GROWTH INHIBITION STUDIES WITH SELECTED NATIVE RANGE PLANTS

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CHAPTER I

INTRODUCTION

There are many millions of uncultivable acres in the United States suited only for native range. Forage production from these areas is low and any prospect of intensive usage is discouraging. Along with such things as low soil fertility and poor soil structure, low performance is often attributed to competition presented by weeds or to "soil sickness" (Muller, 1966).

The so-called "soil sickness" problem, familiar to most agronomists in nature if not by name, has in recent years received renewed interest as a real and tangible soil problem. Progressively decreased productivity with continuous planting of the same crop, even when fertility and proper cultivation practices are maintained, and decreased productivity due to the presence of weeds has been partially attributed to the antibiotic effect that certain plant exudates, extracts or by-products have on plant growth.

This study was conducted with selected range species and other plants in an effort to uncover some antagonistic actions and to study the nature of those actions between species. Perhaps this information may help explain, in part, the inter-relationships and effects within a range plant association.

CHAPTER II

LITERATURE REVIEW

Weed competition for moisture, light, and soil nutrients does not nearly account for the decreased production of many crops (Garb, 1961). Furthermore, repeated plantings of the same crop in grain belts of the world produced progressively smaller yields, even with conditions of optimum tillage and fertilization (Loehwing, 1937). These phenomena led many researchers to investigate the possibility of growth inhibitors produced by plants. This idea has intrigued agriculturists since it was first postulated by DeCondolle in 1832 (Garb, 1961).

Allelopathy has been defined as any direct or indirect deleterious effect that one plant has on another through the production of chemical compounds that escape into the environment (Wilson and Rice, 1968). The significance of allelopathy to agricultural and ecological theory appears to be very great. Small quantities of toxins may be responsible for deranged water or mineral absorption and massive reductions in plant growth. Traditional theories of competition are all subject to re-evaluation where allelopathy can be demonstrated.

Plants produce compounds which must be excreted, whether into the atmosphere or the soil, a fact to which we often blind ourselves because plants have no distinctly recognizable excretory system. Muller (1965) found that terpenes volatilizing from the leaf surfaces of Salvia leucophylla, especially during times of high temperature, were

causing the inhibition of certain surrounding plants. He at first thought the surrounding plants absorbed the volatile terpenes in the cuticle layer of their leaves. Later research (Muller and del Moral, 1966) indicated it was more likely the terpenes were accumulated by the colloidal soil fraction and gained eventual entry into the plants through the root system. Muller agreed, as do most authors, that soil is the distributive medium for the chemicals responsible for allelopathy.

Garb (1961) noted that the production of plant growth inhibitors was widespread throughout the plant kingdom, encompassing agricultural and woodland plants and the lower class and phyla of fungi and bacteria. Numerous authors have contended that where microorganisms were thought responsible for stunting of plant growth, the action was due solely to microbial tie-up of nitrogen (Kimber, 1967). However, Kimber's (1967) work with aseptic extracts of rotting wheat (Triticum aestivum) straw applied to oat (Avena sativa) and wheat seeds showed that extracts made from straw that had rotted 2-4 days was more toxic than other wheat straw extracts to oat and wheat seedling growth. Experimentation by other researchers revealed similar results (Behmer and McCalla, 1963; Patrick and Koch, 1958).

The compounds produced by both higher class plants and microorganisms cover a wide range of organic chemicals. Abdul-Wahab and Rice (1967) found a number of growth inhibitory compounds in Johnsongrass (Sorghum halepense), the most abundant of which could be classified as phenolics. Wilson and Rice (1968) reported that sunflower (Helianthus annuus) contained copious amounts of inhibitory compounds classified as phenolics. Mountain mahogany (Cercocarpus montanus)

achenes contained growth inhibitors tentatively identified as cyanide (Moore, 1963). Woods (1960) named fifteen types, classes, or groups of chemical compounds which contained members proven inhibitory to plant growth. Plant growth inhibitors seem to have a somewhat similar action to antibiotics in that often chemically non-related compounds have an overlapping spectra of activity.

Guenzi and McCalla (1966) classified growth inhibitory compounds as merely acidic, basic, or neutral, noting that generally the acidic compounds were most inhibitory and neutral compounds the least toxic. Although Guenzi and McCalla found that acidic compounds seemed the most inhibitory, the pH alone rarely, if ever, appeared to be the sole cause for, or even contributory to toxicity (LeTourneau et al., 1956; Moore, 1963). Nor did the osmotic pressure of these chemicals at tested concentrations cause any apparent growth inhibitory actions (Knipe and Herbel, 1966; LeTourneau et al., 1956; Moore, 1963).

Loehwing (1937) indicated that injuries by plant inhibitory compounds were generally characterized by slow root growth, inadequate or deranged nutrient absorption, chlorosis, premature leaf abscission in trees, slow maturation, delay or failure of reproduction, and waxy color of fruit when formed. McCalla and Haskins (1964) were somewhat more specific. They speculated that plant-produced inhibitory compounds were instrumental in the replant problem in peaches and citrus, the soil binding of bromegrass, and stunting of corn associated with stubble mulching.

Although all life stages of many plants can be affected by the same chemical inhibitor, the seedling stage is most sensitive. Therefore, inhibition would probably be more apparent in stands of annual

rather than perennial plants (Muller, 1966). However sensitive seedling growth may be to inhibitors, seed germination has not proven to be a sensitive inhibitor indicator. Not only is germination often insensitive to growth inhibitors, but the germination response is occasionally complicated by the incidence of germination being promoted by compounds which normally inhibit growth (Johnson, 1968; Lavine et al., 1968; LeTourneau et al., 1956; Wilson and Rice, 1968).

Conditions of droughty soil and high temperatures are the most favorable for exhibition of growth inhibition from plant produced compounds (Muller, 1966). Woods (1960) and Miller (1962) noted that sand-grown plants exhibited more prominent indications of toxicity than did those grown in clay bearing soils. Certain soil fractions were thought to absorb some of the inhibitory chemicals and possibly to detoxify them. Knipe and Herbel (1966) observed that the spacing of creosotebush (Larrea tridentata), thought to be controlled by accumulation of growth inhibitors, was much wider during periods of continued low rainfall. Behmer and McCalla (1963), however, indicated that conditions of continued coolness and high moisture caused a greater inhibition of wheat growth. It may be noted that these conditions are conducive to miroorganism growth and that Behmer and McCalla's inhibitor experiment utilized extracts from rotting plant material.

Langdale and Giddens (1967) could not determine that soil amendments of lime, nitrogen, phosphorous, or potassium had any affect on the inhibitory nature of sericea lespedeza (Lespedeza cuneata) stems toward corn (Zea mays). They felt, however, that sericea lespedeza leaves did not cause any inhibition because additional nitrogen released from the leaves stimulated plant growth enough to overshadow any

toxic effect. Wilson and Rice (1968) performed soil analysis which revealed that constant levels of soil pH, organic carbon, total phosphorus, and total nitrogen were present even with widely varying concentrations of certain sunflower produced inhibitors. Some experimentation cited by Guenzi and McCalla (1966) indicated that potassium may have some value as a detoxifying agent, acting by precipitating certain growth inhibitory compounds.

It has been observed that those plants that produce inhibitory compounds, best do so during younger, more actively growing stages. Wilson and Rice (1968) discovered that extracts from the young leaves and flowers of sunflower were the most inhibitory to other plants. Guenzi et al. (1964) found that extracts of alfalfa (Medicago sativa) at the 10 inch stage were more toxic than extracts from more mature plants.

Many plant extracts are reported to have an inhibitory affect on other plants. Abdul-Wahab and Rice (1967) found that Johnsongrass was inhibitory to a number of forbs and grasses of the first stage of prairie plant succession. Lawrence and Kilcher (1962) noted that alfalfa and dandelion (Taraxacum officinale) extracts were highly inhibitory to germination and growth of fifteen tested plant species. Alfalfa extracts have been shown to be inhibitory to the growth of timothy (Phleum pratense), oats, soybeans (Glycine max), peas (Pisum sativum), and corn, and extracts of each of these were in turn inhibitory to at least one other species of this group (Nielsen et al., 1960). Alfalfa extracts also had a highly adverse affect on the growth of wheat (Behmer and McCalla, 1963). Knipe and Herbel (1966) determined that water extracts of all portions of creosotebush were inhibitory to

the growth of black grama (Bouteloua eriopoda) and bush muhly (Muhlenbergia porteri). Smith and Rauchfuss (1958) stated that extracts of halogeton (Halogeton glomeratus) reduced the germination of barley (Hordeum vulgare) from 74 percent to 5 percent and yellow sweet clover (Melilotus officinalis) germination from 24 percent to zero percent. Extracts from juniper (Juniperus virginiana) caused a marked decrease in the germination of blue grama (Bouteloua gracilis), crested wheatgrass (Agropyron cristatum), and sideoats grama (Bouteloua curtipendula), and a moderate decrease on the germination of weeping lovegrass (Eragrostis curvula) (Lavin et al., 1968). LeTourneau and his associates (1956) reported that all of twenty-three plant extracts tested were inhibitory to the growth of wheat.

Many researchers have found that a number of plants act with a homologous action, i.e., they produce inhibitory compounds that affect the growth of themselves. Nielsen and his associates (1960) in their work with alfalfa have found it to be extremely inhibitory to its own growth. Kimber (1967) reported that wheat straw which had rotted for 2-4 days greatly inhibited the growth of wheat seedlings. Muller (1966) observed that in Salvia and Artemisia communities the younger, smaller thickets consisted of vigorous shrubs with dense crowns and a closed canopy of leaves. The interior of larger, older stands had plants with small crowns and few leaves. There were large areas of bare and eroded soil between the old shrubs. Yet, in spite of available space, few seedlings of Salvia or Artemisia grew within such an old, senescent community; indicating the possibility of an accumulation of some inhibitor toxic to Salvia and Artemisia species. Knipe and Herbel (1966) felt the build-up of an autoinhibitor was responsible for

the even spacing of creosotebush. A similar even spacing of annual sunflower was noted by Wilson and Rice (1968), and was attributed to the soil accumulation of an autoinhibitor. Achenes of mountain mahogany are reported to contain compounds which are inhibitory to their germination, as indicated by increased germination from washing the achenes in water for twenty-four hours (Moore, 1963).

Accumulation of large amounts of the compounds responsible for growth inhibition are entirely possible with production figures indicated by some authors. Abdul-Wahab and Rice (1967) reported 3.65 tons of leaves and stems and 2.41 tons of rhizomes per acre of Johnsongrass. Troughton (1957) cited research which indicated that Johnsongrass produced 3.08 tons of rhizomes and roots per acre and timothy produced about 1.25 tons of roots per acre when in pure stands. Research by Weaver (1946) indicated that big bluestem (Andropogon gerardi) lost about 19 percent of its original coarse roots in three years, or about 520-900 pounds of raw organic matter per acre were added annually when in pure stands. The Chernozems of Kansas and Nebraska contained about 2.5 tons of plant parts per acre in the top six inches of soil alone and an additional 10 to 20 tons of humified organic matter (nonidentifiable plant material) was also contained in the upper six inches of soil in areas of native range. Dahlman (1965) estimated that approximately 25 percent of the root system of grasses as a whole would be replaced each year, resulting in the deposition of large amounts of organic matter to the soil.

CHAPTER III

MATERIALS AND METHODS

Soil Additive Study

Three soil additive experiments to evaluate forage production as influenced by (1) different native plant materials, (2) different C/N ratio materials, and (3) different plant materials and extracts combined with fertility were performed. Eufaula loamy fine sand from Perkins, Oklahoma was used at about 400 grams air dried soil per pot. Four by four-inch plastic pots were used with separate plastic watering dishes. All plants were grown under constant fluorescent lighting, at a relatively constant room temperature, and with watering as needed. When harvested, all plants were clipped at soil level and oven dried at 70 degrees centigrade. Analyses of variance and the LSD (least significant difference) test were used to determine differences in response to treatments (Snedecor, 1957).

Influence of Different Native Plant Materials

The first soil additive experiment was to evaluate the forage production of big bluestem (Andropogon gerardi) and switchgrass (Panicum virgatum) as influenced by the soil application of western ragweed (Ambrosia psilostachya) tops, post oak (Quercus stellata) leaves, prairie threeawn (Aristida oligantha) tops, blackjack oak

(Quercus marilandica) leaves, and big bluestem roots. The plant materials were collected from rangeland areas, oven dried at 70 degrees centigrade, and ground to pass a one millimeter screen. The design was a factorial in three replications testing two grass species and six soil additives. Each pot of soil was thoroughly mixed with four grams of the plant material and sufficiently seeded to insure an adequate stand of plants. The plants were harvested after nine weeks, oven dried, and weighed.

Influence of Different C/N Ratio Materials

The second soil additive study was conducted to evaluate the forage production of blue panic (Panicum antidotale), switchgrass, and indiangrass (Sorhastrum nutans) as influenced by the application of different carbon to nitrogen ratio plant materials. The plant materials used in soil applications were: alfalfa (Medicago sativa) leaves, wheat (Triticum aestivum) straw, a mixture of one-half alfalfa leaves and one-half wheatstraw, switchgrass roots, big bluestem roots, and indiangrass roots, all at four grams per pot. The soil was thoroughly mixed with the different applications and seeded with the test species to insure an adequate stand. The nitrogen content of each applied material was determined (Table VII) and used to estimate the carbon to nitrogen ratio. The experimental design was a factorial in four replications testing three grass species and seven soil additives. After seven weeks the plants were harvested, oven dried, and weighed.

Influence of Plant Materials and Extracts Combined with Fertility

This third soil additive study was initiated to determine the effect of the application of plant materials and water extracts of the plant materials in combination with fertility treatments on forage production of blue panic. The experimental design was a completely randomized factorial, testing two fertility levels and five soil additives. Ground plant material applications of big bluestem roots, and western ragweed tops were made at four grams of plant material per 400 grams of soil. Extracts of these plant materials were prepared by boiling a mixture of 50 grams ground plant material in 500 milliliters of distilled water for five minutes, allowing the mixture to stand for 30 minutes and again boiling for 25 minutes. The mixture was strained through several thicknesses of cheese cloth and distilled water added to make a total volume to 500 milliliters. The extract was applied, at the time of first watering, to the soil surface at the rate of 40 milliliters per pot. Half of the pots with each of these treatments were fertilized with applications of nitrogen and phosphorous each equal to 500 ppm of the potted soil. The total fertilizer application was spaced with five waterings during a one week period. The phosphorous and nitrogen fertilizer sources were prepared by separately dissolving 16.28 grams monocalcium phosphate and 11.56 grams ammonium nitrate each in one liter of distilled water. The plants were harvested after five weeks, weighed, and oven dried.

Germination Study

The germination studies were utilized to evaluate the effect of water extracts of prairie threeawn tops, western ragweed tops, post oak leaves, and big bluestem roots upon germination and subsequent growth of big bluestem, oats (Avena sativa), and lettuce (Lactuca sativa). A completely randomized factorial design with six replications was used to test five plant extracts on germination of three plant species. The plant material extracts were prepared in the same manner indicated previously. Fifty seeds of the test species were placed on filter paper in each four by four-inch clear plastic germination box. Ten milliliters of the extract, with distilled water being used as the control, were applied to the big bluestem seeds and the boxes placed in a freezer at 3 degrees centigrade for two weeks before being placed in the germinator. The oats received the same extract applications but were allowed a five day vernalization period (Rules for Testing Seeds, 1960[1]). Prechill treatments were arranged to allow for the placing of all germination boxes in the germinator at the same time. All boxes were placed in the germinator and the temperature set at 24 degrees centigrade. Germination counts and length measurements of roots and shoots were taken after seven days.

All water extracts were analyzed for pH and osmotic pressure. The pH of the solutions was obtained by the potentiometric determination method. Osmotic pressure of the plant material extracts was determined by the standard freezing point depression procedure.

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[1]Anonymous. 1960. Rules for testing seeds. Procd. of the Assoc. of Official Seed Anals. 49: No. 2.

CHAPTER IV

RESULTS AND DISCUSSION

Soil Additive Study

Influence of Different Native Plant Materials

The first soil additive experiment, to study forage production as affected by application of various plant materials, revealed some differences in the rate of plant growth. The growth of big bluestem was not significantly reduced except by the application of big bluestem roots. Switchgrass production was also significantly reduced by the big bluestem root application. But, western ragweed tops and post oak leaves significantly increased forage production of switchgrass above that of control. Applications of prairie threeawn and blackjack oak did not have a significant affect on the forage production of big bluestem or switchgrass (Table I).

A visual appraisal revealed the ragweed treated plants were generally much taller and darker in color than the control. Thus, the next test was designed to obtain more information on the effect of varying C/N ratios of the soil additives.

Influence of Different C/N Ratio Materials

The second experiment showed that alfalfa leaves and the mixture of alfalfa leaves with wheat straw (narrow carbon to nitrogen ratio

TABLE I

FORAGE PRODUCTION AS INFLUENCED BY PLANT MATERIAL APPLICATION, FIRST SOIL ADDITIVE EXPERIMENT

Application	Forage Production (grams/pot)[1/]	
	Big Bluestem	Switchgrass
Western Ragweed Tops	0.73 a[2/]	0.91 a
Post Oak Leaves	0.71 a	0.90 a
None (Control)	0.75 a	0.52 b
Prairie Threeawn Tops	0.69 a	0.53 b
Blackjack Oak Leaves	0.54 ab	0.44 b
Big Bluestem Roots	0.42 b	0.20 c

1/ Means are average of three replications.

2/ Means within a column followed by or including the same letter are not significantly different at the .05 level.

materials) promoted the forage production of all three grasses grown. Application of big bluestem roots, indiangrass roots and wheatstraw (wide carbon to nitrogen ratio materials) reduced the forage production of blue panic and indiangrass, but only wheatstraw significantly reduced the forage production of switchgrass (Table II).

TABLE II

FORAGE PRODUCTION AS INFLUENCED BY CARBON TO NITROGEN RATIO OF APPLIED MATERIAL, SECOND SOIL ADDITIVE EXPERIMENT

Application	C/N Ratio	Forage Production (grams/pot)[1/] Blue Panic	Switchgrass	Indiangrass
Alfalfa Leaves	15.6	0.84 a[2/]	1.01 a	0.63 a
Alfalfa Leaves and Wheatstraw	26.8	0.75 a	0.92 a	0.53 ab
None (Control)		0.46 b	0.39 bc	0.47 bc
Switchgrass Roots	43.1	0.50 b	0.48 b	0.40 cd
Big Bluestem Roots	54.8	0.18 c	0.31 cd	0.34 d
Indiangrass Roots	44.2	0.25 c	0.33 cd	0.30 d
Wheatstraw	96.2	0.25 c	0.24 d	0.13 e

1/ Means are average of four replications.

2/ Means within a column followed by the same letter are not significantly different at the .05 level.

A calculated regression line revealed a significant correlation between carbon to nitrogen ratio of applied material and forage production of the tested species. Application of wide carbon to nitrogen ratio materials reduced forage production and the narrow carbon to nitrogen ratio materials promoted forage production (Figures 1, 2, and 3). Apparently the carbon to nitrogen ratio of applied material had a dominant role in the production differences.

Influence of Plant Materials and Extracts Combined with Fertility

The third soil additive study revealed that if any inhibitor were present it apparently was detoxified by the soil (Table III). Big bluestem roots mixed with the soil decreased production of blue panic. The applications of big bluestem root extracts produced forage production not significantly different from that in which no plant material or extract application was made. The inherent nitrogen content of western ragweed tops (2.27% N.) was apparently responsible for increased production of blue panic without an additional fertility treatment; with fertility treatment the plant material application showed a still larger increase in production. Some of the nitrogen in western ragweed was apparently water soluble and caused an increased forage production above that of control. With application of supplemental nutrients the effect of water soluble nitrogen in the western ragweed extract became less evident.

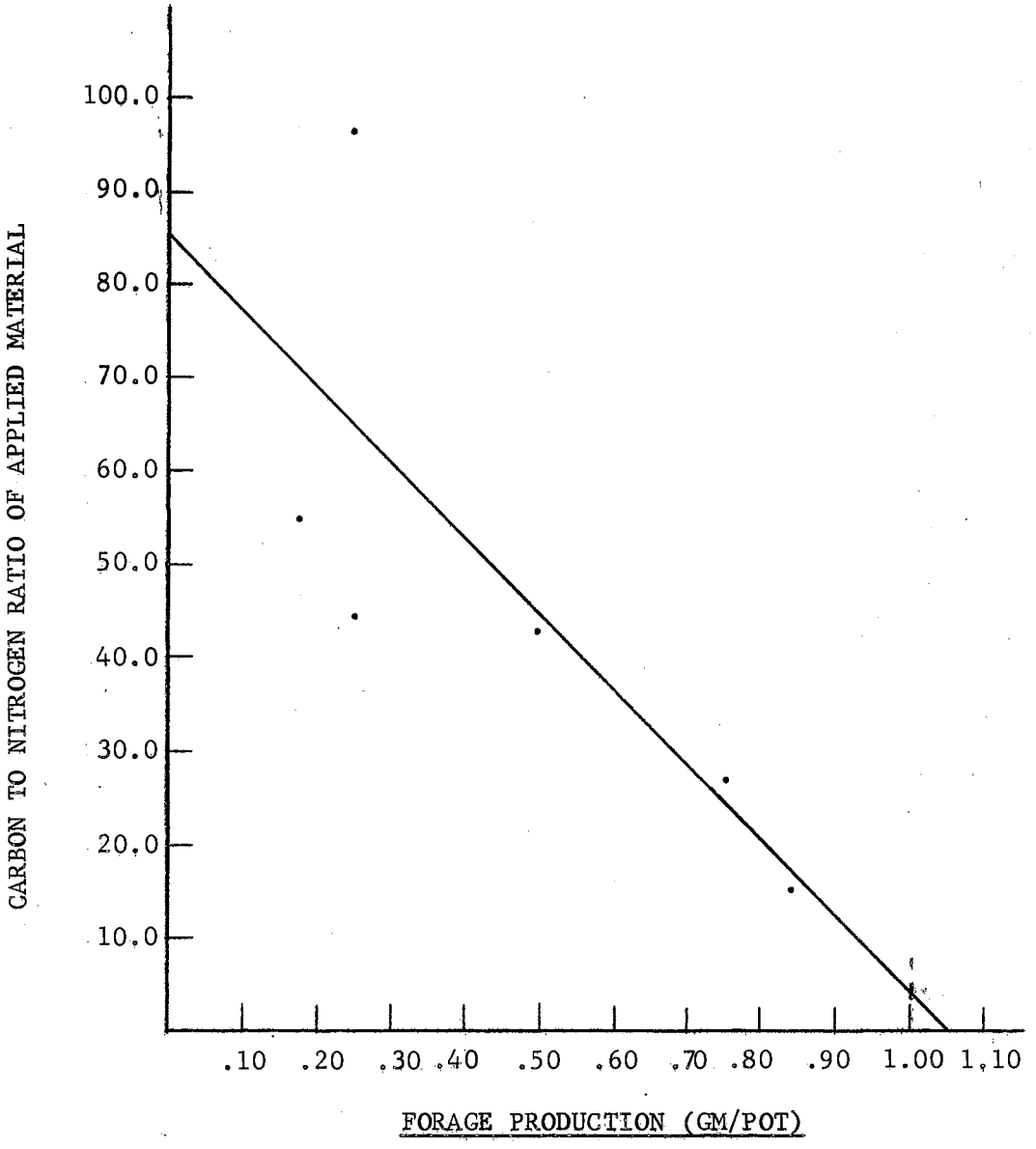

Figure 1. BLUE PANIC: REGRESSION OF C/N RATIO TO FORAGE PRODUCTION (b= -.00766; r= -.7595, significant at .05 level)

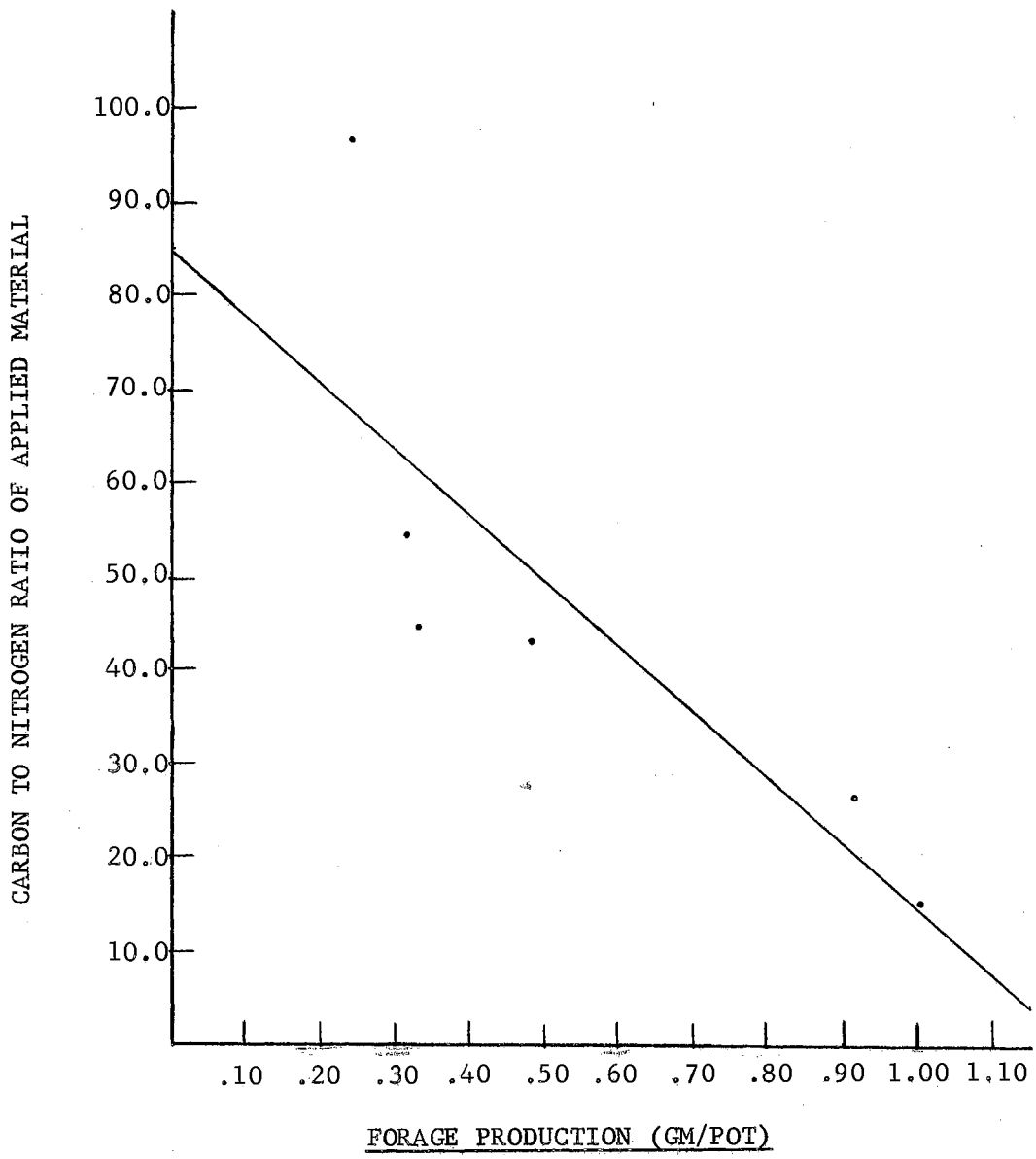

Figure 2. SWITCHGRASS: REGRESSION OF C/N RATIO TO FORAGE PRODUCTION (b = -.01067; r= -.8942, significant at .01 level)

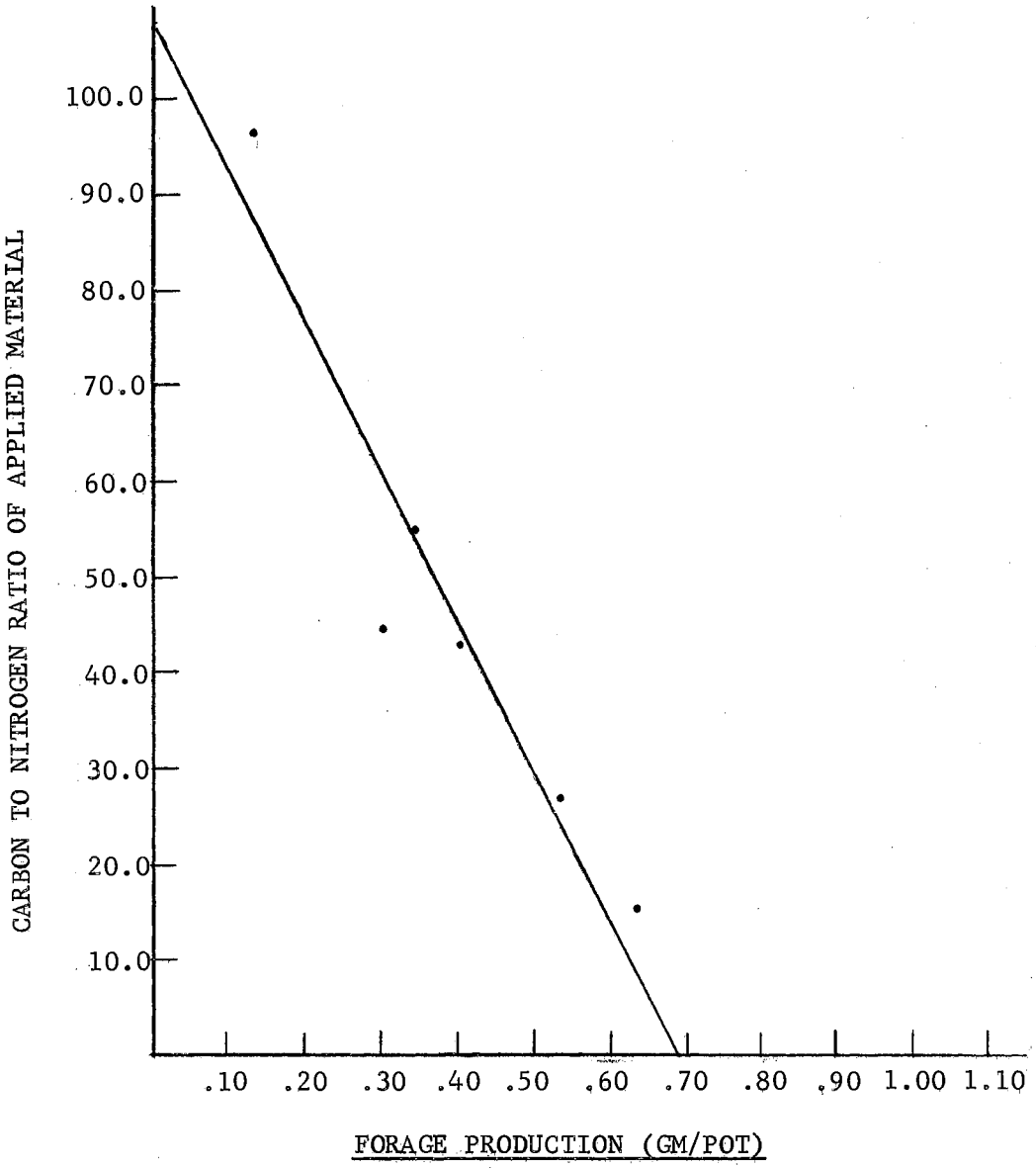

Figure 3. INDIANGRASS: REGRESSION OF C/N RATIO TO FORAGE PRODUCTION (b= -.00599; r= -.9478, significant at .01 level)

TABLE III

FORAGE PRODUCTION (GRAMS/POT) OF BLUE PANIC AS INFLUENCED BY PLANT MATERIAL, PLANT MATERIAL EXTRACT AND FERTILITY, THIRD SOIL ADDITIVE EXPERIMENT

Type of Plant Material Applied	Nutrients Added		Mean
	None	Nitrogen & Phosphorous	
Western Ragweed Tops	0.303 a[1/]	0.608 a	0.456 a
Western Ragweed Extract	0.303 a	0.435 b	0.369 ab
Big Bluestem Root Extract	0.213 ab	0.358 bc	0.286 bc
None	0.148 bc	0.368 bc	0.258 c
Big Bluestem Roots	0.045 c	0.228 c	0.137 d

1/ Means within a column followed by the same letter are not significantly different at the .05 level.

Germination Study

The germination of oat, big bluestem, and lettuce seeds was affected by the application of different plant material water extracts (Table IV). A small decrease in oat germination was effected only by post oak leaf extract. Lettuce germination was significantly reduced by all tested extracts and was completely eliminated by western ragweed extract. Big bluestem germination was not affected by any of the extracts tested.

TABLE IV

PERCENT GERMINATION OF SEEDS AS INFLUENCED BY PLANT MATERIAL EXTRACT[1/]

Source of Extract Application	Oats	Big Bluestem	Lettuce
Prairie Threeawn Tops	94 a[2/]	20 a	30 c
Big Bluestem Roots	97 a	19 ab	35 b
Distilled Water (Control)	94 a	16 ab	41 a
Western Ragweed Tops	98 a	15 b	00 d
Post Oak Leaves	89 b	17 ab	28 c

1/ Means are average of six replications.

2/ Means within a column followed by the same letters are not significantly different at the .05 level.

The root and shoot length measurement for germinating lettuce seedlings were not taken because of the reduced germination from all extract applications. The shoot length of oat seedlings was shorter when extract applications of big bluestem roots, post oak leaves, and western ragweed tops were used (Table V). Only the extracts of post oak leaves and western ragweed tops reduced the shoot length of big bluestem. The root length of oat seedlings was greatly reduced by all tested extracts. The root length of big bluestem seedlings was also significantly reduced by all extract applications except by that of big bluestem roots. Visual inspection of the treated seedlings revealed that often the affected roots were not only shortened by extract application but were shriveled, brownish in color, and devoid of root hairs.

The highest osmotic pressure from any of the extracts was 1.4 for prairie threeawn and the pH ranged from 5.2 for the post oak leaf extract to 8.7 for the western ragweed top extract (Table VI). LeTourneau et al. (1956) and Moore (1963) pointed out that these osmotic pressures or pH values of the tested extracts were probably not responsible for the decreased germination or growth.

TABLE V

SHOOT AND ROOT LENGTH OF GERMINATED SEEDS AS INFLUENCED BY PLANT MATERIAL EXTRACT

Extract Application Source	Length in millimeters[1]	
	Oats	Big Bluestem
	Shoot Length	
Distilled Water (Control	15.80 a[2]	23.57 a
Big Bluestem Roots	12.93 b	23.00 a
Prairie Threeawn Tops	14.37 ab	22.17 a
Post Oak Leaves	10.60 c	17.37 b
Western Ragweed Tops	6.30 d	16.03 b
	Root Length	
Distilled Water (Control)	15.97 a	21.83 a
Big Bluestem Roots	6.10 b	18.93 a
Prairie Threeawn Tops	5.40 bc	15.77 b
Post Oak Leaves	3.77 bc	5.27 c
Western Ragweed Tops	2.77 c	4.10 c

1/ Means are average of measurements from five germinated seeds, selected at random, and six replications.

2/ Means within a column followed by the same letters are not significantly different at the .05 level.

TABLE VI

OSMOTIC PRESSURE AND pH OF PLANT MATERIAL EXTRACTS USED IN APPLICATIONS

Plant Material Extract	Osmotic Pressure[1/]	pH
Big Bluestem Roots	< 0.1	6.4
Prairie Threeawn Tops	1.4	5.5
Western Ragweed Tops	1.3	8.7
Post Oak Leaves	0.7	5.2

1/ Osmotic Pressure expressed in atmospheres.

CHAPTER V

SUMMARY AND CONCLUSIONS

Tests were conducted with some selected native range plants to detect any inhibitory effects of the dried plant material added to soil or in germination tests using water extracts of these dried plant materials.

Big bluestem roots as soil additives significantly reduced growth of big bluestem, switchgrass, blue panic, and indiangrass. Water extracts of big bluestem roots when added to the soil had no effect upon production. Big bluestem root extracts had no effect upon germination of oats and big bluestem but did reduce germination of lettuce. Shoot and root length of the germinating oats was reduced by big bluestem extract. No significant reductions in growth of big bluestem roots or shoots were noted on big bluestem germinating seedlings.

Western ragweed as a soil additive promoted the growth of switchgrass and blue panic. However, water extracts of western ragweed completely eliminated germination of lettuce and significantly reduced growth of roots and shoots of oats and big bluestem. Post oak leaf material exhibited similar growth promotion actions, on switchgrass as a soil additive and germination inhibition on oats and lettuce seeds plus reduction of root and shoot length of oats and big bluestem as an extract. The inhibitory effects of these materials as soil additives were apparently overridden by their fairly high nitrogen content.

Regression and correlation tests of C/N ratios of soil additives revealed that the plant production was inversely related to the C/N ratio of the soil additive. The significance of these findings is that any fluctuation in amount of organic matter returned to range soils can cause fluctuations in forage production. Soil microorganisms temporarily tie up the available soil nitrogen while they decompose the added organic matter. Nitrogen fertilizer added to range soils may also be utilized by these microorganisms and thus be temporarily unavailable to plants. This could explain the low recovery of applied nitrogen to a native hay meadow (McMurphy, 1970).

Prairie threeawn extract was primarily inhibitory to the root growth of tested plants. This extract promoted, to levels approaching significance, the germination of big bluestem. It may be well to note that, if a seed of a tall grass species could be induced to germinate by a high concentration of prairie threeawn extract and then be subjected to the root growth inhibitory nature of that extract, the tall grass seedling would no doubt soon expire without an adequate root system. This action, combined with the inhibition of germination of certain other seeds by threeawn extracts, would allow threeawn plants, in field conditions, to maintain a competition-free environment, and be insured of a long term dominance.

The results from this study indicate that there are some range plants which do produce compounds that are inhibitory to the germination and seedling growth of other plants. Some growth retardant actions, thought to possibly have been inhibitor affected, may merely be related to nutrient availability as affected by cycles of growth and periodic additions of low nitrogen content organic matter.

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APPENDIX

TABLE VII

NITROGEN CONTENT OF PLANT MATERIALS
USED IN MAKING APPLICATIONS

Plant Material	Percent Nitrogen
Big Bluestem Roots	0.66
Switchgrass Roots	0.87
Indiangrass Roots	0.85
Wheatstraw	0.39
Alfalfa Leaves	2.40
Post Oak Leaves	2.08
Blackjack Leaves	1.84
Western Ragweed Tops	2.27
Prairie Threeawn Tops	1.04

TABLE VIII

ANALYSIS OF VARIANCE OF FORAGE PRODUCTION
FOR FIRST SOIL ADDITIVE EXPERIMENT

Source	df	SS	MS	F
Total	35	2.1192		
Replications	2	.0219	.0110	.3607 N.S.
Soil Additives	4	1.1224	.2245	7.3607 **
Species	1	.0283	.0283	.9279 N.S.
Soil Additives X Species	5	.2757	.0551	1.8066 N.S.
Error	22	.6709	.0305	

** Indicates significance at the .01 probability level.

TABLE IX

ANALYSIS OF VARIANCE OF FORAGE PRODUCTION
FOR SECOND SOIL ADDITIVE EXPERIMENT

Source	df	SS	MS	F
Total	83	5.7016		
Replications	3	.0513	.0171	1.0962 N.S.
C/N Ratios	6	3.9824	.6637	42.5452 **
Species	2	.2225	.1113	7.1347 **
C/N Ratios X Species	12	.5070	.0423	2.7116 *
Error	60	.9384	.0156	

* Indicates significance at the .05 probability level.

** Indicates significance at the .01 probability level.

TABLE X

ANALYSIS OF VARIANCE OF FORAGE PRODUCTION
FOR THIRD SOIL ADDITIVE EXPERIMENT

Source	df	SS	MS	F
Total	39	1.1902		
Soil Additives	4	.4608	.1152	11.41 **
Fertility	1	.3881	.3881	38.43 **
Soil Additives X Fertility	3	.0379	.0126	1.25 N.S.
Error	30	.3035	.0101	

** Indicates significance at the .01 probability level.

TABLE XI

ANALYSIS OF VARIANCE FOR PERCENT
SEED GERMINATION EXPERIMENT

Source	df	SS	MS	F
Total	89	115,071		
Replications	5	683	137	4.15 **
Solutions	4	2,093	523	15.85 **
Species	2	105,717	52,859	1,601.79 **
Solutions X Species	8	4,290	536	16.24 **
Error	70	2,288	33	

** Indicates significance at the .01 probability level.

TABLE XII

ANALYSIS OF VARIANCE FOR SHOOT LENGTH EXPERIMENT

Source	df	SS	MS	F
Total	59	2049.95		
Replications	5	155.39	31.0780	4.1098 **
Solutions	4	534.54	133.6350	17.6719 **
Species	1	982.53	982.5300	129.9298 **
Solutions X Species	4	27.21	6.8025	.8996 N.S.
Error	45	340.28	7.5618	

** Indicates significance at the .01 probability level.

TABLE XIII

ANALYSIS OF VARIANCE FOR ROOT LENGTH EXPERIMENT

Source	df	SS	MS	F
Total	59	3454.64		
Replication	5	42.95	8.5900	.6942 N.S.
Solutions	4	1806.77	451.6925	36.5058 **
Species	1	614.40	614.4000	49.6558 **
Solutions X Species	4	433.73	108.4325	8.7635 **
Error	45	556.79	12.3731	

** Indicates significance at the .01 probability level.

VITA

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