Inhibition of Photosynthesis in Pecan Leaves by Fungicides

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ABSTRACT

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Four fungicides used for pest control on pecan (*Carya illinoensis*) reduced net photosynthesis (PN) of mature leaves in an orchard by 20% within 1 day of treatment. Foliage sprayed with propiconazole, benomyl, or triphenyltin hydroxide recovered within 5 days of treatment, but foliage treated with dodine did not recover until 17–31 days after treatment. Leaves showed no visible damage as a result of treatment. When PN was measured 13 days after each of four applications of triphenyltin hydroxide or propiconazole at 14-day intervals, triphenyltin hydroxide always suppressed PN about 20% and propiconazole had no significant effect.

Additional key words: pest management, energy reserves

Greenhouse studies of pecan seedlings indicated that foliar sprays of pecan fungicides can reduce net photosynthesis (PN) for extended periods (10). Such an influence in the commercial orchard might affect the trees' potential for producing energy reserves and contribute to irregular bearing, which is influenced by such reserves (8,9,13,14). Powdery mildew caused by *Microsphaera penicillata* (Wallr.: Fr.) Lév. reduced foliar PN of pecan as much as 42% (6). Low to moderate severities of pecan scab decreased fruit PN 83–88%. The reduction in foliar PN from scab infection was roughly proportional to the amount of foliar surface diseased. Pecan scab also reduced leaf area and crop quality (5; T. R. Gottwald and B. W. Wood, *unpublished*). Current control measures emphasize fungicidal sprays at 14- to 21-day intervals throughout most of the growing season. If fungicides suppress foliar PN, this would offset part of the benefit of disease control and might necessitate changes in pecan pest management recommendations. In this paper, we report suppression of PN under orchard conditions by single and repeated applications of fungicides at rates commonly recommended for control of pecan scab.

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MATERIALS AND METHODS

Fungicide methods. We conducted the investigation on 60-yr-old Stuart pecan trees that received at least 3 cm of water per week by sprinkler irrigation. Trees did not receive pesticide sprays for 4 wk before initiation of the study because of the possibility of long-term effects (10,11) and interactions with treatments. Fungicides were applied with hand sprayers to the foliage of large limbs to thoroughly wet both leaf surfaces to runoff. All treated and control leaves were essentially free of insect pests or disease during the study period.

The influence of specific fungicides on leaf efficiency was evaluated in two experiments from July to October. Each experiment was designed as a randomized complete block with 12–15 blocks represented on three or more mature trees. Fungicides were used at rates recommended by the Georgia Extension Service for use on pecan (4). Since we had shown previously (10) that "pecan fungicides" suppress PN of leaves of greenhouse-grown pecan seedlings, the first experiment was a test of possible PN inhibition in mature leaves in the orchard. Fungicides and rates (g a.i./100 L of water) were: propiconazole (Tilt EC), 20.22; benomyl (Benlate WP), 29.95; triphenyltin hydroxide (Du-Ter WP), 45.55; and dodine (Cyprex WP), 155.8. Fungicides were applied as single sprays and PN was determined 1, 5, 16, and 31 days after treatment. The second experiment was performed to investigate the effects of repeated applications of propiconazole and triphenyltin hydroxide as before. Treatments were applied at 2-wk intervals for 8 wk and PN was measured 13 days (1 day before respraying) after the previous application.

Photosynthesis measurements. Measurements of leaf PN were made with a LI-6000 portable photosynthetic system (LI-COR Instruments Inc., Lincoln, NE) with a 4-L leaf chamber. Measurements were made on the intact mature apical leaflet of the apical leaf associated with a nut cluster. Each leaflet was measured 10 times to determine the mean PN for each individual leaf. PN measurements were generally made between 1000 and 1300 hours with photosynthetically active radiation levels of 1,000^{+} $\mu E\ s^{-1}\ m^{-2}$ (3) and at ambient CO_2 levels. Leaf chamber relative humidity and CO_2 levels characteristically dropped 2% and 30 $\mu g/g$, respectively, during the measurement period. Leaf area was determined by tracing the outline of the attached leaflet on paper. The outline was cut out and the area determined with a LI-3100 leaf area meter. PN was measured 1 day before spray treatment and on several dates thereafter. Photosynthetic rate was expressed as a percentage of the pretreatment PN rate.

RESULTS

All fungicides in experiment 1 reduced leaf PN about 20% as soon as 1 day after application. This reduction was not associated with visible leaf damage. Five days after treatment, PN of leaves treated with propiconazole, benomyl, and triphenyltin hydroxide had recovered, but leaves treated with dodine did not recover until 17–31 days after treatment (Fig. 1).

When propiconazole and triphenyltin hydroxide were applied at 14-day intervals, only triphenyltin hydroxide suppressed PN 13 days after application (Fig. 2). The degree of suppression, relative to the check, was about 20% at each measurement date, thus the effect of repeated applications was not progressively more severe. Leaf photosynthetic efficiency also did not adapt and become insensitive to the fungicide sprays as has been observed for light intensity (2), temperature (1,11), and CO_2 (7) levels in other organisms. PN rates in the controls and all fungicide-treated leaves declined steadily with time after initial treatment.

DISCUSSION

"Pecan fungicides" induced rapid and relatively long-term reductions in PN of mature leaves in the orchard. The least

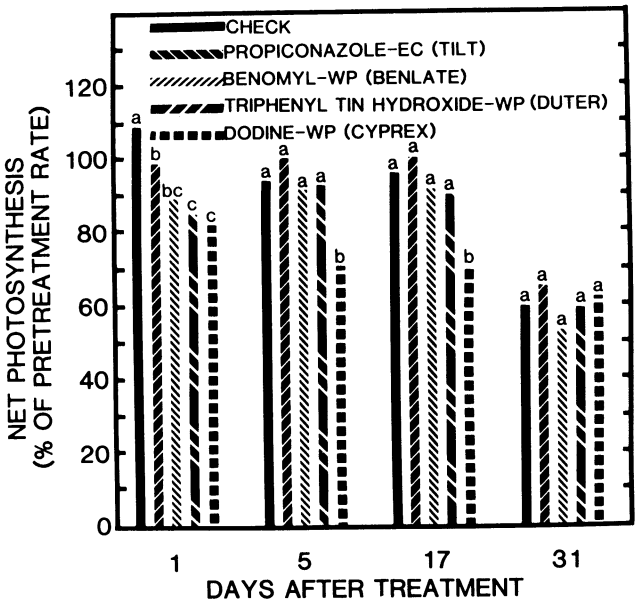

Fig. 1. Net photosynthesis (PN) rate of fully expanded pecan leaves in an orchard as affected by several "pecan fungicide" formulations 1, 5, 17, and 31 days after a single foliar spray application. Mean separation within each date is by Duncan's multiple range test ($P = 0.05$). PN of the check 1 day before treatment was 15.0 μm CO_2 m^{-2} s^{-1}.

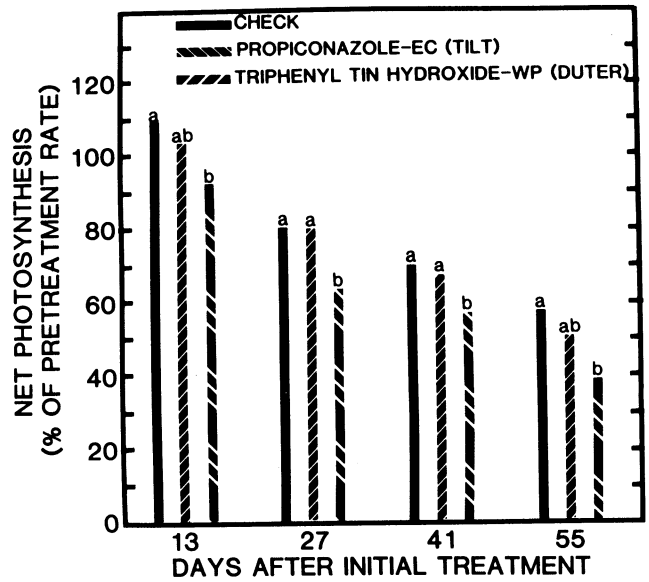

Fig. 2. Influence of repeated sprays of propiconazole and tryphenyltin hydroxide on net photosynthesis (PN) rate of mature pecan leaves in an orchard. Sprays were applied at 14-day intervals and leaf measurements were made 1 day before the next spray. Mean separation among treatments within each date is by Duncan's multiple range test ($P = 0.05$). PN of the check 1 day before treatment was 11.7 μm CO_2 m^{-2} s^{-1}.

damaging fungicides inhibited PN for 1–5 days after treatment. It appears that applications of triphenyltin hydroxide and possibly dodine at 10- to 14-day intervals, as is common for most pecan pest control programs, will result in a sustained reduction in PN for as long as the spray program is in effect. Such an influence could possibly suppress the accumulation of tree energy reserves. Ideally, trees should only be sprayed when disease levels are likely to induce damage exceeding that of the fungicides. Such predictions are currently unavailable. However, some loss of PN by a small amount of disease may be preferable, or at least an economic tradeoff, to reduced PN resulting from overuse of fungicides.

These results are in general agreement with those previously observed for the same treatments on greenhouse-grown seedling foliage (12); however, the suppression in PN was not as persistent in the field study and the influence of all fungicides tended to be less severe. This study establishes the fact that fungicides reduce PN of mature fully expanded pecan leaves typical of those found during the summer season.

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