CORRELATION BETWEEN ANNUAL VARIATIONS OF *POLYGONUM BICORNE* POPULATIONS AND SOIL CONDITIONS IN THE EMPORIA, KANSAS, AREA

A Thesis

Submitted to

the Department of Biology

Kansas State Teachers College, Emporia, Kansas

In Partial Fulfillment

of the Requirements for the Degree

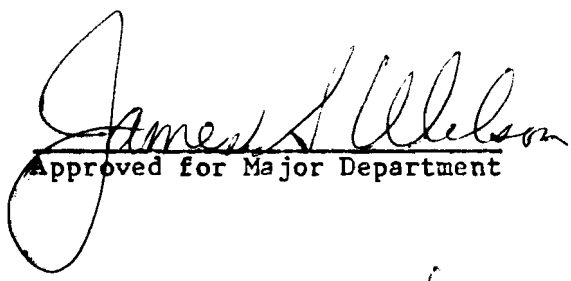
Master of Science

---

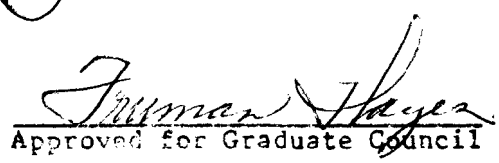
by

Jon Marshall Stucky

January, 1970



Approved for Major Department



Approved for Graduate Council

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

INTRODUCTION

As the scientific knowledge of soils increased, it became more evident that inorganic nutrient factors were of considerable importance in determining the vegetation in an area. It was also discovered that even small differences in these soil factors could be responsible for changes in the vegetational composition of plant communities (Wilde, Burnan, and Galloway, 1937). On two occasions Billings (1941, 1950) succeeded in correlating changes of the amount of inorganic nutrient content of the soil with changes in vegetation. In reference to the inorganic nutrient factors of the soil Oosting (1956) stated, "These components vary in amount and proportion from place to place and the variation may be a significant factor in determining the occurrence of species and vegetational types."

Recent studies showed that plant growth inhibitors, another factor of the soil environment, could affect the reproduction, growth, and distribution of plants (Bonner and Galston, 1944; Cox, Munger, and Smith, 1945; Konis, 1947; Bennet and Bonner, 1953; Peterson, 1965; Rice, 1964). Therefore, it seemed highly probable that changes in the plant growth inhibitor content of the soil, as well as changes in the inorganic nutrient factors of the soil, were capable of affecting the vegetational composition of plant communities. G. L. Funke (1943) concluded that under field conditions Artemisia absinthium excreted a chemical inhibitor which, when accumulated in the soil, inhibited the germination and growth of near-by surrounding plants. Investigations of four species of Helianthus suggested that unusual distribution patterns of these species, such as the "fairy ring" pattern observed in many clones, were responses

to the presence in the soil of toxic chemical substances derived from roots of the Helianthus plants (Curtis and Cottam, 1950). Went (1942) showed that annual desert herbs did not grow near plants of Encelia farinosa, a desert shrub of the Southwest, even though they grew near other shrubs in the area. Later Gray and Bonner (1948) suggested that toxic substances leached from the leaves of E. farinosa inhibited seed germination and subsequent seedling growth near the base of the plants. Also, pure stands of Bromus inermis were observed to thin out after a few years of growth. According to Benedict (1941) this phenomenon was, at least in part, a result of the accumulation in the soil of a homologous growth inhibiting substance produced by B. inermis. Recent observations of Polygonum bicorne populations in the Emporia, Kansas, area showed that they do tend to diminish on recently disturbed soils in a manner similar to that of B. inermis. This also could be due to soil borne growth inhibitors.

Polygonum bicorne is a common, annual, weedy herb in much of Kansas. It blooms as early as mid-May and continues flowering until frost. Populations of it occur commonly in low, wet areas throughout the state and in recently disturbed areas in the eastern half of the state. In the latter area P. bicorne is one of the pioneer, annual weeds that typically becomes established in the areas where the soil and previous vegetation have been strongly disturbed. Personal observations show that during the initial growing season following the disturbance the population of P. bicorne is usually dense. However, in subsequent growing seasons the population may be greatly reduced or even absent. In wet areas, such as deep ditches and shorelines of

ponds where considerable leaching of the soil can occur, populations of P. bicorne seem to remain constant from year to year.

Previous research on Polygonum bicorne showed that it produced biochemical inhibitors. Neill (1967) demonstrated that phenolic extracts from leaves and stems of P. bicorne inhibited tomato seed germination and subsequent seedling growth. Paulus (1968) showed that phenolic extracts from herbarium, greenhouse, and field specimens of P. bicorne inhibited the germination and seedling development of itself. Adams (1968) succeeded in isolating ten phenolic compounds from plant extracts of P. bicorne and suggested that one of these was chlorogenic acid, one of the many phenolic compounds known to function as a plant growth inhibitor (Hemberg, 1961; Mayer and Evenari, 1952; Schreiner and Reed, 1908; Rice, 1965a; Rice and Parenti, 1967).

Adams (1968), Neill (1967), and Paulus (1968) all speculated that the chemical inhibitor produced by Polygonum bicorne might be involved in the observed population variations in newly disturbed areas. The purpose of this research was to determine whether or not the observed yearly population variations of P. bicorne could be correlated with changes in the chemical nutrient factors in the soil, or with the presence of phenolic compounds in the soil, or both.

MATERIALS AND METHODS

Soils

The study was conducted in the Emporia, Kansas, area. The soils in this area are dark, greyish-brown, silty, clay loams of the Sogn, Summit, Florence, and Idana soil series. The parent geologic materials are loess deposits, calcareous shales, limestone, and cherty limestone (Bidwell, 1956).

Study areas

In the fall of 1967 six study areas in Emporia and its vicinity were selected. In each area, prior to its selection, the soil had been strongly disturbed. During the first growing season following this disturbance each area supported populations of Polygonum bicorne. When the vegetational analyses were begun Areas 1-5 were first-year areas and Area 6 was a second-year area.

Area 1 was located in a field bordering 18th Avenue directly east of the Kansas State Teachers College campus. During growing seasons preceeding the vegetational analyses it had been cultivated until it laid fallow throughout the 1967 growing season.

Area 2 was situated in a roadside ditch on the west side of Industrial Street between West 12th and West 15th Avenues. During the study it was mowed, but the soil was not disturbed.

Area 3 was situated on a steep, east-facing slope on the Kansas State Teachers College campus near 18th Avenue. During the winter of 1966 it was disturbed by construction equipment, and in the spring of 1967, Festuca elatior and Lolium multiflorum were planted in the area.

Area 4 was located on the north side of the Emporia bypass approximately one-half mile west of the Merchant Street exit. It was situated on an elevated embankment above the roadside ditch. This area was disturbed by land-moving equipment when construction of the bypass was being completed in the summer of 1967.

In January, 1968, a portion of Area 4 measuring 5 ft x 3 ft was spaded. Consequently, during the growing season of 1968, this small area, Area 4S, was similar to a first-year, study area while the remainder of Area 4 was a second-year area.

Area 5 was located in a vacant lot at the corner of 15th Avenue and Wheeler Street. It was disturbed by land-moving equipment late in 1966.

Area 6 was located in a vacant lot on the east side of Lincoln Street between Old Manor Road and 18th Avenue. It was disturbed in the spring of 1966.

In the summer of 1969, Area 7 was selected to furnish soil for chromatographic analyses. This area was located in a field one mile north of Emporia. Early in the summer this field was cultivated and later abandoned after rains flooded it. When soil was taken from this area it supported a first-year population of Polygonum bicorne.

Vegetational analyses

Vegetational analyses of all study areas except 4S and 7 were conducted during October, 1967. In Areas 1, 2, and 3 rectangular study quadrats that measured $\frac{1}{4}$ m x 4 m were spaced along pre-determined parallel lines at intervals determined by pacing (Oosting, 1956). After

each analysis the data from each area was used to draw a species-area curve (Caine, 1938) to insure that the number of quadrats sampled was sufficient.

Frequency, density, and area occupied for each species encountered in the study quadrats were determined. Area occupied equaled the total aerial area (square inches) occupied by a species in all the quadrats divided by the total area (square inches) of all the quadrats in the study area. Relative values for these three parameters were then determined for each species. The importance percentage for each species was then calculated by dividing the sum of the three relative parameters by the number of parameters. Dominant and important secondary species were determined by inspection of the importance percentages using the method suggested by Kornhaus (1965).

By the time Areas 4, 5, and 6 were to be analyzed in the fall of 1967, frost had killed the plants. Counts and measurements of individuals were then impossible; therefore, an alternative method was used to analyze these areas. They were searched and recognizeable plant remains were collected for species identification. A species list for each area was then compiled.

In June, August, and October, 1968, three more vegetational analyses of Areas 2-6 were conducted using the methods that were used to analyze Areas 1, 2, and 3 in October, 1967. Area 4S was treated as a single study quadrat because it was only 5 ft x 3 ft. Further analyses of Area 1 were impossible because the field in which it was located was cultivated in 1968. Vegetational analyses of Area 7 were not conducted.

Soil inorganic chemical analyses

Soil samples for chemical analyses were collected from Areas 1-6 when each vegetational analysis was conducted. At fifteen randomly located sites within each area a soil auger was used to collect one soil core from the 0-6" soil profile level and one from the 6-12" level. All cores from an area taken from the same level on the same date were then combined to make a composite sample. The composite samples were then air dried, ground in a motorized soil mill, screened through a 0.25 mm sieve, and stored for later analyses.

The pH values for the composite samples were determined by testing a 1:1 (w/v) soil:water solution with a Zeromatic pH meter. The 1:1 solution was used because it closely approximated ratios most likely to occur in the field (Jackson, 1958). Five readings for each composite sample were averaged and the average recorded.

The organic carbon content of the composite samples, an approximation of the organic matter content of the soil, was determined by the Walkley-Black method as described by Piper (1942). The effect of elementary carbon in the soil upon the final values was negligible when this method was used.

Portions of all the composite soil samples were mailed to the Harris Laboratories in Lexington, Nebraska, for determination of the exchangeable magnesium and calcium ion concentrations. The atomic absorption method (see appendix) was used in the determinations.

Total nitrogen was determined by the Kjeldahl method described by Jackson (1958). The final values included nitrogen in the organic, ammonium, and nitrate forms. Nitrite content was not determined because

it was usually found to be negligible in all soils except those which were strongly alkaline and heavily fertilized with ammonium fertilizers.

The 1, 2, 4-aminonapthosulfonic acid-reduced molybdophosphoric blue color method in a perchloric acid system (Jackson, 1958) was used to determine the concentration of total phosphorus. A Bausch and Lomb Spectronic 20 spectrophotometer set at a wavelength of 660 mu was used to detect the blue color intensities. This method was used because it detected phosphorus concentrations over a wide range and because the final values were only slightly affected by moderate variations in soil acidity.

Soil and plant chromatographic analyses

Portions of some of the composite soil samples taken during the first and second growing seasons following disturbance from Areas 2, 3, 4, and 4S were saved for chromatographic analyses for the presence of phenolic compounds which might act as plant growth inhibitors. In addition, soil samples were taken from Area 7 during the summer of 1969 for chromatographic analyses.

Extracts of each of the soil samples were prepared by gently boiling six mixtures of 100 g of soil and 150 ml of 100% methanol on a hotplate for five hours and filtering off the soil particles in a Buchner funnel using Whatman No. 3 filter paper. The six filtered extracts were then combined and evaporated from their original combined volume to 135 ml in a flash evaporator in order to concentrate any phenolic compounds that might be present.

To isolate phenolic compounds, 10 ml of each of the concentrated soil extracts were applied in a streak 30 cm long on four Whatman No. 1

chromatography papers. These streaked papers were developed by descending chromatography in Warner-Chilcott Model A-125 chromatocabs: two in BAW (n-butanol-acetic acid-water, 63-10-27 v/v) and two in 2% aqueous acetic acid, solvent systems suggested for separation of phenolic compounds (Smith, 1960). The developed chromatograms were air dried and then viewed under long and short wave ultraviolet light with and without exposure to ammonia fumes. The fluorescing zones were outlined with pencil, colors of the zones under the different ultraviolet light treatments were recorded, and Rf values of the zones were determined.

A leaf extract of Polygonum bicorne was prepared and chromatographed for comparison with the chromatograms of the soil extracts. The leaf extract was prepared by grinding 20 g of fresh leaves with 100 ml of 100% methanol for 10 minutes in a Waring blender and filtering off the leaf particles in a Buchner funnel using Whatman No. 3 filter paper. Three ml of the filtered extract were applied in a 30 cm streak to each of four Whatman No. 1 chromatography papers. The four papers were developed in the 2% aqueous acetic acid solvent system and viewed for fluorescing zones using techniques that were used with the soil extract chromatograms. Color reactions and Rf values of fluorescing zones on chromatograms of the leaf extracts and soil extracts were compared. Eight more chromatograms of each soil extract which showed fluorescing zones on the original chromatograms were developed in the 2% aqueous acetic acid solvent system and viewed under ultraviolet light.

Fluorescing zones from the soil extract and leaf extract chromatograms which demonstrated similar color reactions under ultraviolet light and similar Rf values were cut into small strips and immersed in 280 ml of 100% methanol for five hours. The elutant was then decanted and 280 ml of fresh 100% methanol was added to the strips. After five more hours, the second elutant portion was decanted and combined with the first portion. The paper strips were then air dried, taped together, and checked under ultraviolet light after exposure to ammonia fumes for the presence of fluorescing compounds.

Half of the combined methanolic elutant of each fluorescing zone from the soil extract and leaf extract chromatograms was evaporated in a flash evaporator to a volume of 15 ml to concentrate phenolic compounds which were present in the elutant. Two ml of each concentrated soil extract and leaf extract elutant were spotted on Whatman No. 1 chromatography paper along with 0.2 ml of a 0.2% solution in 95% ethanol of three different known phenolic plant growth inhibitors; chlorogenic, caffeic, and quinic acids. Chromatograms were air dried and viewed under ultraviolet light for fluorescing zones. The color of the zones and their Rf values were recorded.

Two fluorescing zones developed from each elutant and each phenolic solution were tested with $FeCl_3$-$K_3Fe(CN)_6$ reagents (Smith, 1960), a general test for phenolic compounds. Also, two more of each of the zones were tested with Hoepfner's Reaction reagents (Rice, 1965b; Roberts and Wood, 1951), a specific test for chlorogenic acid isomers.

Seed germination test

A seed germination test was conducted using tomato seeds in solutions of the phenolic compounds detected on chromatograms of soil extracts prepared from the August, 1968, samples from Area 4, a second-year area, and Area 4S, a first-year area. Half of the methanolic elutants were each evaporated in a flash evaporator to a volume of 5 ml and then diluted with enough distilled water to make a 1.5% solution.

Eight hundred tomato seeds were placed on autoclaved white quartz sand in 40, plastic, petri dishes (20 seeds per dish). The sand in each of 10 petri dishes was then saturated with 9 ml of the 1.5% elutant solution from chromatograms of Area 4. To each of 10 other petri dishes, 9 ml of the elutant solution from chromatograms of Area 4S were added. Ten dishes of seeds to which 9 ml of a 1.5% aqueous methanol solution was added served as a control. Sand in 10 other petri dishes of seeds was saturated with 9 ml of distilled water to test the viability of the seeds. Excess loss of moisture was prevented by wrapping the petri dishes with rubber seals. The dishes were set out at a room temperature of 78-82 F. Germination counts were made every 24 hr for a total of seven days.

Root-shoot development test

After the 168 hr seed germination count, one-fourth of the seeds that had germinated in each solution were randomly selected. The root-shoot axis of the germinated seeds was measured and the mean length for the axes in each solution $\pm$ standard error was determined. T-tests were run to statistically compare the growth that occurred in the different solutions.

RESULTS

Vegetational analyses

Results of the vegetational analyses indicated that the dominant species in Area 1 during October, 1967, were Abutilon theophrasti, Digitaria sanguinalis, and Polygonum bicorne. Amaranthus tamariscinus was an important secondary species (Table I).

In Area 2 during October, 1967, Bromus inermis was the single dominant species. Sorghum vulgare and Polygonum bicorne were important secondary species (Table II). During June, 1968, B. inermis was again the only dominant while Setaria viridis was an important secondary species (Table III). Bromus inermis and S. viridis both retained their relative importance in Area 2 through August of 1968, while no other species appeared to increase significantly in importance (Table IV). In October, 1968, B. inermis was by far the most important species. Digitaria sanguinalis and Echinochloa crusgalli were important secondary species (Table V). During none of the three vegetational analyses dates in 1968 was P. bicorne found to approach its importance percentage of 11.7 for October, 1967 (Tables II-V).

In Area 3 during October, 1967, at the end of the first growing season, Buchloe dactyloides, Festuca elatior, and Polygonum bicorne were the dominants. There were no important secondary species with importance percentages above 10.0; however, Setaria lutescens and Echinochloa crusgalli had importance percentages of 9.3 and 8.0, respectively (Table VI). In June, 1968, F. elatior and Lolium multiflorum were dominant. Trifolium repens and Ulmus rubra were important secondary species (Table VII). Again in August, 1968, F. elatior and

L. multiflorum were the dominants and T. repens was an important secondary species (Table VIII). Festuca elatior maintained its position of dominance through October, 1968. At this time S. lutescens and T. repens were important secondary species (Table IX). The highest importance percentage attained by P. bicorne during the three sampling dates of 1968 was 1.6 in both June and August (Tables VII and VIII).

Frost killed the plants in Areas 4, 5, and 6 before a mathematically based vegetational analysis could be conducted; however, results of the identification of plant remains confirmed the presence of Polygonum bicorne in these areas during October, 1967 (Tables X, XVII, and XXX). Personal observations earlier in the fall of 1967 revealed that the P. bicorne populations were dense in Areas 4 and 5, but only moderate in Area 6.

In June, 1968, Trifolium repens was the single dominant species in Area 4. Festuca elatior and Lolium multiflorum were important secondary species. At this time the importance percentage for Polygonum bicorne in Area 4 was 0.7 (Table XI), while in Area 4S its importance percentage was 58.1 (Table XII). In August, 1968, the dominants in Area 4 were Bromus inermis, Setaria lutescens, and T. repens. There were no secondary species with importance percentages above 10.0; however, the importance percentage for F. elatior was 8.7. Polygonum bicorne was not encountered during this vegetational analysis of Area 4 (Table XIII). At this time the importance percentage for P. bicorne in Area 4S was 29.2 (Table XIV). In October, 1968, the dominant species in Area 4 were B. inermis, Setaria faberii, S. lutescens and T. repens. Polygonum bicorne was not encountered during this vegetational analysis (Table XV).

At the same time in Area 4S the importance percentage for P. bicorne was 35.1 (Table XVI).

During June, 1968, the single dominant species in Area 5 was Bromus japonicus. The importance percentage of the other species did not indicate that any were of significant secondary importance (Table XVIII). In August, 1968, Poa pratensis aff. was the dominant in the area (Table XIX). During October, 1968, P. pratensis aff. was again the single dominant. Convolvulus arvensis and Setaria lutescens were important secondary species. The highest importance percentage determined for Polygonum bicorne in Area 5 during the 1968 growing season was 7.8 in October (Table XX).

In June, 1968, Lespedeza striata, Setaria lutescens and Sporobolus vaginiflorus were the dominant species in Area 6. The results indicated no other species of significant secondary importance (Table XXII). In August, 1968, L. striata and S. lutescens were again dominants while S. vaginiflorus was an important secondary species (Table XXIII). In October, 1968, the same three species and Echinochloa crusgalli were the dominants (Table XXIV). The highest importance percentage recorded for Polygonum bicorne in Area 6 during 1968 was 2.8 in June (Table XXII).

Soil inorganic chemical analyses

The results of the analyses of the soil taken from Area 1 in October, 1967, indicated that the properties in the 0-6" and 6-12" soil profile levels differed little from each other. However, it appeared that the total nitrogen content and total phosphorus content of this soil were considerably higher than in the soil from most of the other study areas for October, 1967 (Table XXV). The field in which this

study area was located was cultivated in 1968, so it was impossible to further sample the soil to note any seasonal trends in the chemical properties that might occur.

Results of the Area 2 soil analyses indicated that the chemical properties in the 0-6" and 6-12" soil profile levels closely approximated each other. The only exceptions were the organic carbon content of the August, 1968, sample and the exchangeable magnesium ion concentration of the June, 1968, sample. The pH values of the soil samples taken in 1967 and 1968 were relatively constant. The results indicated a slight increase in the organic carbon content of the soil in this area during the growing season of 1968, but the content in October, 1968, was only slightly higher than the content in October, 1967. Steady decreases in the values for exchangeable calcium ion content of the soil were demonstrated in 1968; however, the values for this property in October, 1968, were also consistent with the values determined for the October, 1967, soil samples. Total nitrogen and total phosphorus content of the soil appeared to remain relatively stable from October, 1967, to October, 1968 (Table XXVI).

The October, 1968, values for pH and exchangeable calcium ion of Area 3 were slightly higher than the corresponding values in October, 1967. Other chemical properties appeared comparatively stable from October, 1967, to October, 1968 (Table XXVII).

In Area 4 the values for exchangeable magnesium ion concentration, total nitrogen, and total phosphorus content of the soil samples fluctuated slightly, but did not show any major changes on the different sampling dates. The values for pH and organic carbon content in the

October, 1968, soil samples were slightly higher than the corresponding values for the October, 1967, samples. The concentration of exchangeable calcium ion did appear considerably higher in October, 1968, than in October, 1967 (Table XXVIII).

Analyses of the soil samples taken from Area 4S during 1968 revealed an increase in the organic carbon content of the soil and a decrease in the exchangeable calcium ion concentration. Values determined for the other chemical factors did not appear to vary greatly during the sampling period of 1968 (Table XXIX).

The pH values of the soil from Area 5 consistently indicated basic conditions. The organic carbon content of the soil was high in October, 1967, when compared to the values determined for 1968. The exchangeable magnesium ion concentration and total nitrogen content of the soil demonstrated minor changes during the study period. The values for the phosphorus concentration remained relatively constant throughout the study even though they were considerably higher than the phosphorus concentration values for all of the other study areas. The exchangeable calcium ion concentration increased in the 0-6" level from October, 1967, to October, 1968, but decreased in the 6-12" level (Table XXX).

The pH, organic carbon content, total nitrogen content, and total phosphorus concentration of the soil from Area 6 remained stable throughout the growing season of 1968 and were comparable to the corresponding values for October, 1967. The exchangeable magnesium and calcium ion concentrations increased significantly during 1968 over their respective values for October, 1967 (Table XXXI).

Soil and plant chromatographic analyses

Fluorescing phenolic zones were detected on the two original chromatograms of each soil extract that were developed in the 2% aqueous acetic acid solvent system; however, no phenolic zones were detected on the chromatograms developed in the BAW solvent system.

The eluted chromatography paper strips did not fluoresce under ultraviolet light after exposure to ammonia fumes. This indicated that the elution process effectively removed the phenolic compounds from the paper.

The results of the chromatography using the elutants extracted from the original streaked chromatograms indicated the presence of phenolic compounds in all the soil extracts. The Rf values and color reactions of most of the phenolic compounds of these different soil extract elutants corresponded closely with one another and with the Rf values and color reactions of one of the phenolic zones of the Polygonum bicorne leaf extract elutant. However, Rf values and color reactions of these phenolic zones did not correlate closely with the Rf values and color reactions of chlorogenic, caffeic, and quinic acids (Table XXXII).

Seed germination test

The seed germination rate appeared to be retarded in both test solutions when compared with the control solution. The biggest difference among the germination percentages occurred in the period between the 72 hr and 120 hr germination counts. The germination percentage in the control solution was higher than in both test solutions until approximately the time that the 144 hr count was made. At this

time, the germination percentage for the seeds in the Area 4S solution surpassed that of the control. Also, at this time, the germination percentage for the seeds in the Area 4 solution closely approached that of the control. Throughout the test, the germination rate in the Area 4 solution appeared to be more retarded than the rate in the Area 4S solution (Figure 1).

Root-shoot development test

At the end of 168 hr of development in the test and control solutions, root-shoot length measurements revealed that growth in the test solutions was retarded when compared with growth in the control solution. T-values indicated that the difference in growth between the seeds in the Area 4 solution and those in the control was significant at or below the 1% level. The difference in growth between the seeds in the Area 4S solution and those in the control was significant at or below the 5% level. Growth appeared to be significantly more retarded in the solution from Area 4 when compared to growth in the solution from Area 4S. The t-value that compared the growth in these two solutions showed a difference significant at or below the 1% level.

DISCUSSION

Vegetational analyses

During October, 1967, vegetational analyses of the first-year, study areas revealed dense and visually dominant populations of Polygonum bicorne and other species that characteristically inhabit waste areas and recently abandoned fields (Clements, 1928; Steyermark, 1963). However, in the second-year, study area, Area 6, during October, 1967, P. bicorne was not visually dominant.

Vegetational analyses of second-year, study areas during the 1968 growing season again revealed dense populations of species that inhabit recently disturbed areas; however, Polygonum bicorne was not one of these species. Dense populations of P. bicorne were limited to the first-year, study areas.

Soil inorganic chemical analyses

The pH values for all soil sampled throughout the study fell into a weak acid to medium alkaline range. This range is consistent with that found by Bailey (1944) for numerous prairie soils throughout the United States. Perkins and Schrenk (1948) determined pH values in a similar range for various Kansas soils.

The organic carbon contents were consistently lower than, but comparable to those determined by Sewell and Latshaw (1925) for soils from Scott County, Kansas. Most of the values for the 0-6" soils were higher than the values for the 6-12" soils as would be expected since humus is added to the surface of the soil. There were no consistent

differences in the organic carbon contents of the soils between the first and second growing seasons.

The values determined for exchangeable calcium and magnesium ions were very high in comparison to values determined by Perkins and Schrenk (1948) for various Kansas soils. These values were not accompanied by correspondingly high pH values or organic carbon contents as might be expected from the trend reported by Black (1957). In the majority of the samples, the concentration of exchangeable calcium and magnesium was greater in the 6-12" than in the 0-6" soil profile level. This difference was probably caused by leaching of the ions from the upper soil profile level. The concentration of exchangeable calcium was higher in some areas during the second growing season than during the first; however, this tendency was not consistent.

The values for total nitrogen content corresponded with the 0.10-0.25% range reported for prairie soils of the central United States by Allison (1957) and with the range determined by Sewell and Latshaw (1925) for soils in Scott County, Kansas. The content for the 0-6" soil profile levels was higher than that for the 6-12" levels as would be expected since the organic matter, from which most of the soil nitrogen was derived, was concentrated near the soil surface. The nitrogen content of the soils from Areas 1 and 5 was higher than that of soils from the other study areas. During the 1966 growing season Area 1 had been fertilized. This possibly explained the high nitrogen content in this study area. No consistent differences in the nitrogen content of the soils were evident when values for the two growing seasons were compared.

The amount of total phosphorus in most of the soils fell within the 2.2-8.3 ppm range reported for most soils by Black (1957). The amounts in the soils from Areas 1 and 5 were higher than the amounts from the other study areas. This corresponded with higher amounts of total nitrogen in these two areas and indicated that Area 5 could have been fertilized as Area 1 had been. No consistent differences in the total phosphorus content of the soils were evident when readings for October, 1967, and October, 1968, were compared.

The noticeable reduction in the Polygonum bicorne populations could not be correlated with consistent changes in any of the inorganic chemical properties of the soil. The factor responsible for the population reduction was probably something other than the inorganic chemical factors that were determined.

Soil and plant chromatographic analyses

Several phenolic compounds were detected in the soil extracts. One of these compounds was present in all soil extracts prepared from soil of both first- and second-year, study areas. Since this phenolic compound demonstrated an Rf value and color reactions similar to those of one of the phenolic compounds detected in leaf extracts of Polygonum bicorne, it is possible that the compounds were identical and that at least some of this compound was originally produced by P. bicorne and later deposited in the soil. This possibility was also suggested by Neill (1967), Adams (1968), and Paulus (1968). The compound could not be identified as either chlorogenic acid, a known plant growth inhibitor found in P. bicorne (Adams, 1968), or its natural breakdown products, caffeic and quinic acids, which are also inhibitory (Schaal and Johnson, 1955).

Seed germination test

Solutions of the phenolic compound inhibited germination of tomato seeds. Since this phenolic compound corresponded with a phenolic compound found in Polygonum bicorne extracts that inhibited the germination of P. bicorne, as well as tomato seeds (Paulus, 1968; Neill, 1967), it is possible that the phenolic compound in the soils could also inhibit germination of P. bicorne seeds.

Germination inhibition was more pronounced in the solution prepared from the soil of Area 4, a second-year area, than in the solution prepared from Area 4S, a first-year area. This indicated that possibly there was a higher concentration of the inhibitory phenolic compound in the soil from the second-year, study area.

Root-shoot development test

Root-shoot development, in addition to seed germination, was inhibited more in the test solution prepared from the second-year, study area, Area 4, than in the solution from the first-year area, Area 4S. This also indicated a greater concentration of the inhibitory compound in the soil from the second-year area.

Inhibition of seed germination and early seedling development can reduce the ability of a species to compete for nutrients, moisture, and sunlight and, consequently, reduce the population density of that species (Clements, 1928). If the phenolic compound found in the soil extracts can inhibit the germination and development of Polygonum bicorne, as well as tomato seeds, the presence of this compound in higher concentrations in the soil of second-year areas than in soil of first-year areas could cause the annual variations of P. bicorne populations in these areas.

SUMMARY

Vegetational analyses of several disturbed areas in Emporia, Kansas, and its vicinity revealed that populations of Polygonum bicorne were dominant, or nearly so, during the first growing season, but sparse during the second growing season following the original disturbances.

Inorganic chemical analyses of soils sampled from the study areas during the first and second growing seasons revealed no consistent differences that could be correlated with the variations of the Polygonum bicorne populations.

Chromatographic analyses of various soil extracts prepared from both first- and second-year soil samples revealed the presence of a phenolic compound which demonstrated an Rf value and color reactions similar to those of a phenolic compound present in Polygonum bicorne extracts.

Tests revealed that the phenolic compound found in soils from both a first- and a second-year area inhibited germination of tomato seeds and subsequent root-shoot development. The inhibition in the solution prepared from soil of the second-year area was greater than that in the solution prepared from soil of the first-year area.

Table I. Vegetational analysis of Area 1, October, 1967.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	8	21.0	11.500	27.2	0.085	16.8	65.0	21.7
Amaranthus tamariscinus	6	15.8	1.625	3.8	0.052	10.3	29.9	10.0
Convolvulus arvensis	2	5.3	0.500	1.2	0.005	1.0	7.5	2.5
Digitaria sanguinalis	5	13.2	9.250	21.9	0.061	12.0	47.1	15.7
Echinochloa crusgalli	1	2.6	0.125	0.3	T*	T	2.9	1.0
Euphorbia maculata	2	5.3	0.250	0.6	0.003	0.6	6.5	2.2
Euphorbia serpens	1	2.6	0.375	0.9	0.004	0.8	4.3	1.4
Iva ciliata	2	5.3	0.250	0.6	0.021	4.1	10.0	3.3
Polygonum bicorne	8	21.0	5.750	13.6	0.240	47.3	81.9	27.3
Setaria lutescens	2	5.3	4.375	10.4	0.020	3.9	19.6	6.5
Unknown grass	1	2.6	8.250	19.5	0.016	3.2	25.3	8.4

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table II. Vegetational analysis of Area 2, October, 1967.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	2.3	0.500	1.1	T*	T	3.4	1.1
Amaranthus tamariscinus	4	9.1	2.250	4.8	0.026	4.7	18.6	6.2
Bromus inermis	4	9.1	18.500	39.2	0.259	47.2	95.5	31.8
Chenopodium album	1	2.3	1.500	3.2	0.021	3.8	9.3	3.1
Chenopodium lanceolatum	1	2.3	0.250	0.5	0.001	0.2	3.0	1.0
Digitaria sanguinalis	3	6.8	2.500	5.3	0.028	5.1	17.2	5.7
Echinochloa crusgalli	2	4.5	0.750	1.6	0.007	1.3	7.4	2.5
Euphorbia dentata	1	2.3	0.250	0.5	0.005	0.9	3.7	1.2
Euphorbia maculata	1	2.3	0.250	0.5	0.002	0.4	3.2	1.1
Geranium carolinianum	2	4.5	1.000	2.3	0.001	0.2	7.0	2.3
Hibiscus trionum	2	4.5	1.000	2.3	0.006	1.1	7.9	2.6
Kochia scoparia	2	4.5	1.250	2.6	0.007	1.3	8.4	2.8
Melilotus officinalis	2	4.5	0.500	1.1	0.011	2.0	7.6	2.5
Oxalis stricta	3	6.8	1.000	2.3	0.007	1.3	10.4	3.5
Panicum virgatum	1	2.3	0.250	0.5	0.010	1.8	4.6	1.5

Table II. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Physalis virginiana	1	2.3	1.750	3.7	0.011	2.0	8.0	2.7
Polygonum bicorne	3	6.8	4.250	9.0	0.106	19.3	35.1	11.7
Rumex crispus	1	2.3	0.250	0.5	0.006	1.1	3.9	1.3
Setaria lutescens	1	2.3	0.250	0.5	0.006	1.1	3.9	1.3
Setaria viridis	1	2.3	0.750	1.6	0.006	1.1	5.0	1.7
Solanum carolinense	2	4.5	0.750	1.6	0.004	0.7	6.8	2.3
Sorghum vulgare	4	9.1	7.250	15.3	0.117	21.3	45.7	15.2
Taraxacum officinale	1	2.3	0.250	0.5	0.002	0.4	3.2	1.1

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table III. Vegetational analysis of Area 2, June, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	4	7.8	5.250	4.7	0.003	0.4	12.9	4.3
Bromus inermis	4	7.8	38.000	34.1	0.523	62.9	104.8	34.9
Bromus japonicus	3	5.9	1.250	1.1	0.026	3.1	10.1	3.4
Erigeron canadensis	3	5.9	1.000	0.9	0.004	0.5	7.3	2.4
Geranium carolinianum	3	5.9	1.250	1.1	0.026	3.1	10.1	3.4
Helianthus annuus	2	3.9	1.250	1.1	0.003	0.4	5.4	1.8
Hibiscus trionum	4	7.8	15.250	13.7	0.011	1.3	22.8	7.6
Lepidium virginicum	4	7.8	7.250	6.5	0.023	2.8	17.1	5.7
Melilotus officinalis	3	5.9	0.750	0.7	0.032	3.8	10.4	3.5
Oenothera laciniata	2	3.9	0.750	0.7	0.008	1.0	5.6	1.9
Physalis virginiana	2	3.9	3.250	2.9	0.040	4.8	11.6	3.9
Polygonum bicorne	1	2.0	0.250	0.2	T*	T	2.2	0.7
Rumex crispus	1	2.0	0.250	0.2	0.002	0.2	2.4	0.8
Setaria viridis	3	5.9	24.500	22.0	0.050	6.0	33.9	11.3
Silene antirrhina	2	3.9	0.500	0.4	0.004	0.5	4.8	1.6

Table III. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Solanum carolinense	4	7.8	8.250	7.4	0.056	6.7	21.9	7.3
Sporobolus asper	2	3.9	1.000	0.9	0.003	0.4	5.2	1.7
Taraxacum officinale	2	3.9	0.500	0.4	0.014	1.7	6.0	2.0
Tragopogon major	2	3.9	0.750	0.7	0.004	0.5	5.1	1.7

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table IV. Vegetational analysis of Area 2, August, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	2.3	0.750	1.1	0.001	0.1	3.5	1.2
Bromus inermis	4	9.1	22.000	32.4	0.508	63.1	104.6	34.9
Convolvulus arvensis	1	2.3	0.250	0.4	0.002	0.2	2.9	1.0
Digitaria sanguinalis	2	4.5	1.500	2.2	0.006	0.7	7.4	2.5
Erigeron canadensis	2	4.5	1.000	1.5	0.003	0.4	6.4	2.1
Eriochloa contracta	2	4.5	0.500	0.7	0.003	0.4	5.6	1.9
Euphorbia dentata	2	4.5	1.000	1.5	0.008	1.0	7.0	2.3
Euphorbia maculata	1	2.3	0.250	0.4	0.001	0.1	2.8	0.9
Helianthus annuus	1	2.3	0.250	0.4	0.003	0.4	3.1	1.0
Hibiscus trionum	4	9.1	6.500	9.6	0.022	2.7	21.4	7.1
Kochia scoparia	1	2.3	0.250	0.4	0.001	0.1	2.8	0.9
Lactuca scariola	1	2.3	0.500	0.7	0.004	0.5	3.5	1.2
Lespedeza striata	2	4.5	0.500	0.7	0.008	1.0	6.2	2.1
Medicago sativa	2	4.5	0.500	0.7	0.005	0.6	5.8	1.9
Oxalis stricta	1	2.3	0.250	0.4	0.001	0.1	2.8	0.9

Table IV. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Physalis virginiana	2	4.5	3.250	4.8	0.050	6.2	15.5	5.2
Rumex crispus	2	4.5	0.500	0.7	0.010	1.2	6.4	2.1
Setaria lutescens	1	2.3	4.000	5.9	0.023	2.9	11.1	3.7
Setaria viridis	3	6.8	16.750	24.6	0.081	10.1	41.5	13.8
Solanum carolinense	4	9.1	5.000	7.4	0.042	5.2	21.7	7.2
Solanum rostratum	1	2.3	1.500	2.2	0.008	1.0	5.5	1.8
Sorghum vulgare	1	2.3	0.250	0.4	0.006	0.7	3.4	1.1
Taraxacum officinale	2	4.5	0.500	0.7	0.006	0.7	5.9	2.0
Xanthium pensylvanicum	1	2.3	0.250	0.4	0.003	0.4	3.1	1.0

Table V. Vegetational analysis of Area 2, October, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	2.9	0.250	0.3	T*	T	3.2	1.1
Aristida oligantha	1	2.9	0.500	0.6	0.005	0.7	4.2	1.4
Bromus inermis	4	11.4	42.250	47.5	0.588	82.0	140.9	46.9
Convolvulus arvensis	1	2.9	0.250	0.3	0.002	0.3	3.5	1.2
Digitaria sanguinalis	3	8.6	19.000	21.4	0.049	6.8	36.8	12.3
Echinochloa crusgalli	4	11.4	1.500	1.7	0.002	0.3	13.4	4.5
Eriochloa contracta	1	2.9	0.250	0.3	T	T	3.2	1.1
Euphorbia dentata	3	8.6	1.500	1.7	0.007	1.0	11.3	3.8
Hibiscus trionum	3	8.6	5.500	6.2	0.007	1.0	15.8	5.3
Melilotus officinalis	1	2.9	0.250	0.3	0.001	0.1	3.3	1.1
Polygonum bicorne	1	2.9	0.250	0.3	T	T	3.2	1.1
Rumex crispus	1	2.9	0.500	0.6	0.005	0.7	4.2	1.4
Setaria lutescens	3	8.6	11.750	13.2	0.030	4.2	26.0	8.7
Setaria viridis	3	8.6	3.000	3.4	0.003	0.4	12.4	4.1
Solanum carolinense	1	2.9	0.250	0.3	0.001	0.1	3.3	1.1

Table V. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Sorghum vulgare	2	5.7	1.000	1.1	0.011	1.5	8.3	2.8
Taraxacum officinale	2	5.7	0.750	0.8	0.006	0.8	7.3	2.4

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table VI. Vegetational analysis of Area 3, October, 1967.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	1.4	0.250	0.4	0.001	0.1	1.9	0.6
Amaranthus tamariscinus	7	9.6	3.125	5.1	0.037	4.5	19.2	6.4
Ambrosia trifida	5	6.8	1.125	1.9	0.023	2.8	11.5	3.8
Buchloe dactyloides	7	9.6	13.125	21.7	0.252	30.7	62.0	20.7
Digitaria sanguinalis	2	2.7	1.000	1.7	0.005	0.6	5.0	1.7
Echinochloa crusgalli	8	11.0	4.500	7.5	0.044	5.4	23.9	8.0
Euphorbia maculata	4	5.5	1.500	2.5	0.009	1.1	9.1	3.0
Euphorbia supina	2	2.7	0.250	0.4	0.001	0.1	3.2	1.1
Festuca elatior	8	11.0	20.875	34.6	0.180	21.9	67.5	22.5
Kochia scoparia	1	1.4	0.125	0.2	0.003	0.4	2.0	0.7
Melilotus officinalis	7	9.6	1.625	2.7	0.019	2.3	14.6	4.9
Polygonum aviculare	2	2.7	0.250	0.4	0.002	0.2	3.3	1.1
Polygonum bicorne	8	11.0	5.875	9.7	0.165	20.1	40.8	13.6
Setaria lutescens	8	11.0	5.000	9.1	0.065	7.9	28.0	9.3

Table VI. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Trifolium pratense	1	1.4	0.250	0.4	T*	T	1.8	0.6
Trifolium repens	2	2.7	1.000	1.7	0.015	1.8	6.2	2.1

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table VII. Vegetational analysis of Area 3, June, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Bromus japonicus	3	6.7	0.375	0.5	0.003	0.4	7.6	2.5
Convolvulus arvensis	1	2.2	0.125	0.2	0.001	0.1	2.5	0.8
Euphorbia maculata	2	4.4	0.875	1.2	0.001	0.1	5.7	1.9
Euphorbia supina	2	4.4	0.625	0.8	T*	T	5.2	1.7
Festuca elatior	8	17.8	24.875	32.7	0.433	59.3	109.8	36.6
Lolium multiflorum	7	15.6	16.250	21.4	0.141	19.3	56.3	18.8
Medicago lupulina	2	4.4	0.250	0.3	0.001	0.1	4.8	1.6
Melilotus officinalis	6	13.3	0.875	1.2	0.023	3.2	17.7	5.9
Polygonum bicorne	2	4.4	0.250	0.3	T	T	4.7	1.6
Sporobolus asper	1	2.2	0.125	0.2	T	T	2.4	0.8
Trifolium repens	6	13.3	11.500	15.1	0.114	15.6	44.0	14.7
Ulmus rubra	5	11.1	19.875	26.2	0.013	1.8	39.1	13.0

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table VIII. Vegetational analysis of Area 3, August, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Convolvulus arvensis	1	2.2	1.000	1.2	0.001	0.1	3.5	1.2
Erigeron annuus	1	2.2	0.125	0.1	T*	T	2.3	0.8
Euphorbia maculata	3	6.7	1.375	1.6	0.003	0.4	8.7	2.9
Euphorbia supina	3	6.7	1.750	2.0	0.004	0.6	9.3	3.1
Festuca elatior	8	17.8	29.125	33.7	0.465	64.7	116.2	38.7
Lolium multiflorum	8	17.8	17.125	19.8	0.127	17.7	55.3	18.4
Medicago lupulina	1	2.2	0.125	0.1	0.001	0.1	2.4	0.8
Polygonum aviculare	1	2.2	0.125	0.1	T	T	2.3	0.8
Polygonum bicorne	2	4.4	0.250	0.3	T	T	4.7	1.6
Setaria lutescens	5	11.1	10.250	11.9	0.022	3.1	26.1	8.7
Trifolium pratense	1	2.2	0.125	0.1	0.001	0.1	2.4	0.8
Trifolium repens	6	13.3	14.625	16.9	0.087	12.1	42.3	14.1
Ulmus rubra	5	11.1	10.500	12.1	0.008	1.1	24.3	8.1

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table IX. Vegetational analysis of Area 3, October, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Ambrosia trifida	1	2.0	0.125	0.1	0.001	0.1	2.2	0.7
Convolvulus arvensis	1	2.0	2.125	2.4	0.014	1.8	6.2	2.1
Digitaria sanguinalis	5	10.2	2.125	2.4	0.005	0.6	13.2	4.4
Echinochloa crusgalli	2	4.1	0.625	0.7	0.002	0.3	5.1	1.7
Erigeron annuus	1	2.0	0.125	0.1	T*	T	2.1	0.7
Euphorbia maculata	6	12.2	1.875	2.2	0.009	1.1	15.5	5.2
Euphorbia supina	2	4.1	1.250	1.4	0.005	0.6	6.1	2.0
Festuca elatior	8	16.3	44.375	51.0	0.613	77.6	144.9	48.3
Melilotus officinalis	1	2.0	0.250	0.3	0.002	0.3	2.6	0.9
Polygonum aviculare	1	2.0	0.250	0.3	T	T	2.3	0.8
Polygonum bicorne	2	4.1	0.375	0.4	T	T	4.5	1.5
Setaria lutescens	7	14.3	21.250	24.4	0.058	7.3	46.0	15.3
Trifolium repens	6	12.2	7.250	8.3	0.077	9.7	30.2	10.1
Ulmus rubra	6	12.2	5.000	5.7	0.004	0.5	18.4	6.1

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table X. Vegetational analysis of Area 4, October, 1967. Species list determined from identification of plant remains.

Species	Species
Abutilon theophrasti	Medicago sativa
Amaranthus tamariscinus	Panicum dichotomiflorum
Ambrosia artemisiifolia	Panicum scribnerianum
Ambrosia trifida	Plantago aristata
Bromus sp.	Polygonum bicorne
Chenopodium album	Setaria lutescens
Chenopodium sp.	Setaria viridis
Cirsium altissimum	Solanum rostratum
Echinochloa crusgalli	Thlaspi arvense
Festuca sp.	Trifolium repens
Gaura sp.	Verbena sp.
Helianthus annuus	Xanthium sp.
Hibiscus trionum	

Table XI. Vegetational analysis of Area 4, June, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Bromus inermis	1	2.0	1.571	1.4	0.015	1.7	5.1	1.7
Bromus japonicus	6	12.0	2.286	2.1	0.029	3.2	17.3	5.8
Cynodon dactylon	1	2.0	0.143	0.1	0.001	0.1	2.2	0.7
Festuca elatior	5	10.0	14.286	13.1	0.074	8.3	31.4	10.5
Lactuca scariola	5	10.0	2.429	2.2	0.022	2.5	14.7	4.9
Lepidium virginicum	1	2.0	0.143	0.1	T*	T	2.1	0.7
Lolium multiflorum	7	14.0	8.286	7.6	0.108	12.1	33.7	11.2
Medicago sativa	5	10.0	1.571	1.4	0.080	9.0	20.4	6.8
Melilotus officinalis	2	4.0	0.286	0.3	0.010	1.1	5.4	1.8
Plantago aristata	4	8.0	3.286	3.0	0.012	1.3	12.3	4.1
Polygonum bicorne	1	2.0	0.143	0.1	0.001	0.1	2.2	0.7
Sorghum halepense	5	10.0	2.857	2.6	0.035	3.9	16.5	5.5
Trifolium repens	7	14.0	72.143	65.9	0.504	56.6	136.5	45.5

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table XII. Vegetational analysis of Area 4S, June, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Polygonum bicorne	1	50.0	34	61.8	0.113	62.4	174.2	58.1
Unknown grass	1	50.0	21	38.2	0.068	37.6	125.8	41.9

Table XIII. Vegetational analysis of Area 4, August, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Amaranthus tamariscinus	5	8.9	6.714	9.2	0.047	5.6	23.7	7.9
Bromus inermis	7	12.5	19.429	26.7	0.194	23.3	62.5	20.8
Chenopodium album	1	1.8	0.143	0.2	0.001	0.1	2.1	0.7
Digitaria sanguinalis	3	5.4	3.571	4.9	0.023	2.8	13.1	4.4
Eriochloa contracta	4	7.1	2.000	2.7	0.015	1.8	11.6	3.9
Festuca elatior	4	7.1	3.143	4.4	0.122	14.6	26.1	8.7
Lolium multiflorum	1	1.8	0.429	0.6	0.004	0.5	2.9	1.0
Medicago sativa	6	10.7	1.429	2.0	0.073	8.8	21.5	7.2
Poa pratensis	1	1.8	0.714	1.0	0.005	0.6	3.4	1.1
Polygonum convolvulus	1	1.8	0.143	0.2	0.002	0.2	2.2	0.7
Setaria faberii	6	10.7	4.571	6.3	0.048	5.8	22.8	7.6
Setaria lutescens	5	8.9	9.000	12.4	0.098	11.8	33.1	11.0
Setaria viridis	1	1.8	0.429	0.6	0.003	0.4	2.8	0.9
Sida spinosa	1	1.8	0.143	0.2	0.001	0.1	2.1	0.7

Table XIII. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Sorghum halepense	3	5.4	0.714	1.0	0.014	1.7	8.1	2.7
Trifolium repens	7	12.5	20.286	27.8	0.183	22.0	62.3	20.8

Table XIV. Vegetational analysis of Area 4S, August, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	14.3	2	2.4	0.004	0.6	17.3	5.8
Amaranthus tamariscinus	1	14.3	1	1.2	0.020	3.0	18.5	6.2
Euphorbia maculata	1	14.3	1	1.2	0.002	0.3	15.8	5.3
Lolium multiflorum	1	14.3	2	2.4	0.011	1.7	18.4	6.1
Polygonum bicorne	1	14.3	23	28.0	0.298	45.2	87.5	29.2
Setaria faberii	1	14.3	50	61.0	0.318	48.2	123.5	41.2
Trifolium repens	1	14.3	3	3.7	0.007	1.1	19.1	6.4

Table XV. Vegetational analysis of Area 4, October, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Amaranthus tamariscinus	5	10.9	3.000	7.3	0.037	8.9	27.1	9.0
Bromus inermis	5	10.9	4.857	11.8	0.043	10.4	33.1	11.0
Digitaria sanguinalis	2	4.3	2.000	4.9	0.017	4.1	13.3	4.4
Eriochloa contracta	4	8.7	3.429	8.4	0.024	5.8	22.9	7.6
Festuca elatior	4	8.7	1.143	2.8	0.022	5.3	16.8	5.6
Medicago sativa	4	8.7	1.000	2.4	0.016	3.9	15.0	5.0
Setaria faberii	6	13.0	6.429	15.7	0.113	27.3	56.0	18.7
Setaria lutescens	5	10.9	6.143	15.0	0.073	17.7	43.6	14.5
Setaria viridis	1	2.2	0.714	1.7	0.005	1.2	5.1	1.7
Sorghum halepense	3	6.5	0.714	1.7	0.009	2.2	10.4	3.5
Trifolium repens	7	15.2	11.571	28.2	0.055	13.3	56.7	18.9

Table XVI. Vegetational analysis of Area 4S, October, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	20.0	3	4.3	0.013	2.0	26.3	8.8
Amaranthus tamariscinus	1	20.0	1	1.4	0.017	2.6	24.0	8.0
Euphorbia maculata	1	20.0	1	1.4	0.003	0.5	21.9	7.3
Polygonum bicorne	1	20.0	25	35.7	0.320	49.5	105.2	35.1
Setaria faberii	1	20.0	40	57.1	0.294	45.4	122.5	40.8

Table XVII. Vegetational analysis of Area 5, October, 1967. Species list determined from identification of plant remains.

Species	Species
Abutilon theophrasti	Hibiscus trionum
Amaranthus tamariscinus	Kochia scoparia
Ambrosia trifida	Lespedeza striata
Bromus japonicus	Panicum capillare
Chenopodium album	Polygonum aviculare
Chloris verticillata	Polygonum bicorne
Cirsium sp.	Rumex crispus
Convolvulus arvensis	Setaria viridis
Cyperus esculentus	Sida spinosa
Echinochloa crusgalli	Solanum rostratum
Eleusine indica	Sorghum vulgare
Erigeron canadensis	Taraxacum officinale
Gutierrezia dracunculoides	Xanthium sp.
Helianthus annuus	

Table XVIII. Vegetational analysis of Area 5, June, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Ambrosia trifida	2	5.6	0.500	0.2	0.007	0.7	6.5	2.2
Bromus japonicus	4	11.1	218.250	81.7	0.447	46.0	138.8	46.3
Carex sp.	2	5.6	10.750	4.0	0.023	2.4	12.0	4.0
Convolvulus arvensis	3	8.3	3.750	1.4	0.066	6.8	16.5	5.5
Echinochloa crusgalli	1	2.8	17.750	6.6	0.048	4.9	14.3	4.8
Erigeron annuus	1	2.8	1.250	0.5	0.082	8.4	11.7	3.9
Erigeron canadensis	2	5.6	2.000	0.7	0.018	1.9	8.2	2.7
Gaura biennis	1	2.8	0.250	0.1	0.019	2.0	4.9	1.6
Helianthus annuus	1	2.8	0.250	0.1	0.011	1.1	4.0	1.3
Hordeum pusillum	1	2.8	0.250	0.1	T*	T	2.9	1.0
Lactuca scariola	4	11.1	4.750	1.8	0.114	11.7	24.6	8.2
Medicago lupulina	1	2.8	0.250	0.1	0.002	0.2	3.1	1.0
Oxalis stricta	1	2.8	0.250	0.1	0.003	0.3	3.2	1.1
Polygonum bicorne	2	5.6	1.500	0.6	0.013	1.3	7.5	2.5
Physalis virginiana	1	2.8	0.500	0.2	0.016	1.6	4.6	1.5

Table XVIII. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Rumex crispus	3	8.3	1.500	0.6	0.031	3.2	12.1	4.0
Taraxacum officinale	4	11.1	2.500	0.9	0.050	5.1	17.1	5.7
Trifolium repens	1	2.8	0.750	0.3	0.007	0.7	3.8	1.3
Ulmus rubra	1	2.8	0.250	0.1	0.015	1.5	4.4	1.5

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table XIX. Vegetational analysis of Area 5, August, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Abutilon theophrasti	1	1.8	2.167	1.7	0.003	0.4	3.9	1.3
Amaranthus tamariscinus	1	1.8	0.333	0.3	0.001	0.1	2.2	0.7
Ambrosia trifida	3	5.5	1.333	1.1	0.065	8.4	15.0	5.0
Chenopodium album	2	3.6	0.333	0.3	0.002	0.2	4.1	1.4
Chloris verticillata	1	1.8	0.050	0.4	0.008	1.0	3.2	1.1
Convolvulus arvensis	2	3.6	7.000	5.5	0.146	18.9	28.0	9.3
Cyperus esculentus	3	5.5	7.487	5.9	0.069	8.9	20.3	6.8
Digitaria sanguinalis	1	1.8	1.333	1.1	0.007	0.9	3.8	1.3
Echinochloa crusgalli	2	3.6	3.167	2.5	0.040	5.2	11.3	3.8
Erigeron canadensis	1	1.8	1.667	1.3	0.001	0.1	3.2	1.1
Eriochloa contracta	2	3.6	0.667	0.5	0.003	0.4	4.5	1.5
Gaura biennis	1	1.8	0.333	0.3	0.022	2.9	5.0	1.7
Kochia scoparia	2	3.6	3.500	2.8	0.039	5.1	11.5	3.8
Lactuca scariola	1	1.8	0.333	0.3	0.010	1.3	3.4	1.1
Lespedeza striata	2	3.6	0.833	0.7	0.008	1.0	5.3	1.8

Table XIX. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Melilotus officinalis	2	3.6	0.667	0.5	0.015	1.9	6.0	2.0
Physalis virginiana	1	1.8	0.333	0.3	0.015	1.9	4.0	1.3
Poa pratensis aff.	2	3.6	72.500	57.3	0.037	4.8	65.7	21.9
Polygonum aviculare	2	3.6	2.333	1.8	0.013	1.7	7.1	2.4
Polygonum bicorne	5	9.1	3.500	2.8	0.035	4.5	16.4	5.5
Rumex crispus	3	5.5	2.500	2.0	0.079	10.2	17.7	5.9
Schedonnardus paniculatus	1	1.8	0.500	0.4	0.005	0.7	2.9	1.0
Setaria lutescens	5	9.1	7.833	6.2	0.067	8.7	24.0	8.0
Taraxacum officinale	5	9.1	1.500	1.2	0.042	5.4	15.7	5.2
Trifolium repens	2	3.6	2.667	2.1	0.006	0.8	6.5	2.2
Ulmus rubra	1	1.8	0.667	0.5	0.003	0.4	2.7	0.9
Xanthium pensylvanicum	1	1.8	0.500	0.4	0.030	3.9	6.1	2.0

Table XX. Vegetational analysis of Area 5, October, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Amaranthus tamariscinus	3	6.0	1.000	0.4	0.025	4.3	10.7	3.6
Aristida oligantha	1	2.0	1.333	0.5	0.018	3.1	5.6	1.9
Chloris verticillata	1	2.0	0.167	0.1	0.003	0.5	2.6	0.9
Convolvulus arvensis	5	10.0	16.333	6.5	0.107	18.5	35.0	11.7
Digitaria sanguinalis	2	4.0	2.167	0.9	0.007	1.2	6.1	2.0
Echinochloa crusgalli	4	8.0	1.667	0.7	0.019	3.3	12.0	4.0
Eriochloa contracta	3	6.0	3.167	1.3	0.008	1.4	8.7	2.9
Festuca elatior	1	2.0	0.167	0.1	0.002	0.3	2.4	0.8
Kochia scoparia	1	2.0	0.167	0.1	0.002	0.3	2.4	0.8
Poa pratensis aff.	5	10.0	179.667	71.1	0.109	18.9	100.0	33.3
Polygonum aviculare	1	2.0	0.333	0.1	T*	T	2.1	0.7
Polygonum bicorne	5	10.0	5.167	2.1	0.065	11.2	23.3	7.8
Rumex crispus	4	8.0	2.167	0.9	0.083	14.4	23.3	7.8
Schedonnardus paniculatus	1	2.0	0.500	0.2	0.005	0.9	3.1	1.0
Setaria lutescens	5	10.0	30.367	12.2	0.071	12.3	34.5	11.5

Table XX. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Setaria viridis	1	2.0	1.667	0.7	0.002	0.3	3.0	1.0
Taraxacum officinale	4	8.0	3.167	1.3	0.050	8.7	18.0	6.0
Trifolium repens	1	2.0	0.167	0.1	T	T	2.1	0.7
Ulmus rubra	1	2.0	0.167	0.1	0.001	0.2	2.3	0.8
Xanthium pensylvanicum	1	2.0	0.167	0.1	0.001	0.2	2.3	0.8

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table XXI. Vegetational analysis of Area 6, October, 1967. Species list determined from identification of plant remains.

Species	Species
Amaranthus tamariscinus	Gaura biennis
Ambrosia artemisiifolia	Hibiscus trionum
Ambrosia trifida	Lespedeza striata
Aristida oligantha	Panicum capillare
Digitaria sanguinalis	Polygonum bicorne
Echinochloa crusgalli	Setaria lutescens
Eragrostis pectinacea	Setaria viridis
Euphorbia dentata	Solanum rostratum
Euphorbia maculata	Ulmus rubra

Table XXII. Vegetational analysis of Area 6, June, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Ambrosia psilostachya	5	6.1	8.250	3.9	0.039	5.6	15.6	5.2
Ambrosia trifida	7	8.5	4.625	2.2	0.038	5.5	16.2	5.4
Bromus japonicus	1	1.2	0.125	0.1	T*	T	1.3	0.4
Chloris verticillata	1	1.2	1.625	0.8	0.007	1.0	3.0	1.0
Convolvulus arvensis	1	1.2	0.500	0.2	0.003	0.4	1.8	0.6
Cyperus filiculmis	1	1.2	0.125	0.1	T	T	1.3	0.4
Euphorbia maculata	5	6.1	1.875	0.9	0.002	0.3	7.3	2.4
Helianthus annuus	5	6.1	9.125	4.3	0.045	6.5	16.9	5.6
Hibiscus trionum	7	8.5	3.500	1.7	0.012	1.7	11.9	4.0
Lactuca scariola	1	1.2	0.125	0.1	0.001	0.1	1.4	0.5
Lespedeza striata	8	9.8	34.000	16.0	0.172	24.7	50.5	16.8
Medicago lupulina	7	8.5	8.375	4.0	0.052	7.5	20.0	6.7
Oxalis stricta	1	1.2	0.250	0.1	T	T	1.3	0.4
Physalis virginiana	1	1.2	0.125	0.1	T	T	1.3	0.4
Polygonum convolvulus	1	1.2	0.125	0.1	0.001	0.1	1.4	0.5

Table XXII. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Polygonum bicorne	5	6.1	3.875	1.8	0.003	0.4	8.3	2.8
Rhus radicans	1	1.2	0.125	0.1	0.002	0.3	1.6	0.5
Setaria lutescens	8	9.8	50.250	23.7	0.151	21.7	55.2	18.4
Sporobolus vaginiflorus	8	9.8	76.125	35.9	0.163	23.4	69.1	23.0
Ulmus rubra	8	9.8	8.875	4.2	0.006	0.9	14.9	5.0

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table XXIII. Vegetational analysis of Area 6, August, 1968.

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Ambrosia psilostachya	4	5.1	5.375	5.2	0.065	7.7	18.0	6.0
Ambrosia trifida	4	5.1	3.125	3.0	0.075	8.9	17.0	5.7
Chloris verticillata	2	2.6	0.625	0.6	0.004	0.5	3.7	1.2
Convolvulus arvensis	1	1.3	0.500	0.5	0.003	0.4	2.2	0.7
Eragrostis intermedia	2	2.6	0.250	0.2	0.014	1.7	4.5	1.5
Leptochloa contracta	4	5.1	6.000	5.9	0.031	3.7	14.7	4.9
Euphorbia dentata	3	3.9	0.625	0.6	0.004	0.5	5.0	1.7
Euphorbia maculata	5	6.4	1.875	1.8	0.011	1.3	9.5	3.2
Helianthus annuus	2	2.6	2.875	2.8	0.016	1.9	7.3	2.4
Hibiscus trionum	7	9.0	3.750	3.7	0.019	2.3	15.0	5.0
Lactuca scariola	1	1.3	0.125	0.1	0.002	0.2	1.6	0.5
Lespedeza striata	8	10.3	21.875	21.3	0.216	25.7	57.3	19.1
Medicago sativa	3	3.9	0.375	0.4	0.006	0.7	5.0	1.7
Melilotus officinalis	1	1.3	3.500	4.1	0.038	4.5	9.9	3.3
Polygonum bicorne	3	3.9	1.250	1.2	0.006	0.7	5.8	1.9

Table XXIII. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Setaria lutescens	8	10.3	28.000	27.3	0.212	25.2	62.8	20.9
Setaria viridis	6	7.7	6.125	6.0	0.028	3.3	17.0	5.7
Solidago altissima	1	1.3	0.500	0.5	0.005	0.6	2.4	0.8
Solidago missouriensis	1	1.3	1.375	1.3	0.010	1.2	3.8	1.3
Sporobolus vaginiflorus	8	10.3	13.500	13.2	0.062	7.4	30.9	10.3
Ulmus rubra	3	3.9	0.750	0.7	0.013	1.5	6.1	2.0
Xanthium pensylvanicum	1	1.3	0.125	0.1	0.001	0.1	1.5	0.5

Table XXIV. **Vegetational analysis of Area 6, October, 1968.**

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
[illegible] theophrasti	1	1.4	0.125	0.1	T*	T	1.5	0.5
[illegible] elegantha	3	4.2	1.250	1.0	0.004	0.7	5.9	2.0
[illegible] album	2	2.8	0.250	0.2	T	T	3.0	1.0
[illegible] verticillata	1	1.4	0.125	0.1	0.001	0.2	1.7	0.6
[illegible] arvensis	1	1.4	0.375	0.3	0.002	0.4	2.1	0.7
[illegible] sanguinalis	6	8.3	3.625	2.8	0.015	2.8	13.9	4.6
[illegible] crusgalli	8	11.1	13.500	10.4	0.093	17.3	38.8	12.9
[illegible] contracta	2	2.8	2.625	2.0	0.010	1.9	6.7	2.2
[illegible] ciliata	1	1.4	0.125	0.1	T	T	1.5	0.5
[illegible] annuus	3	4.2	0.875	0.7	0.002	0.4	5.3	1.8
[illegible] trionum	3	4.2	0.500	0.4	0.001	0.2	4.8	1.6
[illegible] striata	5	6.9	44.125	34.0	0.112	20.8	61.7	20.6
[illegible] officinalis	5	6.9	1.500	1.2	0.010	1.9	10.0	3.3
[illegible] capillare	3	4.2	0.625	0.5	0.003	0.6	5.3	1.8
[illegible] dichotomiflorum	3	4.2	0.625	0.5	0.004	0.7	5.4	1.8

Table XXIV. (continued)

Species	Freq.	Rel. Freq.	Den.	Rel. Den.	Area Occupied	Rel. Area Occupied	Importance Value	Importance Percentage
Polygonum aviculare	1	1.4	0.125	0.1	T	T	1.5	0.5
Polygonum bicorne	1	1.4	0.125	0.1	0.002	0.4	1.9	0.6
Setaria lutescens	8	11.1	30.000	23.1	0.184	34.2	68.4	22.8
Setaria viridis	6	8.3	5.250	4.0	0.007	1.3	13.6	4.5
Sida spinosa	1	1.4	0.375	0.3	T	T	1.7	0.6
Sporobolus vaginiflorus	6	8.3	22.125	17.0	0.078	14.5	39.8	13.3
Trifolium repens	1	1.4	1.500	1.2	0.010	1.9	4.5	1.5
Ulmus rubra	1	1.4	0.125	0.1	T	T	1.5	0.5

*T - trace, area occupied less than 0.001 of the entire area of all the quadrats.

Table XXV. Inorganic chemical properties of the soil from Area 1.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
October, 1967						
0-6"	6.8	1.50	900	6300	0.204	*
6-12"	6.7	1.56	1080	8100	0.185	9.58

* - test results indicate concentrations above 10.00 ppm; test is not accurate for concentrations above 10.00 ppm.

Table XXVI. Inorganic chemical properties of the soil from Area 2.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
October, 1967						
0-6"	6.4	0.99	920	5000	0.146	4.00
6-12"	6.4	0.96	1260	5400	0.132	3.28
June, 1968						
0-6"	6.6	0.90	800	6600	0.159	5.85
6-12"	6.2	0.87	1400	7400	0.140	4.40
August, 1968						
0-6"	7.0	1.02	1040	6200	0.146	3.61
6-12"	7.0	0.75	1260	6600	0.133	3.40
October, 1968						
0-6"	6.7	1.14	810	4800	0.142	4.24
6-12"	6.5	0.96	1030	5600	0.128	3.40

Table XXVII. Inorganic chemical properties of the soil from Area 3.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
October, 1967						
0-6"	7.3	1.26	880	6200	0.144	5.20
6-12"	7.3	1.14	880	5900	0.089	5.46
June, 1968						
0-6"	7.2	1.20	1000	5300	0.134	3.75
6-12"	7.5	0.94	620	8200	0.087	5.85
August, 1968						
0-6"	7.7	1.05	700	5600	0.132	5.28
6-12"	8.3	0.98	800	7200	0.072	5.63
October, 1968						
0-6"	7.7	1.17	960	7000	0.139	5.63
6-12"	7.8	1.02	750	8000	0.086	5.39

Table XXVIII. Inorganic chemical properties of the soil from Area 4.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
October, 1967						
0-6"	7.3	1.02	720	5400	0.123	6.52
6-12"	7.3	0.87	890	5300	0.109	5.85
June, 1968						
0-6"	7.6	1.02	720	5600	0.134	7.18
6-12"	7.5	0.93	840	6300	0.115	7.18
August, 1968						
0-6"	7.5	1.23	850	6800	0.122	5.63
6-12"	7.6	0.84	790	6400	0.111	5.63
October, 1968						
0-6"	7.7	1.29	830	6300	0.126	7.28
6-12"	7.7	0.93	880	6700	0.106	6.18

Table XXIX. Inorganic chemical properties of the soil from Area 4S.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
June, 1968						
0-6"	7.7	0.87	780	6200	0.122	7.28
6-12"	7.7	0.66	750	7100	0.109	7.40
August, 1968						
0-6"	7.6	0.66	990	7200	0.131	7.15
6-12"	7.7	0.87	730	5100	0.108	6.73
October, 1968						
0-6"	7.6	1.14	830	5600	0.120	7.00
6-12"	7.8	0.78	780	5700	0.108	6.38

Table XXX. Inorganic chemical properties of the soil from Area 5.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
October, 1967						
0-6"	7.8	2.01	630	4400	0.167	*
6-12"	7.4	1.65	790	5000	0.169	*
June, 1968						
0-6"	7.9	0.72	750	5200	0.179	8.00
6-12"	7.6	1.41	550	3600	0.183	8.00
August, 1968						
0-6"	8.2	0.69	600	4500	0.180	*
6-12"	7.7	1.14	550	3200	0.182	*
October, 1968						
0-6"	8.2	1.23	720	5300	0.188	9.00
6-12"	7.7	1.17	580	3700	0.174	*

* - test results indicate concentrations above 10.00 ppm; test is not accurate for concentrations above 10.00 ppm.

Table XXXI. Inorganic chemical properties of the soil from Area 6.

Date and soil profile level	pH	Organic carbon %	Exchangeable cations ppm Mg	Ca	Total N %	Total P ppm
October, 1967						
0-6"	7.3	0.99	740	4000	0.134	3.20
6-12"	7.5	0.75	840	4500	0.123	3.33
June, 1968						
0-6"	7.4	0.69	1240	6800	0.136	3.40
6-12"	6.9	1.02	1180	5400	0.122	3.90
August, 1968						
0-6"	7.0	0.78	1290	6300	0.128	3.52
6-12"	6.7	0.96	1440	6100	0.119	3.30
October, 1968						
0-6"	7.8	0.75	990	5000	0.128	3.20
6-12"	7.5	0.84	1220	6100	0.124	3.90

Table XXXII. Isolated phenolic compounds from soil extracts, leaf extracts of Polygonum bicorne, and solutions of three known phenolic compounds. All runs were made on Whatman No. 1 chromatography paper. Rf values were averages of four runs. Color reactions were recorded for zones tested with phenolic indicators and ultraviolet light, with and without exposure to ammonia fumes.

Material	Rf values		Short and Long UV		$FeCl_3$-$K_3Fe(CN)_6$	Hoepfner's Reaction
	*BAW	**2% AA	$-NH_3$	$+NH_3$		
Area 2, Oct., 1967						
*** Zone a	0.92	0.47	lt. bl.	bl.	lt. bl.	0
Zone b	0.92	0.71	lt. bl.	lt. bl.	lt. bl.	0
Area 2, Oct., 1968	0.92	0.45	lt. bl.	bl.	lt. bl.	0
Area 3, Oct., 1967						
Zone a	0.94	0.33	lt. bl.	bl.	none	0
Zone b	0.93	0.47	lt. bl.	bl.	lt. bl.	0
Zone c	0.93	0.71	lt. bl.	lt. bl.	lt. bl.	0
Area 3, Oct., 1968	0.92	0.47	lt. bl.	bl.	lt. bl.	0
Area 4, Aug., 1968	0.92	0.45	lt. bl.	bl.	lt. bl.	0
Area 4S, Aug., 1968	0.92	0.46	lt. bl.	bl.	lt. bl.	0
Area 7, July, 1969	0.92	0.46	lt. bl.	lt. bl.	lt. bl.	0

Table XXXII. (continued)

Material	Rf values *BAW	Rf values **2% AA	Short and Long UV -NH_3	Short and Long UV +NH_3	$FeCl_3$-$K_3Fe(CN)_6$	Hoepfner's Reaction
Polygonum bicorne						
Zone a	0.36	0.33	pk.	yel.	bl.	0
Zone b	0.93	0.45	lt. bl.	bl.	bl.	0
Zone c	0.91	0.72	lt. bl.	DEG	bl.	+
Chlorogenic acid	0.55	0.62-0.76	bl.	DEG	dk. bl.	+
Caffeic acid	0.79	0.00-0.38	bl.	bl.	dk. bl.	0
Quinic acid			none	none	none	0

* BAW, n-butanol-acetic acid-water (63-10-27 v/v).
** 2% AA, aqueous acetic acid.
*** Zone a, if several zones were found on a chromatogram, they were randomly designated as zones a, b, or c.
Colors - lt., light; dk., dark; bl., blue; pk., pink; yel., yellow; DEG, duck-egg green.

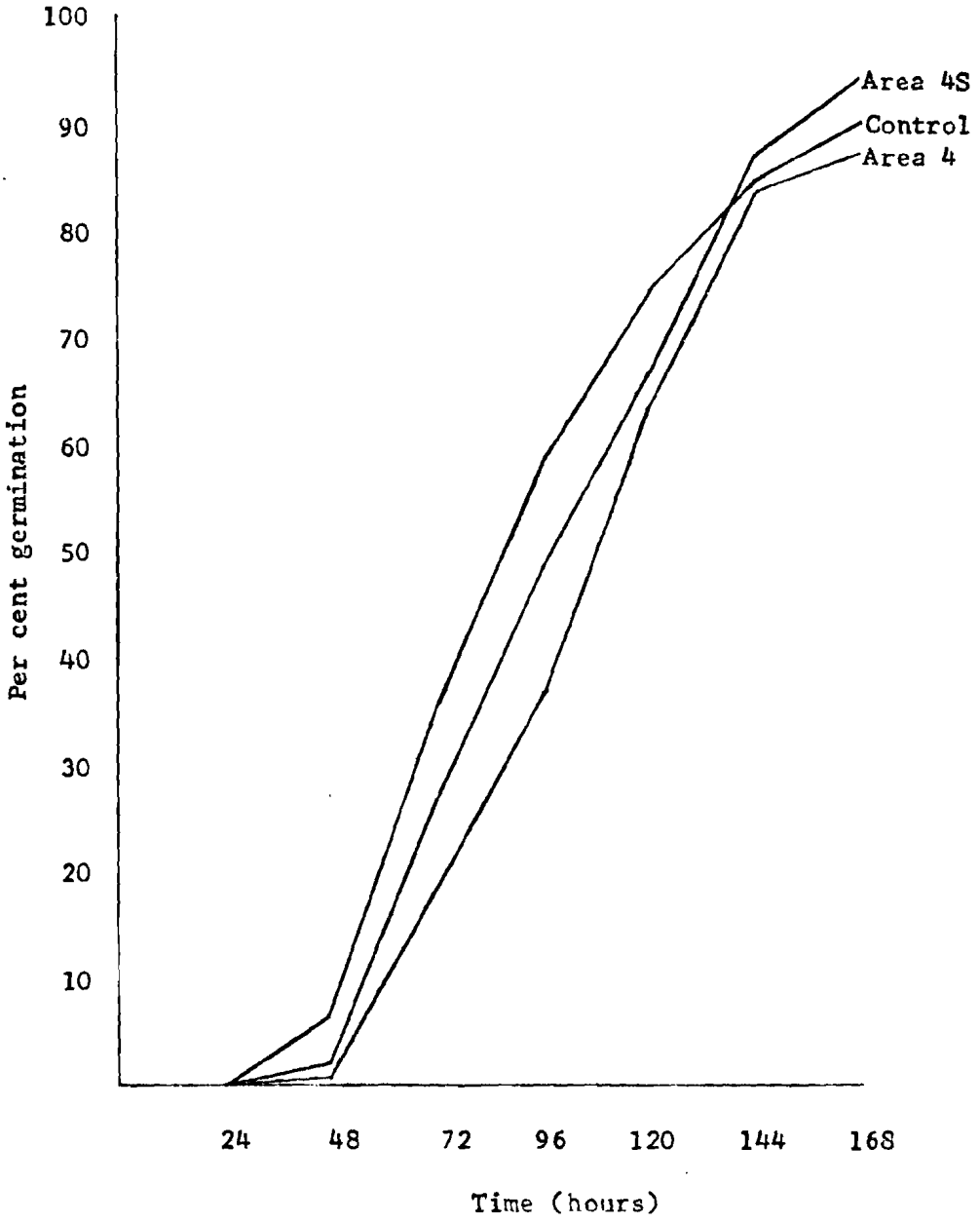


Figure 1. Retardation of the germination rate of tomato seeds by solutions prepared from phenolic compounds eluted from chromatograms of soil extracts prepared from soils collected during August, 1968, from the 0-6" soil profile level of Areas 4 and 4S.

Table XXXIII. Mean root-shoot length ± standard error of tomato seedlings after germination and growth for 168 hr in a control solution and solutions prepared from the phenolic compounds eluted from chromatograms of soils collected during August, 1968, from the 0-6" soil profile level of study Areas 4 and 4S.

Source of Solution	Mean length of root-shoot (cm) ± standard error
Area 4	2.6 ± 0.15 *
Area 4S	3.9 ± 0.27 **
Control	4.8 ± 0.26

* t-value for this test when compared to the control and to Area 4S indicated a significant difference at or below the 1% level.

** t-value for this test when compared to the control indicated a significant difference at or below the 5% level.

LITERATURE CITED

LITERATURE CITED

Adams, R. 1968. The characterization, isolation, and identification of inhibitory compounds from Polygonum longistylum Small. Graduate research paper (Unpublished), Kansas State Teachers College, Emporia.

Allison, F. E. 1957. Nitrogen and soil fertility. p. 85-94. In U. S. Department of Agriculture. Soil, the yearbook of agriculture. U. S. Govt. Printing Office, Washington. 784 p.

Bailey, E. 1944. Hydrogen ion concentrations of the important soils of the United States in relation to other profile characteristics I. Pedocal soils. Soil Sci. 57(6):443-474.

Benedict, H. M. 1941. Inhibitory effect of dead roots on the growth of bromegrass. Agron. J. 33:1108-1109.

Bennet, E. L. and J. Bonner. 1953. Isolation of plant growth inhibitors from Thamnosa montana. Amer. J. Bot. 40:29-33.

Bidwell, O. W. 1956. Major soils of Kansas. Kansas Agr. Exp. Sta. Circ. 336. Manhattan.

Billings, W. D. 1941. Quantitative correlations between vegetational changes and soil development. Ecology 22(4):448-456.

Billings, W. D. 1950. Vegetation and plant growth as affected by chemically altered rocks in the Western Great Basin. Ecology 31:62-74.

Black, C. A. 1957. Soil-plant relationships. John Wiley and Sons, Inc., New York. 332 p.

Bonner, J. and A. W. Galston. 1944. Toxic substances from the culture media of guayule which may inhibit growth. Bot. Gaz. 106:185-198.

Caine, S. A. 1938. The species-area curve. Amer. Midl. Natur. 17:573-581.

Clements, F. E. 1928. Plant succession and indicators. H. W. Wilson Co., New York. 453 p.

Cox, L. D., H. M. Munger, and E. A. Smith. 1945. A germination inhibitor in the seed coats of certain varieties of cabbage. Plant Physiol. 20:289-294.

Curtis, J. T. and G. Cottam. 1950. Antibiotic and antitoxic effects in prairie sunflower. Bull. Torrey Bot. Club 77:187-191.

Funke, G. L. 1943. The influence of Artemisia absinthium on neighboring plants. Blumea 5:281-293.

Gray, R. and J. Bonner. 1940. An inhibitor of plant growth from the leaves of Encelia farinosa. Amer. J. Bot. 35:52-57.

Hemberg, T. 1961. Biogenous inhibitors. Encycl. Plant Physiol. 14:1162-1183.

Jackson, M. L. 1958. Soil chemical analysis. Prentice-Hall, Inc., Englewood Cliffs, N. J. 498 p.

Konis, E. 1947. On germination inhibitors VI. The inhibitory action of leaf-saps on germination and growth. Pal. J. Bot., J. Series 4:77-84.

Kornhaus, D. W. 1965. Vegetation and soil relationships in a native tall grass prairie invaded by Rhus glabra L. in east central Kansas. Graduate research paper (Unpublished), Kansas State Teachers College, Emporia.

Mayer, A. M. and M. Evenari. 1952. The relation between the structure of coumarin and its derivatives, and their activity as germination inhibitors. J. Exp. Bot. 3:246-262.

Neill, R. L. 1967. The possible inhibitory effects of Polygonum lapathifolium L., P. longistylum Small, and P. pennsylvanicum L. Graduate research paper (Unpublished), Kansas State Teachers College, Emporia.

Oosting, H. J. 1956. The study of plant communities. W. H. Freeman and Company, San Francisco. 440 p.

Paulus, D. 1968. Inhibitional effects of Polygonum longistylum Small on P. longistylum. Graduate research paper (Unpublished), Kansas State Teachers College, Emporia.

Perkins, A. T. and W. F. Schrenk. 1948. The analysis and characterization of selected Kansas soils. Trans. Kansas Acad. Sci. 51(2):215-223.

Peterson, E. B. 1965. Inhibition of black spruce primary roots by a water soluble substance in Kalmia angustifolia. Forest Sci. 11(4):473-480.

Piper, C. S. 1942. Soil and plant analysis. Interscience Publishers, Inc., New York. 368 p.

Rice, E. L. 1964. Inhibition of nitrogen-fixing and nitrifying bacteria by seed plants (I.). Ecology 45(4):824-837.

Rice, E. L. 1965a. Inhibition of nitrogen-fixing and nitrifying bacteria by seed plants IV. The inhibitors produced by Ambrosia elatior and A. psilostachya. Southwest. Natur. 10(4):248-255.

Rice, E. L. 1965b. Inhibition of nitrogen-fixing and nitrifying bacteria by seed plants II. Characterization and identification of inhibitors. Physiol. Plant. 18:255-268.

Rice, E. L. and R. Parenti. 1967. Inhibition of nitrogen-fixing and nitrifying bacteria by seed plants V. Inhibitors produced by Bromus japonicus Thunb. Southwest. Natur. 12(1):97-103.

Roberts, E. A. H. and D. J. Wood. 1951. The polyphenols and amino acids of tobacco leaf. Arch. Biochem. and Biophys. 33:299-303.

Schaal, L. A. and G. Johnson. 1955. The inhibitory effect of phenolic compounds on the growth of Streptomyces scabies as related to scab resistance. Phytopathol. 45:626-628.

Schreiner, O. and H. S. Reed. 1907. Certain organic constituents of soil in relation to soil fertility. U. S. Dep. of Agr., Bur. of Soils Bull. 47.

Sewell, M. C. and W. L. Latshaw. 1925. A soil study in Scott County, Kansas. Trans. Kansas Acad. Sci. 31:81-86.

Smith, I. 1960. Chromatographic and electrophoretic techniques. Interscience Publishers, Inc., New York. 617 p.

Steyermark, J. 1964. Flora of Missouri. Iowa State University Press, Ames, Iowa. 1725 p.

Went, F. W. 1948. Ecology of desert plants I. Observations on the germination in the Joshua Tree National Forest, California. Ecology 29:242-253.

Wilde, S. A., S. F. Burnan, and H. M. Galloway. 1937. Nutrient content and base exchange properties of the organic layers of forest soils in the Lake States region. Soil Sci. 44:231-238.

APPENDIX

PROCEDURE FOR DETERMINING EXCHANGEABLE CALCIUM AND MAGNESIUM[1]

Atomic Absorption Method

I. Reagents

A. Extracting Solution: Neutral Normal Ammonium Acetate
Add 1400 ml of ammonium hydroxide to about 10 liters of distilled water. Then add 1160 ml of glacial acetic acid. Shake vigorously. Dilute to 20 liters with redistilled water. Adjust to pH of 7.0 using ammonium hydroxide or acetic acid.

B. Standard Calcium Solution
Use certified 1000 ppm standard or dissolve 1.00 grams of pure $CaCO_3$ in sufficient amount of concentrated redistilled HCl and dilute with redistilled water to one liter. This solution contains 400 ppm calcium. Prepare other standards as follows:

Standard ppm Ca	Soil ppm Ca	ml of 400 ppm required	Dilute to Final Volume
1	500	0.5	200
2	1000	1	200
4	2000	2	200
8	4000	4	200
10	5000	5	200
20	10000	10	200

C. Standard Magnesium Solution
Use certified magnesium standard or dissolve 1.0 grams of pure magnesium metal in a sufficient amount of concentrated redistilled hydrochloric acid and dilute to one liter. This will give 1000 ppm magnesium. Dilute 100 ml of this to 1000 ml to obtain a 100 ppm magnesium standard. Again dilute 100 ml of this to 1000 ml for a 10 ppm standard and use this 10 ppm standard to prepare the following:

Standard ppm Mg	Soil ppm Mg	ml of 10 ppm required	Dilute to Final Volume
0.25	125	2.5	100
0.50	250	5.0	100
1.00	500	10.0	100
2.00	1000	20.0	100
3.00	1500	30.0	100
5.00	2500	50.0	100

[1]Adapted from letter from Harris Laboratories, Lexington, Nebraska.

II. Determination

Measure out 2 grams of soil with a measuring spoon into a plastic vial. Add 10 ml of extracting solution from an automatic dispensing pipette and shake in a mechanical shaker for 30 minutes. Dilute 0.5 ml of the extract to 50 ml and use this diluted extract to determine calcium and magnesium on a #290 atomic absorption unit.