Influence of Single Applications of Fungicides on Net Photosynthesis of Pecan

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ABSTRACT

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Single-fungicide spray treatments were applied to mature leaves of greenhouse-grown pecan seedlings. Six of eight fungicides tested reduced net photosynthesis (PN) 1 day after treatment by 25–35%. These six fungicides continued to reduce PN 9 days after the single spray treatment. Propiconazole and etaconazole had no effects on PN. Benomyl reduced PN 1 day after treatment but had no effect after 9 days. Triphenyltin hydroxide (wettable powder and flowable), fenarimol, chlorothalonil, and dodine had relatively long-term detrimental effects.

Additional key words: carbon exchange, *Carya illinoensis*, *Cladosporium caryigenum*, net assimilation rate, pecan scab

Regular bearing and productivity of pecan is largely dependent on high tree energy reserves. Factors that affect photosynthesis should also affect tree nut production. Pecan scab (*Cladosporium caryigenum* (Ell. et Lang) Gottwald) can greatly reduce net photosynthesis (PN) (5) and reduce tree productivity (4). Control of pecan scab and other foliar diseases is essential for high economic returns. All such control measures involve fungicide sprays applied at frequent intervals. The effects of these chemicals on pecan leaf photosynthesis, however, are unknown. Studies with apple have shown that certain fungicide formulations cause large reductions in photosynthesis (1–3,6). Knowledge of the effects of fungicides commonly used on pecan foliage may contribute to management practices that will induce less damage to the photosynthetic mechanism and increase nut production.

The purpose of this study was to determine the effects of commercial formulations of fungicides on PN of pecan and to tentatively identify formulations that have the greatest potential for optimizing pecan photosynthetic efficiency.

MATERIALS AND METHODS

Curtis pecan (*Carya illinoensis*) seedlings were greenhouse-grown in 15-cm clay pots in a loam:peat (1:1, v/v) mixture until cessation of terminal growth and full expansion of the fifth leaf from the base of the seedling. Light levels were maintained above the photosynthetic saturation level for pecan. Seedlings were fertilized each week with 8-8-8 and maintained free of aphids by mechanical removal with water. Washing was done so as to prevent damage to the leaf cuticle. No fungicides or insecticides were used before application of the commercial fungicides evaluated. After full expansion of the previously described simple leaf at the fifth node, seedlings were treated with the test fungicides 6 wk after germination. It was at this time that seedlings were easily manipulated for photosynthetic measurements.

Fungicide formulations evaluated (g a.i./100 L water) were 50 of propiconazole EC (Tilt), 50 of etaconazole EC (Vangard), 60 of benomyl WP, 96 of triphenyltin hydroxide WP (Du-Ter), 169.8 of triphenyltin hydroxide FL (Super Tin-4L), 42.5 of fenarimol EC (Rubigan), 1,400 of chlorothalonil FL (Bravo 500), and 585 of dodine WP (Cyprex). The check consisted of water. Leaves over the entire seedling were sprayed with a hand sprayer on both surfaces until runoff. These fungicide rates are typical of those used in pecan orchards.

Six weeks after full expansion of the fifth single leaf, PN of the intact fifth leaf was measured 1 day before application of test formulations and 1 and 9 days afterward. Measurement times were

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planned to estimate short- and long-term effects of fungicides on PN. Experimental design was a randomized complete block with six replicates. An experimental unit was a single seedling. PN data were subjected to analysis of variance and means separated by Duncan's new multiple range test at $P = 0.05$.

PN was determined by measuring the flux in CO_2 entering and exiting a photosynthetic chamber with a Beckman 865 IR CO_2 analyzer. The Plexiglas photosynthesis chamber was made gastight with a rubber O-ring and a closed-cell foam gasket. Water jackets were used to maintain the temperature of the air surrounding the test leaves at 27 ± 1C. Chambers were supplied with ambient air at 3 L/min. Photosynthetically active quantum level at the leaf surface was 700 μE m^{-2} s^{-1} (light saturation level) for all PN measurements, as measured by a LI-COR 185 quantum sensor. Photons were provided from a 1,000W sodium vapor lamp suspended 3 ft above the leaf surface. Leaves were conditioned in the light from the lamp for 60 min before measurement of PN. Leaf area was measured with a LI-COR 3100 leaf area meter.

RESULTS AND DISCUSSION

All fungicides except propiconazole and etaconazole decreased leaf PN when measured 1 day after application (Fig. 1). This reduction was from 25 to 35%, depending on the material. PN rates had recovered to control levels 9 days after application of benomyl; however, triphenyltin hydroxide WP, triphenyltin hydroxide FL, fenarimol, chlorothalonil, and dodine were still 24–40% deficient after 9 days. Similar results have been observed in apple for dicofol (6) but benomyl and dodine had no effect (1,2,6). Propiconazole and etaconazole had no effect on PN at either 1 or 9 days after treatment. The data indicate that pecan photosynethetic physiology is sensitive to certain fungicide materials and that the impact on PN was relatively long term.

The data indicate that pecan leaves can recover from benomyl treatments, eg, a study of the influence of insecticides on pecan photosynthesis indicated that recovery generally occurred by 9–14 days after treatment (*unpublished*). This study indicates, however, that recovery from many of the fungicide formulations may require more time; this may be due in part to the closer physiological relationship of fungi to pecan than of insects to pecan. Treatments of apple (3) leaves of different ages with benomyl plus petroleum oil and petroleum oil and other aphicides on pecan (*unpublished*) indicate substantial variability in the tolerance of the leaf photosynthetic physiology to chemicals. Thus, these fungicide formulations may perform quite differently in the field on leaves of different ages.

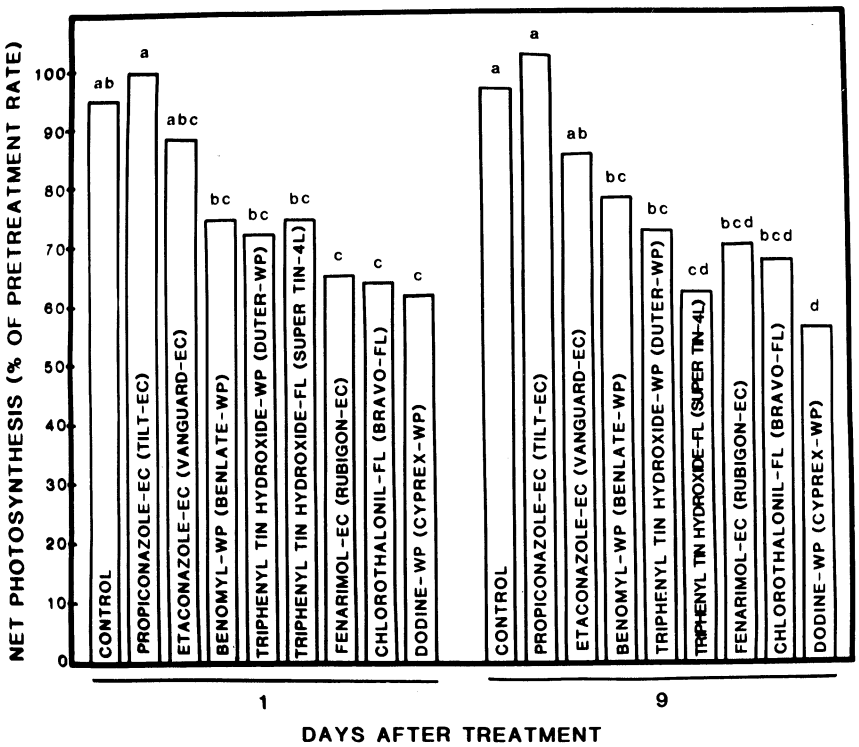

Fig. 1. Net photosynthesis of mature seedling pecan leaves as affected by treatment with several fungicides 1 and 9 days after treatment. Treatments within each date with different letters are significantly different at $P = 0.05$ according to Duncan's new multiple range test. The mean net photosynthetic rate of pretreated leaves was 11.5 mg CO_2 dm^{-2} hr^{-1} with standard deviation of 2.4 mg dm^{-2} hr^{-1}.

Reduction of PN by several fungicides indicates that experiments involving measurement of leaf carbon exchange should be carefully controlled with regard to previous chemical exposure. Although the data was from mature seedling foliage, similar effects seem likely at least for young leaves from mature orchard-grown trees, but the degree of damage may vary with tissue age and cultivar; however, this needs to be evaluated. If these results apply to the field, fungicides may in some cases be causing significant losses in photosynthate, possibly offsetting much of the advantage of their use (as defined by reductions in photosynthetic activity).

The differences in reductions in PN induced by the various fungicides do not necessarily mean that less detrimental ones should be used in lieu of others; the ability of different fungicides to control pests and the number of applications must also be considered. This study does not address the effects of repeated applications or the effects of the simultaneous applications of two or more fungicides. Fungicides should not be used unless truly needed because of potential detrimental effects of reducing energy reserves on regularity of bearing or productivity. This may be especially true for crops such as pecan, in which fruit production has been shown to be highly correlated with energy reserves and leaf efficiency (7–10).

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