AN ABSTRACT OF THE THESIS OF

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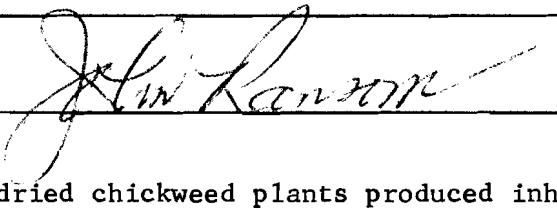
Abstract approved: 

Extracts from dried chickweed plants produced inhibitory effects on Kentucky Bluegrass, Bermuda grass and Fescue 31. The chickweed extracts:

1. inhibited seed germination in Kentucky Bluegrass and Bermuda grass,

2. inhibited seedling development in Kentucky Bluegrass, Bermuda grass, and Fescue 31,

3. inhibited greenhouse-grown grasses in these taxa, and

4. were not self-inhibitory.

CHICKWEED INHIBITION

A Thesis

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INTRODUCTION

Scientific investigations have shown that competition between plants is a function of the abilities of the plants to obtain the necessary minerals, water, and light required for their growth and reproduction. Recently the evidence has indicated that the release of chemical inhibitors by some plants is also a factor in plant competition, affecting the establishment, growth, reproduction, and distribution of plants in a community (Croak, 1969).

Previous investigations have shown that many plants produce chemically toxic substances which have inhibitory effects on other plants. Davis (1928) extracted juglone from mature hulls and roots of black walnut (Juglans nigra) and found it to be inhibitory upon tomato and alfalfa plants when injected into the stems. Gray and Bonner (1948) found that leaves of Encelia farinosa caused severe retardation in the growth of other plants but did not inhibit its own kind. Ahshapanek (1962) observed that extracts from buffalo-bur (Solanum rostratum) were inhibitory to its own kind as well as to many other assay seedlings. Rice (1964, 1965b, 1965c) reported a relationship between the sequency of species invading the fields and their nitrogen requirements. It was also shown that several species of annual grasses and weeds, which require low nitrogen, are inhibitory to nitrogen-fixing and nitrifying bacteria. Rice (1965a) found that phenolic compounds are inhibitory to a free-living nitrogen-fixer, Azotobacter, and to Rhizobium, a symbiotic nitrogen-fixer on legume roots. Dry leaves from Kalmia augustifolia contained a substance that hindered primary root development of black spruce (Peterson, 1965). Pustovoitova (1967) found that apricot leaves,

especially those in wilted condition, contained a growth inhibitor that suppressed the growth of wheat coleoptile segments. Also, Neill (1967) showed that leaf extract from several species of smartweeds, including Polygonum longistylum, inhibited germination and seedling development of tomato plants. Muller, et al (1968) showed that toxic substances produced by Arctostaphylos and certain other chaparral shrubs were inhibitory to annual plants. They also identified these toxins as arbutin, p-hydroxycinnamic acid, and a derivative of coumarin. Blum (1968) showed that phenolic compounds were strongly effective in the reduction of nodulation and the amount of leghemglobin produced in bean plants when added to sand culture or soil in low concentrations. In addition, nodulation of bean plants was strongly reduced by soil from beneath Rhus copallina and Euphorbia supina. Parenti and Rice (1969) found that crabgrass, Digitaria sanguinalis, produced at least three inhibitors. The three, chlorogenic acid, isochlorogenic acid, and sulfosalicylic acid were inhibitory on associated plant seedlings as well as those of its own kind.

Chickweed, Stellaria media, is a common annual, cool-season weed in much of Kansas. The small seeds, which are produced in the spring, retain their vitality for many years (Georgia, 1914). This persistent weed grows throughout the world, even in the Arctic Circle, and usually can be found in gardens, cultivated fields, lawns, meadows, and waste places. It was with the possible inhibitory effects of chickweed on Kentucky Bluegrass, Bermuda grass, and Fescue 31 that this research was concerned.

MATERIALS AND METHODS

Medium to mature chickweed (S. media) plants used in this study were collected in late spring 1977 from the Emporia State University lawns. They were dried in an oven at 100 F for 24 hours. Later extracts of 1.5 g of dried plants were made by grinding them in 100 ml of distilled water in a Waring blender. Seeds of Kentucky Bluegrass (Poa pratensis), Fescue 31 (Festuca elatior), and Bermuda grass (Cynodon dactylon) as well as seeds of chickweed (S. media), were grown in these extracts.

Inhibitory Effects on Germination

To test the effect of chickweed extract on the germination of these three lawn grasses, 200 seeds of each taxon were placed in distilled water at 80 F for 24 hours. These seeds were then placed in sterile petri dishes on sheets of Whatman No. 1 paper. The paper in one petri dish was saturated with 10 ml of distilled water and served as a control; in each of the others the paper was saturated with 10 ml of extract. These petri dishes were placed in the incubator set at 82.4 F. This experiment was repeated three times. Germination counts began at 24 hours and continued daily for 13 days. Data from these were recorded and later statistically analyzed.

Inhibitory Effects on Seedlings

To determine whether chickweed extracts could inhibit seedling growth of these lawn grasses and its own seedlings, seeds of each taxon were soaked in distilled water at 80 F for 24 hours. These were then

placed in white quartz sand in sterile, 16 ml plastic vials, 33 for the controls and 33 for each test group. The sand in each plastic vial was then saturated with distilled water. The vials were placed in a plastic tray, covered with clear plastic, and placed in the growth chamber set at a 15-hour light period and a 9-hour dark period. The temperatures for the light and dark periods were 85 F and 75 F respectively. The vials were watered regularly with distilled water until the seedlings were four weeks old. At this time, seedlings were placed one per vial and grown in either a 5:1 distilled water/Hoagland's No. 1 solution as a control (Hoagland and Arnon, 1950) or in a 5:1 extract/Hoagland's No. 1 solution as a test. Following the 5-day growth period, seedlings were removed and dried at 100 F for 48 hours. Oven-dry masses were determined, recorded, and statistically analyzed.

Inhibitory Effects in Nature

In order to determine the effect of extract solution on these three lawn grasses and upon the chickweed itself, the grasses were taken from lawns in the area and potted in one-gallon plastic pots. The pots were placed in the greenhouse for ten days. These were grown in the 5:1 distilled water/Hoagland's No. 1 solution (2 pots for each control) or in the 5:1 extract solution/Hoagland's No. 1 solution (15 pots for each test.) Following a 14-day growth period, the grasses were harvested and dried at 100 F for 48 hours. Oven-dried masses were determined, recorded, and statistically analyzed.

All statistical analysis were made using the t-test at the $p=.05$ level of significance.

RESULTS

Inhibitional Effects of Extract Solution on Seed Germination

Festuca elatior

The results obtained from the germination tests on fescue seeds indicated that the extract of chickweed did not inhibit seed germination in F. elatior (Table I; Figure 1). Germination of the control seeds began and proceeded more rapidly than those in the extract during the first 48 hours. There was no perceptible difference in inhibiting effect on seed germination from the 96th to the 312th hour (Figure 1). The comparison of the germination of seeds in the extract to those of the control proved not to be significantly different (Table II); however, the percent germination was lower in the test group (Table I).

Cynodon dactylon

Results obtained from the germination tests indicated that the extract of chickweed inhibited seed germination in C. dactylon (Table I; Figure 2). Germination proceeded rapidly in the first 24 hours and then decreased during the next 48 hours. However, germination of the control seeds proceeded more rapidly in the first 24 hours than those in the extract. There was no appreciable difference in seed germination from the 144th hour to the 312th hour; no seed germinated after 216 hours in either the extract or control solutions. There was a significant reduction in percent germination in C. dactylon seeds exposed to the extracts (Table II).

Table I. Average and percent germinations of F. elatior, C. dactylon, and P. pratensis seeds when exposed to S. media extracts and control solutions.

Plant		Number of seed germinations per time period			Total % germination
		24	144	312	
F. elatior	Test	11	33	43	43.77
	Control	21	43	37	50.33
C. dactylon	Test	12	18	2	15.72
	Control	20	23	1	21.33
P. pratensis	Test	1	10	5	7.27
	Control	1	37	12	25.50

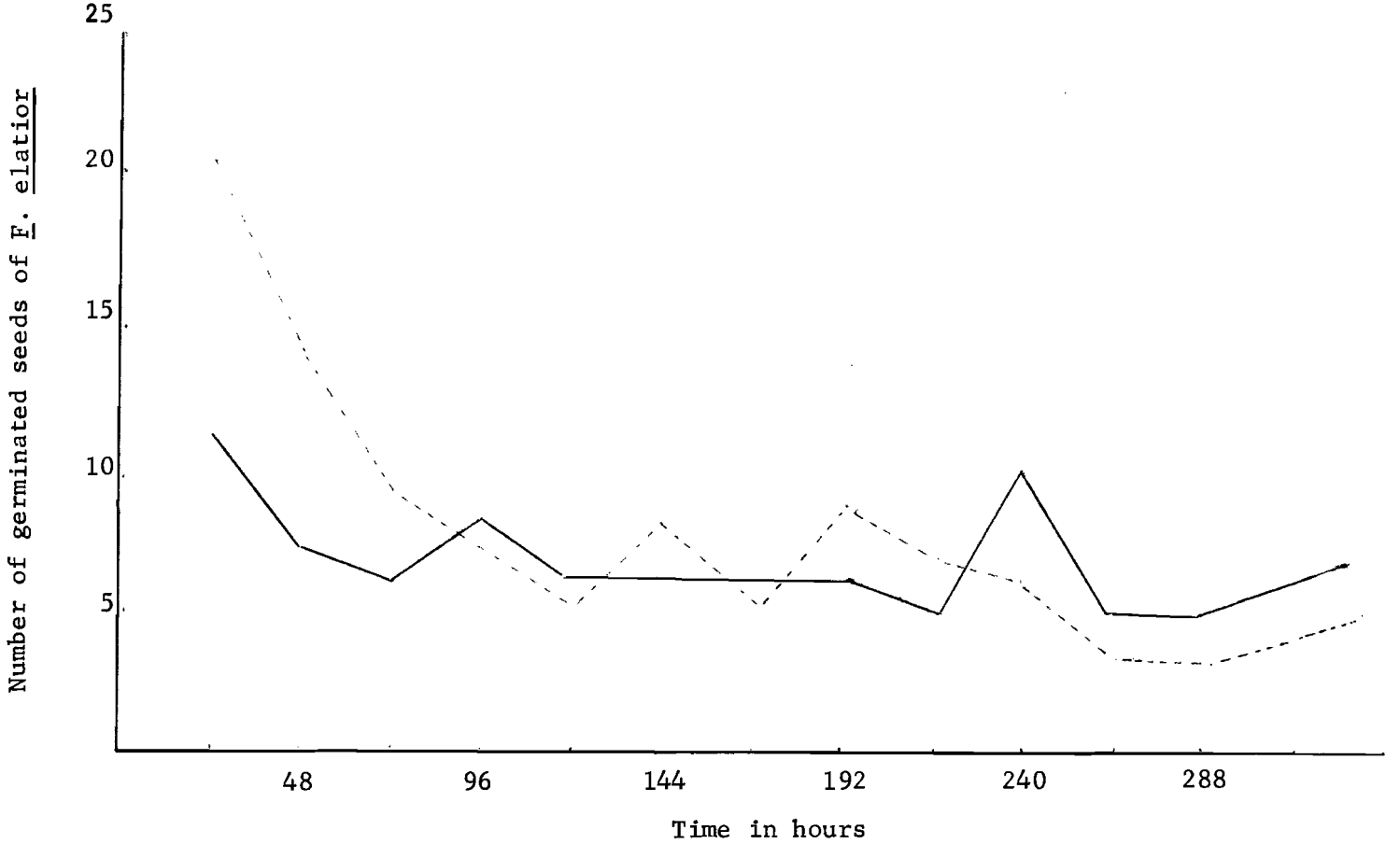

Figure 1. Germination of F. elatior seeds in chickweed extract and control solution.

Table II. Effect of fresh plant water extracts of *S. media* on the germination of seeds of *F. elatior*, *C. dactylon* and *P. pratensis*.

Plant	Mean Germination with Standard Error		T-test	Level of significance
	Control	Test		
F. elatior	68.38 ± 7.12	50.38 ± 6.94	1.80**	5%
C. dactylon	38.77 ± 1.98	26.38 ± 1.70	4.74*	5%
P. pratensis	35.00 ± 5.00	9.54 ± 1.44	4.88*	5%

** The T-test for these tests when compared the controls indicated no significant difference at the 5% level.

* The T-test for these tests when compared the controls indicated a significant difference at the 5% level.

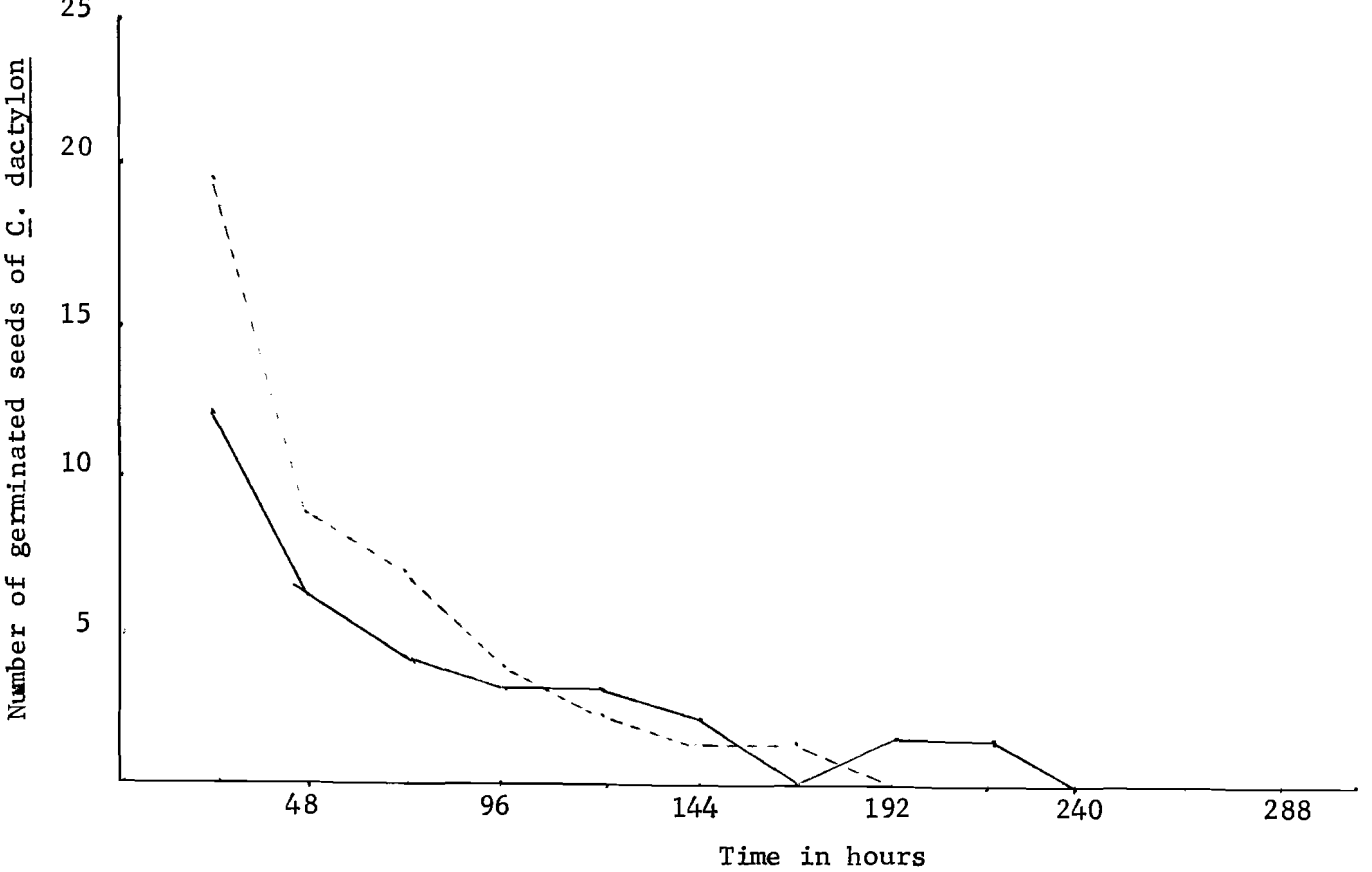

Figure 2. Germination of C. dactylon seeds in the S. media extract and in the control solution.

Poa pratensis

Results obtained from the germination tests indicated that the extract of chickweed inhibited the germination of P. pratensis (Table I; Figure 3). Both the test and the control groups showed good germination during the first 72 hours. There was a general reduction in germination of the test group after 72 hours. The germination in the test was less than one-half of the control from the 2nd to the 7th 24-hour period. In almost all cases, there was a strong inhibiting effect on seed germination in the extract solutions (Table I, II). There was a significant difference between the germination of seeds in the extract and those of the control (Table II).

Inhibitional Effects of Extract Solution on Seedlings

F. elatior

Growth of the four-week-old F. elatior seedlings grown in chickweed extracts was strongly inhibited. Some of the test plants did, however, have longer roots than those of the controls but, overall, the mean dry mass of the seedlings grown in extracts when compared to those of the control groups was significantly less (Table III).

C. dactylon

Growth of the four-week-old seedlings of C. dactylon was significantly reduced when grown in chickweed extract. The test plants often exhibited a chlorotic or bleaching effect at the leaf tips and often produced more fibrous roots than those of the controls. Even though there were more roots in some test plants, there was a significant difference in dry mass between the test plants and the controls (Table III).

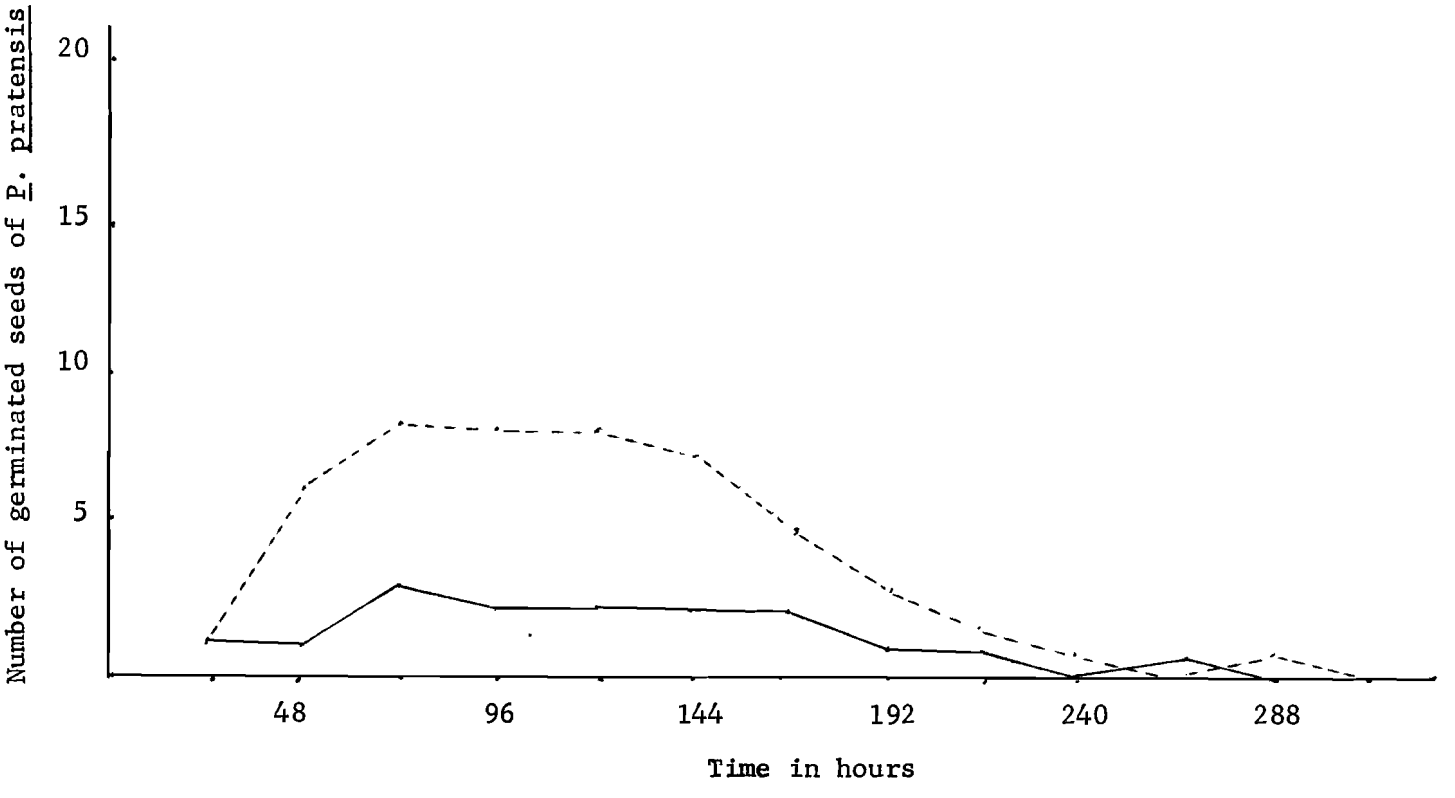

Figure 3. Germination of P. pratensis seeds in S. media extract and control solution.

Table III. Effect of fresh plant water extracts of *S. media* on the seedlings of *F. elatior*, *C. dactylon*, *P. pratensis* and *S. media*.

Plant	Mean Oven-Dry Weight, with Standard Error		T-test	Level of significance
	Control	Test		
F. elatior	0.0122 ± 0.0006	0.0039 ± 0.0002	12.47*	5%
C. dactylon	0.0073 ± 0.0003	0.0019 ± 0.0001	16.02*	5%
P. pratensis	0.0083 ± 0.0004	0.0023 ± 0.0001	13.17*	5%
S. media	0.0026 ± 0.0002	0.0021 ± 0.0002	1.98**	5%

** The T-test for these tests when compared to the controls indicated no significant difference at the 5% level.

* The T-test for these tests when compared to the controls indicated a significant difference at the 5% level.

P. pratensis

Chickweed extracts had a considerable effect on the growth of four-week-old seedlings of P. pratensis. There was a significant reduction in growth (Table III) even though some of the test plants produced more fibrous root growth than the controls. The mean dry mass of the seedlings grown in the extracts was significantly less from those of the controls.

S. media

Chickweed extracts had no effect on the growth of four-week-old chickweed seedlings (Table III). Both the test and control plants grew well. The mean dry mass of the seedlings grown in extracts when compared to those of the control groups was not significantly different.

Inhibitional Effects of Chickweed Extracts on Lawn Grown Samples of F. elatior, C. dactylon, and P. pratensis in the Greenhouse

F. elatior

Greenhouse-grown plants showed a definite reduction in growth when watered with a 1.5 g/100 ml extract of chickweed (Table IV). The test plants were shorter and the leaves less rigid than those of the controls. The mean dry mass was also less than those of the controls and the tests comparing these were significantly different.

C. dactylon

Greenhouse-grown plants were strongly inhibited in their growth when watered with a 1.5 g/100 ml extract of chickweed (Table IV). The

Table IV. Effect of fresh plant water extracts of S. media on F. elatior, C. dactylon, P. pratensis and S. media in nature.

Plant	Mean Oven-Dry Weight, with Standard Error		T-test	Level of significance
	Control	Test		
F. elatior	1.42 ± 0.33	0.97 ± 0.04	3.07*	5%
C. dactylon	3.89 ± 0.20	2.21 ± 0.18	3.31*	5%
P. pratensis	1.09 ± 0.25	0.43 ± 0.03	5.90*	5%
S. media	0.47 ± 0.05	0.44 ± 0.03	0.22**	5%

** The T-test for these tests when compared to the controls indicated no significant difference at the 5% level.

* The T-test for these tests when compared to the controls indicated a significant difference at the 5% level.

test plants appeared to be weaker than those of the controls and the mean dry mass was lower. A comparison of the mean dry masses of the test plants to those of the controls indicated that there was a significant difference.

P. pratensis

Greenhouse-grown plants showed a definite retardation in growth when watered with a 1.5 g/100 ml extract of chickweed. Some test plants had chlorotic basal leaves. In addition, all of the test groups had many more decaying leaves on the surface of the soil. The mean dry mass of the control plants was significantly greater (Table IV) than those of the test plants.

S. media

Chickweed plants grew well in both extract and control solutions. Both were strong and showed no difference in growth patterns. There was no significant difference in dry masses of the test and control plants (Table IV).

DISCUSSION

Personal observations have shown that chickweed (S. media), a frequent lawn invader in early spring, was probably inhibiting the growth of common lawn grasses. It usually invades lawns which have in them such grasses as Kentucky Bluegrass, Bermuda grass and Fescue 31. In areas which chickweed colonies are particularly dense, these grasses are often nearly eliminated.

In this study chickweed extracts usually inhibited the growth of Kentucky Bluegrass, Bermuda grass and Fescue 31. It inhibited seed germination in all taxa but Fescue 31, seedling growth in all taxa, and pot-grown, lawn-collected plants of these grasses grown in the greenhouse. It showed no tendency toward self inhibition in any of the tests run. It is probable that natural decomposition of leaves, stems and roots of chickweed, might explain how plant-synthesized, inhibitory compounds get into the soil in these areas. The inhibitory activity of extracts from dried chickweed indicated that drying did not appreciably reduce the inhibitory potential of the compounds. Since the dried extracts were inhibitory, it was nearly certain that the inhibitory substance was not of proteinaceous composition. It was possible, however, that the inhibitory substance(s) initially involved may have been chemically degraded to other compounds by the heat in the oven-drying process. However, these also proved to be inhibitory.

SUMMARY

Extracts from dried chickweed plants were inhibitory upon Kentucky Bluegrass, Bermuda grass and Fescue 31. The dried chickweed extracts:

1. inhibited seed germination in Kentucky Bluegrass and Bermuda grass,
2. inhibited seedling development in all taxa,
3. inhibited greenhouse-grown grasses in these taxa, and
4. were not self-inhibitory.

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