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Light Intensity and the Absorption and Translocation of 2,4,5-T by Woody Plants[1]

HOMER A. BRADY[2]

Abstract. Absorption of the isooctyl ester of (2,4,5-trichlorophenoxy)-acetic acid varied more than 20% in four woody species when incident light intensity was increased from 40 to 4,000 ft-c. Variations in translocation of the herbicide of 45 to 50% in post oak (*Quercus stellata* Wangenh.) and water oak (*Quercus nigra* L.) accompanied changes in illumination. Light intensity did not affect translocation in longleaf pine (*Pinus palustris* Mill.) or American holly (*Ilex opaca* Ait.)

INTRODUCTION

FOLIAR spraying with herbicides to remove unwanted woody vegetation has yielded unreliable, erratic results (7). Climatic conditions, including light intensity, may influence results. Photosynthesis, transpiration, stomatal opening, temperature, and humidity near the leaf surfaces and respiration all change when light intensity is changed (6). In addition, all ester formulations of phenoxyacids are somewhat volatile, and there is some evidence that they are photosensitive (1).

This paper reports the influence of light intensity at the tops of four woody species on absorption and translocation of the isooctyl ester of (2,4,5-trichlorophenoxy)-acetic acid (2,4,5-T). Nonabsorptive losses of this chemical during prolonged exposure to continuous light also were evaluated.

METHODS

One-year-old potted seedlings of water oak (*Quercus nigra* L.), post oak (*Quercus stellata* Wangenh.), longleaf pine (*Pinus palustris* Mill.), and American holly (*Ilex opaca* Ait.) were preconditioned for 2 weeks at one of four light intensities: 40, 1,360, 2,680, or 4,000 ft-c. The three higher levels were programmed in three controlled environment growth chambers. Three types of lights, warm white, cool white, and incandescent, were used to cover most of the spectrum of the natural sunlight. The intensities are comparable to dense shade, light shade, and full sunlight, respectively, in a forest stand. The 40 ft-c level was achieved by completely surrounding the plants with black polyethylene plastic. This level was designed to be comparable to night, but it was impossible to exclude all light and maintain comparable conditions of temperature and humidity. All chambers were programmed for 16 hr of light with temperature at 27 C and 8 hr of darkness at 18 C. All pots were watered daily. Each treatment was replicated four times on each species.

After the plants were preconditioned, 0.2 g 2,4,5-T in a 1:9 chemical:water emulsion was placed on the foliage of each plant. The liquid was applied to assure full coverage of all foliage and prevent runoff. Treated plants were returned to the programmed growth chambers for 96 hr.

The entire plants then were harvested and washed, and roots were separated from foliage and stems. Some leaves, particularly those of post oak, were shed before harvest. They were included with the foliage sample. All plant materials were dried at 60 C, ground in a laboratory mill, and weighed.

The 2,4,5-T was extracted from the plant material by refluxing in 80:18:2 solution of ethanol, water, and acetic

[1]Received for publication December 16, 1968.

[2]Research Soil Scientist, Alexandria Timber Management Research Project, Southern Forest Experiment Station, Forest Service, U. S. Dep. of Agr., Alexandria, Louisiana.

acid. The extract was cleaned by elution through an anion exchange column to remove plant extracts. The technique of Pursley and Schall (8) was modified to analyze for 2,4,5-T with a gas chromatograph. Chart readings were converted to quantitative measurements by comparing them with a standard curve prepared from charts of known standards, and converted mathematically to micrograms of 2,4,5-T/g of plant tissue. Absorption values were derived by dividing the total amount of 2,4,5-T found in a plant by the weight of the foliage. Translocation was reported directly as the amount of herbicide found in the roots. Differences reported were significant at the 5% level.

Twenty-four filter-paper disks were impregnated with 0.5 g each of the isooctyl ester of 2,4,5-T in 2 ml of a water emulsion and placed in open glass dishes in one growth chamber. The chamber was programmed for continuous light at 4,000 ft-c and 27 C. Four disks were removed after 1, 4, 8, 24, 48, and 96 hr. The 2,4,5-T remaining was extracted and analyzed by the same procedure as for the plant materials.

Results and Discussion

Absorption. Light intensity significantly affected absorption of 2,4,5-T by all four species (Figure 1). In the

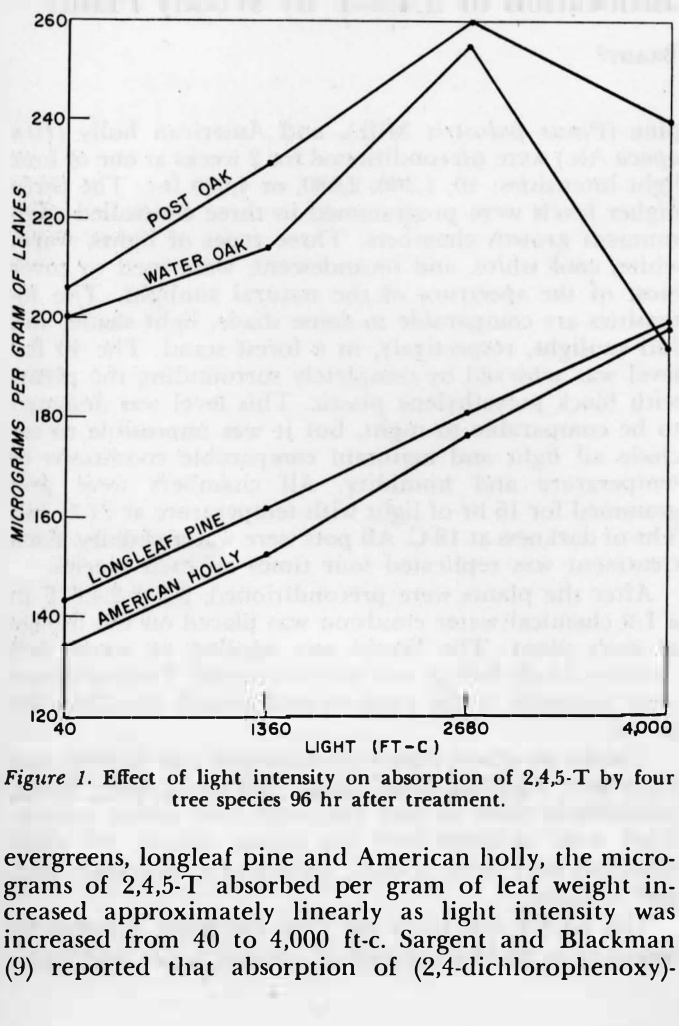

Figure 1. **Effect of light intensity on absorption of 2,4,5-T by four tree species 96 hr after treatment.**

evergreens, longleaf pine and American holly, the micrograms of 2,4,5-T absorbed per gram of leaf weight increased approximately linearly as light intensity was increased from 40 to 4,000 ft-c. Sargent and Blackman (9) reported that absorption of (2,4-dichlorophenoxy)-acetic acid (2,4-D) by leaves of ligustrum *(Ligustrum ovalifolium* Hassk.) increased as light intensity was raised, but the highest intensity used in their studies was 2,000 ft-c.

In contrast to the evergreens, the effect of light on absorption of 2,4,5-T in the two deciduous species was curvilinear. Maximum absorption occurred at 2,680 ft-c. Total absorption by post oak at 4,000 ft-c was comparable to that at 1,360 ft-c. In water oak, absorption at 4,000 and 40 ft-c were about equal. It is well known that photosynthesis in deciduous species reaches a maximum between 2,000 and 3,000 ft-c, a lower level of illumination than the optimum for evergreens. Photosynthesis declines as light intensity is raised above the optimum. This behavior is not completely understood, but increased transpiration, photo-oxidation of enzymes, closing of stomates, and excessive respiration have been reported as contributors (4). These factors may also decrease absorption of applied 2,4,5-T in bright light.

Longleaf pine and American holly absorbed 2,4,5-T in equal amounts of all light levels; both were less efficient than the oaks at intensities of 2,680 ft-c or less. At 4,000 ft-c, uptake by water oak was about equal to that by the evergreens but significantly less than by post oak. Absorption by the two oaks did not differ significantly at the other light intensities.

Average recovery of applied 2,4,5-T was 5% in longleaf pine, 9% in American holly, 10% in post oak, and 11% in water oak. These values are in the lower half of the range of 5 to 20% found in other local studies not yet reported. One probable reason for low recovery was the high rate of application. The dry weights of the leaves of 1-year-old seedlings averaged 10 to 20 g per plant. Thus, the 0.2 g applied was at least 1% of the total weight of treated foliage.

Translocation. To be effective, a herbicide must be translocated to sites where it is lethal—usually the root system in perennial species (5). Crafts (2) has shown that the phenoxyacid herbicides move almost exclusively in the phloem. Therefore, it is likely that movement occurred only from treated foliage to the roots. A measure of translocation, then, is 2,4,5-T content of the roots of treated plants (Figure 2). In longleaf pine and American holly, translocation was not significantly influenced by light intensity.

Light intensity affected translocation to the roots of the oaks, but the pattern varied by species. There was a negative linear relationship between light intensity and 2,4,5-T content of post oak roots. In water oak roots, on the other hand, herbicide levels increased as light intensity increased. No reason was apparent for the different reactions in the two oak species.

Perhaps a better measure of the efficiency of translocation is the percentage of absorbed herbicide found in the roots of foliar-treated plants at a specified time after treatment (Table 1). By this standard, longleaf pine was a more efficient translocator than American holly at 40 ft-c; the two evergreen species were equally efficient at higher light intensities. The oaks moved a higher percentage of the 2,4,5-T to their roots than did the evergreens. Post oak translocated the herbicide more efficiently than water oak at all but the highest light intensity.

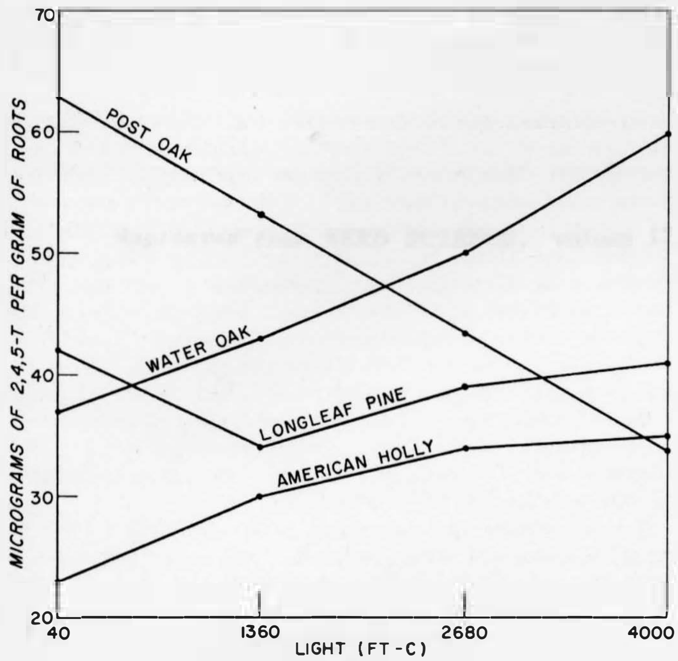

Figure 2. Effect of light intensity on translocation of 2,4,4-T by four tree species 96 hr after treatment.

Table 1. Percent of absorbed 2,4,5-T in roots.

Species	Ft-c of light[a]			
	40	1,360	2,680	4,000
	%	%	%	%
Longleaf pine	27 b	16 a	21 a	21 a
American holly	17 a	22 a	19 a	25 a
Post oak	47 c	33 b	43 b	30 b
Water oak	33 b	28 b	23 a	37 c

[a]Values in a column followed by the same letter do not differ significantly at the 5% level, according to Duncan's multiple range test.

This helps to explain why post oak is easier than water oak to kill with foliar sprays containing 2,4,5-T, and why longleaf pine is resistant.

Herbicide loss. The isooctyl ester of 2,4,5-T disappeared rapidly from filter-paper disks at 27 C under continuous illumination at 4,000 ft-c (Figure 3). During the first 8 hr about 60% was lost. Thereafter, the rate of loss decreased rapidly; an average of 18% of the applied amount remained at the end of 96 hr. The mechanisms of disappearance were not determined. Losses of the magnitude reported here could cause the failure of a treatment if a low rate of application and unfavorable weather conditions were combined. Data from this prolonged test may be misleading, however. Holly (3) reported that the uptake of the phenoxyacid herbicides is very rapid during the first 6 to 12 hr after application and decreases greatly thereafter. Since the highest absorption by any treated plant was 16% and the greatest loss from paper disks was 82%, it is unlikely that the availability of 2,4,5-T would have been limiting in the present tests.

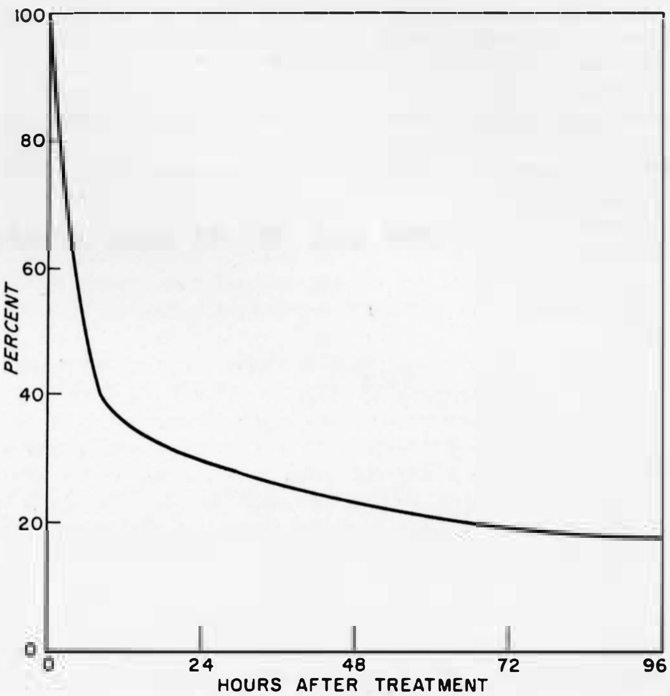

Figure 3. Persistence of 2,4,5-T ester on filter paper exposed to 4,000 ft-c of light.

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