PROMOTING ESTABLISHMENT OF VEGETATION FOR EROSION CONTROL

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PREFACE

A vegetative cover for erosion control is in reality a pavement. Rather than supporting vehicular traffic as does asphalt or concrete, this pavement of plants protects the soil from the impact force of raindrops and from the scouring of runoff waters which dislodge and move soil particles. This action leaves the landscape ugly, provides sediment for pollution, and may endanger structures or roadway.

Paving an area with living plants requires technology, just as does the installation of a first-class travel surface. This living cover does best on a base material that is not compacted. Rather than being a surface which drains quickly, it thrives on moisture. Specifications for planting materials vary with the requirements, just as do those for surfacing materials. The living pavement requires maintenance, even an occasional patch. This report will describe some of the technology used in establishing a protective cover of plants on a roadside. As with any living thing, the early stages in the establishment and development of a plant cover are extremely critical.

The research reported here was supported jointly by the Texas Highway Department and the U. S. Bureau of Public Roads. The authors are indebted to the Maintenance Division, and especially the Landscape Section, of the Texas Highway Department for their support and encouragement. The application of field tests would have been impossible without the fine cooperation of several districts.

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Promoting Establishment of Vegetation for Erosion Control

Soil erosion is a serious problem for highway engineers. The unpaved portion of right of way for a four-lane highway covers approximately 25 acres per mile, and nearly 10 acres consist of cut or fill slopes and other steep areas (Hottenstein, 1963). The relatively high proportion of unsurfaced area, the disturbance of soil during construction, and the concentration of water on slopes and in drainage channels contribute to the hazard of soil erosion (Figure 1). Movement of the soil from the right of way by either wind or water increases maintenance costs, imperils pavements and structures, interferes with traffic safety, and damages adjacent property.

A protective cover of vegetation modifies many of the forces concerned in soil erosion. First, the individual raindrop is intercepted, so that the impact will not loosen and displace particles from the surface of the soil. Second, the rate of movement of wind or water across the soil surface is slowed, and both the cutting and the carrying capacities of these erosive forces are reduced considerably. Slowing the velocity of runoff water also favors entry of water into the soil. Penetration of water into the soil not only reduces runoff but it provides stored moisture for plant growth.

A cover of grass commonly is used to control erosion. It is easily established, persists without intensive management, and is generally accepted by the engineer. While a grass cover can often be achieved naturally in time, usually it is desirable to employ cultural methods to reduce the risk and shorten the time needed to establish a stand of grass for erosion control.

The work was initiated September 1, 1959 in cooperation with the Texas Highway Department. It was continued September 1, 1963 under the joint sponsorship of the Texas Highway Department and the U. S. Bureau of Public Roads. The objectives were to:

1. Compare and improve specified methods of erosion control by determining requirements, planting materials and procedures for establishing a vegetative cover on finished slopes and other areas subject to soil erosion.
2. Adapt recommended agricultural methods of plant control to highway requirements.

Work under the original project emphasized chemical methods of plant control, and only a token amount of research was done on the establishment of vegetation. This report will stress the results from the earlier plantings.

THE PROBLEM

A cover of vegetation for soil protection is installed following construction or when a location is reworked in highway maintenance. There are two general requirements for establishing a cover of desirable plants on roadsides: (1) adapted planting materials and (2) an environment which favors seed germination and plant establishment.

Different plants thrive best within a narrow range of climatic and soil conditions which vary widely over an area as large as Texas. Consequently, the choice of planting materials varies from one area to another. Bermudagrass, *Cynodon dactylon* (L.) Pers., has been widely used in the humid eastern portion of Texas, but native bunchgrasses are better adapted to the drier western portions. Grass plantings for agricultural use ordinarily are not considered where less than 12 to 15 inches of precipitation is received annually. Water erosion is a hazard in eastern Texas, but both wind and water are serious erosive forces in more arid regions.

Bermudagrass can be established by either sodding or seeding, but the bunchgrasses are established from seed. Sodding is utilized where a quick cover is required. Seeding is much less expensive and requires less intensive care during establishment. However, improved technology for seeding roadsides is needed.

Planting materials are available which germinate quickly and develop rapidly. Bermudagrass is slow to grow from seed, so a companion plant commonly is used. In the past, companion plants have consisted of annuals such as sudangrass, *Sorghum vulgare* var. *sudanese* Pers., or ryegrass, *Lolium perenne* L. These fast-growing annuals give a quick cover, but compete with the perennial bermudagrass during establishment.

Grasses for roadsides, like crop plants, should be planted when temperature and moisture conditions are most favorable. The transition from a seedling nourished by food stored in the seed to an organism capable of sustaining itself is a critical time in the development of a plant. Consequently, germinating seeds and seedling plants are very sensitive to unfavorable moisture and temperature conditions. Some practices which maximize favorable conditions include: (1) planting at an optimum time; (2) tilling the slope faces to enhance intake and storage of moisture; (3) applying fertilizer concurrently with seeding; and (4) mulching the soil surface to retard evaporation and moderate the effects

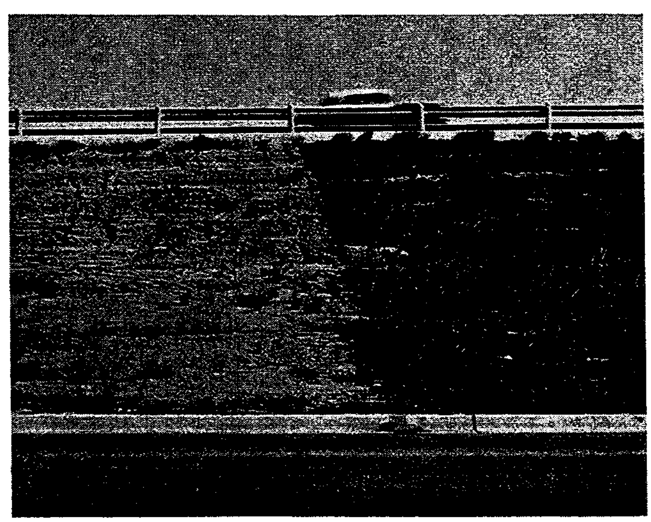


Figure 1. Erosion of a cut or fill slope becomes progressively more severe if the soil surface is not protected with a cover of plants.

VEGETATIONAL AREAS OF TEXAS

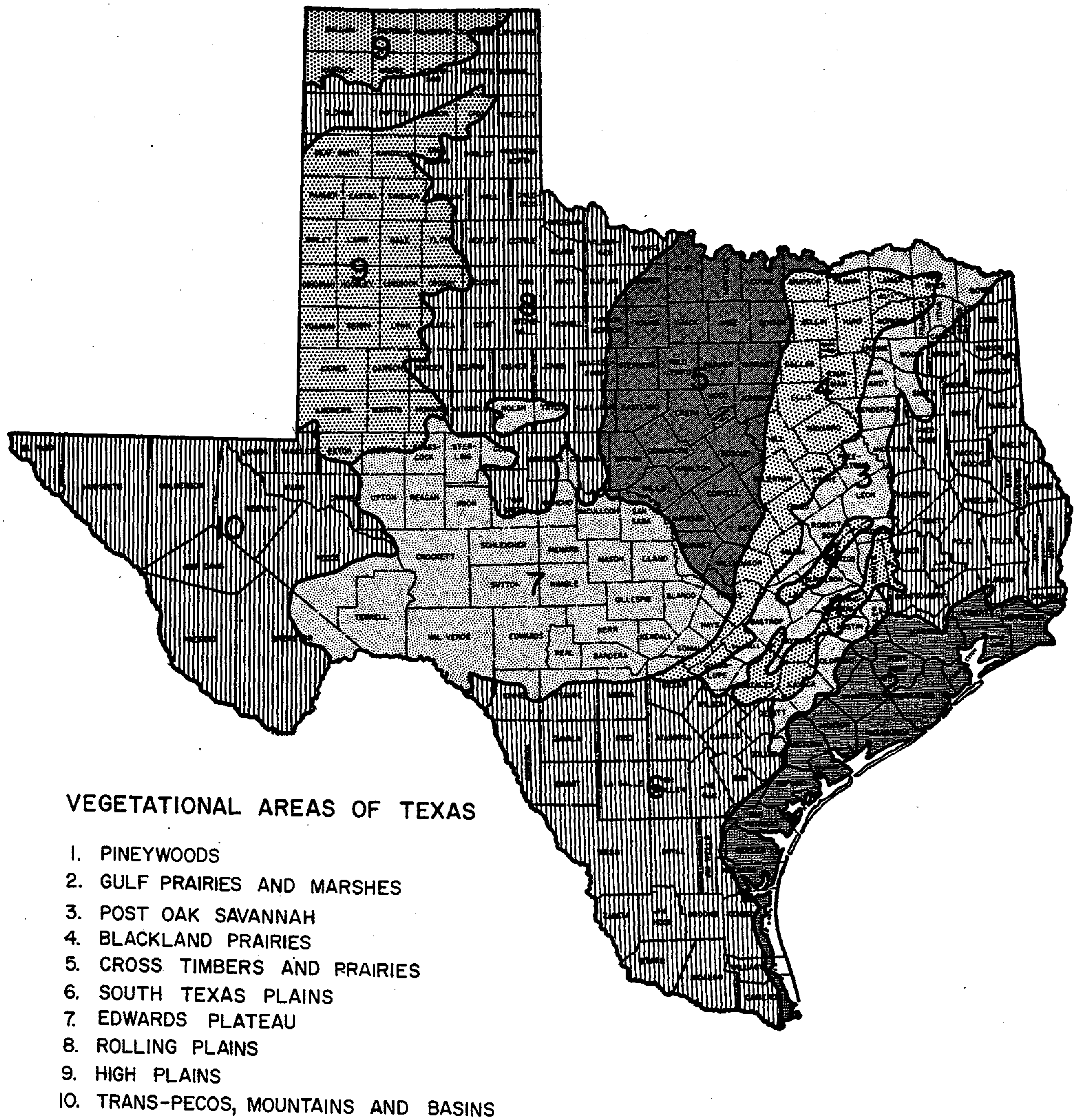


Figure 2. The plant materials used for erosion control in Texas reflect the differences in soil as modified by climate.

of solar radiation and to minimize erosion until the plants become established.

REVIEW OF LITERATURE

Establishing and managing a vegetative cover for controlling erosion is a problem having many facets. The heterogeneous pattern of plants adapted to various parts of Texas reflects the soil characteristics and rainfall patterns (Gould, 1962; Gould, et al., 1964). The annual rainfall varies from approximately 8 inches at El Paso to more than 50 inches at Orange. The frost-free period ranges from approximately 180 days in the northern Panhandle to more than 300 days in the Lower Rio Grande Valley. The native vegetation (Gould, et al., 1964) integrates these variations in growth conditions with existing soils (Figure 2), and provides the basis for recommended planting materials over the western two-thirds of Texas. Several plant materials adapted to this portion of Texas are available commercially for seeding, and others are being refined in studies by the Texas Agricultural Experiment Station.

After a seed mixture of adapted plants has been selected, an environment should be created which favors seed germination and plant establishment. Available moisture and a favorable temperature are the habitat factors of greatest concern. The intensity of these habitat factors can be altered by changing the dates of planting, by applying other cultural practices, or by installing a surface mulch.

The availability of soil moisture is a major factor regulating seed germination and subsequent growth of the seedling plant. Grasses as well as crop plants perform best if they are seeded at a time when moisture and temperature conditions are optimum. Although a surface mulch modifies the moisture and temperature tensions which exist during the hot summer period, the possibility of securing moisture adequate for germination and sustained growth is risky during this season.

Modification of the soil environment in which the seed is planted and grows appears to offer the greatest promise in favoring establishment of a vegetative cover for erosion control. The rate at which water enters a soil (infiltration rate) depends on the relative proportion of large pores at the soil surface (Russell, 1950). Ordinary engineering practices compact the soil on the faces of cut and fill slopes. The dense soil material takes water very slowly. Soil on the faces of these slopes which is not covered with a protective mulch is further puddled by the shattering action of rain drops. A primary reason for plowing ahead of planting crops is to improve the water infiltration into cultivated soils.

Water is lost rapidly from the soil surface by evaporation. In western Texas the moisture in the surface one-half inch of soil has been depleted in less than 24 hours (Hudspeth and Ellis, 1959). Water lost from the soil surface by evaporation is replaced by moisture from below. When the evaporation rate at the soil surface exceeds the supply of deeper moisture, the surface becomes dry and the vapor from lower soil layers moves upward by diffusion (Russell, 1950).

The rate of water loss from the soil surface by evaporation is reduced considerably by using a vapor barrier or mulch. A number of natural materials such as hay, peanut hulls, pecan shells and similar materials make satisfactory mulches.

Various species and varieties of grasses are known to differ considerably in their rate of germination and seedling development. Plummer (1943) observed that germination and the early stages of seedling development are critical periods in the life of a planted grass. Once a plant has lived through the seedling stage, it may be expected to endure wider fluctuations in the environment.

In earlier works Griffith (1910), Thornber (1910) and Wooton (1916) in their separate experiments in southern Arizona felt that unfavorable moisture conditions were the primary causes of seedling failure. Glendening (1939; 1942) determined that seedling survival was ten to twenty times greater on mulched than on bare soil. Moldenhauer (1959) found a mulch was beneficial to several species of grass grown at high soil moisture, and the benefit from mulching was even more pronounced as soil moisture was reduced. Burnham (1955) felt that a mulch offered physical protection to the soil from torrential rains or wind.

Fertilizers also have been used to accelerate the establishment of grass plants. Walker, et al. (1958) found that some grasses developed and set seed if they were fertilized, while unfertilized plants grew only an inch or two in height. Hudspeth et al. (1959) found that the growth of some grasses was stimulated by an application of fertilizer at the time of seeding. Other grasses did not appear to benefit from fertilization, but there was no indication that the applied fertilizer was detrimental. Where soil fertility was low, nitrogen accelerated seedling development. (Barnes, et al., 1952; Burnham, 1955). Hudspeth et al. (1959) found that a combination of nitrogen and phosphorus was superior to nitrogen alone.

Research and experience concerning erosion control along highways confirm the agricultural findings. Peperzak (1956) found that nitrogen/phosphorus fertilization, cultivation, and mulching were important in establishing a vegetative cover on backslopes. Vordenbaum (1956) observed that slick "sand-papered" slopes would not retain either seed or moisture. Hay mulches were tacked with 0.1 gallon of asphalt per square yard. Asphalt alone was also a satisfactory mulch when applied at a rate of 0.25 to 0.30 gallon per square yard over moist soil. Garmhausen (1960) found a wide range of materials were suitable for mulching, and described equipment for mixing and placing the seed and mulch. Button (1958) described the use of hydraulic equipment to distribute seed and fertilizer in a water slurry.

PROCEDURE

The initial seedings in 1960 and 1961 were made at College Station, Texas. Beginning in 1963 experimental locations were selected near Huntsville to represent the relatively humid climate of eastern Texas and near Colorado City as an example of a more arid climate. Both spring-summer and winter seedings were made within each climatic zone.

The seedings at College Station compared several perennial grasses for use along highways, and evaluated the establishment of bermudagrass when planted with sudan or with one of several perennial grasses. Both

Figure 3. Both hay and asphalt are satisfactory mulching materials under prescribed conditions.

bermudagrass and bahiagrass, *Paspalum notatum* Flugge, were seeded at Huntsville. Perennial bunchgrasses were seeded at Colorado City, together with such annuals as sudan, oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.), or ryegrass, depending on the time of planting.

Mulching was a variable in all plantings except the one made in 1961 at College Station (Figure 3). Seedbed preparation using a disc was specified beginning in 1963, and later tillage was done using a pulvi-mixer set for a specified depth. The use of a starter fertilizer was studied at College Station in 1960 and 1961. In later plantings a uniform rate of fertilizer was applied at the time of planting.

Replications were assigned for obvious differences in exposure or soil. Data assembled included both plant counts and harvested production. Where appropriate, the data were submitted to an analysis of variance.

College Station—1960

Opposing slopes, two sandy and two of heavier soil, were planted at College Station in July, 1960 to five species of grass: (1) green sprangle-top *Leptochloa dubia* (H.B.K.) Nees.; (2) cane bluestem, *Andropogon barbinodis* Lag.; (3) buffelgrass, *Pennisetum ciliare* (L.) Link; (4) plains bristlegrass, *Setaria macrostachya* H.B.K.; (5) gordo bluestem, *Andropogon nodosus* (Willem.) Nash. These grasses were planted at a calculated rate of twenty pure live seed per foot of row. The planting materials were obtained from commercial sources or from Texas Agricultural Experiment Station Project H-988, "Evaluation of Potentially Drouth Resistant Grasses for the Southwest." Five cultural treatments were used: (1) peat moss under the seeded row; (2) soil scarification; (3) a vegetative surface mulch; (4) a surface mulch of RC-2 asphalt; and (5) no soil or mulch treatment. A starter fertilizer having an analysis of 16-20-0 was applied over all soil treatments and species planted at 0, 100, 200, and 300 lbs. per acre. The location was watered immediately after seeding and whenever the surface inch of soil became dry.

College Station—1961

The faces of slopes cut through Lufkin or Tabor soils near College Station were scarified with a pulvi-mixer, and the entire location was seeded to bermudagrass in April, 1961. Sudangrass, green sprangletop, and buffelgrass were overseeded individually as companion grasses. A fertilizer having an analysis of 16-20-0 was applied at rates of 200, 400, or 600 lbs. per acre. These seeded areas were not mulched. Plant response was measured in samples stratified across the frontslope, the ditchline and on the backslope.

Huntsville—1963

The faces of cut slopes on IH 10 north of Huntsville were seeded in May and June, 1963 to common and NK-37 bermudagrass, and to bahiagrass. These base plantings were overseeded with green sprangletop, buffelgrass and sudangrass. The seedings were mulched with either asphalt, hay tacked with asphalt, or were left bare. A uniform application of 400 lbs. of 16-8-8 fertilizer was applied. Part of each treatment was cut with a section disc, but the remainder was not tilled. The exposed soils were sandy clay in texture.

At Huntsville during the winter of 1963-64, common and NK-37 bermudagrass together with bahiagrass were planted with either annual ryegrass or the perennial Canada wildrye (*Elymus canadensis* L.) as a companion seeding. The plantings were made in December and again in February. Three tillage depths were accomplished with a pulvi-mixer: 1 inch, 3 to 4 inches, and 7 to 8 inches. The soils were sandy clay in texture. Unmulched seedings were compared with those covered with either an asphalt or hay mulch.

Colorado City—1963

Seedings were made in May, June, and September, 1963, on fill slopes of grade separations along IH 20 near Colorado City. A seed mixture containing sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.); blue grama (*B. gracilis* (Willd. *ex* H.B.K.) Lag.); sand dropseed (*Sporobolus cryptandrus* (Torr.) Gray); and plains bristlegrass was planted using either green sprangletop, sudangrass or buffelgrass as the companion grass. Tillage was applied uniformly using a farm disc, but the light equipment barely cut the compacted soil on the face of the slopes.

The mixtures of the warm-season grasses used for the summer plantings at Colorado City were also seeded in October, December, and January with either oats or rye as a companion planting. Two depths of tillage, 1 inch and 6 inches, were achieved using a pulvi-mixer. The seedings were left unmulched, or were covered with either asphalt or hay.

RESULTS

The grass stands obtained in these various plantings could be either promoted or retarded by choice of planting material, soil moisture, fertility, and soil temperature. The several studies will be analyzed individually.

College Station—1960

The influence of replications, fertilizer, cultural treatment, and grass species, together with the interaction between these various factors, is shown in Table 1. Although a significant difference is indicated for replication, the mean squares do not segregate well by Duncan's test (Table 2). The number of emergent seedlings was not influenced by fertilizer. Plant height was great-

TABLE 1. ANALYSIS OF VARIANCE FOR HEIGHT AND NUMBER OF BOTH EMERGED SEEDLINGS AND ESTABLISHED PLANTS.

Source of Variation	Degrees of Freedom	Mean Squares			
		Seedlings		Established Plants	
		Maximum heights	Number	Average heights	Number
Total	3199				
Replications	3	1620.02	787.11	2509.69	856.43**
Fertilizers	3	1120.84	417.50	6053.55	205.67
R x F (a)	9	138.47	147.96	274.18	107.21
Treatments	4	3345.68**	5210.35**	10498.14**	4919.92**
F x T	12	115.10	216.84	526.68	108.32
R x F x T (b)	48	108.08	116.05	391.16	93.33
Species	4	3581.25**	7712.65**	9869.07**	6376.36**
F x S	12	125.57**	75.18*	780.41**	99.87**
T x S	16	234.39**	572.34**	671.46**	483.38**
F x T x S	48	30.73**	100.16**	150.51**	101.67**
Error (c)	3040	13.91	39.71	48.37	25.96

*Indicates significance at the 95 percent confidence level.

**Indicates significance at the 99 percent confidence level.

er with each rate of fertilizer up to 200 lbs. per acre (Figure 4), but there was no advantage in increasing the rate to 300 lbs. (Table 3). The various grasses varied in their response to fertilizer. Green sprangletop and buffelgrass responded well, but the other three species did not show a striking increase in growth (Figure 5).

The largest number of seedlings were found where no surface mulch was used (Figure 6). The application of asphalt was delayed several days, and only the emergent plants survived. The most vigorous growth occurred where a hay mulch was used, the growth of unmulched plants was intermediate, and relatively little growth occurred with asphalt (Figure 7). Temperatures as high as 140°F were measured in the soil layer immediately under the asphalt. Temperatures above 110°F are considered lethal to most seedling plants.

College Station—1961

Equivalent stands of bermudagrass were obtained with the three companion plantings (Table 4). Among the companion plants buffelgrass produced the greatest cover, but it suffered a high mortality during the winter of 1961-62. Green sprangletop and sudan came up to equivalent stands. The grass stands were better on the shoulder and the lower backslope than on the upper backslope, a reflection of improved moisture conditions. Fertilizer, at rates ranging from 200 to 600 lbs./acre of 16-20-0, did not alter the stand of bermudagrass or any of the companion grasses.

Huntsville—1963

Plantings were made during both the summer and the winter seasons. Summer plantings were made in May and again in June. Approximately twice as many seedlings were counted from the May seeding as from the planting made in June. The number of seedlings per unit area was equivalent for either hay or no mulch, but fewer seedlings were found with an asphalt mulch on each date. There appeared to be some benefit from tillage on the unmulched seedlings made in June or those mulched with asphalt at both seeding dates (Tables 5 and 6).

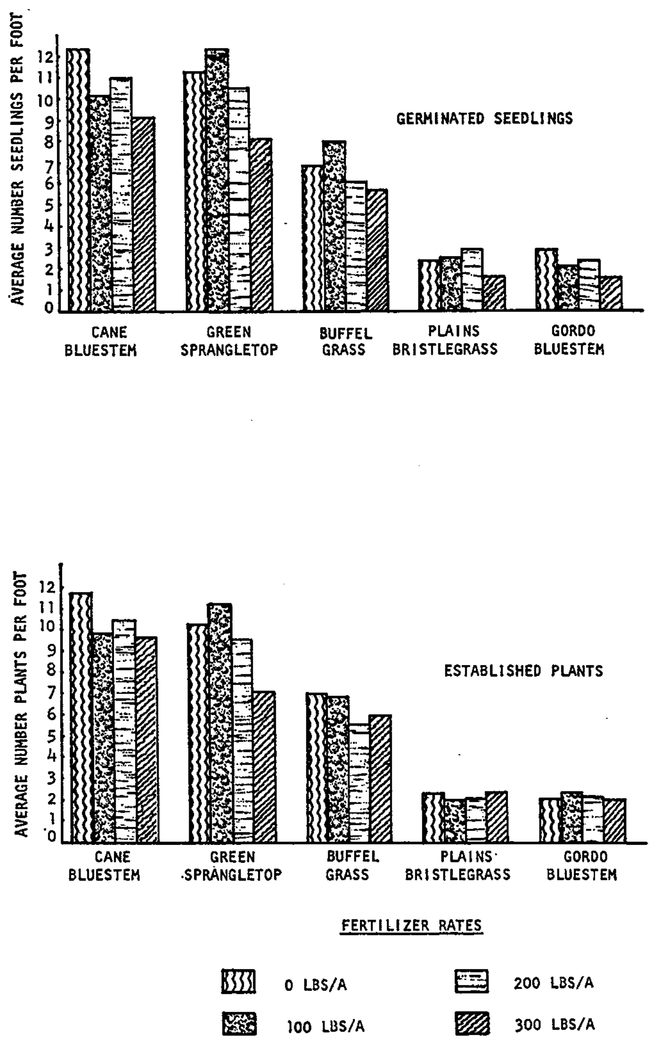


Figure 4. Number of germinated seedlings and established plants per foot of row as influenced by rate of 16-20-0 fertilizer.

TABLE 2. AVERAGE NUMBER AND HEIGHT OF BOTH EMERGENT SEEDLINGS AND ESTABLISHED PLAN PER FOOT OF ROW BY SITE. UNDERLINING INDICATES GROUPING BY DUNCAN'S TEST.

	Clay, South-facing	Sandy, South-facing	Clay, North-facing	Sandy, North-facing
Emergent Seedlings:				
Number (per foot or row)	4.27	5.55	6.29	6.44
Maximum height (cm)	3.84	3.70	4.19	6.72
Established Plants:				
Number (per foot or row)	4.02	5.09	5.58	6.51
Average height (cm)	6.53	7.71	7.14	10.53

Bahiagrass was slow to emerge, and very few seedlings were encountered. There were more seedlings of common bermudagrass than the tall variety (NK-37), using an equivalent rate of seeding. The various companion grasses came up to similar stands.

Measurements made after one year (Table 7) showed that the bahiagrass stand was steadily increasing

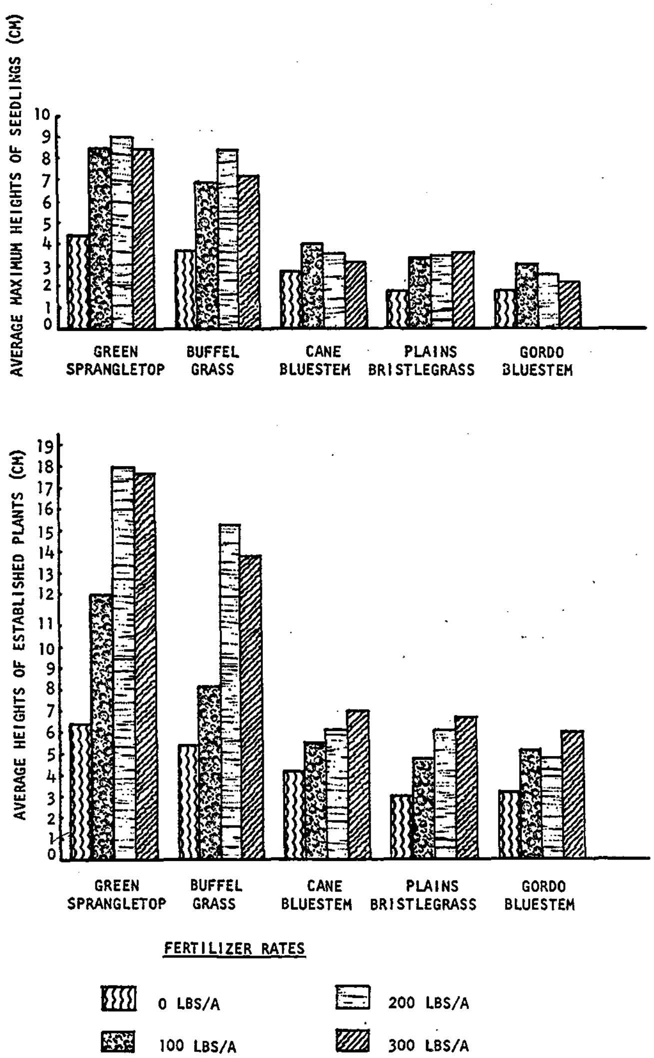


Figure 5. The influence of fertilizer rate on heights of both seedlings and established plants of five grass species.

in density. There was no difference in the stands of bermudagrass obtained from the two dates of seeding. The plant stand with asphalt mulching was equivalent to that obtained with hay mulching, and there were more plants on mulched areas than on unmulched. Sprangletop was present in greater numbers than buffelgrass.

In the winter seedings the annual ryegrass came up to a good stand, but only a few scattered plants of Canada wildrye emerged. Tillage of this sandy clay soil did not always increase the yield of annual rye. One particular combination of exposure, tillage, and mulching showed a definite interaction with plant yield (Table 8).

TABLE 3. THE EFFECTS OF RATE OF FERTILIZER (16-20-0) ON THE HEIGHT OF BOTH EMERGENT SEEDLINGS AND ESTABLISHED PLANTS. BOLDFACE FIGURES INDICATE GROUPING BY DUNCAN'S TEST.

	RATE OF FERTILIZER (Lbs./Acre)			
	0	100	200	300
Maximum height of emergent seedlings (cm)	**2.86**	**5.18**	**5.42**	**5.00**
Average height of established plants (cm)	**4.47**	**7.10**	**10.14**	**10.20**

TABLE 4. ANALYSIS OF VARIANCE COMPARING COVER OF COMMON BUFFELGRASS, GREEN SPRANGLETOP, AND SUDANGRASS AS COMPANION GRASSES IN BERMUDAGRASS PLANTINGS THE SPRING FOLLOWING SEEDING.

Source of Variation	Degrees of Freedom	Mean Square: Companion Grasses	Mean Square: Bermudagrass
Total	107	——	——
Replication	3	352	2132
Fertilization	2	418	30
Error (A)	6	165	841
Species	2	10831**	435
Species X Fertilization	4	20	301
Replication X Species	6	260	136
Error (B)	12	128	386
Strata	2	1504**	6749**
Strata X Fertilization	4	132	89
Strata X Species	4	371	57
Strata X Fertilization X Species	8	93	86
Error (C)	54	139	173

**Indicates significance at the 99 percent confidence level.

TABLE 5. AVERAGE NUMBER OF SEEDLINGS PER SQUARE FOOT OF VARIOUS GRASSES SEEDED IN MAY WITH DIFFERENT CULTURAL TREATMENTS.

Grass Seeded	Cultural Treatment					
	Unmulched		Asphalt Mulch		Hay Mulch	
	Disced	Untilled	Disced	Untilled	Disced	Untilled
Bahiagrass	0	0	0	0	0	0
NK-37 bermudagrass	5.5	4.5	2.8	1.9	1.7	2.0
Common bermudagrass	5.7	10.5	4.5	3.0	5.3	4.8
Buffelgrass	3.8	6.2	2.7	1.5	5.2	5.3
Green sprangletop	5.2	4.1	1.5	0.5	6.7	5.6
Sudangrass	3.9	2.9	1.6	0.5	5.7	3.1

TABLE 6. AVERAGE NUMBER OF SEEDLINGS PER SQUARE FOOT OF VARIOUS GRASSES SEEDED IN JUNE WITH DIFFERENT CULTURAL TREATMENTS.

Grass Seeded	Cultural Treatment					
	Unmulched		Asphalt Mulch		Hay Mulch	
	Disced	Untilled	Disced	Untilled	Disced	Untilled
Bahiagrass	1.6	0.4	0.1	0	0.3	0.3
NK-37 bermudagrass	1.3	0.3	1.3	0.4	1.4	1.4
Common bermudagrass	2.4	0.3	0.9	0.4	1.9	1.5
Buffelgrass	4.8	3.6	1.3	0.9	3.7	3.8
Green sprangletop	2.5	0.7	0.8	0.2	2.0	2.8
Sudangrass	2.6	1.3	0.7	0.1	3.6	3.0

TABLE 7. PERCENTAGE PLANT COVER OF VARIOUS GRASSES ONE YEAR AFTER SEEDING UNDER VARIOUS CULTURAL TREATMENTS.

Grass Seeded	Cultural Treatment					
	Unmulched		Asphalt Mulch		Hay Mulch	
	Disced	Untilled	Disced	Untilled	Disced	Untilled
			May Seeding			
Bahiagrass	3	4	11	11	9	12
NK-37 bermudagrass	39	40	50	58	9	39
Common bermudagrass	39	44	72	66	40	51
Buffelgrass	1	2	3	5	7	2
Green sprangletop	22	6	17	11	33	8
			June Seeding			
Bahiagrass	19	1	14	4	17	14
NK-37 bermudagrass	50	45	58	46	89	62
Common bermudagrass	49	40	84	60	87	67
Buffelgrass	0	2	6	2	1	2
Green sprangletop	1	1	3	0	11	34

TABLE 8. YIELDS IN POUNDS PER ACRE AT MATURITY OF ANNUAL RYEGRASS PLANTS IN DECEMBER AND IN FEBRUARY UNDER VARIOUS CULTURAL TREATMENTS.

	Cultural Treatment								
	Tilled 1″ deep			Tilled 3-4″ Deep			Tilled 7-8″ deep		
	No Mulch	Asphalt Mulch	Hay Mulch	No Mulch	Asphalt Mulch	Hay Mulch	No Mulch	Asphalt Mulch	Hay Mulch
					December seeding				
West	1020	1070	1170	1240	990	1110	700	1460	1630
East	710	580	1460	1860	1490	1240	1450	1280	2340
					February seeding				
West	240	350	820	320	190	600	650	180	620
East	380	240	750	390	560	770	670	480	720

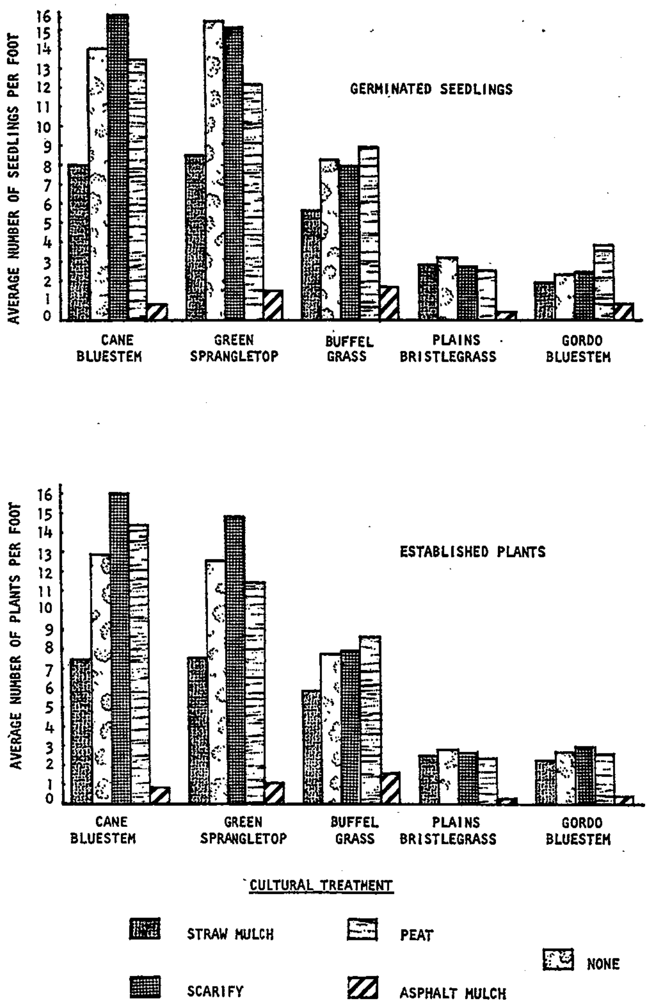


Figure 6. The influence of several cultural treatments on the height of seedlings and established plants of five individual grasses.

Bahiagrass and the two bermudagrasses were evaluated for stand in April and again in July. Only occasional plants of bahiagrass were present, but the bermudagrasses came up to good stands. The competitive effect of the annual ryegrass in reducing stands of both seedlings and established plants of bermudagrass is shown in Figures 8-11. There was no measurable effect by either mulch or tillage on frequency of established plants, but bermudagrass mulched with asphalt appeared to grow very slowly. By July bermudagrass plants from the December seeding were more thrifty than those from the February planting.

Colorado City—1963

At the end of the first year only the May seeding yielded a satisfactory stand. Green sprangletop was the most satisfactory companion planting, buffelgrass was intermediate, and the sudangrass stands were thin. Sideoats grama was the only other plant which emerged during the first year.

After one year the May seeding produced stands containing principally green sprangletop, blue grama, and sideoats grama. Plant frequency was slightly less on north-facing slopes than on south-facing slopes, particularly for blue grama and green sprangletop. Buffelgrass on south-facing slopes survived the first winter, and this plant usually is not considered cold hardy. Green sprangletop was the only species of any consequence in the other two plantings, and the stands of this grass were thin.

Fall and winter plantings were disappointing from the standpoint of establishing a permanent cover. The small grain companion seeding came up to a thin stand, a reflection of the lack of moisture during this season. The yields of small grain were equivalent for either asphalt or hay mulch, and these were considerably greater than for seedings left unmulched. No difference in production of the companion planting could be assigned to tillage. Plants of the warm-season grasses planted were never observed. Even a collection of surface soil to a one-inch depth from these locations placed in a greenhouse failed to yield any seedlings of the planted grasses.

DISCUSSION

Establishing a vegetative cover on roadsides for erosion control requires a balancing of plant growth requirements with engineering specifications. The plant requirements are: (1) planting materials adapted to a particular area, and (2) an environment favorable for

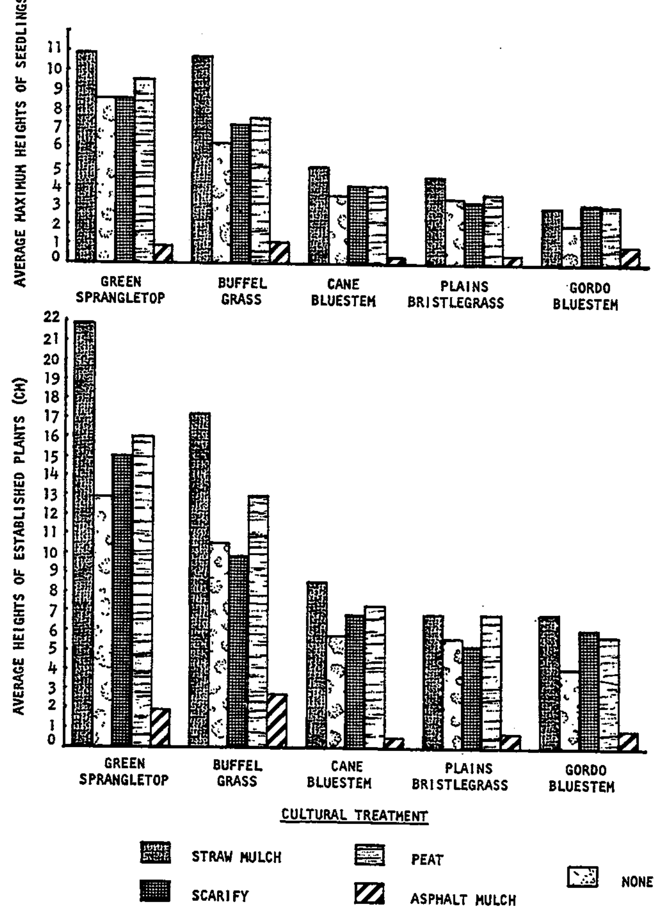


Figure 7. The influence of several cultural treatments on the height of seedlings and established plants of five individual grasses.

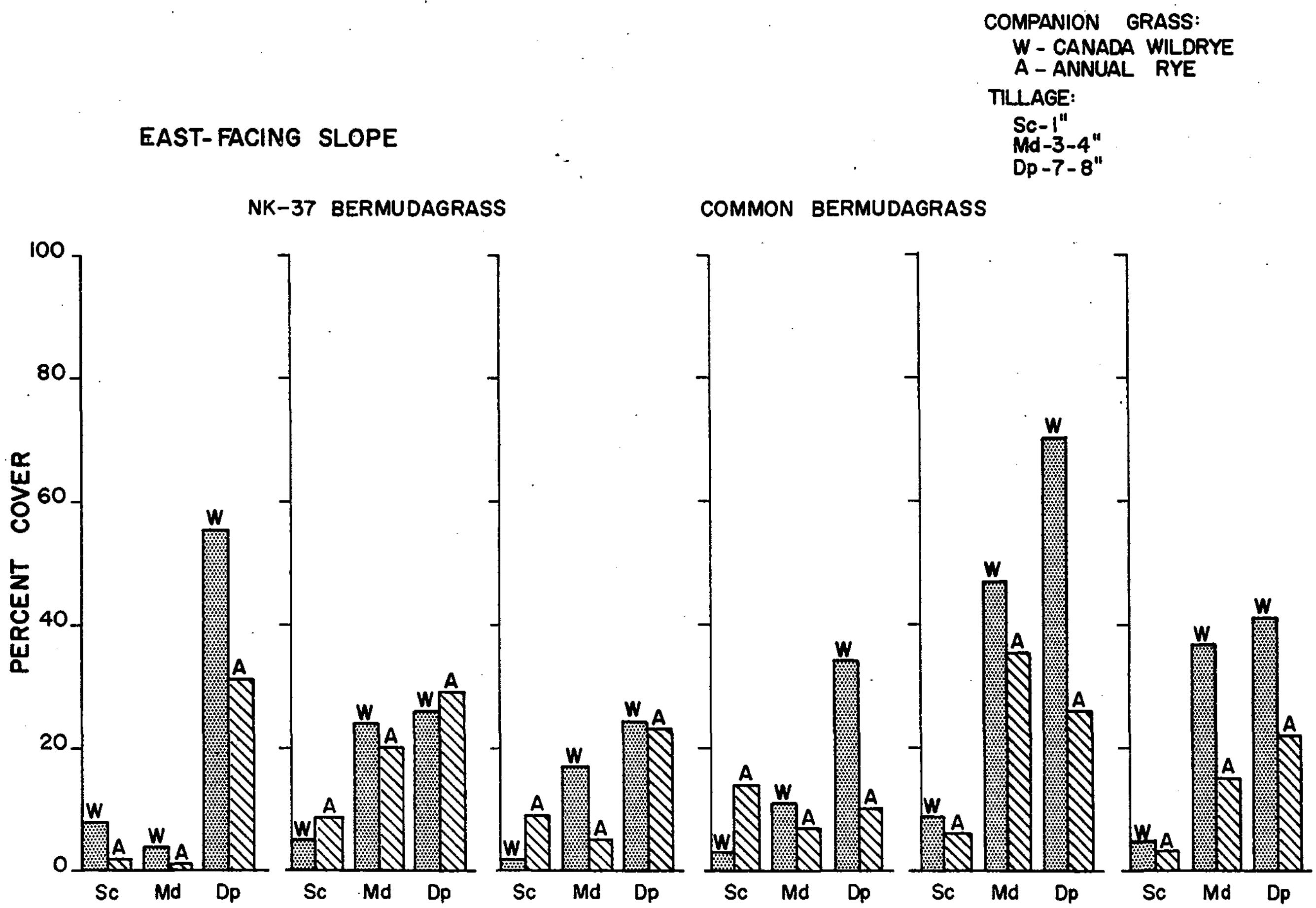


Figure 8. Percent cover of either NK-37 or common bermudagrass overseeded with Canada wildrye or annual ryegrass on IH 45 near Huntsville in December. Determinations made during July following seeding.

seed germination and seedling growth. Some planting materials are generally known, but others are continually becoming available through agricultural research. The seeds used in planting mixtures will be continually compared with the stands obtained, but any conclusions will require more time than is covered by this report.

Planting materials for an area as large as Texas vary considerably. Generally, bermudagrass is seeded in the eastern one-third of Texas, and perennial native bunchgrasses are used in the drier western areas. Seeding usually is not recommended in the portion of Texas receiving less than 12 to 15 inches of rainfall annually. Specific grass varieties are designated for specific areas, and these should be used where the premium on seed cost is not great.

Bermudagrass is seeded during the spring and summer with green sprangletop, and during the fall and winter with annual ryegrass. In one comparison bermudagrass stands were superior to those obtained from bahiagrass, but the bahia gained in density during the second season. This grass is more competitive than bermudagrass, and merits further testing in seed mixtures.

Seed mixtures for spring and summer plantings in western Texas consist mainly of green sprangletop, sideoats grama and blue grama. Sand dropseed was included in several of the mixtures, but it is best adapted to sandy soils and did not grow well on the heavier soils of the test locations.

Planting mixtures are important to the success of summer seedings. Work under this project showed that annual sudangrass could be replaced with a perennial grass which germinated quickly (McCully, Larsen and Hill, 1963). Green sprangletop or buffelgrass produced a cover as quickly as sudangrass, and did not adversely affect the emergence of bermudagrass planted concurrently. Green sprangletop has a larger area of adaptability than does buffelgrass, but buffelgrass is a better plant type for soil protection. Green sprangletop has performed very well in a number of seeding mixtures, and buffelgrass has persisted at Colorado City, well northwest of the usual limit recommended along a line

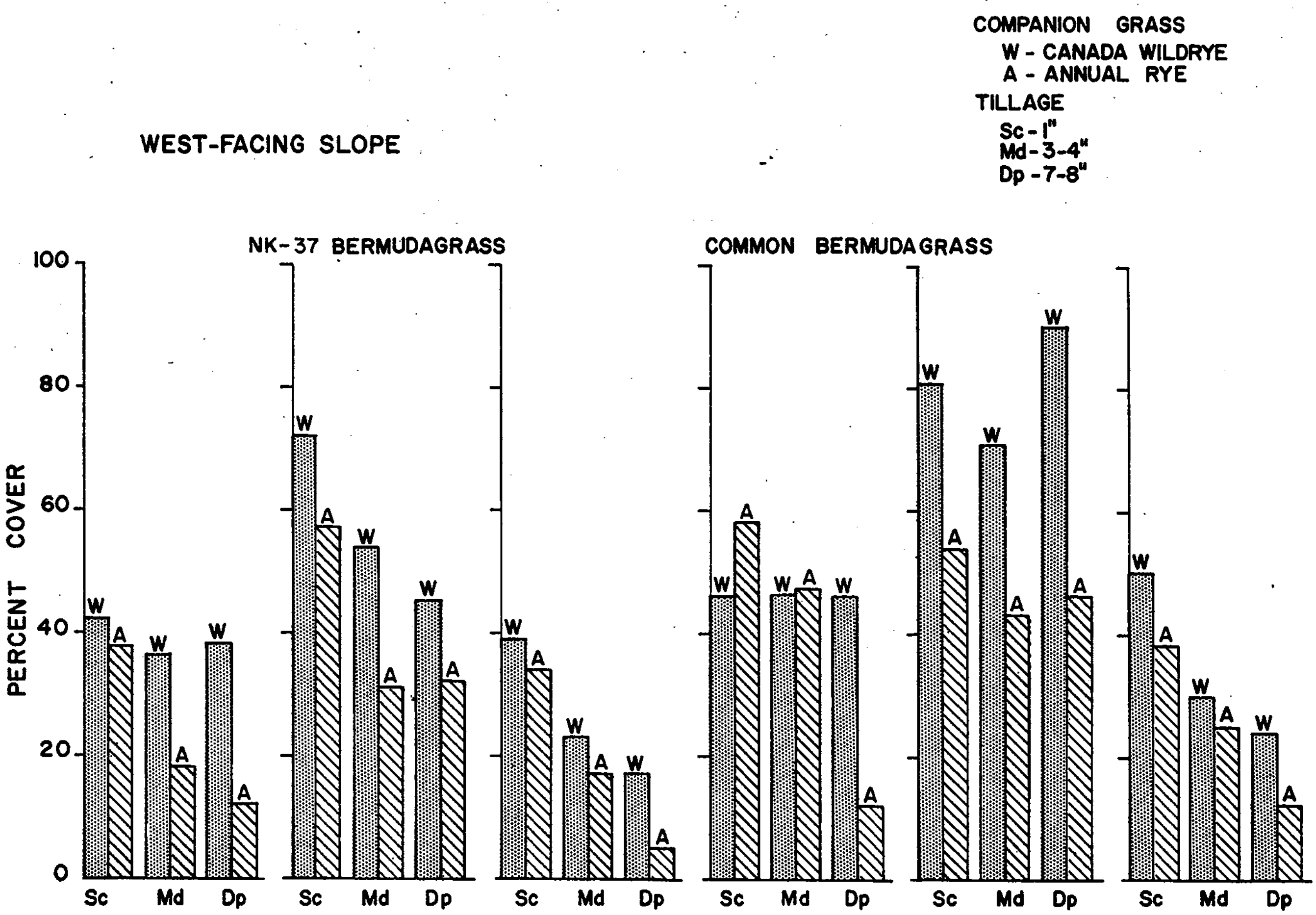


Figure 9. Percent cover of either NK-37 or common bermudagrass overseeded with Canada wildrye or annual ryegrass on IH 45 near Huntsville in December. Determinations made during July following seeding.

through Austin and San Antonio. Green sprangletop stands in eastern Texas are not so consistent as those further west where sprangletop grows naturally.

Winter seedings are a problem in both the humid and the more arid sections of Texas. The concept of a quick-starting companion grass to furnish an immediate cover with the more permanent base grass developing later is not always successful with winter plantings. The companion plants, usually ryegrass or small grains, are so competitive that the later-growing base grass has difficulty becoming established. In western Texas where rainfall is not too plentiful, two crops seldom can be produced on natural precipitation. For a roadside this means that the engineer must decide whether to depend upon a temporary cover which must be installed annually or to wait until a suitable planting time and establish a permanent cover.

In eastern Texas the problem is partly one of competition for water between ryegrass and bermudagrass, but bermudagrass is known to be intolerant of shade, such as that produced by a thick stand of ryegrass. One seeding at Huntsville utilized a comparison of annual ryegrass and the perennial wildrye as a companion plant. Very little if any bermudagrass became established on those areas seeded to annual ryegrass which came up to a thick stand. On the other hand, a good stand of bermudagrass grew on the plots seeded to the perennial wildrye, which came up to a very poor stand. While many engineers prefer to establish a cover for protection against erosion before bermudagrass can become established, there does not appear to be a satisfactory perennial cool season grass which can be seeded concurrently with bermudagrass.

The most favorable environment for establishing plants for controlling erosion represents a merging of moisture and temperature conditions conductive to germination and seedling growth. Under field conditions this is done by using the recommended seedling date, preparing a seed bed by tilling the soil material, and applying a surface mulch over the seeded area. The dates of seeding specified for crop plants integrate fav-

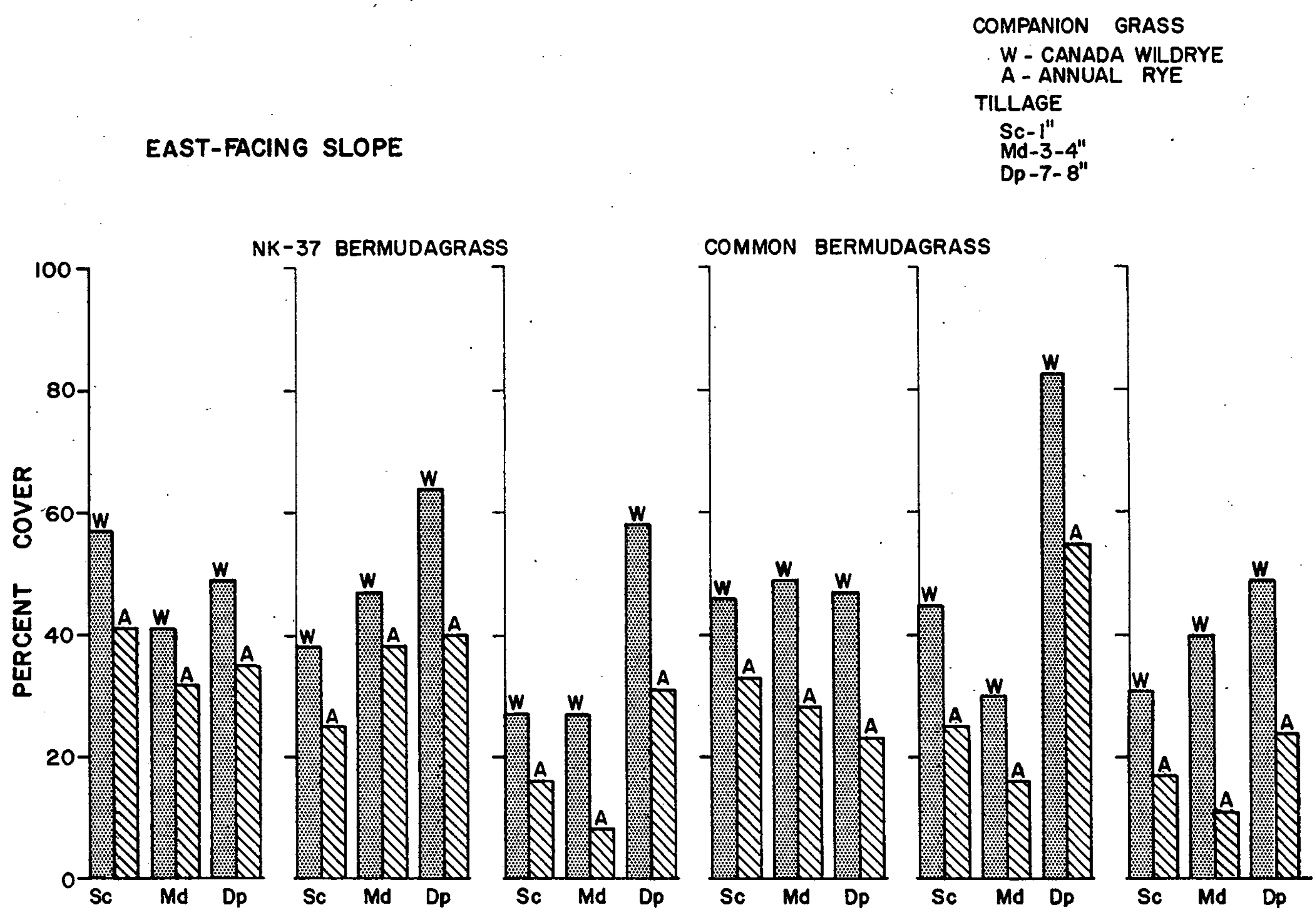


Figure 10. Percent cover of either NK-37 or common bermudagrass overseeded with Canada wildrye or annual ryegrass on IH 45 near Huntsville in February. Determinations made during July following seeding.

orable temperatures and an expectation of continued moisture for plant growth. Grass plantings for erosion control should follow these same guide lines. Seedings made after May at both Huntsville and Colorado City were slow to develop a satisfactory cover. The June seeding at Huntsville produced a fair cover by the second year. The June and September seedings at Colorado City produced a scattered stand of plants with mulching, but the stands were too thin for erosion control.

Mulching is the most important single cultural practice in obtaining a stand of grass for erosion control. Even on slopes which are made up of dense material, such as those at Colorado City, the contrast between mulching and no mulching was very striking. Not only is a vapor barrier installed between the soil surface and the atmosphere, but the intense radiation on the surface of a bare soil is intercepted by the mulch material. A vegetative mulch such as hay or straw cools the soil surface and the seed zone appreciably, but an asphalt mulch absorbs the radiant energy and intensifies the heat in the zone occupied by the seed for seedling plant. Of the plants used in these tests only bermudagrass can tolerate temperatures as high as 140°F measured under an asphalt mulch at College Station. Consequently, it often comes up to at least a partial stand where asphalt is the mulching material.

Garmhausen (1960) has pointed out that a number of materials make satisfactory mulches, but a comparison of mulching materials other than hay and asphalt was not made. The results from most of the seedlings show close agreement with those reported by others (Hudspeth and Ellis, 1959; Glendening, 1939 and 1942; Moldenhauer, 1959). The amount of physical protection to the soil while the grass cover was being established was not critically evaluated, although the mulched plots usually had little or no erosion. In a few cases local areas on mulched slopes did erode, but this usually could be traced to excessive water from above the slope.

Tilling the surface layer of material on a slope face is desirable to accommodate plant growth, but it is contrary to engineering practice. This layer of loose material absorbs and holds moisture needed for the germi-

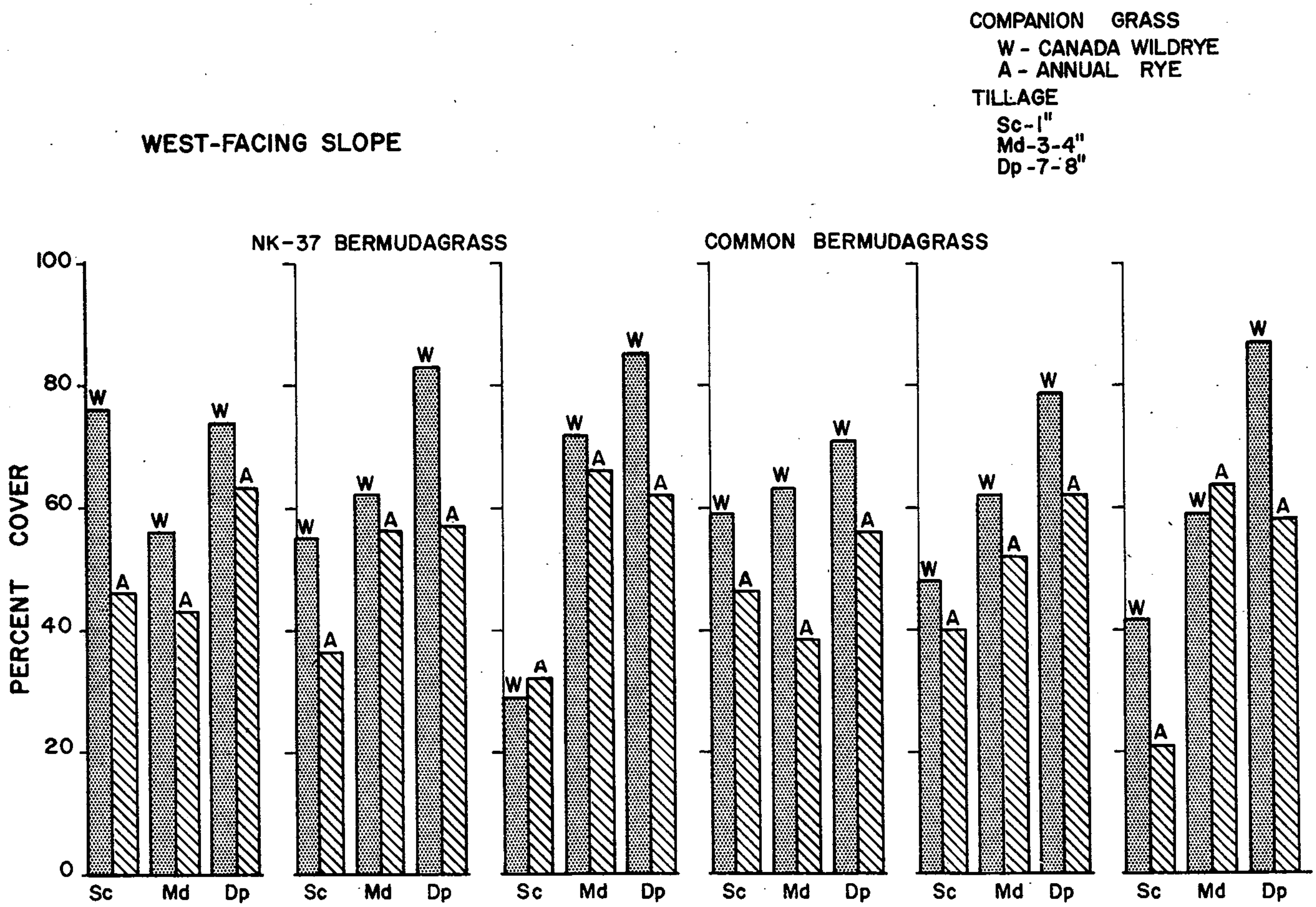


Figure 11. Percent cover of either NK-37 or common bermudagrass overseeded with Canada wildrye or annual ryegrass on IH 45 near Huntsville in February. Determinations made during July following seeding.

nation and growth of seeded grasses. A tilled layer six inches thick will absorb the moisture from an inch or more of rain without runoff, while the same slope untilled will show considerable rilling and other evidence of soil erosion.

Some soils did not remain in a satisfactory state of tilth following tillage, and this problem is being studied further. Most of the tillage in the studies reported here was done with a light disc, and was unsatisfactory. The later plantings were made following tillage using a pulvimixer, which leaves an excellent seedbed.

The use of a starter fertilizer does not affect germination, but it often improves the seeded stand. Fertilizer trials at College Station showed that plant development was promoted by fertilizer rates up to 220 lbs. per acre of 16-20-0, but no advantage could be measured for higher rates. Rates as high as 600 pounds showed no detrimental effects. The results from these applications parallel those reported by Hudspeth, et al. (1959) and by Walker et al. (1958). Since some of the grasses in a seeding mixture benefit more than others from a starter fertilizer, application should be made at the time of seeding.

CONCLUSIONS

The stability of the unpaved portion of a right of way bears directly on the permanence and utility of the travelway and associated structures. Erosion of the areas of open soil endangers the stability of the entire roadway, and increases the outlay for maintenance or replacement of various components of the roadway.

Establishing a vegetative cover for erosion control involves the acceptance of biological technology by the engineer. These biological conditions are aimed at reducing the environmental stresses on the grass plants during the stages of growth when they are most vulnerable. The field practices which will reduce the risk of establishing a protective vegetative cover are:

(1) Choose planting materials which are adapted to the particular area in question, and spe-

cifically to the type of soil or soil material on which they will be planted.

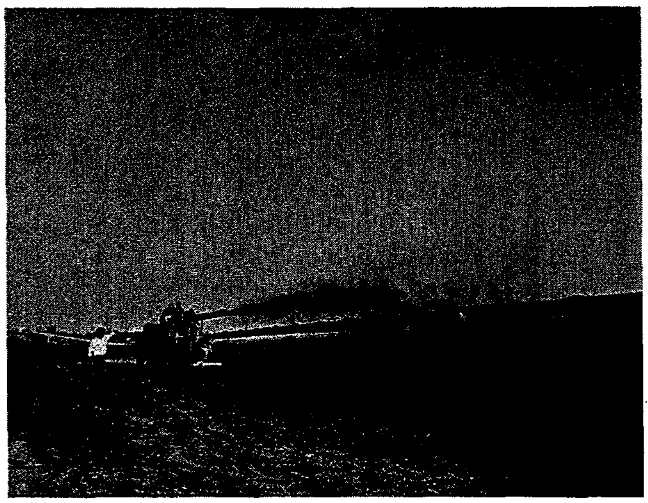
(2) Plant these materials during a time when temperature and moisture are expected to be most favorable for their growth and development. Generally, these seeding times will coincide rather closely with those specified for planting crops in the area.

(3) Provide a reservoir of soil moisture by tilling the surface to be planted. This practice should be followed on all materials except loose sand.

(4) Install a vapor barrier or mulch which is not too dense to prevent the emergence of the seedling plants. The mulching material selected should not create a condition unfavorable for plant growth. Asphalt is a satisfactory mulching material, but it may trap sufficient heat during warm days to damage seeds or seedling plants. A hay mulch, even when tacked with asphalt, does not generate this unfavorable condition. Usually the seed zone immediately under the hay mulch is somewhat cooler than the ambient air temperature.

(5) Apply fertilizer at the time of seeding to favor the rate of development of grass seedlings. The rate used should not be less than 200 pounds of 16% nitrogen fertilizer, and rates as high as 600 pounds were not found to be detrimental. Combinations of nitrogen and phosphorus or complete fertilizers are better than nitrogen alone.

While these general principles will improve the establishment of a plant cover for an erosion control, there are still a number of problems to be solved by research. Many of these problems are concerned with unfavorable physical or chemical properties of the soil or soil material on the surface of a right of way.



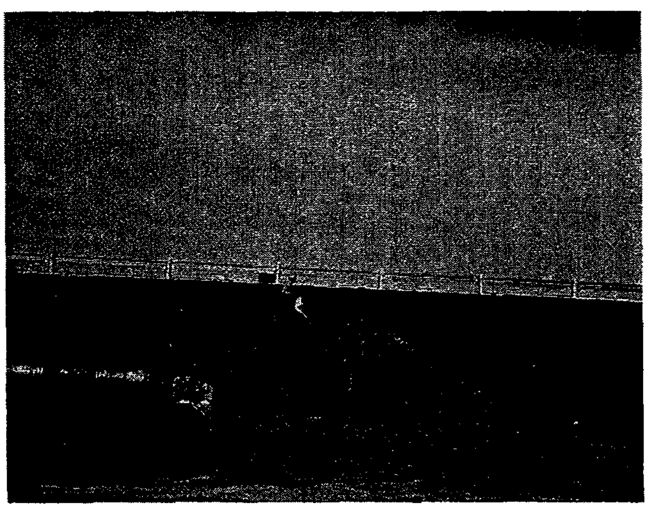


Figure 12. Hay mulch can be spread by hand and tacked with asphalt, or a mechanical mulcher can be used. Where only asphalt is used as mulching material, it usually is applied with a hand distributor.

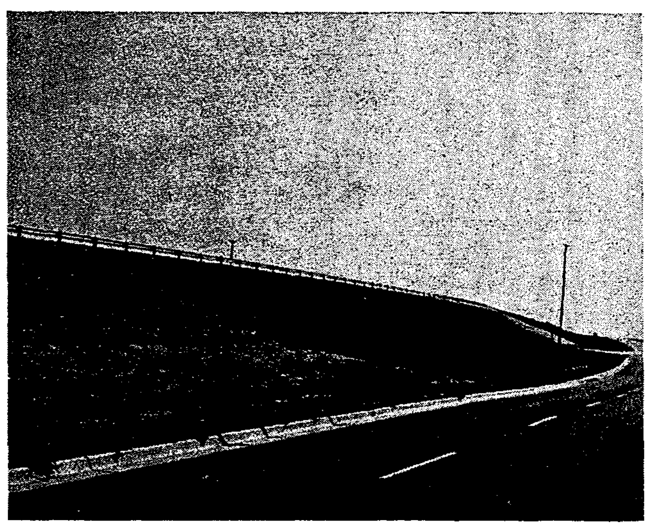


Figure 13. A surface mulch to conserve moisture in the seed zone is equally important in humid East Texas (top) as in the more arid climate of West Texas (bottom) to establish a permanent plant cover. Unmulched areas seeded with perennial grasses supported only a thin cover of annual plants which soon disappeared with the onset of hot dry weather and left the slopes subject to erosion.

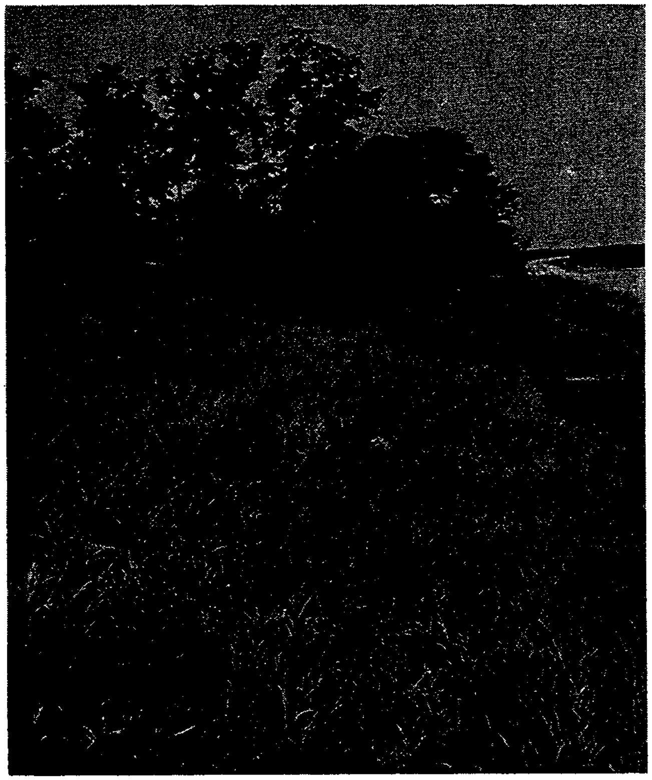


Figure 14. A hay mulch (foreground) gave a better stand of grass than did the asphalt mulch (background) where they were applied during warm weather conditions in mid-May.

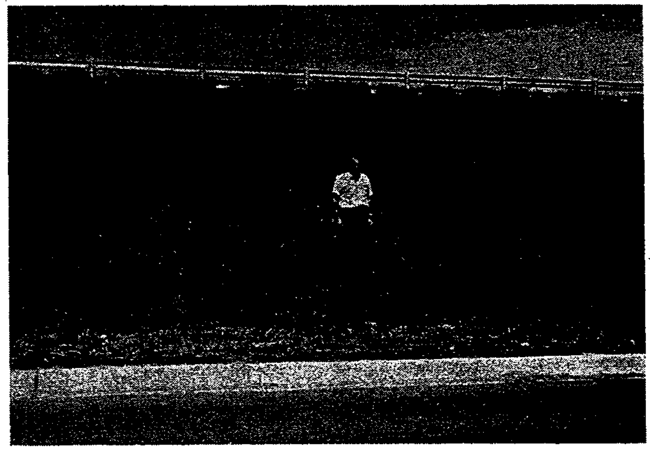


Figure 15. A satisfactory stand of grass for erosion control can be established on existing soil materials if an environment favorable for seed germination and seedling growth is provided.

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