REDUCED NET PHOTOSYNTHESIS OF LEAVES FROM MATURE PECAN TREES BY THREE SPECIES OF PECAN APHID

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ABSTRACT

Pecan, *Carya illinoensis* (Wang.) K. Koch, foliage from 60-year-old 'Stuart' trees infested by phloem feeding pecan aphids experienced a reduction in net photosynthesis (Pn) as the population density of *Monellia caryella* (Fitch), *Monelliopsis pecanis* Bissell, or *Mellanocallis caryaefoliae* (Davis) increased. The increase was curvilinear for *M. caryella* and *M. pecanis,* but linear for *M. caryaefoliae.* The degree of reduction by an individual aphid was similar for *M. caryella* and *M. pecanis,* but *M. caryaefoliae* was far more detrimental. When the densities of the three aphid species are within the currently recommended spray threshold levels, there is very little adverse influence on Pn.

Key Words: *Carya illinoensis,* carbon exchange, *Monellia caryella, Monelliopsis pecanis, Melanocallis caryaefoliae,* pest management.

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INTRODUCTION

Pecans, *Carya illinoensis* (Wang.) K. Koch, trees naturally exhibit an alternate bearing characteristic that is expressed by essentially all commercially significant cultivars. Alternate bearing is associated with tree energy reserves and the ratio of sink to source tissues (Sitton 1931; Sparks and Brack 1972; Worley 1979; Wood and Tedders 1982). It is thus influenced by factors which effect energy reserves or the balance of energy within the tree (Sparks 1983). One such factor is insect pests that parasitize pecan foliage. Aphid pests, such as the blackmargined aphid, *Monellia caryella* (Fitch), the yellow pecan aphid, *Monelliopsis pecanis* Bissell, and the black pecan aphid, *Melanocallis caryaefoliae* (Davis) can be especially detrimental because of their ability to reduce a tree's energy level, nut yield, and nut quality (Tedders et al. 1981; Wood and Tedders 1982; Dutcher et al. 1984; Tedders and Wood 1984). They have also been observed to reduce leaf net photosynthesis (Pn) and dark respiration of young greenhouse grown pecan seedlings (Wood et al. 1985). Such feeding was observed to permanently reduce Pn levels by 50% after aphid population density had reached about 800 *M. pecanis M. caryella* per leaf, presumably due in part to the clogging of parasitized phloem tissue (Wood et al. 1985). Pn was observed to decline exponentially as the density of *M. caryella* and *M. pecan* increased from 0 to 30 aphids cm^{-2} of leaf surface; and linearly as the density of *M. caryaefolia* increased. Such findings suggest a devastating potential for aphids in the orchard environment; however, their actual impact of field Pn levels is currently unknown. The extrapolation of the effects of aphids on greenhouse grown material can be misleading in that such leaves differ markedly in morphological and physiological traits. The curves previously generated for aphids on greenhouse grown materials do not have a sufficiently high degree of resolution so as to determine the effects on Pn by the lower aphid densities more typical of those found in the field environment. This study reports the influence of various pecan aphid density levels on Pn of sun leaves (non-shaded leaves on the periphery) of mature pecan trees of a commercial orchard environment.

MATERIALS AND METHODS

The influence of feeding by all three aphid species on Pn was estimated by randomly selecting leaflets from several well-managed 60-year-old 'Stuart' trees with leaflets being essentially parasitized by aphid populations of each species at various density levels. Measurements were made in late August 1984 when aphid levels were increasing from a period of low aphid pressure during the summer and prior to an aphid population crash. Also, trees were subjected to insignificant aphid numbers during the preceding spring. Trees were not sprayed with pesticides during the 8 weeks preceding aphid measurements so as to prevent the possible suppression of leaf Pn by pesticides (Wood and Payne 1986).

Leaf Pn was measured with a LI-6000 (LI-COR, Lincoln, NB) portable photosynthetic system equipped with a 4-liter leaf chamber. Intact, mature leaflets of sun leaves being exposed to full sunlight with various aphid densities were selected for gas exchange measurements. Sample leaflets were first counted to determine aphid numbers (numbers of aphids per developmental stage were not determined) and aphids were gently brushed off the leaflet with a camel-hair brush. Leaflets were then allowed to acclimate for about 2-minutes. Pn measurements were then made on the attached leaflet. Measurements were made with a photosynthetic photon flux density exceeding 1000 μmol $s^{-1}m^{-2}$ and at ambient CO_2 levels. Leaf temperature typically increased from 0.1° to 0.3°C during the measurement period, while both leaf chamber relative humidity and CO_2 levels characteristically dropped less than 2% and 30 ppm, respectively, during the 90-sec measurement period. Leaflets were removed after measurement and area determined with a LI-3100 (LI-COR, Lincoln, NB) leaf area meter. Pn values were then plotted, with the means representing 10 Pn measurements, and regression equations calculated.

RESULTS AND DISCUSSION

The influence of pecan aphids on Pn of pecan leaflets adapted to the field environment was similar to that observed for such aphids on Pn of seedlings in the greenhouse (Wood et al. 1985) in that increasing aphid density resulted with a suppression of Pn (Figs. 1, 2, and 3). The influence of the two "yellow" aphid species on Pn was curvilinear and very similar with the relationship being $Y = 10.54 + 0.48X - 0.18X^2$ (r^2 0.58) and $Y = 11.43 - 0.33X - 0.8X^2$ ($r^2 = 0.72$) for *M. caryella* and *M. pecanis*, respectively. The curvilinear relationship may be due to the offsetting of detrimental influence of low "yellow" aphid densities by the stimulation of leaf photosynthesis due to increased depletion of photosynthate from leaf tissues, thus reducing feedback inhibition of the photosynthetic mechanism by photosynthetic products. These equations indicate that low densities ($\leq$ 2 or 3 aphids cm^{-2}) of aphids do not have a large measurable influence on Pn; however,

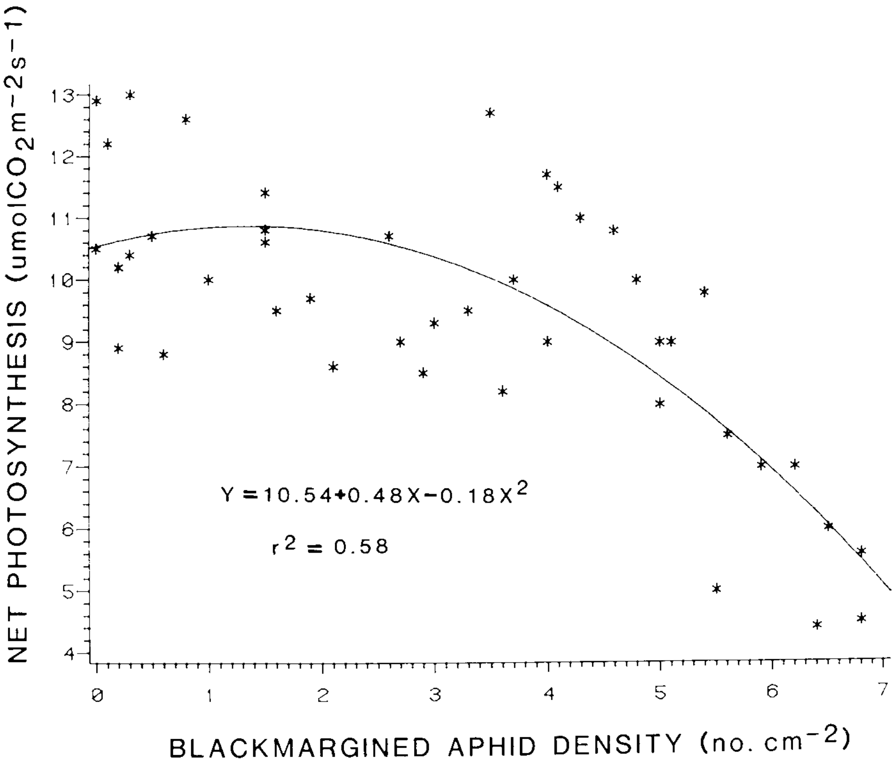

Fig. 1. Relationship of net photosynthesis of 'Stuart' pecan sun leaves, growing in the field environment, to various population densities of *M. caryella* (blackmargined aphid) feeding on infested leaflets.

higher densities ($\geq$ 4 aphids cm^{-2}) result in a large and probably physiologically significant influence on Pn and subsequently energy production. This influence on Pn may be a factor in making infested leaves unsuitable for subsequent colonization as reported by Liao and Harris (1984).

The current aphid management spray threshold levels for the "yellow" aphids generally call for aphicide sprays when the leaf aphid population reaches 10 - 50 aphids, depending upon season and State Extension service recommendations. Pecan leaf surface area is variable, but approximates 100 cm^2 per leaf. If aphids are uniformly distributed, then this reflects a spray threshold density of 0.1 to 0.5 aphids cm^{-2} which in this study caused very little suppression in Pn if field populations are held with this level. However, since "yellow" aphids do not distribute themselves uniformly on a pecan leaf but rather concentrate on certain leaflets (Tedders 1978), their suppression of Pn can be great on certain leaflets while most leaflets might be unaffected.

Suppression of Pn by the black pecan aphid was much more dramatic, on a per aphid basis, than that of the "yellow" aphids (Fig. 3). This is at least partially because they induce severe leaf chlorosis, and loss of chlorophyll at their feeding

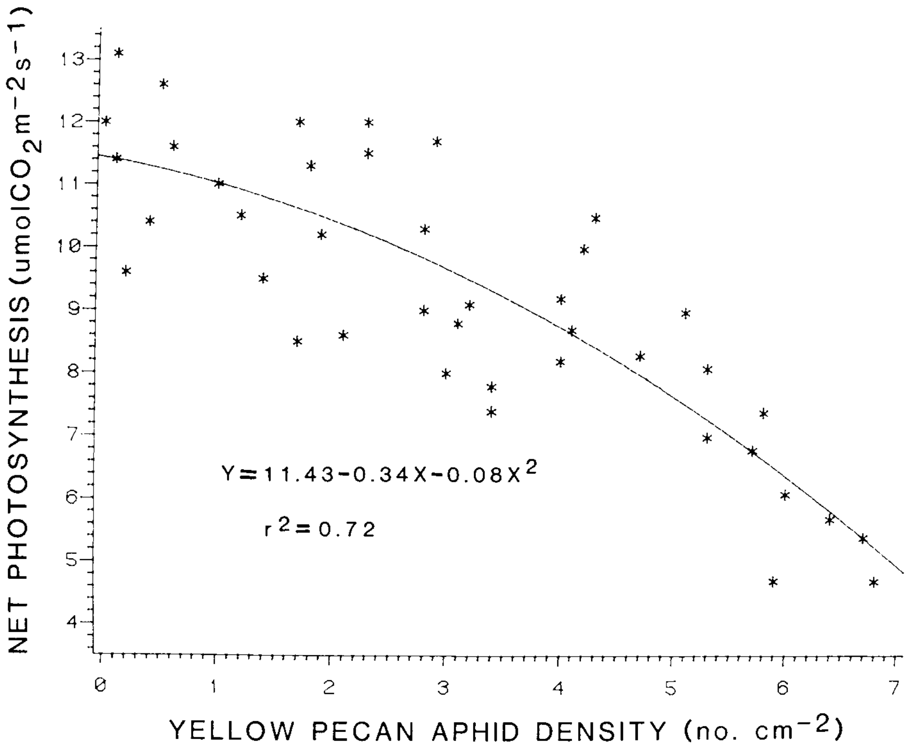

Fig. 2. Relationship of net photosynthesis of 'Stuart' pecan sun leaves, growing in the field environment, to various population densities of *M. pecanis* (yellow pecan aphid) feeding on infested leaflets.

sites. As the black pecan aphid population increased on the leaflets, there was a linear ($Y = 7 - 5.3X$, $r^2 = 0.90$) decline in not only Pn but also in the relative percentage of chlorophyll ($Y = 6.67 - 0.06\ X$, $R^2 = 0.96$) (Fig. 3). After Pn and also chlorophyll had both been reduced by abot 50%, the black pecan aphid population declined with fewer aphids per leaflet but a contained loss of Pn ($Y = 0.26 + 4.7X$, $r^2 = 0.88$) due to feeding by these aphids. Thus, the relationship of black aphid density is approximately parabolic. The current recommended spraying of black pecan aphids at a field threshold of one-per-leaf seems to be justifiable, considering the severe damage to phytosynthetic physiology and leaf efficiency, in that a density as small as 0.1 per cm^{-2} would be expected to adversely influence tree energy production.

These data indicate that the blackmargined, yellow pecan and black pecan aphids are capable of suppressing Pn of mature sun leaves in the field environment. This influence likely adversely effects tree energy production and reserves, especially at high density levels reached just prior to natural population crashes. When considered from strictly a Pn standpoint, the blackmargined and yellow pecan aphids do not appear to be particularly detrimental at densities at or below

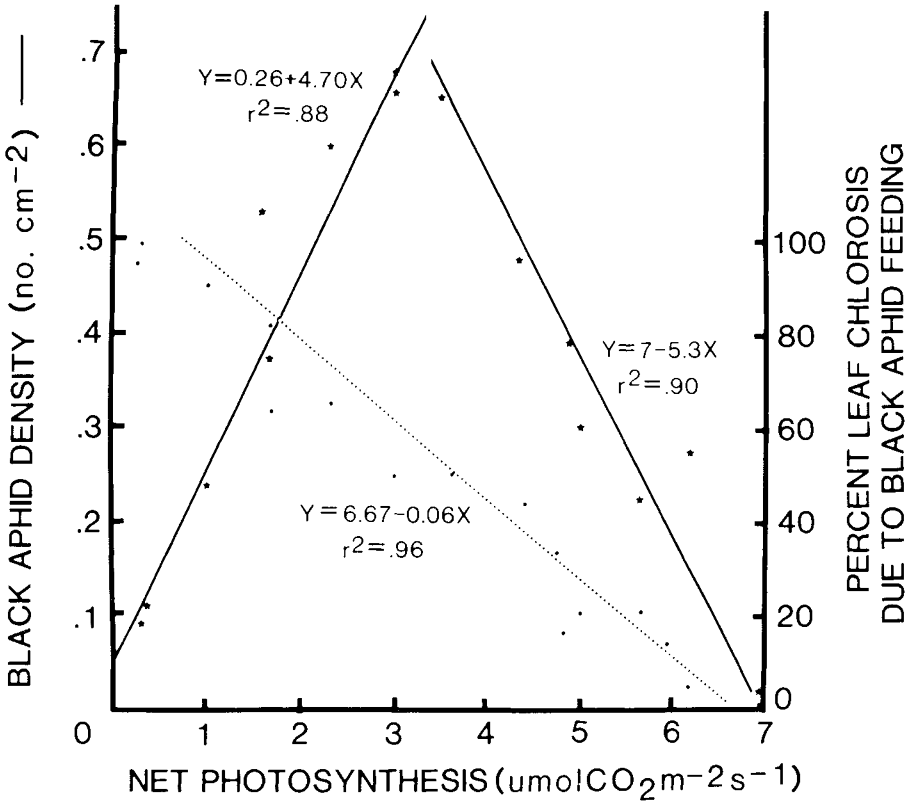

Fig. 3. Relationship of net photosynthesis and leaf chlorophyll level of 'Stuart' pecan sun leaves, growing in the field environment, to various population densities of *M. caryaefoliae* (black pecan aphid) feeding on infested leaflets.

current recommended threshold levels. The black pecan aphid is especially detrimental and should not be allowed to develop to even low densities. The measured influence of all three aphid species on Pn indicates that their threshold levels do not appear to result with economically significant reduction in energy production; however, high population densities would be expected to be especially detrimental.

LITERATURE CITED

Dutcher, J. D., R. E. Worley, J. W. Daniell, R. B. Moss, and K. F. Harrison. 1984. Impact of six insecticide-based arthropod pest management strategies on pecan yield, quality and return bloom under four irrigation/soil fertility regimes. Environ. Entomol. 13: 1644-53.

Liao, H., and M. K. Harris. 1984. Population growth of the blackmargined aphid on pecan in the field. Agriculture, Ecosystems and Environment 12: 353-61.

Sitton, B. G. 1931. A preliminary report on the relation of foliage to filling of the pecan. Proc. National Pecan Grow. Assoc. Bull. 30: 120-25.

Sparks, D., and C. Brack. 1972. Return bloom and fruit set of pecan from leaf and fruit removal. HortScience 7: 131-32.

Sparks, D. 1983. Alternate fruit bearing in fruit trees. Proc. Northern Nut Grow. Assoc., pp. 197-230.

Tedders, W. L., and B. W. Wood. 1985. Estimates of the influence of feeding by *Monelliopsis pecanis* and *Monellia caryella* on the fruit, foliage, carbohydrate reserves, and tree productivity of mature 'Stuart' pecans. J. Econ. Entomol. 78: 642-46.

Tedders, W. L., B. W. Wood, and J. W. Snow. 1981. The effects of feeding by *Monelliopsis nigropunctata, Monellia caryella,* and *Melanocallis caryaefoliae* on the growth of pecan seedlings in the greenhouse. J. Econ. Entomol. 75: 287-91.

Tedders, W. L. 1978. Important biological and morphological characteristics of the foliar-feeding aphids of pecan. U. S. Dept. Agric. Bull. 1579.

Wood, B. W., and J. A. Payne. 1986. Net photosynthesis of orchard grown pecan leaves reduced by insecticide sprays. HortScience 21: in press.

Wood, B. W., W. L. Tedders, and J. M. Thompson. 1985. Feeding influence of the pecan aphid species on carbon exchange and phloem integrity of seedling pecan foliage. J. Amer. Soc. Hort. Sci. 110: 393-97.

Wood, B. W., and W. L. Tedders. 1982. Effects of an infestation of blackmargined aphid on carbohydrates in mature 'Stuart' pecan. HortScience 17: 236-38.

Worley, R. E. 1979. Fall defoliation date and seasonal carbohydrate concentration of pecan wood tissue. J. Amer. Soc. Hort. Sci. 104: 195-99.