Pesticides may reduce lettuce yield

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High-value crops such as strawberries, broccoli, and iceberg lettuce often receive "preventive" or "insurance" pesticide treatments, which may result in weekly scheduled applications of insecticides. Many times such treatments are unwarranted economically and may reduce yields by detrimental effects on the plants. Decreases in strawberry yields due to preventive insecticide treatments in the absence of economically significant pest populations have been reported. Research supported by the California Iceberg Lettuce Research Advisory Board indicated that head lettuce plots kept insect pest-free were generally not the highest yielding plots. Further analysis of the data indicated that a high number of insecticide applications before lettuce head formation may reduce lettuce yields. We report here on the effects of certain classes of insecticides on lettuce photosynthesis, transpiration, and productivity.

Insecticides

Insecticides in the various "classes," such as chlorinated hydrocarbons (DDT, endrin, and methoxychlor), organophosphates (guthion, parathion, and methyl-parathion), carbamates (malathion and methomyl), and synthetic pyrethroids (fenvalerate and permethrin), differ in their effects on plants. Additionally, the rates, number, and timing of applications may alter a compound's effect upon the plant, for either a short time or several days.

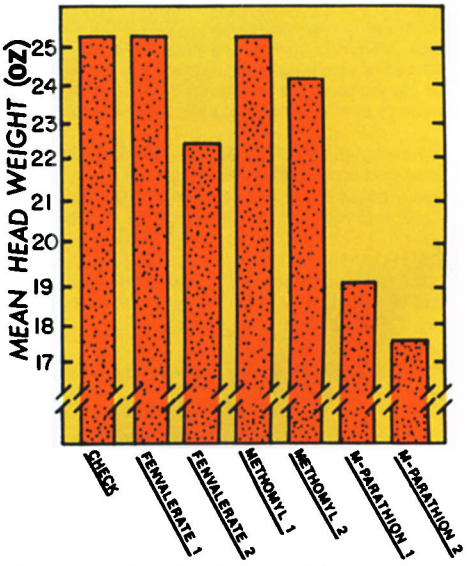
Many compounds are phytotoxic when applied at high rates or under certain environmental conditions, such as extreme heat or moisture. Resulting damage to the plant is usually clearly visible. Insecticides applied at normal rates and under the right environmental conditions may subtly damage a plant but remain unobserved, because symptoms are not visible.

During the last few years, plant physiologists at University of California, Riverside, have developed the dual isotope porometer, which provides accurate, simultaneous measurements of a plant's photosynthesis and transpiration rates in the field. Entomologists have used the instrument to measure effects of mite feeding on almond, cotton, avocado, and strawberry foliage. In this study, we used the porometer to measure the effects of certain insecticides on the lettuce plant's photosynthesis and transpiration rates.

In the 1979 investigation, Climax variety lettuce was winter-grown at the U.C. South

Dual isotope porometer developed by plant physiologists at U.C., Riverside, simultaneously measures effects of insecticides on lettuce photosynthesis and transpiration.

Author Frank Sances demonstrates use of porometer in lettuce field.



Mean weights of lettuce heads harvested from plots treated with one of three insecticides once and twice weekly.

Coast Field Station (SCFS), Santa Ana. Four compounds, representing the previously mentioned insecticidal classes were applied to the lettuce at the following rates of active ingredient per acre: methomyl (Lannate, Nudrin) at 0.9 and 1.8 pounds, methoxychlor (Marlate) at 2 and 4 pounds, methyl-parathion (Red Top Methyl Parathion) at 1 and 2 pounds, and permethrin (Pounce, Ambush) at 0.2 and 0.4 pound by a CO_2-charged row crop sprayer. An untreated check was included. Applications were also made at night to detect whether the insecticides penetrated the plant through the stomates (which are closed at night). The plant's photosynthesis and transpiration rates were measured on the first and eighth days after treatment to observe both acute and chronic effects of the compounds.

In 1980, Great Lakes and Mesa lettuce varieties were planted at the Citrus Research Station (CRS), Riverside, and effects of three compounds on lettuce head productivity were studied. Experimental plots were divided into two groups, which received treatments either once or twice weekly. The following amounts of active ingredient per acre were applied at each application: methomyl at 0.9 pound, methyl-parathion at 1 pound, and fenvalerate (Pydrin) at 0.2 pound. In each group, half of the plots were sprayed during the whole season from germination to harvest, and the other half were treated from germination to thinning and from head formation to harvest.

Plant responses

All insecticides examined at SCFS adversely affected photosynthesis and transpiration rates but differed in their relative effect and severity of injury (see table). On both sample dates, untreated plants had highest rates. Methoxychlor-treated plants did not have significantly different photosynthesis and transpiration rates than untreated plants.

Transpiration and photosynthesis declined 9 and 8 percent, respectively, 24 hours after plants were treated with methomyl. One week after treatment, overall photosynthesis had decreased to 20 percent of the normal rate. Similar trends were observed with the other insecticides investigated. Methyl-parathion induced an initial 17 percent reduction in transpiration and 10 percent reduction in photosynthesis, which decreased to 27 and 18 percent reductions, respectively, after one week.

Permethrin had the most detrimental effects on transpiration on both sample dates. Photosynthesis rates of permethrin-treated plants were reduced most significantly on the first sample date. By the second date, high variation among samples due to leaf age obscured statistical significance of the insecticides' influence on photosynthesis.

No significant differences were detected when chemicals were applied in darkness or sunlight, nor did the two rates of each chemical applied alter responses measured.

Data collected at the CRS indicated that neither variety nor number of insecticide applications per week appeared to reduce lettuce head weight and diameter significantly. However, lettuce sprayed weekly during the entire growing season weighed significantly less (22.1 ounces) than that not treated during the growth period from thinning to head formation (23.7 ounces).

Lettuce plants sprayed weekly with both weekly rates of methyl-parathion produced heads that weighed significantly less than those in other treatments (see graph). Methyl-parathion-treated heads were significantly smaller in diameter (about 7 percent) than those in the check and plots treated with both weekly rates of methomyl and the low weekly rate of fenvalerate.

Plant physiology

Transpiration is directly related to stomatal opening, which is essential for leaf intake of carbon dioxide for photosynthesis. Photosynthesis is a more general measurement of carbon dioxide intake and fixation (sugar production). Both processes are interrelated and are directly related to plant growth and productivity. The higher value of transpiration occurred on insecticide-free plants on both sample dates. Photosynthesis was also higher in the untreated check, suggesting that all insecticide treatments adversely influenced both stomatal opening and overall photosynthesis rates and that the effect remained for at least one week. Reductions of lettuce head weight and diameter in plants treated weekly with methyl-parathion indicate the cumulative effect on yield that results from pesticide inhibition of physiological processes.

Since no differences were observed between the photosynthesis and transpiration rates of plants treated in daylight or darkness, it may be assumed that insecticide uptake by the plant is independent of stomatal opening.

Conclusions

Methyl-parathion (organophosphate) and permethrin (pyrethroid) had the greatest effects on photosynthesis and transpiration rates. Methyl-parathion significantly reduced lettuce head yields. Studies on other crops have shown that parathion reduces photosynthesis, possibly by inhibiting certain processes in the chloroplast where photosynthesis takes place.

Unwarranted insecticide treatments with methyl-parathion in the absence of economically significant insect populations may reduce yields by reducing photosynthesis and transpiration. However, although methoxychlor least adversely affected lettuce plants, and permethrin and methyl-parathion caused the greatest reductions in physiological processes, when relative effectiveness in regulating a pest population is considered, the latter compounds are more desirable.

As more data are obtained on the effects of pesticides, systematic screening of new compounds for their impact on photosynthesis and consequently on yield may become essential. Our results indicate that the dual isotope porometer has great potential in instantaneously measuring subtle changes in plant photosynthesis and transpiration rates in the field and in quantifying recovery over time. Development of a "pesticide threshold" that would indicate the maximum number of applications at recommended rates on designated crops may thus be desirable.

Effect of insecticide sprays on photosynthesis and transpiration rates of lettuce leaves

	One day post treatment*		Eight days post treatment*	
Insecticide	Photosynthesis†	Transpiration‡	Photosynthesis†	Transpiration‡
Untreated check	18.93 a	2.54 a	17.90 a	1.84 a
Methoxychlor	18.06 ab	2.41 a	16.15 a	1.64 ab
Methomyl	17.40 abc	2.31 ab	15.15 a	1.49 b
Methyl-parathion	16.97 bc	2.12 b	14.72 a	1.47 b
Permethrin	16.25 c	2.11 b	14.72 a	1.34 b

*Mean separations in vertical columns by Duncan's new multiple range test ($P < 0.05$).
†mg CO_2 assimilated/dm² leaf area/hr.
‡g H_2O lost/dm² leaf area/hr.

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