OKLAHOMA PROJECT

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ROADSIDE DEVELOPMENT AND EROSION CONTROL

Final Report

(Part I of III Parts)

Causes and Control of Soil Erosion

on

Oklahoma Highways

by

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in cooperation with

The Oklahoma Department of Highways

and

The United States Department of Transportation

Federal Highway Administration

Bureau of Public Roads

Oklahoma Agricultural Experiment Station

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CAUSES AND CONTROL OF SOIL EROSION

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RECOMMENDATIONS

DESIGN

1. Flatten backslopes and fills as much as possible. Avoid slopes steeper than 3:1 if possible where a vegetative ground cover is to be used for erosion control. If 2:1 backslopes must be designed as on urban roadways particularly, plans for permanent supplemental irrigation should be initiated at the time.

2. Provide for interceptor ditches at the top of cut slopes particularly, and on the berms of deep cuts, to facilitate the orderly removal of excess water that pours down from terrace outlets or watersheds above, or that falls on the slope itself.

3. Utilize a physical barrier along the outer side of the shoulder on long slopes particularly, and on the inside of curves for the purpose of concentrating and removing excess water in an orderly fashion that otherwise would result in excessive erosion of fill slopes.

EROSION CONTROL

1. Apply no more starter fertilizer than 200 pounds of 13-13-13 per acre at the time of seeding for optimum germination and establishment of the desired grasses.

2. Weeping lovegrass seems to be more widely adapted and easier to establish for erosion control in Oklahoma than other species tested. Its use in western, central, and eastern Oklahoma is to be encouraged until such time a more satisfactory grass becomes available.

3. The use of high-grade hay or excelsior for vegetative mulch is strongly recommended. No more than a trace of weeds (preferably none) with mature seeds should be present in the vegetative mulch. Low-grade vegetative mulch composed of undesirable weedy annuals, or perennial johnsongrass should be avoided without exception.

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INTRODUCTION

Over $4 million are spent each year for erosion control on Oklahoma highways and roads. The cost per mile for erosion control increased approximately 45 percent from 1965 to 1966. With more than 12,000 miles of federal and state highways in Oklahoma now, and more being constructed each year, the need for determining the causes of soil erosion and the most satisfactory and economical methods for control becomes obvious.

FACTORS RESPONSIBLE FOR SOIL EROSION

Many factors are responsible for soil erosion on the highway system. Some are more universal than others, but each contributes to the total cost for control.

The principal causes of soil erosion are wind, water, and man. It is when man steps in and alters the balance of nature that erosion becomes destructive and expensive to maintain.

To ultimately develop a program for the satisfactory and economical control of soil erosion on Oklahoma highways and roads, the cause of factors most frequently involved first had to be determined.

Investigations in all divisions of the highway system repeatedly turned up some factors of erosion that were generally common to all areas.

CAUSES OF SOIL EROSION ON OKLAHOMA HIGHWAYS

The major causes of soil erosion on all areas of the highway system, but especially on cut and fill slopes, generally were found to be improper design, or maintenance, or both. The factors responsible for failure in stand establishment, or to persist after successful establishment generally were found to be as follows:

1. The use of weedy, low-grade vegetative mulch. On newly seeded cut and fill slopes the vegetative (hay) mulch frequently was composed largely of annual grasses and weeds, or was so heavily contaminated with seeds of these rapidly growing, undesirable plants that the slower growing, seeded perennials died or failed to become successfully established because of the competition for moisture, nutrients, and space. The results from the use of poor-quality, weedy vegetative mulch on newly seeded areas can be illustrated by Figure 1.

2. Improper use of maintenance equipment. The operation of mowers particularly, on highly erosive cut and fill slopes is the most destructive force currently acting upon the erosion control vegetative ground cover. The protective vegetative cover is not only destroyed by the improper practice of mowing too short and too frequently, but also by being physically torn from the soil by the shearing action of the tractor sliding as it attempts to traverse the slope generally in a horizontal direction (Figure 2), or from the spinning wheels in ascending the steep slopes, or as they slide in an attempt to stop or turn as they descend (Figure 3).

   The "blading-off" of established vegetative ground cover especially native grasses, on the highway shoulders, or soil removal from the top or slopes of stabilized cuts for repairs on fill slopes adds greatly to the cost of erosion control in the highway system.

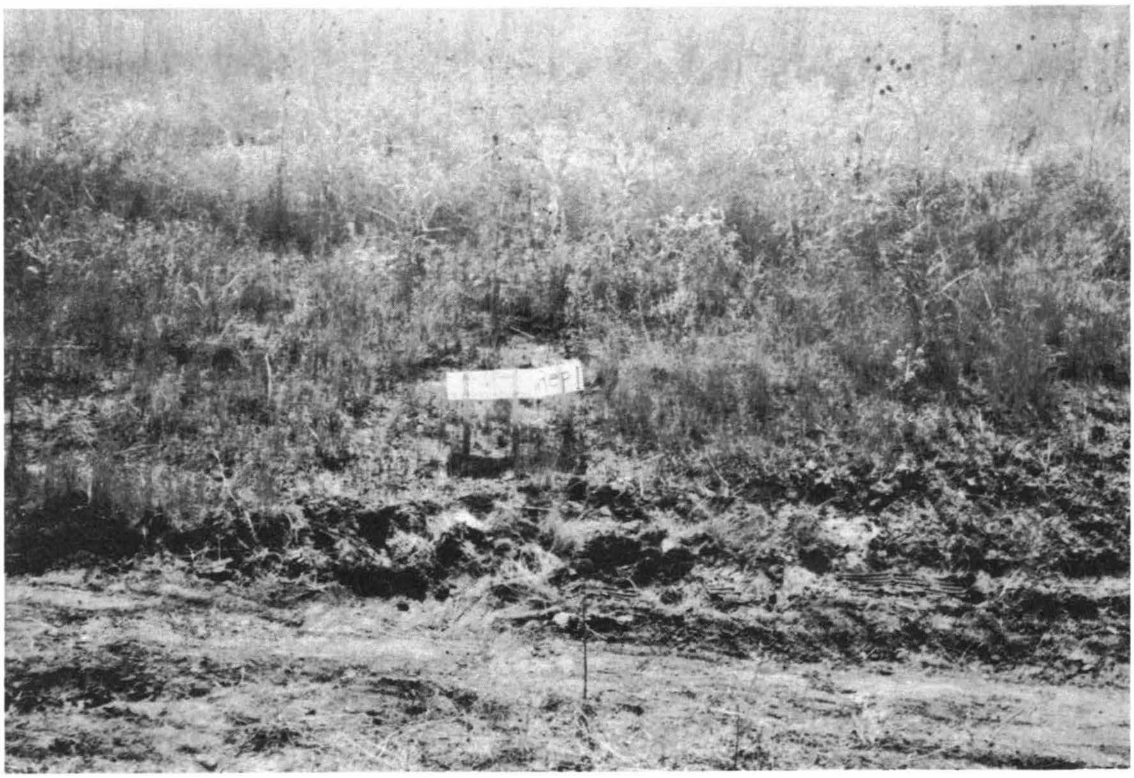
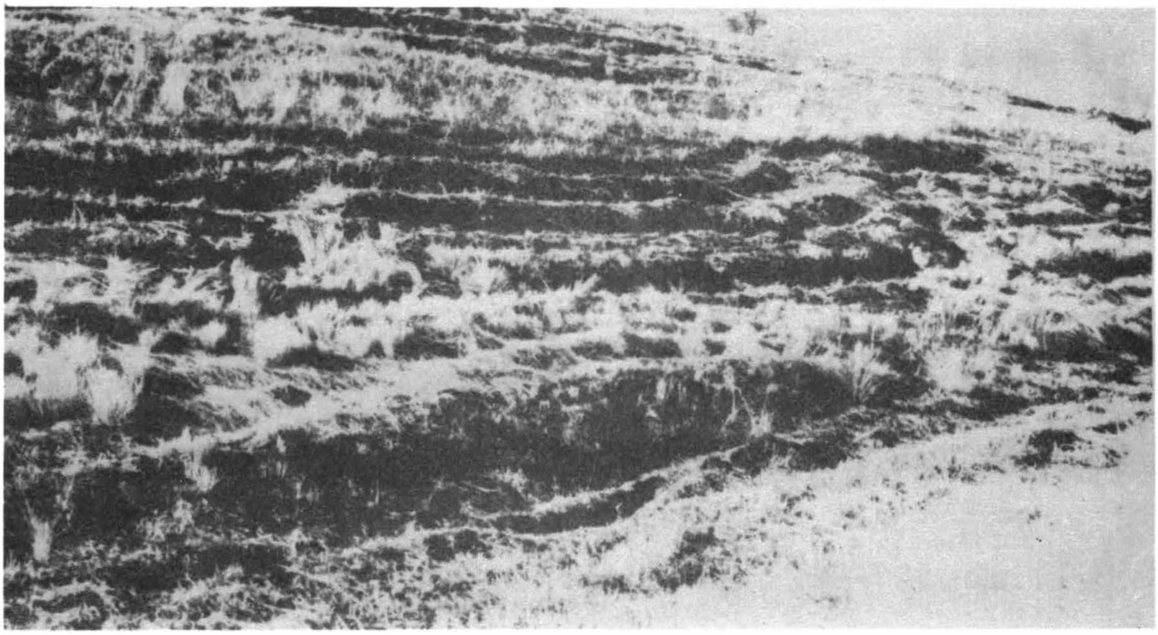


Figure 1. Trashy, low-grade vegetative mulch composed largely of annual grasses and weeds, or mature johnsongrass is frequently the cause of a failure in stand establishment of perennial grasses seeded for erosion control



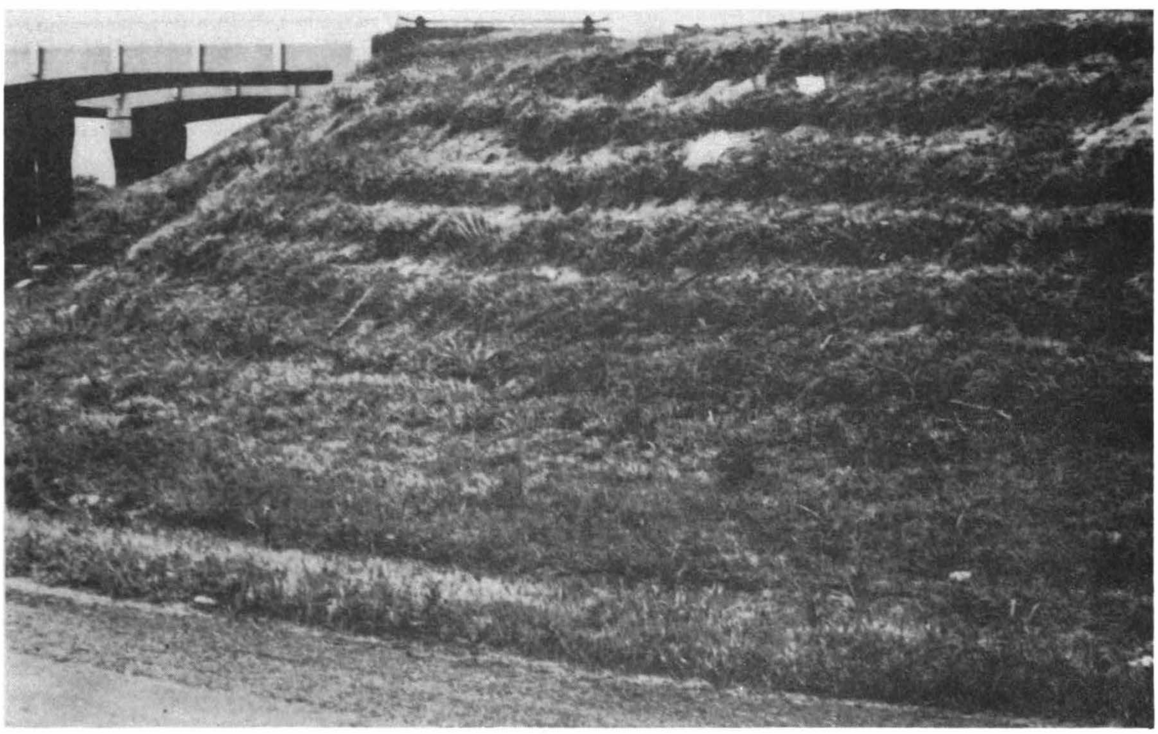


Figure 2. The operation of maintenance equipment, mowers particularly, on highly erosive cut (top photo) and fill (bottom photo) slopes destroys the vegetative cover and accelerates soil erosion by physically tearing the grass from the soil as the tractor slides in traversing the slope.

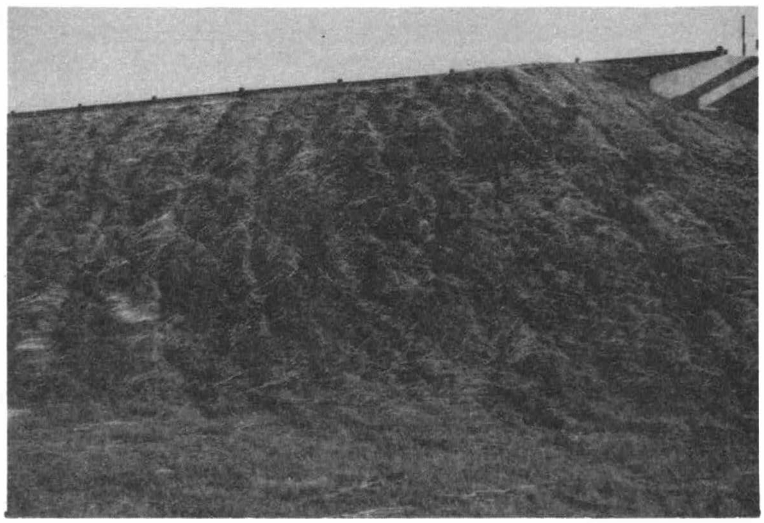


Figure 3. Soil erosion is greatly accelerated by the destruction of grass and the creation of ruts as the mower wheels spin as they ascend or slide in an attempt to stop or turn on the way down.

3. Decline in soil fertility. Failure to provide maintenance levels of fertilizer to well established bermuda, weeping love, or native grass covers has led to a thinning (Figure 4) or complete destruction of the vegetative cover resulting in certain soil erosion and costly repairs.

4. Improper highway design. Failure to acquire adequate rights-of-way for the construction of interceptor ditches on the top of cut clopes particularly, to facilitate the orderly removal of excess water has resulted in serious erosion from water pouring down the slope from terrace outlets or watershed above (Figure 5).

Previously, many backslopes were designed with a 3:1 slope, and some cases even 2:1 which created a droughty, difficult condition first for the establishment of the erosion control vegetative ground cover, and second for the maintenance over a period of time. Frequently, through the expenditure of considerable funds a satisfactory ground cover for erosion control was established only to decline in density and protective ability because of the droughty soil created by steepness of the slope preventing good water penetration and accompanying winter kill from deep penetration in the soil of cold air because of a lack of water in the soil pores to slow or prevent damaging effects of low temperatures.

The lack of a physical barrier along the outer side of the shoulder from near the crest of a slope to the bottom for the purpose of concentrating and removing excess water in an orderly fashion has resulted in excessive erosion of fill slopes. Erosion of this type occurs primarily because of superelevation, highway slope is designed to the outside, and the accumulation of gravel on the shoulder that tends to concentrate the runoff water along the dike until a sufficient volume accumulates to break through the gravel ridge and down the fill slope.

Figure 4. The decline in soil fertility following the successful establishment of a grass, particularly bermuda, results in a thinning or complete loss of the vegetative cover, soil erosion and costly repairs.

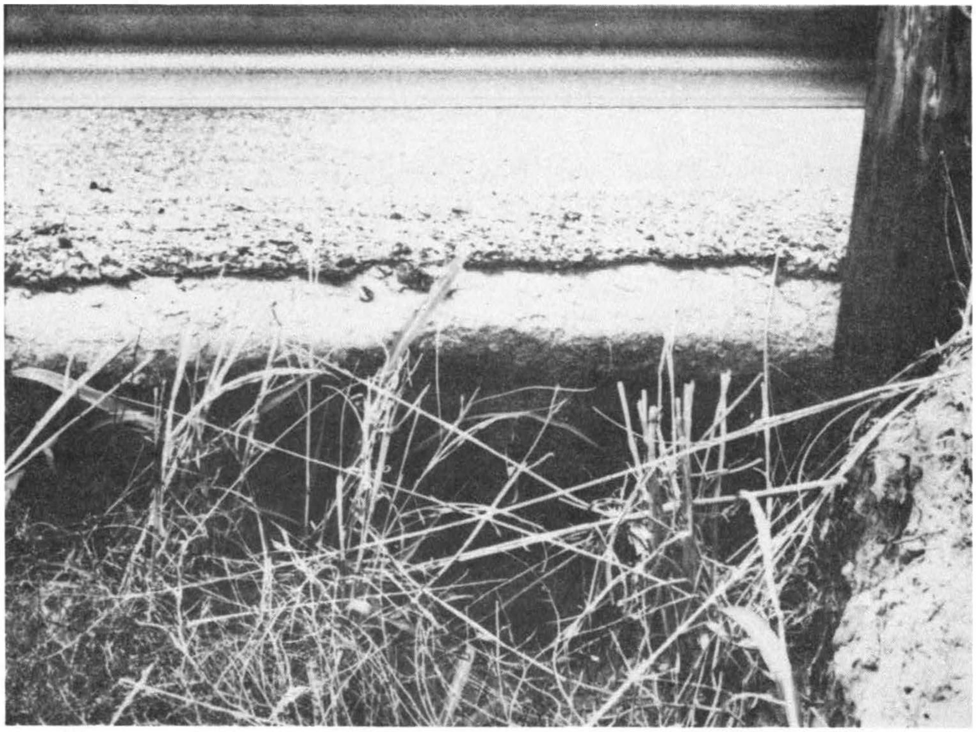


Figure 5. Soil erosion occurs as a result of improper design through omission of a physical barrier along the shoulder to concentrate and remove excess water (top photo), and because of inadequate rights-of-way interceptor ditches could not be constructed on top of cut slopes particularly for the orderly removal of excess water (bottom photo) from terrace outlets, or adjacent watershed.

CONTROL OF SOIL EROSION

The principal objectives of this part of the research project were to find satisfactory and economical methods for the prevention and control of soil erosion along Oklahoma highways. To achieve these objectives several factors were to be evaluated. The principal factors involved in erosion control are plant species, soils and soil fertility, slope and exposure, and cultural practices best suited for the establishment and maintenance of permanent vegetation.

FINDINGS AND CONCLUSIONS

1. Laboratory analyses of soil samples taken from all research locations, including samples taken every six inches from top to bottom of 23 feet high (33%) backslope in central Oklahoma[1/] indicate a need for supplemental fertilization for optimum growth of grasses for erosion control. Levels of available phosphate ranged from a low of 0.0 pounds on the above mentioned backslope in central Oklahoma to a high of 32.1 pounds per acre at another location. The levels of available potassium ranged from a low of 90 pounds to a high of 380 pounds per acre. The soil pH ranged near or above neutral in all samples tested. Based upon these tests no lime would be required for neutralizing the soil pH in central and western Oklahoma.

1/ Bailey, Richard E. 1966. Evaluation of Grass Species and Mulches for Erosion Control on Oklahoma Highways. Unpublished M.S. Thesis. Oklahoma State University.

2. Laboratory investigations of the effect of bulk density and soil water pressure on grass seedling emergence indicate that moisture is the most important factor influencing the emergence of common bermudagrass and weeping lovegrass seedlings for the range of bulk density and soil water pressures studied[2/]. Both grasses gave approximately the same emergence at the -1/3 and -1 bar soil water pressures.

3. Weeping lovegrass (Eragrostis curvula Nees.) is one of the most widely adapted, easily established grasses tested for the control of soil erosion on Oklahoma highways. Its use in western, central, and eastern Oklahoma is to be encouraged.

Successful seedings of weeping lovegrass were made on sandy soils and clays, and on north facing slopes as well as those that faced south. Seedings made on highly erosive cut slopes in western Oklahoma near Elk City showed weeping lovegrass mulched with either asphalt or Turfiber[3/] provided more cover initially for erosion control (Figures 6 and 7) than any other grass in the test. Heavy rains from the south occurred the week after seeding and caused severe loss of soil, seed, and mulch from the south facing slope that largely accounts for the decline in plant protection (Figure 7).

Bermudagrass (Cynodon dactylon (L.) Pers.) responded to the warmer temperatures of the south facing cut slope in north-central Oklahoma east of Stillwater, and provided slightly more protection from soil

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[2/] Hughes, Tom D. 1966. The Effect of Bulk Density and Soil Water Pressure on Grass Seedling Emergence. M.S. Thesis. Oklahoma State University. (Published in Agron. Jour. 58:549-553. 1966.)

[3/] Product of International Paper Company.

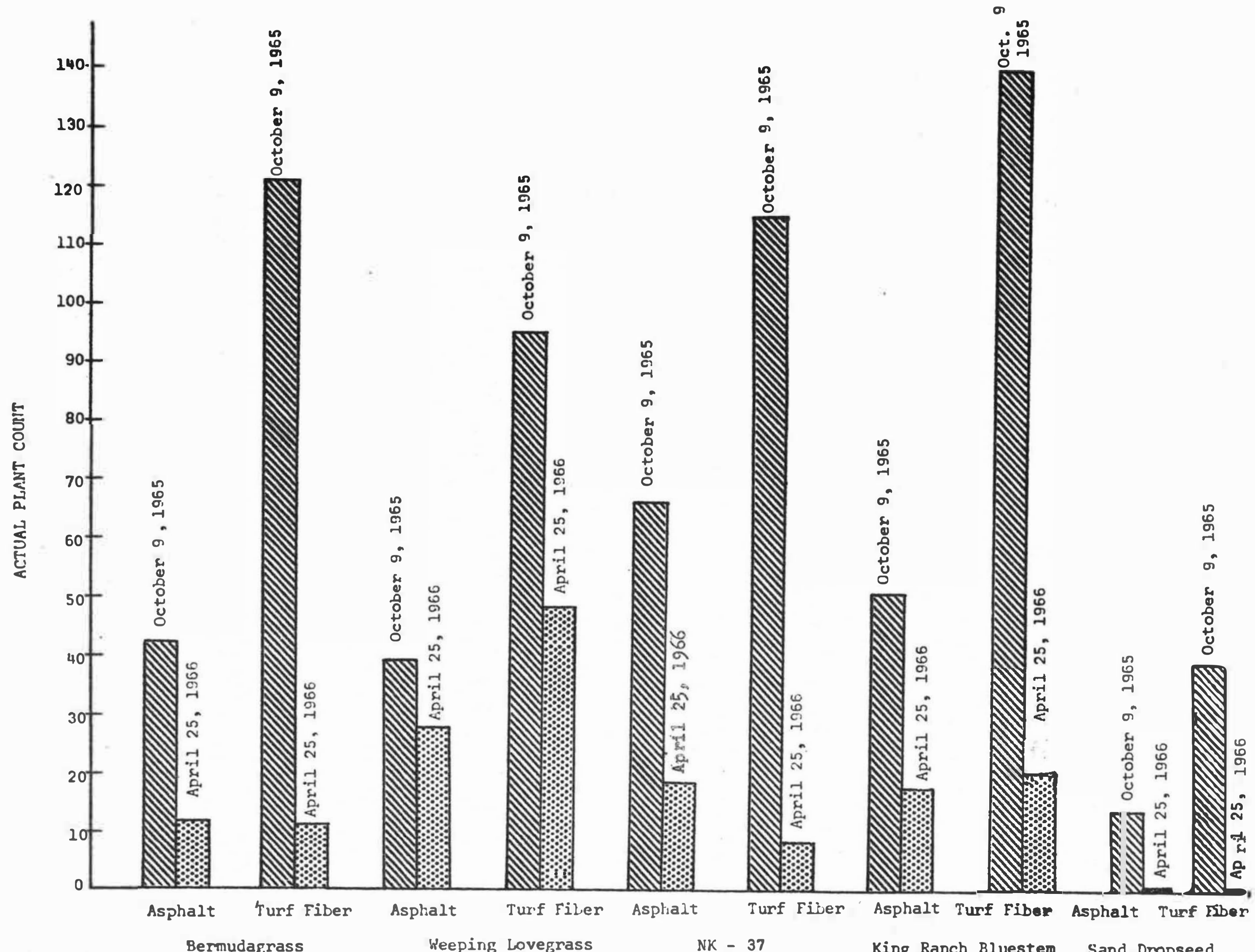

Figure 6. The evaluation of five grasses and two mulches for erosion control on a north facing cut slope seeded and mulched June 9, 1965, on SH-6 four miles west of US-66 intersection west of Elk City, Oklahoma. This area was fertilized with 200 lbs. 10-20-10 per acre on June 9, 1965, and again on March 17, 1966.

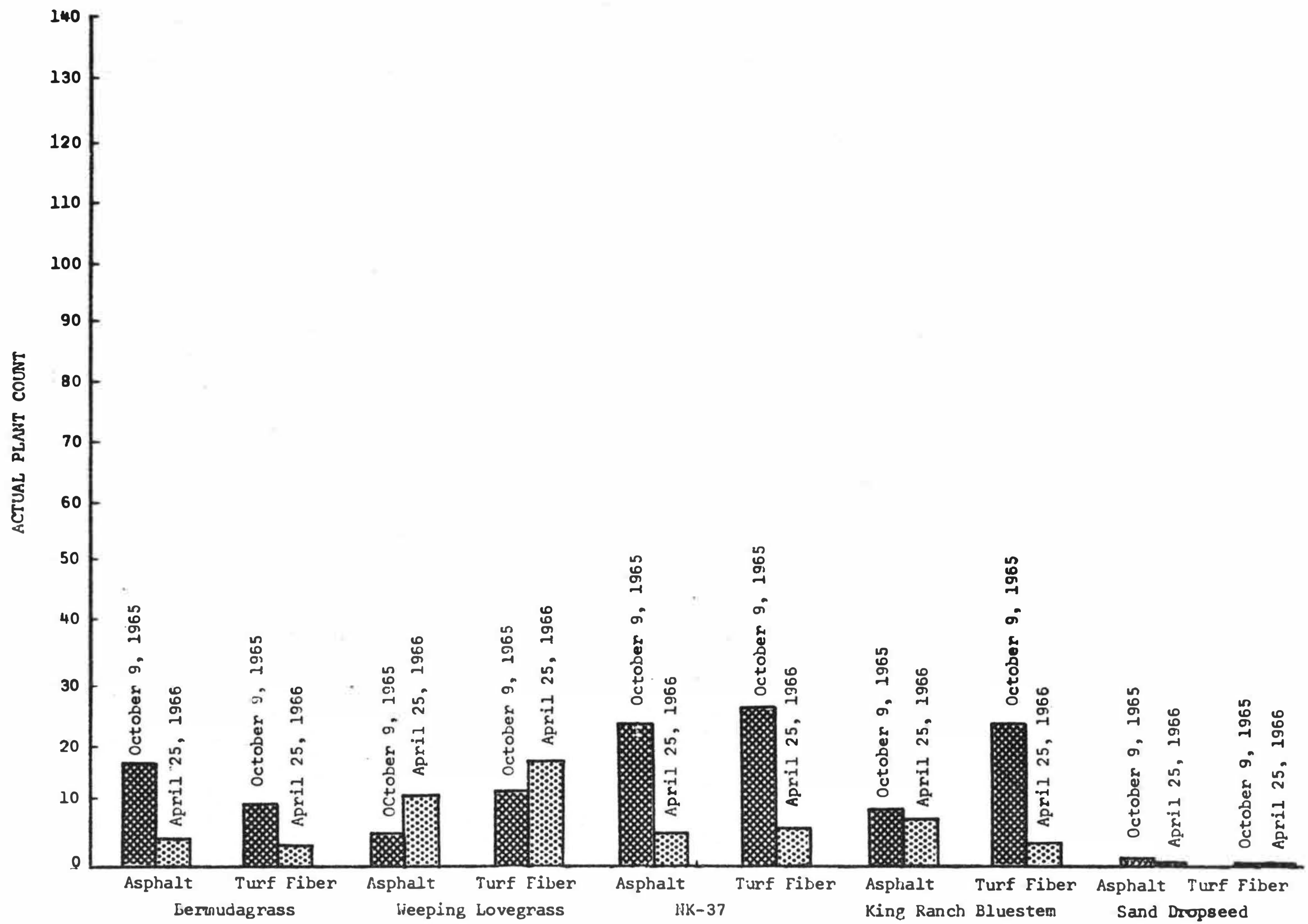

Figure 7. The evaluation of five grasses and two mulches for the control of erosion on a south facing cut slope seeded and mulched June 9, 1965, on SH-6 four miles west of US-66 intersection west of Elk City, Oklahoma. This area was fertilized with 200 pounds 10-20-10 per acre on June 9, 1965, and again on March 17, 1966.

erosion the year after seeding than did weeping lovegrass as determined by actual plant count (Figure 8). The effect of a north exposure on bermudagrass was quite evident with a decline in plant population one year after seeding, whereas the number of weeping lovegrass plants increased more than 55 percent (Figure 9).

Benefits for the Oklahoma Department of Highways derived either partly or entirely from this research includes a savings of about $11.00 per acre for seedings made in central Oklahoma from the use of only 8 pounds of weeping lovegrass per acre compared to the previous practice of almost 40 pounds of seed from a mixture of 5 grasses. In southeast Oklahoma the savings are even greater amounting to $14.00 per acre from the seeding of 8 pounds of lovegrass, or $14.20 saved per acre if 15 pounds of common bermudagrass is seeded per acre instead of 40 pounds of seed from a mixture of 4 grasses.

4. The type, or kind of mulch seemed to make no real difference in the germination, or plant population of weeping lovegrass so long as it offered no competition by contamination with weedy annuals, or perennial johnsongrass. Good prairie hay (with no mature weed seeds) used as a mulch for new seedings was comparable to excelsior slope mats in the number of weeping lovegrass plants that became established on a sandy fill-slope in southwestern Oklahoma near Rush Springs, and both were only slightly better than baled excelsior blown on as a mulch (Figure 10).

5. In the production of a protective bermudagrass cover on a droughty, geological soil as found on a deep, west-facing backslope in central Oklahoma the most effective method studied was the incorporation of 2 percent hydrated lime (20 tons/acre) in the spring, followed seven

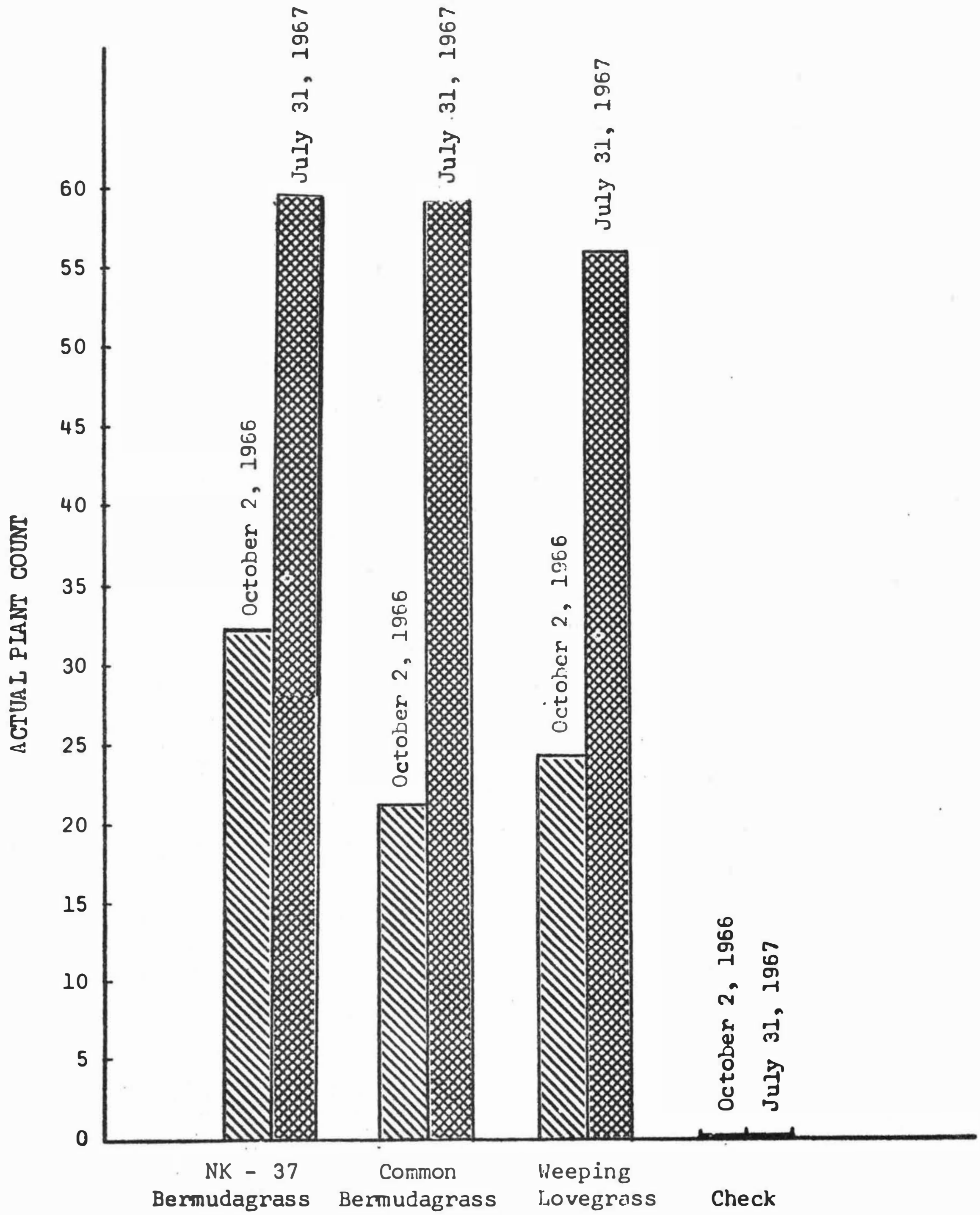

Figure 8. A comparison of three grasses for erosion control on a south facing cut slope east of Stillwater, Oklahoma, on SH-51 four miles east of SH-108 seeded and hay mulched May 4, 1966, and fertilized with 435 lbs./acre of 10-20-10 on May 23, 1967.

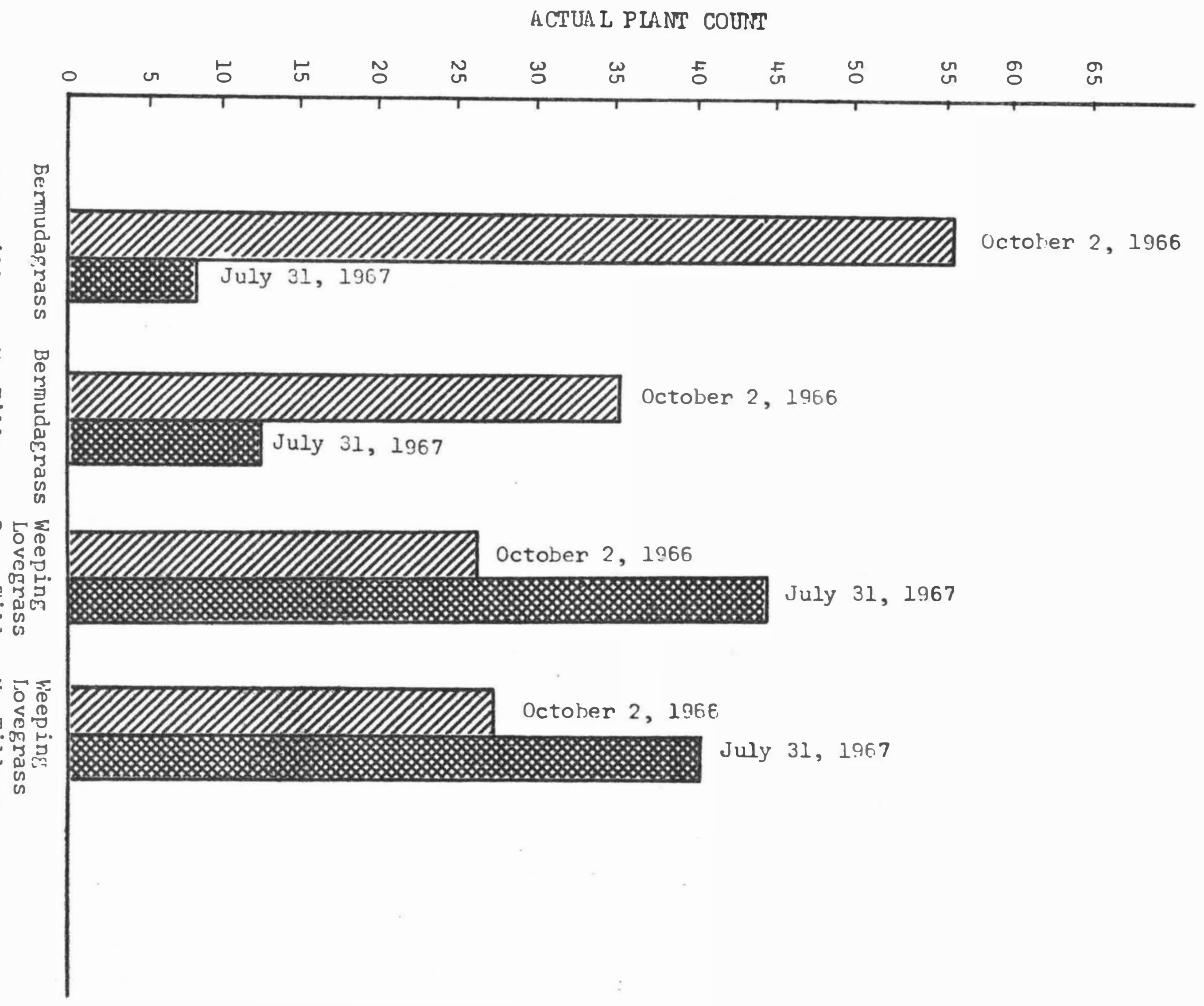

Figure 9. The effect of a deep-tillage operation on the establishment of bermudagrass and weeping lovegrass seeded and hay-mulched May 4, 1966, and fertilized with 435 lbs./acre of 10-20-10 May 23, 1967, on a north facing cut slope east of Stillwater, Oklahoma on SH-51 four miles east of SH-108.

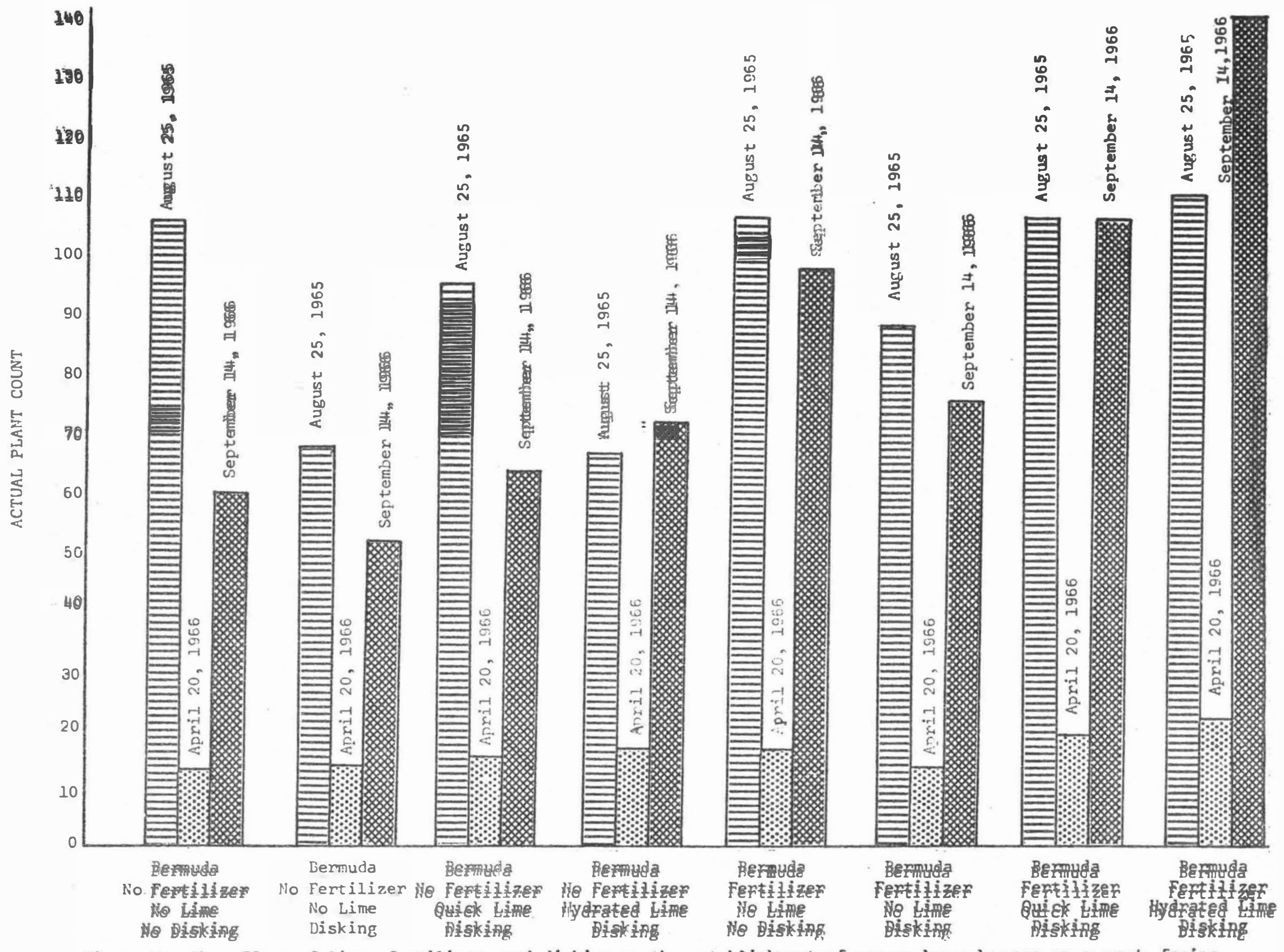

Figure 11. The effect of lime, fertilizer, and disking on the establishment of common bermudagrass on a west facing cut slope one mile north of SH-33 on I-35 east of Guthrie, Oklahoma. Lime was applied June 18, 1964, the area seeded February 3, 1965, and fertilized June 24, 1965, with 400 lbs. of 10-12-12 per acre.

seedings at a cost of $100.00 per ton results in a savings to the Oklahoma Department of Highways of $10.00 per acre. On a two-lane road with 100 feet of rights-of-way having about 7 acres per mile to be seeded, this would amount to a savings of approximately $7,000.00 every 100 miles.

7. Vegetative mulch composed of undesirable weedy annuals, or perennial johnsongrass was found to be responsible for many failures in the establishment of desired grasses for erosion control.

Competition for available soil moisture, space, and nutrients accounts for the decline and ultimate failure in the establishment of perennial grasses that are slow in their rate of growth the first year, and the abundance of undesirable, short-lived, rapidly growing annuals.

No vegetative mulch should be used on erosion control seedings that contain seed or live vegetative parts of johnsongrass, or more than a trace of other weeds, either annual or perennial with mature seeds.

8. Soil moisture primarily determines whether a protective vegetative cover can be successfully established on the highway system. In the absence of adequate soil moisture germination of the seeded grass is delayed and consequently the length of the growing season is correspondingly reduced until such time even though excellent germination is obtained the seedling plants are unable to survive the rigors of the first winter.

Seedings were made in the early summer of 1965 on east and west facing cut slopes in central Oklahoma near Chandler. Fertilizer at the rate of 200 pounds of 12-12-12 per acre, and a soil conditioner (Humicite[4/]) at the rate of 1.1 gallons per acre was applied to this area,

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[4/] Product of South Texas Soil Conditioner Service, Inc.

seeded with five grasses and mulched with 1.7 tons of Turfiber per acre. Three days after seeding a supplemental watering of 6,000 gallons (equivalent to about 0.22 inch) per acre was made in an attempt to increase germination and stand establishment. The grasses included common bermudagrass, giant (NK-37) bermudagrass, weeping love, King Ranch bluestem, and a mixture of native grasses (mostly little bluestem).

Common bermudagrass produced more protective ground cover on both the east and west facing cut slopes than any other grass in the test. The soil conditioner (Humicite) had no influence on the growth of these grasses. As a result of the dry soil conditions that prevailed none of these seedings were considered satisfactory, and practically all plants died the first winter.

High temperatures and inadequate soil moisture in 1965 caused the complete failure of seedings made in July near Meeker in central Oklahoma. Five grasses and two mulches, an asphalt emulsion (AE-5) and Turfiber were included in this investigation.