EVALUATION OF SEVERAL SEEDING RATES OF

SIX GRASSES USED IN MIXTURES AND

PURE STANDS FOR HIGHWAY

EROSION CONTROL

By

DONALD DEE HOOS

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1971

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1978

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Thesis Approved:

Wayne W. Huffine
Thesis Adviser

J. Q. Lynd

P. L. Claypool

Robert M. Ahring

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

My sincere appreciation is extended to my major adviser, Dr. Wayne Huffine, and to the other members of my committee, Dr. J. Q. Lynd and Dr. Larry Claypool, for their guidance, advice, and assistance throughout the course of this study.

Special appreciation is extended to the Agronomy Department of Oklahoma State University and the Oklahoma Department of Transportation for providing funds, a location, and materials needed to make this study possible.

I wish to thank Mr. Steven Batten, Mr. Tom Fermanian, Mr. Bill Bird, Mr. Bill Shrum, and Mr. Kevin Ehlers for their assistance and the labor they provided during the course of this study, and to thank Sharon Dunn and Val Harp for their help in the typing of this thesis.

And last, but not least, I wish to express my thanks to my wife, Regina, and our children, Steffany and David, for their encouragement and support throughout this study.

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CHAPTER I

INTRODUCTION

Grasses are recognized to be the most practical roadside cover for most situations; however, one of the drawbacks in the use of grasses is the variation in their speed of germination and growth. Failure of seedlings to germinate and emerge has been attributed largely to soil crusting, diseases, and alternate wetting and drying. These problems are maximized further on cut and fill slopes along highway roadsides where much of the topsoil has been removed or redistributed and the soil surface has been compacted by the movement of heavy machinery. At these locations there is a need for quick cover and thick stands for stabilization and erosion control, but not to the extent that excessive competition will reduce the plant population in later years and allow invasion by undesirable species.

The Oklahoma Department of Transportation frequently uses seed mixtures containing weeping lovegrass, little bluestem, Kings Ranch bluestem, sideoats grama, buffalograss, and blue grama grass. The seeded mixtures contain from three to five grasses. With these mixtures there have been numerous stand failures resulting in erosion damage and invasion by undesirable species.

The objectives of this experiment were (1) to determine the best species for a seeding mixture and the best rates to use for highway erosion control, (2) to determine the effect of competition between species used in the mixtures on first-year establishment, and (3) to try to provide a means of perdicting the optimum amount of each species to use in a seeding mixture. There were six grasses used in seven seeding mixtures and three grasses used in pure stands during the course of this study.

CHAPTER II

REVIEW OF LITERATURE

Rapid ground coverage is desirable in all new grass plantings, especially in areas that are subject to destructive erosion. In many cases seedling stands do not develop adequate ground coverage until tillering gives rise to additional plants, and poor initial stands may never become dominant because of weed and undesirable grass competition. Launchbaugh (1970) found the consistent relative behavior of species and their independent performance in mixtures suggest first-year stand composition may be controlled to a large extent by compounding seed mixtures in terms of viable seed numbers, rather than arbitrarily proportioning pounds per acre in seedling mixtures. His findings suggested that relatively high rates of viable seeds would be required to produce stands of one or more plants per square foot of the native grasses studied [big bluestem (*Andropogon gerardi* Vitman), switchgrass (*Panicum virgatum* L.), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), western wheatgrass (*Agropyron smithii* Rydb.), buffalograss (*Buchloe dactyloides* (Nutt.) Engebm.) and blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex. Steud.)]. Average first-year plants per foot of row were 0.37, 0.64, 1.34, and 2.80 from pure live seed rates of 4, 12, 36, and 108, respectively. Average percent establishment in relation to seeding rate was 9.3, 5.3, 3.7, and 2.6 in the same order. Planting two-species mixtures in various proportions and at increasing rates did not significantly influence plant numbers compared with pure species plantings at similar rates.

In an investigation conducted by McGinnies (1960), he reported rate of seeding had no significant influence on herbage yields of crested wheatgrass and smooth brome in western Colorado; however, narrow row spacings produced higher yields immediately after establishment than wider row spacings seeded at the same density per row. The narrower row spacings gave better control of cheatgrass (Bromus tectorum), which agrees with findings of Hull (1948). He found no significant differences in yield of crested wheatgrass in 6-, 12-, 18-, 24-inch row spacings, but the 6- and 12-inch row spacings gave better control of cheatgrass. McGinnies (1960) found that crested wheatgrass produced more seedlings in 7-inch row spacings than 14-inch row spacings with the same quantity of seed per acre; however, they yielded about the same forage after the plants became established.

The ideal combination of intensity and spacing is that which results in equal distance among plants in all directions. Closely planted seed gives better stands but efficiency per pounds of seed may be poorer. Cook et al. (1967) found in Utah that close-spaced rows also reduced weed numbers and increased both germination percentages and survival percentages among planted grasses. They also found there were no significant differences between thick and thin stands in maximum depth, depth of root concentration, or number of roots per plant. No significant differences in percent soil moisture was found between thick and thin stands or between sampling locations near the plants or in the center of the interspaces. This suggests that lateral roots of grasses in both stand densities tend to utilize moisture in equal amounts to at least a depth of 18 inches. In 1955 Mueggler and Blaisdell found that when drilling crested wheatgrass at 2, 4, 8, 12, and 24 lb./acre on the Snake River plains of Idaho the highest rates gave the best stands for the first three years, but by the sixth year all stands produced similarly. Hull (1972) found the best seeding rate for crested wheatgrass to be 6 lb./acre of live pure seed; however, he suggests at higher elevations, elevations with reduced emergence, higher mortality and a shorter growing season, the rate of seeding a mixture should be increased to 12 lb./acre to get a good stand within a reasonable length of time. Hull also found that the higher the rate of seeding, the greater the number of seedlings and the higher the rating; however, there was a higher percentage of seedlings counted at the lower rates than at the higher rates.

In an experiment conducted in northern Colorado (McGinnies, 1971), pipes with diameters of 10.2, 15.2, 22.9, 30.5, and 45.7 cm were used to simulate plant densities of approximately 123, 55, 24, 14, and 6 plants per square meter. Crested wheatgrass, Russian wildrye, and blue grama were grown in the pipes for six years. As growing space became more restricted: (a) seedstalk height decreased, (b) number of seedstalks per plant decreased, (c) number of seedstalks per square meter increased, and (d) herbage yield per plant decreased. As pipe diameter decreased, the root/shoot ratio increased for all species, and the percentage of total root yield found in the surface 20 cm of soil increased.

In another investigation of plant populations Karp and Harper (1974) concluded that the result of tillering, tiller death, and genet death is to adjust the number of tillers to a density that is extraordinarily similar despite wide variations in seeding rate and light intensity. Populations of *Lolium perenne* were sown at a wide range of densities and allowed to develop without defoliation under full daylight and under reduced light intensities. The multiplication of tillers, the growth in their mean weight, and the death of genetic individuals (genets) acted together to regulate the character of the population and to determine that the density of tillers per unit area became independent of sowing density. The rate of elimination of genets from the population was related to the rate of growth of the survivors, but under low light intensities the thinning process was radically altered in a way that suggests that the density stress within the grass populations was caused by mutual self-shading.

Although only with time can come a complete evaluation of species, Huffine et al. (1977) have made a tentative list of dominant grasses from original seedings on man-made soils on Oklahoma highways. They found that in the eastern half of Oklahoma the dominant grasses on south-facing cut slopes appeared to be K. R. bluestem and weeping lovegrass, followed by bermudagrass and a trace of switchgrass. On north-facing cut slopes, weeping lovegrass seems to be best, followed by K. R. bluestem and small amounts of bermuda and switchgrass. Bermudagrass seems to be best on both east- and west-facing cut slopes. In the western half of Oklahoma, west of U.S. Highway 81, switchgrass and sideoats grama seem to be best on north-facing cut slopes, followed by weeping lovegrass. On south-facing cut slopes weeping love seems to be best, followed by sideoats grama and switchgrass, in that order. On east- and west-facing slopes sideoats grama appears to be best, followed by buffalograss and weeping lovegrass.

CHAPTER III

METHODS AND MATERIALS

This experiment was conducted on the Agronomy Research Station at Stillwater, Oklahoma. The research period extended from July 7, 1977, to October 19, 1977. Five grasses were evaluated in six mixtures, six grasses were evaluated in one mixture, and three grasses were evaluated in pure stands to determine an optimum rate of seeding for maximum seedling establishment initially and subsequent effects on plant populations as the plants mature.

The grasses selected for evaluation were little bluestem (Schizachyrium scoparius Nash), Plains bluestem (Bothriochloa ischaemum var. ischaemum (L.) Keng.), sideoats grama (Bouteloua curtipendula (Mich.) Torr.), buffalograss (Buchloe dactyloides (Nutt) Engelm), weeping lovegrass (Eragrostis curvula (Schrad. Nees), and switchgrass (Panicum virgatum L.). Seeding rates for each treatment are outlined in Table I. Seeding rates were based on the number of pure live seeds (PLS) per square foot. Since no research had been conducted on these species in the same mixture, a wide variety in number of seeds per square foot was used. Treatments were designed to have a plant density ranging from approximately one seed per square inch up to a maximum of four seeds per square inch. From the grasses chosen for evaluation weeping lovegrass and Plains bluestem are known as quick germinators, and they were chosen for their ability to provide a quick cover.

TABLE I

SPECIES AND SEEDING RATES OF GRASSES USED ALONE AND IN MIXTURES FOR ESTABLISHMENT OF EROSION RESISTANT GROUND COVERS

Grass	Seeding Rate kg/ha PLS	Seeding Rate kg/ha Bulk	Seeding Rate Lb/A PLS	Seeding Rate Lb/A Bulk	No. Seed Sq. Ft.
1. Weeping Lovegrass	2.3	2.7	2.0	2.3	68.8
Little Bluestem	2.5	9.2	2.2	8.0	15.9
Sideoats Grama	12.5	17.3	10.8	15.0	35.4
Switchgrass	10.3	11.5	8.9	10.0	79.5
Plains Bluestem	--	11.1	--	9.6	89.0
		51.8		44.9	288.6
2. Weeping Lovegrass	4.6	5.4	4.0	4.6	137.6
Little Bluestem	2.5	9.2	2.2	8.0	15.9
Sideoats Grama	12.5	17.3	10.8	15.0	35.4
Switchgrass	10.3	11.5	8.9	10.0	79.5
Plains Bluestem	--	11.1	--	9.6	89.0
		54.5		47.2	357.4
3. Weeping Lovegrass	6.9	8.1	6.0	6.9	206.4
Little Bluestem	2.5	9.2	2.2	8.0	15.9
Sideoats Grama	12.5	17.3	10.8	15.0	35.4
Switchgrass	10.3	11.5	8.9	10.0	79.5
Plains Bluestem	--	11.1	--	9.6	89.0
		57.2		49.5	426.2
4. Weeping Lovegrass	6.9	8.1	2.0	2.3	68.8
Little Bluestem	2.5	9.2	1.4	5.0	9.9
Sideoats Grama	12.5	17.3	7.2	10.0	23.6
Switchgrass	10.3	11.5	4.5	5.0	39.7
Plains Bluestem	--	11.1	--	9.6	89.0
		57.2		31.9	231.0
5. Weeping Lovegrass	2.3	2.7	2.0	2.3	68.8
Little Bluestem	1.6	5.8	2.2	8.0	15.9
Sideoats Grama	8.3	11.5	10.8	15.0	35.4
Switchgrass	5.2	5.8	8.9	10.0	79.5
Plains Bluestem	--	11.1	--	14.4	133.5
		36.9		49.7	333.1
6. Weeping Lovegrass	2.3	2.3	2.0	2.3	68.8
Little Bluestem	2.5	9.2	2.2	8.0	15.9
Sideoats Grama	12.5	17.3	10.8	15.0	35.4
Switchgrass	10.3	11.5	8.9	10.0	79.5
Plains Bluestem	--	16.6	--	19.2	178.0
		56.9		54.5	367.6

TABLE I (CONTINUED)

	Grass	Seeding Rate kg/ha PLS	Seeding Rate kg/ha Bulk	Seeding Rate Lb/A PLS	Seeding Rate Lb/A Bulk	No. Seed Sq. Ft.
7.	Weeping Lovegrass	7.4	8.4	6.4	7.3	218.4
	Little Bluestem	1.7	6.6	1.5	5.7	11.3
	Sideoats Grama	2.9	4.0	2.5	3.5	8.3
	Switchgrass	2.6	3.0	2.3	2.6	20.6
	Plains Bluestem	--	17.3	--	15.0	139.1
	Buffalograss	11.5	17.3	10.0	15.0	60.0
			56.6		49.1	457.7
8.	Weeping Lovegrass	4.6	5.4	4.0	4.6	137.6
9.	Plains Bluestem	--	16.6	--	14.4	133.5
10.	Buffalograss	11.5	17.3	10.0	15.0	60.0

Sideoats grama, switchgrass, little bluestem, and buffalograss were chosen because they are native to the area and are grasses that have predominated in the past on our Oklahoma highway roadsides. Since weeping lovegrass and Plains bluestem have a quick germinating potential it was decided to have all mixtures contain in excess of 50% of these two grasses. This was done in order to determine if these grasses would provide a quick initial cover and still allow the other grasses to germinate and furnish a portion of the ground cover at later periods.

The pure live seed content was determined by multiplying the percent germination by the percent purity then dividing by 100:

$$\text{Percent Pure Live Seed} = \frac{\text{Percent Germination x Percent Purity}}{100}$$

The percent pure live seed was then used to calculate the number of pure live seeds per unit of seed weight of each of the grasses. Percent purity and germination of each of the grasses was that reported by the supplier at time of purchase for all grasses except Plains bluestem. The PLS content of Plains bluestem was determined by a germination test at 30^{o} C for a 21-day period by placing 0.1 gm of seed in water solution, replicating this three times, and the average count was determined as the PLS. The PLS of each grass is reported in Appendix Table II.

The experiment was arranged in a randomized block design. The treatments were randomized and replicated three times, with the replications in a line east to west over the test area. The plots were 1.54 m (5 ft.) by 1.54 m (5 ft.). The soil type is a Kirkland silt loam, with a pH of 6.1 and high in potassium. It had less than a 2% slope.

The plots were seeded July 7, 1977, by hand from pre-weighed packets containing the appropriate seeding mixture. After seeding a Brillion culti-packer seeder was pulled across all plots in a line from east to west to press the seed into the soil. Prior to seeding the seedbed was disked, harrowed, and raked by hand. After seeding and packing the plots were watered with portable irrigation system with fixed risers and impulse sprinkler heads. Water was applied as needed during a one-month period, after which water was applied at less frequent intervals. During the initial germination period the soil was kept moist and the water was applied until just before runoff occurred to prevent movement of seeds to adjacent plots. No fertilizer was added during the experiment.

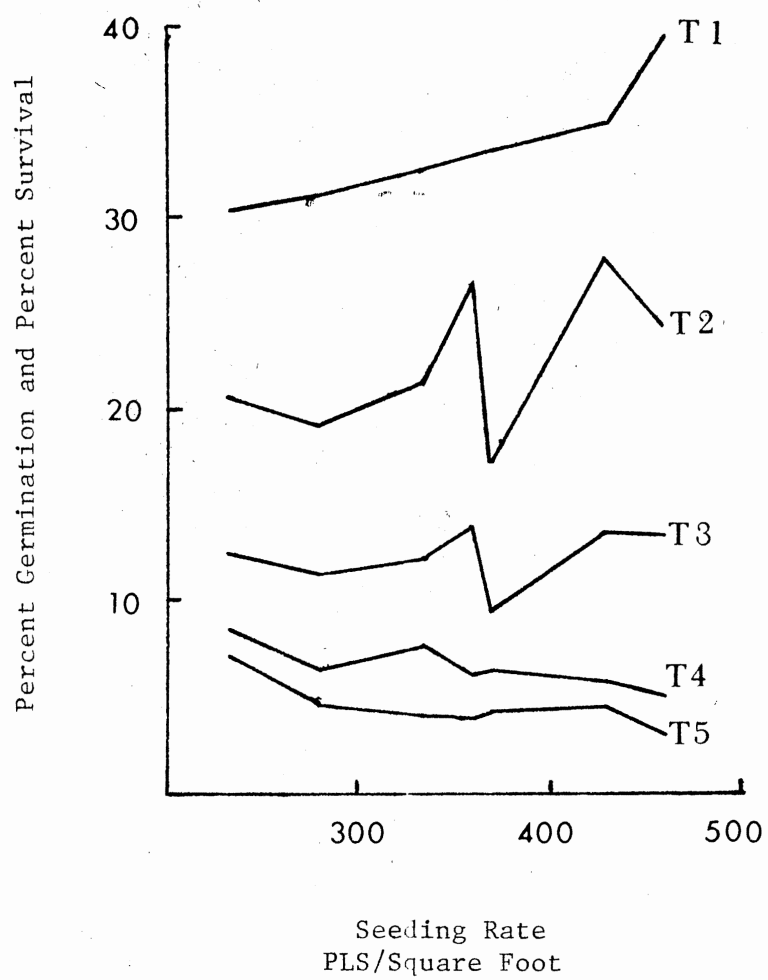
Evaluations were begun on July 21, 1977, and ended October 19, 1977. Evaluations were based on plant density and were measured by counting the number of plants in a 15.24 cm (6 in.) square placed at random three times in each plot. Evaluations conducted July 21, 1977, and August 3, 1977, counted only total number of plants; subsequent evaluations on August 22, 1977, September 21, 1977, and October 19, 1977, identified the number of plants by species.

CHAPTER IV

RESULTS AND DISCUSSION

At the end of the growing season all treatments appeared to have provided similar dense stands of grass, with the exception of the pure stand of buffalograss. All seeding mixtures had nearly equal overall plant densities and all appeared they would provide adequate cover and protection against erosion damage. However, initially, as indicated in Figure 1, the higher seeding rates had a higher percentage germination and plant density. As time passed the plant population as a percentage of possible plants decreased as seeding rate increased, but the actual number of plants present was very nearly the same for all treatments. There were highly significant differences in plant densities at the first plant count on July 21, 1977. After this count there were no significant differences in total plant density in any of the treatments for the remainder of the experiment. As shown in Appendix Table XV, a comparison of the means of plant densities on July 21, 1977, shows there were no differences between any of the seeding rates that exceeded 333 PLS/sq. ft. As shown in Figure 1, after the first two weeks plant populations began reducing and within two months after planting, there were no significant differences in total plant populations in any of the treatments.

In order to determine the effects of competition between species in the first-year establishment, a statistical analysis was attempted



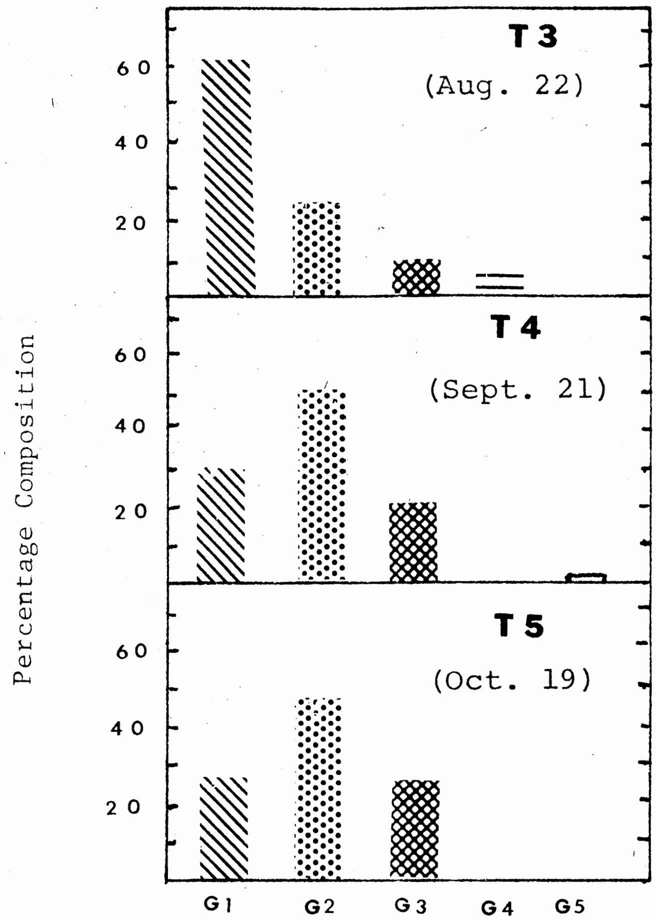
T1 - July 21, 1977
T2 - August 3, 1977
T3 - August 22, 1977
T4 - September 21, 1977
T5 - October 19, 1977

Figure 1. The Percentage Germination of Seven Seeding Mixtures Measured at Five Different Times After Planting

that would compare the overall seeding rate per treatment with the plant density of each type of grass in the treatment, the date after planting, and the date x rate interactions.

There were significant differences in rates and dates in the performance of weeping lovegrass as noted in Appendix Table III. The means of plant density of weeping lovegrass are compared in Appendix Table IV. Overall seeding rates of 137, 426, 457, and 357 PLS/sq. ft. were not significantly different. If we look at the seeding rate of weeping lovegrass per treatment we find that all plots which had 137 PLS/sq. ft. or more of weeping lovegrass were not significantly different and they had the highest mean plant densities for this species. Mean plant densities of weeping lovegrass on August 22 were significantly higher than those on September 21 and October 19. This may be due to the quick germinating character of weeping lovegrass resulting in more plants earlier, or it may be because weeping lovegrass was not able to compete with other grasses later in the season. This decline in population is shown in Figures 2-8 where in most seeding mixtures the percent composition of weeping lovegrass declined as the season progressed.

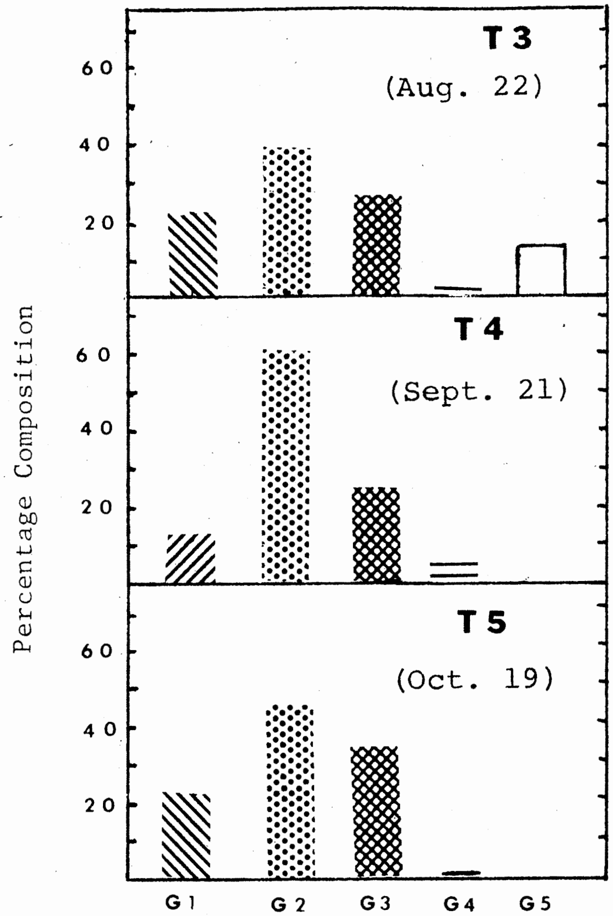
The analysis of variance for Plains bluestem in Appendix Table VI shows significant differences in rates and dates. Duncan's new multiple range test of the means of Plains bluestem (Appendix Table VI) shows no differences between overall seeding rates of 133, 333, 367, or 457 PLS/sq. ft. If we look at the amount of Plains bluestem in each of these treatments we see that they all contained more than 133 PLS/ sq. ft. If we ignore the pure stand of Plains bluestem and just look at the seeding mixtures we find there were no significant differences



GRASSES

G1 - Weeping lovegrass 137.6 PLS/sq. ft.
G2 - Plains bluestem 89.0
G3 - Sideoats grama 35.4
G4 - Little bluestem 15.9
G5 - Switchgrass 79.5

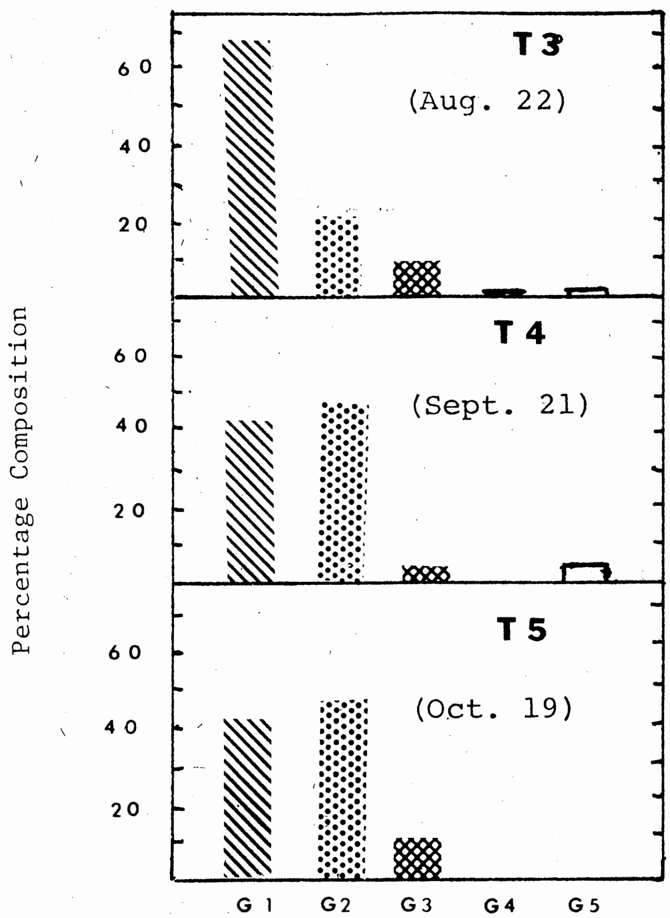
Figure 2. The Percentage Composition of Each Grass in a Seeding Mixture Containing 357 PLS/ Sq. Ft. at Three Times After Planting



GRASSES

G1 - Weeping Lovegrass 68.8 PLS/Sq. Ft.
G2 - Plains bluestem 89.0
G3 - Sideoats grama 35.4
G4 - Little bluestem 15.9
G5 - Switchgrass 79.5

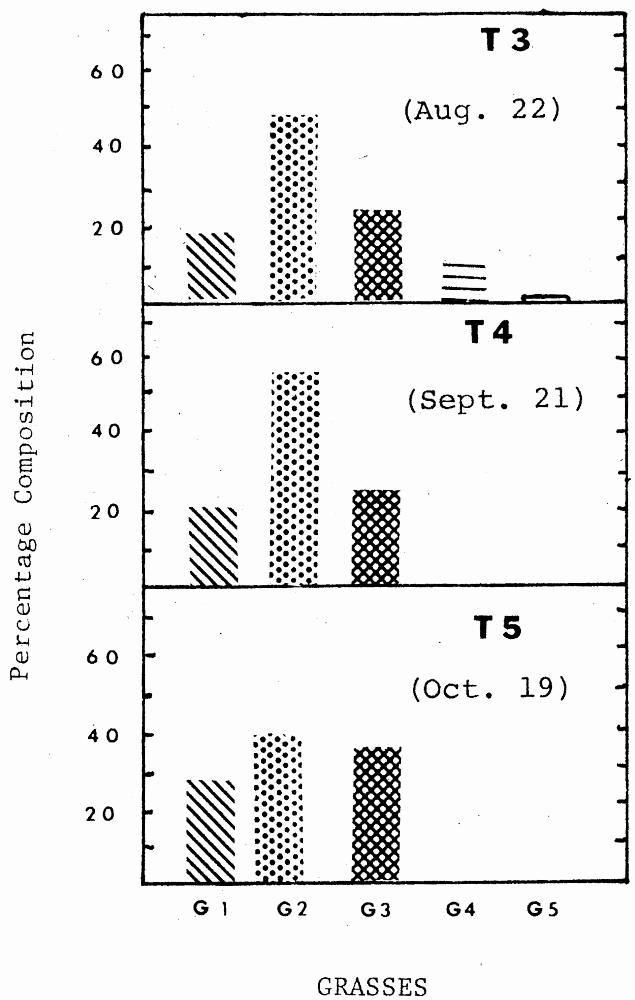
Figure 3. The Percentage Composition of Each Grass in a Seeding Mixture Containing 288.6 PLS/Sq. Ft. at Three Times After Planting



GRASSES

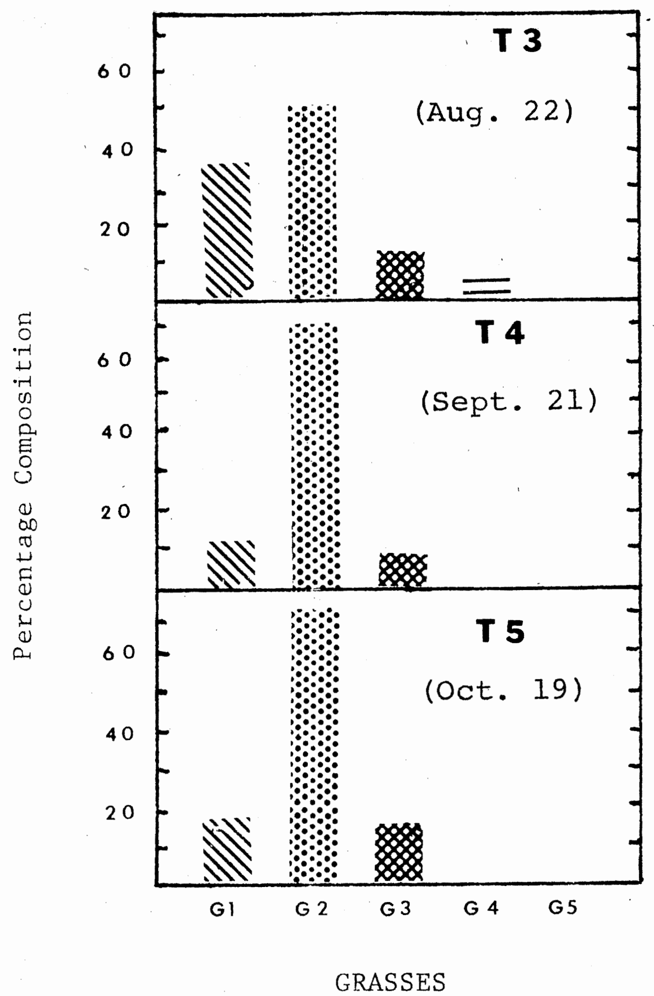
G1	Weeping lovegrass	206.4 PLS/Sq. Ft.
G2	Plains bluestem	89.0
G3	Sideoats grama	35.4
G4	Little bluestem	15.9
G5	Switchgrass	79.5

Figure 4. The Percentage Composition of Each Grass in a Seeding Mixture Containing 426 PLS/ Sq. Ft. at Three Times After Planting



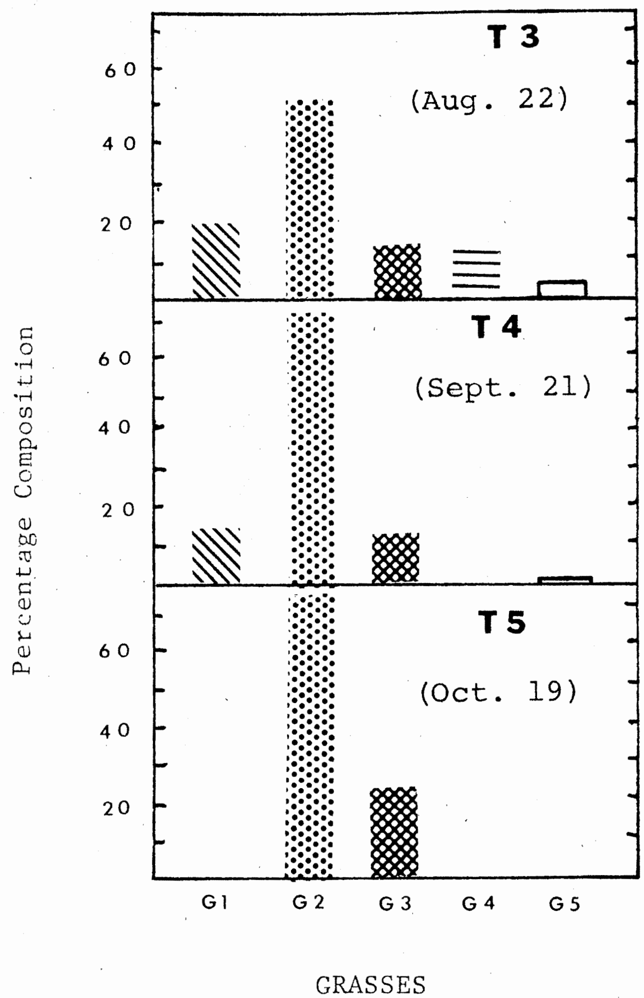
G1 - Weeping lovegrass 68.8 PLS/Sq. Ft.
G2 - Plains bluestem 89.0
G3 - Sideoats grama 23.6
G4 - Little bluestem 9.9
G5 - Switchgrass 39.7

Figure 5. The Percentage Composition of Each Grass in a Seeding Mixture Containing 231 PLS/ Sq. Ft. at Three Times After Planting



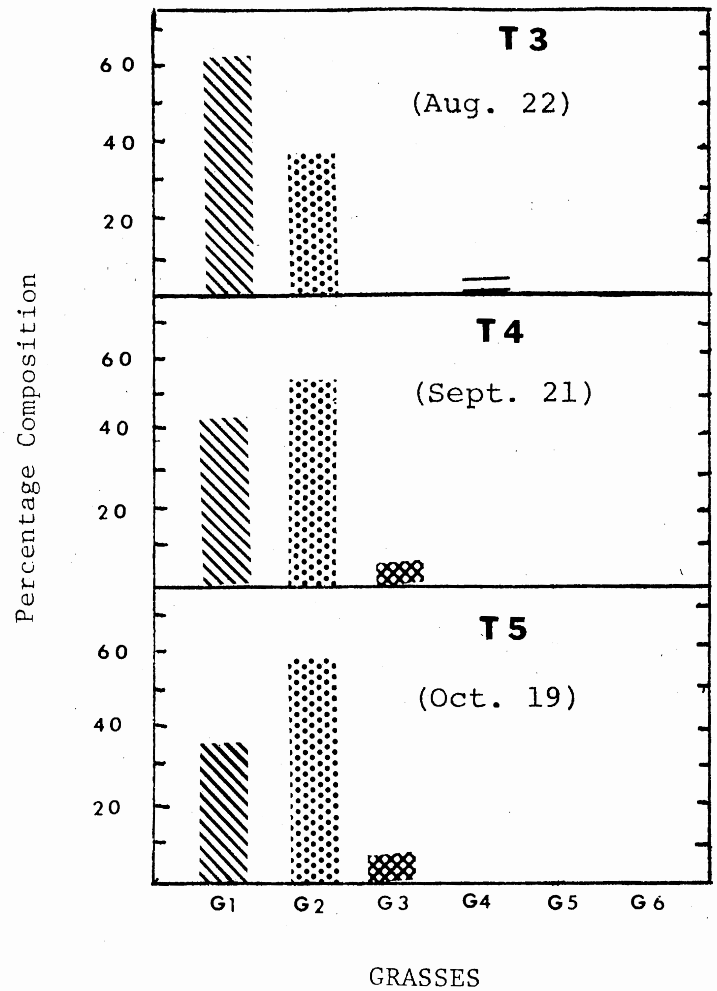
G1 - Weeping lovegrass 68.8 PLS Sq. Ft.
G2 - Plains bluestem 133.5
G3 - Sideoats grama 35.4
G4 - Little bluestem 15.9
G5 - Switchgrass 79.5

Figure 6. The Percentage Composition of Each Grass in a Seeding Mixture Containing 33 PLS/ Sq. Ft. at Three Times After Planting



G1 - Weeping lovegrass 68.8 PLS/Sq. Ft.
G2 - Plains bluestem 178.0
G3 - Sideoats grama 35.4
G4 - Little bluestem 15.9
G5 - Switchgrass 79.5

Figure 7. The Percentage Composition of Each Grass in a Seeding Mixture Containing 367 PLS/Sq. Ft. at Three Times After Planting



G1	- Weeping lovegrass	218.4 PLS/Sq. Ft.
G2	- Plains bluestem	139.1
G3	- Sideoats grama	8.3
G4	- Little bluestem	11.3
G5	- Switchgrass	20.6
G6	- Buffalograss	60.0

Figure 8. The Percentage Composition of Each Grass in a Seeding Mixture Containing 457 PLS/ Sq. Ft. at Three Times After Planting

in any of the mixtures in relation to the number of Plains bluestem plants present. There were no differences in means between August 22 and September 21, but a significant reduction in plant density occurred between September 21 and October 19. If we look at Figures 2-8 we see that in all seeding mixtures in which the rate of Plains bluestem was greater than 133 PLS/square foot the percent composition of Plains bluestem comprising the plant population increased with time. In those with 89 PLS sq. ft. of Plains bluestem the percentage composition was generally reduced with time.

The analysis of variance of sideoats grama in Appendix Table VII shows a significant difference at the 0.05 level in rates, but no significant differences in dates. The Duncan's New Multiple Range Test (Appendix Table VIII) shows no differences in rates between any plots with overall seeding rates less than 367 PLS/sq. ft. In most mixtures the seeding rate of sideoats grama was constant 35.4 PLS/sq. ft.; therefore, as overall seeding rate of the mixture increased the percentage composition of sideoats grama decreased. The mean plant population of sideoats grama also decreased as the percentage composition decreased. Looking at Figures 2-8 we see in all seeding mixtures the percentage composition of sideoats grama increased with time. This is probably an indication of its ability to compete equally with or better than other grasses in the mixtures.

There were no differences in the rates of little bluestem, but dates were significant as shown in Appendix Table IX. By the last plant count on October 19 no little bluestem could be found in any of the treatments and it had been eliminated from most treatments by the plant count conducted on September 21. For little bluestem to be used in a mixture with the other grasses of this test, it would probably have to be used in much higher rates.

In the statistical analysis of the data of switchgrass, as with little bluestem, rates were not significant but dates were significant. Switchgrass, also, had been eliminated from all plots by the last count on October 19, thus accounting for the high level of significance for dates. At no time did a high population of switchgrass occur in any of the treatments. Switchgrass probably either did not germinate quickly enough and was shaded and out competed by the other grasses or was not seeded in high enough quantities to be useful in the mixtures.

Appendix Table XIII showing the analysis of variance for buffalograss indicates that only rates were significant for buffalograss. Buffalograss occurred in only two treatments; one was a pure stand, and the other a mixture. Buffalograss was eliminated from the mixture after August 22 and all other observations of buffalograss were from the pure stand. This probably accounts for the significance in rates.

An attempt was made to predict the response of the components in the seeding mixtures by use of a regression analysis. The regression equation would have been used to predict the amounts of each of the grasses to use in a seeding mixture. The regression analysis attempted to use the seeding rate per plot with the percentage of that grass being analyzed used in that mixture as the analysis indicators. Using these terms in the analysis resulted in R-square values that in most cases were very low. This indicates that there are other factors not being considered accounting for a large portion of our variation.

These may include too many observed values of zero in the analysis or environmental factors that are unaccounted for in the experiment.

CHAPTER V

SUMMARY AND CONCLUSION

To determine an optimum rate of seeding of the treatments evaluated in the experiment, plant counts were initiated two weeks after seeding and continued at regular intervals until the end of the growing season. The only time significant differences occurred in overall plant densities was two weeks after planting, at which time the higher the seeding rate, the higher the plant count and percentage germination. After this time no differences could be detected in overall seeding rates, and all treatments appeared to have adequate ground coverage and plant densities. Seeding rates in excess of 333 PLS/square foot showed the best results on the July 21 scoring date.

The analysis conducted to determine the effects of competition between species revealed significant differences in rates and dates for weeping lovegrass and Plains bluestem, rates for sideoats grama and buffalograss, and dates for little bluestem and switchgrass. Weeping lovegrass performed best in mixtures that contained more than 137 PLS/square foot weeping lovegrass. Weeping lovegrass had significantly higher plant densities on the early counting date of August 22 and declined in density in mixtures from August 22 to October 19. Plains bluestem performed best in mixtures that contained more than 133 PLS/square foot Plains bluestem. In these mixtures the percent composition of Plains bluestem in the mixture increased with time. The analysis of variance for sideoats grama showed significant differences at the 0.05 level. The highest mean plant densities of sideoats grama occurred in the treatments with less than 367 PLS/sq. ft. or those treatments with the highest percentage sideoats grama. The percent composition of sideoats grama increased in all mixtures from August 22 to October 19. The significant differences in dates of little bluestem and switchgrass were probably due to the elimination of both grasses from all mixtures by October 19. The difference in rates of buffalograss was probably due to the elimination of buffalograss in the seeded mixture, then comparing it with a pure stand.

No valid predictions could be made about the performance of these grasses in a mixture or what rates to use based on the regression analysis. With the R-square values as low as they were, it would indicate that another approach must be used in the regression analysis based on the rate per species of each grass would give a better explanation.

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APPENDIXES

TABLE II

PERCENT PURE LIVE SEED OF GRASSES USED IN THIS EXPERIMENT

Grass	Percent Pure Seed	Percent Germination	PLS
Weeping Lovegrass*	98	87	88
Little Bluestem	33	58	27
Sideoats Grama	85	80	72
Switchgrass	--	--	89
Plains Bluestem**	--	89 Plants/ 0.1 gm	--
Buffalograss	--	--	66.6

*Percent germination and pure seed based on suppliers' data at time of purchase for all grasses except Plains bluestem.

**PLS of Plains bluestem based on germination test at 30^{o} C for 21-day period in water.

TABLE III

ANALYSIS OF VARIANCE FOR WEEPING LOVEGRASS

Source	Degrees of Freedom	Mean Squares	F
Replication	2	70.68	
Dates	2	878.22	54.74**
Rates	7	264.82	17.11**
Dates x Rates	14	72.21	4.66**
Error	46	15.47	
Total Corrected	71	77.10	

**Exceeds 1% level of significance.

TABLE IV

DUNCAN'S NEW MULTIPLE RANGE TEST OF THE MEANS FOR DIFFERENT RATES AND DATES OF WEEPING LOVEGRASS

Seeding Rate (PLS/sq. ft.) of Weeping Love per Plot	137*	206	218	137	69	69	69	69
Overall Seeding Rate (PLS/sq. ft.) per Plot	137	426	457	357	333	231	288	367
Means	16.22	13.0	12.77	10.3	5.0	3.33	3.22	2.33
	———	———	———	———				
		———	———	———	———	———		
				———	———	———	———	———

Dates	August 22	September 21	October 19
Means	15.16	5.83	3.83
0.01 Level		———	———

*Any two means not underscored by the same line are significantly different.
*Any two means underscored by the same line are not significantly different.
#Pure Stand.

TABLE V

ANALYSIS OF VARIANCE FOR PLAINS BLUESTEM

Source	Degrees of Freedom	Mean Squares	F
Replication	2	30.05	
Dates	2	225.68	32.93**
Rates	7	92.53	13.50**
Dates x Rates	14	18.34	2.67**
Error	46	6.85	
Total Corrected	71	24.38	

**Exceeds 1% level of significance.

TABLE VI

DUNCAN'S NEW MULTIPLE RANGE TEST OF THE MEANS FOR DIFFERENT RATES AND DATES OF PLAINS BLUESTEM

Seeding Rate (PLS/sq. ft.) of Plains Bluestem per Plot	133*	133	178	139	89	89	89	89
Overall Seeding Rate (PLS/sq. ft.) of Plot	133	333	367	457	231	426	357	288
Means of Plains Bluestem Plants per Plot	16.1	12.6	12.0	10.4	8.0	7.5	7.4	7.3
	———	———	———	———				
0.01 Level		———	———	———	———	———	———	———
0.05 Level	———	———	———					
		———	———	———	———			
			———	———	———	———	———	———

Dates	August 22	September 21	October 19
Means	13.16	10.37	7.04
0.01 Level	———	———	

*Any two means not underscored by the same line are significantly different.
*Any two means underscored by the same line are not significantly different.
#Pure Stand.

TABLE VII

ANALYSIS OF VARIANCE FOR SIDEOATS GRAMA

Source	Degrees of Freedom	Means Squares	F
Replication	2	0.59	
Dates	2	9.06	1.43 NS
Rates	6	17.29	2.73*
Dates x Rates	12	2.32	0.44 NS
Error	40	6.32	
Total Corrected	62	6.59	

NS - Not Significant
* - Exceeds 5% level of significance.

TABLE VIII

DUNCAN'S NEW MULTIPLE RANGE TEST OF THE MEANS FOR DIFFERENT
RATES AND DATES OF SIDEOATS GRAMA

Seeding Rate (PLS/sq. ft.) of Sideoats Grama per Plot	23.6	35.4	35.4	35.4	35.4	35.4	8.3
Overall Seeding Rate (PLS/sq. ft.) of Plot	231	288	357	333	367	426	457
Means of Sideoats Grama Plants per Plot	4.33	4.33	3.22	3.0	2.66	1.77	0.44
0.05 Level*							

Dates	August 22	Septebmer 21	October 19
Means	3.57	2.57	2.33

Dates were not significantly different at 0.05 or 0.01 level.

*Any two means not underscored by the same line are significantly different.
*Any two means underscored by the same line are not significantly different.

TABLE IX

ANALYSIS OF VARIANCE FOR LITTLE BLUESTEM

Source	Degrees of Freedom	Means Squares	F
Replication	2	1.02	
Dates	2	13.92	20.39**
Rates	6	0.53	0.78 NS
Dates x Rates	12	0.94	1.37 NS
Error	40	0.68	
Total Corrected	62	1.15	

NS - Not Significant
** - Exceeds 1% level of significance.

TABLE X

DUNCAN'S NEW MULTIPLE RANGES TEST OF THE MEANS FOR DIFFERENT RATES AND DATES OF LITTLE BLUESTEM

Seeding Rate (PLS/sq. ft.) of Little Bluestem per Plot	15.9	9.9	15.9	15.9	15.9	11.3	15.9
Overall Seeding Rate (PLS/sq. ft.) per Plot	367	231	288	333	357	457	426
Means	1.00	0.66	0.55	0.44	0.44	0.44	0.22
0.01 and 0.05 Levels	________	________	________	________	________	________	________

Dates	August 22	September 21	October 19
Means	1.47	0.14	0.00
0.01 and 0.05 Levels	________	________	________

*Any two means not underscored by the same line are significantly different.
*Any two means underscored by the same line are not significantly different.

TABLE XI

ANALYSIS OF VARIANCE FOR SWITCHGRASS

Source	Degrees of Freedom	Means Squares	F
Replication	2	1.63	
Dates	2	3.63	5.18**
Rates	6	1.42	2.03 NS
Dates x Rates	12	1.59	2.27 NS
Error	40	0.70	
Total Corrected	62	1.06	

NS - Not Significant
** - Exceeds 1% level of significance.

TABLE XII

DUNCAN'S NEW MULTIPLE RANGE TEST OF THE MEANS FOR DIFFERENT RATES AND DATES OF SWITCHGRASS

Seeding Rate (PLS/sq. ft.) of Switchgrass per Plot	79.5	79.5	79.5	39.7	79.5	79.5	20.6
Overall Seeding Rate (PLS/sq. ft.) of Plot	288	426	367	231	357	333	457
Mean	1.11	0.55	0.44	0.22	0.11	0.00	0.00

*No rates were significantly different.

Dates	August 22	September 21	October 19
Means	0.81	0.23	0.00
0.05 and 0.01 Levels			

**Any two means not underscored by the same line are significantly different.
**Any two means underscored by the same line are not significantly different.

TABLE XIII

ANALYSIS OF VARIANCE FOR BUFFALOGRASS

Source	Degrees of Freedom	Means Squares	F
Replication	2	1.72	
Treatments	10	2.45	
Dates	2	1.38	0.56 NS
Rates	1	93.38	38.03**
Dates x Rates	2	1.05	0.43 NS
Error	10	2.45	
Total Corrected	17	7.42	

NS - Not Significant
** - Exceeds 1% level of significance.

TABLE XIV

DUNCAN'S NEW MULTIPLE RANGE TEST OF THE MEANS FOR DIFFERENT RATES AND DATES OF BUFFALOGRASS

Seeding Rate (PLS/sq. ft.) of Buffalograss per Plot	60	60
Overall Seeding Rate (PLS/sq. ft.) of Plot	60	457
Mean	4.67	0.11
*All rates significant.		

Date	August 22	September 21	October 19
Means	2.67	2.67	1.83
0.05 and 0.01 Levels	________	________	________

**Any two means not underscored by the same line are significantly different.
**Any two means not underscored by the same line are not significantly different.

TABLE XV

THE EFFECT OF DIFFERENT SEEDING RATES AS DETERMINED BY MEAN PLANT DENSITIES ON JULY 21, 1977, ANALYZED BY DUNCAN'S NEW MULTIPLE RANGE TEST

Seeding Rate PLS/Square Foot	Means* Plants/0.1186 m^2
457.7	45.13 a
426.2	37.33 ab
367.6	30.80 abc
357.4	29.60 abc
333.0	26.86 abc
288.6	22.53 abc
137.6	21.26 abc
133.0	19.80 abc
231.0	18.00 abc
60	1.73 d

*Means bounded by a common letter are not significantly different.

VITA[2]

Donald Dee Hoos

Candidate for the Degree of

Master of Science

Thesis: EVALUATION OF SEVERAL SEEDING RATES OF SIX GRASSES USED IN MIXTURES AND PURE STANDS FOR HIGHWAY EROSION CONTROL

Major Field: Agronomy

Biographical:

Personal Data: Born in Pryor, Oklahoma, June 23, 1948, the son of Eunice and Edythe Hoos.

Education: Graduated from Pryor High School, Pryor, Oklahoma, in May, 1966; received Bachelor of Science degree from Oklahoma State University in May 1971, with a major in Agronomy. Completed requirements for Master of Science degree at Oklahoma State University in 1978.

Experience: Six years experience in golf course maintenance from 1964 to 1970; served as officer in the United States Army Field Artillery from January, 1971, to April, 1976; graduate research assistant for Oklahoma State University, Department of Agronomy from June, 1976, to December, 1977.