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Effect of Some Soil-applied Herbicides on Net Photosynthesis and Growth of Apple Trees[1]

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Abstract. **The effect of 4 soil-applied herbicides (4.5 kg/ha) on the net photosynthesis (Pn) of greenhouse grown 'Golden Delicious'/M 7 apple trees (*Malus domestica* Borkh.) was determined by infrared CO_2 analysis. Monuron caused the greatest decrease in Pn, followed by atrazine and simazine. Diuron had no effect on Pn. Monuron and atrazine applications resulted in a decreased plastochron index. The influence of herbicides on Pn was apparent 10 days following treatment, and the effect persisted for the remainder of the experimental period of 40 days.**

The *s*-triazine and anilide herbicides act primarily by inhibiting the Hill reaction of photosynthesis (4, 8). Their slow movement in the soil and their adsorption at the cation exchange sites (8, 12) make soil-application of these herbicides relatively safe for fruit crops (1, 10). Atrazine and monuron (8, 13) are more mobile and have more influence on the growth of apple trees than the less mobile simazine and diuron (12).

The objective of this investigation was to evaluate the effects of simazine, atrazine, monuron, and diuron on Pn and growth of apple trees.

'Golden Delicious' apple trees on Malling (M) 7 rootstocks were grown in 20 cm pots containing 5 kg of silt-loam soil (organic matter 3.2%, pH 6.0). At planting, the trees were headed back to 4 to 6 buds from the bud-union. Later a single shoot was allowed to develop. Diuron, monuron, simazine and atrazine (80% formulations) were applied at the rate of 4.5 kg/ha to actively growing trees. The herbicide was mixed in 50 g of soil which was spread evenly over the surface of the pot. Treatments were arranged in a randomized block design with 3 replications. After the herbicide was applied, each pot was mulched with 5 cm of gravel in order to insure uniform moisture conditions. Each tree was given 0.5 liter of H_2O/day and fertilized weekly with 200 ppm each of N, P_2O_5 and K_2O. Insects and mites were controlled as needed with chemicals shown in a preliminary trial not to influence Pn. The trees were placed in a growth chamber 3 days before treatment. The chamber had a light intensity of 21.6 klx at median plant height with the lights programmed for a 15 hr light (21°C) and 9 hr dark (16°) cycle.

Pn was measured by an infra-red gas analyzer (MSA Model 200 Lira) with a flowing reference cell. The leaf in the chamber was supplied with outside air at the rate of 3 liters/min. Phosphorus-coated metal-arc lamps provided 43.2 klx of light inside the leaf chamber. A running water bath located between the light source and leaf chamber aided in maintaining the temperature at the leaf surface 25°±1°C.

Leaf age exercises a great influence on the photosynthetic rate. The concept of plastochron, period between initiation of successive leaves, has been used to judge the leaf age. Since the leaves in a constant environment are initiated at relatively uniform rates, Erickson and Michelini (6) proposed a plastochron index to relate morphogenetic measurements with anatomical, physiological, and bio-chemical events or processes. Larsen and Isebrands (11) concluded from their studies on cottonwood that the plastochron index could serve 2 useful purposes: 1) to adjust plants of different developmental stages to a standardized morphological time scale, and 2) to predict developmental processes or events from simple nondestructive measurements. Dickman (3) found leaf plastochron index was correlated with the rates of photosynthesis and respiration. The plastochron index procedures (3,6) was modified by using the youngest leaf with a blade length $\geq$3 cm as the index leaf. the leaves were numbered serially beginning with the leaf immediately below the index leaf which is a deviation from Erickson and Michelini (6). The 15th leaf from the index leaf was chosen for Pn determinations. Pn and plastochron index were observed after 0.5, 1.5, 2.5, 10, 20, 30, 40 and 50 days after treatment.

Monuron, simazine and atrazine caused a gradual decline with time in Pn (Fig. 1). Although monuron, atrazine and simazine reduced the Pn from the beginning of treatment, the maximum influence was evident 10 days after application, with Pn reductions of 72%, 64% and 22%, respectively. These effects persisted throughout the trial. Diuron showed no significant effect on Pn.

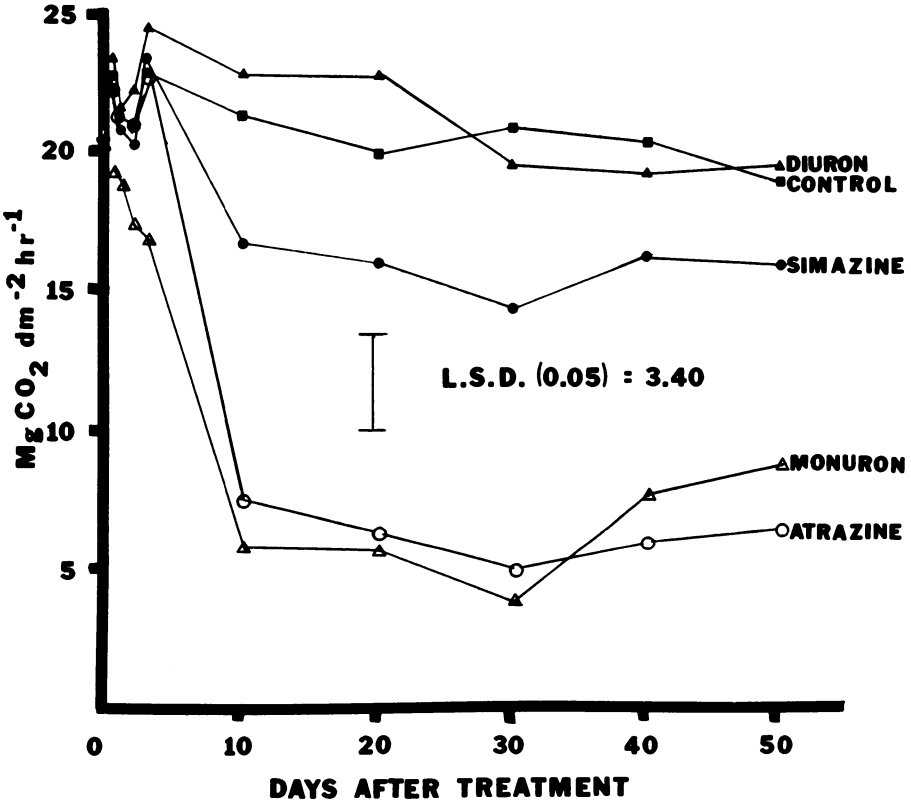

Fig. 1. Effect of soil applied simazine, atrazine, monuron and diuron on net photosynthesis of 'Golden Delicious' apple leaves.

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Table 1. Effect of diuron, monuron, simazine and atrazine[z] on the plastochron index of 'Golden Delicious' apple trees.

	Plastochron index[y]								
	Days after herbicide application								
Treatment	0.5	1.5	25.	3.5	10.5	20.5	30.5	40.5	50.5
Control	16.3a	16.7a	17.1a	17.3a	19.5a	23.1a	25.8a	27.1c	30.7c
Diuron	15.5a	15.8a	16.0a	16.3a	18.3a	22.8a	27.3a	30.8a	34.3a
Monuron	15.8a	16.0a	16.3a	16.5a	18.2a	21.9a	25.1a	26.8c	27.7c
Simazine	16.0a	16.4a	17.0a	17.4a	19.1a	23.0a	27.1a	30.1ab	33.0ab
Atrazine	15.7a	15.9a	16.3a	16.3a	18.7a	22.4a	25.7a	27.5bc	28.5c

[z]80% formulations of the herbicides were used at 4.5 kg/ha.

[y]Youngest leaf with ≥3 cm blade length was used as index leaf for determining index.

[x]Mean separation in columns by Duncan's multiple range test at 5% level.

The influence of herbicides on the plastochron index began to appear 40 days after treatment (Table 1); however, no leaf phytotoxicity was present. Monuron caused the greatest reduction in tree growth as evidenced by the lower leaf plastochron index values, followed by atrazine. At the conclusion of the experiment, control trees had a lower leaf plastochron index than diuron- or simazine-treated trees.

All these herbicides are potential inhibitors of photosynthesis (5, 7). Since monuron (8) and atrazine (13) have greater soil mobility, they probably moved into the root zone and were absorbed, thereby causing a greater reduction in Pn of apple trees than the less mobile diuron and simazine. Monuron and atrazine, through their influence on Pn, also reduced growth as indicated by reductions in leaf plastochron index.

Simazine reduced Pn and increased the leaf plastochron index in the later stages of the experiment. This increase was probably due to the lower leaf plastochron index values for the control treatment rather than a stimulatory influence of simazine. During the experiment, the control treatment in one replication produced only 6 leaves as compared to an average of 15 leaves by the other trees. However, there are reports of increased nitrogen and protein contents of leaves and stimulation in growth and cropping of apples by simazine treatment (2, 9).

It is very difficult to correlate a complex phenomenon like growth directly to Pn. The nature of the herbicide and its influence on other plant processes is an important factor in determining the minimal change in Pn values required to influence plant growth. It is reasonable to assume that the degree of inhibition in Pn is inversely correlated with the time required for the appearance of visible reduction in plant growth. After longer periods of time the reduction in Pn would probably be reflected in the tree growth.

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Multiple Applications of Dicofol and Dodine Sprays on Net Photosynthesis of Apple Leaves[1]

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Abstract. **The effect of dicofol and dodine on photosynthesis (Pn) of greenhouse-grown apple trees (*Malus domestica* Barkh.) was determined by infrared CO_2 analysis. Multiple sprays of dicofol reduced Pn of apple foliage significantly; the reduction was greater in 'Golden Delicious' /M#7 than in 'Delicious'/M#7. The maximum decline occurred after the second spray and subsequent applications did not cause further decrease. Multiple sprays of dodine had no significant influence on Pn.**

Dicofol (2,2,2-tricholoro-1, 1-di (4-chlorophenyl) ethanol), and acaricide, and dodine (n-dodecylguanidine acetate, a fungicide, are commonly used on apple trees for control of mites and diseases. Dicofol did not reduce growth or dry wt of leaves (7). Dodine-sprayed 'McIntosh' apple trees yielded less than zineb- or captan-treated trees (4) and dodine injured 3% of the apples (3). No significant differences were recorded in the fruiting performance of 'Stayman' trees treated with this chemical (2). In a recent study, dodine did not alter the net photosynthesis of apple leaves (1). The objectives of the present investigation were to evaluate the effects of multiple sprays of dicofol and dodine on Pn and the differential response, if any, of 'Delicious' and 'Golden Delicious' apple trees to these treatments.

One-year-old apple trees ('Delicious' /Malling (M) 7 and 'Golden Delicious'/ M#7) were grown in 20 cm plastic containers in a 3 loam:1 peat: 1 perlite mixture. The trees were kept in cold storage at 2°C until planting on July 3, 1973. At the time of treatment, the trees had an average of 36 leaves. Pn was determined on the 15th leaf from the index leaf (youngest leaf with petiole length of 3 cm). The same leaf was measured throughout the trial.

The treatments were applied in a randomized block arrangement with 3

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