|---|---|---|---|---|
| None | 166 | 17.9 | 3511 | 7.7 | 48.6 |
| Lower 1/3 | 1·68 | 18.2 | 3483 | 7.4 | 49.1 |
| Lower ½ | 169 | 17.2 | 3287 | 7.0 | 49.3 |
| Lower 2/3 | 170 | 16.4 | 2649 | 6.3 | 50.0 |
| Middle 1/3 | 167 | 17.2 | 2758 | 6.8 | 50.0 |
| Middle 2/3 | 170 | 15.5 | 2006 | 5.4 | 49.8 |
| Upper 1/3 | 163 | 17.4 | 2492 | 7.1 | 46.4 |
| Upper ½ | 163 | 16.2 | 1553 | 5.2 | 45.4 |
| Upper 2/3 | 161 | 12.4 | 685 | 3.8 | 38.4 |
| All | 152 | 08.3 | 90 | 2.2 | 25.6 |
| CV (%) | 2.4 | 6.5 | 7.3 | 6.8 | 3.3 |
| LSD (0.05) | 5.7 | 1.5 | 238 | 0.6 | 2.2 |

Table 2: Simulation of leaf damage by artificial defoliation and its effect on sunflower performance during, 1993

| Defoliation treatment | PH (cm) | HD (cm) | Yield (kg ha$^{-1}$) | 100-AW (gm) | OC (%) |
|---|---|---|---|---|---|
| None | 178 | 17.6 | 2426 | 6.3 | 39.8 |
| Lower 1/3 | 185 | 19.7 | 1778 | 6.1 | 37.8 |
| Lower ½ | 183 | 16.8 | 1474 | 5.4 | 38.5 |
| Lower 2/3 | 182 | 16.5 | 1247 | 5.4 | 37.5 |
| Middle 1/3 | 184 | 17.8 | 1545 | 5.8 | 37.8 |
| Middle 2/3 | 186 | 14.4 | 663 | 4.9 | 37.3 |
| Upper 1/3 | 181 | 17.4 | 1512 | 5.5 | 36.1 |
| Upper ½ | 180 | 17.2 | 1339 | 4.8 | 35.0 |
| Upper 2/3 | 181 | 13.5 | 606 | 3.8 | 33.4 |
| All | 175 | 10.0 | 308 | 3.6 | 21.9 |
| CV (%) | 3.4 | 15.0 | 16.5 | 7.2 | 4.7 |
| LSD(0.05) | 8.9 | 03.5 | 308 | 0.6 | 2.5 |

the sunflower yield was observed when upper 2/3, 1/2 and 1/3 leaves were removed giving 685, 1533 and 2492 kg ha$^{-1}$ seed yield, respectively. Seed yield also reduced significantly when middle 1/3 (2758 kg ha$^{-1}$) and 2/3 leaves (2006 kg ha$^{-1}$) were removed. The lowest yield of 90 kg ha$^{-1}$ was obtained when all the leaves were removed, which was significantly lower than all other defoliation treatments. In T10 the plants failed to attain more seed filling because all the leaves were removed earlier to reach physiological maturity stage. These results are in agreement with those obtained by Steer *et al*. (1988), Schneiter *et al*. (1987), Butignol (1983), Fleck *et al*. (1983) and De Beer (1983). By removing upper leaves in treatment T7, T8 and T9, the yield reduction was to the tune of 29.0, 55.8 and 80.0 percent, respectively. While removing of lower leaves in T2, T3 and T4, the yield reduction was 0.8, 6.4 and 24.6 percent, respectively. These results are in agreement with those obtained by Johnson (1972), Mitchell (1984), Belloni *et al*. (1990) and Da Silva *et al*. (1984). During 1993, the trend in reduction of yield due to defoliation treatments was almost similar although the magnitude was little different (Fig. 1). The main difference in both years result was that in 1993, the removal of lower 1/3 and 1/2 leaves also reduced the seed yield significantly (Table 2). Similarly, removal of middle 1/3 and 2/3 leaves caused severe reduction (36.3 and 72.7 percent, respectively in seed yield during 1993, while reduction in yield during 1992 was little less and ranged from 21.4 to 42.9 percent for removal of middle 1/3 and 2/3 leaves.

However, during both the years, effect of removal of upper leaves was more drastic on seed yield, seed development and oil content than removal of middle and lower leaves (Sharma and Sharma, 1986; Banerjee and Haque, 1984). It was probably because the upper leaves are younger, and intercept the sunlight the most, therefore, had more photosynthetic activity (Da Silva *et al*., 1984). Moreover, lower leaves are shaded by the upper leaves and therefore cannot contribute to the production of photosynthates as effectively as upper leaves can. Correspondingly, the results reflected that damages caused by insect pests, hail and foliage diseases which distribute themselves on upper leaves of the plants can cause more reduction in seed yield as compared with middle and lower leaves of sunflower (De Beer, 1983). The results also indicated that the upper leaves contribute more towards sink compared to the lower ones. In addition, reduction in leaf area reduced the contribution of photosynthates to sink proportionately (Fig. 2 and 3), which was conspicuous in all parts of the plant, i.e., lower, middle and upper leaves. During, 1992 the maximum oil content (50.1 percent) was obtained by the T5 in which the middle 1/3 leaves were removed. Other treatments which gave more oil percent were T2, T3, T4 and T6 which were statistically not different from each other and from T1 (all leaves intact). The removal of upper leaves in case of T7, T8, and T9 reduced the oil content significantly. The treatment having plants without leaves had only 25.6 percent oil in the seed. Similar results were obtained during 1993.

The results indicated that the contribution to oil content was not proportionally linked to defoliation of lower and middle leaves, however, reduction in oil content was conspicuous in removal of upper leaves. It indicates that upper leaves contribute most to oil synthesis. The largest head diameter was obtained when the lower 1/3 leaves were removed during both the years.

The treatments which reduced the head diameter significantly were the removal of upper 2/3 and middle 2/3 leaves. These results are in conformation with those obtained by Moscardi and Boas (1983) and Singh and Khan (1981). Plant height was not significantly affected by most of the defoliation treatments during both the years, however, effect of removal of leaves was more obvious in 1993. Removal of all leaves reduced the plant height significantly (Mariko and Hogetsu, 1987). The plant height in both years, increased with all defoliation treatments except T10. During, 1992, increase in plant height was more when lower leaves were removed than increase in height due to removal of

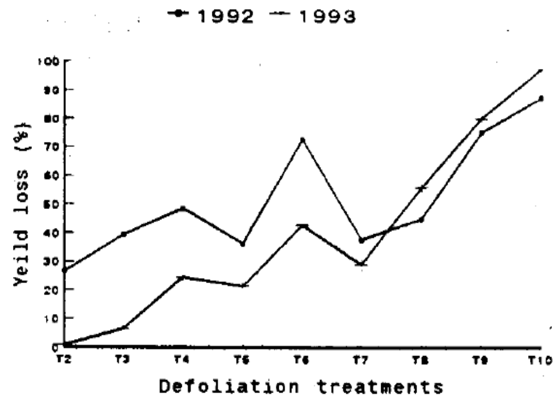


Fig. 1: Yield loss in sunflower due to various artificial defoliation treatments compared to the control treatment haveing all leaves intact

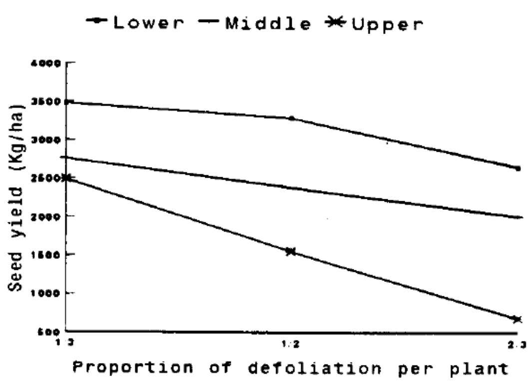


Fig. 2: Simulation of leaf damage by artificial defoliation and its effect on sunflower yield, during 1992.

upper leaves, however, in 1993 the removal of upper leaves in T7, T8, and T9 reduced he plant height. All defoliation treatments irrespective of leaf position on plant, reduced the 100-achene weight significantly. During both the years, reduction in seed size was significantly more when upper 2/3, upper 1/2 and middle 2/3 leaves were removed as compared to the removal of leaves from lower 1/2 lower 2/3 and upper 1/3. The removal of lower 1/3 leaves reduced the seed size but it was not statistically significant. These results are in agreement to that obtained by Da Silva *et al*. (1984). The leaves were clipped in various proportion from different parts of the plant i.e., lower, middle and upper. The removal of upper 2/3 and 1/2 leaves caused a yield reduction of 29 and 55.8 percent in 1992 and 37 and 44.8 percent in 1993, respectively. These results indicated that removal of upper 2/3 and 1/2 leaves affected seed yield the most. It showed that the upper leaves contribute more assimilates towards sink (yield) than lower leaves in sunflower. It indicates that the upper laves are more actively involved in photosynthesis in sunflower. It is probably because upper leaves are younger than the lower leaves. There was very low yield decline in which lower 1/3 and 1/2 leaves were removed.

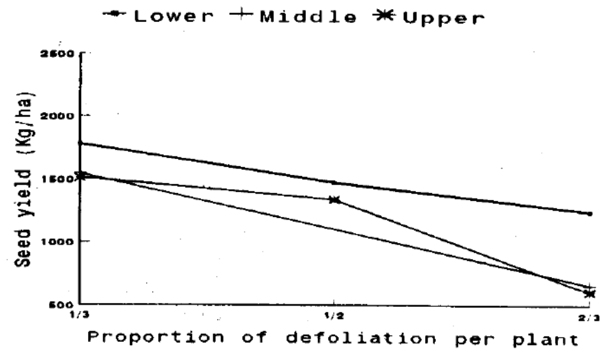


Fig. 3: Simulation of leaf damage by a artificial defoliation and its effect on sunflower yield, during 1993

The results reflected that the damages caused by insect pests, hail and foliage diseases, which distribute themselves in the upper portion of sunflower plants can reduce the yield upto maximum, if the attack is severe. This indicated that upper leaves (source) contribute more towards sink (seed yield) as compared to the lower ones. Correspondingly, the results indicated that insects and pests feeding on the upper portion of the sunflower plant can cause more reduction in seed yield than the lower leaves.

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