GRASS SEEDLING GROWTH AND ESTABLISHMENT AS INFLUENCED BY FERTILIZATION AND WEED CONTROL

By

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CHAPTER I

INTRODUCTION

A need for revegetation exists on many millions of acres of abandoned cropland and depleted range in the Southern Great Plains. These areas are producing far less than their potential and range reseeding will be necessary to bring these lands back into peak production. This revegetation may be accomplished either naturally or by reseeding.

Natural succession is time consuming, often requiring decades to reach optimum production. By reseeding, the task of revegetation may be reduced to a few years with an immediate increase in production.

Reseeding is costly and risky. A rancher may find that the success or failure of a grass seeding depends on: adaptability of the species; seed germination and emergence; seedling vigor, growth, and survival; seedbed; climatic conditions; soil moisture and fertility; plant competition; and management after seeding. Even with the use of proper techniques, failures are too common.

The responses of established stands to fertilization and weed control have been evaluated many times. On seedling grasses, little research has been conducted concerning these factors and results are contradictory.

This study was conducted to better clarify the influences of weed control and fertilization on growth, establishment, and subsequent production of seedling grasses. It is hoped that any results obtained will be of benefit to agricultural workers by increasing the number of successful seedings.

CHAPTER II

LITERATURE REVIEW

Costello (1944) reported the time for natural revegetation of the mixed-grass prairie region of Colorado to be 30 to 60 years. Abandoned cropland in Oklahoma and Kansas was not approaching the original prairie stage after 31 years (Booth, 1941). Savage and Runyon (1937) found the time required for desirable grasses to reclaim abandoned fields in the Central and Southern Great Plains region varied from 25 to 40 years.

The rate of succession was affected by many factors. Booth (1941) listed burning, intensity of grazing, and severity of erosion as factors affecting the rate of secondary succession. The rate of secondary succession was influenced by previous cultivation, management of adjacent fields, grazing intensity, nearness of plowed fields and pasture lands, topography, and soil type (Savage and Runyon, 1937). After many years of natural revegetation, many areas still contained a high percentage of unpalatable forbs and low value grasses. Forage production was far below the potential. A lack of seed source has often been mentioned as a factor in delaying secondary succession. The time for revegetation may be reduced to five years or less by planting seed on these areas. Hull et al. (1962) found that depleted areas in Colorado could be returned to production in 2 or 3 years by reseeding.

Oklahoma, Kansas, and Texas have over 26,000,000 acres of abandoned cropland and depleted rangeland that need reseeding (Oklahoma Conservation Needs Committee, 1962; Cleavinger and Willoughby, 1946; Rechenthin et al., 1965). Reseeding is risky and failures are very common. The Great Plains Committee (1966) arbitrarily chose one seedling per square foot as the criteria for a successful stand. In their survey, 25% of the plantings in Oklahoma during 1961-1963 were classified as failures, and only 60% were considered successful. In Kansas, only 40% of the plantings in these same years were considered successful.

Lloyd and Cook (1960) considered the stand successful if it contained one plant per four square feet. Twenty-five percent of all surveyed Utah seedings were described as failures.

Launchbaugh and Anderson (1963) in a five year Kansas study used one seedling per square foot as the standard for a successful stand and found less than 50 percent stands on the best seedings.

The cost of reseeding abandoned rangeland and sagebrush areas in New Mexico was $7.57 per acre plus the loss of three years of use (Pingery and Dortignac, 1957). In Idaho, the cost of reseeding was $7.52 per acre and varied with the size of the seeded area (Caton and Beringer, 1960). Lloyd and Cook (1960) reported the cost of reseeding Utah rangeland to be $8.92 per acre. The cost of reseeding a failure was an additional 41 percent. Colorado rangeland reseeding costs were $7.73 per acre (Gardner, 1961).

Total production of pastures at Woodward, Oklahoma, was increased by reseeding (McIlvain and Savage, 1950). In seven and one-half years, seeded pastures produced 2 to 3 times more beef per acre than adjacent native pastures. The total net income from this period was increased as much as $51.58 per acre.

Frishknect (1951) concluded that the seedling stage was the critical period in stand establishment. No differences were found in the total number of surviving plants of fall or spring seedlings, but emergence was higher in the fall seedings. Better survival with less winter kill was observed in the spring seedings. Losses of seedlings due to winter killing ranged from 10% in the spring seedings to 48% in the fall seedings.

The importance of seedling vigor in seedling establishment was reported by Kneebone and Cremer (1955). Differences in seedling vigor among grass species and among strains within species were described. The differences in seedling vigor within a given strain were partly attributed to seed size. Seed size had little effect on germination within a species, but seedlings from large seeds emerged and grew faster than those from smaller seeds.

The ease of establishment was directly related to the inherent seedling vigor of the species (Welch, et al., 1962). Those species with high inherent seedling vigor were easier to establish and gave more initial growth response to fertilizer than those species with low inherent seedling vigor. Species with low seedling vigor were difficult to establish in Texas and did not respond to fertilization.

McMurtry (1945) in an Oklahoma survey pointed out the necessity of a proper seedbed for better stands. Reduction of weed competition and protection from grazing for 2 to 3 years were essential for stand establishment. Two to five years were required for the seedings to make a satisfactory ground cover for erosion control and to produce sufficient forage for grazing.

McIlvain and Savage (1950) stated that the most successful method of native grass stand establishment at Woodward, Oklahoma, was to plant a well adapted native mix using a double-disk-banded coulter drill on a firm seedbed composed of a sorghum or sudangrass stubble mulch. Recommended practices were the control of weeds by mowing and protection from grazing until the stand was established, then grazing for maximum sustained production.

Soils differences caused differences in the stand of crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) in Utah (Cook, 1961). Sherwin (1923) reported that soil class did not influence germination. Damage to germination was directly proportional to the amount and solubility of the fertilizer used. Fertilizer did inhibit germination possibly due to decreasing osmotic absorption of water from the soil solution. The degree of inhibition was greater as rates of fertilizer increased and as the solubility of the fertilizer increased.

The relationship between seedling emergence and soil moisture has been noted by several researchers. Moldenhauer (1959) found an increase in the number of seedlings on both high and low moisture levels with mulching. Mulch was required at low moisture levels for emergence of seedlings, and three times as many seedlings emerged at the high moisture level with mulch than without mulch. More seedlings were found at the high moisture level than at the low level.

Shaddox (1955) concluded that moisture was more important in obtaining grass stands than fertility in an Oklahoma study. Check plots produced better stands than did the fertilizer treatments. No stands were established in years when moisture was limiting. Fertilizer had no effect on the growth rate of any species.

Norris and Valentine (1962)[1] related seedling emergence to rainfall in New Mexico. Excellent emergence resulted in areas receiving above normal precipitation, while poor stands were found on lower rainfall sites. Soil moisture appeared to be the major limiting factor in stand establishment. At least 5 inches of rainfall during the growing season was required for stand establishment. The distribution of precipitation during the growing season was also important.

Fertility appeared to be a greater limiting factor than moisture for range production in Montana, even on a coarse-textured, droughty soil with limited rainfall (Klages and Ryerson, 1965).

Six times more western wheatgrass (*Agropyron smithii* Rydb.) plants were established with the aid of supplemental moisture in a South Dakota experiment (Cosper and Alsayegh, 1964). Starter fertilizer had no effect on the number of established plants under optimum moisture conditions. Under droughty conditions starter fertilizer doubled the number of established plants over the nonfertilized plots.

Welch et al. (1962) found that starter fertilizers did not improve seedling emergence or final plant stand, but increases in growth rate of seedlings were noted on fertilized plots in Texas.

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[1]Norris, J. J. and K. A. Valentine. 1962. Artificial revegetation of desert grassland in New Mexico. Range Res. Tech. Comm. (GP-6) PR-1962.

Response to starter fertilizer was found to be species specific by McIlvain and Schoop (1961)[2]. Low rates of phosphate and low rates of nitrogen improved blue grama (*Bouteloua gracilis* (H.B.K.) Lag. X Steud.) plant establishment. Nitrogen at the lowest rates gave 50% better stands. Higher rates of nitrogen decreased stands. Switchgrass (*Panicum virgatum* L.) establishment was not affected by any fertilizer treatment. A 40% increase in vigor was noted in nitrogen fertilized blue grama. Limestone, bentonite, and gypsum gave increases in seedling establishment when applied as starter fertilizer.

Norris and Valentine (1962)[1] reported no increase in seedling emergence from fertilizing, mulching, deep-furrow planting or a combination of these variables when rainfall was twice normal. These variables did improve growth rate and seedling vigor which resulted in two to three times greater seedling survival.

Hudspeth et al. (1959) concluded from a Texas study that fertilizer combinations would enhance the rate of seedling development, improve stands, and increase seedhead development when soil moisture conditions were favorable for seed germination. Phosphate did not increase seedling growth, but nitrogen favored the initial growth. Final stands were increased with fertilizer combinations by increasing the survival of the seedlings.

The rate of seedling development in the early growth stages was increased in Texas by fertilization with nitrogen and phosphorus (Walker, et al., 1958). Fertilizer placement or rate did not influence

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[2]McIlvain, E. H. and M. C. Shoop. 1961. Establishment methods. U.S. Southern Great Plains Field Sta. Annual Report: 53-71.

the plant stand, growth rate, and seed or forage yield.

Silker et al. (1950) found nitrogen and phosphorus essential for stand establishment of introduced grasses. Bermuda grass (*Cynodon dactylon* (L.) Pers.) could not be established from seed without fertilization. The best stands on other species were also obtained with fertilization.

Heavy fertilization with favorable rainfall conditions in Oklahoma was found to reduce plant vigor and stand of side oats grama (*Bouteloua curtipendula* (Michx.) Torr.) (Ahring, 1958).

Baggett (1953) observed toxic effects of ammonium nitrate on the emergence of sand bluestem (*Andropogon hallii* Hack.). Potassium additions resulted in higher germination of smooth bromegrass (*Bromus inermis* Leyss.). Systox retarded date of germination. Switchgrass and sand lovegrass (*Eragrostis trichodes* (Nutt.) Wood) germination and emergence were not affected by any additive.

Hackett (1965) stated that the addition of calcium, iron, manganese, and potassium had no beneficial effect on growth of *Deschampia flexuosa* (L.). The optimum nitrate level was 10 p.p.m. of nitrate ions.

Increased seedhead production in an Oklahoma study was attributed to nitrogen fertilization by Burnham (1955), but these plants also suffered more severely from moisture shortages than did the unfertilized plants.

Cook (1965) observed that nitrogen fertilization of seeded foothill ranges in Utah increased yield of herbage, number of seeds per plant, basal area of grass crown, palatability and root numbers. Plant height and leaf length were not affected. Phosphate fertilization had no effect on any of the above. On mountain ranges, phosphorus improved herbage yields, but not as much as did nitrogen. Additive effects of nitrogen and phosphorus were found. On arid rangeland, starter fertilizers had no beneficial effects on seedling establishment, seedling emergence, plant survival, or subsequent production.

Perhaps the greatest obtacle to successful establishment of native grass seedings in Oklahoma has been competing vegetation (Thompson and Schaller, 1960). Spraying with 2,4-D to control broadleaf weeds increased the number of emerged seedlings, surviving plants and herbage production. A second spraying at the beginning of the second year increased the number of plants established at the end of the second year. Small quantities of phosphate and nitrogen applied at planting were beneficial when annual weed seeds were not present.

When seedlings had to compete with existing perennial vegetation no successful seedings, with or without fertilization, were obtained. (Cosper, 1962[3]; McIlvain and Savage, 1950).

Welch et al. (1962) noted that the effects of weed competition could be overcome by fertilization. Fertilizer combinations gave increased growth and counteracted the reducing effect of the weed competition. In years of above normal rainfall, weed competition reduced the plant stands on all treatments.

Nitrogen fertilizer applied at the time of seeding was detrimental to seedling establishment because it increased weed growth and

[3]Cosper, H. R. 1962. The influence of fertilizer rates, moisture, and range plant competition in establishing range vegetation. Range Res. Tech. Comm. (GP-6) PR-1962.

competition at Woodward (McIlvain and Savage, 1950).

McIlvain and Schoop (1961)[2] recommended mowing in preference to spraying with 2,4-D for weed control in seedings. Mowed plots contained more established plants than did sprayed plots. Spraying of young grass seedlings appeared to be detrimental to stand establishment as evidenced by fewer seedlings and an invasion of short-lived perennial grasses.

Three methods of weed control before seeding were recommended by Stark et al. (1947). These were: (1) summer fallowing, (2) cultivation with a ducks-foot cultivator before drilling, or (3) a controlled burn in late spring. Burning was cheapest, but the summer fallowing was found to give the best results.

CHAPTER III

MATERIALS AND METHODS

Greenhouse Study

The greenhouse experiment, conducted during the winter of 1964, was to study the effects of fertilizers on seedling emergence, growth, and herbage and root production. Four species were tested; big bluestem (*Andropogon gerardi* Vitman), weeping lovegrass (*Eragrostis curvula* (Schrad.) Nees), switchgrass (*Panicum virgatum* L.) and old world bluestem (*Bothriochloa ischaemum* (L.) Keng. var. *ischaemum*).

A completely randomized design was used with five replications and two clipping dates. The first sampling date was in the seedling stage, seven weeks after emergence. The second sampling date was at eleven weeks after emergence when some of the plants had started to mature and produce inflorescences.

The soil was a Norge fine sandy loam and from the Perkins Experiment Station. No previously recorded fertilizer treatments had been applied to the soil. Approximately 3300 grams of soil were placed in plastic bags in one gallon containers for each treatment.

Ammonium nitrate in solution at the rate of 100 pounds of actual nitrogen per acre was used in the initial trial. This was added to the soil before seeding. A second trial was required because of poor germination on nitrogen plots. A reduced rate, 30 pounds of nitrogen, was used in the second trial and applied to the soil surface after seedlings had emerged. Phosphate, as a solution of phosphoric acid, was applied at the rate of 13 pounds of actual phorphorus per acre and applied one half inch below the seed prior to planting.

Following seedling emergence the pots were thinned to contain no more than ten seedlings per pot. Herbage yields and root weights were taken at seven weeks and eleven weeks after emergence of plants. Plants were clipped at ground level and roots washed free of soil. Samples were oven dried at 70°C for 48 hours before weighing. An attempt to use plant height as an indicator of vigor and growth was discarded due to difficulty in defining plant height and the variation within pots.

The data were statistically analyzed and the differences tested by use of Duncan's multiple range test (Ostle, 1963).

Field Study

The field study was initiated at the Perkins Experiment Station in May, 1965, to determine the effects of fertilizer additions and weed control on the growth and establishment of seedling grasses. Species tested were Kaw big bluestem (*Andropogon gerardi* Vitman), Indiangrass (*Sorghastrum nutans* (L.) Nash), Caddo switchgrass (*Panicum virgatum* L.), weeping lovegrass (*Eragrostis curvula* (Schrad.) Nees), and "M" blend of the old world bluestems (*Bothriochloa ischaemum* (L.) Keng. var. *ischaemum*).

The experiment was conducted on a Norge fine sandy loam soil that is medium to high in available phorphorus and potassium and has an organic matter content of approximately two percent. The soil solution tests moderately acid.

The experimental design was a split, split block with six replications. The main block treatments were grass species and weed control versus no weed control. The sub-block treatments were the fertility levels, which were randomized within each grass species.

A firm seedbed was prepared by plowing and harrowing. The area had been in small grains the previous winter and some litter was present. Soil moisture was good at the time of seeding.

The plots were seeded on May 26, 1965. Seeding rates were at a heavier rate than is normally recommended in this area to insure a good stand. On a per acre basis, seeding rates were; big bluestem 10 pounds, indiangrass 4.5 pounds, switchgrass 3.5 pounds, and weeping lovegrass 0.75 pounds. The old world bluestem, a recent introduction not yet tested, had no published seeding rate and was seeded at 10 pounds per acre. Seeding of all chaffy seeded species was accomplished with a V-belt seeder, while the smooth seeded species were planted with a Planet Jr. seeder. Each plot was composed of three rows, one foot apart and twelve feet in length.

The fertility treatments were 30 pounds of actual nitrogen per acre, 13 pounds of actual phosphorus per acre, 30 pounds of nitrogen plus 13 pounds of phosphorus per acre, and the unfertilized check.

The phosphate fertilizer, 0-46-0, was broadcast and roto-tilled into the upper four inches of soil prior to seeding. Following seedling emergence, the ammonium nitrate fertilizer, 33.5-0-0, was broadcast.

Weed control was accomplished with a hoe and these plots were kept free of weeds throughout the season. The plots with weed competition were infested with crabgrass (*Digitaria* spp.).

Stand counts were taken July 21 and November 20, 1965. A full stand was considered to be the presence of at least one plant in each four inch space for eight feet of the row.

A sod reserve study was conducted to obtain a more quantitative evaluation of each treatment. The procedure of Burton and Jackson (1962) was modified to include the use of a four inch sod plug and absolute darkness. One sod plug was pulled from each plot of three replications. With adequate moisture, constant temperature (80°F), and no light, the plants were allowed to exhaust the sod reserves. Tiller number, length, and weight were obtained upon cessatation of growth. The top growth was clipped at crown height and oven-dried at 80°C for 48 hours before weighing.

Forage yields of weeping lovegrass were taken on May 31, 1966. An eight foot length of row was sampled for forage production.

The data were analyzed for statistical significance and any differences were tested using Duncan's multiple range test (Ostle, 1963).

CHAPTER IV

RESULTS AND DISCUSSION

Greenhouse Study

A greenhouse study was conducted in an attempt to evaluate the effects of fertilization on seedling emergence and growth. Seven days after emergence the pots were thinned to contain no more than 10 plants. All seedlings had emerged from all treatments within 36 hours of the first observed emergence, therefore, it was concluded that seedling emergence was not appreciably affected by fertility treatment.

Weeping Lovegrass

A significant increase in forage yield of 7 week old weeping lovegrass seedlings was noted on the 30N plus 13P treatment (Table I). No other treatment produced a significant response in forage production. Forage yields in the later harvest were not significantly different.

Root production of weeping lovegrass seedlings in the first harvest was not significantly altered by fertilization (Table I). A significant increase in root weights of 11-week old seedling was noted in both phosphate treatments. Nitrogen alone did not affect root weights.

TABLE I

WEEPING LOVEGRASS PRODUCTION FROM THE GREENHOUSE STUDY*

Treatment Pounds/acre		Forage yield (grams/pot)		Root yield (grams/pot)	
N	P	7 weeks	11 weeks	7 weeks	11 weeks
0	0	.914 a	2.558 a	.205 a	1.472 a
30	0	.882 a	2.804 a	.221 a	1.250 a
0	13	1.018 a	2.718 a	.268 a	2.380 b
30	13	1.272 b	3.486 a	.315 a	2.370 b

*Means within a column followed by the same letter are not significantly different at the 5% level.

Old World Bluestem

Forage production of old world bluestem seedlings seven weeks after emergence was significantly increased by nitrogen fertilizer alone and phosphorus fertilizer alone (Table II). The fertilizer combination yields were not significantly different from any other treatment yields. By the eleventh week significant increases in forage production were observed in both phosphorus treatments. Nitrogen alone did not change the yield.

TABLE II

OLD WORLD BLUESTEM PRODUCTION FROM THE GREENHOUSE STUDY*

Treatment Pounds/Acre		Forage Yield (grams/pot)		Root yield (grams/pot)	
N	P	7 weeks	11 weeks	7 weeks	11 weeks
0	0	.634 a	1.880 a	.335 a	1.270 a
30	0	1.010 b	1.310 a	.324 a	1.378 a
0	13	1.162 b	2.658 b	.403 a	1.312 a
30	13	.928 ab	3.972 c	.320 a	1.782 b

*Means within a column followed by the same letter are not sifnificantly different at the 5% level.

The first harvest of seedling roots produced no changes as a result of fertilizer treatment (Table II). A significant increase was observed in the nitrogen plus phorphorus treatment in the last harvest. No other treatment increased root production over the check.

Switchgrass

Forage yields of switchgrass seedlings were not affected by fertilization in the 7-week stage (Table III). In the advanced growth stage, both nitrogen treatments increased forage production over the check. Phosphate alone did not significantly increase forage yield and was not different from the nitrogen treatments.

TABLE III

SWITCHGRASS PRODUCTION FROM THE GREENHOUSE STUDY*

Treatment Pounds/Acre		Forage Yield (grams/pot)		Root Yield (grams/pot)	
N	P	7 weeks	11 weeks	7 weeks	11 weeks
0	0	.698 a	.702 a	.842 c	1.680 b
30	0	.580 a	1.400 b	.510 ab	1.102 a
0	13	.804 a	1.034 ab	.684 bc	1.746 b
30	13	.744 a	1.260 b	.496 a	1.120 a

*Means within a column followed by the same letter are not significantly different at the 5% level.

Root weights of switchgrass seedlings were significantly influenced by fertilization at both harvest dates (Table III). Seedling roots were retarded by nitrogen fertilization. Phosphorus alone did not affect root weights.

By the eleventh week both nitrogen treatments produced significantly lower quantities of roots than did the check or phosphate alone treatments. This is the reverse of the results in forage production. Phosphorus apparently did not influence root production.

Big Bluestem

The forage yields of big bluestem seedlings were not different from the unfertilized check (Table IV). However, the phosphorus treatments produced significantly more forage than those fertilized with only nitrogen at the first harvest. Forage yields at the 11-week stage were similiar in all fertilizer treatments.

TABLE IV

BIG BLUESTEM PRODUCTION FROM THE GREENHOUSE STUDY*

Treatment Pounds/Acre		Forage Yield (grams/pot)		Root yield (grams/pot)	
N	P	7 weeks	11 weeks	7 weeks	11 weeks
0	0	.872 bc	1.258 a	.400 a	1.794 ab
30	0	.608 a	1.394 a	.317 a	1.462 a
0	13	1.042 c	1.438 a	.455 a	2.072 b
30	13	.772 ab	1.782 a	.317 a	1.462 a

*Means within a column followed by the same letter are not significantly different at the 5% level.

Root weights at the 7-week stage were not affected by fertilizer treatments (Table IV). At the 11-week harvest no root yields were different from the check. The phosphorus alone treatment produced significantly more roots than did either of the nitrogen treatments.

Field Study

Initial climatic conditions were favorable and good seedling emergence resulted on all treatments. Crabgrass seedlings emerged with the planted grass seedlings and provided some weed competition. The growing season precipitation of 1965 was below normal (Table V) and moisture stress was often encountered throughout the season.

TABLE V

RAINFALL DATA FOR PERKINS, OKLAHOMA, 1965*

	Inches of Precipitation	Departure from normal
January	2.16	+ .63
February	1.00	- .46
March	1.88	- .32
April	2.34	- .82
May	3.66	-1.43
June	4.44	- .14
July	1.77	-1.68
August	1.95	-1.24
September	10.64	+6.83
October	.88	-2.33
November	.05	-1.85
December	2.43	+1.01
Total	33.20	-1.80

*Climatological data. 1965. Oklahoma, annual summary. 74(13):221.

Stand counts revealed no differences in the stand of any species due to fertilization or weed control (Tables VI and VII). Survival of the seedlings was not influenced by any cultural treatment. The estimated seedling success varied with the different species from 36% to 99%. Evaluated on the basis of one seedling per square foot for a successful stand (Great Plains Committee, 1966), all seedings could be

TABLE VI

PERCENT STAND OF FIELD STUDIED SPECIES*

Treatment Pounds/Acre N	P	% Stand (7-21) With Weed Competition	% Stand (7-21) With Weeds Controlled	% Stand (11-20) With Weed Competition	% Stand (11-20) With Weeds Controlled
			Big Bluestem		
0	0	42	41	42	42
30	0	42	46	40	40
0	13	36	42	40	41
30	13	40	47	34	48
			Switchgrass		
0	0	83	81	78	81
30	0	83	85	63	88
0	13	74	77	56	75
30	13	81	74	65	78
			Indiangrass		
0	0	51	51	55	51
30	0	47	56	54	61
0	13	52	44	56	45
30	13	41	50	51	53
			"M" Blend of Old World Bluestem		
0	0	78	87	85	88
30	0	81	84	82	84
0	13	81	84	76	87
30	13	88	87	85	90
			Weeping Lovegrass		
0	0	99	97	97	97
30	0	97	99	94	94
0	13	94	98	96	97
30	13	99	97	99	99

*All percentages are based on the number of four inch units of row which contained at least one plant.

TABLE VII

SUMMARY OF THE PERCENT STAND ESTABLISHED BY ALL SPECIES FOR EACH CULTURAL PRACTICE

Treatment Pounds/Acre N	P	With Weed Competition	With Weeds Controlled	Average
0	0	71.5	71.7	71.6
30	0	66.5	73.3	69.9
0	13	64.6	68.9	66.8
30	13	66.7	73.5	70.1
Average		67.3	71.8	

considered successful.

Only one species was markedly affected by the summer drought. Switchgrass seedlings with crabgrass competition were reduced from an average stand of 80% to 65%. On the whole, weed control slightly increased the percentage of seedlings established, while the non-fertilized check plots had the highest per cent established seedlings of the fertility treatments.

By mid-summer it was observed that seedlings in the weedy plots were smaller, less robust, less vigorous, and shorter than the seedlings in the weed control plots. Signs of moisture stress in the form of leaf wilting were observed in the seedlings with weed competition. No signs of moisture stress were noted in the seedlings with weed control.

Some inflorescenses were present on all species without weed competition by August 25, 1965. By late November, the plots with weed competition still had produced no seedheads with one exception;

the old world bluestem produced some seedheads in the weedy plots although there were far more seedheads on the weed control plots.

Total sod reserves were evaluated on the basis of tiller numbers and tiller weight (Tables VIII and IX). Weed control significantly increased both tiller number and tiller weight in big bluestem, indiangrass, and old world bluestem. No statistical differences due to weed competition were found in the tiller number or weight of switchgrass and weeping lovegrass.

Fertilization did not significantly alter the number of tillers or weight of tillers produced by the sod reserves of any species (Tables X and XI).

The total length of tillers was also measured, but these measurements were relative to both the number of tillers and tiller weights, and no statistical analysis was made.

TABLE VIII

TILLERS NUMBERS AS INFLUENCED BY WEED COMPETITION ON SOD RESERVES (FIELD STUDY)*

	Tiller Number/pot**				
Treatment	Big Bluestem	Indiangrass	Switchgrass	"M" Blend	Weeping Lovegrass
With Weed Competition	44.0 a	61.3 a	75.3 a	147.7 a	270.7 a
With Weeds Controlled	106.7 b	161.3 b	179.7 a	286.0 b	445.3 a

*Means are average of three replications.

**Means within a column followed by the same letter are not significantly different at the 5% level.

TABLE IX

TILLER WEIGHTS AS INFLUENCED BY WEED COMPETITION ON SOD RESERVES (FIELD STUDY)*

	Tiller weight (grams/pot)**				
Treatment	Big Bluestem	Indiangrass	Switchgrass	"M" Blend	Weeping Lovegrass
With Weed Competition	.194 a	.478 a	.243 a	.587 a	1.598 a
With Weeds Controlled	1.122 b	2.588 b	1.841 a	1.517 b	5.093 a

*Means are average of three replications.

**Mean within a column followed by the same letter are not significantly different at the 5% level.

TABLE X

TILLER NUMBER AS INFLUENCED BY FERTILIZER TREATMENT ON SOD RESERVES (FIELD STUDY)*

Treatment Pounds/Acre		Tiller Number/pot**				
N	P	Big Bluestem	Indiangrass	Switchgrass	"M" Blend	Weeping Lovegrass
0	0	22.3	27.0	29.3	70.4	97.3
30	0	20.8	41.2	32.3	46.8	86.9
0	13	17.3	15.7	30.0	54.7	99.9
30	13	14.8	27.5	37.5	45.3	73.7

*Means are average of three replications.

**Means within a column are not significantly different at the 5% level.

TABLE XI

TILLER WEIGHTS AS INFLUENCED BY FERTILIZER TREATMENT ON SOD RESERVES (FIELD STUDY)*

Treatment Pounds/Acre		Tiller Weight (grams/pot)**				
N	P	Big Bluestem	Indiangrass	Switchgrass	"M" Blend	Weeping Lovegrass
0	0	.188	.318	.231	.358	.922
30	0	.204	.701	.297	.229	.748
0	13	.144	.123	.205	.272	.987
30	13	.123	.391	.362	.193	.689

*Means are average of three replications.

**Means within a column are not significantly different at the 5% level.

Forage production of weeping lovegrass was significantly increased by both weed control and fertilization (Table XII). Weed control was more effective in increasing forage yield than was fertilization. Forage yields were doubled, even tripled by the use of weed control. The weed control check plot significantly out-produced the best treatment in the weed competition plots by 1350 pounds of oven-dry forage per acre.

The effect of fertilizer on production was less striking than the effect of weed control. With weed competition, the nitrogen phosphate combination, 30-13, significantly increased yield over the weedy check plot. An increase of 1173 pounds of oven-dry forage per acre was attributed to this treatment. Nitrogen alone and phosphorus alone did not significantly increase yield over the check plot.

TABLE XII

WEEPING LOVEGRASS FORAGE PRODUCTION, FIELD STUDY

	Treatment Pounds/Acre N	P	Forage Yield Pounds/Acre*
With Weed Competition	0	0	1893 a
	30	0	2775 ab
	0	13	2111 ab
	30	13	3066 b
With Weeds Controlled	0	0	5411 c
	30	0	6309 cd
	0	13	6449 d
	30	13	6796 d

*Yields followed by the same letter are not significantly different at the 5% level.

When weeds were controlled phosphorus alone and in combination with nitrogen, significantly increased forage yield over the non-fertilized plots, but not over the yields from nitrogen alone. An increase of 1037 pounds of oven-dry forage per acre was found because of phosphorus fertilization. Fertilization with 30N plus 13P increased forage production by 1358 pounds per acre.

Forage yields were not taken on the other species because the plants were still in critical growth stages. Clipping in this stage could have been detrimental to the establishment and growth of the stand.

CHAPTER V

SUMMARY AND CONCLUSIONS

A greenhouse trial and field study were conducted to evaluate the effects of nitrogen and phosphate fertilization on seedling growth. The field study also included weed competition and seedling establishment was evaluated.

Greenhouse studies revealed no significant increase in forage or root production from nitrogen fertilization. All significant increases in yields were produced by phosphorus alone or in combination. No decreases in yields resulted from fertilization by phosphorus alone. In the field study stand emergence and survival were not affected by any fertilizer treatment or by weed control. All species in the weed control plots produced seedheads the first year; whereas only the old world bluestem produced a few seedheads with weed competition.

Sod reserve studies revealed significant increases in tiller number and weight due to weed control in three species; big bluestem, indiangrass, and old world bluestem. Fertilization did not influence sod reserves of any species.

In years of below normal rainfall, weed control appears to be the more desirable treatment when compared to fertilization. Forage production of weeping lovegrass was increased by fertilization with

30 pounds of nitrogen plus 13 pounds of phosphorus per acre with weed competition and weed control. Phosphorus alone appeared to be of benefit in increasing forage production of weeping lovegrass, but only when weed competition was not present. Nitrogen alone did not increase production. Fertilizer did not overcome the effects of weed competition on forage production.

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