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Title THE EFFECT OF SOIL MIXTURE AND SOIL COVER ON RESIDUAL ACTIVITY OF HERBICIDES MEASURED BY SEEDLING EMERGENCE OF *POA ANNUA*, L.

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(Major Professor)

Greenhouse studies were carried out with *Poa annua*, L. as a bioassay to determine the influence of cover and soil mixture on residual herbicide activity.

Covers of organic matter stripped from an *Agrostis tenuis* Sibth. var. Highland (Highland bentgrass) lawn and washed sand were used. Soil mixtures were sand, clay, sand-organic matter, and clay-organic matter. Plantings were made at 0, 4, and 8 weeks after spraying. Counts of healthy seedlings were made two weeks after planting. Covers were applied after each planting.

Field studies were made using mature turf to measure selective toxicity of chemicals between *Poa annua* and desirable turf species.

Applications were made pre-emergence to *Poa annua* in early fall and post-emergence to *Poa annua* in early

spring. In late spring, heavy rates of chemicals were applied to investigate damage to desirable turf.

Four weeks after spraying, the best residual activity was exhibited by 2,6-dinitro-N-N-di-n-propyl-α,α,α-tri-fluro-p-toluidine (trifluralin), sec-Butyl-N-3-Chloro-phenyl carbamate (BP9, experimental chemical of Pittsburg Plateglass Co.), 0-(2,4,-dichlorophenyl)0-methyl iso-proply phosphoamidothioate (Zytron, trade mark of Dow Chemical Co.), and N,N-dimethyl-2,2-diphenylacetamide (diphenamid). Eight weeks after spraying trifluralin and diphenamid had the best residual activity.

Four weeks after spraying, 3,6-endozohexahydrophthalic acid (endothal) and TD282 (experimental analog of endo-thal, Pennsalt Chemical Co.) had more activity in organic matter covers, while Niagara 6370 (experimental chemical of Niagara Chemical Co.) and N(β-0,0diisopropyldithio-phosphorylethyl)benzene sulfonamide (Betasan, trade mark of Stauffer Chemical Co.) had more activity in a sand cover. Eight weeks after spraying, BP9 and TD282 had more activity in organic matter cover than in sand cover, while endothal, Dimethyl-2,3,5,6,-tetrachloroterephthalic acid (Dacthal, trade mark of Diamond Alkali Co.), Betasan, Zytron, and diphenamid had more activity in a sand cover.

Four weeks after spraying, Niagara 6370, BP9, endothal, and Betasan (granular) had more residual activity in organic soils, while Betasan (emulsifiable concentrate) had more activity in clay mixtures and trifluralin had more activity in sand mixtures. Eight weeks after spraying, Dacthal had more activity in clay-organic matter mixtures, while Niagara 6370, TD282, trifluralin, and Zytron had more residual activity in sand mixtures.

Diphenamid was very stable under the conditions of this experiment. It showed no significant differences between and among rates, covers, and soil mixtures.

Trifluralin damaged turf at 4 lb/A. Diphenamid damaged turf at 8 and 16 lb/A.

This study shows that cover and soil mixtures do influence the activity of chemical soil active herbicides.

Future investigations involving the chemical control of *Poa annua* should include diphenamid, Betasan, and trifluralin.

THE EFFECT OF SOIL MIXTURE AND SOIL COVER ON RESIDUAL ACTIVITY OF HERBICIDES MEASURED BY SEEDLING EMERGENCE OF *POA ANNUA*, L.

by

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INTRODUCTION

Annual weedy grasses are a problem both in turf and commercial grass fields. These compete with desirable species and their seeds contaminate seed intended for turf use. *Poa annua* L. performs as an annual grass when grown under normal conditions. It forms a dense and functional turf when irrigation, fertilization, and cool-moist atmospheric conditions are favorable. If dry, warm conditions develop, *Poa annua* will mature and die. When this species dies, the vacant area is invaded by other undesirable weeds such as *Digitaria*, *Taraxacum*, *Plantago*, *Holcus*, *Trifolium*, and *Medicago* species or any other plant that would not be able to compete with a dense turf. Once these weeds become well established in the turf, desirable species are unable to recover the area formerly occupied by *Poa annua*.

Poa annua behaves as an annual in most temperate climates. Vegetative growth occurs in the fall and early spring. The plant flowers and sets seed in early spring. *Poa annua* will germinate over a period of several months if conditions are suitable.

A soil-active, selective herbicide with long residual life that would affect only germinating seed would be desirable as a control measure, since established grass would be essentially unharmed. Chemicals which kill germinating *Poa annua* are known, but in most experiments the chemicals have been applied on bare soil. The same chemicals applied on established turf usually give little or no control.

The proportion of sand, clay, and organic matter in a soil may influence the residual activity of a chemical. Organic matter and clay generally reduce the activity of soil-active herbicides. Older stands of turf, especially golf greens, may develop thick covers of thatch which may reduce the activity of surface applied herbicides. Soils on which turf is usually produced are quite variable in these constituents.

This study is an effort to better understand the influence of organic matter cover and soil mixtures on the residual activity of various herbicidal chemicals.

LITERATURE REVIEW

Description of Poa annua

> Poa annua L. ANNUAL BLUEGRASS. Tufted bright green, erect to spreading, sometimes rooting at the lower nodes, usually 5 to 20 cm. tall, sometimes taller, forming mats; clums flattened, blades soft, lax, mostly 1 to 3 mm. wide; panicle pyramidal, open, 3 to 7 cm. long; first glume 1.5 to 2, the second 2 to 2.5 mm. long; lemmas not webbed at base, distinctly 5 nerved, more or less pubescent on the lower half of all the nerves, the long hairs on the lower part of the keel sometimes simulating a web; another 0.5 to 1 mm. long.
>
> Habitat is open ground, lawns, pastures, waste places, and openings in woods, Newfoundland and Labrador to Alaska, south to Florida and California; tropical America at high altitudes; introduced from Europe. In warmer parts of the United States the species thrives in the winter; in intermediate latitudes it is a troublesome weed in lawns, growing luxuriantly in spring, dying in early summer and leaving unsightly patches. Occasionally found in flooded places and stream banks, the clums spreading Hitchcock (19, p. 106).

Peck (25, p. 97) described Poa annua as having glabrous blades and sheaths with a general distribution in moist, open habitats.

Clausen, Keck, and Hiesey (5, p. 121) stated that Poa annua appears to have developed as an amphiploid and has a n=14 chromsome number. They hypothesize that Poa annua developed from species in the mountains of the Mediterranean region. It is hypothesized that Poa exilis (Tomm) Murb. n=7, which is a tender Mediterranean annual and Poa supina Schard n=7, which is a sub-alpine perennial are the species that combined in the amphiploid, Poa annua, which has a wider ecological amplitude than either contributing diploid species.

Sprague and Burton (35, p. 3) described Poa annua's resemblance to other bluegrasses. It has a folded leaf, like the prow of a boat, and transparent lines on each side of and paralleling the leaf midrib. The lines are visible when held to the light. It differs from Poa pratensis L. (Kentucky bluegrass) in being more dwarf in growth and having an absence of creeping underground stems. A short prostrate rooting stem may develop on the soil surface, but like Poa trivialis L. the plant is not truly stoloniferous. The leaves of Poa annua are shorter, broader, and lighter green than other Poa species. Leaves are shiny on the underside, and the plant is smooth. The plant has no auricles. The ligule is nearly colorless, well developed, and has a pointed apex.

Growth Habit Under Turf Conditions

Piper and Oakley (27, p. 39) describe *Poa annua*, when grown under turf conditions, as tufted with fiberous roots. The leaves are bright green with no blue color, soft texture, and have a cross crumpling near the base. In the latitude of Washington, D. C., it blooms before winter and will also bloom before the other grasses in the spring.

Hoover (20, p. 688) stated that growth is started in the late summer or early fall. Seedheads are produced even when the turf was mowed ¼" high.

Sprague and Burton (35, p. 18) stated that *Poa annua* is a weak competitor compared with desirable turf species. Adequate daylight seems to be an important factor in production of abundant seed. The ten hour days in early spring or early fall are more conducive to seed formation than are the longer days of summer. For abundant seed production the grass is suited to the light relations in the early season. Seed production takes place before the more permanent grasses have appeared and are in their period of maximum growth.

Grau (16, p. 31) noted that heavily watered turf, either by irrigation or natural rainfall, had a heavy infestation of Poa annua. He noted that it cannot recover after a period of severe drying.

Sprague and Burton (35, p. 15-16) investigated the fertility requirements of Poa annua. They found that phosphorous was required for optimum growth and a heavy nitrogen rate reduced the number of seedheads produced. To study invasion of turf areas by Poa annua, Sprague and Burton (35, p. 19) used sand cultures and grew Poa annua, Agrostis tenuis Sibth. (colonial bentgrass), and Kentucky bluegrass. They found Poa annua root development was favorable and comparable to the other grasses grown when cultures were at pH 6.5 than at pH 5. The concluded invasion of turfed areas by Poa annua is due to some growth character other than acidity and nitrogen supply.

Abundant seed supplied on damaged turf areas and prompt germination in late summer when weather conditions are favorable could be responsible for the rapid invasion. Sprague and Burton (35, p. 8) found organic fertilizer with a slow breakdown rate during cold weather allowed thinning of the turf and invasion by Poa annua. Grau (16, p. 32) found Poa annua dies after producing seed, therefore during the summer the dead patches may be filled by *Digtaria*, *Eleusine*, *Trifolium*, and *Polygonum* species. He reported the highest germination rate of *Poa annua* is during cool, moist spring and fall weather.

Sprague and Burton (35, p. 41), in contrast, stated *Poa annua* will continue vegetative growth after it has produced seed. Death is caused by extreme heat or moisture shortage. After ten days of extreme weather conditions, *Poa annua* will have no active growth and bare spots will develop in the turf.

Ferguson (13, p. 25) summed up the environmental characteristics of *Poa annua*: (1) shallow rooted, (2) not drought resistant, (3) annual by nature, (4) will produce seed when plants range ¼" to 8" in height, and (5) attacked by such diseases as *Helminthosporium* spp. and *Fusarium* spp.

Conditions favoring *Poa annua* when competing with bentgrass are: (1) *Poa annua's* heavy seed production, (2) its occupation of depressed soil surface areas where water may leach slowly, (3) a compact soil limiting oxygen movement for the deeper rooted bentgrass roots, and (4) high moisture content of thatch and organic matter in which *Poa annua* does better.

Sprague and Burton (35, p. 11-12) studied root development under favorable conditions of loose soil and adequate fertilization. They found *Poa annua* had an abundant root system far denser in loose soil than in a compacted soil. *Poa annua* root development was similar to permanent turf plants when grown under similar conditions. They concluded that *Poa annua* develops a shallow root system if forced to do so. Limitations of roots to the upper inch or two of soil is an index of unfavorable soil conditions rather than a demonstration of the plants inability to occupy lower levels in the soil.

Poa annua seed needs no vernalization or rest period following the ripening process. Seed will germinate immediately after harvest. Seed is spread by wind, water, mowing machines, and shoes of persons using the turf.

Hallowell (17, p. 30-32) noted that once *Poa annua* is established it will reseed annually and make a fine quality cover throughout the winter. A uniform cover of *Poa annua* can be produced on *Cynodon* spp. (bermudagrass), but thatch must be removed by light renovation or by mowing the bermuda grass very short. Early fall renovation and frequent watering were necessary for seed germination. Application of nitrogen was necessary during the winter for a dense and even turf. The fine textured bermudagrass varieties like Tifton 127 or Tifton 123 may not permit the growth of Poa annua so well as the common bermudagrass varieties.

Sprague and Burton (35, p. 9) thought abundance of Poa annua was due to a loss of vigor by the permanent grass in critical periods. The bare patches would furnish an invasion opportunity for new plants of Poa annua.

Grau (16, p. 31) supposed that close mowing would weaken the desirable turf plants and use of chemicals to control disease would prevent loss of weak turf plants. If a disease does attack, the injured areas offer an opportunity for invasion by Poa annua.

Attempts to Control Poa annua

Hand eradication of Poa annua has been advised (1, p. 213-214; 28, p. 127; 29, p. 184). The plugging of desirable bentgrasses into large areas of Poa annua has been suggested. The application of top dressing including ammonium sulfate to encourage the plugs and established bentgrass has been proposed.

On putting greens of the Pine Valley Golf Course in Pennsylvania where arsenate of lead at 5 lb/1,000 square feet per month was applied during the previous year for the control of earthworms, it was observed that desirable grass had crowded out *Poa annua* during the spring and summer (11, p. 11). Sprague and Burton (35, p. 10) found a reduced abundance of *Poa annua* but no specific response to arsenate of lead. There was a general shift to more unfavorable growth conditions for *Poa annua* as compared to *Agrostic palustris* Huds. (Virginia Creeping Bentgrass) turf following the use of arsenate of lead. Enlow (10, p. 220) failed to control *Poa annua* by using arsenate of lead. Engel and Aldrich (9, p. 28) found that two to three treatments of sodium arsenite plus ¼ lb. of 2,4-dichlorophenyloxyacetic (2,4-D) at two week intervals reduced the amount of *Poa annua* in turf. Grau (15, p. 29) noted a slow healing of bentgrass greens took place after sodium arsenite had been used. Management of the turf affected the response of calcium arsenate suppression of *Poa annua*, when applied at rates varying from six to twenty pounds per 1,000 square feet (8, p. 25). Slife (32, p. 4) reported turf damage by calcium arsenate and lead arsenate.

Control of _Poa annua_ might be accomplished by preventing viable seed production. Engel and Aldrich (9, p. 28) found maleic hydrazide reduced the number of seedheads of _Poa annua_ but damaged the bentgrass turf. Anderson, and McLane (2, p. 58) found that 4-Fluorophenoxyacetic acid would sterilize _Poa annua_, when plants were grown under greenhouse conditions from four to six weeks. The plants sprayed with 4-Fluorophenoxyacetic acid had panicles that appeared but were malformed. The main rachis and branches of the panicles failed to elongate. The most sensitive stage of differentiation was when three to four leaves were visible. The panicle was 0.2 to 0.4 mm long at this stage of leaf growth. In mowed lawn, plants failed to produce seedheads during spring flowering peak after a 4-Fluorophenoxyacetic acid treatment had been applied five weeks earlier.

Engel and Aldrich (9, p. 27-28) used 3,6-endoxohexahydrophthalic acid (endothal) at ½ lb/A, this was applied at two week intervals during four growing seasons. They found a good reduction of _Poa annua_. Endothal appeared to suppress the _Poa annua_ by contact. Mild to severe discoloration of *Poa annua* occurred. The bentgrass was slightly discolored and clover was eliminated by the first season treatments.

Chappell (4, p. 91-97) used dimethyl 2,3,5,6-tetrachloroterephthalic acid (Dacthal, a trade mark of Diamond Alkali Co.) at 10, 20, and 30 lb/A, 0(2,4-dichlorophenyl) 0-methyl isopropyl phosphoramidothioate (Zytron, a trade mark of Dow Chemical Co.) at 10, 20, and 30 lb/A, and calcium arsenate at 300 and 450 lb/A with treatments applied in autumn, winter, and spring to control *Poa annua*. He found 30 lb/A of Zytron damaged the turf early in the season. In preliminary studies (39), *Poa annua* seedlings emerged but failed to develop when Dacthal and Zytron were used. Mature plants of both desirable and undesirable grasses were not affected.

Hallowell (17, p. 31-32) and Ferguson (12, p. 32) (13, p. 27-28) suggested that management control of *Poa annua* should include: (1) keeping phosphorus availability level low, (2) using arsenic applications to discourage *Poa annua*, (3) reducing soil compaction, (4) using strains of bentgrasses that compete well with *Poa annua*, (5) fertilizing, if possible when *Poa annua* is inactive,

(6) controlling the diseases, insects, and weeds, (7) keeping the turf area dry during *Poa annua* germination season, and (8) minimizing thatch.

Engel and Aldrich (9, p. 28) noted severe injury by endothal and sodium arsenite when applied in the fall in contrast to slight injury after spring application of the same chemicals.

> Any treatment which destroys existing annual bluegrass is unsatisfactory unless there is sufficient bentgrass to close the cover rather quickly or bentgrass can be established promptly (9, p. 28).

The foliage of *Poa annua* and desirable turf grasses are about equal in their sensitivity to foliar applied herbicides. A chemical that will destroy the foliage of *Poa annua* will probably destroy or damage the foliage of desirable turf species. Since the desirable turf grasses are generally perennial in nature, a possible weak point in the development of the *Poa annua* plant could be the seed germination stage.

Factors Affecting Persistence of Soil Herbicides

Klingman (22, p. 64-65) states that success of a pre-emergence herbicide treatment depends largely on the presence of a high concentration of the herbicide in the upper one-half inch of soil; this is where most of the annual weeds germinate. Some factors affecting the persistence of soil herbicides are microorganism decomposition, chemical decomposition, adsorption on soil colloids, leaching, volatility, and photo-decomposition (22, p. 65) (25, p. 269).

Upchurch (36, p. 169-170) found a tenfold variation of toxicity among some soils when 3(3,4-dichlorophenyl)1, 1-dimethylurea (diuron) was used. Soil organic matter and cation exchange capacity were highly correlated with herbicide activity of the diuron. A soil containing 0.8 percent organic matter required approximately 0.75 ppm of diuron to produce 50 percent reduction in dry shoot weight of cotton. For each one percent increase in organic matter, approximately 2.0 ppm additional diuron was required to produce the same reduction in dry shoot weight. Upchurch and Mason (37, p. 14) found equal residual toxicity in various soils required approximately five times more herbicide for a soil with a 20 percent organic matter content than a soil with a four percent organic matter content regardless of the herbicide involved. Upchurch

(36, p. 120) suggested that adsorption of diuron to some soil fraction is responsible for detoxification. The adsorptive capacity of a soil would be limiting, therefore diuron in excess of the soils adsorptive capacity would be in the soil solution and available for absorption by susceptible plants. After the adsorptive capacity of the soil is saturated, toxicity should increase very quickly.

Soil colloids are organic and inorganic particles, which are 0.001-0.1 microns in diameter. A cubic centimeter of colloid clay having the size of 0.1 microns has a surface area of 600,000 square centimeters. Different types of clays have different adsorptive capacities. Montmorillonite clay capacity is three to five times that of kaolinite clay. Organic colloids have about four times the capacity of montmorillonite and twenty times the capacity of kaolinite. The minimum rate of application is positively correlated with soil adsorptive capacity. In practice, the range of herbicidal rates of application are much less than might be predicted from the very wide range in adsorptive capacity of the soils (22, p. 70-72).

Ogle (24, p. 27) believed organic matter was partly responsible for an increased breakdown of chemicals as soils varied from sandy to silt loam to muck. Crafts and Rosenfels (6, p. 168) found arsenic toxicity high in Fresno sandy loam, intermediate in Columbia fine sandy loam, and low in Yolo clay loam and Stockton adobe clay. Arsenic toxicity was correlated with texture; toxicity was high in sandy soils and low in clay soils.

Crafts and Drever (7, p. 17) found initial toxicity of herbicides in order of decreasing toxicity to be 3-phenyl-1,1-dimethylurea (fenuron), 3-(p-chlorophenyl)1,1-dimethylurea (monuron), isopropyl N-(3-chlorophenyl) carbamate (CIPC), 2,2-dichloropropionic acid (dalapon), trichloroacetic acid (TCA), and 2,3,6-trichlorobenzoic acid (TBA). Inactivation order from the most rapid to slowest was TCA, dalapon, CIPC, TBA, fenuron, and monuron. No correlation was found between soil type and rate of chemical inactivation.

Movement by leaching may determine effectiveness of a herbicide and may explain selectivity or account for removal of the herbicide from the soil. The extent of leaching is determined: (1) by solubility of the herbicide in water, (2) by the amount of water passing downward through the soil, and (3) the adsorptive relationships between the herbicide and the soil (2, p. 73-74). Rauser and Sevitzer (30, p. 64) considered leaching had two steps: (1) the herbicide going into solution and (2) the adsorption of the herbicide on the soil from the percolating solution. They suggested that downward movement of herbicide in the soil depended upon the application rate of water not upon the total amount of water applied. This downward movement could be explained by a mass action effect, where the percolating soil solution swept the herbicide along allowing adsorption on the colloidal soil particles. Splittstosser and Dersheid (33, p. 306) using 2-chloro-4,6-bis(ethylamino)-s-triazine (simazine), 2-chloro-4-ethylamino-6-isopropylamino-s-triazine (atrazine), and 2-chloro-N,N-diallylacetamide (CDAA), concluded that water leached chemicals into dry soil, but movement was along a concentration gradient in wet soil.

Algae, fungi, actinomycetes, and bacteria are capable of detoxifying herbicides. Some herbicides are more resistant to detoxification than others. The rate of microorganism detoxification of herbicides is related to halogenation of the benzene ring in chlorinated phenoxyacetic acids, carbamates, and phenylureas (22, p. 69)

(31, p. 172).

Factors influencing growth and rate of multiplication of microorganisms are: (1) temperature, (2) water, (3) oxygen, (4) minerals, (5) nutrient supply, and (6) soil pH.

When factors are favorable for growth, there may be an increase of microorganisms that can detoxify herbicides or no increase in number as with the phenylureas and substituted triazines (31, p. 171).

All compounds are volatile to some degree. Formulations of herbicides are different for example, the isopropyl ester of 2,4-D is more volatile than the sodium salt. The volatilization of carbamates has been related to their effectiveness as pre-emergence herbicides. Isopropyl N-phenylcarbamate (IPC) volatilizes more rapidly than CIPC particularly at temperatures of 60° F - 85° F (30, p. 173).

Co-distillation (steam distillation) of ethyl N,N-di-n-propylthiocarbamate (EPTC) and 2,4-D has been reported (22, p. 75).

Photo-decomposition may contribute to the loss of diuron toxicity if it is placed on the surface of the soil without rain or irrigation to move the chemical into the soil may contribute to loss of the herbicide's toxicity. Other factors complicating the amount of toxicity lost by this means are high soil surface temperature, biological and chemical deactivation, and adsorption (18, p. 101).

Goetze (14, p. 36) reported medium soluble arsenic applied to a 1½ inch mat of material caused the most bentgrass damage. The arsenic materials, which remained in the mat zone for the longest period, were the most damaging.

Preliminary studies (39) under greenhouse conditions have shown the presence of straw cover at the time of spraying endothal and IPC for cheatgrass control will almost completely remove the effect of the herbicides.

MATERIAL AND METHODS

Greenhouse

Greenhouse studies were conducted using *Poa annua* as a bioassay plant to determine the influence of cover and soil mixture on the residual activity of herbicides.

An attempt was made to maintain the greenhouse temperature at 75° F day and night; however, daytime temperatures inside the greenhouse increased briefly to 80°-85° F when the temperature outside the greenhouse increased above the cooling capacity of the air conditioning system.

Soils were compounded to represent various soil mixtures of sand, clay, sand-organic matter, and clay-organic matter. The sand mixture included three parts by volume of sandy loam soil used as regular greenhouse soil and five parts by volume of washed cement sand. The soil designated as clay in this study is the upper sub-soil layer of Amity silt loam described by Kocher (23, p. 1670) as a soil composed of mottled brown, light-brown, or grayish brown silt loam or silty clay loam of a moderately compact nature. The organic matter in these mixtures was composed of dead leaves and stolons stripped from an

Agrostis tenuis Sibth. var. Highland (Highland bentgrass) lawn. The soil mixtures were made using a ratio of 1:1 of organic matter to sand or clay. A cement mixer was used to mix the soil mixtures. Soils were mixed for 15 minutes or until proportions were evenly distributed.

Individual plots in the greenhouse consisted of no. 10 cans. The cans were washed and four triangular shaped holes were punched on the sides of the cans adjacent to the bottom. The cans were filled and irrigation started ten days prior to planting the seeds. The early irrigation allowed time for equal distribution of moisture throughout the soil mixture.

Equal volumes of *Poa annua* seeds were planted in the individual plots. The volume was a leveled ¼ teaspoon measure which contained approximately 350 seeds.

The first planting was done before covering the seeds or spraying. The sand and organic matter coverings were the same as used in the soil mixtures. The depth of cover was sufficient to prevent movement of the seeds when plots were irrigated. Individual plots were irrigated with 1/8 inch of water after covers were applied. Herbicides were applied after the first irrigation of the first planting of *Poa annua* by using an automatic sprayer delivering 40 gallons of herbicide-water solution per acre. The aliquot of herbicide water solution was sprayed on the individual plot by a single nozzle delivering a flat pattern. The amount of granular formulation was weighed per individual plot area and hand distributed. The properties, manufacturer, and designation of the herbicides used in this study are listed in Table 1.

Approximately 1/8 inch of water was applied per irrigation. During the germination period, irrigation was applied once or twice daily, depending upon weather conditions. The plots were maintained at a high moisture content throughout the study. The total amount of water applied after treatments were made and final counts taken over a period of ten weeks was approximately ten inches.

Two additional plantings were made at four and eight weeks after the original spraying.

Stand counts of healthy plants were made two weeks after planting.

A split-plot design was used in the greenhouse study and two replications were used.

Treatment by cover means were plotted to observe

Table 1 Properties and Manufacturers of the Chemicals Used in This Study

Chemical	Physical State	Solubility Water	Term Chemical Company
3,6- endoxohexa-hydrophthalic acid	Solid	21%	Endothal 1/ Pennsalt Chemical Co.
Experimental Analog of endothal	Solid	---	TD282 3/ Pennsalt Chemical Co.
N,N-dimethyl-2,2-diphenyl-acetamide	Solid	260 ppm	Diphenamid 2/ Eli Lilly Co.
2,6-dinitro-N-N-di-n-propyl-α,α,α-trifluro-p-toluidine	Solid	24 ppm	Trifluralin 2/ Eli Lilly Co.
Dimethyl-2,3,5,6-tetrachloro-terephthalic acid	Solid	5 ppm	Dacthal 1/ Diamond Alkali Co.
Sec-Butyl-N-3-Chlorophenyl Carbamate	Liquid	---	BP9 3/ Pittsburg Plate-Glass Co.
N(β-0,0diisopropyldithio-phosphorylethyl)benzene sulfonamide	-----	---	Betasan 1/ Stauffer Chemical Co.
0-(2,4,-dichlorophenyl)0-methyl isopropyl phosphoamido-thioate	Solid	5 ppm	Zytron 1/ Dow Chemical Co.
------------------	-----	---	Niagara 6370 3/ Niagara Chemical Co.

1/ Trade Mark 2/ Common name accepted by Weed Society of America 3/ Experimental Herbicide.

data distribution normality. Transformations of data occurring as a Poisson distribution were made using $\sqrt{x + 1}$; where x equals an individual observation. The transformation was made so that the data would be a better approximation for use in statistical calculations (24, p. 338).

Analyses of variance were performed using the transformed data of the fourth week planting and original data of the eighth week planting. Mean separations of significantly different F values at the 5% level were by Duncan's Multiple Range Test.

Field

Investigation of residual activity of herbicides in a clay soil under natural turf conditions was carried out. A completely randomized design was used including three replications. September, 1962 applications, applied preemergence to Poa annua on the lower campus of Oregon State University, consisted of trifluralin at ½, 1, and 2 lb/A, Niagara 6370 at 16 and 32 lb/A, and Betasan at 4, 6, and 8 lb/A. March, 1963 applications applied postemergence to Poa annua were endothal at ½, 1, and 2 lb/A and TD282 at ½, 1, and 2 lb/A.

To study residual activity in a sandy soil under natural turf conditions, herbicide applications were made at the North Rockwood Grade School, Portland, Oregon. Three replications were used. Trifluralin at ½, 1, and 2 lb/A, Niagara 6370 at 8 and 16 lb/A, Betasan at 4, 6, and 8 lb/A, and Dacthal at 2, 4, and 6 lb/A were applied in October, 1962. Endothal and TD282 were applied in March, 1963. The same rates were used as those that were applied on the lower campus site.

The residual activity of the herbicides which were applied to the turf areas was measured by the quadrate frequency method (21). Determinations for a suitable sub-quadrant size were made (Appendix, Table 1). The three inch square sub-quadrant resulted in approximately 50 percent of the sub-quadrants occupied by *Poa annua* in the infestation that had no herbicide application. Seventy-two sub-quadrants were used.

Analysis of variance and mean separation by Duncan's Multiple Range Test were used for field data analysis.

The herbicides that showed good residual toxicity in the greenhouse were applied to an established golf turf in June, 1963 at the Agate Beach Golf Course, Agate Beach, Oregon. The chemicals were applied to determine possible damage to desirable turf species. Betasan at 15 and 20 lb/A, BP9 at 3 and 6 lb/A, trifluralin at 1 and 2 lb/A, Zytron at 15 lb/A, and diphenamid at 4 and 8 lb/A were applied on a fairway turf. Betasan at 15 lb/A was applied on a putting green. Two weeks after the herbicides were applied to the Agate Beach turf damage was noted.

Application rates were increased to further investigate this damage; trifluralin at 2 and 4 lb/A, Betasan at 16 and 32 lb/A, and diphenamid at 8 and 16 lb/A were applied the last week in June, 1963 to established turf on the lower campus of Oregon State University.

Visual estimates of damage to desirable turfgrass were made on both the Agate Beach Golf Course and lower campus trials.

RESULTS

Greenhouse

No statistical analysis was performed using the initial planting data. A Poisson distribution occurred with both the original and $\sqrt{x + 1}$ transformed data of the initial planting (Appendix, Figures 1 and 2). A logarithmic transformation was also used on the initial planting date but the data remained as a Poisson distribution. Graphing the fourth week treatment means (Appendix, Figure 3) revealed a Poisson distribution and a $\sqrt{x + 1}$ transformation of the fourth week planting data was performed (Appendix, Figure 4). The eight week treatment by cover means were graphed (Appendix, Figure 5). Since there was a normal distribution, no transformation of the eighth week treatment by cover data was carried out.

Analysis of variance for the fourth and eighth weeks after spraying (Table 2) showed significant differences among treatments, treatment by cover interaction, and treatment by mixture interactions. Treatment by cover by mixture interactions were significantly different at eight weeks after spraying but not at four weeks after

Table 2 Significant Values in the Analysis of Variance of Greenhouse Data Four and Eight Weeks After Spraying

Source of Variation	Observed F		Required F
	Four Weeks	Eight Weeks	
Treatments	179.95*	65.29*	1.66
T x C 1/	26.62*	4.28*	1.66
T x M 2/	2.23*	2.40*	1.43
T x M x C 3/	------	4.37*	1.43

Complete analysis of variance data can be found in Appendix, Tables 2 and 3.

* Significant at the 5% level.

1/ Treatment by cover 2/ Treatment by mixture
3/ Treatment by mixture by cover.

spraying.

Trifluralin, Zytron, and diphenamid exhibited no differences in activity between rates at four weeks after spraying (Table 3). Niagara 6370, TD282, endothal, Zytron, and diphenamid exhibited no differences in activity between rates eight weeks after spraying (Appendix, Tables 6 and 7). The emulsifiable formulation of Betasan showed better residual activity than the granular formulation throughout the duration of the study. The best residual activity at eight weeks after spraying was obtained from all three rates of diphenamid and trifluralin at rates of 1 and 2 lb/A (Table 3).

The best residual activity on sand cover eight weeks after spraying was shown by Zytron, Betasan (emulsifiable concentrate), trifluralin, and diphenamid (Table 4). Diphenamid was also superior under organic matter cover but not significantly different from sand cover. Endothal, TD282, and BP9 had better residual activity when applied to an organic cover than to a sand cover. Niagara 6370 and Dacthal had better residual activity when applied to a sand cover than to an organic matter cover (Appendix, Tables 6 and 7).

Table 3 Greenhouse Treatments Having the Best Residual Activity*

Four Weeks After Spraying		Eight Weeks After Spraying	
Chemical	lb/A	Chemical	lb/A
Trifluralin	1/2	Diphenamid	4
Trifluralin	1	Diphenamid	6
Trifluralin	2	Trifluralin	1
BP9	6	Diphenamid	8
Zytron	5	Trifluralin	2
Zytron	10		
Zytron	15		
Diphenamid	4		
Diphenamid	6		
Diphenamid	8		

* No significant difference among treatments as tested by Duncan's Multiple Range Test at 5% level. Means are listed in Appendix, Tables 4 and 5.

Table 4 Greenhouse Treatment by Cover Interaction Having the Best Residual Activity*

Four Weeks After Spraying			Eight Weeks After Spraying		
Cover 1/	Chemical	lb/A	Cover 1/	Chemical	lb/A
OM	TD282	½	S	Trifluralin	½
OM	Dacthal	2	OM	Diphenamid	4
S	Dacthal	6	S	Zytron	5
S	Trifluralin	½	OM	Diphenamid	6
S	Betasan	16	OM	Diphenamid	8
OM	Dacthal	4	OM	Trifluralin	1
S	Trifluralin	1	S	Trifluralin	1
OM	Dacthal	6	S	Zytron	10
S	Dacthal	4	S	Zytron	15
OM	BP9	3	S	Betasan	4
OM	TD282	1	S	Trifluralin	2
S	Betasan	4	OM	Trifluralin	2
S	Trifluralin	2	S	Betasan	16
OM	Trifluralin	½	S	Diphenamid	4
S	BP9	6	S	Diphenamid	6
OM	BP9	6	S	Diphenamid	8
OM	Trifluralin	1			
OM	Trifluralin	2			
S	Zytron	5			
S	Zytron	10			
S	Zytron	15			
OM	Zytron	5			
OM	Zytron	10			
OM	Zytron	15			
S	Diphenamid	4			
S	Diphenamid	6			
S	Diphenamid	8			
OM	Diphenamid	4			
OM	Diphenamid	6			
OM	Diphenamid	8			

* No significant difference among treatment and cover interaction as tested by Duncan's Multiple Range Test at 5% level. Means are listed in Appendix, Tables 6 and 7.

1/ S-sand; OM-organic matter.

Soils had little effect on the residual activity of diphenamid (Table 5). Diphenamid showed no significant difference among soil mixtures at neither four weeks nor eight weeks counting periods. BP9, endothal, and Betasan (granular) at four weeks and eight weeks and Dacthal at eight weeks had their best respective residual activities on clay and clay-organic matter mixtures (Appendix, Table 9). Niagara 6370 at the four and eight week periods and trifluralin, Zytron, and TD282 at the eight week period had their best respective residual activities on the sand mixtures. Betasan (emulsifiable concentrate) had its best residual activity on the clay at the four week period but no significant differences between soil mixtures were observed at the eight week period (Appendix, Tables 8 and 9).

Field

Analysis of variance of lower campus data showed treatment means to be significantly different for all three months (Table 6).

The lower campus turf application of pre-emergence chemicals were made in the fall and late winter. Higher

Table 5 Greenhouse Treatment by Soil Mixture Interaction Having the Best Residual Activity*

Four Weeks After Spraying			Eight Weeks After Spraying		
Mixture 1/	Chemical	lb/A	Mixture 1/	Chemical	lb/A
S	Dacthal	2	C-OM	Zytron	10
S-OM	Betasan	4	C	Zytron	10
S	Dacthal	4	S-OM	Betasan	4
C	Trifluralin	½	S-OM	Zytron	5
C	Dacthal	2	C-OM	BP9	6
C	Dacthal	6	S-OM	Diphenamid	4
C-OM	Dacthal	6	C	BP9	6
S-OM	Dacthal	2	S-OM	Zytron	15
S	Dacthal	6	C-OM	Dacthal	4
C-OM	Trifluralin	1	C-OM	Zytron	15
S-OM	Betasan	16	S	Betasan	16
C-OM	Betasan	4	S	Zytron	15
C	BP9	3	S	Diphenamid	6
C	Dacthal	4	S	Zytron	5
S	BP9	3	S	Zytron	10
S-OM	Dacthal	4	S-OM	Diphenamid	8
S-OM	Dacthal	6	C-OM	Trifluralin	1
C-OM	Dacthal	2	S-OM	Trifluralin	½
S	Trifluralin	1	S	Diphenamid	8
C-OM	Dacthal	4	S-OM	Diphenamid	6
C	Trifluralin	2	C	Trifluralin	1
C	Trifluralin	1	S-OM	Trifluralin	1
C-OM	Betasan	16	S	Trifluralin	½
C	Betasan	16	C-OM	Diphenamid	4
C-OM	Trifluralin	1	S	Trifluralin	1
C-OM	Trifluralin	½	C	Trifluralin	2
S-OM	Trifluralin	½	S	Diphenamid	4
S-OM	Trifluralin	2	C	Diphenamid	4
C-OM	Trifluralin	2	C	Diphenamid	8
S	Trifluralin	2	S-OM	Trifluralin	2
C	BP9	6	C-OM	Trifluralin	2
S	BP9	6	S	Trifluralin	2
C-OM	BP9	6	C	Diphenamid	6
S-OM	BP9	6	C-OM	Diphenamid	6

Continued on page 34

Table 5 continued from page 33

Four Weeks After Spraying			Eight Weeks After Spraying		
Mixture 1/	Chemical	lb/A	Mixture 1/	Chemical	lb/A
C-OM	BP9	3	C-OM	Diphenamid	8
C	Zytron	5			
S	Zytron	5			
C-OM	Zytron	5			
S-OM	Zytron	5			
C	Zytron	10			
S	Zytron	10			
C-OM	Zytron	10			
S-OM	Zytron	10			
C	Zytron	15			
S	Zytron	15			
C-OM	Zytron	15			
S-OM	Zytron	15			
C	Diphenamid	4			
S	Diphenamid	4			
C-OM	Diphenamid	4			
S-OM	Diphenamid	4			
C	Diphenamid	6			
S	Diphenamid	6			
C-OM	Diphenamid	6			
S-OM	Diphenamid	6			
C	Diphenamid	8			
S	Diphenamid	8			
C-OM	Diphenamid	8			
S-OM	Diphenamid	8			

* No significant difference among treatment by mixture interactions as tested by Duncan's Multiple Range Test at 5% level. Means are listed in Appendix, Tables 8 and 9.

1/ C-clay; S-sand; OM-organic matter

Table 6 Observed F Values of Treatments Applied to Lower Campus

Time of Reading	Observed F	Required F
April	2.2041*	2.0148
May	6.3869*	2.0148
July	64.4755*	2.0148

* Significant at 5% level.

rates of each chemical gave better kill of Poa annua. The post-emergence chemicals, endothal and TD282, gave control without re-invasion (Table 7). There were no significant differences between rates of each chemical until the July counting (Appendix, Tables 11, 12, and 13).

No active Poa annua was found either on the treated or the check plots when counts were to be made on the plots located at North Rockwood Grade School in Portland, Oregon.

Damage of desirable turf by diphenamid at 8 lb/A was noted by visual estimation on the turf plots at the Agate Beach Golf Course.

Damage of desirable turf by diphenamid at 8 and 16

Table 7 Treatments Applied to Lower Campus Which Had the Best Residual Activity*

April		May		July	
Chemical	lb/A	Chemical	lb/A	Chemical	lb/A
Betasan	8	TD282	½	TD282	2
Trifluralin	½	Betasan	16	Betasan	16
Trifluralin	1	TD282	1	TD282	½
Betasan	16	TD282	2	Endothal	½
Trifluralin	2	Endothal	2	Endothal	2
Endothal	2	Endothal	1		
Endothal	1	Endothal	½		
TD282	1				
Endothal	½				
TD282	½				
TD282	2				

* No significant difference among treatments as tested by Duncan's Multiple Range test at 5%. Means are listed in Appendix, Tables 11, 12, 13.

lb/A and trifluralin at 4 lb/A was noted by visual estimate on the turf plots on the lower campus of Oregon State University.

DISCUSSION

Greenhouse

Since there were some treatments in the fourth and eighth weeks after the original planting with counts of *Poa annua* which exceeded the checks, there may have been induced dormancy which was broken between the fourth and eighth weeks when Niagara 6370, endothal, TD282, and BP9 were used (Appendix, Tables 4 and 5). The higher rate of BP9 caused toxicity or a dormancy which was not broken in the duration of this study, since the stand count means of these treatments were significantly lower than the check.

The slow release and consequent low toxicity of Betasan at 8 lb/A from the granular carrier caused a difference between its toxicity and the toxicity of the emulsifiable concentrate at 4 lb/A which is in a readily available form.

Adsorption on soil particles would explain the decreased activity of Dacthal at 2 lb/A compared with 4 and 6 lb/A. The soil particles probably adsorbed the lower rate of chemical before toxic amounts of the chemical could accumulate in the soil solution.

Volatilization of trifluralin from the surface of soils has been noted (33). Herbicidal activity is reduced by 25 percent if soil incorporation does not take place within four to six hours after surface application. Incorporation must be done within fifteen to thirty minutes after application if 100 percent of the grasses are to be controlled. A reduction of toxic activity of trifluralin from volatilization was possible in this study since there was no soil incorporation. The 1 and 2 lb/A rates as compared to the ½ lb/A rate probably had sufficient herbicide to allow some leaching of the chemical into the soil where loss by volatilization was minimized.

Endothal has been used for post-emergence applications (9, p. 27-28). When applied pre-emergence under conditions in this experiment, endothal and its analog TD282 had more residual activity under organic matter cover than under sand cover. TD282 had slightly more toxic activity than endothal. Since the water solubility of endothal is 21 percent (Table 1), it would seem unlikely that the herbicide would remain in place any length of time with the heavy watering schedule used in this study. Decreased germination of _Poa annua_ under a thick organic cover was noted under mature turf conditions in California (16, p. 30-32). A thick cover of organic matter would have reduced all treatments in the study, not just endothal and TD282. Endothal and TD282 adsorption to the organic matter with a subsequent release to obtain the death of the seedlings is not known at this time.

Slife (32, p. 5) found that Niagara 6370 at 6 and 9 lb/A gave zero percent and ten percent control of _Digitaria_ spp. (crabgrass) respectively as compared to 100 percent crabgrass control by Zytron and trifluralin. Slife showed that high rates are necessary for even a minor amount of crabgrass control. Under the conditions of this experiment, Niagara 6370 was more influenced by cover and soil than either Zytron or trifluralin. Toxicity of Niagara 6370 is very low as indicated (Appendix, Table 4), but this apparent toxicity may have been an inhibition of germination, since the healthy plant counts were higher than check counts (Appendix, Table 5). Niagara 6370 was detoxified in some manner by the seedlings. The total area of the seedling blade was chlorotic when the blade emerged; but as growth continued, the chlorotic tissue was replaced by photosynthetic tissue. Replacement of chlorotic tissue by photosynthetic tissue was from the soil surface or in strips across the blade.

Since there was more residual activity under sand cover where Dacthal and Zytron were applied and since the water solubility of these chemicals is fairly low (Table 1), the influence of cover on these chemicals would seem to be one of decreased adsorption on sand cover and increased adsorption on organic cover rather than loss of toxicity by leaching. Betasan (emulsifiable concentrate) also seems to be detoxified by adsorption to organic cover, as in the case of Dacthal and Zytron. The detoxification rate of Betasan (emulsifiable concentrate) under conditions of this experiment was faster than Dacthal and Zytron. Betasan had significantly different residual activity between covers at the fourth week, but Dacthal and Zytron did not. At the eighth week Dacthal, Zytron and Betasan (emulsifiable concentrate) had higher residual activity in sand cover.

In this experiment detoxification of Dacthal by adsorption to soil particles would explain the rates and treatment by cover interaction but not the differences of the treatment by mixture interactions. The higher residual activity of Dacthal found in clay-organic matter mixture is not related to adsorption on soil particles.

The higher residual activity of endothal and BP9 in clay-organic matter soil mixtures and organic matter covers and the inconsistent reaction of Dacthal in soil mixtures and cover should be investigated further.

Germination of weedy grasses was inhibited as long as three months following application of Zytron and Dacthal (38). Preliminary greenhouse studies (39) showed Dacthal and Zytron to be effective on <u>Digitaria</u> spp. one year after application. This did not agree with field plots which were completely reinfested one year after treatment. If the surface of the soil is disturbed, crab-grass seeds would be exposed to untreated soil and germination would take place. The low water solubility of Zytron would reduce leaching loss and the higher residual activity under sand cover would suggest detoxification of Zytron by adsorption to clay and organic matter particles.

Diphenamid was very stable under the conditions of this experiment. It shows no significant differences between and among rates, covers, and soil mixtures.

Chemical inhibition of *Poa annua* germination could be used if the inhibition were continued until environmental conditions were unsuitable for the growth of *Poa annua*. A detailed study of the conditions for germination would be needed for the best use of chemicals for a continued inhibition of germination.

Field

Endothal and TD282 severely damaged turf and recovery was very slow. All desirable turf was damaged leaving only the thatch and bare soil. Recovery by desirable turf took place only as the weather warmed in late spring.

Since the pre-emergence plots and checks (high mean) were on an area that had been used as a softball field, the thinning of the turf resulted in an opportunity for *Poa annua* infestation to increase. This could explain the differences between pre and post-emergence checks. The general increase and decrease of infestation in the field plots was probably a seasonal variation since the means are generally in the same proportions for the three readings. The greater proportional change of Betasan at 16 lb/A could be a toxic action of Betasan. Reduced root depth of _Poa annua_ caused by toxic activity of Betasan may have resulted in an earlier death of the plants as dry weather conditions dried the surface soil.

No comparison can be made between residual activity of herbicides in clay and in sand under natural turf conditions. The North Rockwood Grade School plots had an even stand of _Poa annua_ prior to application of herbicides. When counts were to be taken in the spring, no _Poa annua_ was found either in the treatment plots or in the check plots. No _Poa annua_ was found in the area surrounding the plots. Since the plots were exposed to the cold winds during the winter and the sand soil was shallow with poor drainage, the _Poa annua_ seedlings could have been killed by being lifted out of the ground by alternate freezing and thawing during the winter.

Heavy irrigation was causing ponding of water on the Agate Beach Golf Course. Damage by diphenamid was noted where water tended to pond although damage was not consistent. The center of the ponded areas showed more damage than the edges. This could have been caused by movement to the center resulting in a concentration of the chemical.

The reason for inconsistency by diphenamid on the lower campus of Oregon State University is not known. The 4 lb/A rate of trifluralin damaged the turf very consistently in all three replications. The damage was noticeable but not as severe as diphenamid damage which resulted in the loss of all green color. Trifluralin damage at this rate has been reported (3, p. 16).

The chemicals causing no visible damage at Agate Beach Golf Course were: Betasan at 15 and 20 lb/A, BP9 at 3 and 6 lb/A, trifluralin at 1 and 2 lb/A, Zytron at 15 lb/A, and diphenamid at 4 lb/A. The chemicals causing no visible damage on lower campus of Oregon State University were: trifluralin at 2 lb/A and Betasan at 16 and 32 lb/A. The chemicals at these rates appear to be nontoxic to established desirable turf grasses.

Greenhouse and preliminary field trials show that future studies concerning the control of _Poa annua_ should include diphenamid, trifluralin, and Betasan. Turf studies with these chemicals should include rates of chemical and time of application for _Poa annua_ control. A chemical with slower activity would be better where infestation is heavy as compared to a fast acting chemical when infestations are lighter. Severe turf damage would result if the *Poa annua* population were large and fast-acting chemicals were used. This bare soil would then be invaded by weedy species if the desirable turf did not have the vigor to cover the bare soil quickly. The studies should be carried out on established turf planted with a known amount of *Poa annua* to insure a less variable population. The known population would provide a more reliable measure for estimation of the residual activity of herbicides rather than a natural infestation.

SUMMARY

Greenhouse studies using *Poa annua* as a bioassay to determine the influence of cover and soil mixture on residual activity of herbicides demonstrated significant interaction between herbicides and cover and herbicides and soil mixture.

Eight weeks after treatment, diphenamid at 4, 6, and 8 lb/A and trifluralin at 1 and 2 lb/A had greater residual activity than other materials studied. Endothal, TD282, and BP9 exhibited better residual activity under organic cover while Dacthal, Zytron, and Betasan had better activity under sand cover. Trifluralin, Zytron, TD282, and Niagara 6370 had best residual activity in sand soil mixtures while endothal, Dacthal, and BP9 had highest activity in clay-organic soil mixtures.

Field studies on a clay soil mixture showed that herbicides had more residual activity as the application rate of chemicals increased. Damage to desirable turf was caused by post-emergence application of both endothal and TD282 at 1 and 2 lb/A. Damage was caused by post-emergence application of trifluralin at 4 lb/A and

diphenamid at 8 and 16 lb/A.

It is concluded that cover and soil mixture influenced the residual activity of the soil-active herbicides used in this study.

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APPENDIX

Table 1 Quadrate Frequency Using Varying Sizes of Sub-Quadrants 1/

2" Square		4" Square		6" Square		2 7/8" Square	
Number Sub-Quadrants Occupied by *Poa annua*	%	Number Sub-Quadrants Occupied by *Poa annua*	%	Number Sub-Quadrants Occupied by *Poa annua*	%	Number Sub-Quadrants Occupied by *Poa annua*	%
28	39	58	81	64	89	42	57
25	35	63	88	69	95	59	82
51	71	60	86	69	95	27	37
Ave 34	48	60	85	67	93	42	58

1/ Total sub-quadrants equaled 72

Table 2   Analysis of Variance of Transformed Greenhouse Data, Four Weeks After Spraying

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Observed F	Required F
Replications	0.03	1	0.03		161.45
Cover	136.03	1	136.03	62.11	161.45
Error	2.19	1	2.19		
Total	138.25	3			
Mixtures	61.76	3	20.58		4.76
M x C 1/	5.41	3	1.80		4.76
Error	159.74	6	26.62		
Total	226.91	15			
Treatments	14,533.26	23	631.88	179.95*	1.66
T x C 2/	2,155.00	23	93.70	26.62*	1.66
T x M 3/	541.50	69	7.85	2.23*	1.43
T x M x C 4/	232.34	69	3.37		1.43
Error	647.64	184	3.52		
Total	18,109.74	383			

* Significant at 5% level.

1/ Mixture by Cover. 2/ Treatment by Cover. 3/ Treatment by Mixture. 4/ Treatment by Mixture by Cover.

Table 3 Analysis of Variance of Non-Transformed Greenhouse Data, Eight Weeks After Spraying

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Observed F	Required F
Replications	79,666.56	1	79,666.56	5.42	161.45
Cover	119,172.26	1	119,172.26	8.11	161.45
Error	14,690.43	1	14,690.43		
Total	213,529.25	3			
Mixtures	96,146.82	3	32,048.94	2.29	4.76
M x C 1/	37,962.75	3	12,654.25		4.76
Error	83,909.69	6	13,984.94		
Total	431,548.51	15			
Treatments	3,642,248.62	23	158,358.63	65.29*	1.66
T x C 2/	238,706.62	23	10,378.54	4.28*	1.66
T x M 3/	401,212.62	69	5,814.67	2.40*	1.43
T x M x C 4/	731,096.62	69	10,595.60	4.37*	1.43
Error	446,252.57	184	2,425.28		
Total	6,104,594.81	383			

* Significant at 5% level.

1/ Mixture by Cover. 2/ Treatment by Cover. 3/ Treatment by mixture. 4/ Treatment by mixture by cover.

Table 4 Separation of Greenhouse Transformed Treatment Means, Four Weeks After Spraying 1/

Chemical	lb/A	Mean 1/	Statistical Significance 2/
Endothal	½	18.87	a
Check		18.56	a
Endothal	1	17.28	b
Niagara 6370	8	13.52	c
Betasan (gran)	8	13.08	c
TD282	½	9.83	d
TD282	1	9.61	d
Niagara 6370	16	8.64	e
Betasan	4	3.25	e
Dacthal	2	2.53	f
Betasan	16	2.53	f
BP9	3	2.17	fg
Dacthal	6	1.97	fgh
Dacthal	4	1.80	gh
Trifluralin	½	1.57	ghi
Trifluralin	1	1.43	hi
Trifluralin	2	1.07	i
BP9	6	1.00	i
Zytron	5	1.00	i
Zytron	10	1.00	i
Zytron	15	1.00	i
Diphenamid	4	1.00	i
Diphenamid	6	1.00	i
Diphenamid	8	1.00	i

Standard Error of Mean 0.22

1/ $\sqrt{x + 1}$ transformation used on individual plots. "x" denotes number of plants per plot.

2/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 5 Separation of Greenhouse Non-Transformed Treatment Means, Eight Weeks After Spraying

Chemical	lb/A	Mean 1/	Statistical Significance 2/
Niagara 6370	8	288.7	a
Niagara 6370	16	287.8	a
BP9	3	274.5	ab
TD282	½	256.3	abc
Endothal	½	252.0	abc
Check		248.7	bc
TD282	1	236.3	c
Endothal	1	234.4	c
Betasan (gran)	8	231.8	c
Dacthal	2	196.4	d
Dacthal	4	160.8	e
Dacthal	6	141.1	ef
Betasan	4	117.3	fg
BP9	6	115.4	gh
Betasan	16	102.4	gh
Zytron	5	98.1	gh
Zytron	10	90.7	h
Zytron	15	69.7	h
Trifluralin	½	64.7	h
Diphenamid	4	19.8	i
Diphenamid	6	15.6	i
Trifluralin	1	15.4	i
Diphenamid	8	11.2	i
Trifluralin	2	.9	i

Standard Error of Mean 12.31

1/ Number of plants per plot.

2/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 6 Separation of Greenhouse Transformed Treatment by Cover Interaction Means, Four Weeks After Spraying 1/

Cover 2/	Chemical	lb/A	Mean 1/	Statistical Significance 3/
S	Endothal	½	19.94	a
S	Endothal	1	18.56	b
S	TD282	1	17.90	b
OM	Endothal	½	17.81	b
S	TD282	½	17.24	b
OM	Endothal	1	15.99	c
OM	Betasan (gran)	8	15.89	c
OM	Niagara 6370	8	13.77	d
S	Niagara 6370	8	13.27	d
S	Betasan (gran)	8	10.28	e
OM	Niagara 6370	16	9.96	e
S	Check		9.93	e
OM	Check		8.63	f
S	Niagara 6370	16	7.32	g
OM	Betasan	4	5.26	h
OM	Betasan	16	3.09	i
S	BP9	3	2.78	ij
S	Dacthal	2	2.78	ij
OM	TD282	½	2.41	ijk
OM	Dacthal	2	2.28	ijk
S	Dacthal	6	2.11	ijk
S	Trifluralin	½	2.09	ijk
S	Betasan	16	1.97	ijk
OM	Dacthal	4	1.96	ijk
S	Trifluralin	1	1.86	ijk
OM	Dacthal	6	1.83	ijk
S	Dacthal	4	1.65	ijk
OM	BP9	3	1.57	jk
OM	TD282	1	1.32	jk
S	Betasan	4	1.22	k
S	Trifluralin	2	1.14	k
OM	Trifluralin	½	1.05	k
S	BP9	6	1.00	k
OM	BP9	6	1.00	k
OM	Trifluralin	1	1.00	k

Continued on page 59.

Table 6 continued from page 58

Cover 2/	Chemical	lb/A	Mean 1/	Statistical Significance 3/
OM	Trifluralin	2	1.00	k
S	Zytron	5	1.00	k
S	Zytron	10	1.00	k
S	Zytron	15	1.00	k
OM	Zytron	5	1.00	k
OM	Zytron	10	1.00	k
OM	Zytron	15	1.00	k
S	Diphenamid	2	1.00	k
S	Diphenamid	6	1.00	k
S	Diphenamid	8	1.00	k
OM	Diphenamid	2	1.00	k
OM	Diphenamid	6	1.00	k
OM	Diphenamid	8	1.00	k

Standard Error of Mean 0.44

1/ $\sqrt{x + 1}$ transformation used on the individual plot data. "x" denotes number of plants per plot.

2/ OM-organic matter; S-sand.

3/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 7 Separation of Greenhouse Non-Transformed Treatment by Cover Interaction Means, Eight Weeks After Spraying

Cover 1/	Chemical	lb/A	Mean 2/	Statistical Significance 3/
S	Niagara 6370	8	313.0	a
S	BP9	3	310.2	ab
OM	Niagara 6370	16	306.8	ab
S	Endothal	½	287.7	abc
S	TD282	½	287.5	abc
S	Check		282.1	abcd
S	TD282	1	269.7	abcd
S	Niagara 6370	16	268.6	abcd
OM	Niagara 6370	8	264.3	abcde
S	Betasan (gran)	8	256.3	abcdef
S	Endothal	1	254.0	bcdef
OM	BP9	3	238.7	cdef
OM	Dacthal	2	234.0	cdef
OM	Betasan	4	231.6	cdef
OM	TD282	½	224.8	cdefg
OM	Endothal	½	216.2	defgh
OM	Dacthal	6	216.1	defgh
OM	Check		215.2	defgh
OM	Endothal	1	214.7	defgh
OM	Betasan (gran)	8	207.2	efgh
OM	Dacthal	4	205.0	efgh
OM	Betasan	16	204.7	efgh
OM	TD282	1	202.7	efgh
OM	Zytron	10	171.8	fghi
OM	Zytron	5	163.7	hij
S	Dacthal	2	158.8	hijk
OM	Zytron	15	136.2	ijk
S	BP9	6	122.1	ijkl
S	Dacthal	4	116.6	ijklm
OM	BP9	6	108.6	jklm
OM	Trifluralin	½	78.7	lmn
S	Dacthal	6	66.1	mno
S	Trifluralin	½	50.7	nop
OM	Diphenamid	4	39.5	nop

Continued on page 61.

Table 7 continued from page 60.

Cover 1/	Chemical	lb/A	Mean 2/	Statistical Significance 3/
S	Zytron	5	32.5	nop
OM	Diphenamid	6	31.2	nop
OM	Diphenamid	8	22.3	nop
OM	Trifluralin	1	17.3	op
S	Trifluralin	1	13.3	op
S	Zytron	10	9.5	op
S	Zytron	15	3.1	p
S	Betasan	4	2.8	p
S	Trifluralin	2	1.6	p
OM	Trifluralin	2	.3	p
S	Betasan	16	.0	p
S	Diphenamid	4	.0	p
S	Diphenamid	6	.0	p
S	Diphenamid	8	.0	p

Standard Error of Mean 17.41

1/ OM-organic matter; S-sand.

2/ Number of plants per plot.

3/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 8 Separation of Greenhouse Transformed Treatment by Soil Mixture Interaction Means, Four Weeks After Spraying 1/

Soil Mixture 2/	Chemical	lb/A	Mean 1/	Statistical Significance 3/
C	Endothal	½	19.98	a
S	Check		19.26	a
C	Check		18.85	a
S	Endothal	½	18.84	a
C	Endothal	1	18.82	a
S-OM	Endothal	½	18.44	ab
C-OM	Endothal	½	18.23	abc
S-OM	Check		18.13	abc
S	Betasan (gran)	8	18.09	abc
C-OM	Check		18.01	abc
S	Endothal	1	17.35	abcd
S-OM	Endothal	1	17.05	abcd
C-OM	Endothal	1	15.89	bcd
C-OM	Niagara 6370	8	15.51	cde
C	Niagara 6370	8	15.10	de
C	Betasan (gran)	8	14.25	def
S-OM	Niagara 6370	8	13.13	efg
C	Niagara 6370	16	12.00	fgh
C	TD282	½	10.57	ghi
S	Niagara 6370	8	10.35	hi
S-OM	TD282	1	10.33	hi
S-OM	Betasan (gran)	8	10.33	hi
S	TD282	½	10.04	hi
C-OM	Betasan (gran)	8	9.66	hij
S-OM	TD282	½	9.57	hij
C	TD282	1	9.49	hij
S	Niagara 6370	16	9.26	hij
C-OM	TD282	½	9.13	hij
S	TD282	1	9.11	hij
C-OM	TD282	1	8.96	ij
S-OM	Niagara 6370	16	6.93	jk
C-OM	Niagara 6370	16	6.39	kl
S	Betasan	16	5.83	kl
S	Betasan	4	5.22	klm

Continued on page 63.

Table 8 continued from page 62.

Soil Mix-ture 2/	Chemical	lb/A	Mean 1/	Statistical Significance 3/
S	Trifluralin	½	4.49	klm
S-OM	BP9	3	4.37	klmno
C	Betasan	4	4.32	klmnop
S	Dacthal	2	4.00	lmnopq
S-OM	Betasan	4	3.70	lmnopq
S	Dacthal	4	2.75	mnopq
C	Trifluralin	½	2.69	mnopq
C	Dacthal	2	2.62	mnopq
C	Dacthal	6	2.24	nopq
C-OM	Dacthal	6	2.13	nopq
S-OM	Dacthal	2	2.09	nopq
S	Dacthal	6	2.05	nopq
C-OM	Trifluralin	1	1.97	nopq
S-OM	Betasan	16	1.90	nopq
C-OM	Betasan	4	1.75	nopq
C	BP9	3	1.72	nopq
C	Dacthal	4	1.72	nopq
S	BP9	3	1.60	nopq
S-OM	Dacthal	4	1.46	nopq
S-OM	Dacthal	6	1.46	nopq
C-OM	Dacthal	2	1.43	opq
S	Trifluralin	1	1.36	opq
C-OM	Dacthal	4	1.29	pq
C	Trifluralin	2	1.29	pq
C	Trifluralin	1	1.21	q
C-OM	Betasan	16	1.21	q
C	Betasan	16	1.18	q
C-OM	Trifluralin	1	1.18	q
C-OM	Trifluralin	½	1.10	q
S-OM	Trifluralin	½	1.00	q
S-OM	Trifluralin	2	1.00	q
C-OM	Trifluralin	2	1.00	q
S	Trifluralin	2	1.00	q
C	BP9	6	1.00	q
S	BP9	6	1.00	q
C-OM	BP9	6	1.00	q

Continued on page 64.

Table 8 continued from page 63.

Soil Mixture 2/	Chemical	lb/A	Mean 1/	Statistical Significance 3/
S-OM	BP9	6	1.00	q
C-OM	BP9	3	1.00	q
C	Zytron	5	1.00	q
S	Zytron	5	1.00	q
C-OM	Zytron	5	1.00	q
S-OM	Zytron	5	1.00	q
C	Zytron	10	1.00	q
S	Zytron	10	1.00	q
C-OM	Zytron	10	1.00	q
S-OM	Zytron	10	1.00	q
C	Zytron	15	1.00	q
S	Zytron	15	1.00	q
C-OM	Zytron	15	1.00	q
S-OM	Zytron	15	1.00	q
C	Diphenamid	4	1.00	q
S	Diphenamid	4	1.00	q
C-OM	Diphenamid	4	1.00	q
S-OM	Diphenamid	4	1.00	q
C	Diphenamid	6	1.00	q
S	Diphenamid	6	1.00	q
C-OM	Diphenamid	6	1.00	q
S-OM	Diphenamid	6	1.00	q
C	Diphenamid	8	1.00	q
S	Diphenamid	8	1.00	q
C-OM	Diphenamid	8	1.00	q
S-OM	Diphenamid	8	1.00	q

Standard Error of Mean 0.88

1/ $\sqrt{x + 1}$ transformation used on individual plot data. "x" denotes number of plants per plot.

2/ C-clay; S-sand; OM-organic matter.

3/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 9 Separation of Greenhouse Non-Transformed Treatment by Soil Mixture Interaction Means Eight Weeks After Spraying

Soil Mixture 1/	Chemical	lb/A	Mean 2/	Statistical Significance 3/
C	Niagara 6370	16	344.5	a
C	Niagara 6370	8	326.5	ab
C	BP9	3	321.5	ab
C	Betasan (gran)	8	312.2	abc
C	TD282	½	305.5	abcd
S-OM	BP9	3	305.0	abcd
S	Niagara 6370	8	298.8	abcde
C-OM	Niagara 6370	16	297.0	abcde
S-OM	Endothal	1	291.5	abcde
S-OM	Niagara 6370	16	289.0	abcde
S	Betasan (gran)	8	280.5	abcdef
S-OM	Niagara 6370	8	280.3	abcdef
C	Endothal	½	278.0	abcdef
C	TD282	1	277.8	abcdef
S	BP9	3	272.8	abcdefg
S-OM	Endothal	½	271.8	abcdefg
S	Endothal	½	266.3	abcdefgh
S	TD282	½	263.3	abcdefgh
S	Check		263.0	abcdefgh
C	Check		261.0	abcdefgh
S	Endothal	1	260.8	abcdefgh
C	Endothal	1	254.5	bcdefghi
C-OM	TD282	1	252.3	bcdefghij
C-OM	Niagara 6370	8	249.3	bcdefghijk
S-OM	Check		246.0	bcdefghijk
S-OM	Dacthal	2	232.3	cdefghijkl
C-OM	TD282	½	230.3	cdefghijkl
S	Dacthal	6	230.0	cdefghijkl
S-OM	TD282	½	226.3	cdefghijkl
C-OM	Check		224.8	defghijklm
S-OM	TD282	1	223.3	defghijklmn
S	Niagara 6370	16	220.5	defghijklmn
C	Dacthal	4	217.3	efghijklmn
S-OM	Dacthal	4	214.5	efghijklmno

Continued on page 66.

Table 9 continued from page 65.

Soil Mixture 1/	Chemical	lb/A	Mean 2/	Statistical Significance 3/
C	Dacthal	2	214.3	efghijklmno
C-OM	BP9	3	198.7	fghijklmnop
C-OM	Endothal	½	192.0	ghijklmnopq
S	TD282	1	191.8	ghijklmnopq
C-OM	Dacthal	2	183.0	hijklmnopqr
S	BP9	6	181.8	hijklmnopqr
C-OM	Endothal	1	175.7	ijklmnopqrs
C-OM	Betasan (gran)	8	167.5	jklmnopqrst
S-OM	Betasan (gran)	8	167.0	jklmnopqrst
S-OM	Dacthal	6	165.0	klmnopqrstu
C	Zytron	5	158.3	lmnopqrstu
S	Dacthal	2	156.3	lmnopqrstu
S	Dacthal	4	154.3	lmnopqrstu
S-OM	BP9	6	153.5	lmnopqrstu
S-OM	Zytron	10	150.0	lmnopqrstu
C	Dacthal	6	140.8	mnopqrstuv
S	Betasan	4	135.8	nopqrstuvw
S-OM	Betasan	16	130.8	opqrstuvwx
C	Betasan	16	130.0	opqrstuvwx
C-OM	Dacthal	6	128.7	pqrstuvwx
C-OM	Betasan	4	126.3	pqrstuvwxy
C	Betasan	4	125.5	pqrstuvwxy
C	Trifluralin	½	120.0	pqrstuvwxyz
C-OM	Zytron	5	113.3	pqrstuvwxyzA
C	Zytron	15	112.0	qrstuvwxyzA
C-OM	Trifluralin	½	102.8	rstuvwxyzAB
C-OM	Betasan	16	95.5	stuvwxyzABC
C-OM	Zytron	10	91.0	stuvwxyzABCD
C	Zytron	10	85.3	tuvwxyzABCD
S-OM	Betasan	4	81.5	uvwxyzABCD
S-OM	Zytron	5	80.0	uvwxyzABCD
C-OM	BP9	6	64.5	vwxyzABCD
S-OM	Diphenamid	4	64.5	vwxyzABCD
C	BP9	6	61.8	vwxyzABCD
S-OM	Zytron	15	58.3	vwxyzABCD
C-OM	Dacthal	4	57.3	vwxyzABCD

Continued on page 67.

Table 9 continued from page 66.

Soil Mixture 1/	Chemical	lb/A	Mean 2/	Statistical Significance 3/
C-OM	Zytron	15	57.0	vwxyzABCD
S	Betasan	16	53.3	wxyzABCD
S	Zytron	15	51.5	wxyzABCD
S	Diphenamid	6	48.0	xyzABCD
S	Zytron	5	41.0	yzABCD
S	Zytron	10	36.5	zABCD
S-OM	Diphenamid	8	29.8	ABCD
C-OM	Trifluralin	1	28.5	ABCD
S-OM	Trifluralin	½	25.5	BCD
S	Diphenamid	8	16.5	BCD
S-OM	Diphenamid	6	14.5	BCD
C	Trifluralin	1	14.5	BCD
S-OM	Trifluralin	1	14.3	BCD
S	Trifluralin	½	10.8	BCD
C-OM	Diphenamid	4	10.8	BCD
S	Trifluralin	1	4.3	D
C	Trifluralin	2	3.5	D
S	Diphenamid	4	3.3	D
C	Diphenamid	4	0.5	D
C	Diphenamid	8	0.5	D
S-OM	Trifluralin	2	0.3	D
C-OM	Trifluralin	2	0.0	D
S	Trifluralin	2	0.0	D
C	Diphenamid	6	0.0	D
C-OM	Diphenamid	6	0.0	D
C-OM	Diphenamid	8	0.0	D

Standard Error of Mean 24.62

1/ C-clay; S-sand; OM-organic matter.

2/ Number of plants per plot.

3/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 10 Analysis of Variance Lower Campus Field Data, April Reading

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Observed F	Required F
Treatment	157.29	15	10.49	2.2041*	2.0148
Error	152.23	32	4.76		
Total	309.52	47			

Analysis of Variance Lower Campus Field Data, May Reading

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Observed F	Required F
Treatment	112.95	15	7.53	6.3869*	2.0148
Error	37.73	32	1.18		
Total	150.68	48			

Analysis of Variance Lower Campus Field Data, July Reading

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Observed F	Required F
Treatment	138.69	15	9.25	64.4755*	2.0148
Error	4.59	32	.14		
Total	143.28	47			

* Significant at 5% level.

Table 11 Separation of Lower Campus Transformed Treatment Means, April Reading 1/

Chemical	lb/A	Mean 1/	Statistical Significance 2/
Niagara 6370	16	7.05	a
Check-pre-emergence		6.79	a
Niagara 6370	32	5.20	ab
Betasan	4	4.91	abc
Betasan	8	4.64	abcd
Trifluralin	½	4.04	abcd
Trifluralin	1	4.03	abcd
Betasan	16	3.79	abcd
Trifluralin	2	3.44	bcd
Check-post-emergence		2.74	bcd
Endothal	2	2.63	bcd
Endothal	1	1.90	cd
TD282	1	1.62	cd
Endothal	½	1.55	d
TD282	½	1.33	d
TD282	2	1.00	d

Standard Error of Mean 0.63

1/ $\sqrt{x + 1}$ transformation used on individual count data. "x" denotes number of sub-quadrants occupied per quadrant.

2/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 12 Separation of Lower Campus Transformed Treatment Means, May Reading 1/

Chemical	lb/A	Mean 1/	Statistical Significance 2/
Niagara 6370	16	8.14	a
Check-pre-emergence		7.23	a
Niagara 6370	32	7.01	a
Betasan	8	6.52	abc
Betasan	4	6.33	abc
Trifluralin	2	6.15	abc
Trifluralin	1	5.96	bc
Trifluralin	½	5.70	bcd
TD282	½	4.70	cde
Betasan	16	4.66	cde
TD282	1	3.80	de
TD282	2	3.70	de
Endothal	2	3.62	e
Endothal	1	3.60	e
Check-post-emergence		3.52	e
Endothal	½	3.15	e

Standard Error of Mean 1.26

1/ $\sqrt{x+1}$ transformation used on individual count data. "x" denotes number of sub-quadrants occupied per quadrant.

2/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 13 Separation of Lower Campus Transformed Treatment Means, July Reading 1/

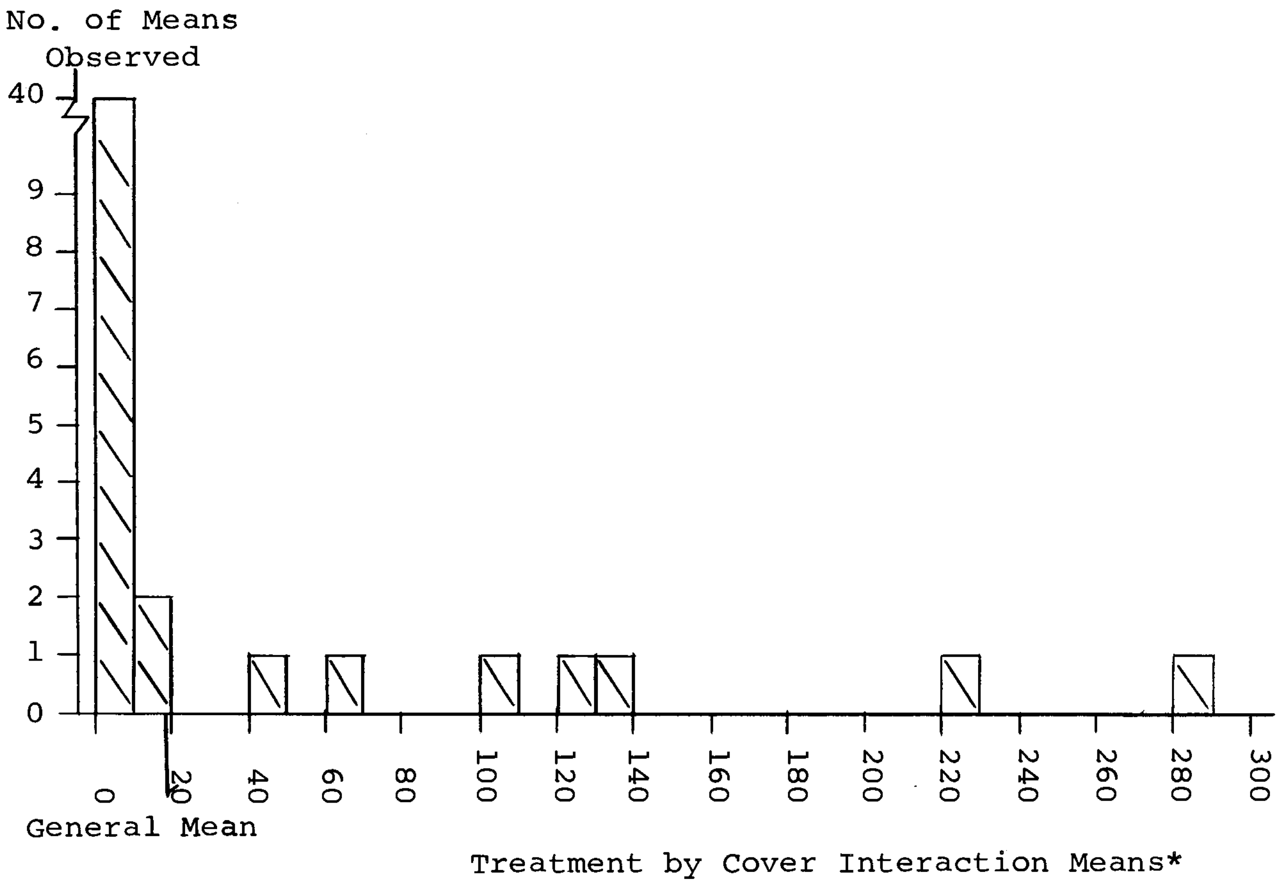
Chemical	lb/A	Mean 1/	Statistical Significance 2/
Check-pre-emergence		6.90	a
Niagara 6370	16	6.54	a
Niagara 6370	32	5.77	b
Betasan	4	5.13	c
Trifluralin	1	4.96	c
Betasan	8	4.31	d
Trifluralin	½	3.93	de
Trifluralin	2	3.90	de
Endothal	1	3.44	ef
TD282	1	3.16	f
Check-post-emergence		2.95	f
TD282	2	2.19	g
Betasan	16	1.86	g
TD282	½	1.82	g
Endothal	½	1.58	g
Endothal	2	1.55	g

Standard Error of Mean 0.218

1/ $\sqrt{x + 1}$ transformation used on individual count data. "x" denotes number of sub-quadrants occupied per quadrant.

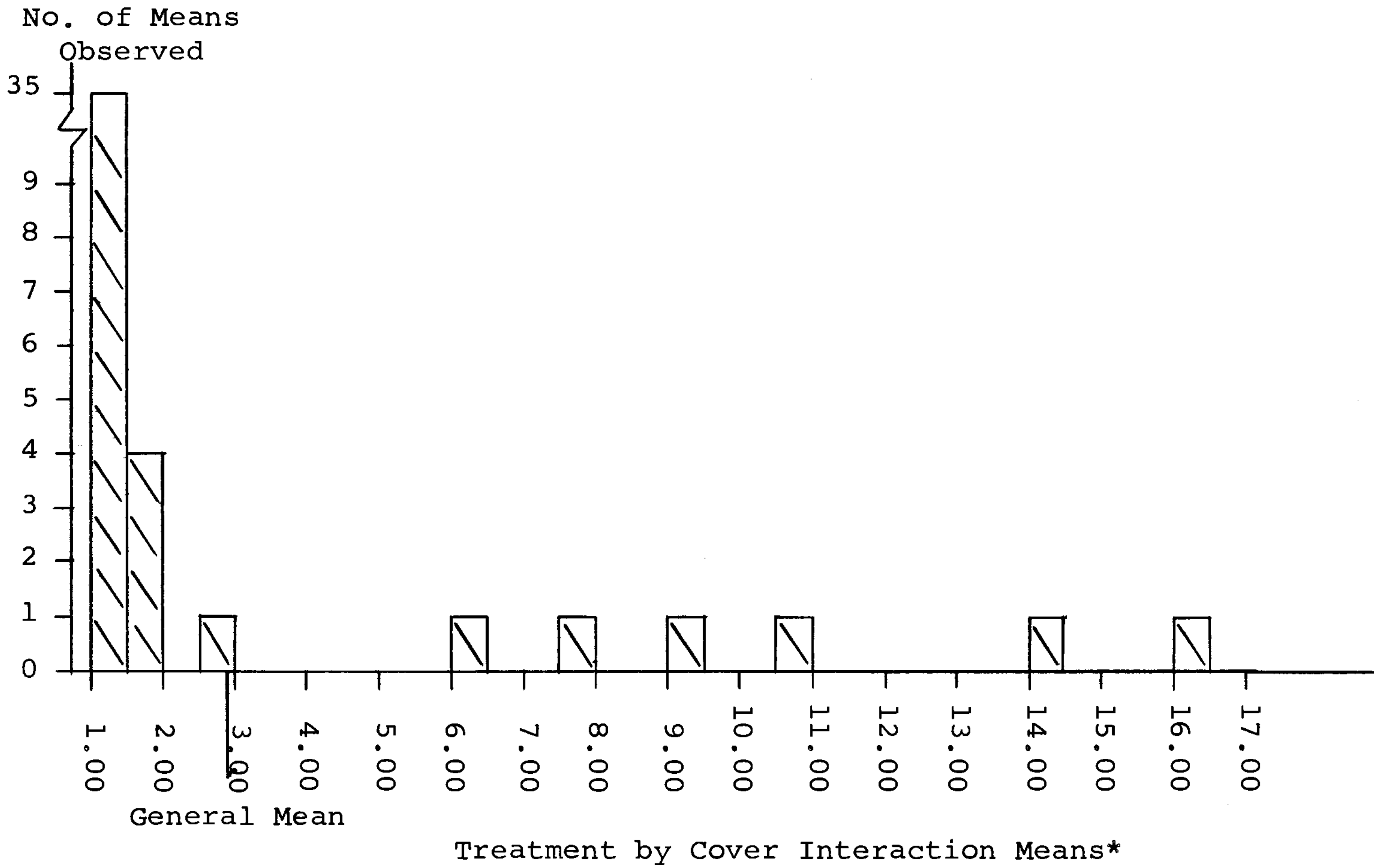
2/ Mean followed by letter "a" is significantly different from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Figure 1. Distribution of Non-Transformed Treatment by Cover Interaction Means of Initial Greenhouse Planting.



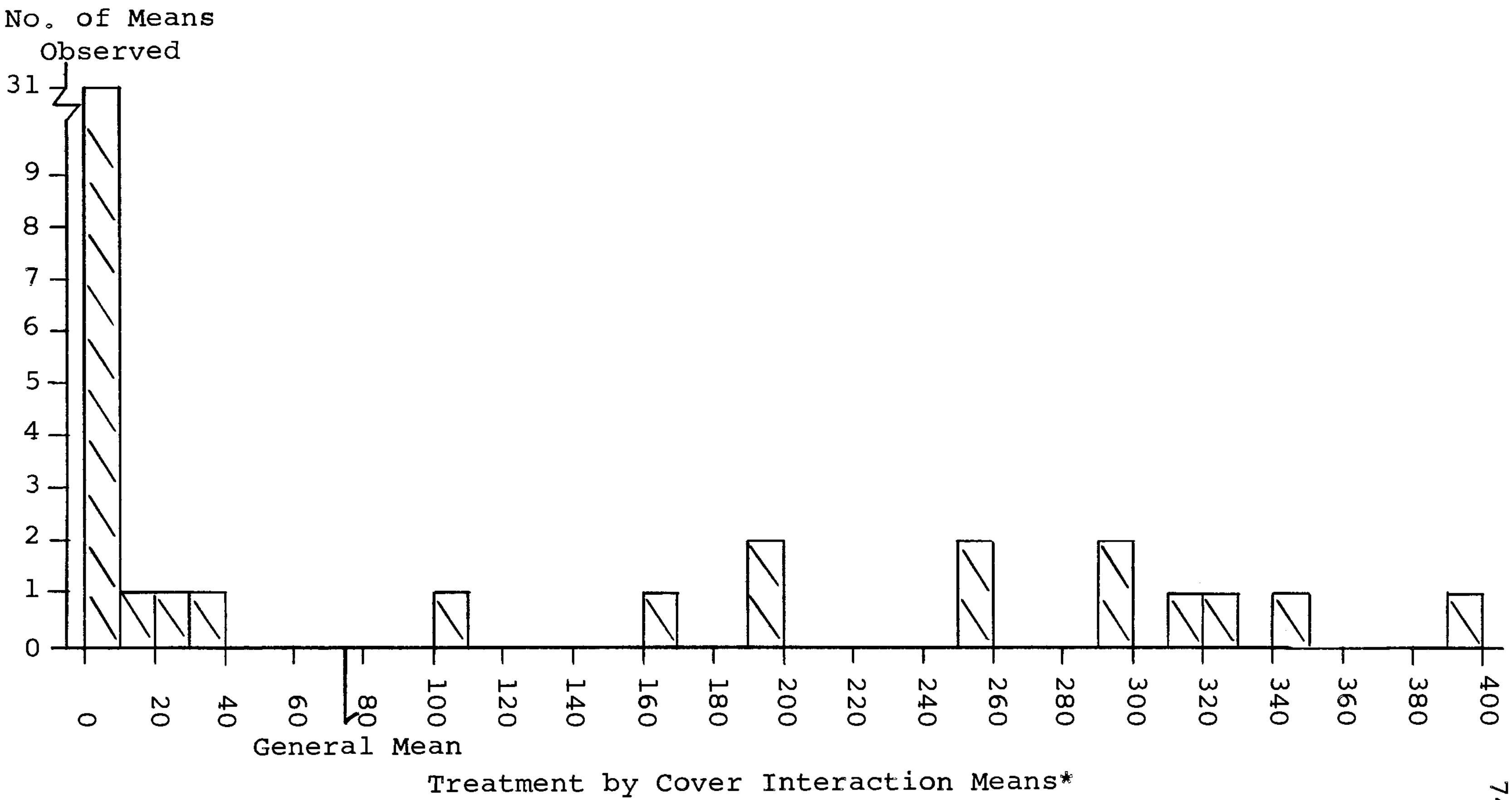
* Number of plants per plot

Figure 2. Distribution of Transformed Treatment by Cover Interaction Means of Initial Greenhouse Planting.



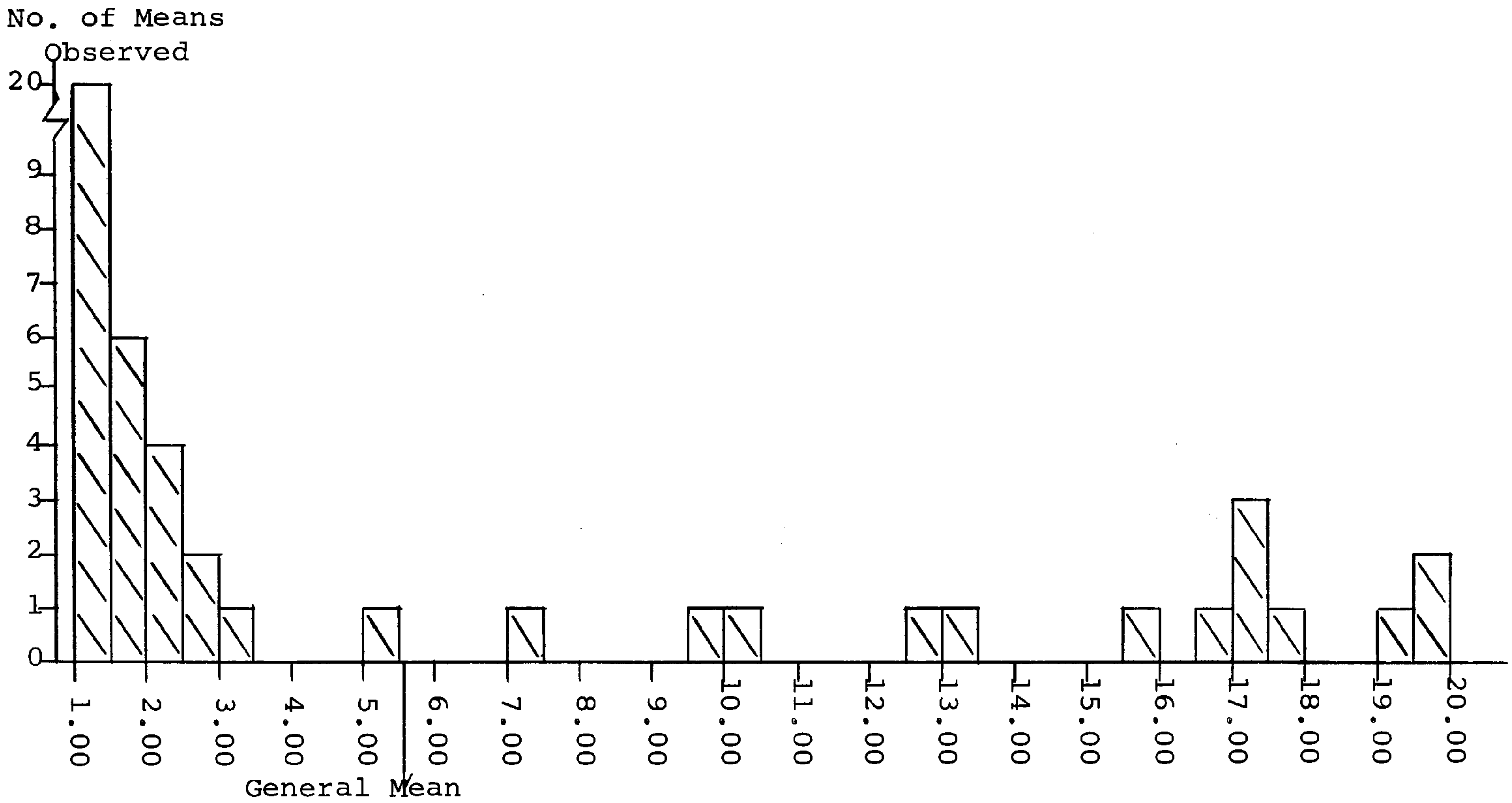
* $\sqrt{x + 1}$ transformation was used. "x" is the number of plants per plot.

Figure 3. Distribution of Non-Transformed Treatment by Cover Interaction Means for the Fourth Week Greenhouse Planting.



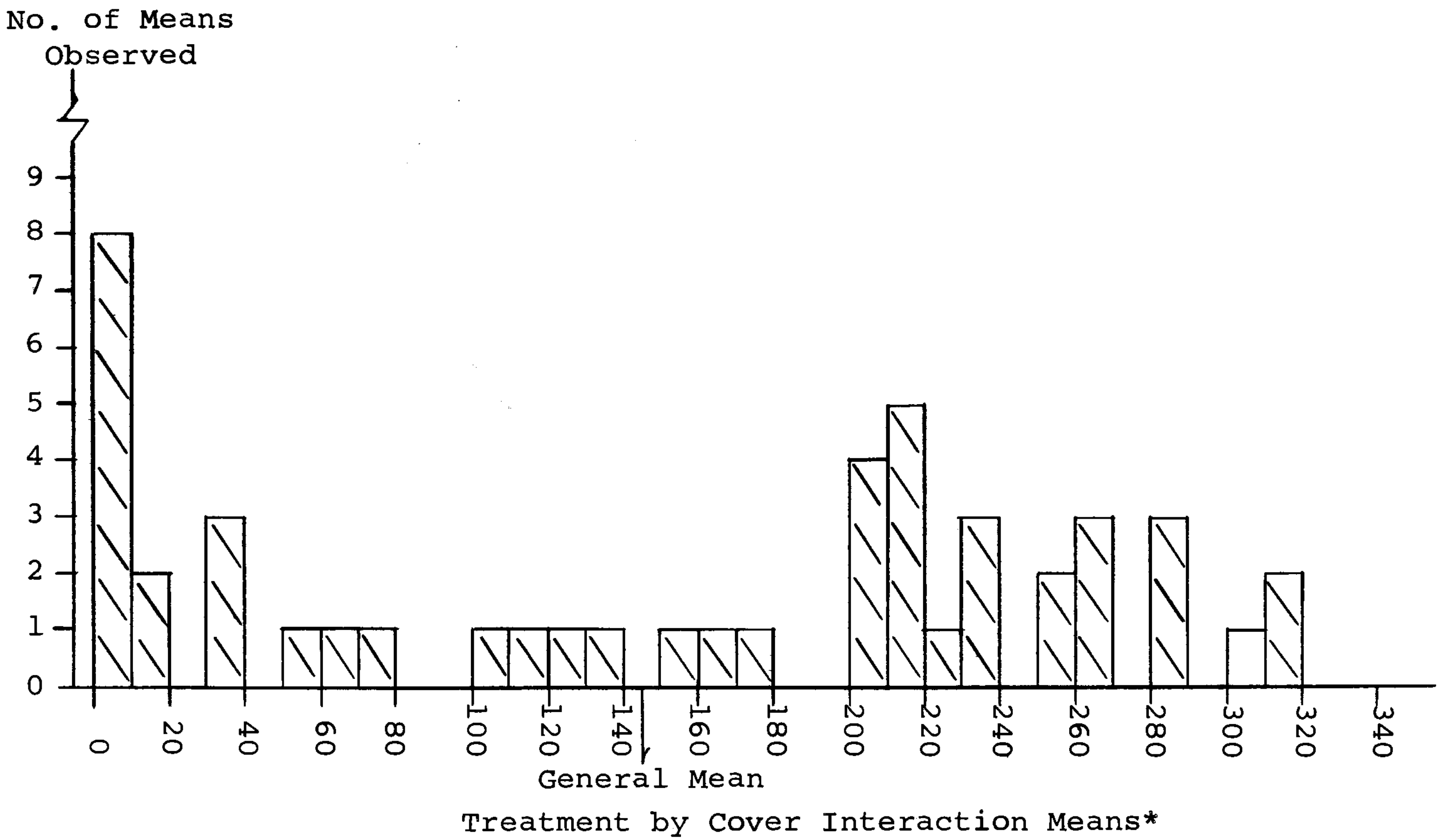
*Number of plants per plot.

Figure 4. Distribution of Transformed Treatment by Cover Interaction Means for the Fourth Week Greenhouse Planting.



$*\sqrt{x + 1}$ transformation was used. "x" is the number of plants per plot.

Figure 5. Distribution of Non-Transformed Treatment by Cover Interaction Means for Eighth Week Greenhouse Planting.



* Number of plants per plot.