AN EVALUATION OF FOUR NATIVE GRASSES AND THEIR COMPETITIVE EFFECTS ON COTTON

by

FRANCIS MARION ROUQUETTE, JR., B. S.

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CHAPTER I

INTRODUCTION

Accompanying the current human population explosion is a reduction in land area per capita. Agronomists are now faced with the task of producing more agricultural commodities on less land area. In order to accomplish this goal, intensive management of land and water resources must be developed. One cultural practice that may be employed as a means of obtaining higher total production, and utilizing land and water resources more efficiently is that of intercropping.

An intercropping system may involve numerous crop combinations that range from the seeding of grasses and legumes between row crops to the association of shade trees and the lower-growing coffee plants. Intercropping, as it is used in this thesis, refers to alternate 4-row plantings of cotton and grass. Regardless of the simplicity or complexity of an intercropping system, however, plant competition is always present.

Aspinall (1960) defines competition as the restriction in plant growth that arises from the association with other plants. Competition may exist between the above-ground plant parts, the below-ground plant parts, or a combination of both. Any one, or a combination of the three major environmental factors, light, soil moisture and soil nutrients, are involved in plant competition, and these factors are in constant demand by plants. Depending upon the plant species concerned, the degree and amount of competition that occurs between plants is quite variable. Because of more closely related and often identical microenvironmental demands by plants of the same species, intraspecific competition is always greater than interspecific competition.

Selection of crops to be used in an intercropping system should be based on their competing ability and growth requirements. Within the past two decades, agronomists have initiated numerous exploratory competition studies involving plant species that have never before been intercropped or grown in close association. Investigations at the Big Spring Field Station, Big Spring, Texas, reveal the possibility of interplanting native perennial grasses with cotton as a means of controlling wind erosion.

The investigation reported in this thesis was initiated to measure the amount of competition that occurs when grasses are interplanted with cotton. The objectives of this investigation are twofold: (1) to evaluate the producing ability of four native perennial grasses, and their competitive effects on the production of lint cotton; and (2) to study several cultural practices including grass herbage removal, cotton fertilization, grass root pruning, and skip-row planting of cotton as methods of reducing the amount of competition occurring between the grass species and cotton.

CHAPTER II

REVIEW OF LITERATURE

The first general characterization of plant competition was apparently given by DeCandolle in 1820 when he stated that all the species of a given area are in a state of war with respect to each other. Clements, Weaver, and Hanson (1929) stated that the first definite study of competition in crop plants was probably that of Sachs in 1860. Sachs conducted an experiment using two plant populations, wherein he reported competition for light and nutrients.

Clements *et al*. (1929) defined plant competition as follows:

> Competition is a question of the reaction of the plant upon the physical factors that encompass it and of the effect of these modified factors upon the adjacent plants. In the exact sense, two plants do not compete as long as the water-content and nutrients, the heat and light are in excess of the needs of both. The moment, however, that the roots of one enter the area from which the other draws its water supply, or the foliage of one begins to overshade the leaves of the other, the reaction of the former modifies unfavorably the factors controlling the latter, and competition is at once initiated.

Odum (1959) states that competition occurs whenever plant populations adversely affect one another in a struggle for food, nutrients, living space, or other common need. Oosting (1958) relates that the intensity of competition is determined by the amount in which the demands exceed the supply.

Plant Competition for the Major Environmental Factors

Light Competition

Competition for light may take place whenever one plant casts a shadow on another plant; thereby, causing a shading effect of the leaves within a plant or between plants. Stahler (1948) and Donald (1963) reported that in the presence of abundant soil moisture and plentiful soil nutrients, light is the primary factor around which competitive forces develop.

Pendleton and Seif (1962) found that shading from adjacent, taller rows of corn resulted in a 30% reduction in corn yields. Nieto and Staniforth (1961) used a corn-yellow foxtail (*Setaria lutescens* [Weigel] Hubb.) assocation in observing light competition, and found that the growth and yield of yellow foxtail was severely limited by the shading effect of corn. Wilson (1962) grew orchardgrass (*Dactylis glomerata* L.), common white clover (*Trifolium repens* L.), and creeping red fescue (*Festuca rubra* L.) in association to observe light competition. Dry matter yields decreased as light intensities were decreased. By reducing light intensities to 32% of full exposure, Eaton and Ergle (1954) diminished the yield of seed cotton by 47%.

Donald (1958) studied the effects of light competition between perennial ryegrass (*Lolium perenne* L.) and Hardinggrass (*Phalaris tuberosa* L.) in a greenhouse culture. Shading by perennial ryegrass caused a reduction in the photosynthetic activity of Hardinggrass. The reduction in photosynthesis depressed carbohydrate production, thereby resulting in a depression of the whole metabolism of the plant. There was a higher percentage of nitrogen in the shaded plants than in the unshaded plants, but the uptake of nitrogen was reduced by 20%. The direct effect of competition for light, therefore, was a reduction in photosynthesis, while the indirect effect was a decreased capacity to utilize nitrogen. Competition for light between perennial ryegrass and Hardinggrass was strongest under conditions giving maximum production of foliage and greatest mutual shading.

Light-Nutrient Interaction

When competition occurs for both light and nutrients, the overall effect, according to Donald (1958), is not a simple interaction between two factors, but rather an interaction between two groups of factors which may lead to a marked intensification of effects. A reduction in the nitrogen supply to Hardinggrass resulted in a 75% diminution of foliar development, thereby lessening its capacity to utilize light. Donald concluded that the effects of light and nutrient competition will interact even though there is competition for only one factor.

Aspinall (1960), using barley (*Hordeum vulgare* L.) and white persicaria (*Polygonum persicaria* L.), found that the major responses from addition of nutrients were a significant increase in plant height and in leaf production. Increases in nutrient concentrations led to magnifications in light interception. Mixed plantings of barley and persicaria resulted in an immediate shading of persicaria and eventual decrease in leaf area ratio. The results indicated that light influences the rate of root extension through the supply of assimilate to the root, which in turn, affects the rate of nutrient uptake. Aspinall concluded that nutrient supply plays the principal role in suppressing growth.

Nutrient Competition

Aspinall (1960) suggested that the diminished growth of the less successful of two associated species is first due to restricted nutrient uptake, associated with a root system that is always smaller. Aspinall concluded that roots will always interfere with growth before shoots of the aggressor species begin to shade the less successful competitor, and a species with the most extensive root system at the stage when competition begins is the most likely to succeed.

Donald (1958) found that when perennial ryegrass competed with Hardinggrass solely for nutrients in the greenhouse, ryegrass diminished the quantity of available nitrogen to the weaker competitor. Peterson and Bendixen (1961), Wilson and McGuire (1961), and Wilkinson and Gross (1964) reported that with each additional increment of nitrogen, orchardgrass yields increased while ladino clover

(*Trifolium repens* L.) and common white clover yields decreased. Orchardgrass benefited more from nitrogen additions than did clover; therefore, orchardgrass offered more competition to clover. Clover yields were eventually reduced because of competition from orchardgrass.

Welbank (1961, 1962) investigated nutrient competition for nitrogen between quackgrass (*Agropyron repens* [L.] Beauv.) and annual jewelweed (*Impatiens parviflora* D.C.). High nitrogen levels increased the density and yield of quackgrass. Quackgrass competition depressed root growth and net assimilation rate of annual jewelweed.

Nieto and Staniforth (1961), using three levels of fertility and four levels of corn plant populations, tested the effects of yellow foxtail infestations on corn yields. The greatest effect of foxtail on corn yields occurred under conditions of low soil nitrogen availability. Corn yield reductions resulting from foxtail infestations averaged 20, 14, and 10 bu per acre with applications of 0, 70, and 140 pounds of nitrogen per acre, respectively.

Moisture Competition

Welbank (1961, 1962) investigated competition for soil moisture between quackgrass and annual jewelweed. Competitive effects on both root and leaf growth-rates were significantly reduced by additional increments of water. Nitrogen applications increased soil nitrogen percent and plant nitrogen content in competition plots; whereas, water additions to field capacity increased nitrogen content and nitrogen percent in plants growing in competition plots. Welbank concluded that competition involves both nitrogen and water, but under normal conditions, water is the more important factor in plant growth.

Wright (1962) investigated root weights of blue panicgrass (Panicum antidotale Retz.) as affected by fertilizers, clipping heights, and soil-moisture stress. Blue panicgrass roots in the 0 to 2 foot zone assumed a major role in forage production under irrigation where soil moisture was replaced as it was used. Roots in the 2 to 12 foot zone assumed greater importance in forage production when available moisture was limited in the upper 2 feet. Root weights significantly increased as the clipping height was raised from 3 to 12 inches. A significant linear decrease in blue panicgrass root weights occurred as soil moisture was reduced to the wilting point at depths of 6, 12, 18, and 24 inches.

Madison and Hagan (1962) observed soil moisture extraction by the Merion strain of Kentucky bluegrass (Poa pratensis L.). Moisture determinations at 4-inch increments indicated that most of the moisture extraction occurred in the top 20 inches of soil. The more frequent irrigation periods resulted in a shallower root system.

Scott and Patterson (1962) examined moisture competition between 'Ranger' alfalfa (Medicago sativa L.) and 'Midland' grain sorghum (Sorghum vulgare Pers.) in a greenhouse culture. Although alfalfa proved to be superior to sorghum in the ability to withstand drought conditions, there was apparently very slight competition between the two species; and it was therefore concluded that competition for moisture would not limit the use of alfalfa and sorghum as companion crops.

Reducing Plant Competition by Cultural Practices

Herbage Removal

Herbage removal of grasses by clipping, mowing, or grazing generally results in decreased root growth. Neiland and Curtis (1956) reported that a decrease in the photosynthetic area of grasses is directly related to a reduction in the development of the root system and in reserve carbohydrate storage.

Parker and Sampson (1931), Biswell and Weaver (1933), and Robertson (1933) found that defoliation of grasses by clipping, mowing, or grazing resulted in the development of reduced root diameters. Both cortex and stele were reduced in addition to a diminution in the number and diameter of xylem vessels and phloem tubes.

Clipping experiments by Sullivan and Sprague (1943, 1953) with perennial ryegrass and orchardgrass, indicated that the immediate effect of a partial or a complete removal of the plant's active shoot tissue is a transfer of food reserves from the roots and other storage organs to the remaining shoot tissue for the production of new growth. The food reserve transfer results in a loss in weight of the underground storage organs.

Buckey and Weaver (1939) studied the effects of frequent clipping on underground food reserves of big bluestem (Andropogon gerardi Vitman.) and little bluestem (Andropogon scoparius Michx.). Severe clipping of the two species diminished the amount of carbohydrates stored by the roots, thereby resulting in species destruction within a period of a few years. Aldous (1930) and Thaine (1954) stated that root reserves decreased with an increased number of clippings. McCarty and Price (1942) reported that the quantity of reserve carbohydrates stored in the roots and stem bases of grasses was related to the amount of foliage present during a normal storage period. Close removal of herbage at any time during the storage period had the effect of reducing the reserve carbohydrates. Sampson and McCarty (1930) and McCarty (1935, 1938) stated that defoliation between the time of flower stalk production and seed maturity prevents maximum accumulation of reserve carbohydrates in grasses.

Crider (1955) showed that removal of 40% or more of grass foliage caused a cessation of apical root growth within 24 hours of defoliation. Single clippings that removed 80 to 90% of the grass tops resulted in the stoppage of root growth for a 6 to 18-day period. Parker and Sampson (1931) caused root growth to stop for an 8 to 10-day period as a result of clipping.

Oswalt, Bertrand, and Teel (1959) found that root decomposition commenced within 36 to 48 hours following top growth removal. Robertson (1933), De Perlata (1935), and Weaver (1950) reported that roots of defoliated grass plants deteriorated from the root tip upwards toward the crown.

Root Pruning

Troughton (1957) stated that pruning roots of a plant resulted in an increase in the rate of root formation. The number of laterals produced on the remaining portion of the shoot also increased if the severed root was sufficiently long and young. The growth rate of the shoot, however, was reduced.

Jacques (1944) found that the severing of perennial ryegrass roots at a depth of 12 inches during a dry summer resulted in the death of the plants. Laude (1953) pruned roots of pine bluegrass (*Poa scabrella* [Thurb.] Benth.) at depths of 2 and 4 feet below the soil surface. The root pruned plants did not commence growth after their summer dormancy until rainfall occurred, and soil moisture was available for growth. Plants that had not been root pruned began growth some weeks before this time. Laude concluded that pruned roots required more moisture to begin growth than did unpruned roots.

Jacques and Edmond (1952) examined the effect of root pruning on both shoot and root growth. Root pruning increased root production, but decreased herbage production.

Nedrow (1937) pruned the roots of sudangrass (*Sorghum sudanense* [Piper] Stapf.) at various depths to quantitatively determine the effect upon above-ground and below-ground plant growth. Root severing lessened root extensions, decreased total root volume, and retarded shoot development.

Cotton Fertilization

The competitive effects between two plants may be increased or decreased by altering factors of the environment. By increasing the nutrient supply to one plant through fertilization, the detrimental effects of competition may be lessened.

Quinby and Fisher (1955) conducted fertilizer studies on soils of the Rolling Plains in Texas that had been in cultivation for fifty to sixty years. Cultivation, in addition to wind erosion, had progressively depleted the soil fertility. Ammonium sulfate was applied to the soil at rates of 30 and 60 pounds of nitrogen per acre. The 30-pound rate increased yields as effectively as the 60-pound rate. Thaxton and Walker (1957), on the High Plains of Texas, obtained significant increases in lint yield from applications of 30 and 70 pounds of nitrogen per acre.

Christensen and Lyerly (1952) in the El Paso Valley studied cotton yields as influenced by applications of ammonium nitrate. Applications of 60 and 120 pounds of nitrogen per acre resulted in increased cotton seed yields ranging from 200 to 900 pounds per acre.

Longenecker, Lyerly, and Christensen (1955) applied ammonium nitrate to irrigated cotton at rates of 60, 120, and 180 pounds of nitrogen per acre and obtained an increase in the seed yield of cotton per pound of nitrogen applied of 6.5, 4.2, and 2.8 pounds, respectively. Application of 60 pounds of nitrogen per acre was the most economical fertilizer rate.

Longenecker, Thaxton, and Lyerly (1961) side-dressed ammonium nitrate at rates ranging from 0 to 300 pounds of nitrogen per acre in two applications. The 240-pound nitrogen application produced maximum additional seed cotton yields of 800 pounds per acre.

Skip-row Planting of Cotton

Various methods have been suggested for decreasing or eliminating the amount of competition occurring between cotton plants in a solid-planted field. One of the most promising methods of decreasing cotton competition is a system of alternately planting and fallowing various numbers of rows, commonly referred to as skip-row planting. The two skip-row systems that have received the greatest attention are: (1) plant 2 rows, fallow 2 rows, and (2) plant 4 rows, fallow 4 rows.

Douglas and Brooks (1963) reported the effects of two levels of inter-row competition on cotton yields. It was concluded that the plant 2-fallow-2 system produces less inter-row competition than the plant 4-fallow-4 system or the conventional solid-planting system of cotton. In the plant 2-fallow-2 method of planting, every row is a border row; thus, competition between rows is greatly reduced.

In a three year skip-row planting study initiated by Dick and Ramey (1957) and completed by Dick and Owings (1959), it was reported that both the plant 2-fallow-2 and plant 4-fallow-4 systems increased cotton yields. In a similar study, Grissom and Spurgeon (1963) found that the plant 4-fallow-4 method produced 45% more seed cotton than solid plantings, while the plant 2-fallow-2 system resulted in a 67% increase in cotton seed yields.

Longenecker and Lyerly (1962) reported that a plant 2-fallow-2 system produced an additional one bale of lint cotton per acre when compared to solid-planting. The plant 4-fallow-4 system resulted in an additional one-half bale of cotton lint per acre. Generally, the plant 4-fallow-4 skip-row system is the most popular method since the fallowed portion is large enough to qualify as deferred acreage.

CHAPTER III

EXPERIMENTAL AREA AND PROCEDURE

The study area was located one mile west of Lubbock, Lubbock County, Texas, on the Texas Technological College Agronomy Farm.

The 36-year mean annual precipitation recorded by the Lubbock Weather Station is 16.7 inches. Total precipitation recorded during 1966 was 18.2 inches with approximately 10 inches occurring within a 3-week period from mid-August until September 2.

Soil Type

The soil type in the experimental area was an Amarillo fine sandy loam, the major type on the Southern High Plains of Texas. Because of the coarse texture of the surface horizon, water infiltration is rapid. Depth to the indurate caliche layer varies in the Amarillo soil series from approximately 30 to 60 inches. In the experimental area, no caliche layer was present within 30 inches of the surface.

The nearly level topography of the study area retarded excess runoff and facilitated irrigation of the plots.

Experimental Design

In 1963, four native species of perennial grasses were established in the experimental area on the Texas Technological College Agronomy Farm. The four grasses, green sprangletop (Leptochloa dubia [H.B.K.] Nees.), spike bristle-grass (Setaria leucopila [Scribn. & Merr.] K. Schum), the Premier strain of sideoats grama (Bouteloua curtipendula [Michx.] Torr.), and the Grenville strain of switchgrass (Panicum virgatum L.), were intercropped with 'Blightmaster' cotton (Gossypium hirsutum L.) in a 4-row strip cropping design. Although not related to the objectives of this study, a strip cropping system design seemed best suited for measuring the competitive effects of the grasses on the cotton.

The treatments were arranged in a split-split plot design with four replications. The plot size of each replication was 24, 40-inch rows, 400 feet long. In each replication, a total of 12 rows were planted with grasses, and a total of 12 rows were planted with cotton. The four grasses were established in a plant 4-fallow-4, skip-row system. Cotton was then planted in the 4-row fallow strips between the grass rows (Fig. 1).

The four grass species were randomly placed in each replication in sub-plots, each having a length of 100 feet (Fig. 2). Within each grass species, four treatments were randomly located (Fig. 3). The four treatments were as follows:

1. Grass clipped and cotton fertilized.
2. Grass clipped and cotton not fertilized.
3. Grass not clipped and cotton fertilized.
4. Grass not clipped and cotton not fertilized.

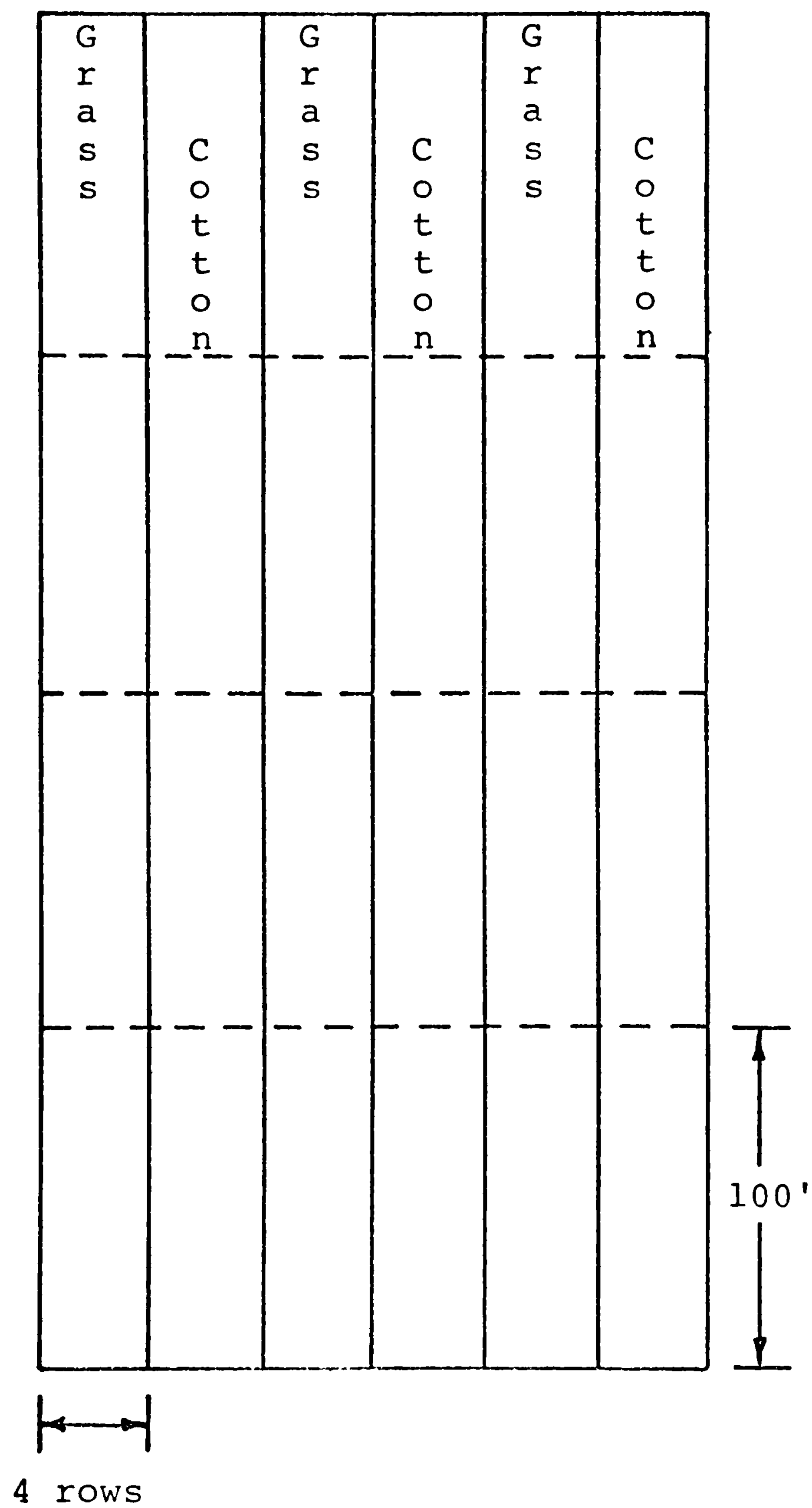

Figure 1. View of one replication showing the strip cropping planting design used to measure competition.

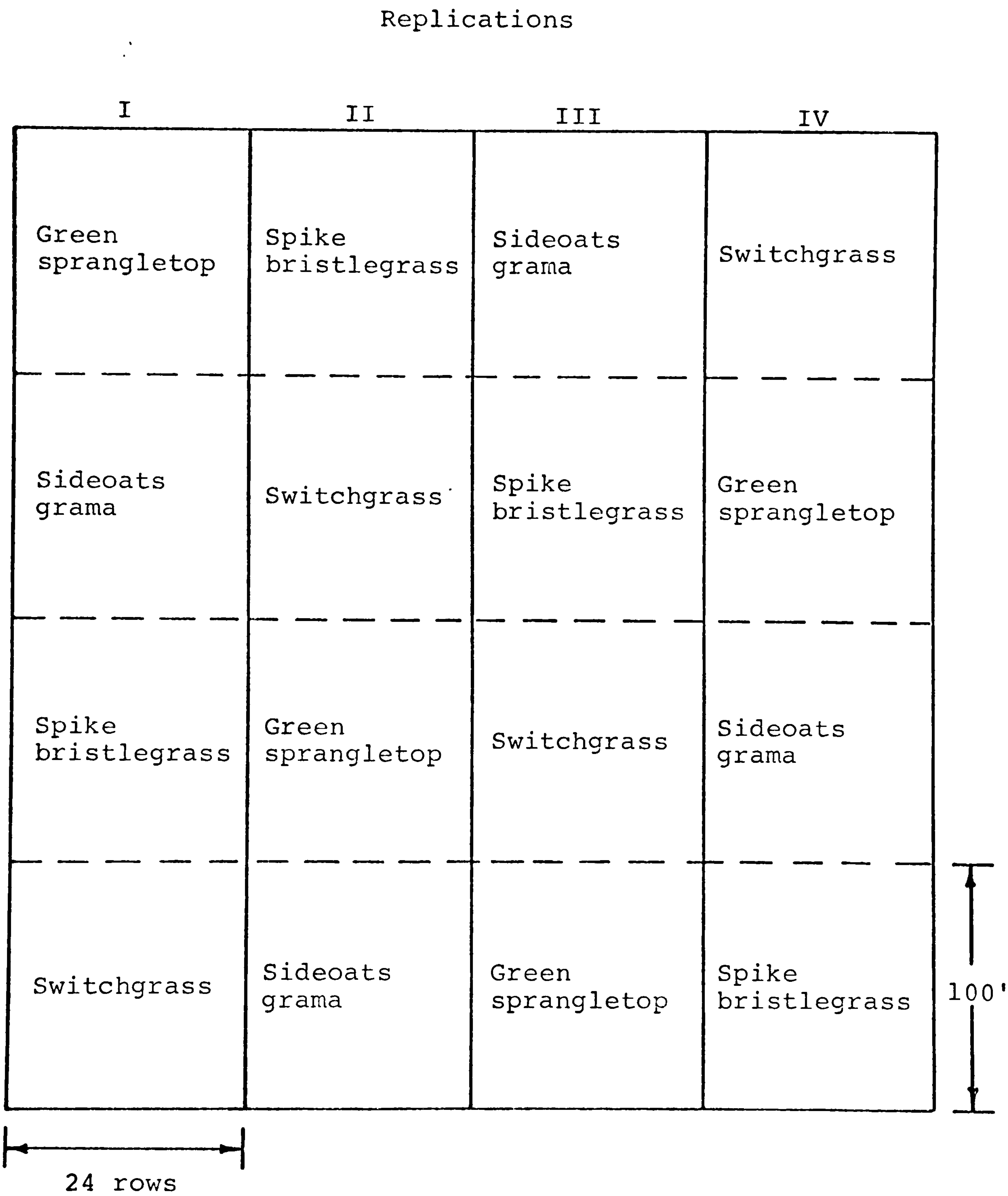

Figure 2. Diagram illustrating the random placement of the four grasses in all four replications.

Replications

I	II	III	IV
1	2	1	4
4	4	3	1
2	3	2	3
3	1	4	2
4	2	3	2
3	3	2	1
2	4	1	3
1	1	4	4
1	2	4	1
4	1	2	3
2	4	1	4
3	3	3	2
1	1	2	3
2	2	3	4
3	4	4	1
4	3	1	2

25'

24 rows

Figure 3. Illustration of the four treatments, each 25 feet in length, randomized within each grass species of the four replications.

1. Grass clipped and cotton fertilized.
2. Grass clipped and cotton not fertilized.
3. Grass not clipped and cotton fertilized.
4. Grass not clipped and cotton not fertilized.

Grass Clipping

Forage yields were taken from two of the three 4-row grass strips in each replication. Two grass rows in each strip, one adjacent to the cotton and the second, one row removed from the cotton, were used in collecting the forage data (Fig. 4). The center eight feet of plots receiving a clipping treatment were hand clipped once a month from June through September. The 17 feet of grass row that were not hand clipped, and the remaining grass rows that were not involved in the sample collection but were part of the clipping treatments were mowed with a sickle type power mower.

Grenville switchgrass was clipped at a height of eight inches; while spike bristlegrass, green sprangletop, and sideoats grama were clipped at a 4-inch stubble height. All forage samples were oven dried, weighed, and the dry weight converted to pounds per acre.

Cotton Planting and Fertilization

On April 21, ammonium nitrate at the rate of 200 pounds of nitrogen per acre was applied to plots receiving fertilizer.

Rains in excess of three inches occurred the next day after fertilization. Blightmaster cotton was planted at the rate of 16 pounds per acre on May 9 in the fallow rows between the grass (Fig. 1). Rainfall in excess of one inch occurred at the end of May, in mid-June, and at the end of

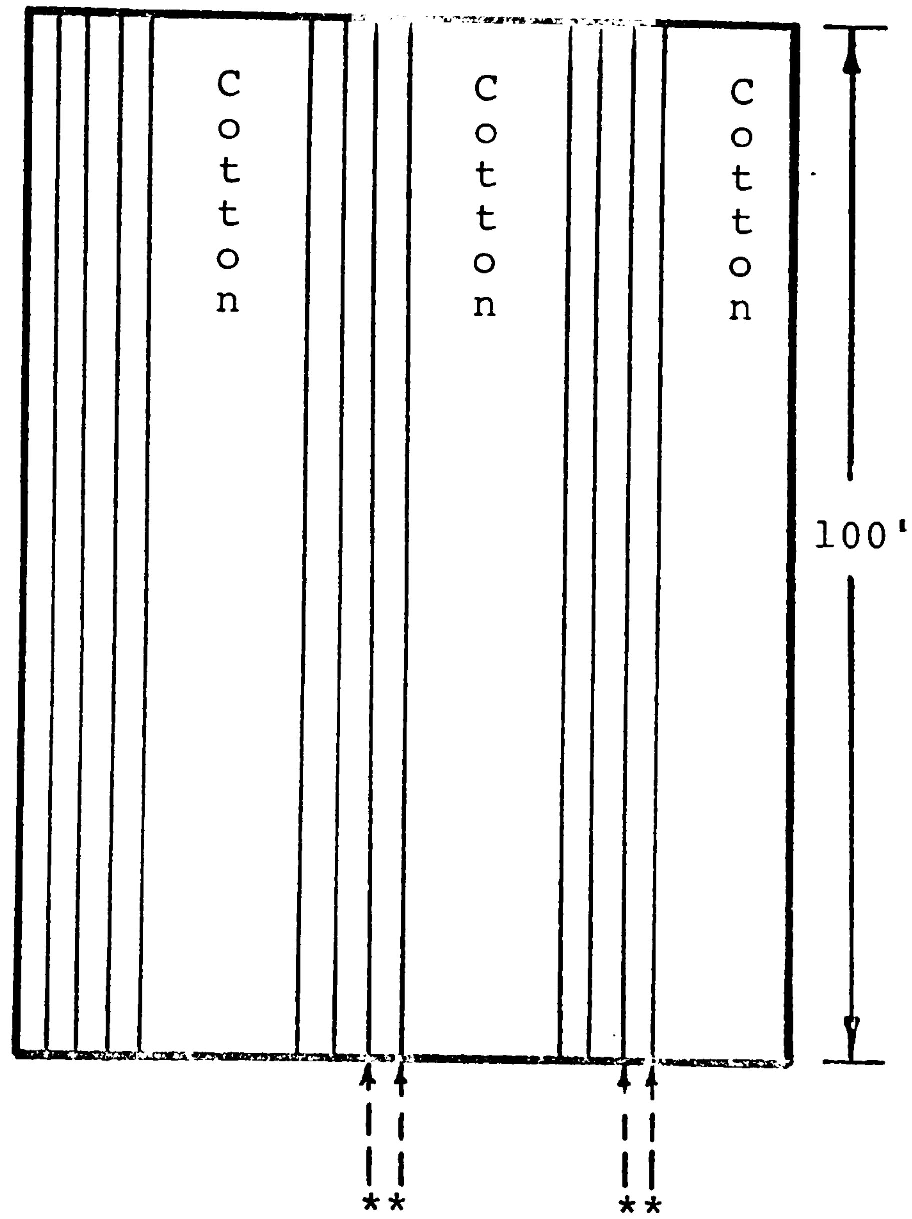

Figure 4. Diagram of the four grass rows that were clipped in each grass species.

*Rows clipped.

August. The experimental area received one summer irrigation in mid-July.

The center eight feet of cotton in each row of the 25-foot treatment plots were hand picked, ginned, and the weight converted to pounds of lint per acre.

Skip-row Cotton Planting

Between two 4-row grass strips in each replication, cotton was planted in a skip-row system. The rows immediately adjacent to the grass rows were not planted with cotton, while the center two rows in each 4-row plot were planted with cotton (Fig. 5). The plant 2-fallow-1 skip-row system was employed as a means of reducing the competition between the grasses and the cotton.

The skip-row plots received the same clipping-fertilizer treatments as the other plots in the experiment. The center eight feet of each cotton row in every treatment plot were hand picked and the weight converted to pounds of lint per acre after ginning.

Root Pruning of the Grasses

Another cultural practice employed to diminish the grass-cotton competition was that of pruning the roots of the grasses. One of the 4-row strips of grass in each replication was root pruned once a month from June through September. Grass roots were pruned between a designated row of cotton and the adjacent row of grass, and between the

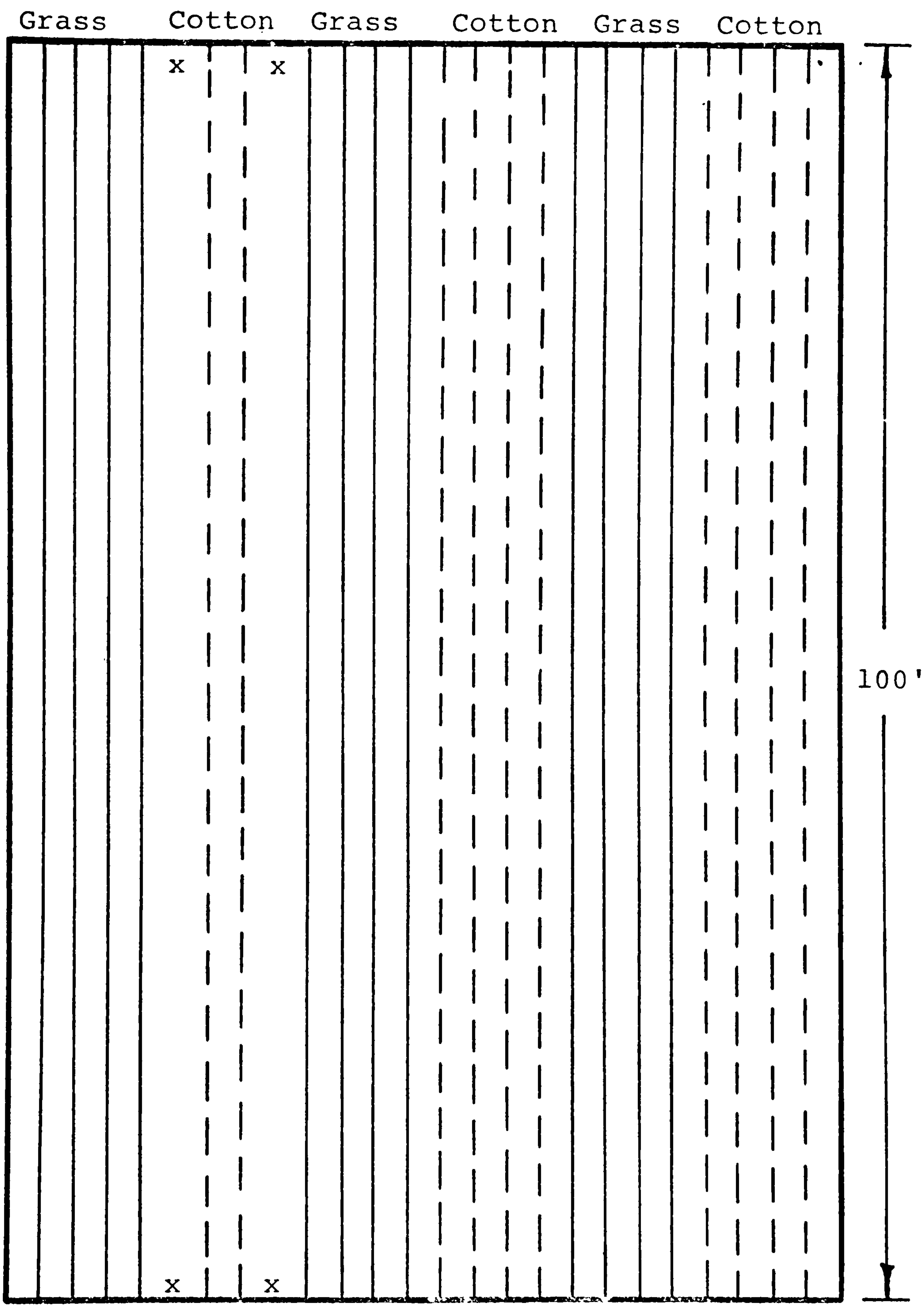

Figure 5. Design of skip-row planting of cotton in each species of grass.

x = Row omitted.

next two rows of grass. Thus, roots from the three rows of grass immediately adjacent to cotton were pruned (Fig. 6).

Root pruning was conducted with two anhydrous ammonia chisels mounted on a draw-bar (Fig. 7). The chisels, placed 22 inches apart, cut a furrow approximately 9 inches from the center of each row, and severed the roots at a depth of 10 inches (Figs. 6 and 8).

P^{32} Placements

Radioactive phosphorus was used to study competitive effects of the grasses on the cotton. The isotope was also used to determine the effectiveness of the root pruning treatment.

The radioactive phosphorus, in a weak hydrochloric acid solution, was obtained from the Nuclear Science and Engineering Corporation, Pittsburgh, Pennsylvania. The P^{32} solution was placed in a measured volume of distilled water to give a diluted specific activity of approximately 0.0030 mc per ml.

A technique similar to that employed by Pettit (1965) was used in the placement of the radioactive isotope. Paper cups with a capacity of 20 ml were placed on squares of dry ice, and were then filled with the P^{32} solution. After the solution had frozen, the paper cups were removed from the P^{32} cubes (Fig. 9). The cubes were then placed in a large container and transported to the study area.

Radioactive phosphorus placement sites were prepared

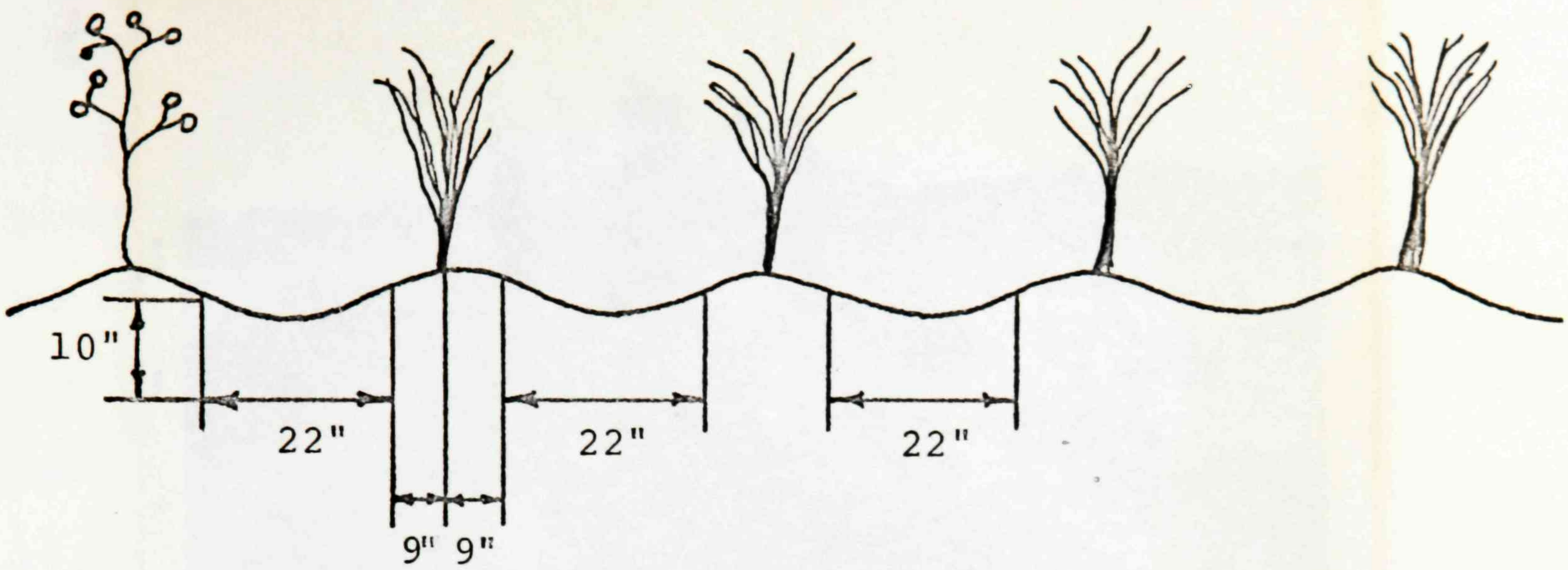

Figure 6. Illustration of the pruning depths and distances in relation to the four grass rows and the one cotton row.

Figure 7. View showing the two anhydrous ammonia chisels used to prune the grass roots.

Figure 8. Chisel furrows made by the pruning device.

Figure 9. Paper cups being removed from the P^{32} cubes.

with a hydraulic soil core sampler powered by a farm tractor (Fig. 10). The three placement depths, 10, 20, and 30 inches, were randomly located between the grass and cotton rows within each 25-foot clipping-fertilizer plot. At each placement depth, three holes, one foot apart, were formed to insure interception of the roots. A minimum distance of six feet between each three-hole site was maintained to prevent isotope contamination (Fig. 11). As shown in Figure 10, each hole was placed seven inches laterally from the cotton plants.

One P^{32} cube was placed in each hole, after which soil was pushed into the hole and firmly tamped to prevent root channeling. A Geiger-Müller counter was used to detect the presence of P^{32} in the foliage of the grass and cotton. Readings were taken weekly until the P^{32} counts could no longer be detected.

Statistical Analysis

All data were statistically analyzed by an analysis of variance. Snedecor (1946) defines analysis of variance as the partitioning of degrees of freedom and corresponding sums of squares with each part providing an estimate of variance. Computation of sums of squares for a split-split plot of a randomized complete block experiment was followed as outlined by LeClerg, Leonard, and Clark (1962).

The F-test, named by Snedecor (1934), is used to determine whether two independent estimates of variance can be

Figure 10. Hydraulic soil core sampler used to form the P^{32} channels seven inches laterally from the cotton plant.

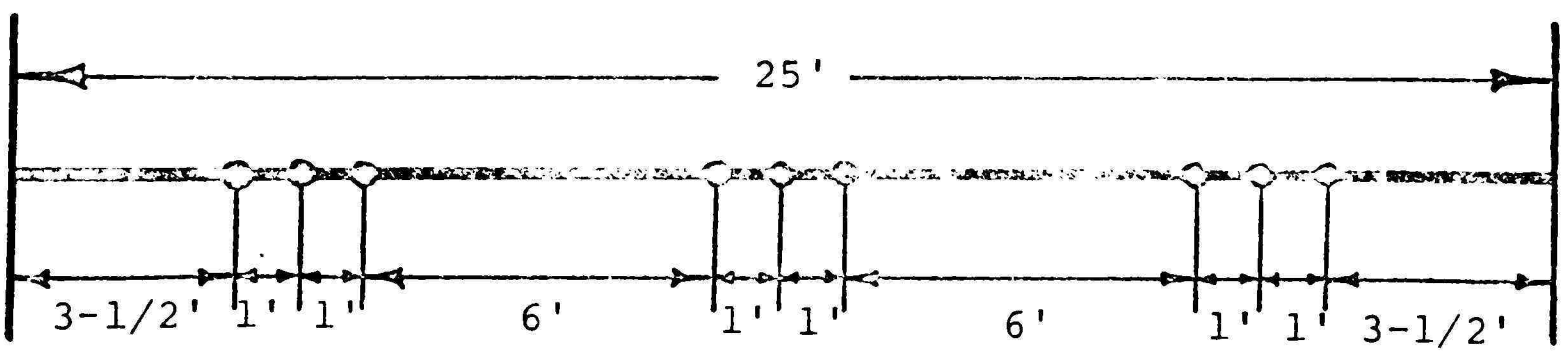

Figure 11. Diagram of P^{32} placement sites within each 25-foot treatment plot.

assumed to be two estimates of the variance of a single, normally distributed population. At a given probability level a significant F value does not indicate, however, which of the treatment means are statistically different. The Duncan multiple range test was used in making multiple comparisons of every treatment mean combination.

CHAPTER IV

RESULTS AND DISCUSSION

Grass Forage Yields

Forage data for the four grasses are summarized in Table 1. The average forage production ranged from 3321 pounds per acre for sideoats grama to 1391 pounds per acre for green sprangletop. Yield differences were not significant between green sprangletop and spike bristlegrass, or between switchgrass and sideoats grama. In every plot, grass rows adjacent to cotton rows yielded considerably more forage than grass rows that were one row removed from cotton.

TABLE 1. DRY MATTER PRODUCED BY EACH GRASS IN POUNDS PER ACRE

Grass Species	Unpruned	Pruned[1]	Average
Green sprangletop	1406	1375	1391 a[2]
Spike bristlegrass	1762	1664	1713 a
Switchgrass	2944	3511	3227 b
Sideoats grama	3248	3394	3321 b

[1]The root pruning treatment did not significantly decrease or increase forage yields at the .05 probability level.

[2]Means in a given column, followed by the same letter, are not significantly different at the .05 probability level.

Root pruning diminished the yields of green sprangletop and spike bristlegrass, whereas yields of sideoats grama and switchgrass from pruned plots were increased. The root pruning treatment did not significantly decrease or increase forage yields.

Although ammonium nitrate was applied only to the cotton rows, all of the grasses produced more forage from rows adjacent to the fertilizer treatments (Table 2). Significant increases in forage yield due to cotton fertilization occurred in switchgrass and sideoats grama plots. The data showed that switchgrass and sideoats grama exerted more competition for soil nutrients than did green sprangletop and spike bristlegrass.

TABLE 2. DRY MATTER OF FORAGE IN POUNDS PER ACRE

Grass Species	Unfertilized[1] Cotton	Fertilized[2] Cotton
Green sprangletop	1392 a[3]	1617 a
Spike bristlegrass	1904 a	2288 a
Switchgrass	3756 b	4362 b*
Sideoats grama	3729 b	4411 b*

[1]Forage samples were taken from grass rows adjacent to unfertilized cotton.

[2]Forage samples were taken from grass rows adjacent to fertilized cotton.

[3]Means in a given column, followed by the same letter, are not significantly different at the .05 probability level.

*Indicates a significant difference in yield between treatments at the .05 level.

Monthly Grass Yields

The yield at each clipping period and the corresponding percentage of total forage production are shown in Table 3. Switchgrass, which produced 70% of its total forage at the first clipping and only 5% at the last clipping, had the most erratic trend in forage production. On the other hand, sideoats grama had the most evenly distributed pattern of forage yield with 20 to 29% of the total production occurring at each clipping.

With the exception of sideoats grama, all grasses exhibited an increase in yield following the mid-July irrigation. Compared to forage production at the third clipping, the yield of every grass was reduced on the final clipping despite the abundant rainfall that occurred at the end of August.

Cotton Lint Yields

The average yield of lint cotton is shown in Table 4. Lint production ranged from 582 pounds per acre on the plots intercropped with spike bristlegrass to 414 pounds of lint per acre on plots that were intercropped with switchgrass. The differences between cotton yields, however, were not significant. Although cotton yields were not statistically different, a consistent and measurable difference was expected between cotton intercropped with spike bristlegrass, and cotton intercropped with switchgrass.

TABLE 3. MONTHLY YIELD AND PERCENT OF TOTAL YIELD AT EACH CLIPPING

	Percentage of Yield at Each Clipping			
Grass	June	July	Aug	Sept
Bocu	25%	29%	26%	20%
Pavi	70%	8%	17%	5%
Sele	22%	23%	33%	22%
Ledu	18%	17%	35%	31%

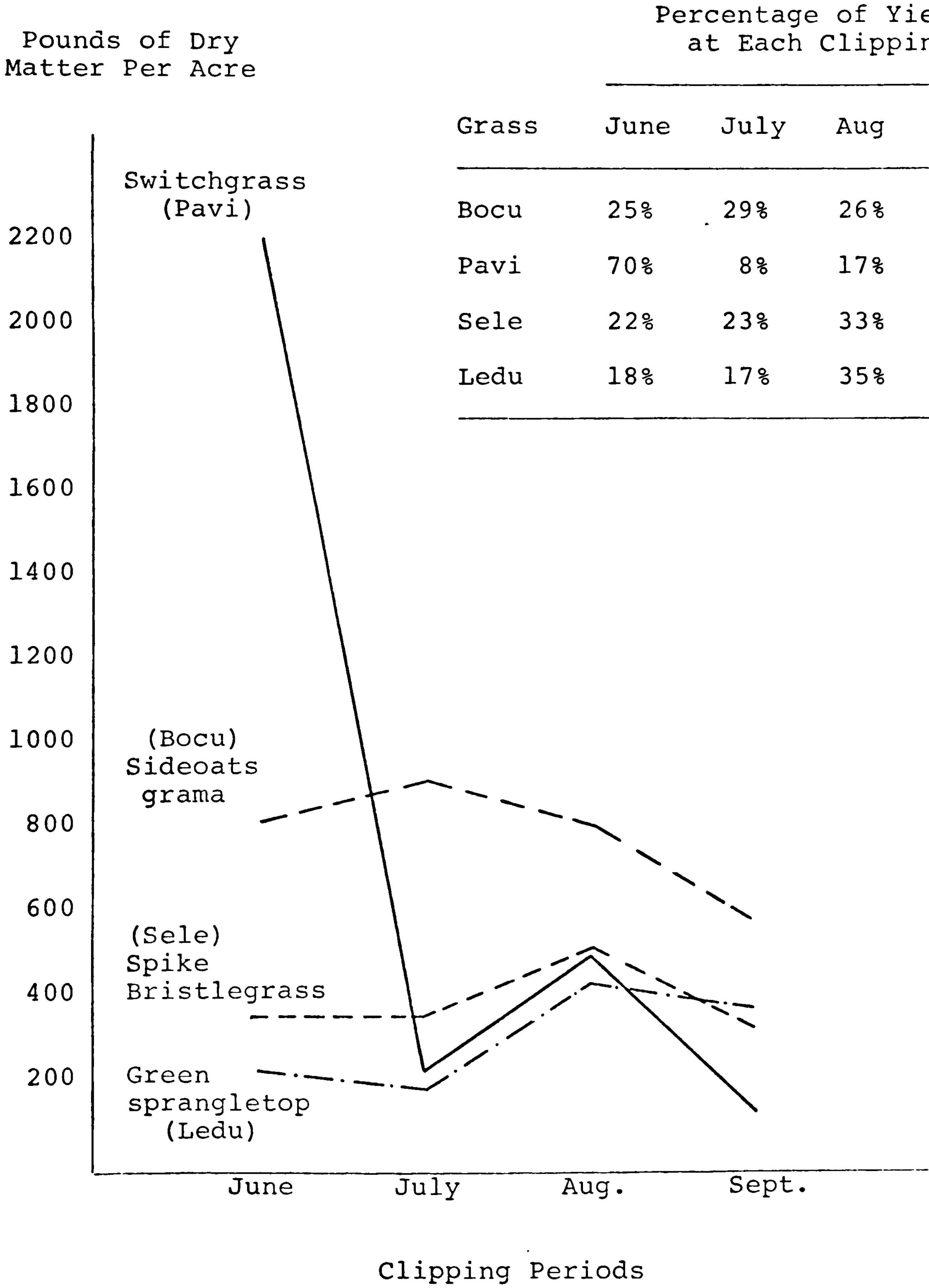

TABLE 4. COTTON LINT PRODUCTION IN POUNDS PER ACRE

Grass Species[1]	Yield
Spike bristlegrass	582 a[2]
Green sprangletop	528 a
Sideoats grama	525 a
Switchgrass	414 a

[1]Lint yields grouped according to the grass species with which cotton was intercropped.

[2]Means in a given column, followed by the same letter, are not significantly different at the .05 probability level.

Higher yields of cotton were obtained from rows located on the north side of the grass than from rows of cotton on the south side of the grass (Table 5).

TABLE 5. COTTON LINT PRODUCED ON EITHER SIDE OF GRASS IN POUNDS PER ACRE

Grass Species	North Side[1]	South Side[2]
Spike bristlegrass	597 a[3]	574 a
Green sprangletop	536 a	497 a
Sideoats grama	535 a	506 a
Switchgrass	431 a*	367 a

[1]Average lint yields from cotton rows on the north side of the grass plots.

[2]Average lint yields from cotton rows on the south side of the grass plots.

[3]Means in a given column, followed by the same letter, are not significantly different at the .05 probability level.

*Indicates a significant difference in yield between north and south side of row at .05 level.

A significant increase in cotton yield from rows on the north side of grass occurred only in rows intercropped with switchgrass. Severe stunting in growth of cotton occurred in rows on the south side of switchgrass. Cotton failed to germinate in many rows located on the south side of the grass (Figs. 12 and 13).

Figure 12. Picture of cotton located on the south side of switchgrass. The row adjacent to the grass failed to germinate.

Figure 13. Picture of cotton growing on the north side of switchgrass. Cotton in the row adjacent to the grass is small and stunted.

Significant differences between each cotton row sampled are shown in Table 6. Lint yields are grouped according to the grass species with which cotton was intercropped.

TABLE 6. COTTON LINT YIELDS IN POUNDS PER ACRE

Rows Sampled	Grasses[1]			
	Ledu	Sele	Bocu	Pavi
Skip-row plots on north side of grass	687 a[2]	793 a	758 a	627 b
Pruned plots, one row removed from north side of grass	661 ab	713 b	684 b	706 a
Unpruned plots, one row removed from north side of grass	637 b	660 c	593 d	572 a
Unpruned plots, one row removed from south side of grass	622 b	673 bc	661 bc	551 c
Skip-row plots on south side of grass	624 b	762 a	635 c	537 c
Pruned plots, adjacent to north side of grass	464 c	450 d	393 e	217 d
Unpruned plots, adjacent to north side of grass	283 d	338 e	255 f	93 e
Unpruned plots, adjacent to south side of grass	246 d	286 f	221 f	12 f

[1]Grass species appear in abbreviated form according to the scientific name: Ledu-(Leptochloa dubia) Green sprangletop; Sele-(Setaria leucopila) Spike bristlegrass; Bocu-(Bouteloua curtipendula) Sideoats grama; Pavi-(Panicum virgatum) Switchgrass.

[2]Means in the same column and having the same letter are not significantly different at the .05 level. Letters also indicate the highest to lowest yielding row when intercropped with each grass.

Effect of Herbage Removal on Cotton Yield

Lint cotton data from rows adjacent to the clipped grass plots are reported in Table 7. Higher cotton yields were obtained from all rows that were adjacent to the clipped grass plots with the exception of spike bristlegrass, which had an inverse relationship. Cotton yield differences were not significant between clipped and unclipped grass plots. A significant yield difference occurred, however, between cotton intercropped with switchgrass, and cotton intercropped with the other three grasses.

TABLE 7. COTTON LINT YIELDS IN POUNDS PER ACRE FROM ROWS ADJACENT TO CLIPPED AND UNCLIPPED GRASS[1]

Grass Species	Clipped	Unclipped
Green sprangletop	273 a[2]	257 a
Spike bristlegrass	262 a	362 a
Sideoats grama	262 a	215 a
Switchgrass	86 b	20 b

[1]Yields are from cotton rows which were adjacent to clipped and unclipped grass plots.

[2]Means in a given column, followed by the same letter, are not significantly different at the .05 probability level.

With one exception, cotton growing in the second row from clipped grass plots produced less lint than did cotton in the second row from unclipped grass plots (Table 8). Yield differences between clipped and unclipped plots, however, were not significant. Cotton production in the second row away from all four grasses were not significantly different. The data showed that clipping or not clipping the grasses did not significantly effect cotton yields.

TABLE 8. YIELDS OF COTTON LINT HARVESTED FROM THE SECOND ROW FROM CLIPPED AND UNCLIPPED GRASS PLOTS[1]

Grass Species	Pounds per Acre	
	Clipped	Unclipped
Spike bristlegrass	632 a[2]	702 a
Green sprangletop	599 a	660 a
Sideoats grama	598 a	656 a
Switchgrass	597 a	527 a

[1]Lint yields from cotton rows that were separated from clipped and unclipped grass plots by one row of cotton.

[2]Means in a given column, followed by the same letter, are not significantly different at the .05 probability level.

Fertilized Cotton

Ammonium nitrate applications resulted in an increase in cotton yields, but the yield increase was significant only in rows intercropped with sideoats grama (Table 9). The greatest increase in yield occurred in cotton rows inter-cropped with green sprangletop although the increase was not significant. Fertilizer applications produced an average increase of approximately one-fourth of a bale of cotton per acre.

TABLE 9. COTTON LINT YIELDS IN POUNDS PER ACRE FROM FERTILIZED AND UNFERTILIZED PLOTS

Grass Species	Fertilized	Unfertilized
Spike bristlegrass	641	522
Green sprangletop	605	451
Sideoats grama	584*	466
Switchgrass	484	344

*Indicates a significant difference in yield between treatments at the .05 level.

Root Pruned Plots

A significant increase in yields of cotton resulted from plots in which roots of the adjacent grass were pruned (Table 10). Root pruning of the grasses was the most effective treatment used to increase cotton yields by reducing grass-cotton competition.

TABLE 10. COTTON LINT PRODUCED IN POUNDS PER ACRE FROM ROWS ADJACENT TO PRUNED AND UNPRUNED GRASS

Grass Species	Pruned	Unpruned
Spike bristlegrass	450*	312
Green sprangletop	465*	265
Sideoats grama	394*	239
Switchgrass	217*	54

*Indicates a significant difference in yield between treatments at the .05 level.

With the exception of cotton intercropped with green sprangletop, pruning grass roots significantly increased cotton production in rows that were one row removed from the grass plots (Table 11). The results showed that grass roots were competing with cotton in the second row away from the grass plots for soil moisture and soil nutrients.

TABLE 11. COTTON LINT PRODUCTION PER ACRE FROM ROWS THAT WERE ONE ROW REMOVED FROM PRUNED AND UNPRUNED GRASS

Grass Species	Pruned	Unpruned
Spike bristlegrass	713*	660
Green sprangletop	661	637
Sideoats grama	685*	593
Switchgrass	706*	572

*Indicates a significant difference in yield between treatments at .05 level.

Skip-row Cotton

Cotton production was higher in the skip-row plots than in the solid planted 4-row plots (Table 12). Skip-row planting of cotton significantly increased yields in rows that were intercropped with spike bristlegrass and with sideoats grama. The largest increase in yield from skip-row plots occurred in cotton intercropped with spike bristlegrass, while the smallest increase in yield was obtained from cotton interplanted with switchgrass.

TABLE 12. COTTON LINT YIELDS FROM SKIP-ROW PLOTS IN POUNDS PER ACRE

Grass Species	Skip-row	Solid[1]
Spike bristlegrass	778*	667
Sideoats grama	697*	627
Green sprangletop	656	630
Switchgrass	582	562

[1]Yields were obtained from the middle two rows of the 4-row planting.

*Indicates a significant difference in yield between skip-row and solid planting at the .05 level.

Radioactive Phosphorus

Data from the P^{32} placements in cotton growing next to grass that was not root pruned are shown in Table 13. Most roots of the cotton plants intercepted the isotope within three weeks after placement. Roots of cotton in plots intercropped with unclipped switchgrass did not contact P^{32} until the sixth and eighth weeks after placement. The roots of switchgrass in clipped, but unpruned plots absorbed the isotope three weeks after placement. Roots of the other grasses in the experiment picked up P^{32} in four to eight weeks. Green sprangletop was the only grass that did not show complete interception of the isotope.

The data from the P^{32} placements in cotton growing next to grass show that pruning restricted the lateral growth of the grass roots (Table 14). Four weeks after

TABLE 13. INTERCEPTION OF P^{32} BY COTTON AND GRASS ROOTS IN UNPRUNED PLOTS

Treatment	Depth of Placement	Intercepted by		
		Cotton	Grass	
Grass clipped and Cotton fertilized	10"	+[1]	o[2]	Green sprangletop
	30"	+	o	
	20"	+	o	
Grass not clipped and Cotton not fertilized	30	+	+	
	20	+	o	
	10	+	o	
Grass clipped and Cotton not fertilized	10	+	+	
	20	+	o	
	30	+	o	
Grass not clipped and Cotton fertilized	20	+	o	
	10	+	+	
	30	+	+	
Grass clipped and Cotton fertilized	10"	+	+	Spike bristlegrass
	30"	+	+	
	20"	+	+	
Grass not clipped and Cotton not fertilized	30	+	+	
	20	+	+	
	10	+	+	
Grass clipped and Cotton not fertilized	10	+	+	
	20	+	+	
	30	+	+	
Grass not clipped and Cotton fertilized	30	+	+	
	20	+	+	
	10	+	+	

[1]Plus sign indicates uptake of P^{32}.

[2]Zero sign indicates no uptake of P^{32}.

TABLE 13. Continued

Treatment	Depth of Placement	Intercepted by Cotton	Intercepted by Grass	
Grass not clipped and Cotton not fertilized	20" 10" 30"	+[1] + +	+ + +	Sideoats grama
Grass not clipped and Cotton fertilized	10 30 20	+ + +	+ + +	Sideoats grama
Grass clipped and Cotton not fertilized	20 10 30	+ + +	+ + +	Sideoats grama
Grass clipped and Cotton fertilized	20 30 10	+ + +	+ + +	Sideoats grama
Grass clipped and Cotton fertilized	10" 30" 20"	+ + +	+ + +	Switchgrass
Grass clipped and Cotton not fertilized	10 20 30	+ + +	+ + +	Switchgrass
Grass not clipped and Cotton fertilized	20 30 10	+ + +	+ + +	Switchgrass
Grass not clipped and Cotton not fertilized	30 10 20	+ + +	+ + +	Switchgrass

[1]Plus sign indicates uptake of P^{32}.

TABLE 14. INTERCEPTION OF P^{32} BY COTTON AND GRASS ROOTS IN PRUNED PLOTS

Treatment	Depth of Placement	Intercepted by Cotton	Intercepted by Grass	
Grass clipped and Cotton fertilized	10"	+[1]	o[2]	Green sprangletop
	20"	+	o	
	30"	+	o	
Grass not clipped and Cotton not fertilized	20	+	o	
	10	+	o	
	30	+	o	
Grass clipped and Cotton not fertilized	20	+	o	
	10	+	o	
	30	+	o	
Grass not clipped and Cotton fertilized	20	+	o	
	30	+	o	
	10	+	o	
Grass clipped and Cotton fertilized	30"	+	o	Spike bristlegrass
	10"	+	o	
	20"	+	o	
Grass not clipped and Cotton not fertilized	10	+	o	
	20	+	+	
	30	+	o	
Grass clipped and Cotton not fertilized	10	+	o	
	30	+	o	
	20	+	o	
Grass not clipped and Cotton fertilized	20	+	+	
	10	+	o	
	30	+	o	

[1]Plus sign indicates uptake of P^{32}.

[2]Zero sign indicates no uptake of P^{32}.

TABLE 14. Continued

Treatment	Depth of Placement	Intercepted by Cotton	Intercepted by Grass	
Grass not clipped and Cotton not fertilized	10"	+[1]	o[2]	Sideoats grama
	30"	+	+	
	20"	+	+	
Grass not clipped and Cotton fertilized	30	+	o	
	20	+	o	
	10	+	o	
Grass clipped and Cotton not fertilized	10	+	o	
	20	+	o	
	30	+	o	
Grass clipped and Cotton fertilized	30	+	o	
	10	+	o	
	20	+	+	
Grass clipped and Cotton fertilized	10"	+	o	Switchgrass
	20"	+	o	
	30"	+	+	
Grass clipped and Cotton not fertilized	10	+	o	
	30	+	o	
	20	+	o	
Grass not clipped and Cotton fertilized	20	+	+	
	30	+	+	
	10	+	+	
Grass not clipped and Cotton not fertilized	30	+	+	
	20	+	+	
	10	+	+	

[1]Plus sign indicates uptake of P^{32}.

[2]Zero sign indicates no uptake of P^{32}.

the P^{32} placements, nearly all of the cotton plants had picked up the isotope. The adjacent switchgrass which was so effective in picking up the radioactive material in unpruned plots, intercepted P^{32} in six to eight weeks after the placement date. The isolated cases of P^{32} interception by sideoats grama and spike bristlegrass occurred in eight to eleven weeks after placement.

CHAPTER V

SUMMARY AND CONCLUSIONS

A competition study between four native grasses and one variety of cotton was conducted during the growing season of 1966 on the Texas Technological College Agronomy Farm. The amount of competition exerted by each grass on the cotton was measured by lint yields. The grasses were evaluated on the basis of forage production and competing ability. Grass herbage removal, grass root pruning, and skip-row planting of cotton were employed to reduce the competitive effects between the grasses and the cotton. Cotton was fertilized to promote its ability to compete with the grasses. In addition to the use of forage and lint yields as measures of plant competition, radioactive phosphorus was utilized in testing the effectiveness of grass root pruning in reducing plant competition.

The following conclusions were drawn from this experiment:

(1) The outside grass rows in each 4-row plot produced more forage than did the inner grass rows. This yield difference was the result of reduction in the amount of intraspecific competition exerted on the grass in the outside row.

(2) Forage yields of switchgrass and sideoats grama were significantly greater than forage yields of green sprangletop and spike bristlegrass. In comparing results

of monthly forage yields, total forage production, and competitive effects on cotton, it was concluded that sideoats grama was the best of the four grasses studied for use in situations similar to those found in this study.

(3) Root pruning the grasses had no affect on forage yields from a statistical standpoint. Certain trends, however, in forage production resulting from the pruning treatment indicated that continued pruning might have a depressing effect on yields of green sprangletop and spike bristlegrass.

(4) Ammonium nitrate applications to cotton resulted in significant increases in forage yields of switchgrass and sideoats grama. The yield increases that occurred in green sprangletop and spike bristlegrass plots, however, were not significant at the .05 probability level. The data indicated that the root systems of switchgrass and sideoats grama competed with cotton roots for soil nutrients, thus, the beneficial effects of fertilizer applications on cotton yields were reduced.

(5) The interaction of plant maturity factors and day length caused a reduction in yields of all grasses between the third and fourth clipping periods.

(6) Although measurable differences in lint yield occurred in cotton intercropped with the various grasses, yield differences were not statistically significant. The wide range in variation among cotton yields resulted in a large error value in the analysis of variance, therefore statistical differences in cotton yields were not obtained.

(7) Significantly higher yields of cotton were obtained from rows located on the north side of switchgrass than from rows of cotton located on the south side of switchgrass. Lint yield increases in cotton rows on the north side of sideoats grama, green sprangletop, and spike bristlegrass were not statistically different at the .05 probability level. Cotton rows on the north side of grass plots were partially shaded throughout the day, thus, soil moisture on the north side of grass was not evaporated as rapidly as moisture on the south side of grass. From this evidence, it was concluded that yield differences between cotton on the north side and cotton on the south side of grass occurred as a result of the combined effects of shading and evaporation.

(8) Since clipping the grasses did not affect cotton yields, it was concluded that the clipping heights were not short enough to reduce root competition.

(9) Ammonium nitrate applications to cotton resulted in a significant increase in lint yields in rows intercropped with sideoats grama. Yield increases in cotton intercropped with the other three grasses were not statistically different at the .05 level. Although an increase of one-fourth bale per acre was not statistically significant, this difference might be of considerable value from an economic standpoint.

(10) Root pruning of the grasses, which resulted in a significant increase in cotton yield in all rows, proved

to be the most effective treatment in reducing grass competition. The cotton rows adjacent to grass benefited more from the root pruning treatment than did cotton rows that were one row removed from grass. Data from the P^{32} sites showed that root pruning of the grasses reduced lateral root growth, and therefore reduced root competition.

(11) The skip-row planting of cotton increased lint yields in rows intercropped with spike bristlegrass and with sideoats grama. The skip-row method reduced intraspecific competition by eliminating the outside cotton rows in each 4-row strip. The two remaining inner cotton rows received additional increments of soil moisture, soil nutrients, and light than did the conventional solid planted cotton.

The results of this study suggest that further investigations involving grass fertilization, light interception, soil moisture, and clipping treatments be conducted to fully evaluate the competing abilities of the four grasses.

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