SOIL PARAMETERS IN DEGRADATION SEQUENCES OF CHLORINATED PYRIDINE BIOCIDES

By

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OF CHLORINATED PYRIDINE BIOCIDES

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INTRODUCTION

Highly effective biocides have recently been developed with pyridine compounds. These are used as pesticides and have value as broadleaf and grass herbicides, insecticides, plant growth regulators, and as nitrification inhibitors. These pyridines may eventually have considerable agronomic value. However, soil characteristics and microbial activities greatly influence persistence, effectiveness, and their eventual fate in soils.

The pyridine base compounds are of particular interest to the biologist because of the essential nature of the pyridines in all living cell metabolism. An outstanding characteristic of the pyridine ring is its chemical inertness and resistance to degradation, although substitutions on ring loci and condensation reactions occur readily. The principal common alkaloids are complex pyridines and are almost all poisonous.

The purpose of this study was to determine the soil factors influencing the magnitude and rates of compound phytotoxicity diminution and to attempt to establish manipulations of soil components which govern biological transformations of these compounds.

LITERATURE REVIEW

Pyridines that have been reported as having biocidal properties are: 2-chloro-6-(trichloromethyl) pyridine (N-Serve)[1] (2, 9, 10, 19)[2]; 4-amino-3,5,6-trichloropicolinic acid (Tordon) (3, 13); 2,3,5-trichloro-4-pyridinol (Daxtron) (6); 0,0 diethyl-0-3,5,6-trichloro-2-pyridyl phosphorothioate (Dursban) (5, 12) and 4-amino-3,5-6-trichloro-2-(trichloromethyl) pyridine (23).

An important goal of good soil management is to minimize the losses of nitrogen from the soil. The ammonium ion once sorbed by the soil, is not easily leached or subjected to volatilization. However, nitrite and nitrate nitrogen are easily leached and may be reduced or converted in the soil to nitrogen gas or volatile oxides of nitrogen (1). N-Serve, is a nitrification inhibitor that has been shown to be highly toxic to organisms converting ammonia to nitrite and to have a low order of toxicity to other microorganisms and the seedlings of many plants (2, 9, 10). However, McKell and Whalley (15) reported a reduction in growth, changes in nodule morphology and deformation of root tips on alfalfa seedlings grown on N-Serve treated soil.

N-Serve additions increased efficiency of fertilizers containing ammonium nitrogen on sweet corn, cotton and sugar beets (2, 18, 20).

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[1] Names in parenthesis refer to the trade name of the chemical compound and for simplicity will be used throughout this paper.

[2] Figures in parenthesis refer to Literature Cited.

Increasing soil organic matter content, raising pH levels to 8.5 and increasing temperature to 90° F. decreased efficiency of N-Serve (9).

Redemann et al. (16) stated that N-Serve is lost by two methods after being applied to the soil; by volatilization and by breakdown to 6-chloropicolinic acid. The rate of this loss varied with soil type. Slowest rates of loss were obtained with soils which had high organic matter content. Results by these workers have shown that residues in N-Serve treated plants were 6-chloropicolinic acid rather than N-Serve (17).

Tordon has been reported as one of the most active systemic herbicides discovered in recent years. Inconsistency in results with N-Serve led to the discovery of phytotoxic properties of Tordon (3). Tordon is comparable to 2,4-dichloro-phenoxyacetic acid (2,4-D) and 2,4,5-trichloro-phenoxyacetic acid (2,4,5-T) in toxicity, foliage absorption and translocation characteristics. Under certain soil conditions, Tordon has been 50 percent effective for 568 days, compared to 56 days for 2,4-D and 87 days for 2,4,5-T (13).

Tordon has shown effective control for many deep-rooted perennial herbaceous weeds (14,21), brush (22, 23) and woody rangeland species (7).

Persistence of Tordon has not been completely evaluated. However, it was reported that this compound is susceptible to leaching in soils (11, 13). Biopathways of Tordon degradation in soil is not known at this time. There is evidence to conclude that Tordon is changed to 6-chloropicolinic acid in soil (8). Wiltse (23) reported on another pyridine that hydrolyzes to Tordon in soils, which is only slightly soluble in water and leaches more slowly from the soil. This compound

is 4-amino-3,5,6-trichloro-2-(trichloromethyl) pyridine. It may have use in areas where leaching of Tordon is a problem.

Daxtron is a systemic herbicide, which is readily absorbed and translocated by both roots and foliage of grasses and broadleafs. Dechlorophyllation occurs on most plant species following treatment. It is subject to leaching from soil. However, under most soil conditions Daxtron has a long residual period (6).

Dursban is an insecticide, which controls a wide variety of insect pests, especially mosquitos, and household and turf pests (12). Chinch bugs and sod webworm have been effectively controlled in St. Augustinegrass with Dursban (5).

MATERIALS AND METHODS

Two soils were used in these studies: a Typic Quarzipsamment, Eufaula sand and a Typic Arqiustoll, Brewer clay loam. The physical and chemical analyses of these two soils were determined and the results are given in Table 1 (4).

TABLE I

CHEMICAL AND PHYSICAL CHARACTERISTICS OF EUFAULA AND BREWER SOILS AS DETERMINED BY LABORATORY ANALYSES.

Determination	Eufaula 0-6"	Brewer 0-6"
Mechanical Analysis		
% Sand	90.0	27.1
% Silt	7.0	44.6
% Clay	3.0	29.3
Textural Class	Sand	Clay Loam
pH	5.7	6.3
% Organic Matter	0.5	3.1
% Total Nitrogen	0.04	0.11
Cation Exchange Capacity*	2.7	14.6
Exchangeable Cations*		
Calcium	1.1	9.5
Magnesium	0.9	3.1
Potassium	0.3	0.5
Available Phosphorus**	6.8	6.4

* m.e. per 100 grams soil (1 N Ammonium acetate)
** pounds per acre (.025 N HCl)

Air-dry soil that had previously passed through an 8-mesh sieve was placed in 3½ inch square plastic pots, except in Experiment 11, where 3½ inch round clay pots were used to facilitate the sterilization. Four hundred gram soil cultures were used in each experiment with three replications per treatment.

EXPERIMENT I. Effect of Soil Organic Matter Amendments

Soil organic matter amendments which varied in carbon-nitrogen ratios were combined with Eufaula soil (Table II). Finely ground organic matter additions consisted of wheat straw, black locust foliage and a mixture of straw and black locust in equal weights. These additions were mixed with the soil at a level of one percent of the soil weight.

TABLE II

CHEMICAL COMPOSITION OF ORGANIC MATERIALS USED FOR SOIL AMENDMENTS

Organic Materials	%N	%P	%K	%Ca
Wheat Straw	0.39	0.03	0.48	0.06
Black Locust Foliage	2.88	0.15	0.83	0.38

Ten scarified Black Locust (Robinia pseudoacacia) seeds were planted at ¼ inch depth. The seedlings were thinned to five per pot after emergence. N-Serve treatments of 0, 1, 2.5, 5, and 10 ppm were applied in water solution to the soil surface. These cultures were maintained under adequate moisture for growth and continuous light of 500 foot candles from florescent "Grolux" lamps at room temperature for 35 days.

Plant height and dry weight of above ground material were determined at harvest.

The soils were allowed to air dry and then stirred and replanted. The same procedure of growth and harvesting was used in this harvest as in the previous one. The second planting was harvested at the end of 51 days.

EXPERIMENT II. Effect of Soil Sterilization

Sterilized and unsterilized Eufaula sand were used in this experiment. The soil was steam sterilized for twelve hours and the same levels of N-Serve and bioassay procedures were used in this experiment as in Experiment I. However, this study was grown in the greenhouse. The plants were harvested at the end of 59 days.

EXPERIMENT III. Effect of Soil Reaction

Soil reaction interactions with the same levels of N-Serve as previously used were determined for Eufaula sand. Acid and alkaline pH levels of Eufaula were obtained with additions of sulfur and calcium oxide to supply sulfur and calcium at levels approximately twice the cation exchange capacity. Eufaula sand was then mixed in equal amounts with the acid and alkaline pH level soils and using the original Eufaula gave five pH levels for this study.

The bioassay procedures were the same as used in Experiment I with three harvests taken. The first was 25 days, second 37 days and the third 61 days after planting.

EXPERIMENT IV. Effect of Soil Cation Exchange Capacity

Brewer clay loam and Eufaula sand were used in this study to make varying textural differences. The seven mixtures gave cation exchange capacities of 2.7, 4.2, 5.7, 7.2, 8.6, 11.7 and 14.6 milliequivalents per 100 grams of soil. Bioassay procedures and N-Serve levels were the same as in Experiment I. There were two harvests taken on this study. The first was 35 days and the second was 46 days after planting.

EXPERIMENT V. Effect of Soil Temperature

Soil temperatures were maintained at 20, 30, and 38 degrees Centigrade with thermostatically controlled water baths. The pots were lined with plastic bags to prevent water from entering. The experiment was maintained in the greenhouse. The soil, levels of N-Serve and bioassay procedures were the same as in Experiment I. Only one harvest was taken at the end of 37 days.

EXPERIMENT VI. Effect of Plant Material Taken From N-Serve Treated Soil

Black Locust plant material that had been grown on N-Serve treated soil was finely ground to pass through a 20 mesh sieve. This was applied at levels of 1, 2, 4 and 8 grams per culture. N-Serve was applied at the same levels as in Experiment I. Black Locust foliage which had not been treated with N-Serve was also added at the same levels as the treated foliage. Bioassay procedures were the same as in Experiment I with the harvest at the end of 53 days.

EXPERIMENT VII. Effect of Other Pyridines

Eufaula sand was treated with 5 ppm of N-Serve and 13 other pyridines: Quinolinic acid, Br-pyridine, nicotinic acid, nicotine, trigonelline, nicotino-nitrile, 4-picolinic acid, 2,4-di-hydroxy-3-CN-pyridine, 6-hydroxy-nicotinic acid, 2-picolinic acid, 2,4-di-3-CN-6-chloro-pyridine, N-me-nicotinanide, and nicotinamide. Bioassay procedures were the same as previously used. Harvest occurred 45 days after planting.

EXPERIMENT VIII. Biocidal Degradation

Thirteen soil inhabiting fungi; Paecilomyces varioti, Mucor pusillus, Trichoderma viride, Curvularia lunta, Alternaria tenius, Cladosporium resinae, Pencillium funiculosium, and the Aspergilli: tamarii, chevalieri, sydowi, niger, flavus, and oryzae, were cultured on a liquid broth media containing 0, 10, 25, 50 and 100 ppm levels of N-Serve. The basic medium in grams per liter consisted of: sucrose 100, citric acid 2, potassium sulfate 1, ammonium nitrate 3, and inorganic salt mixture (Phillip-Hart) 3. Composition of the salt mixture (percent) was: dipotassium phosphate 32.2, calcium carbonate 30.0, sodium chloride 16.7, magnesium sulfate 10.2, monocalcium phosphate 7.5, ferrio citrate 2.75, manganese sulfate .51, potassium iodide .08, copper sulfate .03, zinc chloride .25, and cobalt chloride .005.

Forty milliliters of the medium were used in 500 ml cotton stoppered Erlenmeyer flasks for each culture. Three replications were used per treatment. Autoclave sterilization at 15 psi for 20 minutes was used and upon cooling all cultures were inoculated with spore suspensions of the respective organisms and incubated for 5 days.

Following incubation, the fungi mycelial pads were removed with forceps, washed, dried at 100 degrees C. for 24 hours and weighed. The residual medium from each culture was brought to 50 ml volume with distilled water and frozen immediately.

Bioassay of the residual media and fungus pads was performed using only the 50 ppm level. Eufaula sand was used with three replications, 400 grams per pot. The level of N-Serve was 5 ppm in the soil after the media was applied to the soil. Techniques of growth and harvesting were the same as used before.

Harvest was taken after 51 days.

EXPERIMENT IX. Effect of Soil Cation Exchange Capacity

Brewer clay loam and silica sand were mixed in varying proportions to give mixtures of varying exchange capacities of: 2, 4, 6, 8, 10, 12, and 14 m.e./100 grams. Tordon levels of 0, 0.05, 0.1, 0.5, and 1.0 ppm were applied in water solution to 400 grams of the mixtures. Improved Long Green cucumbers were planted at one-quarter inch depth. Pot size and experimental design and other procedures were the same as in Experiment I.

The plants were harvested at the end of 17 days for the first harvest and after 22 days for the second harvest.

EXPERIMENT X. Comparison of Four Biocides

Daxtron, Tordon, N-Serve, and 6-chloropicolinic acid were used in this experiment with Eufaula sand to compare their phytotoxicity on Black Locust.

Tordon levels were 0.005, 0.01, 0.05, 0.1 and 0.2 ppm. Daxtron and 6-chloropicolinic acid levels were 10 times and N-Serve levels were 100 times those of Tordon.

The treatments were applied in the same way with the bioassay procedures the same except for the growing time, which was much shorter because the Tordon treatments died at a much faster rate. The harvest was taken 20 days after planting.

RESULTS AND DISCUSSION

Manipulations and amendments to soils used in these studies influenced the growth of indicator plants without pyridine herbicide additions. Soil amendment treatments which did not receive pyridine additions were used as 100% base for the relative evaluations of phytotoxicity within each specific soil amendment series. Relative yields at each herbicide level within each soil amendment series were then expressed as "percent of check". These data were then graphed as three dimensional figures. A comparative reference for the relative value of this method in expressing bioassay results are shown with Figure 1 and Figure 2. Both are graphic representations of the same data except that in Figure 1 these data are shown as amount of plant growth in grams and in Figure 2 as percent of zero herbicide level within the various soil amendment treatments. Data from these studies are presented both in three dimensional graphs showing relative growth as a function of soil treatment with pyridine addition levels and in data tables appearing in the Appendix.

Results of organic matter amendments and N-Serve levels are shown in Figure 1 and 2. Black Locust growth with zero N-Serve level increased with finely ground organic materials additions of the 1% Black Locust foliage and 1% mixture of straw and Black Locust foliage additions. Phytotoxicity of N-Serve was increased with all levels of organic matter amendments, especially with the 1% Black Locust foliage addition. This

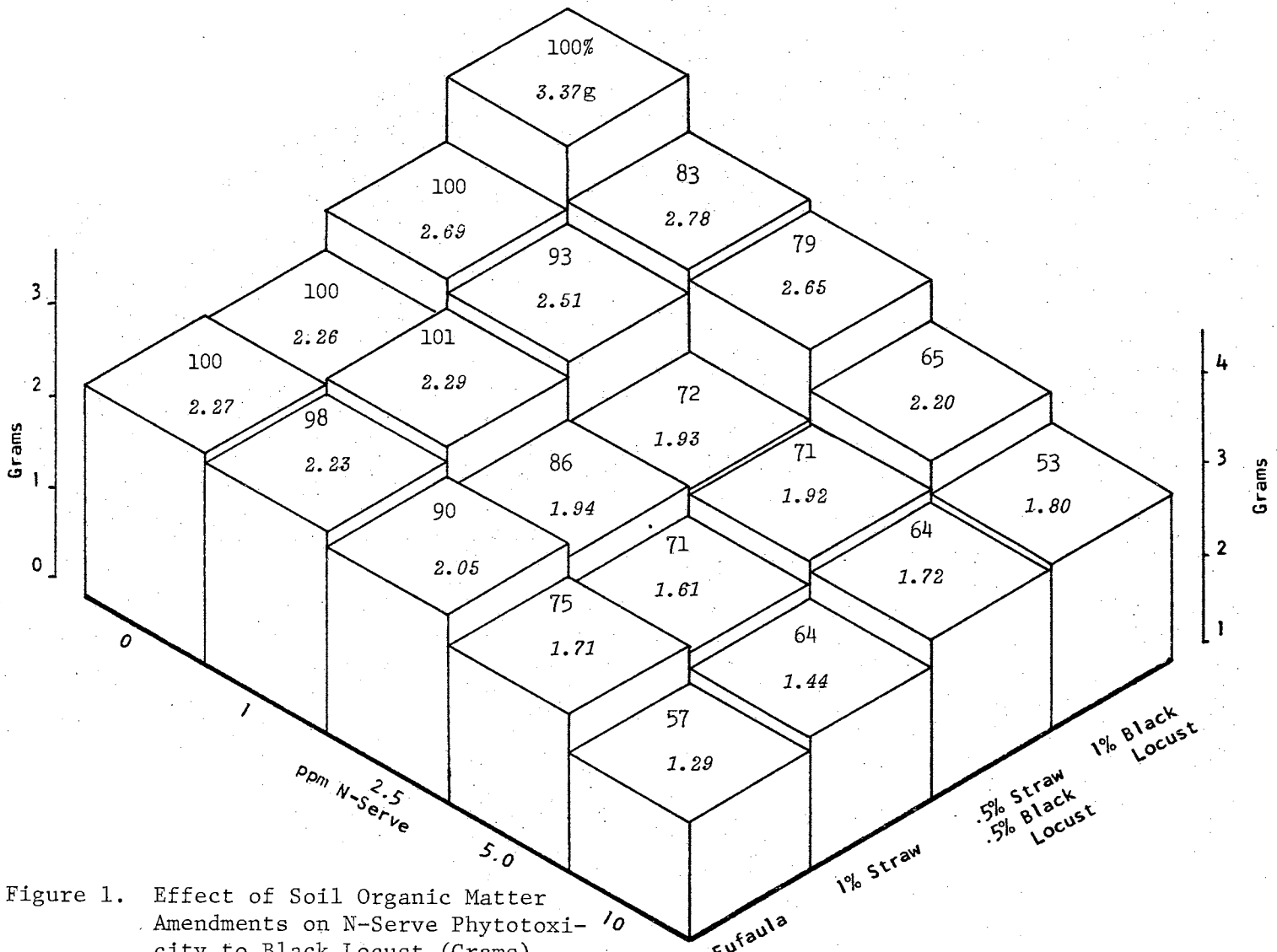

Figure 1. Effect of Soil Organic Matter Amendments on N-Serve Phytotoxicity to Black Locust (Grams).

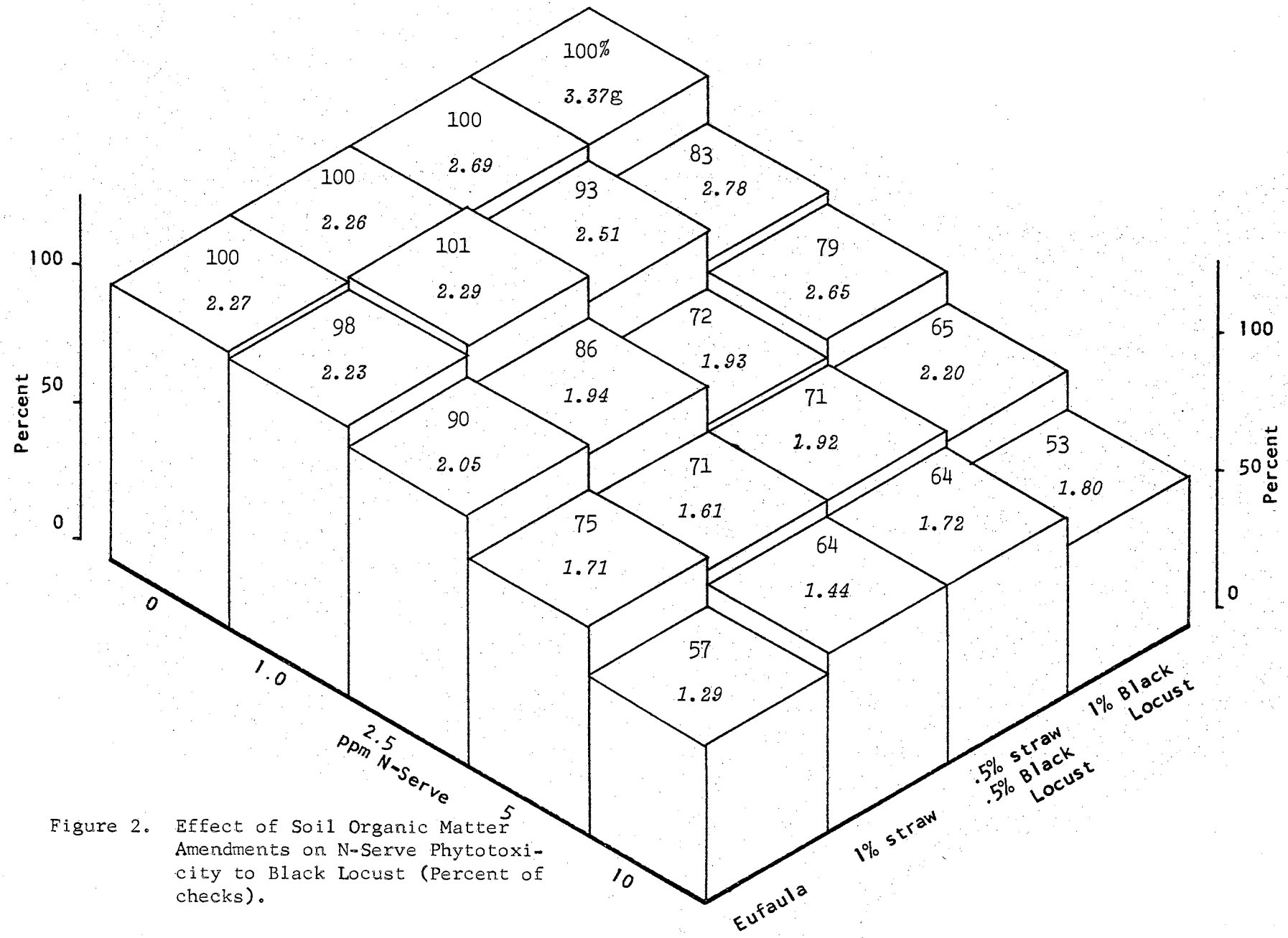

Figure 2. Effect of Soil Organic Matter Amendments on N-Serve Phytotoxicity to Black Locust (Percent of checks).

treatment apparently was particularly effective for increasing soil microorganism activity.

Soil sterilization resulted in reductions in phytotoxicity of N-Serve at the 5 and 10 ppm levels in Experiment II as shown in Figure 3. There were no large differences in the phytotoxicity on the 1 and 2.5 ppm levels between differential soil sterilization treatments.

Results from Experiments III and IV are shown in Appendix Table V and VI. No general trend was apparent either as reduction or as an increase in phytotoxicity of N-Serve in relation to variations in exchange capacity or soil reaction. Difficulty in establishing uniform seedling stands in these two studies contributed to variability in these results.

As the soil temperature increased the phytotoxicity increased at the 10 ppm level, as shown in Figure 4. Black Locust grew much better at the two higher temperatures. However, there was greater percentage of reduction at 30 and 38° C. than at 20° C. Less total growth was obtained at 20° C. Soil microorganism activity was increased with the higher soil temperature.

In Experiment VI, Black Locust growth was slightly reduced with addition of four or more grams of dry Black Locust foliage. A very large reduction resulted with additions of dry Black Locust foliage exhibiting phytotoxic symptoms grown on treated soil. These responses are compared to plants grown with specific N-Serve levels in Figure 5. These results show that the pyridine still retains its phytotoxicity after being taken into the plant and being released again either by leaching or microbial breakdown of the plant tissue.

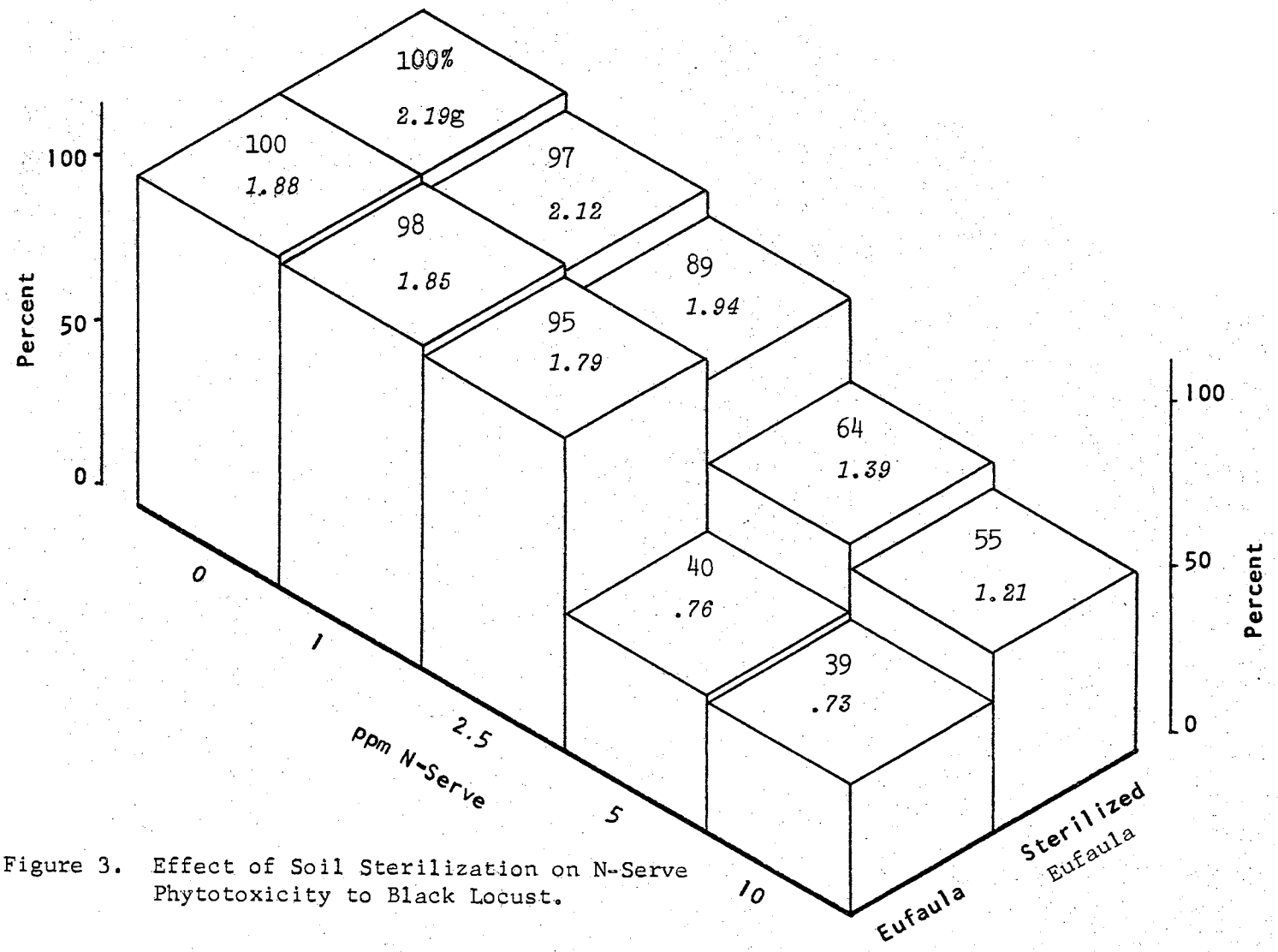

Figure 3. Effect of Soil Sterilization on N-Serve Phytotoxicity to Black Locust.

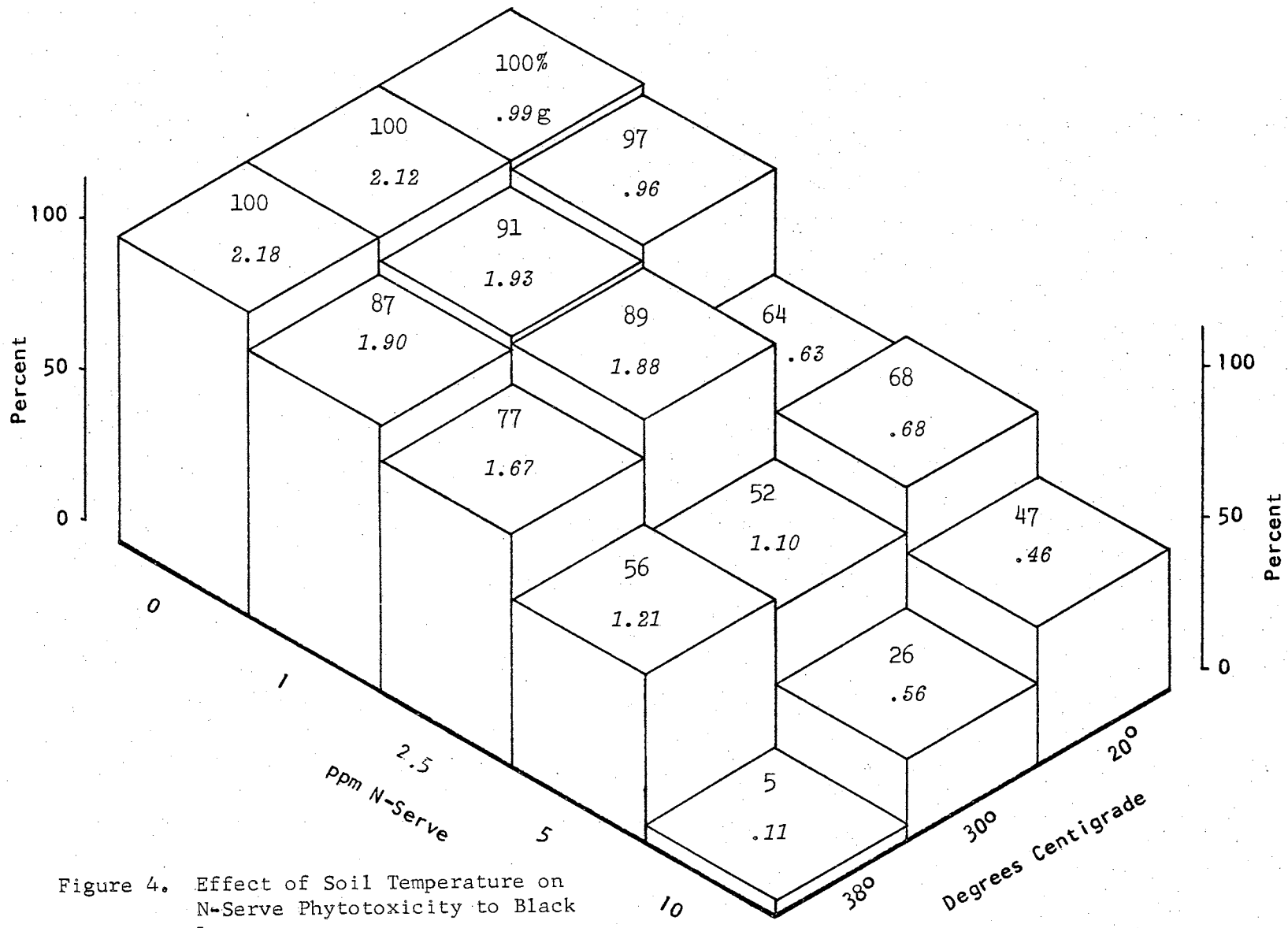

Figure 4. Effect of Soil Temperature on N-Serve Phytotoxicity to Black Locust.

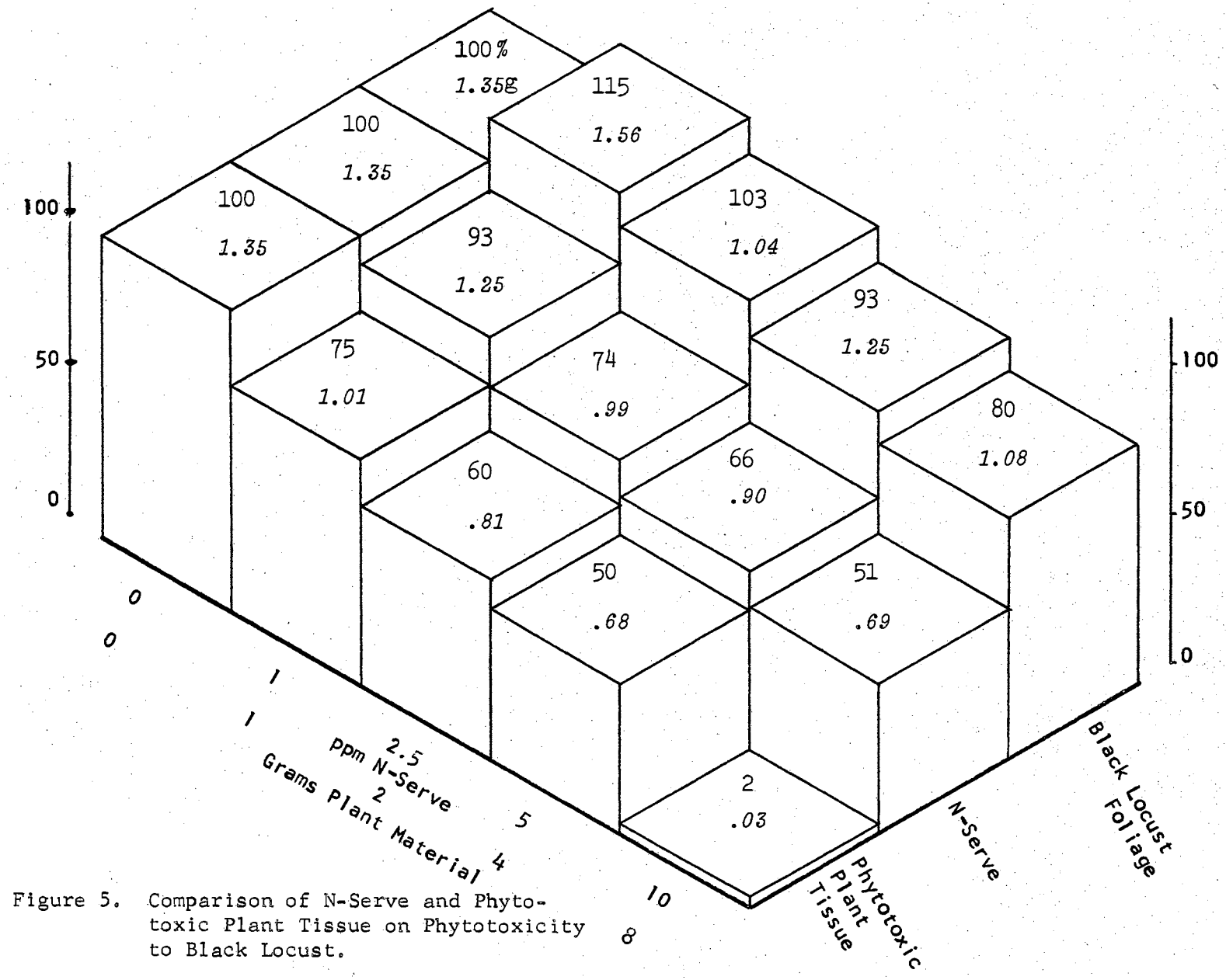

Figure 5. Comparison of N-Serve and Phytotoxic Plant Tissue on Phytotoxicity to Black Locust.

Table IX presents results from Experiment VIII. None of the pyridines tested in this experiment resulted in phytotoxicity to Black Locust.

Microorganism growth of all species tested as indicated by mycelial pad weights was not reduced with levels of N-Serve additions up to 100 ppm as shown in Table X. These results are in agreement with those reported by Goring and others (2, 9, 10).

Bioassay of mycelial pads for phytotoxicity showed that several of these microorganisms accumulated a phytotoxic material (Table XI). However, it would be possible that the active pyridine compound may have adhered to the mycelium and was not removed during washing.

Bioassay of the media indicated less phytotoxicity in all residual media as compared to uninoculated medium. However, 5 ppm N-Serve did cause a large reduction in growth with uninoculated media than this same N-Serve level in all other studies.

The influence of cation exchange capacity (CEC) on Tordon phytotoxicity is shown in Figure 6. No large differences were noted due to an increase in CEC at the lower levels of Tordon. However, on the 0.5 and 1.0 ppm treatments, greater percentage of germination and plant weight was obtained as CEC increased.

The lack of a reliable measure of Tordon phytotoxicity prevented evaluations as done with N-Serve in earlier experiments. The rapidity of kill and ability of abnormal plants not killed to have equal or greater weight and height than untreated plants presented evaluation problems.

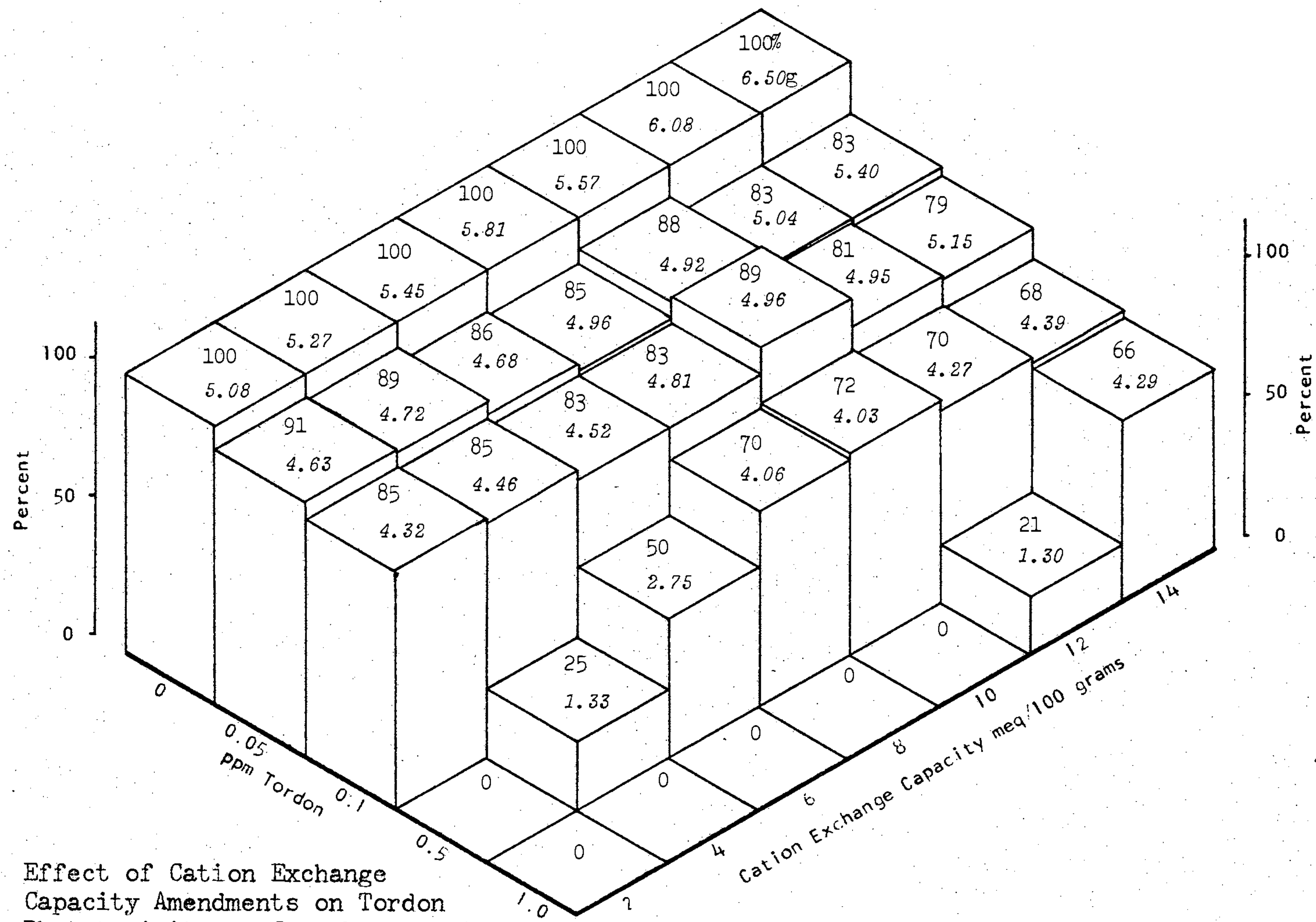

Figure 6. Effect of Cation Exchange Capacity Amendments on Tordon Phytotoxicity to Cucumbers.

Comparison of the four pyridine herbicides as shown in Figure 7 showed that Tordon exhibited about 10 times the phytotoxicity as Daxtron and 6-chloropicolinic acid and about 100 times the phytotoxicity of N-Serve at equivalent application levels.

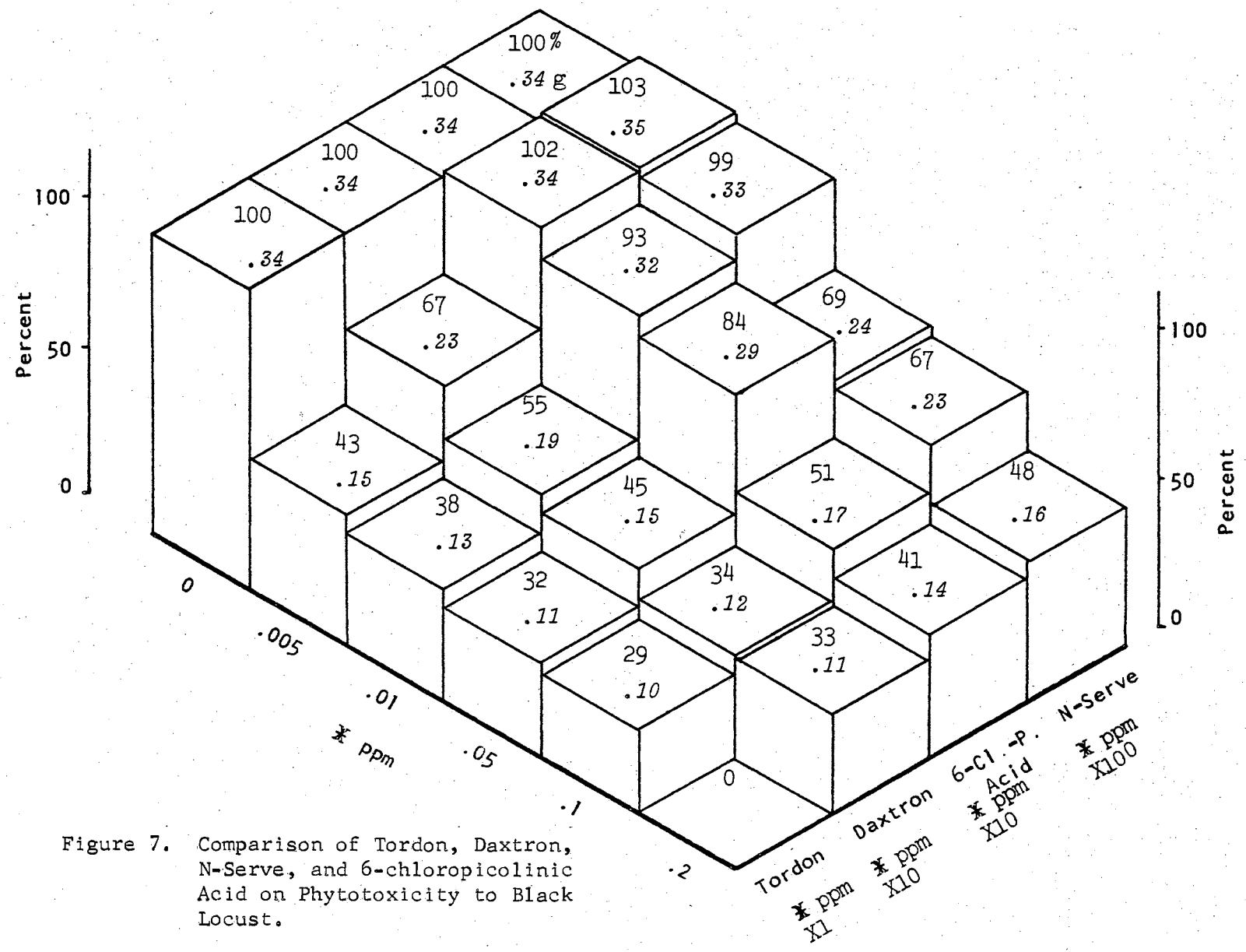

Figure 7. Comparison of Tordon, Daxtron, N-Serve, and 6-chloropicolinic Acid on Phytotoxicity to Black Locust.

SUMMARY AND CONCLUSIONS

The objective of this study was to determine the influence of various soil factors on the rates and magnitude of pyridine herbicide phytotoxicity diminution with two soils, Brewer and Eufaula. Variables in these studies included organic matter amendments, soil sterilization, soil reaction, cation exchange capacity, and soil temperature. Relative phytotoxicity of four pyridine herbicides, N-Serve, Tordon, Daxtron, and 6-chloropicolinic acid, was determined. Black Locust (Robinia pseudoacacia) foliage which exhibited phytotoxic symptoms was used to determine if absorbed herbicide materials retained phytotoxic properties within the plant. Thirteen soil inhabiting fungi isolates were screened for their degradation effects with N-Serve.

N-Serve was found to initially increase in activity with increased organic matter levels which indicated that microorganism activity influenced activation. Steam sterilized soil had less activity than non-sterilized soil and percent relative toxicity increased with increasing temperatures. A highly active form of this pyridine accumulated in plant materials, with four grams dry plant tissue giving an equivalent response corresponding to 5 ppm level of N-Serve.

Fungi species not inhibited by the additions of 100 ppm of N-Serve included: Paecilomyces varioti, Mucor pusillus, Trichoderma viride, Curvularia lunta, Alternaria tenius, Cladosporium resinae, Pencillium funiculosium, and the Aspergilli: tamarii, chevalieri, sydowi, niger,

flavus, and oryzae. Bioassay of residual pads and media indicated these organisms degrade and reduce toxicity of the N-Serve.

Equivalent phytotoxic levels of Tordon were approximately 10 fold higher than 6-chloropicolinic acid and Daxtron and 100 times higher than N-Serve. A decrease in phytotoxicity of Tordon was apparent at herbicide levels of 0.5 and 1.0 ppm as cation exchange capacity increased from 2 to 14 m.e./100 grams.

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A P P E N D I X

TABLE III

EFFECT OF ORGANIC MATTER AMENDMENTS ON N-SERVE PHYTOTOXICITY

TREATMENTS		Robinia pseudoacacia growth*				
		Harvests				
ppm N-Serve	Organic Addition	First	Second	Total	Percent Check**	Mean***
0	0	.95	1.32	2.27	100	.76
1	0	.94	1.29	2.23	98	.74
2.5	0	.78	1.27	2.05	90	.68
5	0	.73	.98	1.71	75	.57
10	0	.44	.85	1.29	57	.43
0	straw	.58	1.68	2.26	100	.75
1	straw	.59	1.71	2.30	101	.77
2.5	straw	.50	1.44	1.94	86	.65
5	straw	.45	1.16	1.61	71	.54
10	straw	.32	1.12	1.44	64	.48
0	½ Blk. Loc. & ½ str.	.60	2.09	2.69	100	.89
1	½ Blk. Loc. & ½ str.	.57	1.94	2.51	93	.84
2.5	½ Blk. Loc. & ½ str.	.54	1.39	1.94	72	.64
5	½ Blk. Loc. & ½ str.	.43	1.49	1.92	71	.64
10	½ Blk. Loc. & ½ str.	.40	1.32	1.72	64	.57
0	Black Locust	.75	2.62	3.37	100	1.12
1	Black Locust	.71	2.07	2.78	83	.93
2.5	Black Locust	.67	1.98	2.65	79	.88
5	Black Locust	.57	1.63	2.20	65	.73
10	Black Locust	.42	1.38	1.80	53	.60
F=16.84 (P >.01)		C. V. = 10.06%			.01 LSD = 0.10	

* Sum of three replications; dry weight in grams.
** Ratio of untreated to treated sums.
*** Average weight of three replication.

TABLE IV

EFFECT OF STERILIZATION ON N-SERVE PHYTOTOXICITY

Treatment	*Robinia pseudoacacia* growth* ppm	mean weight	Percent check**
Nonsterilized	0	.63	100
Nonsterilized	1	.62	98
Nonsterilized	2.5	.59	95
Nonsterilized	5	.25	40
Nonsterilized	10	.24	39
Sterilized	0	.73	100
Sterilized	1	.71	97
Sterilized	2.5	.65	89
Sterilized	5	.46	64
Sterilized	10	.40	55
F=7.99 (P>.01)	C. V. = 25.03%		.01 LSD=.14

* Average of three replications; dry weight in grams.
** Ratio of untreated to treated means.

TABLE V

EFFECT OF SOIL REACTION ON N-SERVE PHYTOTOXICITY

Treatment ppm	pH Range	*Robinia pseudoacacia* growth* First Harvest weight	Second Harvest weight	Third Harvest weight	Total weight
0	4.7-5.0	.32	.69	2.30	3.31
1	4.7-5.0	.33	.93	2.41	3.67
2.5	4.7-5.0	.44	.86	2.08	3.38
5	4.7-5.0	.35	.75	1.74	2.84
10	4.7-5.0	.30	.38	1.29	2.07
0	5.2-5.6	.38	.89	2.32	3.59
1	5.2-5.6	.42	.57	2.42	3.41
2.5	5.2-5.6	.35	.66	2.23	3.24
5	5.2-5.6	.31	.63	1.83	2.77
10	5.2-5.6	.29	.54	1.48	2.31
0	6.0-6.5	.57	1.15	1.78	3.50
1	6.0-6.5	.48	1.04	2.37	3.89
2.5	6.0-6.5	.38	1.12	1.76	3.29
5	6.0-6.5	.31	.72	2.07	3.10
10	6.0-6.5	.26	.47	1.80	2.53
0	7.7-8.0	.48	.99	1.88	3.35
1	7.7-8.0	.35	1.10	1.63	3.08
2.5	7.7-8.0	.32	.91	1.94	3.17
5	7.7-8.0	.26	.86	2.32	3.44
10	7.7-8.0	.20	.39	1.53	2.12
0	8.1-8.5	.32	.83	1.78	2.93
1	8.1-8.5	.41	.84	1.50	2.75
2.5	8.1-8.5	.43	.78	1.58	2.79
5	8.1-8.5	.30	.71	2.19	3.20
10	8.1-8.5	.37	.44	1.51	2.37
F=19.16 (P >.01)		C. V. = 42.41%			

* Sum of three replications; dry weight in grams.

TABLE VI

EFFECT OF CATION EXCHANGE CAPACITY ON N-SERVE PHYTOTOXICITY

Treatment ppm	C.E.C.*	Robinia pseudoacacia growth** First Harvest weight	Second Harvest weight	Total weight
0	2.7	.76	1.39	2.15
1	2.7	.65	1.42	2.07
2.5	2.7	.62	1.51	2.13
5	2.7	.60	1.48	2.08
10	2.7	.46	.86	1.32
0	4.2	.96	1.80	2.76
1	4.2	.57	.90	1.47
2.5	4.2	.59	1.33	1.92
5	4.2	.72	1.26	1.98
10	4.2	.50	.63	1.13
0	5.7	1.15	1.99	3.14
1	5.7	.97	.94	1.91
2.5	5.7	.49	.48	.97
5	5.7	.55	.69	1.24
10	5.7	.40	.23	.63
0	7.2	.90	1.08	1.98
1	7.2	.87	1.45	2.32
2.5	7.2	.85	1.31	2.16
5	7.2	.65	.53	1.18
10	7.2	.52	.52	1.04
0	8.6	1.09	1.60	2.69
1	8.6	1.14	1.09	2.23
2.5	8.6	.79	1.23	2.02
5	8.6	.61	.79	1.40
10	8.6	.49	.91	1.40
0	11.7	.81	1.08	1.89
1	11.7	.61	.73	1.34
2.5	11.7	.68	.76	1.44
5	11.7	.54	.82	1.36
10	11.7	.52	1.17	1.69
0	14.6	.97	1.85	2.82
1	14.6	.56	2.00	2.56
2.5	14.6	.96	1.68	2.64
5	14.6	.82	1.27	2.09
10	14.6	.71	.72	1.43
F=5.89 (P >.01)		C.V.=43.38%		

* m.e./100 grams.
** Sum of three replications; dry weight in grams.

TABLE VII

EFFECT OF SOIL TEMPERATURE ON PHYTOTOXICITY OF N-SERVE

Treatment ppm	Temperature*	Robinia pseudoacacia growth** mean weight	Percent check***
0	20	.33	100
1	20	.32	97
2.5	20	.21	64
5	20	.22	68
10	20	.15	47
0	30	.71	100
1	30	.64	91
2.5	30	.63	89
5	30	.37	52
10	30	.19	26
0	38	.73	100
1	38	.63	87
2.5	38	.56	77
5	38	.40	56
10	38	.04	5
F=14.55 (P >.01)	C.V.=27.89%		.01 LSD=.10

* Degrees Centigrade.
** Average of three replications; dry weight in grams.
*** Ratio of untreated to treated means.

TABLE VIII

COMPARISON OF N-SERVE TO N-SERVE TREATED PLANT TISSUE

Treatment	ppm	grams added	Robinia pseudoacacia mean weight* growth	Percent check**
N-Serve	0		.45	100
N-Serve	1		.42	93
N-Serve	2.5		.33	73
N-Serve	5		.30	67
N-Serve	10		.23	51
Phytotoxic Plant Tissue		1	.34	75
Phytotoxic Plant Tissue		2	.27	60
Phytotoxic Plant Tissue		4	.23	50
Phytotoxic Plant Tissue		8	.01	2
Black Locust Foliage		1	.52	115
Black Locust Foliage		2	.47	103
Black Locust Foliage		4	.42	93
Black Locust Foliage		8	.36	80
F=9.66 (P >.01)	C.V.=15.08%		.01 L.S.D.=.09	

* Average of three replications; dry weight in grams.
** Ratio of untreated to treated means.

TABLE IX

DRY WEIGHT OF BLACK LOCUST AS AFFECTED BY SUBSTITUTED PYRIDINES

Treatment*	*Robinia pseudoacacia* growth Weight**
Check	1.38
N-Serve	.56
Quinolinic Acid	1.38
Br-Pyridine	1.39
Nicotinic Acid	1.40
Nicotino	1.46
Trigonelline	1.52
Nicotino-Nitrile	1.55
4-Picolinic Acid	1.56
2,4-Di-Hydroxy-3-CN-Pyridine	1.58
6-Hydroxy-Nicotinic Acid	1.67
2-Picolinic Acid	1.74
2,4-Di-3-CN-6-Chloro-Pyridine	1.78
N-me-Nicotinamide	1.80
Nicotinamide	2.01
C.V.=16.23%	

* All treatments applied at 5 ppm.
** Sum of three replications; dry weight in grams.

TABLE X

EFFECT OF N-SERVE ON WEIGHT OF FUNGUS PADS

Fungus	Weight* 0	10	25	50	100 ppm
Aspergillus niger	2.93	2.29	2.36	2.22	1.97
Aspergillus sydowi	1.76	1.82	1.68	1.65	1.80
Aspergillus flavus	1.70	1.67	1.58	1.62	1.64
Aspergillus tamarii	1.29	1.32	1.34	1.26	1.20
Aspergillus oryzae	2.09	1.86	1.87	1.83	1.66
Aspergillus chevalieri	1.51	1.66	1.13	1.89	1.86
Penicillium funiculosium	1.46	1.48	1.48	1.43	2.07
Cladosporium resinae	.76	.90	.84	.90	1.09
Alternaria tenius	.87	1.44	1.48	1.44	1.04
Curvularia lunta	1.99	2.10	1.83	1.91	1.54
Trichoderma virides	.97	1.04	.85	.90	.70
Mucor pusillus	1.33	1.34	1.16	1.40	1.47
Paecilomyces varioti	1.48	1.58	1.38	1.32	1.49

C.V.= 29.61%

* Sum of three replications; dry weight in grams.

TABLE XI

EFFECT OF FUNGUS GROWTH ON PHYTOTOXICITY OF N-SERVE

Fungi	*Robinia pseudoacacia* growth* MEDIA ppm 0	5	%**	Rank	PAD ppm 0	5	%**	Rank
Aspergillus niger	1.62	.93	57	1	2.14	1.64	77	8
Aspergillus flavus	1.56	.58	37	2	2.51	2.10	83	7
Penicillium funicolosium	1.37	.51	37	2	1.43	1.46	102	3
Curvularia lunta	1.30	.46	36	3	1.68	1.28	76	9
Paecilomyces varioti	1.19	.44	36	3	1.73	1.75	101	4
Aspergillus chevaleri	1.30	.43	33	4	1.60	1.39	87	6
Aspergillus tamarii	1.60	.51	32	5	2.08	1.58	76	9
Mucer pusillus	1.47	.46	31	6	1.88	1.67	89	5
Aspergillus oryzae	1.12	.33	30	7	1.46	1.67	114	1
Aspergillus sydowi	1.60	.44	28	8	1.53	1.76	114	1
Cladosporium resinae	1.31	.34	26	9	1.27	1.30	102	3
Alternaria tenius	1.30	.32	25	10	1.69	1.24	73	10
Trichoderma virides	1.75	.39	22	11	1.46	1.55	106	2
Uninoculated check	1.75	.33	19	12				
$F = 5.01$ ($P > .01$)	C.V.= 28.67%							

* Sum of three replications; dry weight in grams.
** Ratio of untreated to treated sums.

TABLE XII

EFFECT OF CATION EXCHANGE CAPACITY ON PHYTOTOXICITY OF TORDON

Treatment ppm	C.E.C.**	Cucumis sativus growth* First Harvest	Second Harvest	Total	Percent check***	Mean Weight
0	2	.81	4.27	5.08	100	1.69
0.05	2	.44	4.19	4.63	91	1.54
0.1	2	.23	4.09	4.32	85	1.44
0.5	2	---	----	----	0	----
1.0	2	---	----	----	0	----
0	4	.91	4.36	5.27	100	1.76
0.05	4	.48	4.24	4.72	89	1.57
0.1	4	.25	4.21	4.46	85	1.49
0.5	4	---	1.33	1.33	25	0.44
1.0	4	---	----	----	0	----
0	6	1.02	4.43	5.45	100	1.48
0.05	6	.38	4.30	4.68	86	1.56
0.1	6	.27	4.25	4.52	83	1.51
0.5	6	---	2.75	2.75	50	0.92
1.0	6	---	----	----	0	----
0	8	1.34	4.47	5.81	100	1.94
0.05	8	.71	4.25	4.96	85	1.65
0.1	8	.54	4.27	4.81	83	1.60
0.5	8	---	4.06	4.06	70	1.35
1.0	8	---	----	----	0	----
0	10	1.08	4.49	5.57	100	1.52
0.05	10	.63	4.29	4.92	88	1.64
0.1	10	.70	4.26	4.96	89	1.65
0.5	10	---	4.03	4.03	72	1.34
1.0	10	---	----	----	0	----
0	12	1.52	4.56	6.08	100	2.03
0.05	12	.71	4.33	5.04	83	1.68
0.1	12	.64	4.31	4.95	81	1.65
0.5	12	.28	3.99	4.27	70	1.42
1.0	12	---	1.30	1.30	21	0.43
0	14	1.99	4.51	6.50	100	2.17
0.05	14	1.03	4.35	5.40	83	1.80
0.1	14	.74	4.41	5.15	79	1.72
0.5	14	.27	4.12	4.39	68	1.46
1.0	14	.25	4.04	4.29	66	1.43
Treatment F = 16.97 (P > .01)			C.V.= 19.41%		.01 L.S.D. = .18	

* Dry weight in grams; sum of three replications.
** Cation exchange capacity expressed as a milliequivalent per 100 grams.
*** Ratio of untreated to treated sums.

TABLE XIII

COMPARISON OF PHYTOTOXICITY OF FOUR PYRIDINES

Treatment	ppm	*Robinia pseudoacacia* growth weight*	Percent check**
Check	0	.34	100
Tordon	0.005	.15	43
Tordon	0.01	.13	38
Tordon	0.05	.11	32
Tordon	0.1	.10	29
Tordon	0.2	--	0
Daxtron	0.05	.23	67
Daxtron	0.1	.19	55
Daxtron	0.5	.15	45
Daxtron	1.0	.12	34
Daxtron	2.0	.11	33
6-cl.P. Acid	0.05	.34	102
6-cl.P. Acid	0.1	.32	93
6-cl.P. Acid	0.5	.29	84
6-cl.P. Acid	1.0	.17	51
6-cl.P. Acid	2.0	.14	41
N-Serve	0.5	.35	103
N-Serve	1.0	.33	99
N-Serve	5.0	.24	69
N-Serve	10.0	.23	67
N-Serve	20.0	.16	48
Treatment F=9.11 (P >.01)		C.V.=20.02%	.01 LSD=.11

* Average of three replications, dry weight grams
** Ratio of untreated to treated means.

VITA

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Candidate for the Degree

of

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