EVALUATION OF GRASS SPECIES AND MULCHES FOR EROSION CONTROL ON OKLAHOMA HIGHWAYS

By

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CHAPTER I

INTRODUCTION

The development of multiple lane highways and intricate freeway systems, with expansive areas of roadside, have confronted man with the problems of protection of these exposed surfaces from the erosive forces of nature. A critical factor confronting engineers and agronomists alike, in this pursuit, is the necessity of establishing a quick, dense, permanent vegetative cover. Unless this can be done, erosion will be rampant, leading to costly refilling and regrading operations, possible undermining of roadbeds, and reduced asthetic value of the vast roadside complex.

The Oklahoma panhandle rises in elevation to approximately 5,000 feet; six hundred miles south-east in the rugged Quachita Highlands elevations drop below 400 feet. This average gradient or decline in elevation of 7-8 feet per mile of horizontal distance, favors rapid erosion of surface soils. This combined with Oklahoma's light textured soils and its widely varying climatic factors - temperature, rainfall, and wind velocity - create unique problems confronting successful establishment of stabilized roadsides.

More than 15,000 miles of state and federal highways are maintained by the Oklahoma State Highway Department. This figure could be doubled to represent the miles of roadside that must be stabilized against erosion. The annual maintenance cost of these 826,000 acres of roadside runs in excess of 20 million dollars per year. Successful stabilization of this vast roadside area would result in both economic savings and asthetic improvements.

One of the principle objectives of this study was to find satisfactory and economical methods for the prevention and control of soil erosion along Oklahoma highways. Grass varieties tested included: common bermudagrass (Cynodon dactylon (L.) Pers.), weeping lovegrass (Eragrostis curvula Nees), NK-37 bermudagrass (Cynodon dactylon), King Ranch Bluestem (Andropogon ischaemum var.), sand dropseed (Sporobolus cryptandrus (Torr.)), and mixed native grasses (dominantely little bluestem) (Andropogon scoparius Michx.). Mulches tested included prairie hay, Turfiber, and asphalt emulsion. Humicite as a soil conditioner was evaluated. All plots received fertilizers, though fertility was not an experimental variable. Soil analyses were made to determine levels of pH and availability of macro- and micro- mineral elements.

CHAPTER II

LITERATURE REVIEW

Varieties

Success in establishment of a dense, permanent vegetative cover on roadside areas is related to the selection of properly adapted varieties and species. Mulching, fertilization, and other cultural practices are often limited in effectiveness by the degree of adaptation of the species used.

Basic differences in both the rate of establishment and the fertility maintenance requirements of grasses and legumes makes their combination desirable in Virginia. Grass species recommended my Musser (29)[1] for Virginia Highways include Kentucky-31 fescue, and bermudagrass in warmer, humid areas; legume varieties suggested included lespedeza sericia and crownvetch. Results of a series of experiments indicated that mixtures of crownvetch with either Kentucky-31 fescue or ryegrass produced the best permanent slope cover.

Results of a three year study in Illinois, conducted by Foote (16) and co-workers, favors the seeding of perennial ryegrass, or alfalfa in areas where bluegrass is common. Tall fescue is recommended for areas not common to bluegrass.

A subsequent Iowa study by Aikman (1) involving native midwestern grasses indicates that mixtures, particularly of grasses and legumes,

[1]Figures in parenthesis refer to literature cited.

are more productive of total yield and produce more permanent stands, than to pure varieties. Prairie grasses form a vegetative cover having a large volume of stems and leaves above ground and of roots and underground stems below the soil surface, protecting and holding the soils to a higher degree than most vegetation.

The acute need for adapted perennial legumes as components of turf along Virginia highways has been stressed by Blaser (5). Grass turf often degenerates due to low soil nitrogen. In certain soils degeneration is associated with low calcium, high aluminum, and low phosphate levels. He points out also that grasses are more shallow rooted than perennial legumes, such as Sericia lespedeza. Seedings of lespedeza alone and in combination with Kentucky-31 is recommended. Sericia lespedeza characteristically is slow to establish; adapted to wide latitude, altitude, and variable soil conditions; persistent under low phosphorous and acid soil conditions; and exhibits very deep root penetration. In areas where slopes are steep the liberal use of nitrogen fertilizer and high grass seeding rates are recommended to attain a quick stand thus avoiding serious erosion. Sericia is then seeded the following year with little or no nitrogen fertilizer to keep seedling competition to a minimum.

Year-round permanent seeding in Missouri, as reported by Griffin (19), involves Kentucky-31 fescue, smooth brome, Kentucky bluegrass, and bermudagrass. In permanent seeding mixtures clovers are utilized as companion crops, and cereal grains as cover crops.

Highway vegetation research conducted in Texas by McCully (27) suggests the choice of plants used should suit the particular soil belt or climatic zone. In Texas these are bermudagrass for areas receiving over

30 inches rainfall annually, and bunchgrasses such as sideoats grama, green sprangletop, and sand dropseed for drier areas.

Varieties suggested for Utah highways under conditions of limited rainfall and low humidity have been reported by Larson (26). In Utah standard grass varieties for highway purposes include Fairway strain crested wheatgrass and Sodar wheatgrass. Varieties sometimes used include western wheatgrass and smooth brome.

Mulches

Highway seeding experiments indicate that mulches invariably improve the rate of germination and seedling growth, shorten the period of development of a suitable grass stand, and reduce water and soil losses.

A comparison of fiber glass and other mulch materials, as reported by Dolling and Shrader in Iowa (13), indicated fiber glass as well as wood chips and oat straw furnished adequate erosion protection for highway backslopes during the seed establishment period. These mulch materials excelled over a wide range of climatic and soil conditions.

In an experiment with straw and Turfiber mulches on northern and southern exposures, Blaser (6) reported that seedling growth and stands of grass on cool slopes (northern exposures) under straw or Turfiber were similiar; stands and growth were slightly better with the straw than Turfiber mulched plots on the warm slopes (southern exposures). The germination and growth of seedlings of all species were considered satisfactory on both slopes seeded with the Turfiber method. Growth was better on the northern than on the southern slope because of more favorable temperatures and moisture.

Research conducted by Diseker and Richardson (12) on the effectiveness of different mulches used to aid in the establishment of crownvetch on highway slopes favors pine straw, sericia, and grain straw applied at the rate of 1½ to 2 tons per acre. Water soluble latex, diluted with water and applied by sprayer appeared promising the first year. The temporary coating formed by the latex gradually disentegrated as the seed germinated and developed.

Standard mulching procedure incorporated by Griffin (19) of Missouri involves the application of 1½ tons of cereal grain straw and 150 gallons of asphalt per acre. Various mulch nettings and blanket materials are being tested on critical slope areas.

McCully (27) of Texas suggests mulching treatments consisting of hay and asphalt to hold moisture with the asphalt serving as a binder for the soil against erosion. Asphalt, however, as a mulch is not recommended for seeding during the excessive heat of summer.

Fertilization

Roadside soil conditions which may be satisfactory from an engineering standpoint are not always desirable from an agronomic standpoint. Intensive drainage requirements, compaction of the soil and cutting and grading operations which often expose or mix in less fertile subsoils, are not often suitable or desirable for successful establishment of vegetative cover.

Friday (17) has reported that generally any soil which has been disturbed by grading or moving requires twice the amount of fertilization for good stands as the same soil prior to grading operations. Beers (3) has stated that subsoils exposed when roadsides are cut and filled are nearly always low in nitrogen and vary widely in phosphate and potash content. Soils high in phosphate in surface layers may have almost no phosphate a foot or more in depth into the soil.

Research done by Musser (29) in Pennsylvania favors initial applications of 1200 pounds of 5-10-10 fertilizer, and 2 tons of lime per acre when seeding the tall fescues, crownvetch, bermudagrass, and lespedeza.

On all new road construction areas Griffin (19) of Missouri recommends fertilization amounts based on representative soil sample analyses. Average amounts of fertilizer used in Missouri are 120 pounds of nitrogen, 180 pounds of available P_2O_5, and 140 pounds of K_2O per acre. The average amount of effective calcium (C_a) required for most areas is 900 pounds per acre.

Blaser (4) in Virginia reports on fertility recommendations for successful vegetative establishment of backslopes. Since soil materials in the humid east are invariably low in organic matter and fertility, particularly nitrogen and phosphorous, 1000 pounds of 10-20-10 fertilizer and two tons of lime per acre are recommended.

Research conducted in Georgia by Diseker (12) indicates that roadbank subsoils in the project area were almost devoid of plant food when first exposed. Soils tested showed only traces of K_2O and P_2O_5, and no nitrogen. A study revealed heavy loss of applied plant nutrients from roadside banks in proportion to length and steepness of slope. Greatest plant nutrient loss occurred on the steepest, longest slopes. Treatments prior to planting included 4-12-12 fertilizer at one ton per acre and lime at two tons per acre.

Additional work was conducted in Georgia by Richardson et al. (32) involving the effect of fertility rates on growth of crownvetch and Abruzzi rye. Yields of both species increased as fertilizer rates were increased, up to 1500 pounds of 12-6-6 per acre.

In bermudagrass seedings on highway slopes in Texas, McCully (28) indicates 400 pounds of 16-20-0 per acre appears to be the most favorable rate for successful stand establishment.

CHAPTER III

MATERIALS AND METHODS

The purpose of this study is to evaluate grass species and mulches relative to their separate and combined effectiveness in stabilizing highway slope areas. The studies involved in this evaluation were located on Interstate 35 north of Guthrie, hereafter referred to as the Guthrie experiment, U.S. 177 west of Chandler (the Chandler experiment), U.S. 62 west of Meeker (the Meeker experiment), and S.H. 6 west of Elk City (referred to as the Elk City experiment). Grass varieties tested included common bermudagrass, weeping lovegrass, NK-37 bermudagrass, King Ranch bluestem, sand dropseed and mixed native grasses. Mulches evaluated were Turfiber, prairie hay, and asphalt emulsion. Humicite as a soil conditioner was evaluated. Representative soil samples were taken to determine levels of pH and availability of macro- and microelements.

The Guthrie experiment was located on a west facing cut slope of 25% grade. Main plots were 40 ft. x 80 ft. in size. A split plot design was used where main plots consisted of four tillage and lime combinations. These are (1) disking with no lime, (2) disking with quick lime, (3) disking with hydrated lime, and (4) check. The subplots were laid out with two levels of fertilizer (1) none, and (2) 400 lbs. of 12-12-12/acre. The main plots were laid out as a randomized block design with four replications as shown in Appendix Figure 1. The test area was seeded to common bermudagrass (unhulled) at an 18 pound/acre rate with a Lawn Beauty spreader. Straw mulch was subsequently applied at a 2.5 ton/acre rate. Lime treatments were applied by hand prior to seeding, and the disking operation followed the application of straw mulch. Fertilizer was applied with a Cyclone seeder. The lime and disking treatments were completed June 18, 1964; seeding and mulching was completed February 3, 1965. Later fertilizer applications were made with the Cyclone seeder on June 24, 1965 and March 14, 1966.

The Chandler experiment was placed on east-west facing cut slopes each with a 33% grade. Main plots which were 15 ft. x 49 ft. on the east exposure and 15 ft. x 44 ft. on the west exposure were laid out as a split plot in strip design with three replications. Main treatments consisted of the following grass varieties and rates. Seeding rates listed are bulk rates unless noted otherwise.

Grasses	Seeding Rate #/A
Common bermudagrass (unhulled)	15
Weeping lovegrass	6
NK-37 bermudagrass	15
King Ranch bluestem (pure live seed)	2
Mixed native grasses (pure live seed)	5

Highway U.S. 177 served to split both treatment strips of the east-west slope exposures as shown in Appendix Figure 2.

Subtreatments consisted of Turfiber, a natural wood cellulose fiber, and Humicite, a microbe soil conditioner. Turfiber was applied to all plots at a rate of 1.7 tons per acre. Humicite which served as the experimental variable was applied at a rate of 1.1 gallons per acre. Each plot was fertilized at the rate of 200 pounds of 12-12-12 per acre. Preweighed fertilizer and seed quantities were mixed together and applied with a Cyclone seeder (except for King Ranch bluestem and mixed native grasses whose lightness and texture prevented dissemination by this method). Turfiber was applied with a Bowie Hydro-mulcher; Humicite with a portable spray unit. Ten gallons of water per plot served as the Humicite carrier. Humicite was applied June 28, 1965 and all plots were seeded, fertilized, and sprayed with Turfiber on June 29, 1965. The entire test was watered on July 2, 1965 (14 gal/100 sq. ft.) to supplement natural rainfall. Supplemental fertilization consisting of 400 pounds of 12-12-12 was applied March 14, 1966.

The Meeker experiment was placed on north-south facing cut slopes, each with a 33% grade. Main plots which were 15 ft. x 78 ft. on the north exposure, and 15 ft. x 58 ft. on the south exposure, were laid out as a split plot in strip design with three replications. Main treatments consisted of the following grass varieties and rates. Seeding rates listed are bulk rates unless otherwise noted.

Grasses	Seeding Rate #/A
Common bermudagrass (hulled)	15
Weeping lovegrass	6
NK-37 bermudagrass	15
King Ranch bluestem (pure live seed)	2
Mixed native grasses (pure live seed)	5

Highway U.S. 62 served to split both treatment strips of the north-south slope exposures as shown in Appendix Figure 2.

Subtreatments consisted of Turfiber applied at a rate of 1000 pounds per acre, and asphalt emulsion (AE-5), a high viscosity, medium set emulsified asphalt, at a rate of one gallon of dilution (one part AE-5 in three parts water) per 3 sq. yds. Fifty percent of the plots received each of the above treatments. All plots received 12-12-12 fertilizer at the rate of 200 pounds per acre. Pre-weighed seed and fertilizer quantities were mixed and applied with a Cyclone seeder (except for King Ranch bluestem and mixed native grasses). Turfiber was applied with a Bowie Hydro-mulcher and the asphalt emulsion with an Oklahoma Highway Department asphalt distributor. All plots were seeded and fertilized on July 28, 1965; asphalt emulsion was applied on July 28, 1965, and Turfiber was applied on July 29, 1965. Supplemental fertilization consisting of 400 pounds of 12-12-12 per acre was applied with a Cyclone seeder on March 18, 1966.

The Elk City experiment was located on north-south cut slopes. The north facing slope has a 30% grade; the south facing slope a 33% grade. Main plots were 15 ft. x 71 ft. on the north exposure, and varied from 15 ft. x 71 ft. to 15 ft. x 109 ft. on the south exposure. Main plots were laid out as a split plot in strip design with three replications. Main treatments consisted of the following grass varieties and rates. Seeding rates listed are bulk rates unless noted otherwise.

Grasses	Seeding Rate #/A
Common bermudagrass (hulled)	15
Weeping lovegrass	6
NK-37 bermudagrass	15
King Ranch bluestem (pure live seed)	17
Sand dropseed	3

State Highway 6 served to split both treatment strips of north-south slope exposures as shown in Appendix Figure 2.

Subtreatments consisted of Turfiber applied at 1.7 tons per acre and two asphalt mulches (AE-5 and MC-4) applied at rates to permit uniform coverage. Fifty percent of the plots received each of the above treatments. AE-5 was applied at a rate of 4.13 gallons of dilution/ 100 sq. ft. to five plots on the north exposure only; other plots on both exposures receiving asphalt mulch were sprayed with MC-4. All plots received 200 pounds of 12-12-12 fertilizer per acre. Pre-weighed seed and fertilizer quantities were applied with a Cyclone seeder (except for King Ranch bluestem and sand dropseed). Turfiber was applied with the Bowie Hydro-mulcher and the asphalt mulch was applied using an Oklahoma Highway Department asphalt distributor. All plots were seeded and fertilized on June 9, 1965. The Turfiber and asphalt mulch were applied on June 9 and 10, 1966. Supplemental fertilization consisting of 400 pounds of 12-12-12 per acre was applied with a Cyclone seeder on March 17, 1966.

Plant population counts, reported as mean density in percent, or mean basal density in percent, were taken during the fall of 1965 and spring of 1966. Counts were taken using an inclined point transect on all tests, with the exception of the Guthrie experiment. Opposite exposures in each test area were marked off identically to exclude crest and base portions of each slope from sampling. Within these predetermined areas of each plot, readings were taken. Care was taken to avoid sampling immediately adjacent to plot borders. Fifty random settings of the inclined point transect were made in each plot during each reading date. A square foot quadrat was used to determine mean bermudagrass density in percent in the Guthrie experiment. Thirty random samples were taken in each plot at each reading date. Readings from each test location were taken from the same predetermined sampling areas for each date.

The method for statistical analyses of data was taken from Ostle(30). The analyses of variance were calculated on percent plant basal density, with the exception of the Guthrie experiment in which percent ground cover was used.

Soil samples were taken from each highway research area to determine levels of pH, organic matter, phosphorous, potassium, manganese, cobalt, copper, iron, zinc, and molybdenum. For sampling purposes all test area slopes were divided horizontally into thirds with the exception of the Guthrie experiment which was divided into two parts of unequal size. Equal sample numbers were taken to six inch depths from each test area. Additional soil samples were taken at six inch intervals and depths from a west facing cut slope at the Chandler experiment location. This slope length was 23 feet with a 29% grade. Samples were taken from base to crest in an attempt to characterize the fertility level of the entire slope. The area sampled had received no supplemental fertilization as had the research areas. Levels of pH, organic matter, phosphorous, and potassium were determined. Prior to laboratory analyses all samples were air dried, finely ground and screened. Procedures used for testing each sample for pH, percent organic matter, available phosphorous and potassium are those currently in use by state soil testing laboratories of the Southern Region of the United States (31). Methods used in the determination of manganese, cobalt, copper, iron, zinc, and molybdenum are outlined by Hunter and Coleman (24).

CHAPTER IV

RESULTS AND DISCUSSION

During the fall of 1965 and spring of 1966 data from each of four highway research locations were collected and analyzed statistically. These results were expressed as percent density, or mean basal density, and were compared. In addition, effects of mulch treatments and slope exposures upon density were evaluated.

Statistical analyses of data taken from the Guthrie experiment indicates fertilization to be the only significant experimental variable favoring bermudagrass density as shown in Table I. Lack of significance of fertilization treatment during April of 1966 may be due in part to slowness of germination and growth resulting from extremely dry summer and spring growing conditions. Differences in bermudagrass density resulting from machine operation and lime (quick and hydrated) treatments were recorded although they were neither significant nor apparent.

A statistical analyses of data taken from the Chandler experiments indicate differences in percent basal density between varieties to be significant as shown in Tables II and III. Highly significant differences were found in late October of 1965, and significant differences in mid-April of 1966. No significant differences in percent basal coverage, as influenced by the Humicite soil conditioner, were detected. Differences in percent basal coverage as influenced by slope exposure were both highly significant (1% level) and readily visible in April

TABLE I

THE EFFECT OF FERTILIZATION, LIME AND DISKING TREATMENTS ON THE MEAN BERMUDAGRASS GROUND COVER, AS DETERMINED ON THREE DATES, OF A WEST FACING HIGHWAY SLOPE LOCATED ON INTERSTATE 35 NEAR GUTHRIE

Date	Treatments[1]	No Fertilizer	Fertilizer[2]	Average
Aug. 25, 1965	Check	21.00	21.27	21.13
	Disking	13.41	17.56	15.49
	Quick lime, Disking	18.97	25.13	22.05
	Hydrated lime, Disking	13.29	21.96	17.63
	Average	16.67	21.48	
Oct. 27, 1965	Check	22.17	35.11	28.64
	Disking	22.27	35.11	28.69
	Quick lime, Disking	19.83	36.16	28.00
	Hydrated lime, Disking	23.61	39.11	31.36
	Average	21.97	36.37	
Apr. 20, 1966	Check	2.42	3.10	2.76
	Disking	2.53	2.59	2.56
	Quick lime, Disking	2.93	3.56	3.25
	Hydrated lime, Disking	3.57	4.10	3.83
	Average	2.86	3.34	

[1]Machine operation and lime variables were not significant at the 5% level of probability (F tabulated).
[2]Fertilizer treatment was significant at the 5% level of probability on Aug. 25, 1965, and highly significant at the 1% level of probability on Oct. 27, 1965. Fertilizer treatment consisted of 400 lbs. of 12-12-12/acre.

TABLE II

THE EFFECT OF TURFIBER MULCH, WITH AND WITHOUT HUMICITE, AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED OCTOBER 22, 1965 ON HIGHWAY SLOPES LOCATED ON U.S. 177 NEAR CHANDLER

Exposure x Mulch

	Turfiber	Turfiber (Humicite)	Average
East	2.64	2.96	2.80
West	3.08	2.65	2.87
Avg.	2.86	2.81	

Exposure x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Mixed Native Grasses	Average
East	4.73	1.97	2.37	4.07	0.87	2.80
West	5.80	1.83	4.70	1.63	0.37	2.87
Avg.	5.27	1.90	3.53	2.85	0.62	

Mulch x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Mixed Native Grasses	Average
Turfiber	5.77	1.50	3.03	3.07	0.93	2.86
Turfiber (Humicite)	4.77	2.30	4.03	2.63	0.30	2.81
Avg.	5.27	1.90	3.53	2.85	0.62	

TABLE III

THE EFFECT OF TURFIBER MULCH, WITH AND WITHOUT HUMICITE, AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED APRIL 18, 1966 ON HIGHWAY SLOPES LOCATED ON U.S. 177 NEAR CHANDLER

Exposure x Mulch

	Turfiber	Turfiber (Humicite)	Average
East	0.88	1.07	0.98
West	2.27	1.63	1.95
Avg.	1.58	1.35	

Exposure x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Mixed Native[1] Grasses	Average
East	1.50	1.50	0.33	0.57	0.00	0.98
West	3.20	1.30	2.57	0.73	0.00	1.95
Avg.	2.35	1.40	1.45	0.65	0.00	

Mulch x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Mixed Native[1] Grasses	Average
Turfiber	3.07	1.13	1.53	0.57	0.00	1.58
Turfiber (Humicite)	1.63	1.67	1.37	0.73	0.00	1.35
Avg.	2.35	1.40	1.45	0.65	0.00	

[1]Not included in Statistical Analyses or computation of means.

as shown in Tables II and III. Percent basal density recorded on the west exposure was twice that recorded on the east exposure. The percent basal density recorded on both east and west exposures were consistently highest in those plots seeded to common bermudagrass. On the west facing slope NK-37 bermudagrass closely paralleled common bermudagrass in basal density, followed by weeping lovegrass and King Ranch bluestem. All varieties were inconsistent in basal density readings between dates on the east facing slope. Late fall readings favored common bermudagrass, NK-37 bermudagrass, and King Ranch bluestem in this order, whereas early spring results favored common bermudagrass, NK-37 bermudagrass, and weeping lovegrass. Germination and growth of mixed native grasses was poor under both east and west exposure environments. Warmer surface temperatures resulting from more direct afternoon sun rays may be an important factor favoring earlier germination and growth of plants on the west facing slope.

Grass varieties seeded on U.S. 62 near Meeker failed to germinate and survive. Failure may be attributed to high afternoon temperatures during late July, lack of sufficient moisture for germination, or insufficient soil moisture to support growth of germinated seedlings.

Statistical analyses of data taken from experiments on S.H. 6 near Elk City indicate significant differences in percent basal density within grass varieties, and within varieties between mulch treatments and slope exposures as shown in Tables IV, V and VI. Differences between grass varieties during both fall and spring months were consistently highly significant. Weeping lovegrass, common and NK-37 bermudagrasses, and King Ranch bluestem produced the highest yield in terms of percent basal density on north facing plots. Fall readings indicated highly

TABLE IV

THE EFFECT OF TURFIBER AND ASPHALT MULCH AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED AUGUST 3, 1965 ON HIGHWAY SLOPES LOCATED ON S.H. 6 NEAR ELK CITY

Exposure x Mulch

	Turfiber	Asphalt	Average
North	5.73	2.98	4.36
South	2.58	1.97	2.28
Avg.	4.16	2.48	

Exposure x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Sand Dropseed[1]	Average
North	4.10	5.43	4.87	3.03	0.00	4.36
South	1.03	3.33	3.27	1.47	0.00	2.28
Avg.	2.57	4.38	4.07	2.25	0.00	

Mulch x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Sand Dropseed[1]	Average
Turfiber	3.27	5.57	4.17	3.63	0.00	4.16
Asphalt	1.87	3.20	3.97	0.87	0.00	2.48
Avg.	2.57	4.38	4.07	2.25	0.00	

[1]Not included in the statistical analyses or computation of means.

TABLE V

THE EFFECT OF TURFIBER AND ASPHALT MULCH AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED OCTOBER 9, 1965 ON HIGHWAY SLOPES LOCATED ON S.H. 6 NEAR ELK CITY

Exposure x Mulch

	Turfiber	Asphalt	Average
North	20.37	8.51	14.44
South	2.85	2.19	2.52
Avg.	11.61	5.35	

Exposure x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Sand Dropseed	Average
North	16.43	13.43	18.10	18.97	5.27	14.44
South	2.67	1.73	4.93	3.17	0.10	2.52
Avg.	9.55	7.58	11.52	11.07	2.68	

Mulch x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Sand Dropseed	Average
Turfiber	13.10	10.73	14.07	16.23	3.93	11.61
Asphalt	6.00	4.43	8.97	5.90	1.43	5.35
Avg.	9.55	7.58	11.52	11.07	2.68	

TABLE VI

THE EFFECT OF TURFIBER AND ASPHALT MULCH AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED ARPIL 25, 1966 ON HIGHWAY SLOPES LOCATED ON S.H. 6 NEAR ELK CITY

Exposure x Mulch

	Turfiber	Asphalt	Average
North	4.82	3.70	4.26
South	1.30	1.32	1.31
Avg.	3.06	2.51	

Exposure x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Sand Dropseed[1]	Average
North	2.40	7.50	2.90	4.23	0.00	4.26
South	0.67	2.57	1.03	0.97	0.00	1.31
Avg.	1.53	5.03	1.97	2.60	0.00	

Mulch x Variety

	Common Bermuda	Weeping Lovegrass	NK-37 Bermuda	King Ranch Bluestem	Sand Dropseed[1]	Average
Turfiber	1.47	6.27	1.67	2.83	0.00	3.06
Asphalt	1.60	3.80	2.27	2.37	0.00	2.51
Avg.	1.53	5.03	1.97	2.60	0.00	

[1] Not included in the statistical analyses or computation of means.

significant differences in the effect of Turfiber mulch in each of these plots when compared with the asphalt (MC-4 and AE-5) mulch treatments. NK-37 bermudagrass, weeping lovegrass, King Ranch bluestem and common bermudagrass, in that order, responded with the best basal density readings under severe growing conditions on the south exposure. Germination and subsequent growth of sand dropseed was poor under both exposures, regardless of mulch treatments. The effects of mulches were negligible as related to basal density of all varieties seeded on the south facing slope. Heavy rains in early June combined with steep slopes, and a sandstone base beneath loose surface soil, all contributed to the large scale removal of soil, seed, and mulch. The fact that the north facing slope was essentially undamaged during this period of time may be the result of the hard southerly winds which drove sheets of rain directly into the southern exposure whereas the northern exposure was somewhat protected. Differences in percent basal density of the grass varieties as reflected by slope exposure are obvious and expected. Severe erosion of the south exposure and absence of large amounts of moisture conserving mulch, attributed to a more severe environment for grass germination and growth.

Laboratory analyses of soil samples taken from all research locations, including stratified samples from the Chandler location, indicates a need for supplemental fertilization. Plotted data, based on the stratified sampling, fails to indicate definite nutrient level patterns, or distinct regions of lower or higher concentrations as shown in Figures 1, 2 and 3. Failure to identify any obvious fertility stratification features may be due to unnaturally exposed, disturbed, or relocated soils composing the top six inch soil layer. Levels of pH,

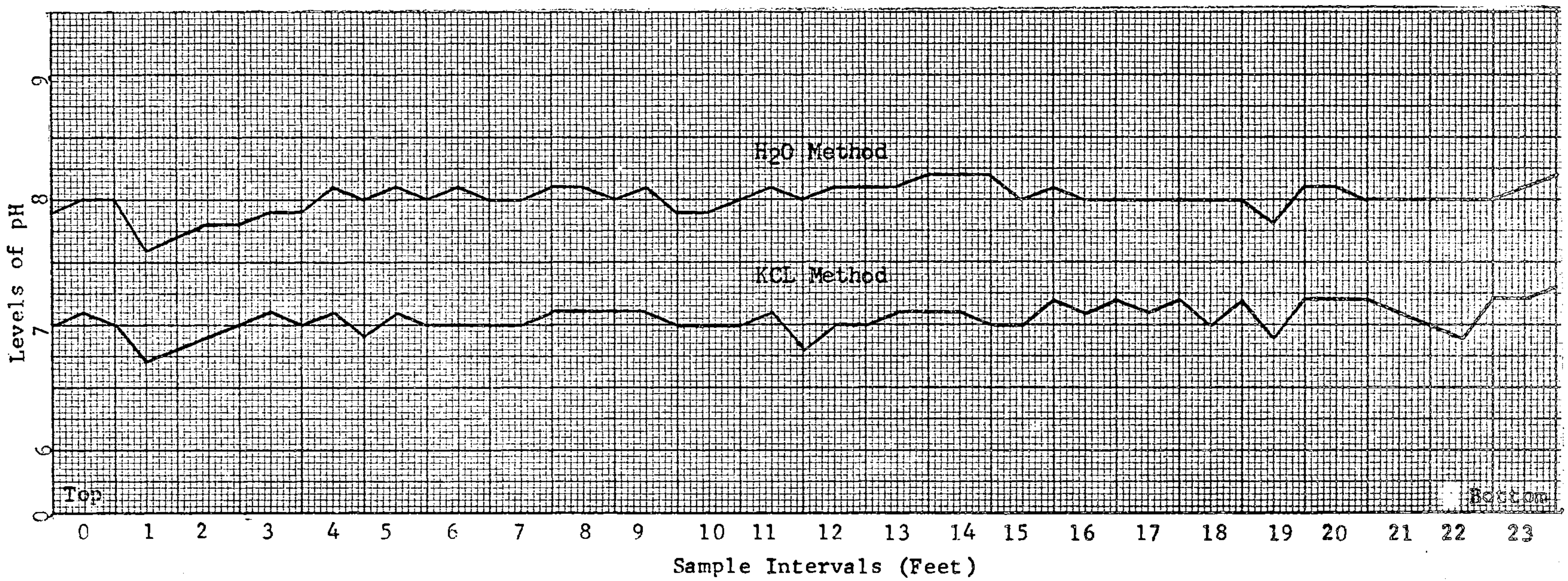

Figure 1. Soil pH of Stratified Samples Taken From the Top to the Bottom of A Highway Backslope Near Chandler.

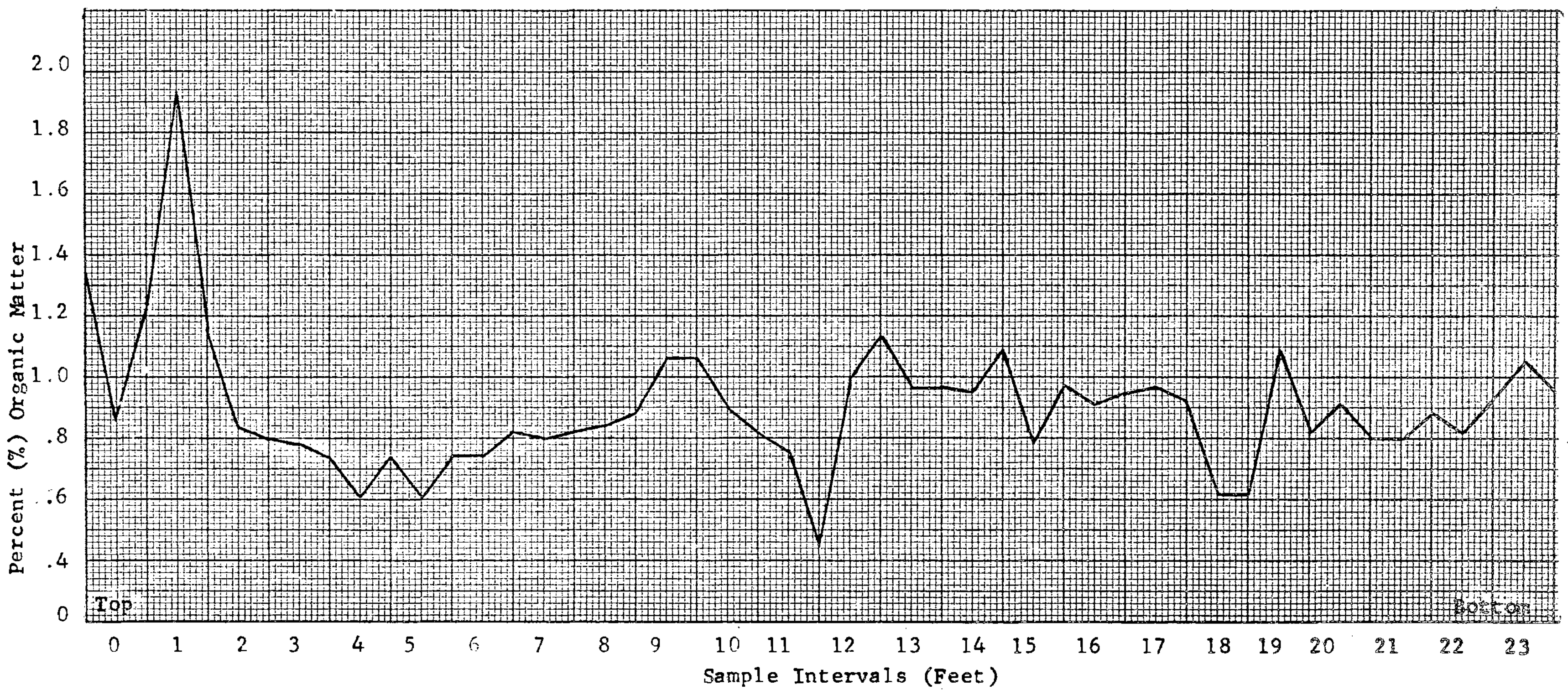

Figure 2. Percent Organic Matter in Stratified Soil Samples Taken From the Top to the Bottom of A Highway Backslope Near Chandler.

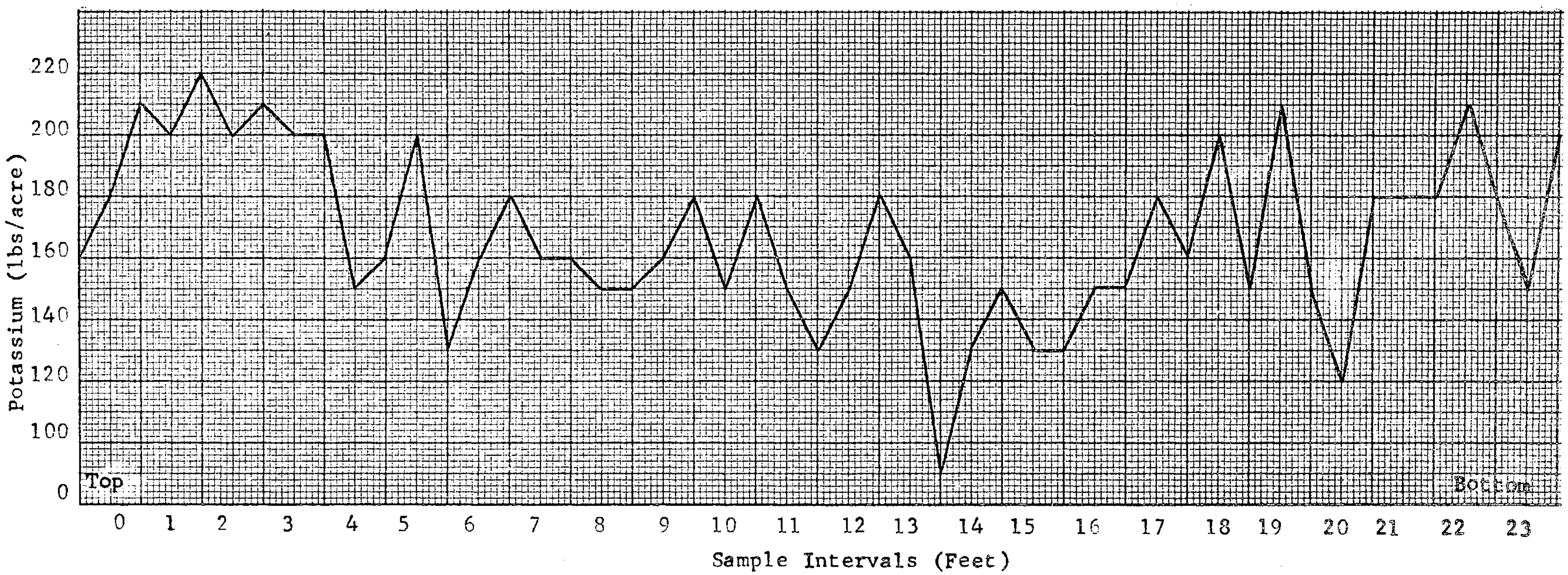

Figure 3. Pounds of Available Potassium in Stratified Soil Samples Taken From the Top to the Bottom of A Highway Backslope Near Chandler

as determined by both paste (H_2O) and KCL methods ranged near or above neutral in all samples tested. Paste pH results consistently averaged one pH level higher than results obtained by the KCL method. Percent organic matter levels ranged from a low of 0.30% to a high of 2.10%. Levels of available phosphorous ranged from a low of 0.0 pounds to a high of 32.1 pounds per acre. Levels of available potassium ranged from a low of 90 pounds to a high of 380 pounds per acre as shown in Tables VII, VIII and IX. Levels of trace elements are listed in Table VIII.

TABLE VII

SOIL PH, ORGANIC MATTER, AND CERTAIN MACRO-ELEMENTS IN

SLOPE SAMPLES TAKEN RANDOMLY FROM HIGHWAY RESEARCH AREAS

						Pounds Per Acre	
Location	Exposure	Sample[1]	pH (H_2O)	pH (KCL)	% OM	P (Available)	K (Available)
Guthrie	West	Upper	7.4	6.6	2.1	9.4	380
		Lower	8.0	7.5	0.9	7.5	270
Chandler	West	Upper	7.6	6.3	0.6	1.9	180
		Middle	7.8	6.6	0.6	1.9	150
		Lower	8.1	6.9	1.0	3.8	160
	East	Upper	7.0	6.3	0.6	0.0	180
		Middle	8.0	6.8	0.5	3.8	160
		Lower	8.3	7.1	0.6	7.5	150
Meeker	North	Upper	7.7	6.7	1.0	1.9	270
		Middle	7.3	6.4	1.6	5.7	240
		Lower	7.7	6.8	1.7	7.5	210
	South	Upper	7.1	6.1	1.4	7.5	270
		Middle	7.2	6.4	2.1	32.1	250
		Lower	7.1	6.1	1.7	17.0	210
Elk City	North	Upper	7.3	6.3	0.7	17.0	250
		Middle	7.9	6.7	0.3	5.7	210
		Lower	7.9	7.1	0.6	28.3	240
	South	Upper	7.8	7.0	0.8	24.5	240
		Middle	8.0	7.0	0.6	20.0	210
		Lower	7.8	7.0	0.6	22.6	210

[1]Readings are means of equal sample numbers taken randomly at six inch depths. Slopes were divided horizontally into thirds or halves for sampling purposes.

TABLE VIII

SOIL PH, ORGANIC MATTER, AND CERTAIN MACRO- AND MICRO-ELEMENTS IN SLOPE SAMPLES TAKEN RANDOMLY FROM HIGHWAY RESEARCH AREAS

					Pounds Per Acre (Extractable)								
Location	Exposure	pH (H_2O)	pH (KCL)	% OM	P (Available)	K (Available)	Mn	Co	Cu	Fe	Zn	Mo
Guthrie	West	7.7	7.1	1.5	8.5	325	5	.30	3.6	130	6	0.3
Chandler	West	7.8	6.6	0.7	2.5	163	21	.20	6.2	80	9	0.0
	East	7.8	6.7	0.6	3.8	163	18	.24	5.6	110	6	0.0
Meeker	North	7.6	6.6	1.4	5.0	240	21	.50	3.6	240	5	0.0
	South	7.1	6.2	1.7	18.9	243	17	.50	5.6	240	10	0.0
Elk City	North	7.7	6.7	0.5	17.0	233	8	.46	9.4	110	8	0.0
	South	7.9	7.0	0.7	22.4	220	9	.30	9.8	80	11	0.0

TABLE IX

SOIL PH, ORGANIC MATTER, PHOSPHOROUS, AND POTASSIUM

CONTENT BASED ON STRATIFIED SAMPLING OF A

HIGHWAY BACKSLOPE NEAR CHANDLER

Location	pH	pH	Per Cent	Available	
in Feet	(H_2O)	(KCL)	Organic Matter	Phosphorous	Potassium
Top Surface	7.9	7.0	1.34	18.85	160
0.0	8.0	7.1	0.86	0.00	180
0.5	8.0	7.0	1.22	0.00	210
1.0	7.6	6.7	1.93	0.00	200
1.5	7.7	6.8	1.16	0.00	220
2.0	7.8	6.9	0.84	0.00	200
2.5	7.8	7.0	0.80	0.00	210
3.0	7.9	7.1	0.78	0.00	200
3.5	7.9	7.0	0.74	0.00	200
4.0	8.1	7.1	0.61	0.00	150
4.5	8.0	6.9	0.74	0.00	160
5.0	8.1	7.1	0.61	0.00	200
5.5	8.0	7.0	0.74	0.00	130
6.0	8.1	7.0	0.74	0.00	160
6.5	8.0	7.0	0.82	0.00	180
7.0	8.0	7.0	0.80	0.00	160
7.5	8.1	7.1	0.82	0.00	160
8.0	8.1	7.1	0.84	0.00	150
8.5	8.0	7.1	0.88	0.00	150
9.0	8.1	7.1	1.07	0.00	160
9.5	7.9	7.0	1.07	0.00	180
10.0	7.9	7.0	0.90	0.00	150
10.5	8.0	7.0	0.82	0.00	180
11.0	8.1	7.1	0.76	0.00	150
11.5	8.0	6.8	0.45	0.00	130
12.0	8.1	7.0	0.99	0.00	150
12.5	8.1	7.0	1.13	0.00	180
13.0	8.1	7.1	0.97	0.00	160
13.5	8.2	7.1	0.97	0.00	90
14.0	8.2	7.1	0.95	0.00	130
14.5	8.2	7.0	1.09	0.00	150
15.0	8.0	7.0	0.78	0.00	130
15.5	8.1	7.2	0.97	0.00	130
16.0	8.0	7.1	0.91	0.00	150
16.5	8.0	7.2	0.95	0.00	150
17.0	8.0	7.1	0.97	0.00	180
17.5	8.0	7.2	0.93	0.00	160
18.0	8.0	7.0	0.62	0.00	200

TABLE IX (Continued)

Location in Feet	pH (H_2O)	pH (KCL)	Per Cent Organic Matter	Available Phosphorous	Available Potassium
18.5	8.0	7.2	0.62	0.00	150
19.0	7.8	6.9	1.09	0.00	210
19.5	8.1	7.2	0.82	0.00	150
20.0	8.1	7.2	0.91	0.00	120
20.5	8.0	7.2	0.80	0.00	180
21.0	8.0	7.1	0.80	0.00	180
21.5	8.0	7.0	0.88	0.00	180
22.0	8.0	6.9	0.82	0.00	210
22.5	8.0	7.2	0.93	0.00	180
23.0	8.1	7.2	1.05	0.00	150
Bottom Surface	8.2	7.3	0.95	3.77	200

CHAPTER V

SUMMARY AND CONCLUSIONS

Grass species and mulches were evaluated for erosion control on four highway slope areas in Oklahoma. These slope areas were seeded during the months of February, June, and July. The effect of slope exposure on stand establishment was measured.

In central Oklahoma, as indicated by the Chandler experiment, common bermudagrass ranked highest in percent basal density produced, thereby affording more protection from soil erosion than other grasses tested. Its germination and growth was favored by a western exposure. Germination and growth of NK-37 bermudagrass, weeping lovegrass and King Ranch bluestem were favorable. Mixed native grasses produced insignificant amounts of vegetation for protection of these slopes against soil erosion. The use of Humicite as a soil conditioner produced non-significant results.

Common and NK-37 bermudagrasses, weeping lovegrass and King Ranch bluestem all produced significant amounts of vegetation near Elk City in western Oklahoma. The percent basal density of these varieties was favored by a northern exposure. Sand dropseed produced insignificant amounts of vegetation under the environment of both north and south exposures tested in this investigation. Yields of varieties, in terms of percent basal density, were significantly higher under Turfiber than under asphalt mulch treatments by the end of the first growing season.

The fertilization of common bermudagrass, as evaluated near Guthrie in central Oklahoma, produced highly significant results near the end of its first growing season. Treatments consisting of lime (quick and hydrated) and machine operation (disking) were not significant in increasing percent bermudagrass density.

Desirable germination and growth of most grass varieties resulted from seedings made during the months of February and June. Seedings completed during late July, however, failed completely.

Determination of fertility levels in highway cut areas emphasizes the need for proper adjustments of required nutritional elements for adequate grass germination and growth. Soil analyses in central and western Oklahoma indicated pH levels near or above neutral, and medium to high levels of available potassium. Percent organic matter and available phosphorous levels, however, were sub-minimal in both the central and western regions.

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APPENDIX

APPENDIX TABLE I

AN ANALYSIS OF VARIANCE OF THE EFFECT OF FERTILIZATION, LIME AND DISKING TREATMENTS ON THE MEAN BERMUDAGRASS GROUND COVER, AS DETERMINED ON THREE DATES, OF A WEST FACING HIGHWAY SLOPE LOCATED ON INTERSTATE 35 NEAR GUTHRIE

August 25, 1965

Source	d.f.	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	23	2087.59				
Replications	2	1303.40	651.70	13.21**	5.14	10.9
Treatment (A)	3	168.32	56.11	1.14	4.76	
Error (a)	6	295.96	49.33			
Fertility (B)	1	139.11	139.11	8.97*	5.32	11.3
A x B	3	56.80	18.93	1.22	4.07	
Error (b)	8	124.00	15.50			

October 27, 1965

Source	d.f.	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	23	3782.34				
Replications	2	1418.18	709.09	7.28*	5.14	10.9
Treatment (A)	3	40.09	13.36	0.14	4.76	
Error (a)	6	584.22	97.37			
Fertility (B)	1	1244.45	1244.45	20.69**	5.32	11.3
A x B	3	14.27	4.76	0.08	4.07	
Error (b)	8	481.13	60.14			

April 20, 1966

Source	d.f.	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	23	205.42				
Replications	2	161.29	80.64	17.08**	5.14	10.9
Treatment (A)	3	5.80	1.93	0.41	4.76	
Error (a)	6	28.33	4.72			
Fertility (B)	1	1.34	1.34	1.29	5.32	
A x B	3	0.37	0.12	0.12	4.07	
Error (b)	8	8.31	1.04			

APPENDIX TABLE II

AN ANALYSIS OF VARIANCE OF THE EFFECT OF TURFIBER MULCH, WITH AND WITHOUT HUMICITE, AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED OCTOBER 22, 1965 ON HIGHWAY SLOPES LOCATED ON U.S. 177 NEAR CHANDLER

Source	d.f.	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	59	308.01				
Replications	2	4.96	2.48	4.28	19.00	
Exposure (A)	1	0.07	0.07	0.12	18.50	
Error (a)	2	1.16	0.58			
Mulch (B)	1	0.04	0.04	0.01	4.35	
Variety (C)	4	146.35	36.59	9.76**	2.87	4.43
Mulch x Var.(BC)	4	9.64	2.41	0.64	2.87	
Error (b)	18	67.41	3.75			
AB	1	2.09	2.09	1.19	4.35	
AC	4	38.25	9.56	5.43**	2.87	4.43
ABC	4	6.37	1.59	0.90	2.87	
Error (c)	18	31.67	1.76			

APPENDIX TABLE III

AN ANALYSIS OF VARIANCE OF THE EFFECT OF TURFIBER MULCH, WITH AND WITHOUT HUMICITE, AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED APRIL 18, 1966 ON HIGHWAY SLOPES LOCATED ON U.S. 177 NEAR CHANDLER

Source	d.f.[1]	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	47	102.49				
Replications	2	7.44	3.72	124.00**	19.00	99.00
Exposure (A)	1	11.41	11.41	380.00**	18.50	98.50
Error (a)	2	0.06	0.03			
Mulch (B)	1	0.61	0.61	0.40	4.54	
Variety (C)	3	17.42	5.81	3.82*	3.29	5.42
Mulch x Var (BC)	3	6.58	2.19	1.44	3.29	
Error (b)	14	21.27	1.52			
AB	1	2.00	2.00	1.48	4.54	
AC	3	12.43	4.14	3.07	3.29	
ABC	3	4.45	1.48	1.10	3.29	
Error (c)	14	18.83	1.35			

[1]Mixed native grasses excluded from the analysis of variance.

APPENDIX TABLE IV

AN ANALYSIS OF VARIANCE OF THE EFFECT OF TURFIBER AND ASPHALT MULCH AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED AUGUST 3, 1965 ON HIGHWAY SLOPES LOCATED ON S.H. 6 NEAR ELK CITY

Source	d.f.[1]	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	47	255.51				
Replications	2	26.37	13.19	20.61*	19.00	99.00
Exposure (A)	1	52.08	52.08	81.38	18.50	
Error (a)	2	1.27	0.64			
Mulch (B)	1	34.00	34.00	17.62**	4.54	8.68
Variety (C)	3	40.81	13.60	7.05**	3.29	5.42
Mulch x Var(BC)	3	11.76	3.92	2.03	3.29	
Error (b)	14	27.00	1.93			
AB	1	13.65	13.65	5.15*	4.54	8.68
AC	3	4.40	1.47	0.55	3.29	
ABC	3	7.03	2.34	0.88	3.29	
Error (C)	14	37.11	2.65			

[1]Sand dropseed excluded from the analysis of variance.

APPENDIX TABLE V

AN ANALYSIS OF VARIANCE OF THE EFFECT OF TURFIBER AND ASPHALT MULCH AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED OCTOBER 9, 1965 ON HIGHWAY SLOPES LOCATED ON S.H. 6 NEAR ELK CITY

Source	d.f.	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F (Tab.) 1%**
Total	59	4662.09				
Replications	2	58.40	29.20	0.48	19.00	
Exposure (A)	1	2131.30	2131.30	35.39*	18.50	98.50
Error (a)	2	120.44	60.22			
Mulch (B)	1	589.07	589.07	102.98**	4.35	8.10
Variety (C)	4	617.55	154.39	26.99**	2.87	4.43
Mulch x Var(BC)	4	98.35	24.59	4.30*	2.87	4.43
Error (b)	18	102.98	5.72			
AB	1	470.40	470.40	39.97**	4.35	8.10
AC	4	197.02	49.26	4.19*	2.87	4.43
ABC	4	64.73	16.18	1.37	2.87	
Error (c)	18	211.86	11.77			

APPENDIX TABLE VI

AN ANALYSIS OF VARIANCE OF THE EFFECT OF TURFIBER AND ASPHALT MULCH AND EXPOSURE ON THE MEAN BASAL DENSITY OF GRASS VARIETIES AS DETERMINED APRIL 25, 1966 ON HIGHWAY SLOPES LOCATED ON S.H. 6 NEAR ELK CITY

Source	d.f.[1]	S.S.	M.S.	F (Cal.)	F (Tab.) 5%*	F(Tab.) 1%**
Total	47	343.35				
Replications	2	19.10	9.55	0.99	19.00	
Exposure (A)	1	104.43	104.43	10.87	18.50	
Error (a)	2	19.22	9.61			
Mulch (B)	1	3.63	3.63	2.17	4.54	
Variety (C)	3	87.91	29.30	17.54**	3.29	5.42
Mulch x Var(BC)	3	16.41	5.47	3.28	3.29	
Error (b)	14	23.42	1.67			
AB	1	3.85	3.85	1.64	4.54	
AC	3	20.06	6.69	2.85	3.29	
ABC	3	12.41	4.14	1.76	3.29	
Error (c)	14	32.90	2.35			

[1]Sand dropseed excluded from the analysis of variance.

	REP I				REP II				REP III			
Main Treatments	L_2 M_1	L_0 M_0	L_1 M_1	L_0 M_1	L_0 M_0	L_1 M_1	L_0 M_1	L_2 M_1	L_2 M_1	L_0 M_0	L_0 M_1	L_1 M_1
Sub-Treatments	F_1 | F_0	F_0 | F_1	F_0 | F_1	F_0 | F_1	F_1 | F_0	F_1 | F_0	F_0 | F_1	F_1 | F_0	F_0 | F_1	F_0 | F_1	F_1 | F_0	F_0 | F_1
Plot No.	101	102	103	104	201	202	203	204	301	302	303	304

Code Interpretation

L_0 = no lime

L_1 = quick lime

L_2 = hydrated lime

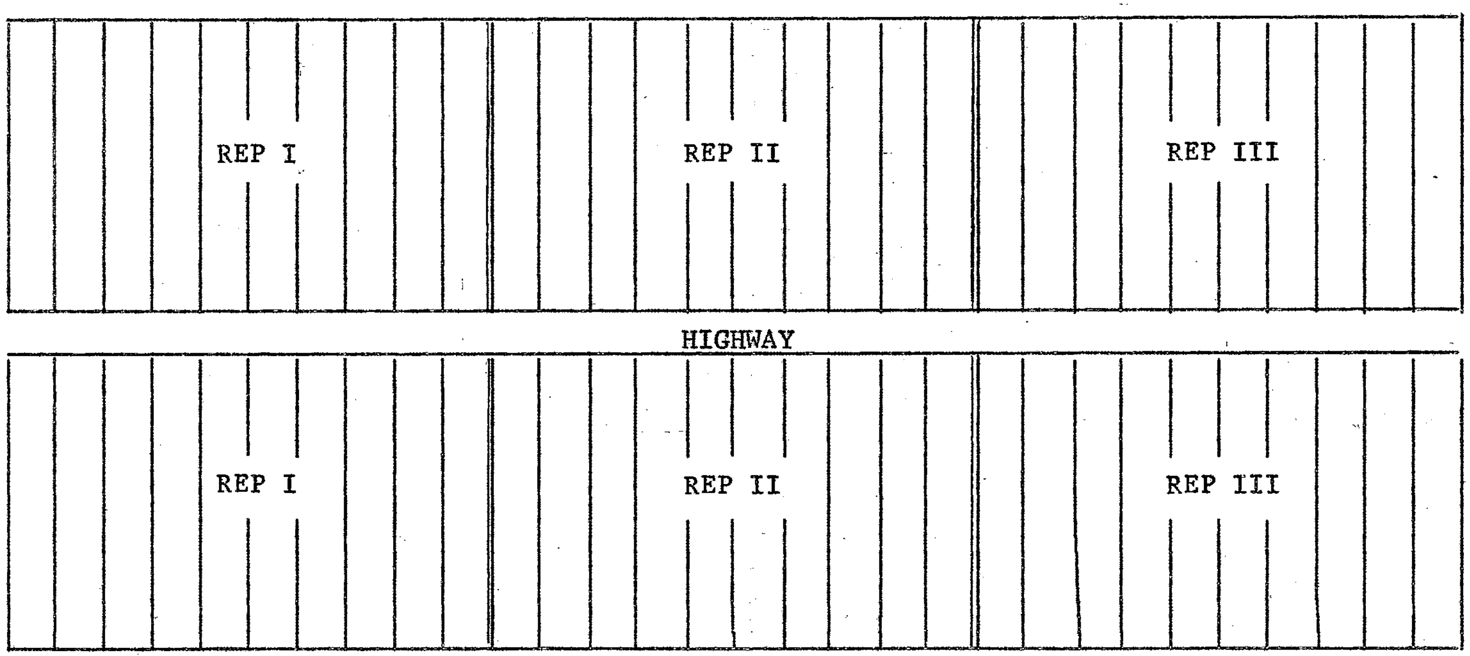
M_0 = no machine operations

M_1 = disking

F_0 = no fertilizer

F_1 = 400 lbs. of 12-12-12/A

Appendix Figure 1. Field Design and Treatments of the Experiment on a Cut Slope on Interstate 35 Near Guthrie.



Appendix Figure 2. Field Design of the Experiments on Cut Slopes of U.S. 177 Near Chandler, U.S. 62 Near Meeker, and S. H. 6 Near Elk City.

VITA

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Master of Science

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