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## Effects of Simulated Insect Injury on Net Photosynthesis of Potted Grapevines

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**Abstract.** Grape (*Vitis vinifera* L.) leaves on potted vines were injured artificially by removing leaf disks with a paper punch. The leaves showed decreased net photosynthesis ( $P_n$ ) for the remaining leaf area as leaf area loss (LAL) increased. This reduced  $P_n$  in the remaining leaf area at low levels of injury was more pronounced after 12 days than after either 1 or 5 days. The effects of LAL and lowered  $P_n$  were additive by 20% LAL for all days tested.

Artificial defoliation studies with grape usually have involved removal of whole leaves or portions of shoots (1, 6, 9, 10) and have been useful for determining the effects of foliar loss resulting from mechanical harvesting or disease on yield and berry maturity. Research with other crops, however, has indicated that it may not be adequate to simulate certain insect injury (5, 11).

Studies on the effects of simulated insect injury on  $P_n$  of apple determined that "the amount of cut surface exposed by injury was more important than the amount of leaf area removed" (5). It is important to avoid cutting the midrib or the main lateral veins of the leaf when simulating damage by insects that feed on interveinal areas. (5, 11). It follows that arthropods that remove portions of a shoot, large portions of leaves, or many

smaller portions, and sucking arthropods (e.g., mites) may all produce different amounts of damage to the plant, even when the amount of leaf area injured or removed is similar.

$P_n$  increased in the remaining leaves on potted grapevines following removal of whole leaves (7).  $P_n$  of the remaining leaf area of grape after removal of a portion of many leaves by insects has not yet been investigated to the best of our knowledge. Researchers have demonstrated a decline in  $P_n$  of apples due to mite damage (4) and have shown that a "secondary reaction" occurs in apple leaves that further reduces  $P_n$  when >20% of the leaf area is removed with a cork borer (5). If a similar drop in efficiency occurs in grape leaves from such insect injury [e.g., Japanese beetle, (*Popillia japonica* Newman)], this drop might increase the leaf area required to mature the fruit compared to estimates based on other forms of defoliation (1, 6, 10).

Information gained in this area may be helpful in determining economic injury levels (EIL) and economic thresholds (ET) for certain insect pests. Studies on effects of simulated insect damage on soybean  $P_n$  reveal that certain artificial injury techniques (e.g., paper punch) adequately simulate damage by certain defoliators (11). This study was initiated to determine if a drop in  $P_n$

(based on remaining leaf area) occurs in grape after leaf area removal and, if so, at what level of interveinal leaf area loss (LAL) it occurs.

Five grafted 'Meurier'/'Elvira' grapevines were grown in 15-cm pots containing peat-vermiculite (Promix) in an open-ended greenhouse from Mar. through July 1984. The vines were fertilized at a rate of 200 ppm N weekly, beginning in April, using a solution of 20N-8.6P-16.6K.

On 1 Aug., four adjacent leaves near the midlength of the shoots ( $\approx 10$  to 18 nodes from the shoot apex) were selected and  $P_n$  of attached leaves was determined with a Beckman model 865 infrared gas analyzer as previously described (12).  $P_n$  again was determined 24 hr after treatment and 5 and 12 days later. The air flow rate into the leaf chamber was 5 liters  $\cdot$  min<sup>-1</sup>; air temperature was 28°  $\pm$  2°C. Photosynthetic photon flux was maintained at 850  $\mu$ mol  $\cdot$  s<sup>-1</sup>  $\cdot$  m<sup>-2</sup>. The leaves were randomly reassigned to one of four treatments ( $\approx 0$ , 10, 20, or 45% LAL) based on leaf size as estimated by length  $\times$  width measurement. Leaf disks (0.31 cm<sup>2</sup>) were removed from the interveinal area using a paper punch.

The outline of each leaf was traced and a paper cut-out was made at the conclusion of the experiment. The tracings and the damaged leaves were measured with a LI-COR model 3000 leaf area meter. The actual percent LAL was determined from the difference between the two measurements and ranged from 9-12% (10% treatment), 20-28% (20% treatment), and 42-52% (45% treatment).

$P_n$  was calculated using posttreatment leaf area to determine the photosynthetic efficiency of the remaining leaf tissue (actual  $P_n$ ) (5). Posttreatment  $P_n$  rates are presented as a percent of the pretreatment rates. A general linear model procedure was used to analyze the data (3).

There was a drop in the  $P_n$  of uninjured leaves (0% treatment) throughout the 14 days of the study. The mean  $P_n$  values for the undamaged leaves on days 0, 1, 5, and 12 were 16, 13, 13, and 12 (mg CO<sub>2</sub>/dm<sup>2</sup> per hr), respectively. This gradual decline in  $P_n$  may have been due to both the handling of the leaves during measurements (2) and/or leaf aging (8).  $P_n$  values below those of the

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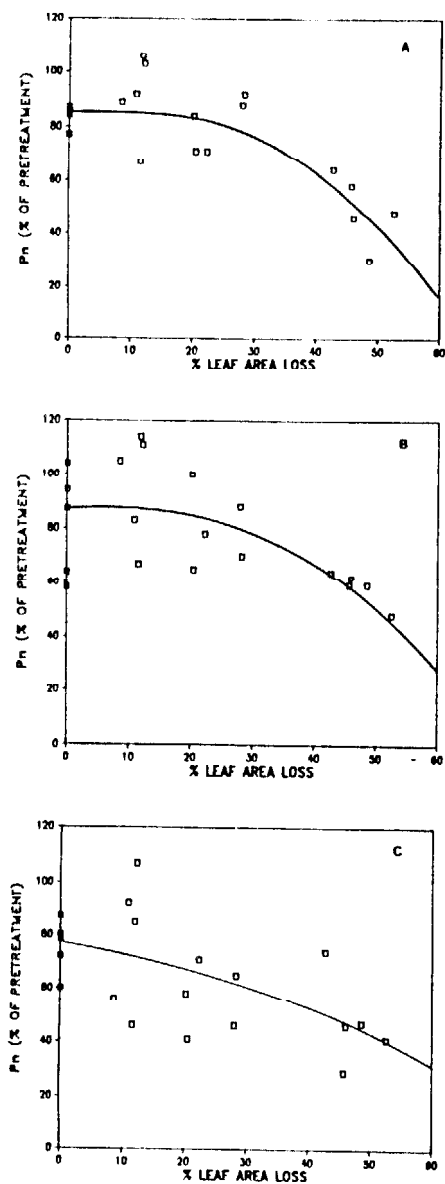


Fig. 1. Net photosynthesis ( $P_n$ ) (A) 1 day after leaf area removal ( $Y = 84.62 + 0.6698X - 0.0297X^2$ ,  $R^2 = 0.70$ ,  $P < 0.01$ ); (B) 5 days after leaf area removal ( $Y = 84.46 + 0.6670X - 0.0261X^2$ ,  $R^2 = 0.43$ ,  $P < 0.01$ ); and (C) 12 days after leaf area removal ( $Y = 76.71 - 0.4821X - 0.0037X^2$ ,  $R^2 = 0.35$ ,  $P < 0.03$ ).

controls (0% treatment) were interpreted as treatment effects.

Leaves showed a similar change in  $P_n$  due to LAL 1 and 5 days after treatment (Fig. 1 A and B). There was a greater depression of  $P_n$  among leaves with low levels of LAL (9–12%) 12 days after damage was inflicted than after 1 and 5 days (Fig. 1C). As the degree of LAL increased (beyond 20%, 1 and 5 days after treatment, and 10% 12 days posttreatment), the efficiency of the remaining leaf area decreased (Fig. 1 A–C).

It appears that there was a secondary response to LAL similar to that reported previously in apple (5), which produced a drop in the efficiency of the remaining tissue of the injured leaves by 20% LAL for all dates tested. Leaves injured in excess of 20% should be considered separately from lower levels of leaf injury when developing EIL for defoliating insects, as they may be affected more than indicated by the loss of tissue alone (Fig. 1 A and B). This relationship may also be the case for leaves with <20% LAL more than 5 days after injury (Fig. 1C). For apple, there was a drop in  $P_n$  efficiency for the remaining leaf tissue at 3 and 7 days after the removal of 15% of the leaf (5).

Specific information on the productivity of injured leaves would become important to developing EIL and ET as the severity and percent of leaves injured increased, especially on less-vigorous vines with trellis systems that do not maximize light exposure. The amount of leaf area exposed to direct solar radiation plays an important role in determining the quality and quantity of the yield (13). Further investigations are necessary to determine the physiological factors involved in the reduction in  $P_n$  efficiency of injured leaves. In addition, it is important to ascertain if adjacent leaves can compensate for partial tissue loss on several leaves and how much they compensate at various levels of LAL. Such information will be valuable in producing the advanced types of ET and EIL.

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