Reprinted from WEED SCIENCE, volume 18, number 2, pages 204-206. March 1970.

Ammonium Nitrate and Phosphoric Acid Increase 2,4,5-T Absorption by Tree Leaves[1]

HOMER A. BRADY[2]

Abstract. Addition of ammonium nitrate greatly increased the absorption of solutions of the isooctyl ester of (2,4,5-trichlorophenoxy)acetic acid (2,4,5-T) by sweetgum *(Liquidambar styraciflua* L.), post oak *(Quercus stellata* Wangenh.), red maple *(Acer rubrum* L.), and loblolly pine *(Pinus taeda* L.) leaves. Phosphoric acid alone and mixed with ammonium nitrate caused less increase. Ammonium nitrate speeded translocation of the herbicide in post oak but not in the other species.

INTRODUCTION

COST of controlling undesirable woody plants with foliar sprays could be reduced if an inexpensive additive could be found that increased absorption and translocation of the herbicide. Fullilove (5) observed that the phytotoxicity of (2,4-dichlorophenoxy)acetic acid (2,4-D) to corn *(Zea mays* L.) was increased when the herbicide was applied in a fertilizer solution. Aliev (1) credited greater acidity of the solution for the increased toxicity to weeds of 2,4-D applied in solutions containing ammonium nitrate and phosphoric acid. Feldman (4) found that addition of boric acid to (2,4,5-trichlorophenoxy)-acetic acid (2,4,5-T) solutions enhanced their effectiveness on brush; he attributed the improvement to increased acidity of the solution. Szabo and Buckholtz (6) found, however, that at a constant pH of 3 the uptake of 2,4-D by sunflower *(Helianthus annuus* L.) leaves was increased by the presence of nitrate or phosphate ions and decreased by iron or calcium ions in the solution.

This paper reports the effects of adding ammonium nitrate and/or phosphoric acid to solutions of the isooctyl ester of 2,4,5-T. Effects on the absorption and translocation of the herbicide were measured in woody plants of four species.

MATERIALS AND PROCEDURES

Treated plants were 1-year-old seedlings of sweetgum *(Liquidambar styraciflua* L.), post oak *(Quercus stellata* Wangenh.), red maple *(Acer rubrum* L.), and loblolly pine *(Pinus, taeda* L.) growing in 6-inch pots. Sixteen plants of each species were selected for uniform height. Soil in the pots was a sandy loam of the Ruston series, a productive upland soil. All plants appeared to be healthy and growing satisfactorily before treatment.

Four formulations were prepared; each contained 96 g/L of the isooctyl ester of 2,4,5-T in total solution plus enough ^{14}C-labeled herbicide to give 0.3 pc of radioactivity in 0.5 ml. Solutions also contained one of four additives: 0.1% ammonium nitrate, 0.1% phosphoric acid, or 0.1% each of ammonium nitrate and phosphoric acid. Distilled water was added to control solutions.

Plants were selected at random within a species to receive each treatment, and each plant received 0.5 ml of solution. To assure that each leaf received some solution, the liquid was dropped on the foliage from a hypodermic syringe. Each treatment was replicated four times on each species.

Plants were harvested after 96 hr and separated immediately into tops and roots. The top included all leaves and branches, and the stem down to just below the lowest branch. Roots included the stem below this branch. All samples were washed to remove soil and unabsorbed herbicide, and frozen until analyzed. Each was dried, weighed, and extracted 4 hr with an 80:18:2 mixture of ethanol, water, and acetic acid in a Soxhlet extractor. The extracting solution was evaporated. The residue was treated with 30% hydrogen peroxide to oxidize colored compounds, and then redissolved in ethyl ether. The ether solution was eluted through an exchange column containing activated chromosorb W, and the ether was evaporated. The herbicide was dissolved in a scintillator solution and placed in a dual-channel scintillation counter. Activities are reported in counts min. Counts from the entire plant indicated total absorption, while those from the roots indicated translocation. After corrections for quenching were applied, the data were analyzed statistically.

Although plants of individual species were approximately equally tall, the average weight of tops differed as much as 25% within species and even more between

[1]deceived for publication June 19, 1969.

[2]Research Soil Scientist, Alexandria Timber Manage. Res. Proj., So. Forest Exp. Sta., U. S. Dep. of Agr. Forest Serv., Pineville, Louisiana.

species. Since larger plants had more absorbing surface than smaller ones, total absorption was expressed per gram of top weight. Relative activity then was calculated to facilitate comparison among the four treatments. A value of 100% was assigned to absorption by the checks, and absorption by plants given other treatments within a species was related to this value.

Results and Discussion

Addition of 0.1% ammonium nitrate to the herbicide solution significantly increased absorption of 2,4,5-1' by all species (Table 1). This compound more than doubled

Table 1. Effects of additives to isooctyl ester of 2,4,5-T on absorption by foliage of four woody plants.

Additive	Total absorbed (count/min)	Average weight of plants (g)	Activity per gram® (count/min)	Relative activity* (%)
Sweetgum				
Check	3,213	7.7	417 a	100 a
0.1% NH«NOJ	8.177	6.9	1,185 b	284 c
0.1% H3PO4	3,906	6.7	583 a	140 b
0.1% each NH4NO3 4-lhPOi	3,272	7.0	467 a	112 a
Post oak				
Check	2,542	6.7	379 a	100 a
0.1% NH4NO.1	6,228	7.2	865 b	228 b
0.1% H3PO4	7,341	6.9	1,064 b	281 c
0.1%> each HN4NO3+H3PO4	6,010	7.1	846 b	223 b
Red maple				
Check	1,965	6.1	322 a	100 a
0.1%, NH4NO3	6,258	5.1	1,227 c	381 c
0.1% H3PO4	2,568	5.9	435 a	135 a
0.1%, each NH4NO3+H3PO4	4,354	6.7	650 b	202 b
Loblolly pine				
Check	1,896	5.2	365 a	100 a
0.1% NU4NO3	3,123	5.0	645 c	177 b
0.1% H3PO4	3,144	5.3	593 be	162 b
0.1% each NH4NO3+H3PO4	2,638	5.5	480 b	132 ab

"For individual species, values followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

absorption per unit of top weight for the hardwoods, and caused a 77% increase in loblolly pine. The same concentration of phosphoric acid significantly increased absorption by loblolly pine and post oak. In plants of the latter species, the increase was greater than that caused by ammonium nitrate.

The combination of ammonium nitrate and phosphoric acid significantly increased absorption by post oak and red maple, but it did not affect absorption by sweetgum and loblolly pine. The mixture was considerably less effective than ammonium nitrate alone on plants of all species except post oak. It usually residted also in less absorption than phosphoric acid alone. Since this mixture contained 0.1% of each of the additives, the chemical concentration in the solutions may have been great enough to injure foliar tissue, and thereby reduce herbicide absorption.

The pH of herbicide solutions containing 0.1% ammonium nitrate was about 4, that of solutions containing phosphoric acid was slightly above 1, and that of a water solution of 2,4,5-T was 5.6. The isoelectric point of compounds of 2,4,5-T is at pH 3.46 (2). Some of the herbicide in ammonium nitrate solution probably was hydrolyzed to acid while some remained in the ester form. Thus, entry into treated plants by both polar and lipoidal routes was possible. In the more acid phosphoric acid solution, complete hydrolysis probably occurred, permitting only polar uptake.

The passage of organic molecules through plant membranes is influenced by inorganic ions in the bathing solution. This mechanism, no doubt, accounted for part of the increased uptake. The reason is not known for the increased uptake by post oak of 2,4,5-T in the phosphoric acid solution.

Ammonium nitrate increased the translocation of 2,4,5-T in post oak; other treatments did not significantly affect translocation (1'able 2). Crafts (3) has proposed that

Table 2. Translocation to roots of foliarly-applied isooctyl ester of 2,4,5-T with three different additives.

Additive	Total in roots'[1] (count/min)	Proportion of total plant activity* (%)
Sweetgum		
Check	393 a	12.23 b
0.1%, NH4NO3	369 a	4.47 a
0.1% H3PO4	433 a	11.15 b
0.1% each NU4NO3+H[9]PO4	434 a	13.28 b
Post oak		
Check	223 a	8.71 b
0.1%, NH4NO3	763 b	12.25 b
0.1% H>PO4	236 a	3.20 a
0.1%> each NH4NO3+H3PO4	190 a	3.19 a
Red maple		
Check	273 a	13.98 b
0.1% NlhNOs	236 a	3.75 a
0.1% II3PO4	250 a	9.66 b
0.1% each NH4NO3+H3PO4	169 a	3.85 a
Loblolly pine		
Check	133 a	7.12 a
0.1% NH4NO3	103 a	3.26 a
0.1% H3PO4	103 a	3.20 a
0.1% each NH4NO3+H3PO4	169 a	6.46 a

[s]For individual species, values followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

as soon as the phenoxyacid herbicides reach the symplasts of treated plants they are hydrolyzed to acid form and fixed to molecules of assimilate. They then move with the assimilate in the "source-to-sink" pattern. These data indicate that one of these steps may have been limiting and that increased absorption was not reflected in increased translocation.

The proportion of absorbed 2,4,5-T that was translocated to the roots varied inversely with the amount absorbed (Table 2, column 3). When absorption was greatly increased by an additive and translocation was unaffected, the proportion that was translocated was substantially lower in treated than in check plants. Significantly lower proportions were recorded for five species-treatment combinations. Because total translocation was not reduced by treatments, the importance of this statistic is not considered great. The important facts are that a number of treatments did increase absorption, and that only one increased translocation. An interval longer than 96 hr between application of the herbicide and harvesting the plants for analysis might have altered the proportion in the roots. It has been determined by the author, however, that a 96-hr interval is proper for near-maximum absorption by treated foliage.

Literature Cited

1. Aliev, A. M. 1960. [The control of weeds in cornfields by 2,4-dichlorophenoxyacctic acid.] Dokl Vses Akad. Sel-Skokhoz VI Lenia 7:8-11.

2. BEHRENS, R. and H. L. MORTON. 1960. Mesquite root inhibition tests to study inhibitory activity, absorption and translocation of 2,4-D and 2,4,5-T. Weeds 8:427-435.
3. CRAFTS, A. S. 1964. Herbicide behaviour in the plant, p. 75-110. *In* L. J. Audus (ed.) The Physiology and Biochemistry of Herbicides. Academic Press, New York.
4. FELDMAN, I. 1965. Control del Chanar (Gcoffroea decorticans Bur.). Rev. Invest. Agropccuar Ser. II Biol. Prod. Vegetal 3:109-122.
5. FULLILOVE, H. M., III. 1968. Herbicide and fertilizer combination found to lower yields. Crops and Soils 20(7):29.
6. SZABO, S. S. and K. P. BUCKHOLTZ. 1961. Penetration of living and nonliving surfaces by 2,4-D as influenced by ionic additives. Weeds 9:177-183.