

OKLAHOMA PROJECT

No. 63-03-3

ROADSIDE DEVELOPMENT AND EROSION CONTROL

Final Report

(Part II of III Parts)

Maintenance of Vegetative Ground Covers

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

Oklahoma State University

Stillwater, Oklahoma

MAINTENANCE OF VEGETATIVE GROUND COVERS
ON
OKLAHOMA HIGHWAYS

CONTENTS

	Page
RECOMMENDATIONS	vii
INTRODUCTION	1
FACTORS RESPONSIBLE FOR THE LOSS OF ESTABLISHED GROUND COVERS	1
FERTILITY REQUIREMENTS FOR IMPROVEMENT AND MAINTENANCE OF VEGETATIVE GROUND COVERS	6
FINDINGS AND CONCLUSIONS	7

LIST OF FIGURES

Figures 1-12.	The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.	Pages 8-19
Figures 13-18.	The effect of various fertilizers applied April 22, 1964, and retreated June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma.	21-26
Figures 19-24.	The effect of various fertilizers applied April 22, 1964, and retreated May 6, 1965, and June 7, 1966, on the growth of four grasses on a north facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma.	27-32
Figures 25-30.	The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.	34-39
Figures 31-36.	The effect of various fertilizers applied April 24, 1964, and retreated June 17, 1966, on the growth of four grasses on a north facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.	40-45
Figures 37-39.	The effect of various fertilizers on the growth of bermudagrass applied April 24, 1964, and again on June 21, 1966 combined with a post-emergence herbicide treatment on May 22, 1965, and again on June 22, 1967 for broadleaf weed control on an east facing cut slope on US-270 south of Shawnee, Oklahoma.	47-49
Figures 40-41.	The effect of various fertilizers applied April 17, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of bermudagrass on an east facing cut slope on I-35 three-fourths of a mile south of SH-51.	51-52
Figures 42-43.	The effect of various fertilizers applied April 18, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of bermudagrass on a west facing cut slope on I-35 three-fourths of a mile south of SH-51 junction.	53-54

- b. DO NOT BORROW SOIL from the top or slopes of stabilized cuts to repair fill slopes, or topdress cut slopes for turfing.

3. Fertilization

a. East of US-81

1. General for ALL GRASS MIXTURES ON ALL SLOPES. Apply 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 or 3 years. Commercial fertilizers that will supply 100-17-16 pounds of elemental N-P-K would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate

or, = 300 pounds ammonium nitrate

or, = 223 pounds urea

PHOSPHORUS: 17 pounds elemental phosphorus = 195 pounds 0-20-0

or, = 86 pounds 0-45-0

2. Predominately WEEPING LOVEGRASS COVERED SLOPES. Apply 50-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years. Commercial fertilizers that will supply 50-17-16 pounds of elemental N-P-K would include among others:

NITROGEN: 50 pounds elemental nitrogen = 250 pounds ammonium sulfate

or, = 150 pounds ammonium nitrate

or, = 112 pounds urea

PHOSPHORUS: 17 pounds elemental phosphorus = 195 pounds 0-20-0

or, = 86 pounds 0-45-0

POTASSIUM: 16 pounds elemental potassium = 32 pounds 0-0-60

3. Predominately BERMUDAGRASS COVERED SLOPES. Apply 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years. Commercial fertilizers that will supply 100-17-16 pounds of elemental N-P-K would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate

or, = 300 pounds ammonium nitrate

or, = 223 pounds urea

PHOSPHORUS: 17 pounds elemental phosphorus = 195 pounds 0-20-0

or, = 86 pounds 0-45-0

POTASSIUM: 16 pounds elemental potassium = 32 pounds 0-0-60

4. Predominately BERMUDAGRASS COVERED SHOULDERS and ALL LEVEL AREAS. Apply 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years. Commercial fertilizers that will supply 100-17-16 pounds of elemental N-P-K would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate

or, = 300 pounds ammonium nitrate

or, = 223 pounds urea

PHOSPHORUS: 17 pounds elemental phosphorus = 195 pounds 0-20-0

or, = 86 pounds 0-45-0

POTASSIUM: 16 pounds elemental potassium = 32 pounds 0-0-60

5. Switchgrass in a vegetative mixture responds to an application of 50-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years. (These rates are the same as for weeping lovegrass. See 3a2.)
6. King Ranch bluestem in a vegetative mixture has indicated no response to supplemental fertilization, therefore none is recommended. It has persisted as well or increased in abundance in the unfertilized experimental areas, as

in the areas that received the maximum rates of fertilizer.

b. West of US-81

1. General for ALL GRASS MIXTURES ON ALL SLOPES. Apply 100 pounds of actual nitrogen per acre per application once every 2 to 3 years. Commercial fertilizers that will supply 100 pounds of elemental nitrogen would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate
or, = 300 pounds ammonium nitrate
or, = 223 pounds urea

2. Predominately WEEPING LOVEGRASS COVERED SLOPES. Apply 100-34-0 pounds of actual nitrogen, and phosphorus respectively per acre, per application once every 2 to 3 years. Commercial fertilizers that will supply 100-34-0 pounds of elemental N-P would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate
or, = 300 pounds ammonium nitrate
or, = 223 pounds urea

PHOSPHORUS: 34 pounds elemental phosphorus = 389 pounds 0-20-0
or, = 172 pounds 0-45-0

3. Predominately BERMUDAGRASS COVERED FILL SLOPES. Apply 100-34-0 pounds of actual nitrogen, and phosphorus respectively per acre, per application once every 2 to 3 years. Commercial fertilizers that will supply 100-34-0 pounds of elemental N-P would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate
or, = 300 pounds ammonium nitrate
or, = 223 pounds urea

PHOSPHORUS: 34 pounds elemental phosphorus = 389 pounds 0-20-0
or, = 172 pounds 0-45-0

4. Sideoats grama in a vegetative mixture responds to an application of 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years. Commercial fertilizers that will supply 100-17-16 pounds of elemental N-P-K would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate
or, = 300 pounds ammonium nitrate
or, = 223 pounds urea

PHOSPHORUS: 17 pounds elemental phosphorus = 195 pounds 0-20-0
or, = 86 pounds 0-45-0

POTASSIUM: 16 pounds elemental potassium = 32 pounds 0-0-60

5. Buffalograss in a vegetative mixture responds to an application of 100 pounds of actual nitrogen per acre per application once every 2 to 3 years. Commercial fertilizers that will supply 100 pounds of elemental nitrogen would include among others:

NITROGEN: 100 pounds elemental nitrogen = 500 pounds ammonium sulfate
or, = 300 pounds ammonium nitrate
or, = 223 pounds urea

6. Switchgrass in a vegetative mixture responds to an application of 50 pounds of actual nitrogen per acre, per application once every 2 to 3 years. Commercial fertilizers that will supply 50 pounds of elemental nitrogen would include among others:

NITROGEN: 50 pounds elemental nitrogen = 250 pounds ammonium sulfate
or, = 150 pounds ammonium nitrate
or, = 112 pounds urea

4. WEED CONTROL

a. All of Oklahoma

The application of a post-emergence herbicide for broadleaf weed control,

such as Banvel-D* (dicamba) at the rate of 1 pound of actual material per acre (commercial material contains 4 pounds of actual ingredient per gallon) following the first application and perhaps subsequent ones, of fertilizer would permit more efficient use of the plant nutrients by the desired grasses.

5. GRASSES

a. East of US-81

1. Weeping lovegrass is better adapted for use on all slopes in this area than any other grass tested.
2. Bermudagrass is better adapted for use on south facing slopes than any other grass tested.
3. Weeping lovegrass is better adapted for use on north facing slopes than any other grass tested.
4. Bermudagrass is better adapted for use on east or west facing slopes than any other grass tested.

b. West of US-81

1. Sideoats grama is better adapted for use on all slopes in this area than any other grass tested.
2. Weeping lovegrass is equally well adapted as sideoats grama for use on south facing slopes of all the grasses tested.
3. Switchgrass is equally well adapted as sideoats grama generally east of the panhandle, for use on north facing slopes of all the grasses tested.
4. Buffalograss is better adapted for use on east or west facing slopes of all the grasses tested.
5. Bermudagrass is better adapted for use on all except north facing fill slopes of all the grasses tested.

*Tradename of Velsicol Chemical Corporation.

MAINTENANCE OF VEGETATIVE GROUND COVERS

ON

OKLAHOMA HIGHWAYS

by

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INTRODUCTION

Statistical records indicate more than \$3 million was spent each year in fiscal 1963, 1964, and 1965 for erosion control on Oklahoma roads and highways. The cost of erosion control in 1965 was \$15,900.00 per mile, and one year later (fiscal 1966) the cost had risen to \$23,000.00 per mile, an increase of approximately 45 percent. The construction of more roads and highways each year added to the more than 12,000 miles now in Oklahoma makes the need for satisfactory and economical means of maintenance even more urgent.

FACTORS RESPONSIBLE FOR THE LOSS OF ESTABLISHED GROUND COVERS

The lack of proper maintenance is the most common reason for the loss of established ground covers. The direction of exposure and degree of slope also contribute to the decline and ultimate loss of some vegetative covers.

The factors most commonly involved in the loss of established ground covers are as follows:

1. The lack of maintenance applications of fertilizer. Historically, an abundance of fertilizer is applied at the time of seeding or sodding for the initial erosion control on the highway system. Once the initial planting is

made generally no additional fertilizer is applied regardless of the need of the plants. Unfortunately, areas successfully stabilized initially with erosion resistant grasses, particularly bermuda (Cynodon dactylon (L.) Pers.) soon eroded so severely major repairs and replanting had to be done primarily as a direct result of the decline in soil fertility. The plants become weak, the vegetative cover becomes thin and ultimately ceases to exist altogether as the available plant nutrients disappear.



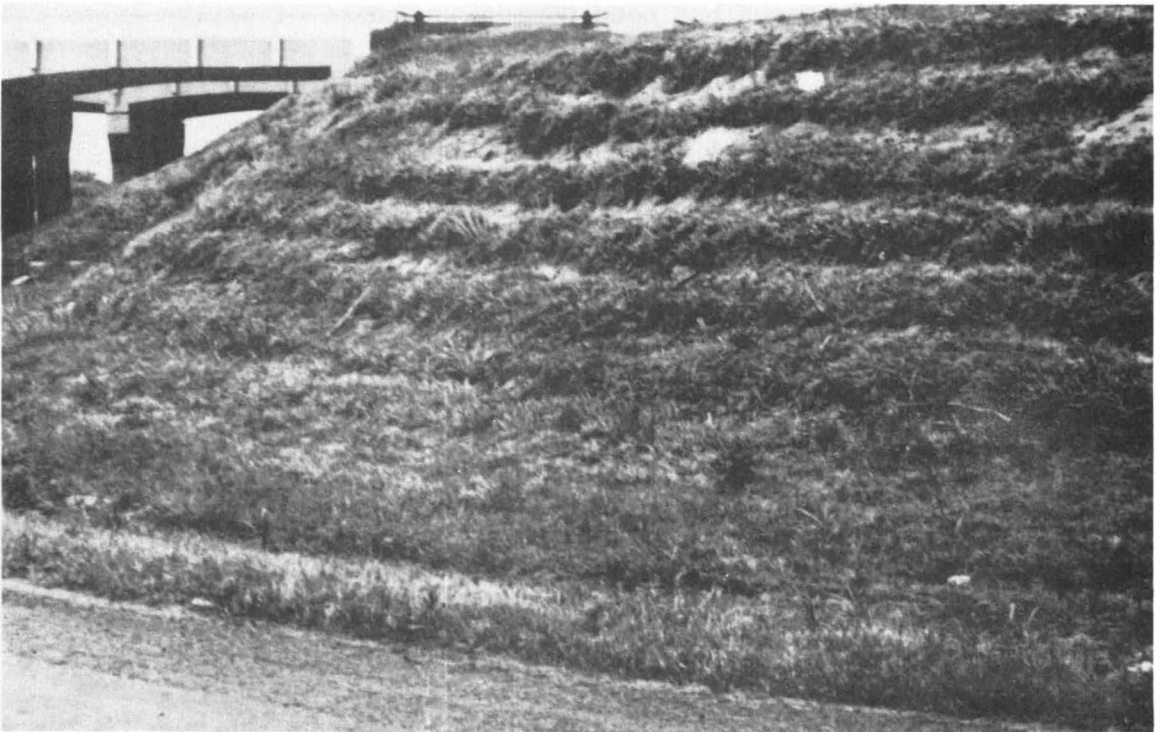
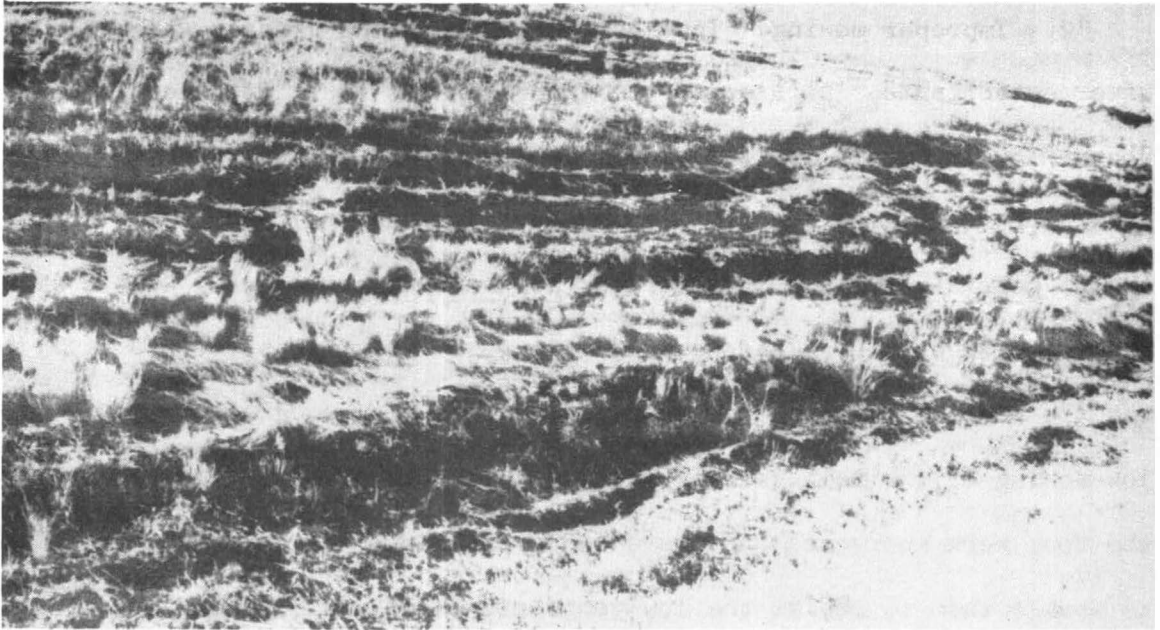
Soil erosion becomes more destructive as the vegetative ground cover weakens and dies with the decline in soil fertility.

2. Improper mowing. In those areas where the grasses were able to persist after establishment because of the inherent soil fertility they were commonly denuded by frequent, improper mowing. The height of clip for the taller, slow-growing bunchgrasses such as little and big bluestems (Andropogon scoparius Michx. and A. gerardi Vitman), indiangrass (Sorghastrum nutans (L.) Nash), switchgrass (Panicum virgatum L.), and weeping lovegrass (Eragrostis curvula Nees.) generally was the same as that for the shorter, fast-growing sodgrass bermuda. The frequent, low-mowing of the tall grasses reduced the depth of root penetration just as the tops were shortened and prevented a build-up of stored food by the plants to enable them to resist the low temperatures of winter and the hot, dry conditions of summer, so eventually they died.

Considerable research has been done on response of native grasses to clipping. Weeping lovegrass has somewhat the same habit of growth as the natives. The growth and vigor of the vegetation appear to be inversely related to frequency of clipping. Likewise numerous investigations have shown a decline in the production of roots of native grasses with frequent clipping. A study conducted at the Oklahoma Agricultural Experiment Station showed the stand density of nativegrass and plant vigor decreased, and broadleaved weeds and annual bromes increased under increased frequency of clipping.¹

The operation of mowers on highly erosive cut and fill slopes is one of the most destructive practices imposed on the protective grass cover. The 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, or from the spinning wheels in ascending the steep slopes, or as they slide in an attempt to stop or turn as they descend.

¹Dwyer, Don D., W. C. Elder and G. Singh. 1963. Effects of Height and Frequency of Clipping on Pure Stands of Range Grasses in North Central Oklahoma. Okla. Agric. Expt. Sta. Bull. B-614.



Mowing destroys the protective grass cover on cut (top Photo) and fill (bottom photo) slopes by tearing the plants from the soil, and creating ruts that speeds up soil erosion.

3. The common practice of "blading-off" the established vegetative ground cover especially the native tallgrasses on the highway shoulders, and in borrowing soil from the top or slopes of stabilized cuts to repair fill slopes, or topdress cut slopes for turfing, destroys much protective plant material and adds greatly to the cost of erosion control in the highway system.



The "blading-off" of established vegetative cover particularly the native grasses, and borrowing soil from the top of stabilized cuts destroys the protective ground cover and adds greatly to the cost of erosion control.

4. Lack of research information on plant adaptation to man-made sites.

THIS IS EQUALLY IMPORTANT AS A CAUSE OF SOIL EROSION REPORTED IN PART I OF THIS REPORT ON "CAUSES AND CONTROL OF SOIL EROSION ON OKLAHOMA HIGHWAYS."

Plants that are known to be well adapted to a particular area under natural conditions may be completely unsuited to sites developed by man that creates an entirely different environment. A high fill or backslope with a north exposure creates an entirely different environment for plant growth than a similar site facing south. North exposures at this latitude tend to be cooler in summer and much colder in winter than those that face south. Too, the intensity and amount of direct sunlight is less on north exposures which greatly influences plant growth and persistence. A west facing slope tends to be hotter, and drier in summer than one facing east.

The steepness of slope on cuts and fills tend to make these soils drier than those nearby. It is known dry soils permit faster and greater changes in temperature in a short period of time than soils that are moist. Therefore, the strong, cold winds of winter inflict the greatest damage to those plants on slopes that face north.

FERTILITY REQUIREMENTS FOR IMPROVEMENT

AND MAINTENANCE OF VEGETATIVE GROUND COVERS

The principal objectives of this part of the research project were to find satisfactory and economical methods to maintain a good vegetative ground cover after its successful establishment, and to restore a protective plant cover on areas where turf failure has occurred principally from a decline in soil fertility. To achieve these objectives several factors were to be evaluated. The major items of concern were:

1. The influence of design on the successful and economical establishment and maintenance of vegetative ground covers on cut and fill slopes.
2. The establishment of fertility requirements for maintenance of vegetatively stabilized slopes.

3. The effect of plant competition on maintenance of the desired vegetation.

FINDINGS AND CONCLUSIONS

Although plant response to fertilizers is generally rapid on low fertility soils, the determination of the most effective and economical treatments is slow because of the numerous variables involved. Weather is one of the most influential variables in field studies. In a five year period, no two years will necessarily have the same weather conditions. Since weather occurs daily and its long-time average is climate, time is required for the reliable evaluation of fertilizer treatments and application frequency for satisfactory and economical erosion control by vegetative means.

An excavation area of raw shale and sand with a 5% slope, located on US-69 near Eufaula, was seeded initially in May 1965 with bermudagrass (Cynodon dactylon), buffalograss (Buchloe dactyloides), little hop clover (Trifolium dubium) and mulched with weeping lovegrass (Eragrostis curvula) hay.² The area was fertilized at the time of seeding with 200 pounds 12-12-12 per acre, and then top dressed with 100 pounds of ammonium nitrate per acre in September 1965. In April 1966 three levels of gypsum were applied on the experimental area, followed by four levels of nitrogen-phosphorus fertilizers applied in late May 1966. The next month a post-emergence herbicide for broadleaf weed control was applied with a surfactant to one-half of each experimental unit. A fair stand of bermuda with traces of lovegrass and buffalo were present initially. The responses from the grasses to these treatments in the first two years of the investigation are shown in Figures 1 through 12. These data indicated a highly significant increase in the bermudagrass cover from nitrogen fertilization. The same results were obtained

²Maddux, Larry Dean. 1967. The Effect of Fertilizer, Gypsum, and Herbicide on Establishment and Maintenance of a Vegetative Ground Cover for Erosion Control on Oklahoma Highways. Unpublished M.S. Thesis. Oklahoma State University.

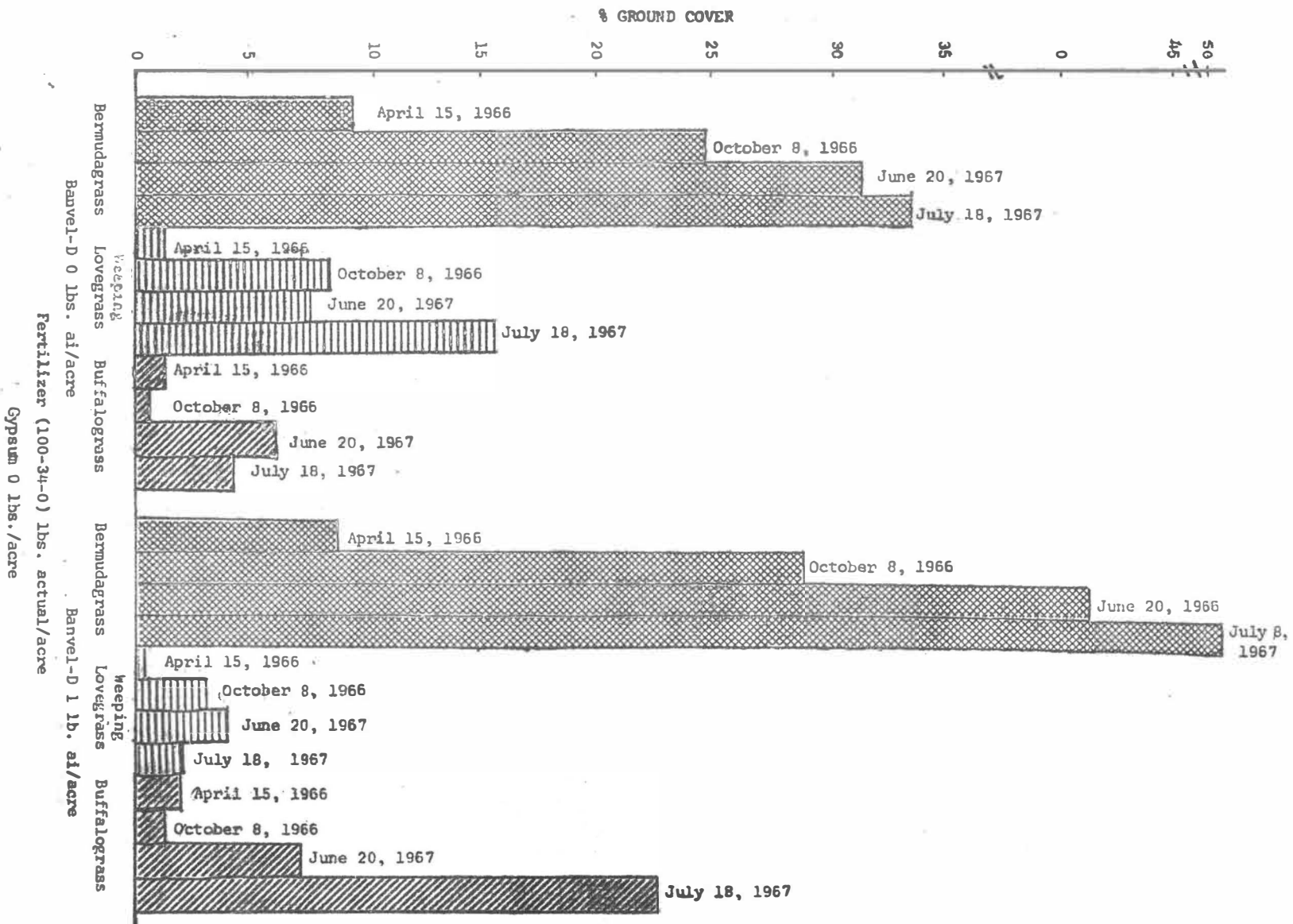


Figure 1. The effect of four rates of fertilizer, three rates of Gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

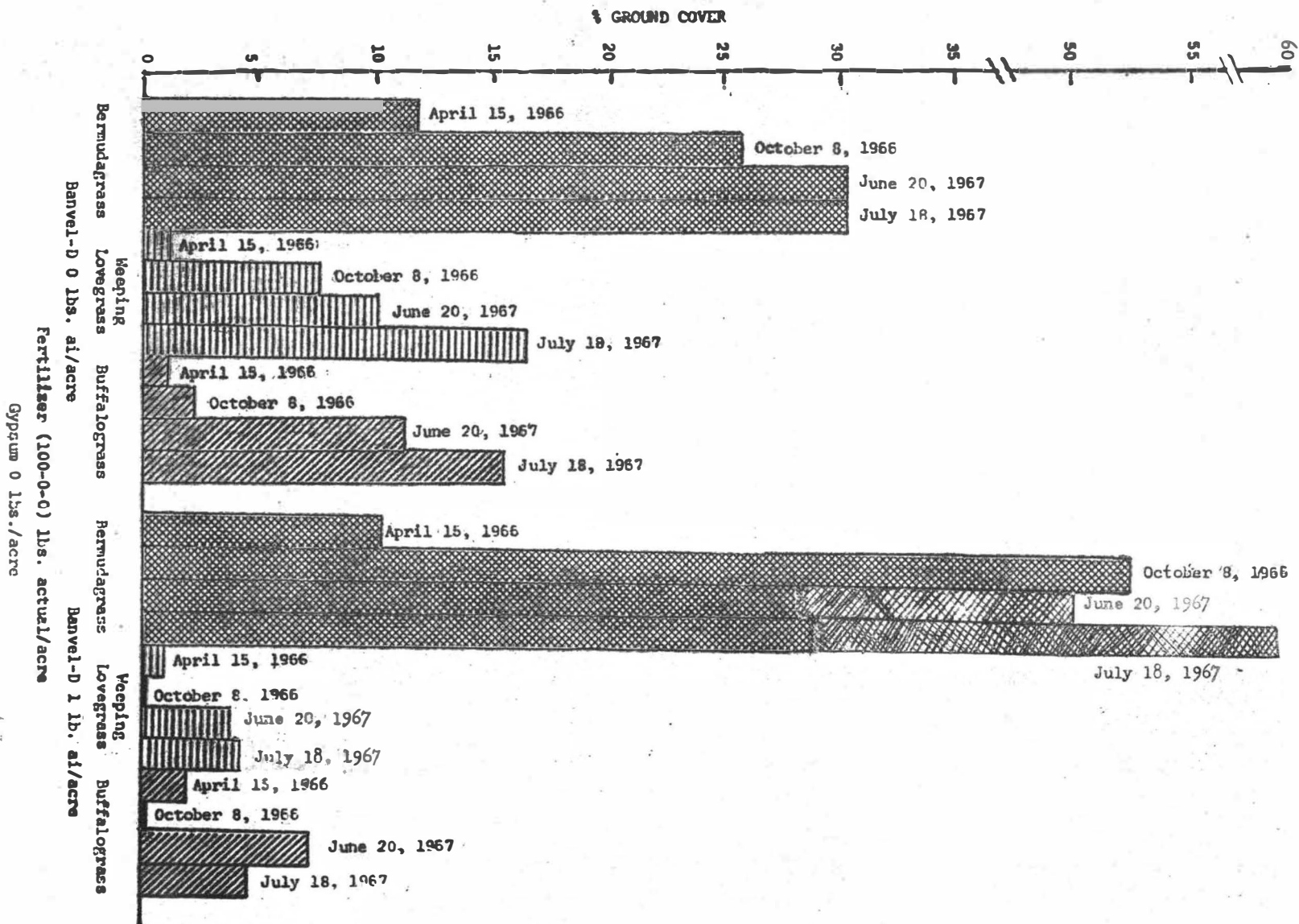


Figure 2. The effect of four rates of fertilizer, three rates of Eupsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

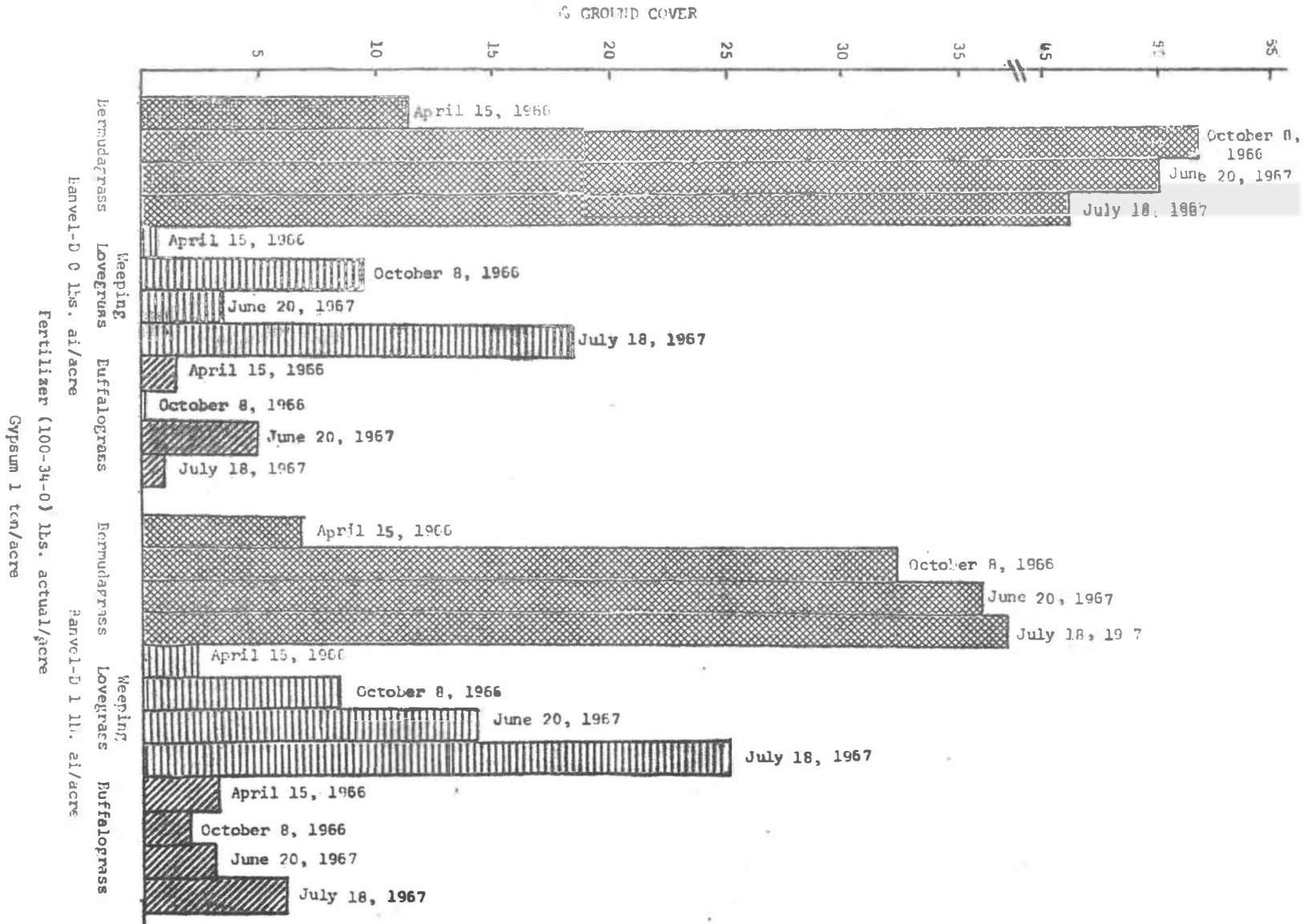


Figure 5. The effect of four rates of fertilizer, three rates of Gyssum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 business route.

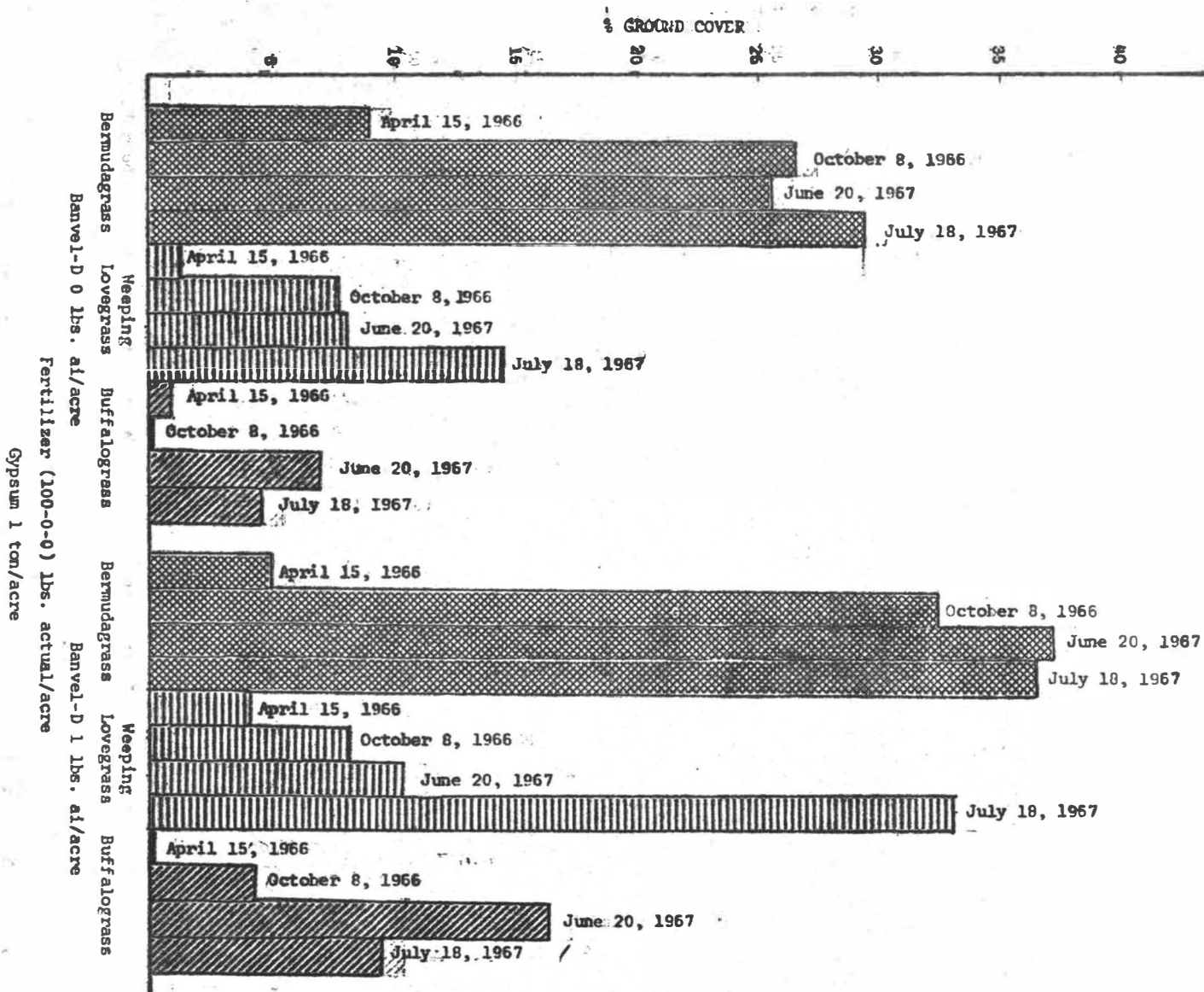


Figure 6. The effect of four rates of fertilizer, three rates of Gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

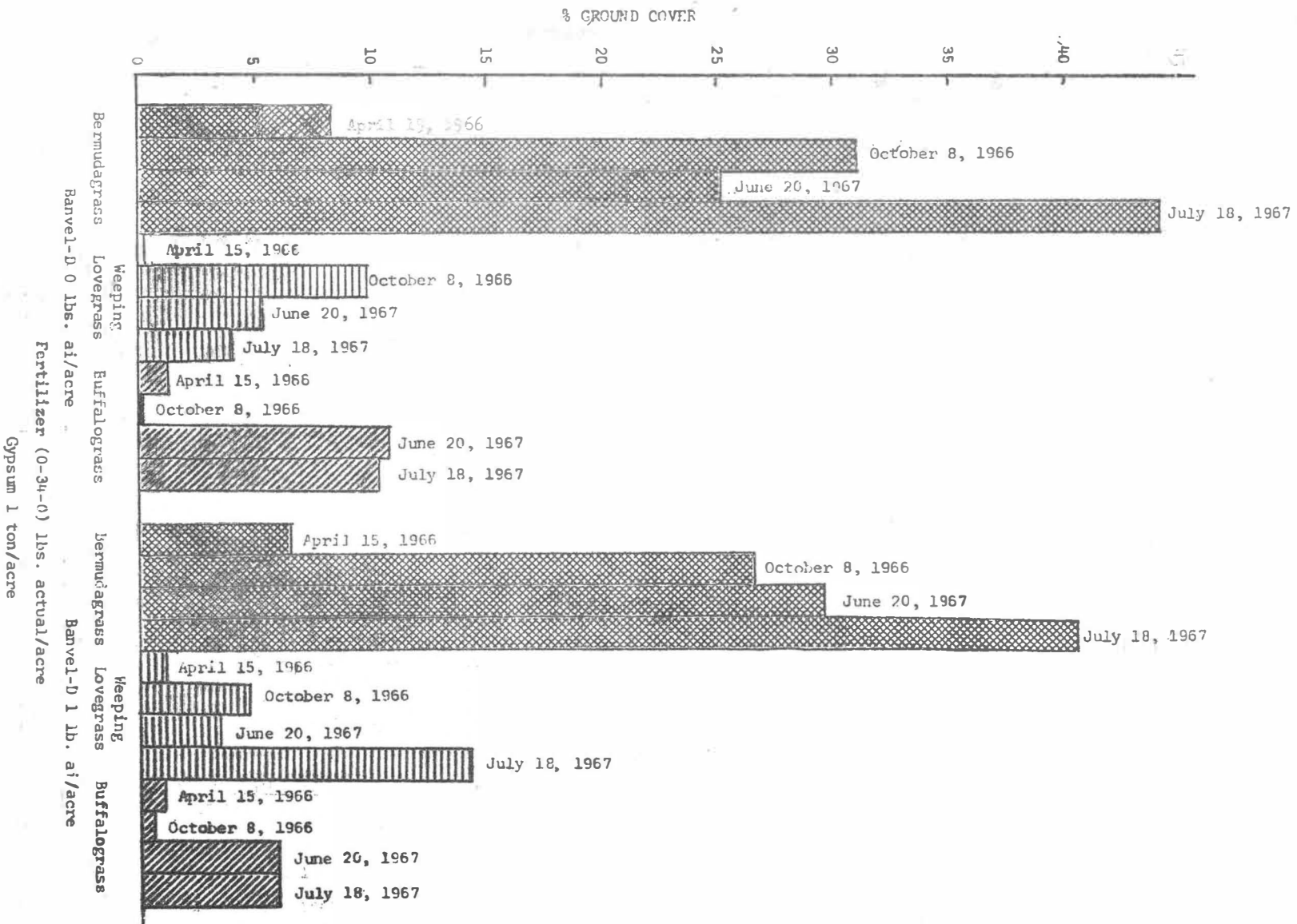


Figure 7. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

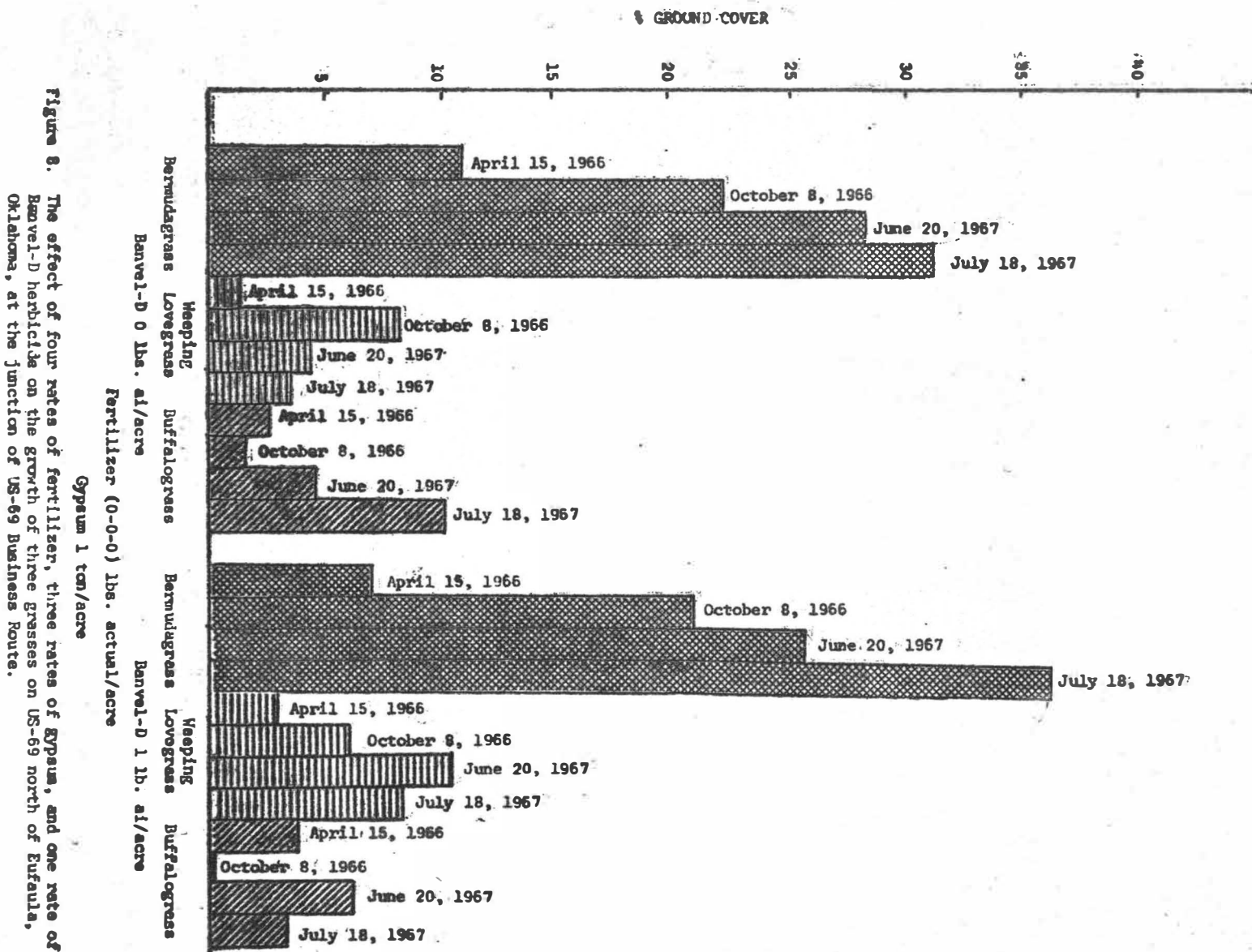


Figure 8. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

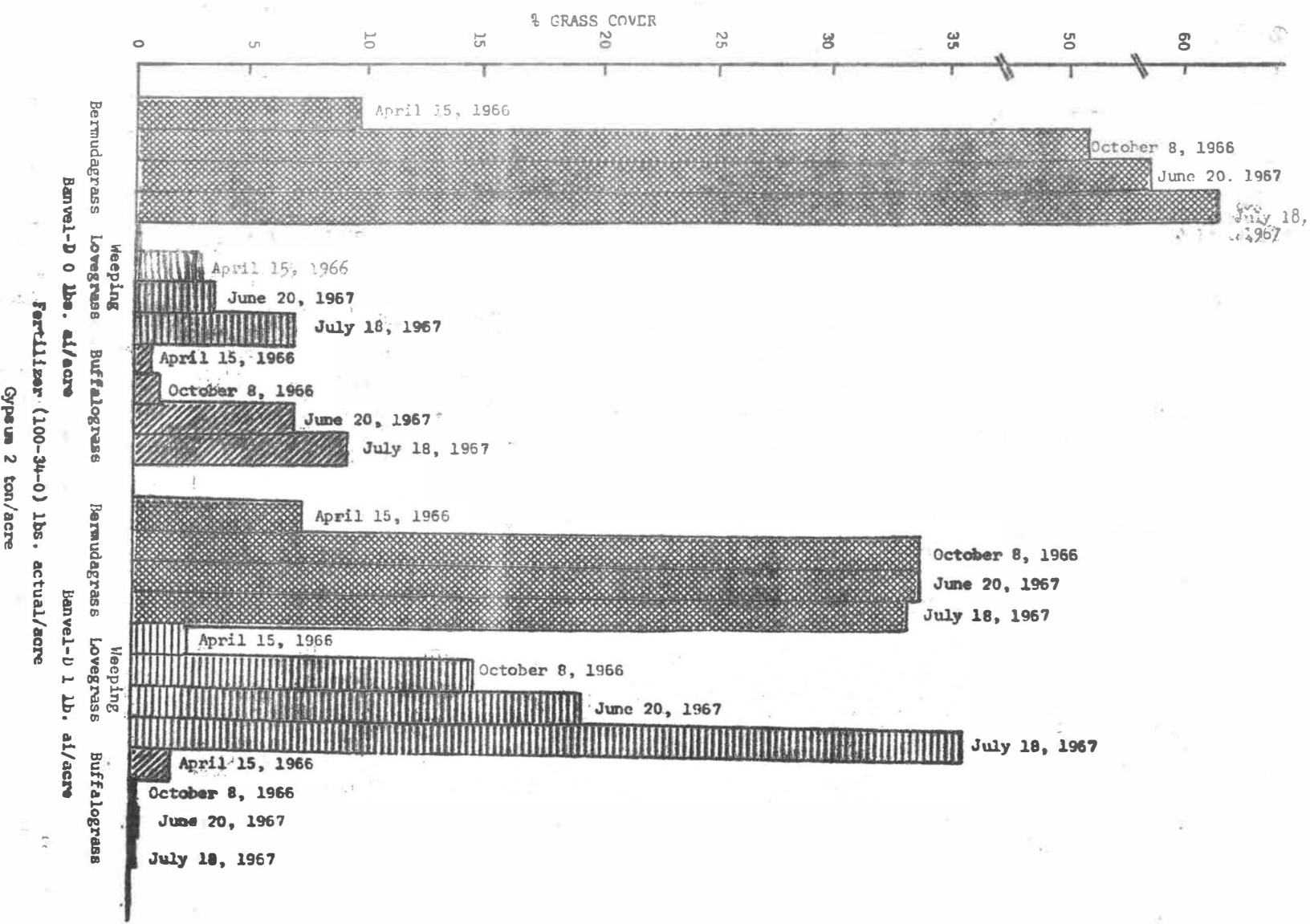


Figure 9. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

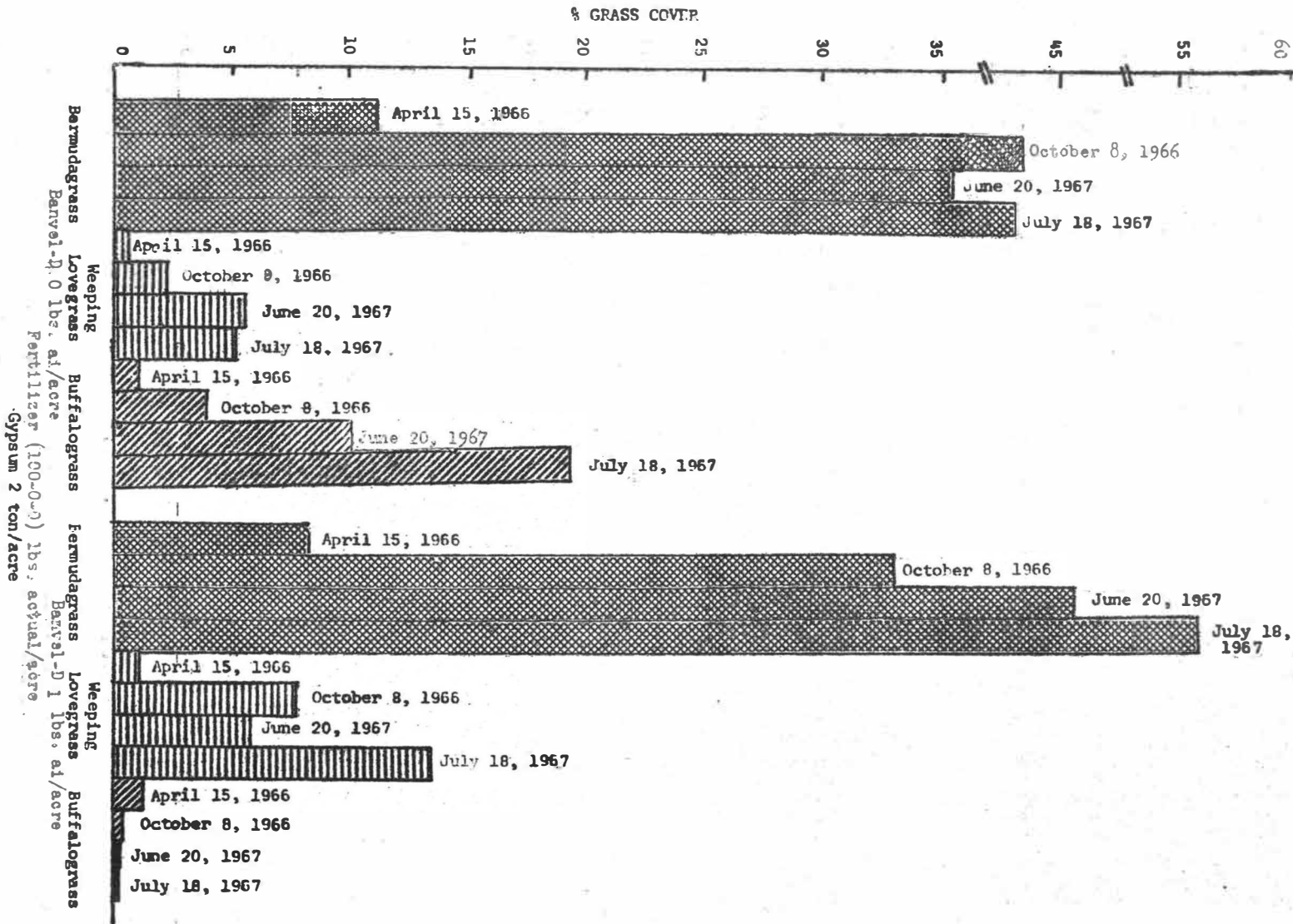


Figure 10. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Barnvel-D herbicide on the growth of three grasses on US-69 north of Tulsa, Oklahoma, at the junction of US-69 Business Route.

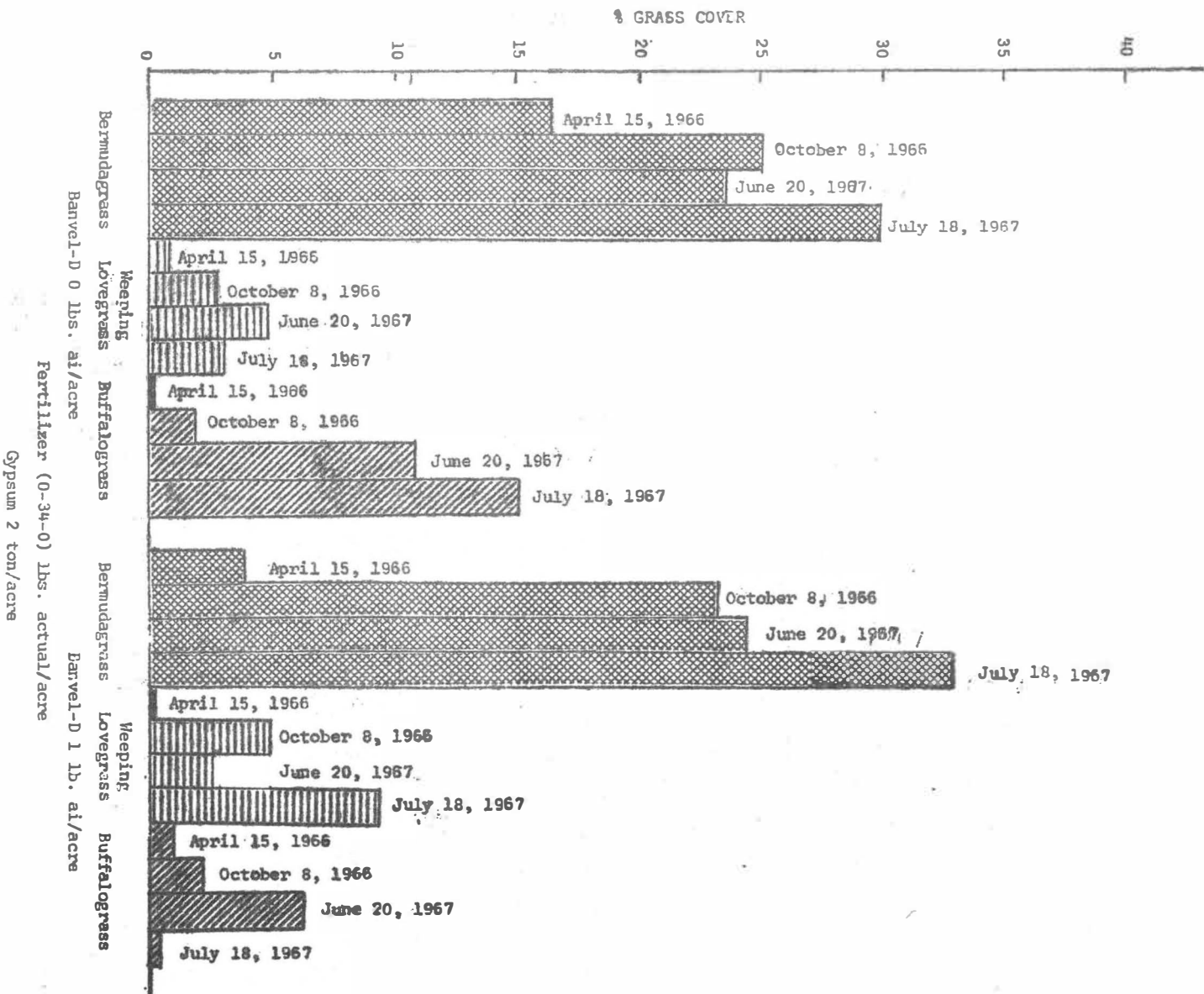


Figure 11. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Bufaula, Oklahoma, at the junction of US-69 Business Route.

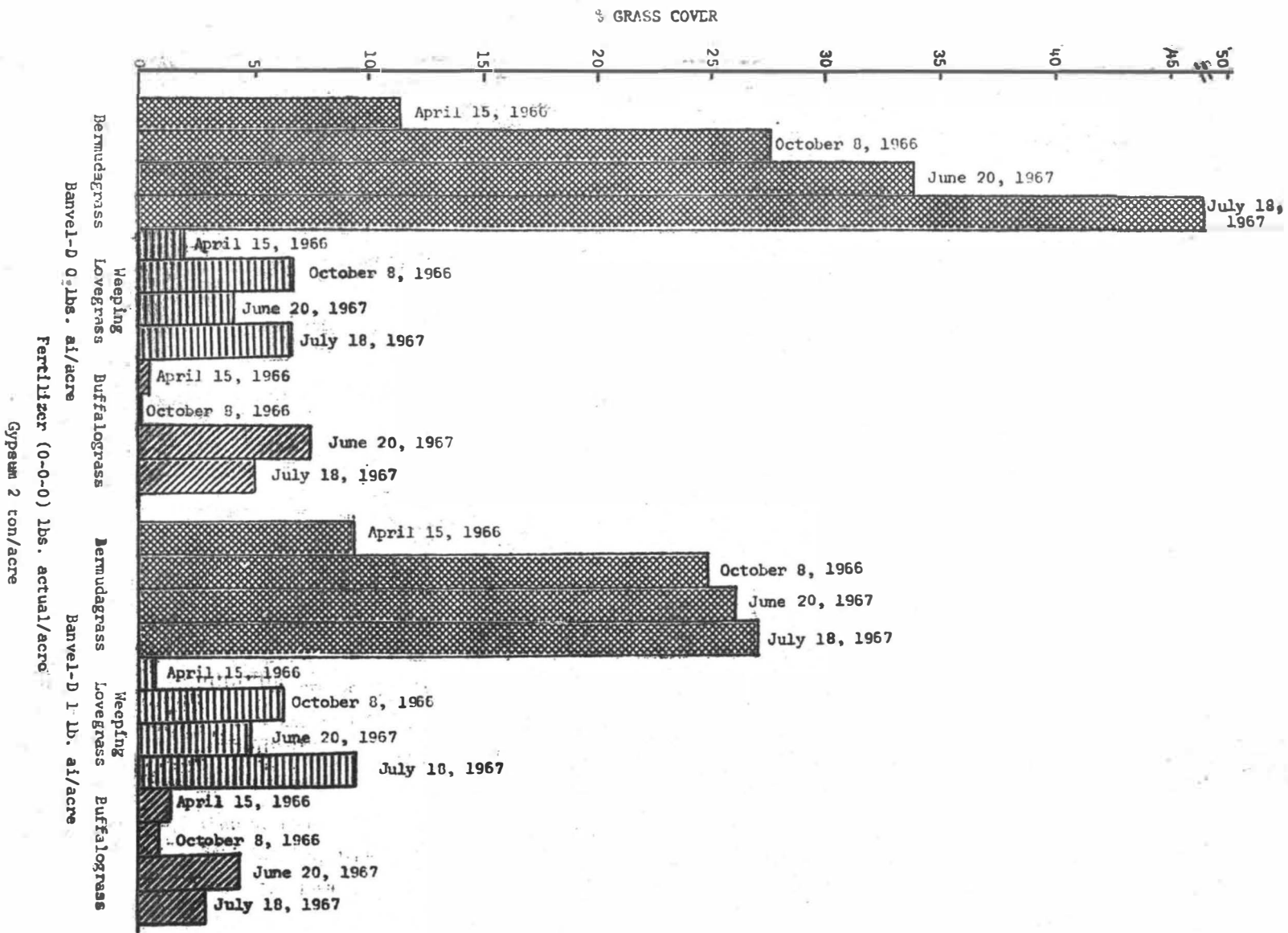


Figure 12. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route.

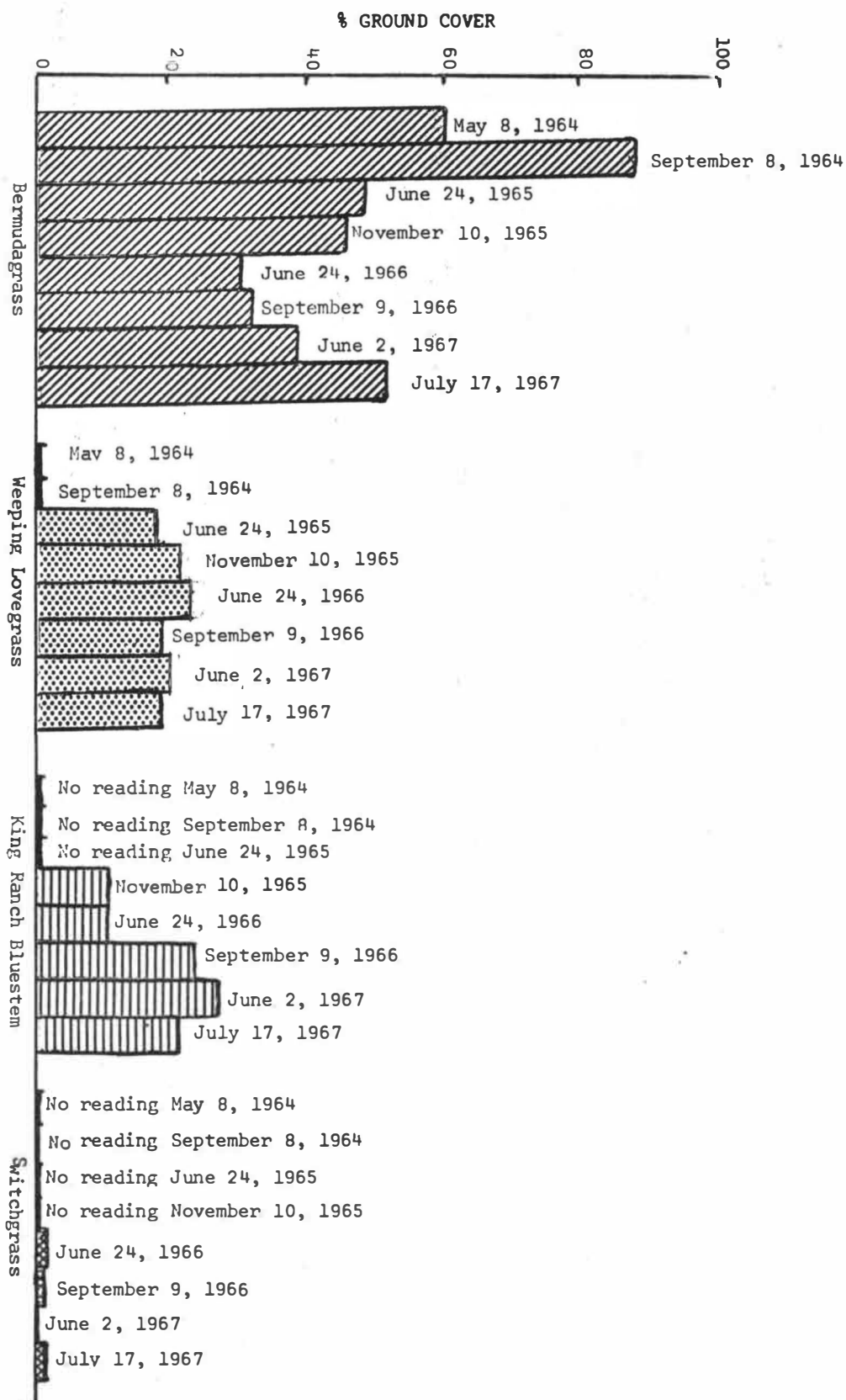
in similar experiments at Buffalo and Shawnee. The response to phosphorus fertilization, gypsum, or herbicide treatment was not significant early, but later there were definite indications of significant increases in the percent ground cover of bermuda and weeping lovegrass from a combination nitrogen-phosphorus fertilization and gypsum treatments. The real effects from phosphorus applications and gypsum treatments would show up more distinctly in plant survival during severe winters, and persistence through periods of moisture stress. These benefits will be more fully realized with time. The herbicide effect through broadleaf weed control was probably overwhelmingly masked at this particular location by the highly significant response to nitrogen fertilization particularly.

To investigate the fertility requirement of erosion resistant grasses and the effect of alternate year applications, six fertilizer treatments were applied to a vegetative ground cover previously established on a US-270 cut slope near Holdenville. The 3:1 slope, composed of a sandy loam soil with shale outcropping near the bottom, was rather well protected with about 65% ground cover, mostly bermudagrass, when the experiment started in 1964. The results of these treatments are shown in Figures 13 through 18.

Without fertilizer the bermudagrass ground cover declined about 30%, while K. R. bluestem increased 1 1/2 times that amount as shown in Figure 18. With only three years of data the complete evaluation of fertilizer response, and application frequency cannot be made. Within a five or ten year period real differences should manifest themselves based on the early trend in the non-fertilized treatment.

Just across the road (US-270) south from the above mentioned experiment is an exact duplication with the exception of a north exposure as shown in Figures 19 through 24. Weeping lovegrass was the predominant ground cover under all treatments. Bermudagrass declined in abundance, or remained in about the same small area on this north facing slope as at the beginning of the investigation three years earlier. Again, a complete evaluation of fertilizer response,

Figure 13. The effect of various fertilizers applied April 22, 1964, and retreated June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma.



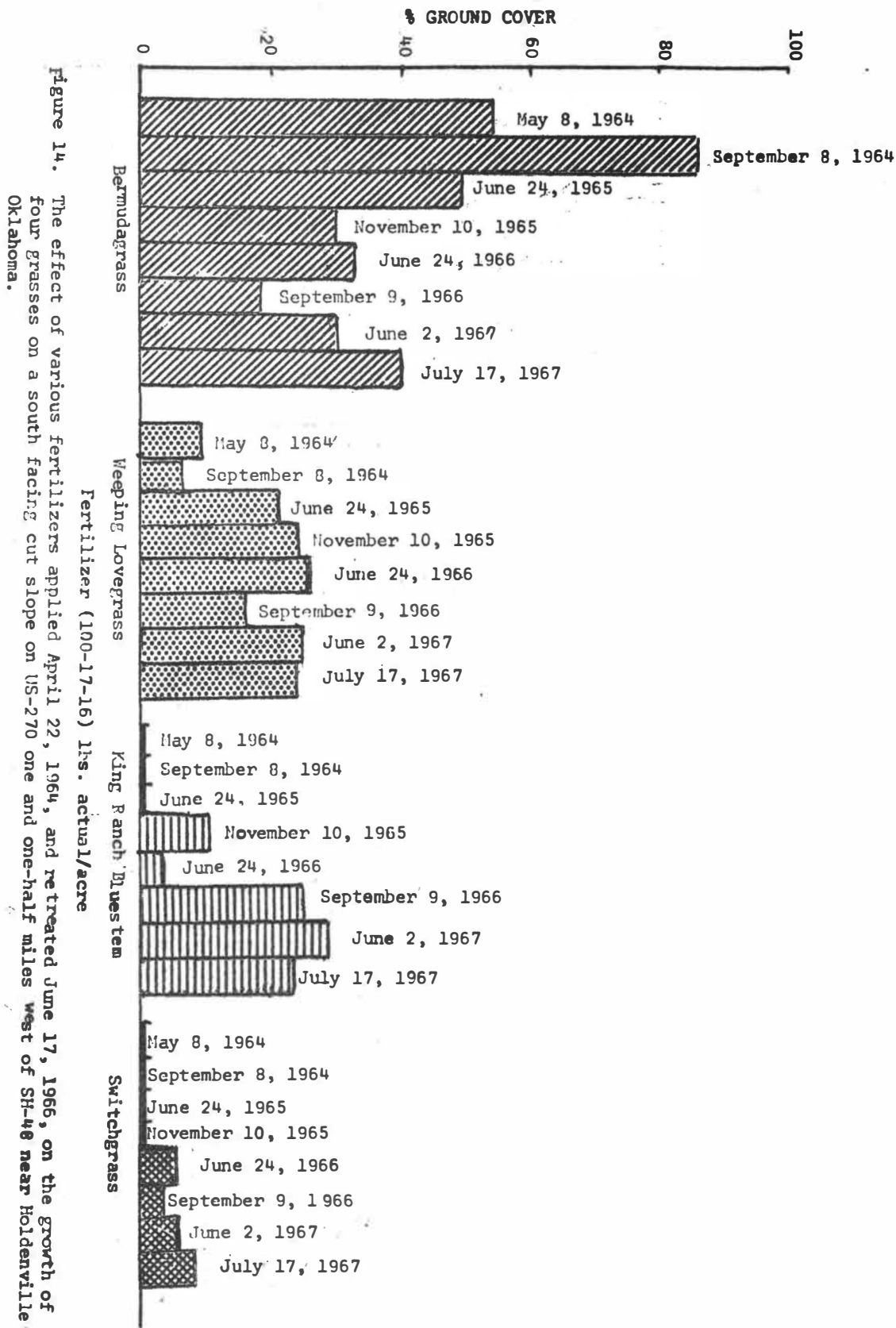
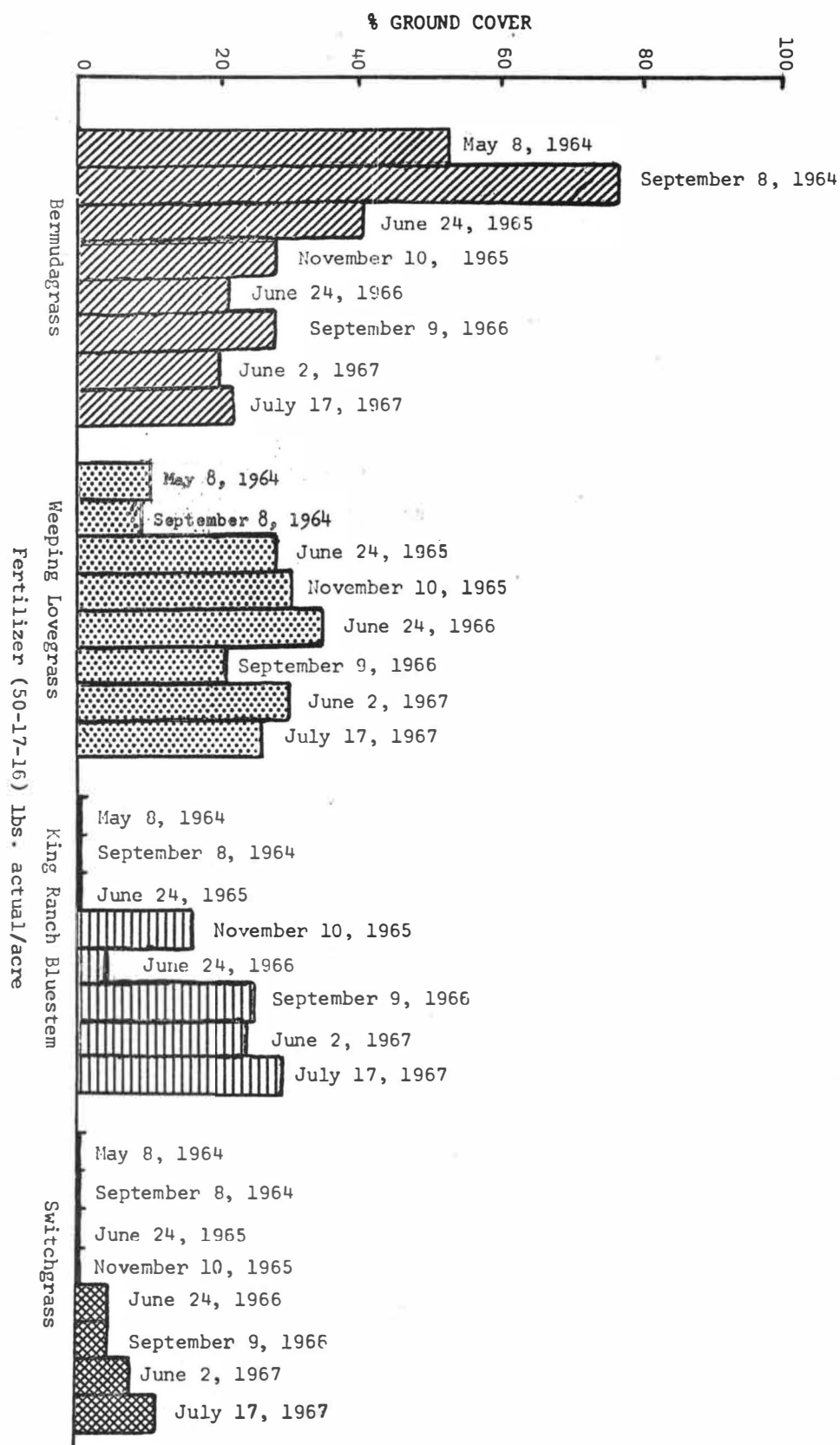


Figure 15. The effect of various fertilizers applied April 22, 1964, and retreated June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma.



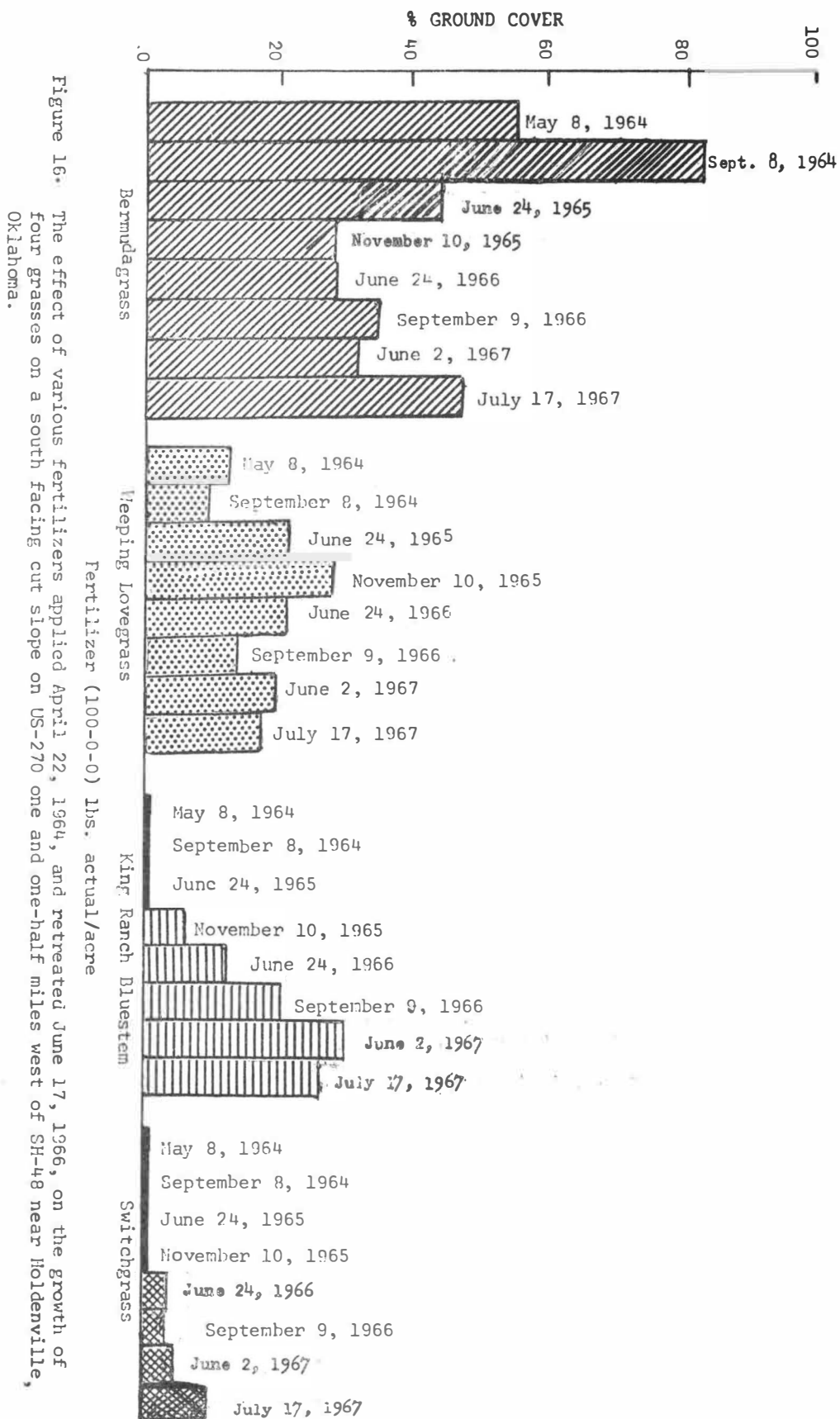
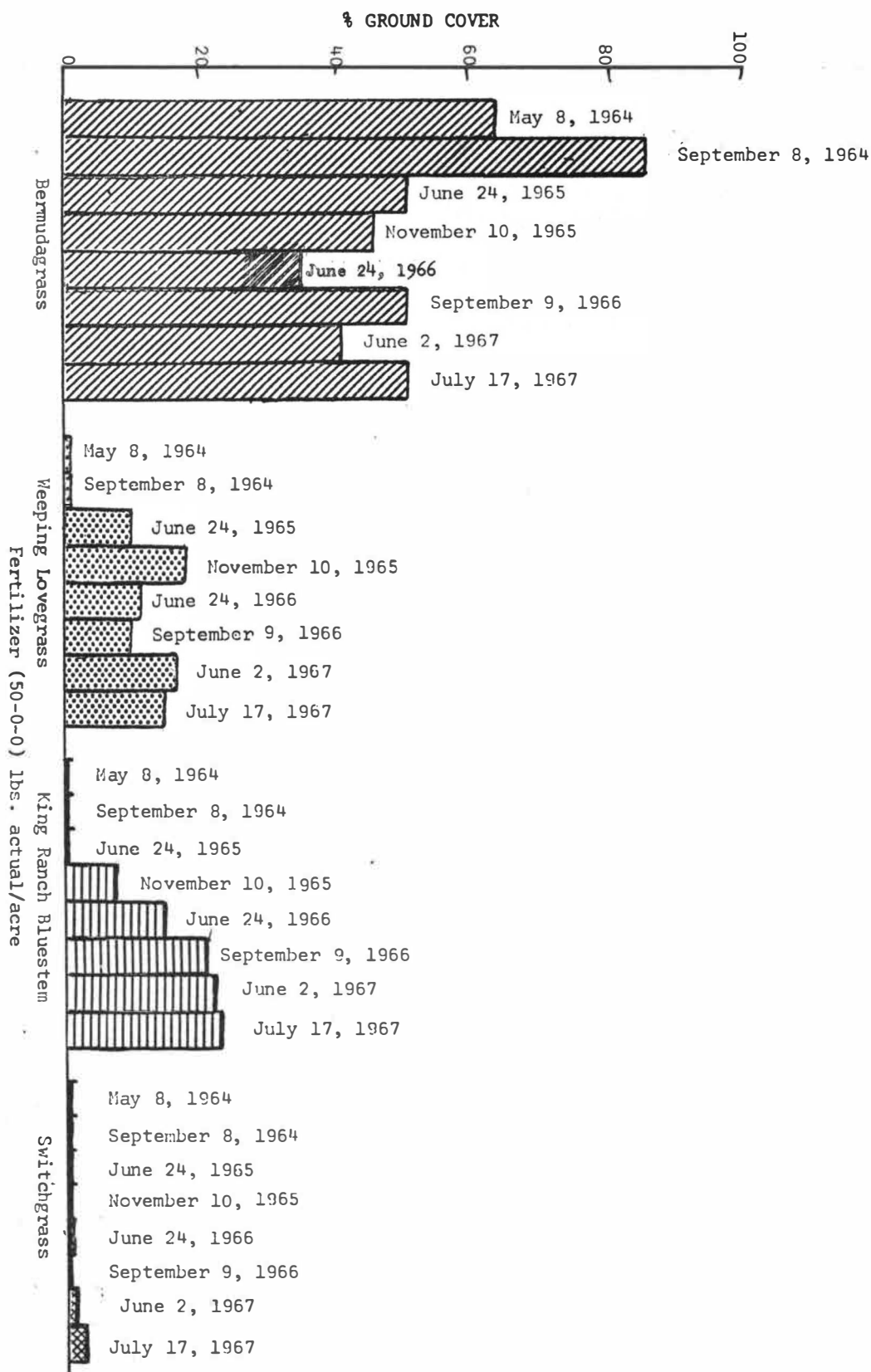
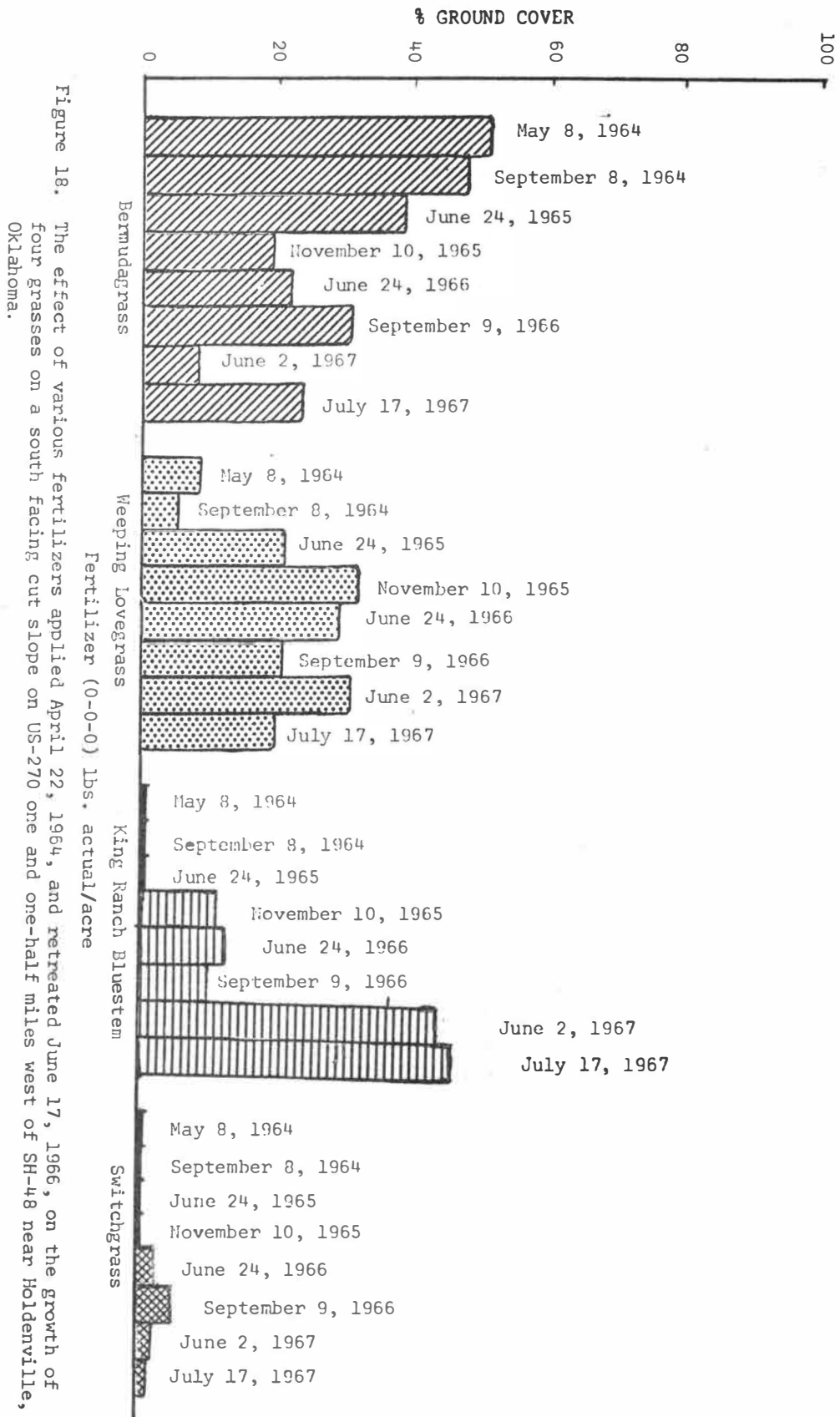
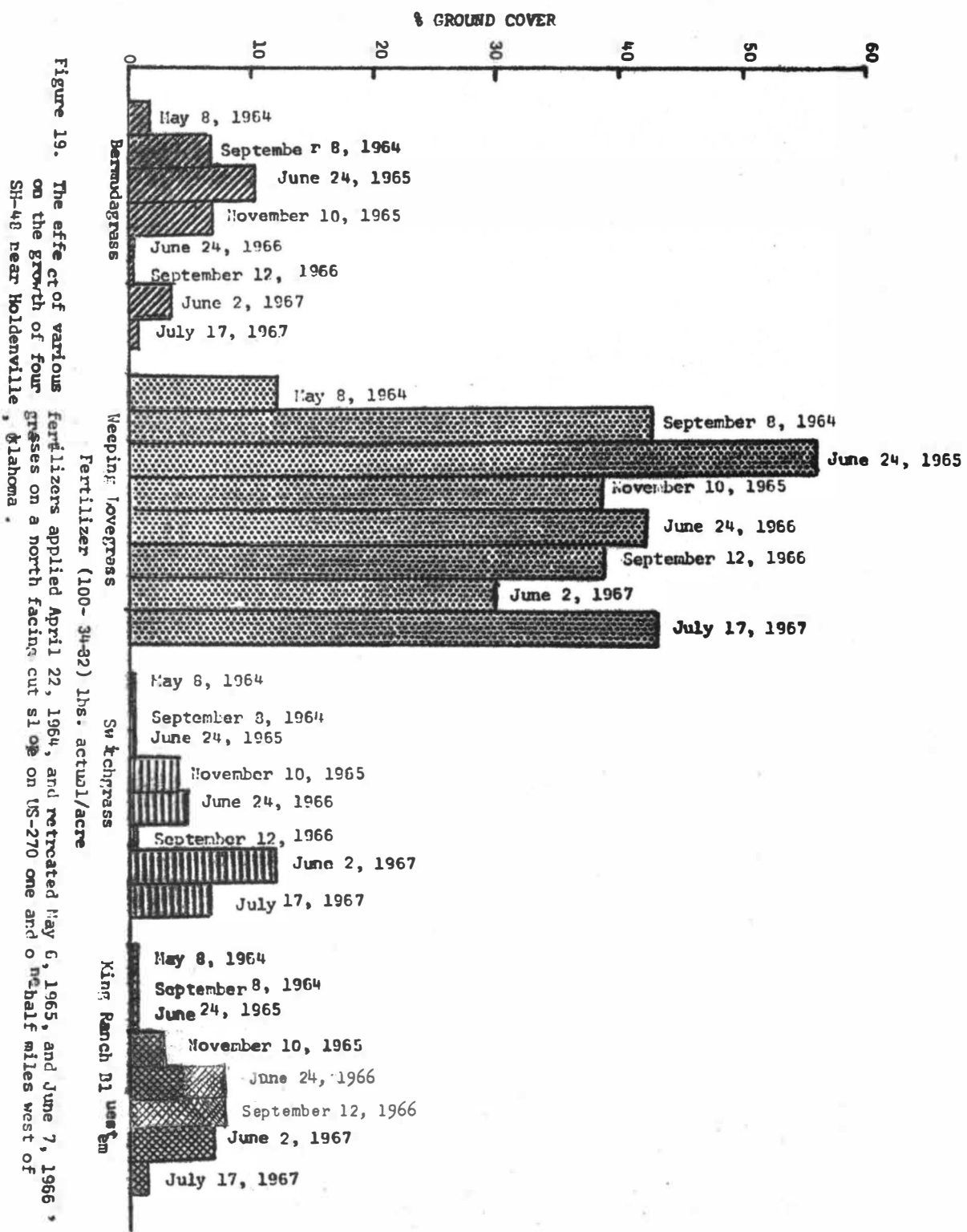
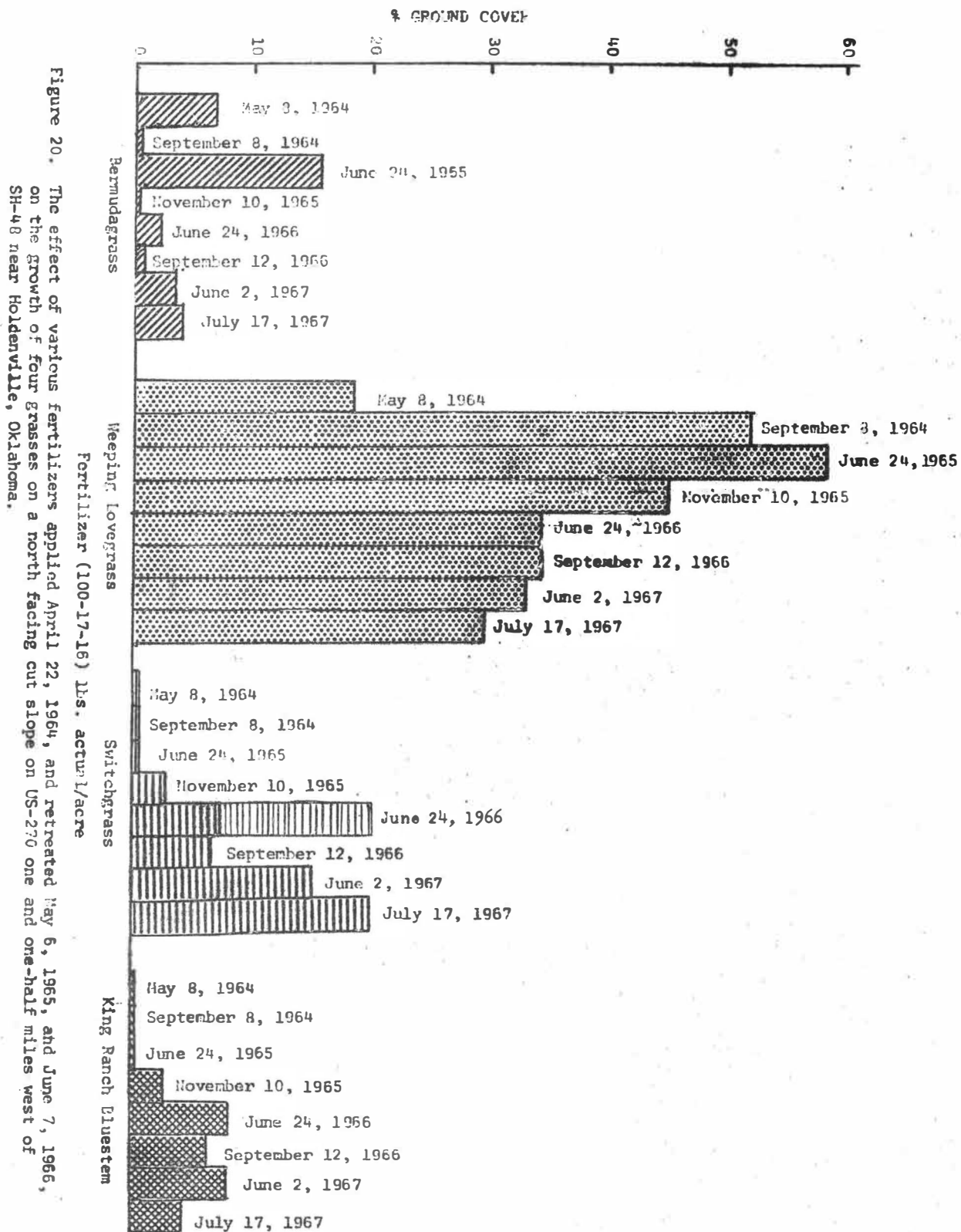


Figure 17. The effect of various fertilizers applied April 22, 1964, and retreated June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville Oklahoma.









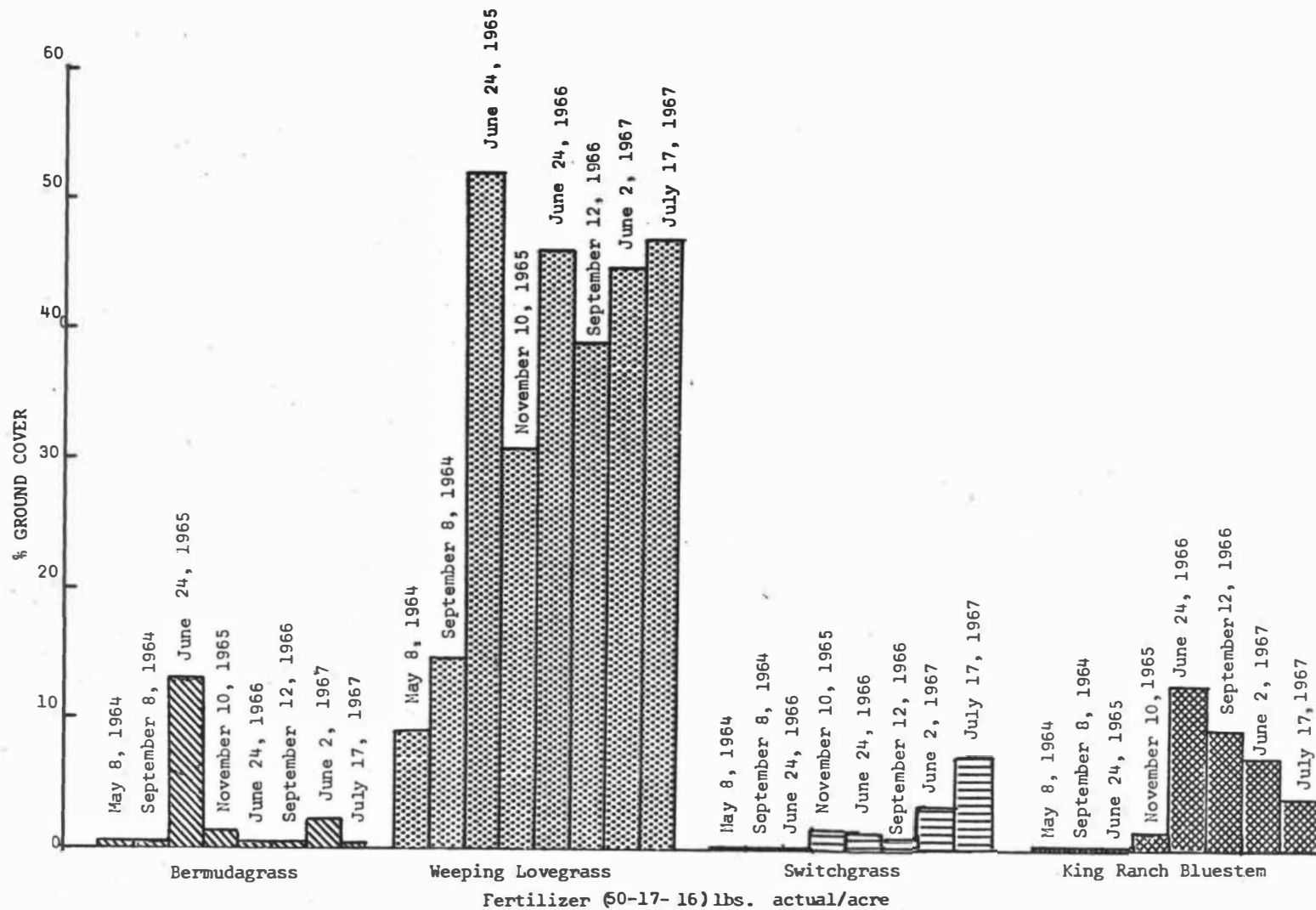


Figure 21. The effect of various fertilizers applied April 22, 1964, and retreated May 6, 1965, and June 7, 1966, on the growth of four grasses on a north facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma.

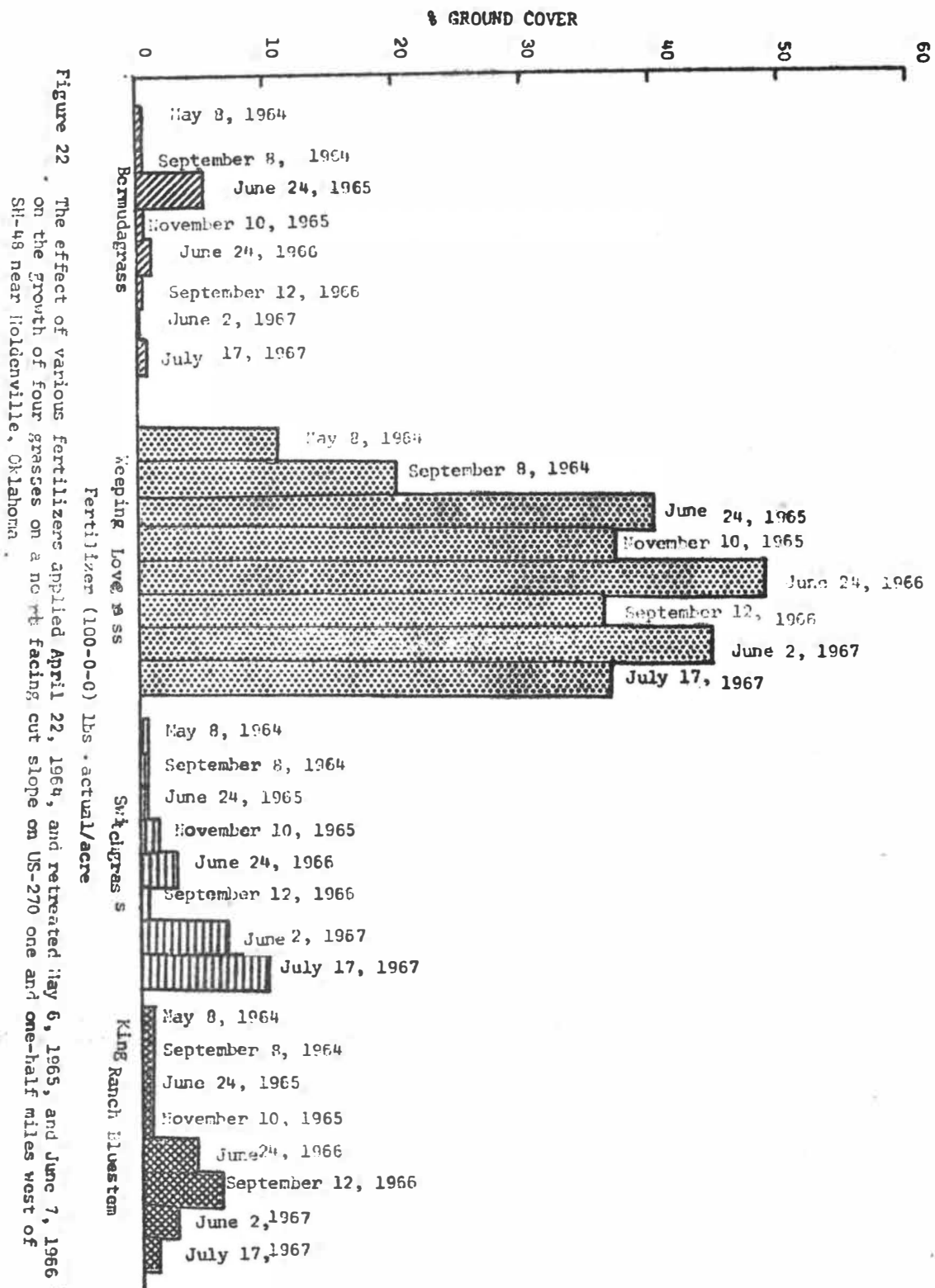


Figure 23. The effect of various fertilizers applied April 22, 1964, and retreated May 6, 1965, and June 7, 1966 on the growth of four grasses on a north facing cut slope on US-270 one and one-half miles west of SH-48 near Hedenerville, Oklahoma.

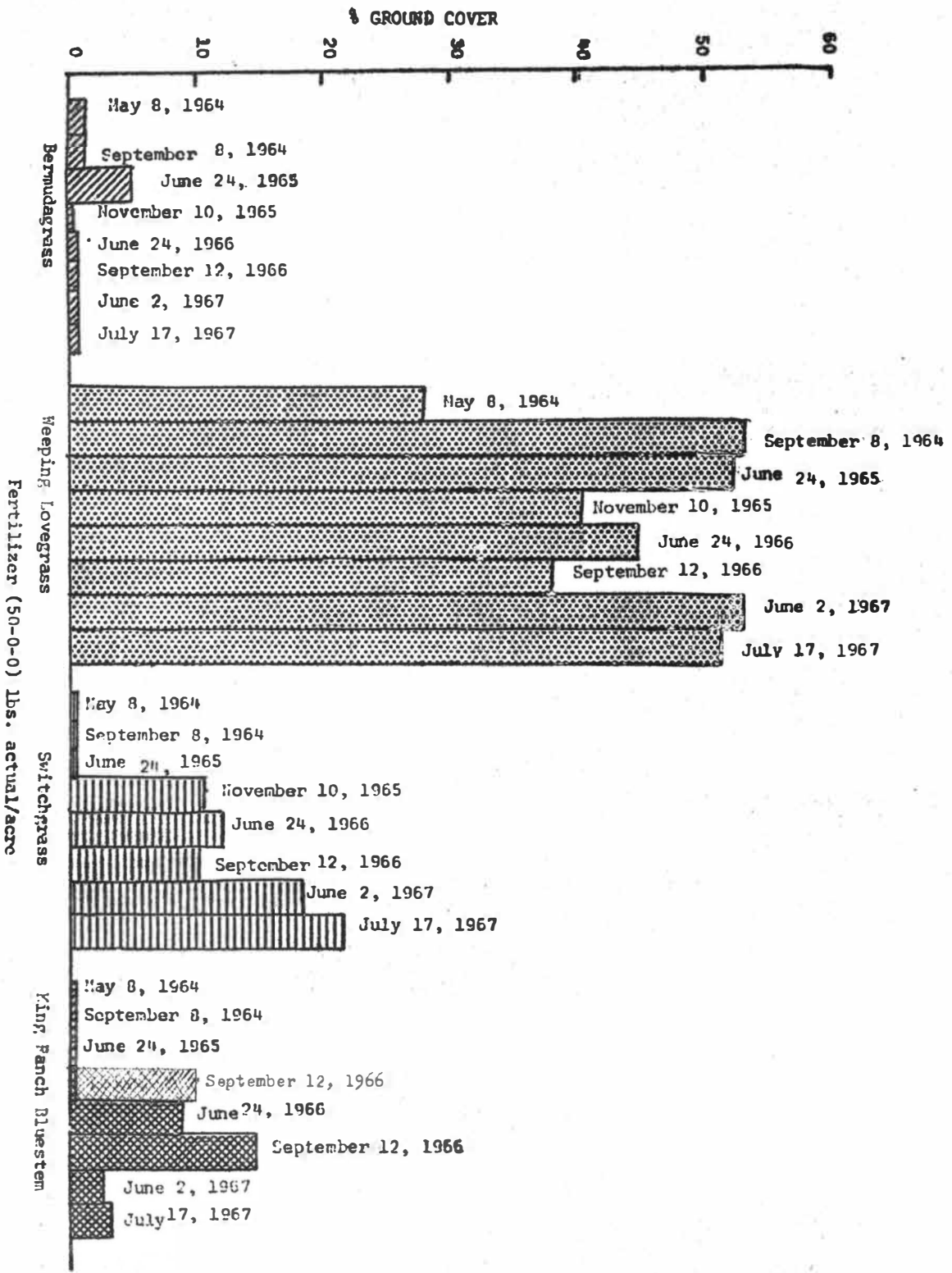
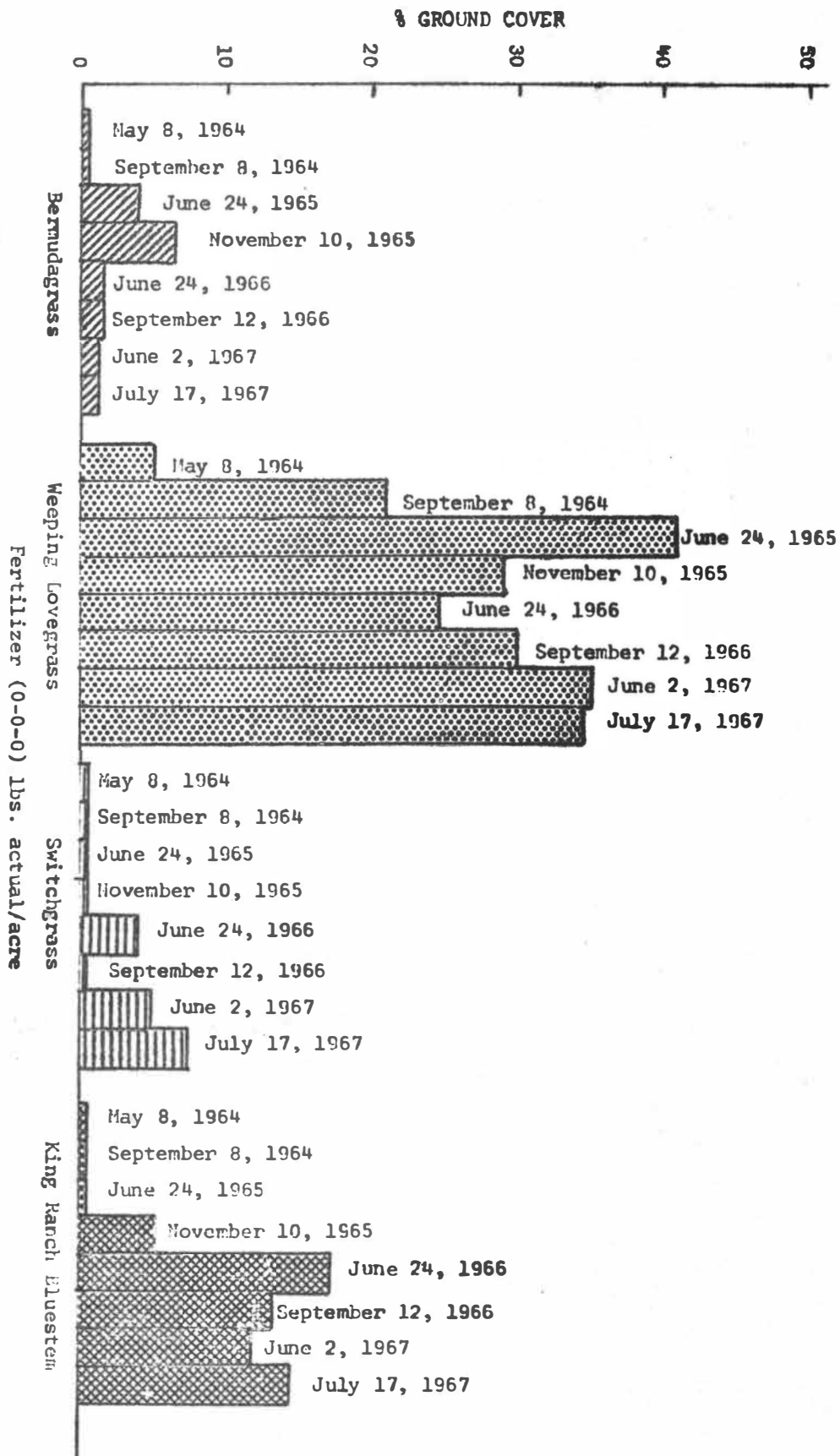


Figure 24. The effect of various fertilizers applied April 22, 1964, and retreated May 6, 1965, and June 7, 1966, on the growth of four grasses on a north facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma.

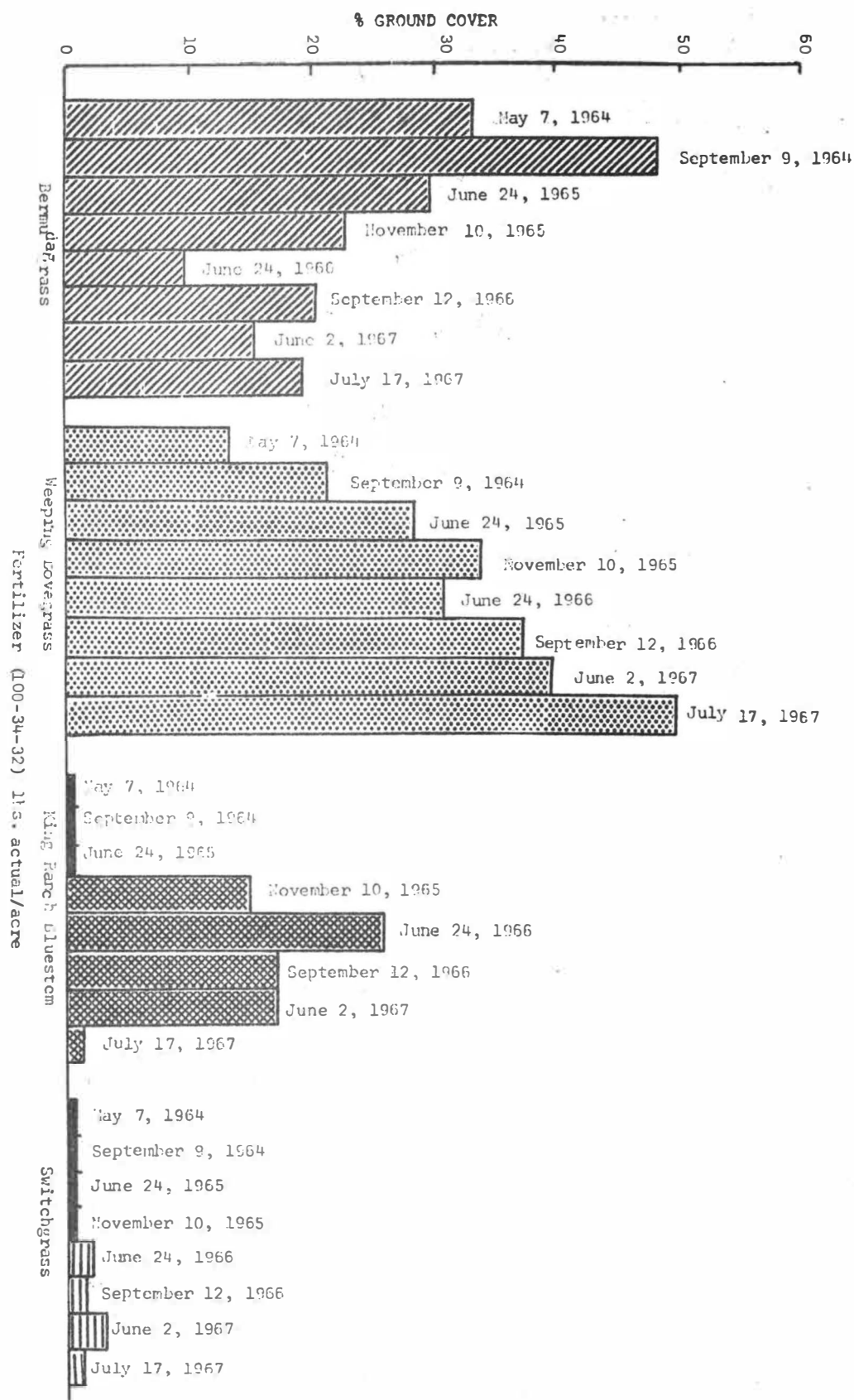


and application frequency could not be made in the brief elapsed time of the experiment. The addition of fertilizer, particularly nitrogen, resulted in a distinct increase in weeping lovegrass, but only a slight increase in switchgrass, and practically no change in the amount of K. R. Bluestem. There is an indication however, that weeping lovegrass is better adapted for use in erosion control on north facing slopes than bermuda.

A duplicate experiment of the above was initiated in 1964 on US-270 about 3 1/2 miles further west on a sandy loam, 3:1 backslope. The preliminary results of these fertilizer treatments are shown in Figures 25 through 30. Initially a good stand of bermudagrass and weeping love were the dominant grasses on the south facing slope with bermuda providing 5 to 20% more ground cover than weeping love. After three years weeping lovegrass had increased in abundance, particularly where fertilized, to the point it provided 15 to 40% more ground cover than bermuda which had declined in density even when fertilized, and was completely gone in those areas that had not been fertilized. In the non-fertilized areas weeping lovegrass further exhibited its usefulness in erosion control by increasing 22% in the amount of ground cover. However, the greatest increase in ground cover on these unfertilized sites was provided by K. R. bluestem which was essentially non-existent in 1964, and then three years later furnished a cover for 44% of the soil surface.

Immediately south, across US-270, a duplicate investigation was conducted except for a north exposure. The initial, but incomplete results of these fertilizer treatments are shown in Figures 31 through 36. On this north facing slope, initially seeded to bermudagrass, weeping love, switchgrass, and K. R. bluestem the bermuda has completely disappeared while weeping love increased in all treatments even without fertilization, to the point of providing ground cover for about 70% or more of the backslope area. Switchgrass increased under nitrogen fertilization, particularly at the higher rates, and furnished about 20% coverage

Figure 25. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.



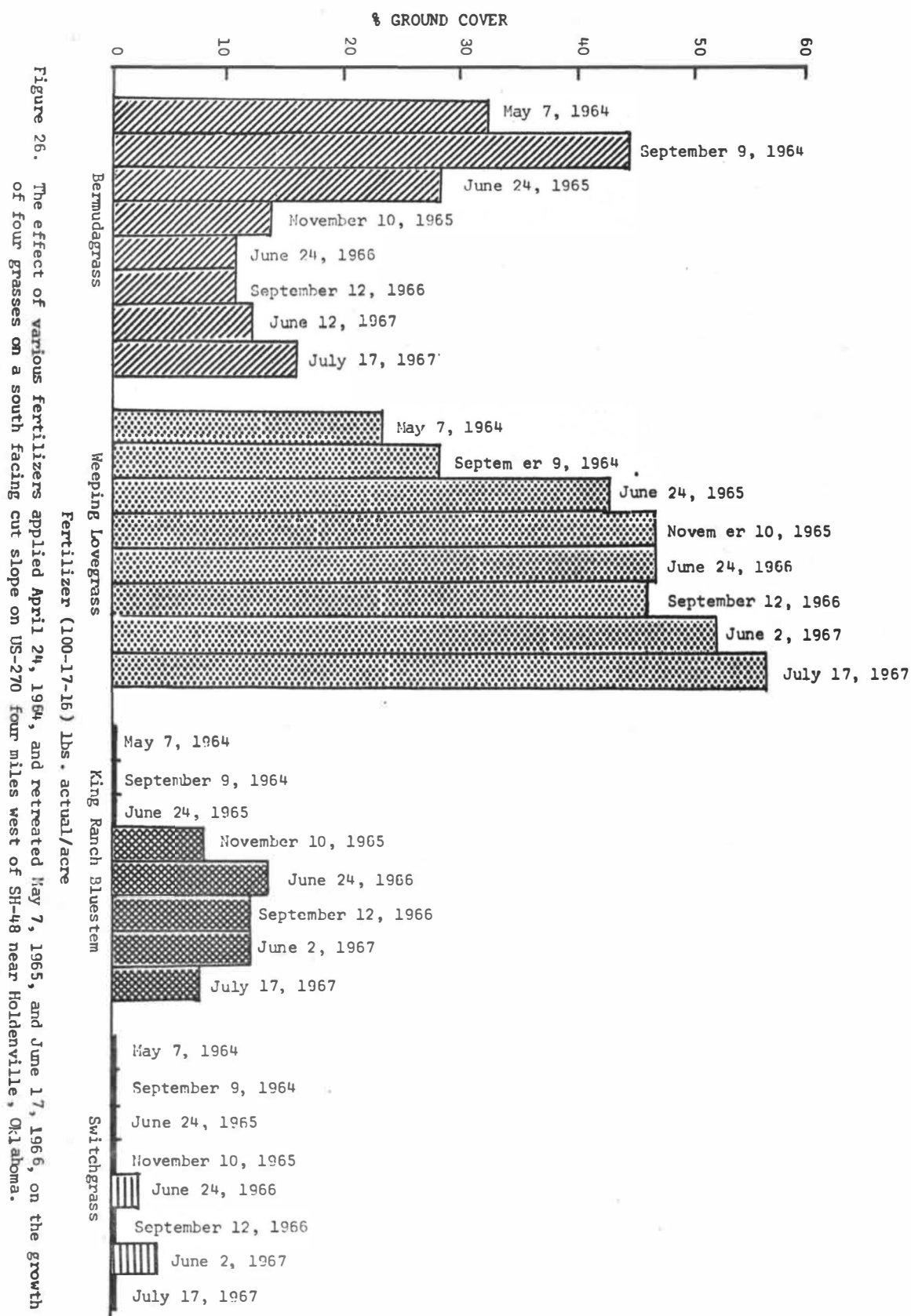


Figure 26. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.

Figure 27. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.

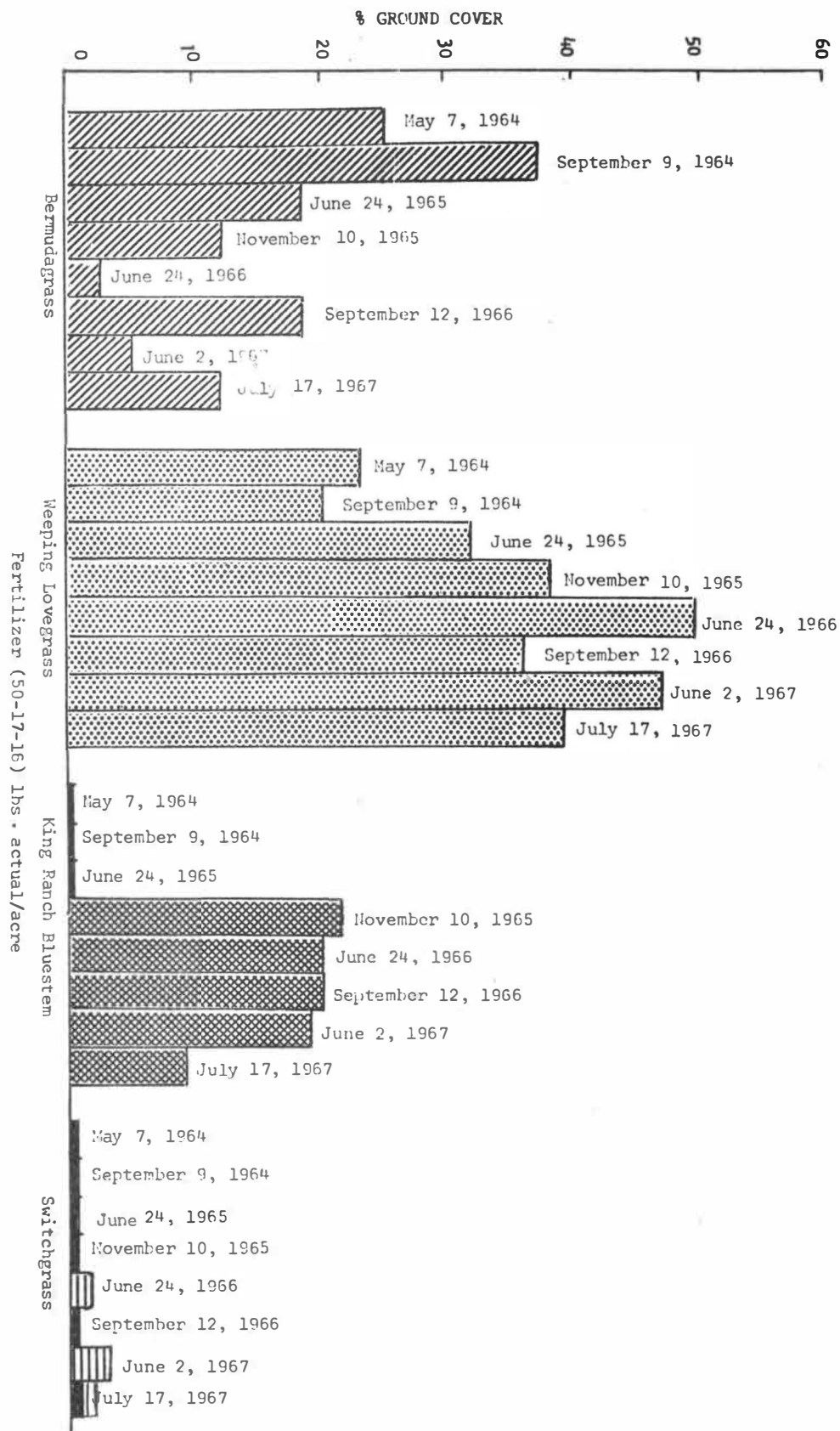


Figure 28. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of Stillwater, Oklahoma.

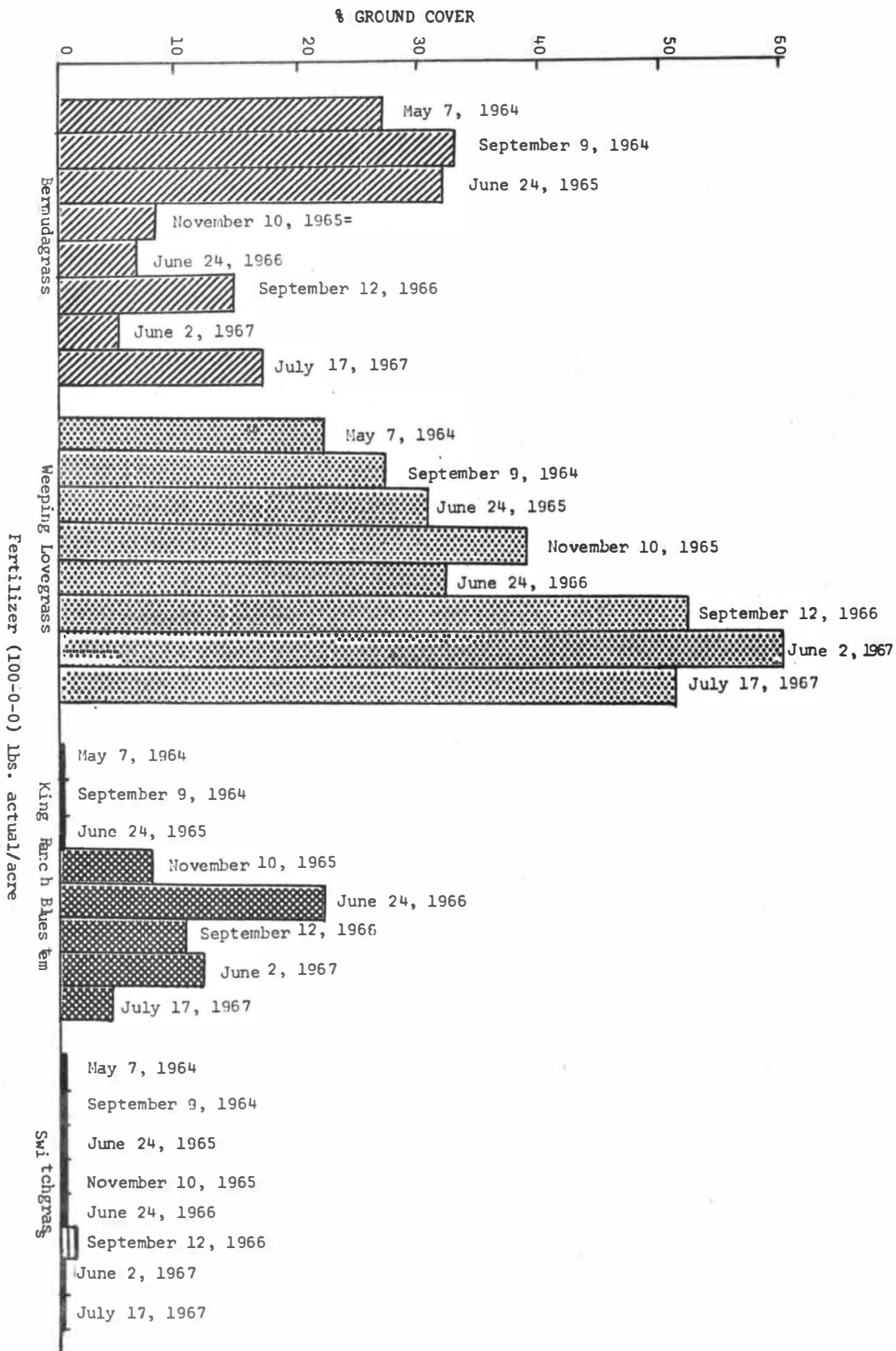


Figure 29. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.

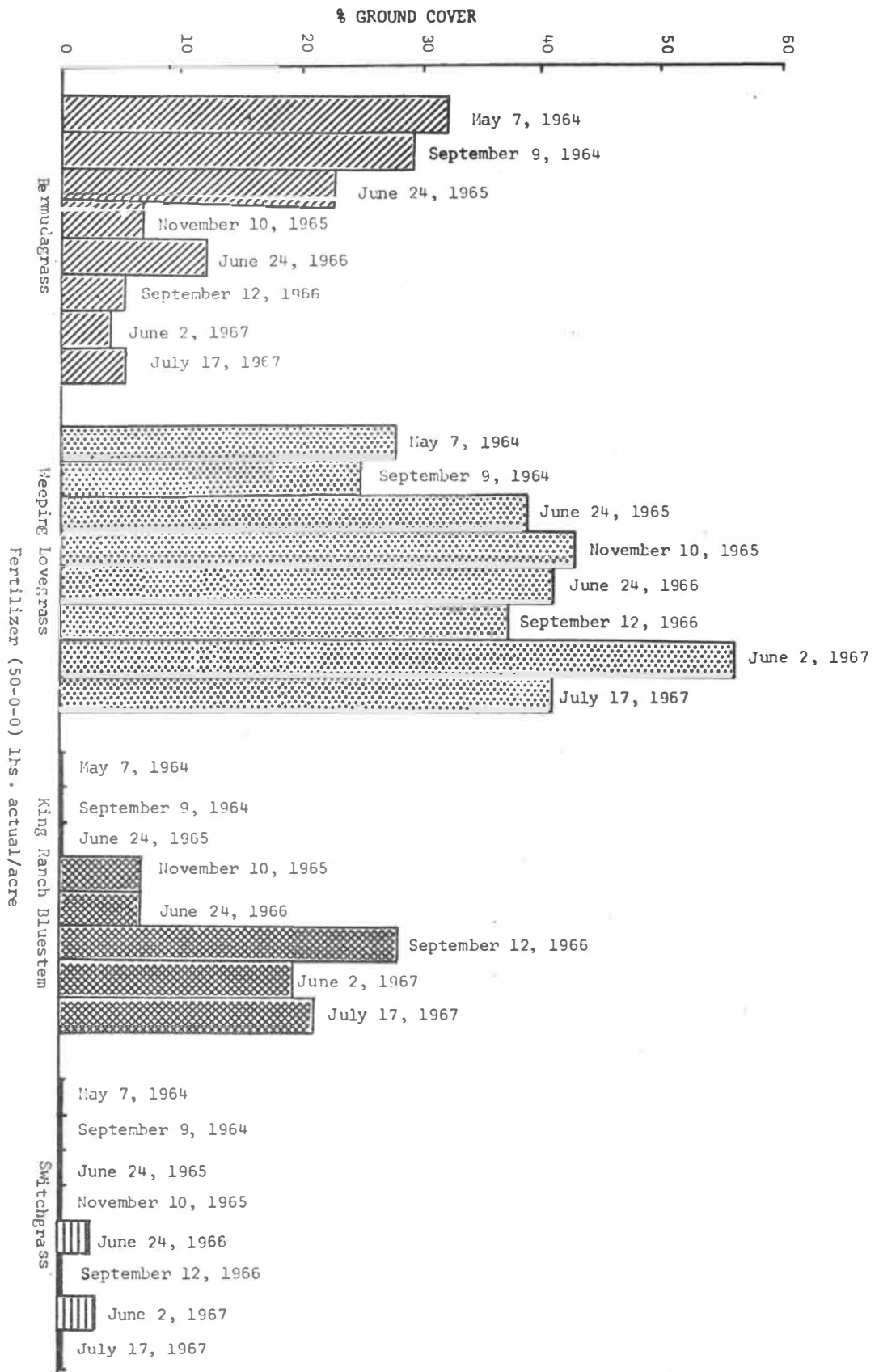
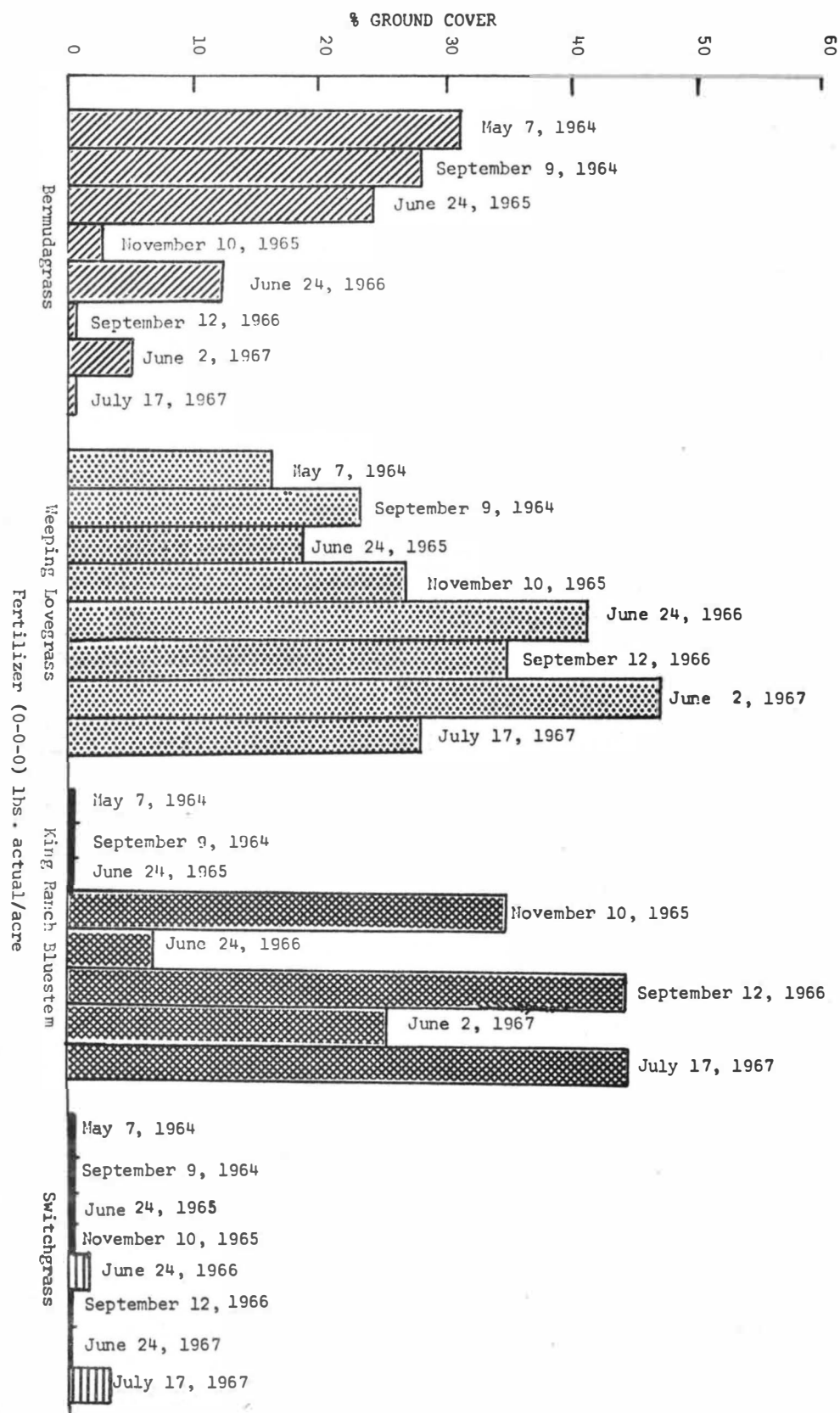
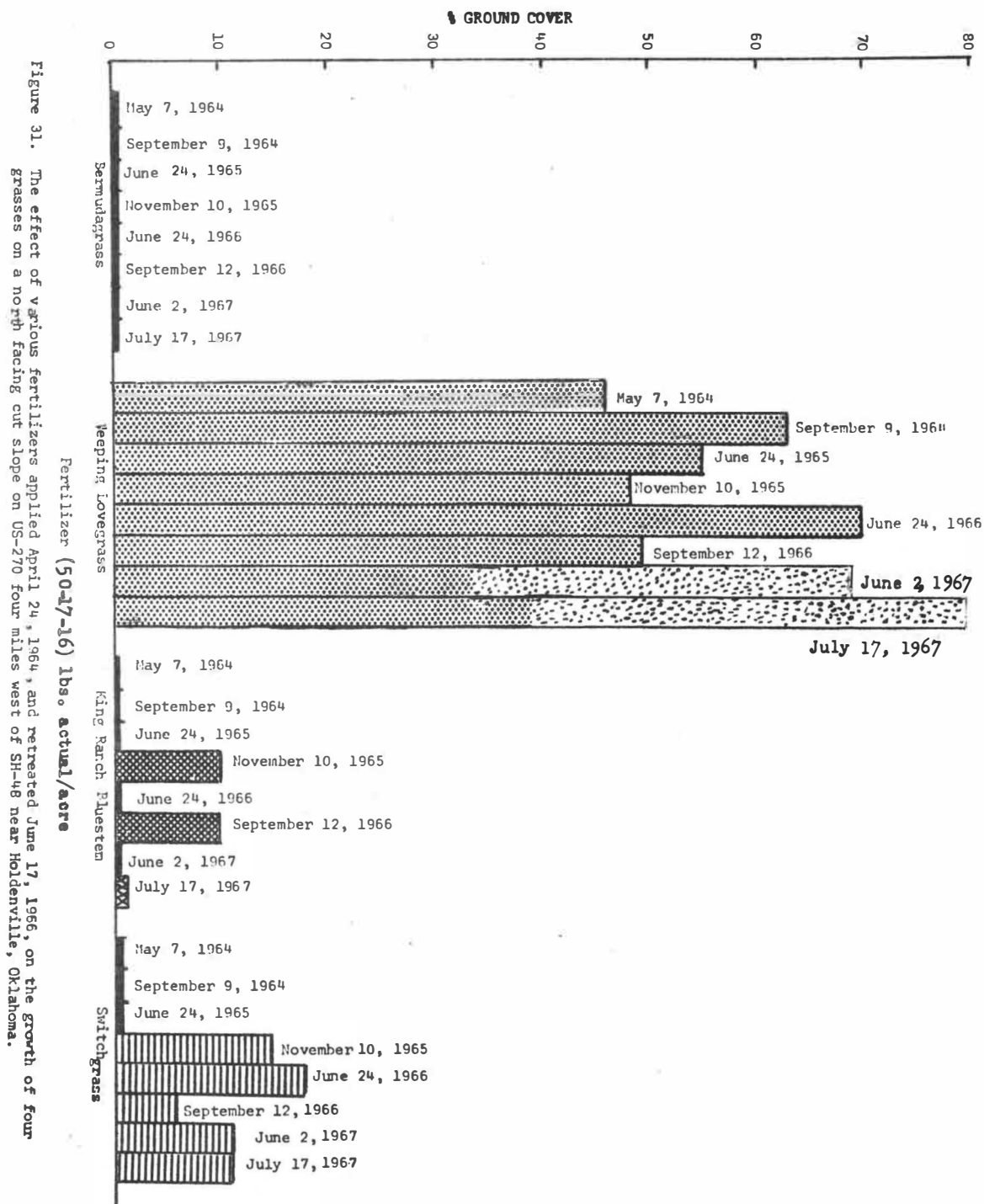
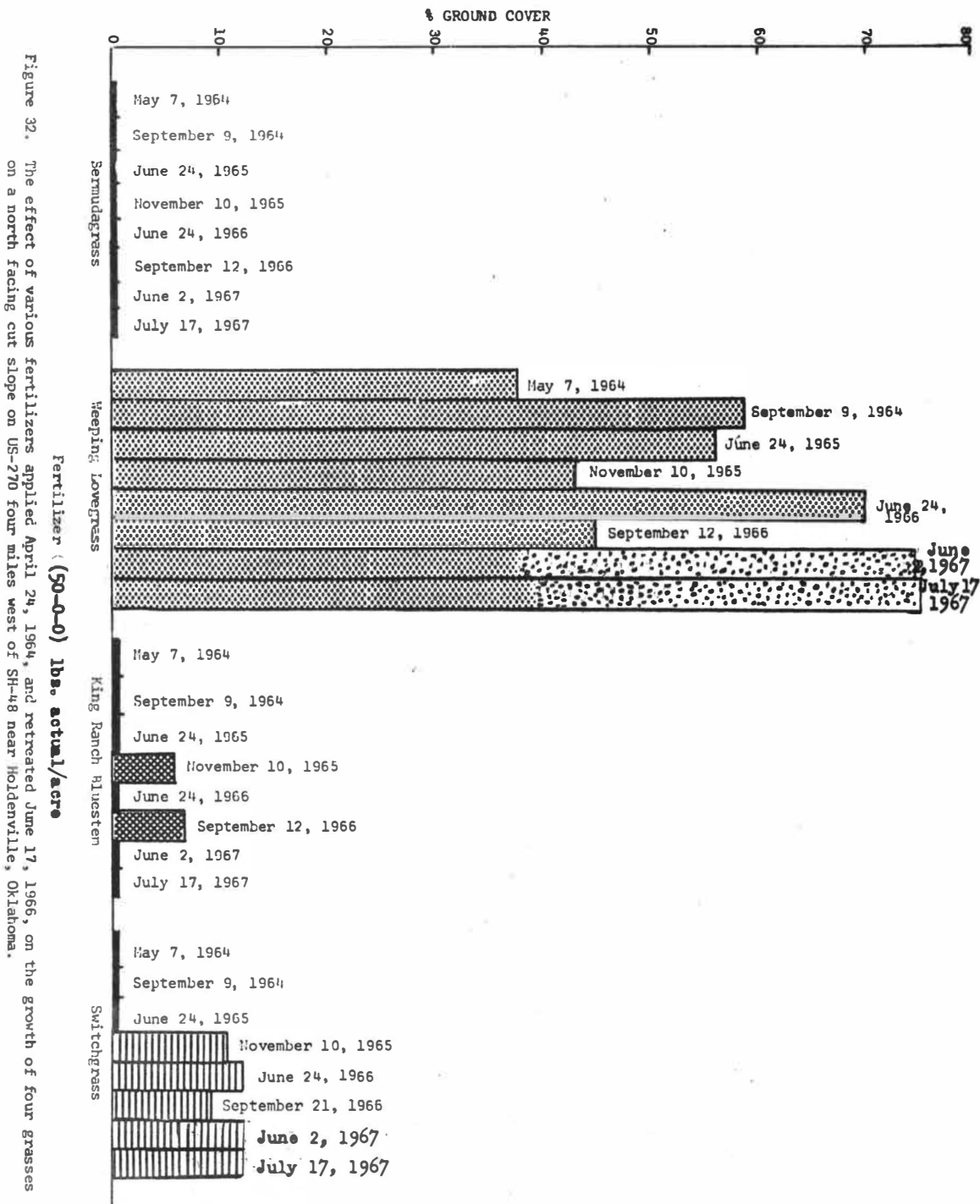
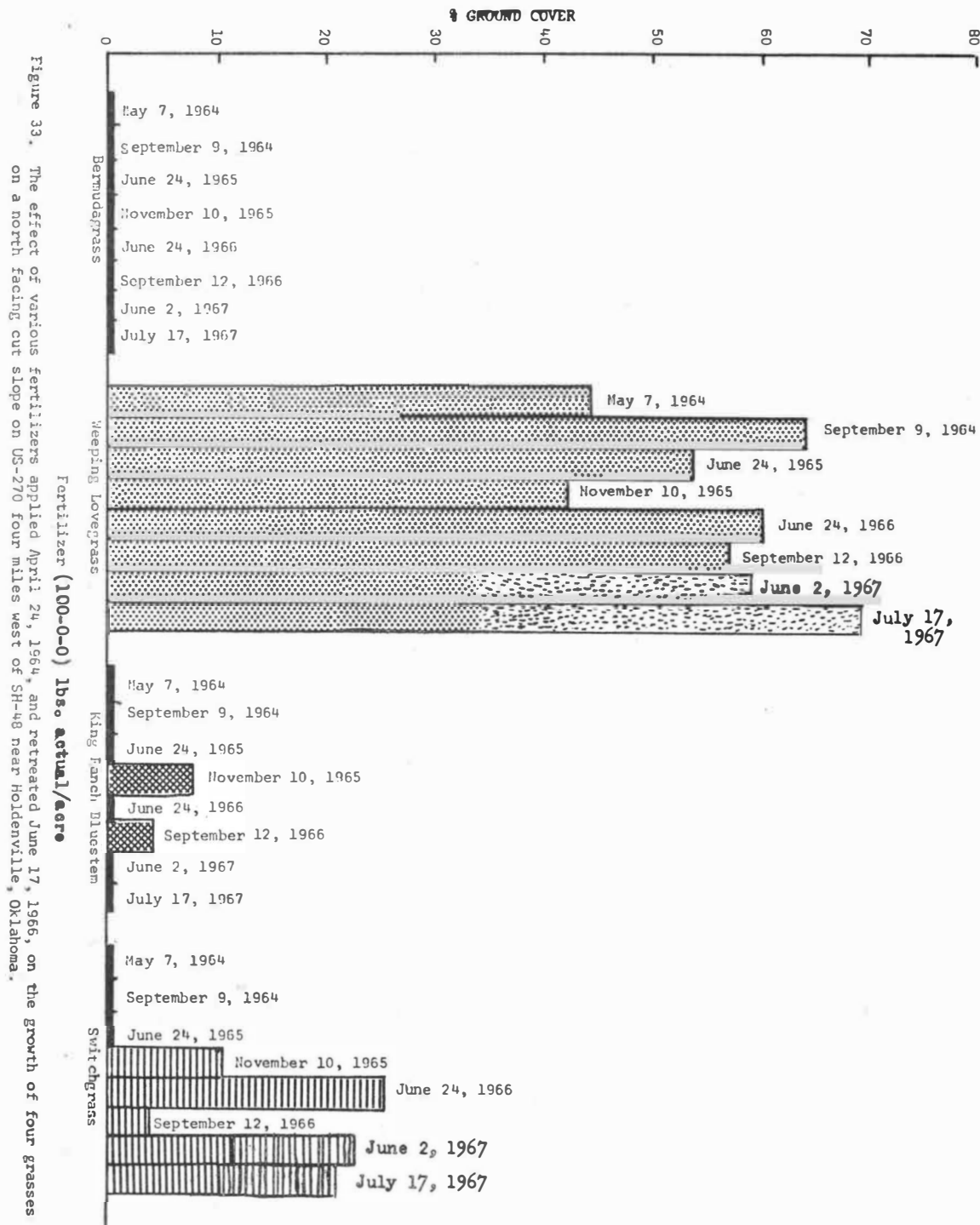


Figure 30. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of four grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.









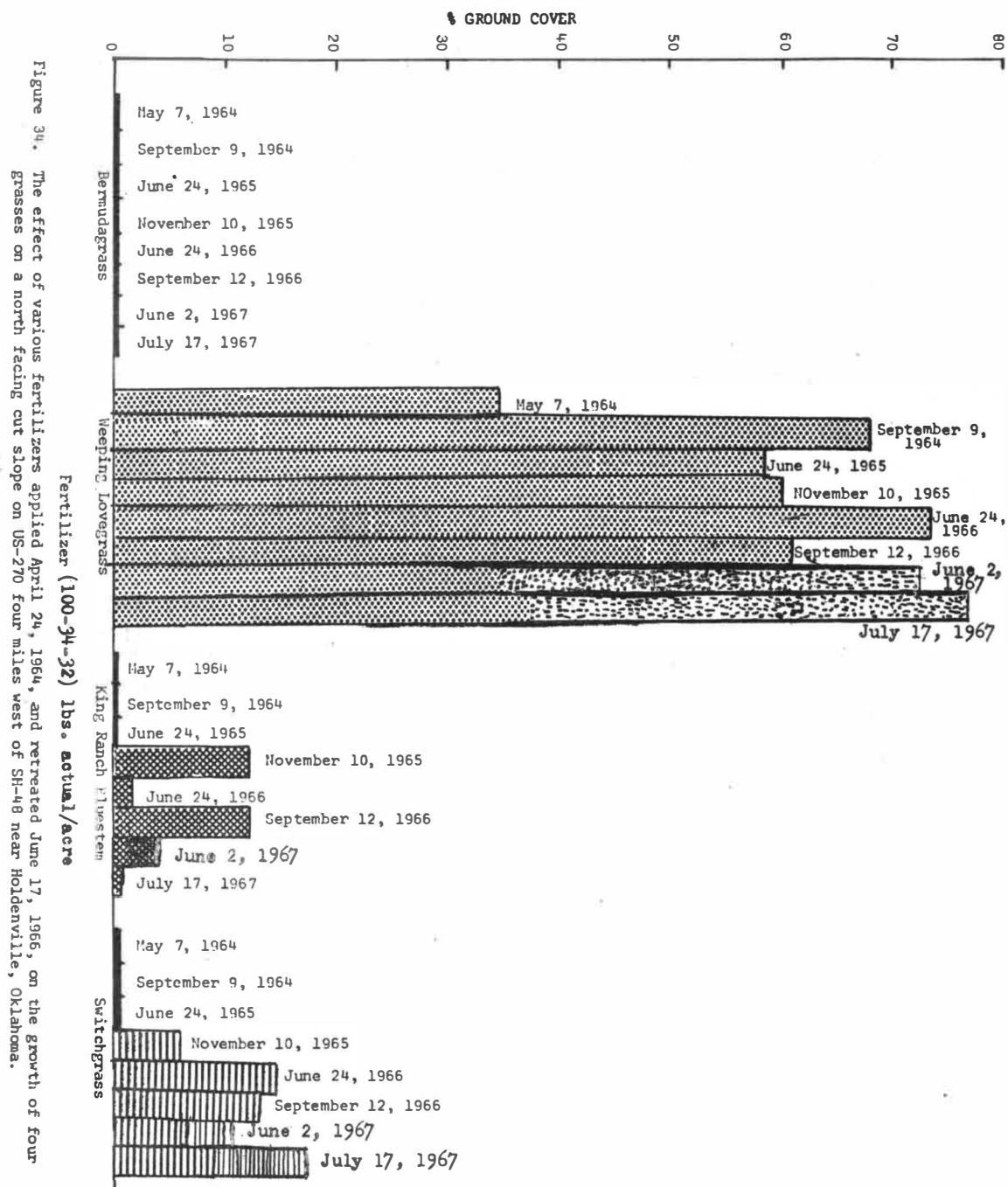
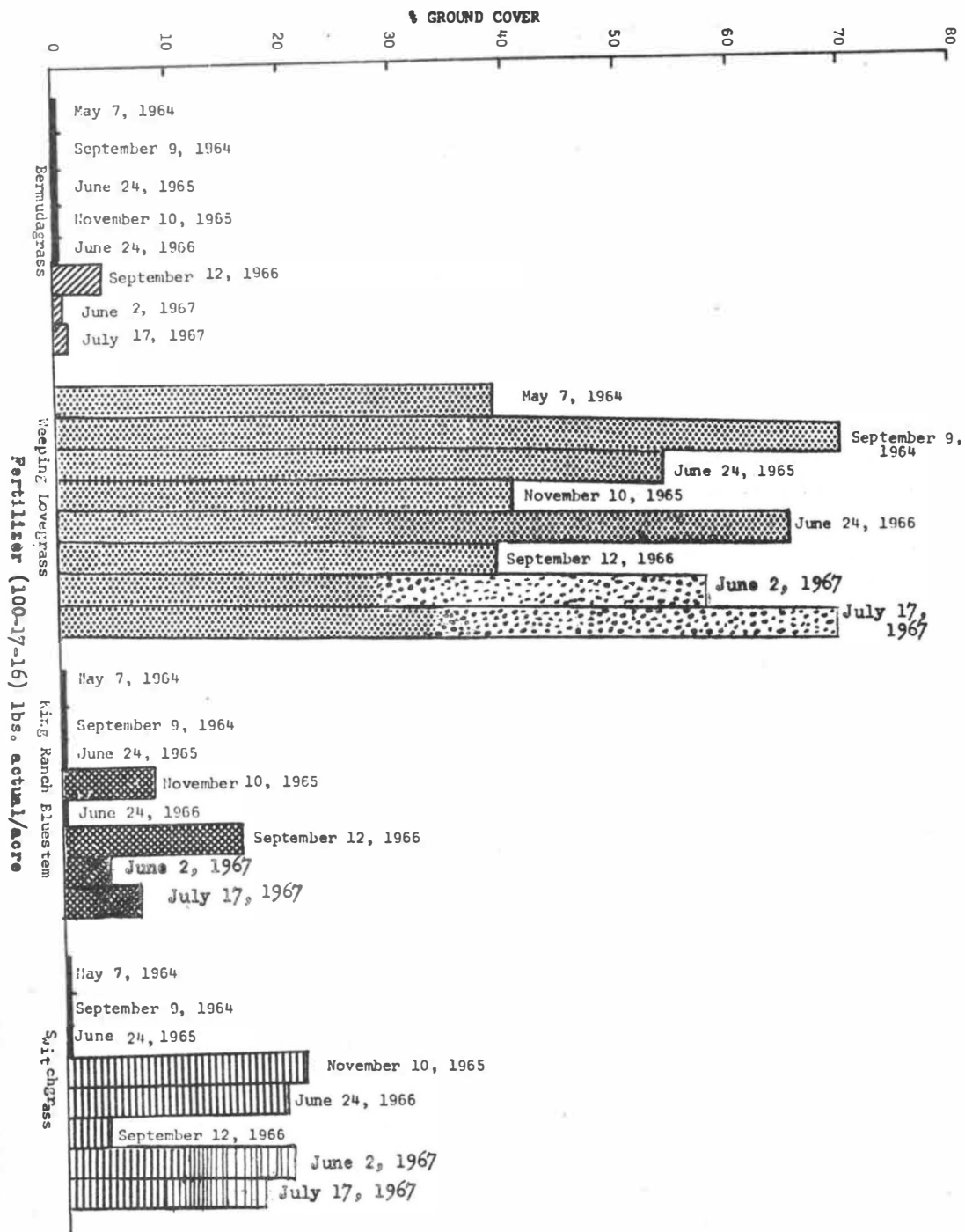
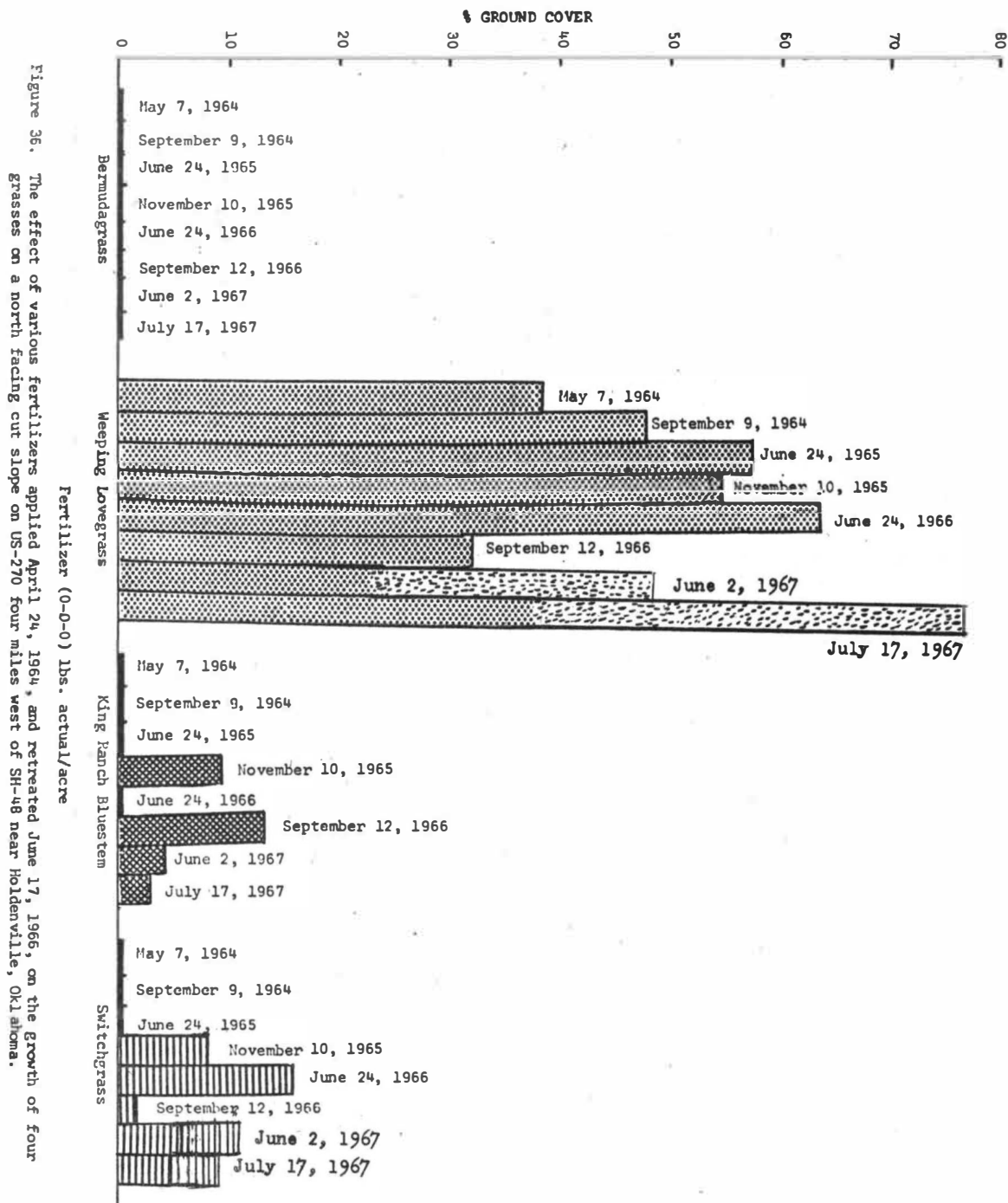
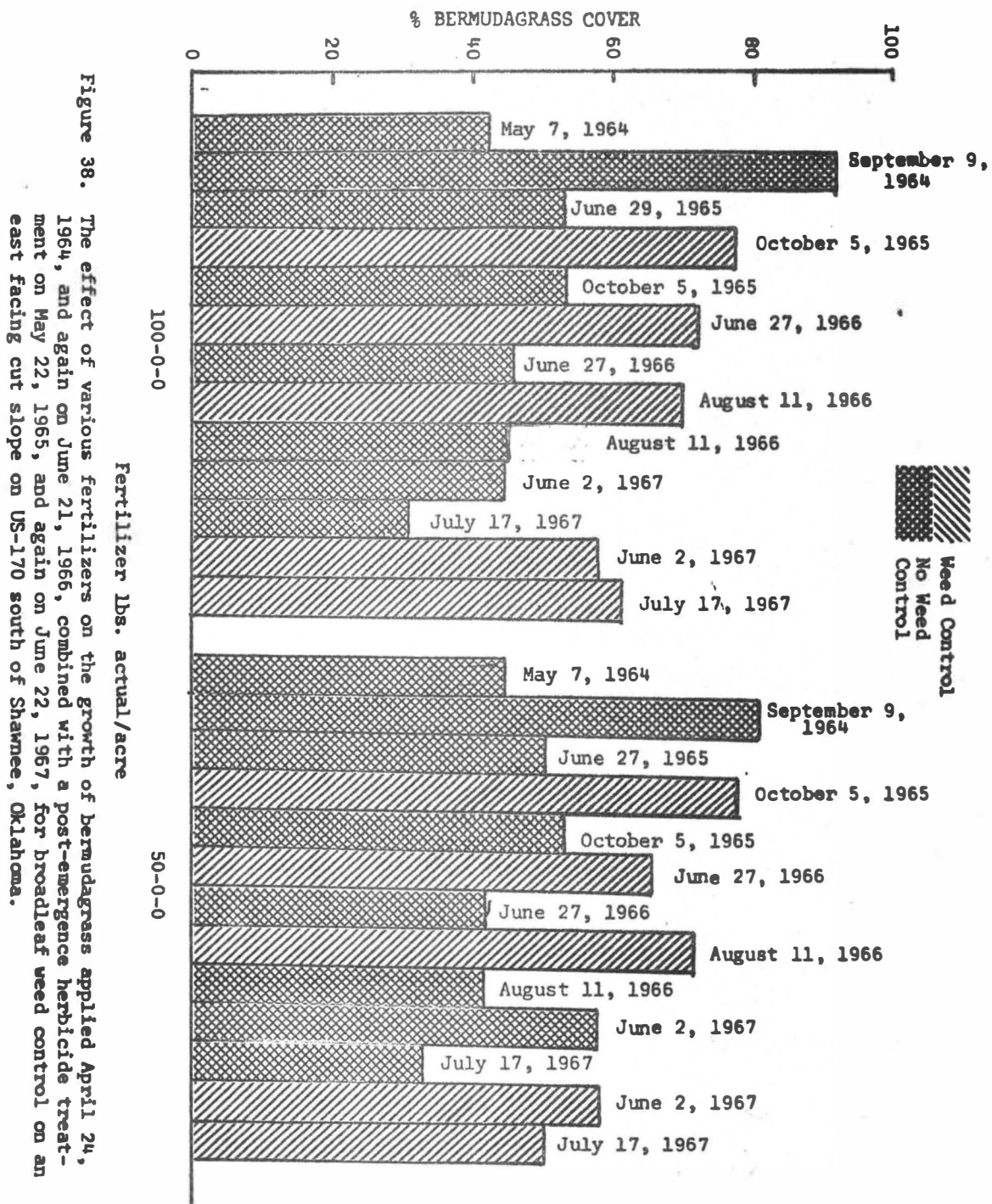
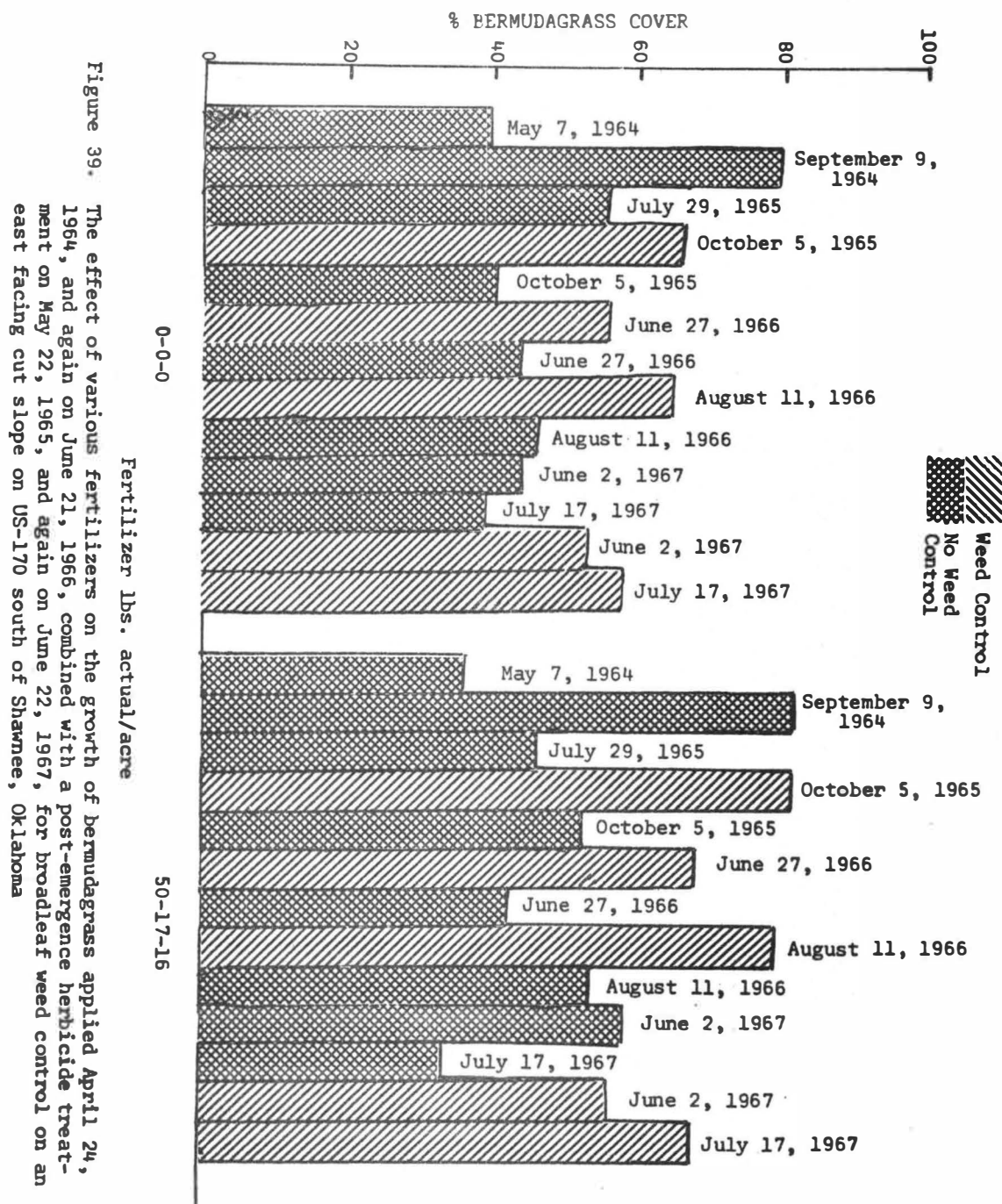


Figure 35. The effect of various fertilizers applied April 24, 1964, and retreated June 17, 1966, on the growth of four grasses on a north facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma.









treatments were reapplied in June the next two years. The initial results of these fertilizer experiments are shown in Figures 40 and 41. A 70% ground cover from bermudagrass is considered to be adequate for protection and soil stabilization on most backslopes in this area.

Three annual applications, each of 100-17-16 lbs. actual fertilizer per acre yielded the greatest increase in bermudagrass cover in this investigation. At the end of the third year after the initial treatment, almost 83% of the backslope was covered with bermudagrass. Almost to the arbitrary level of satisfactory ground cover was the area treated with 50-17-16 lbs. of actual fertilizer elements per acre in each of three successive years. The application of 50 lbs. actual nitrogen per acre in each of these three years almost produced a satisfactory level of bermudagrass cover.

On the hotter, west-facing slope on I-35 across from the above experiment a duplicate investigation was initiated in 1964. Only 33.5% of the backslope was covered with bermudagrass when these experiments started. The preliminary results of these fertilizer experiments are shown in Figures 42 and 43.

All fertilizer treatments with one exception produced more than 70% vegetative cover at this location in three years time. The annual application of 50 lbs. nitrogen per acre for three years was approaching the arbitrary level of satisfactory cover at the end of the third year. The unfertilized portion of this area maintained about the same bermudagrass cover throughout this brief period of time. Only about 40% of the backslope was protected by a bermudagrass cover when no fertilizer was applied. This is considered to be definitely inadequate for erosion control on cut and fill slopes in Oklahoma!

In 1964 six fertilizer treatments were applied to a north facing backslope on Interstate 40 near Hydro in western Oklahoma. The vegetative cover was mostly sideoats grama (Bouteloua curtipendula), switchgrass (Panicum virgatum), and weeping lovegrass in that order. The loamy soil was moderately eroded and the vegetation

Figure 40. The effect of various fertilizers applied April 17, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of bermudagrass on an east facing cut slope on I-35 three-fourths of a mile south of SH-51.

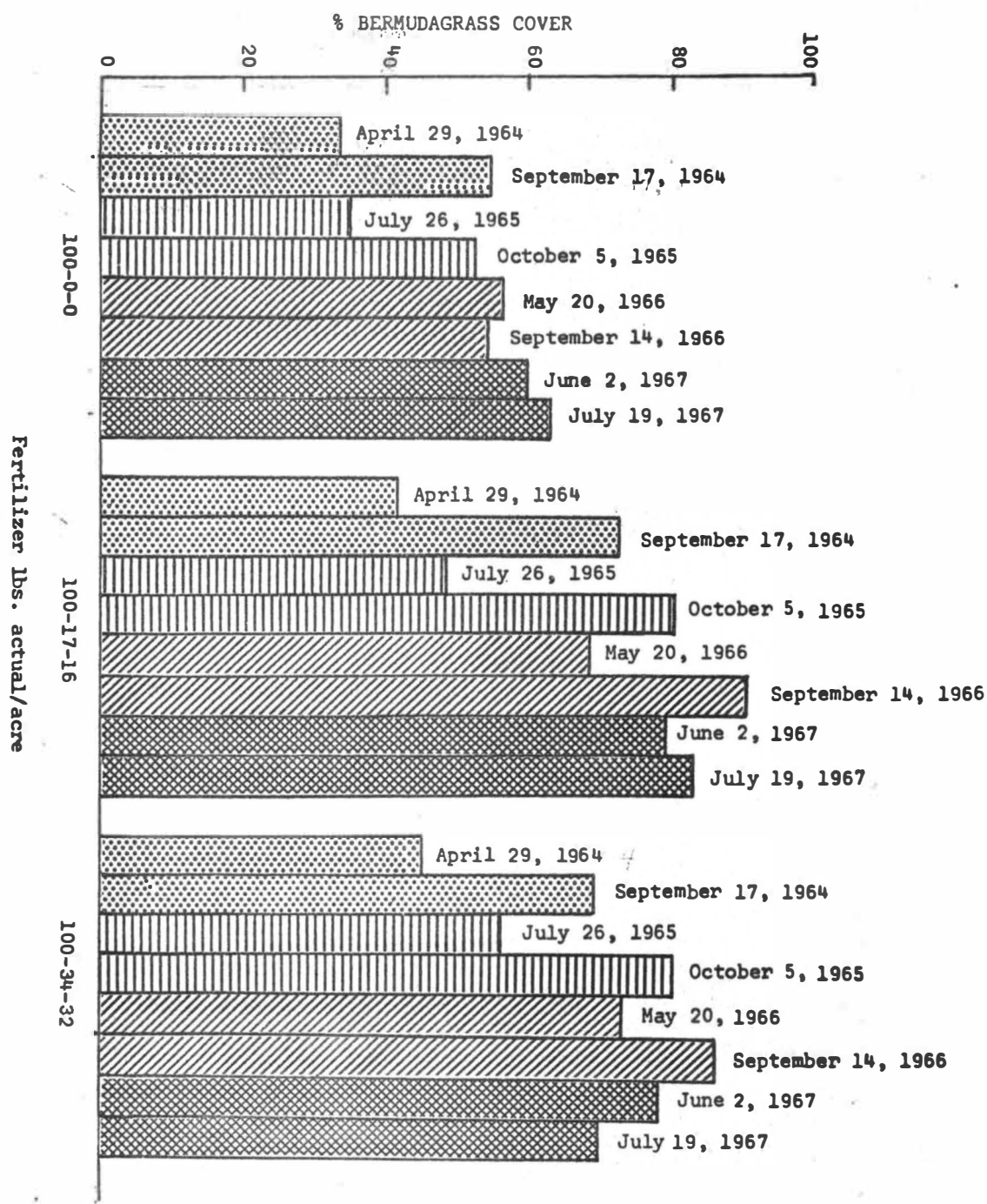


Figure 41. The effect of various fertilizers applied April 17, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of bermudagrass on an east facing cut slope on I-35 three-fourths of a mile south of SH-51

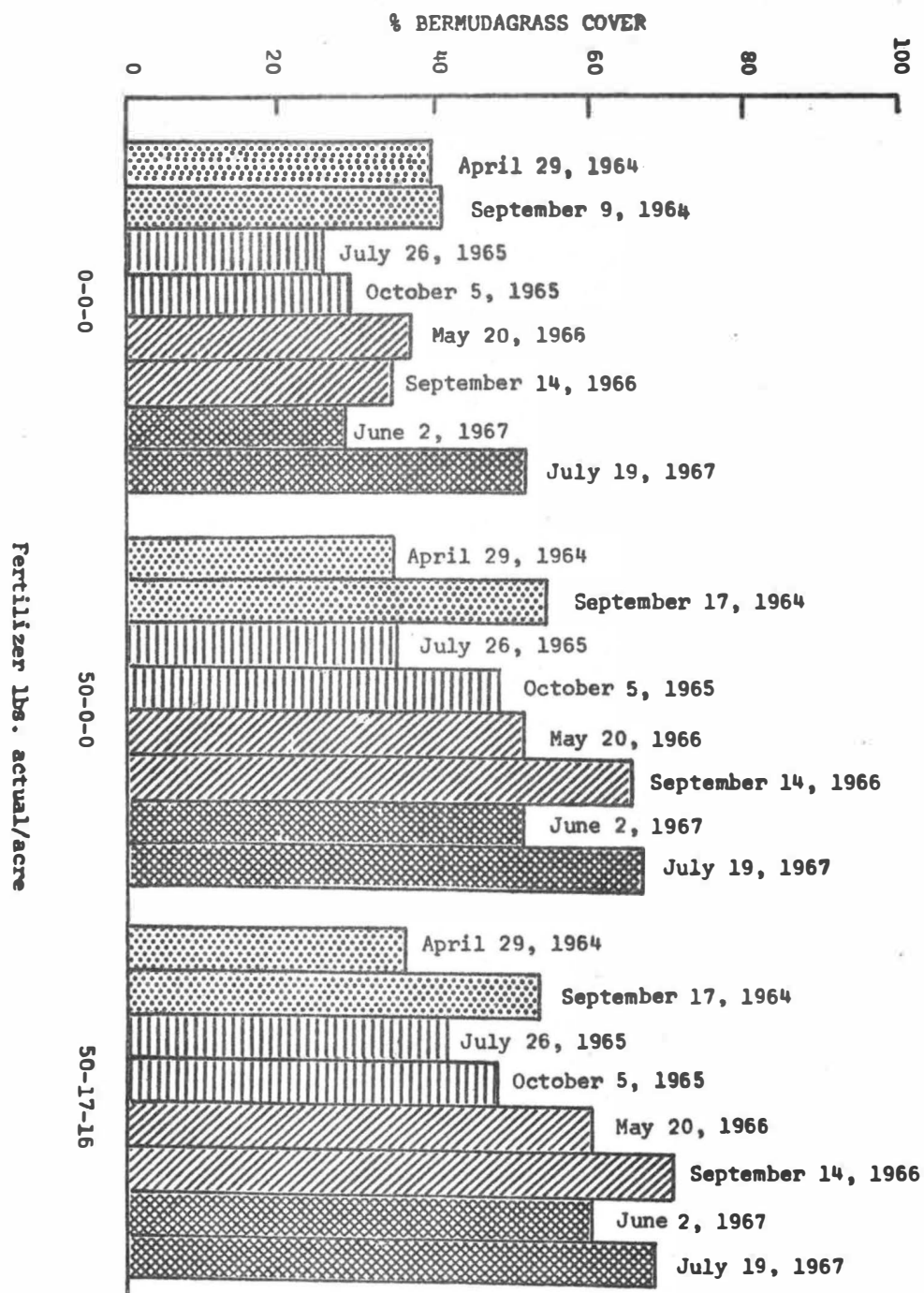
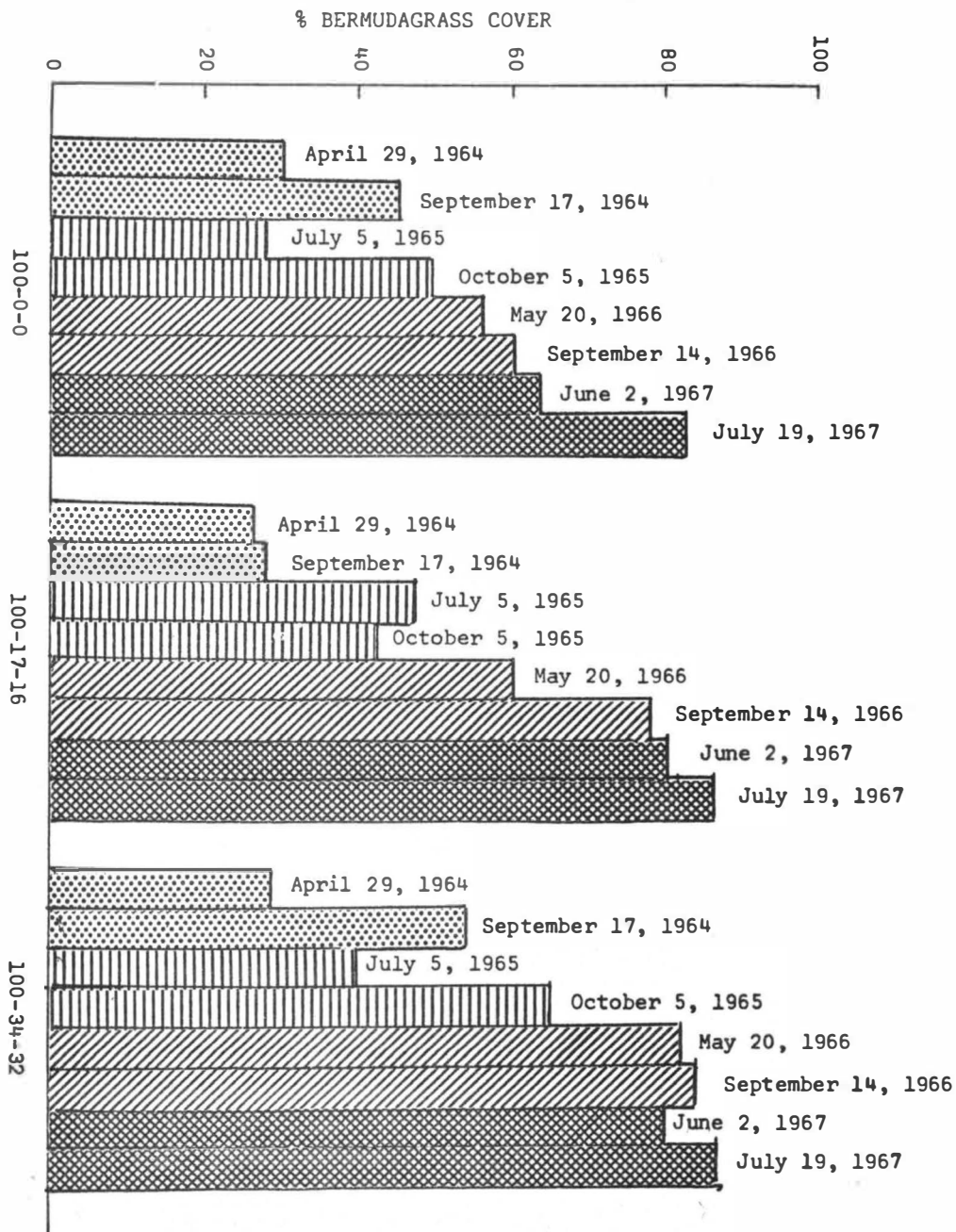
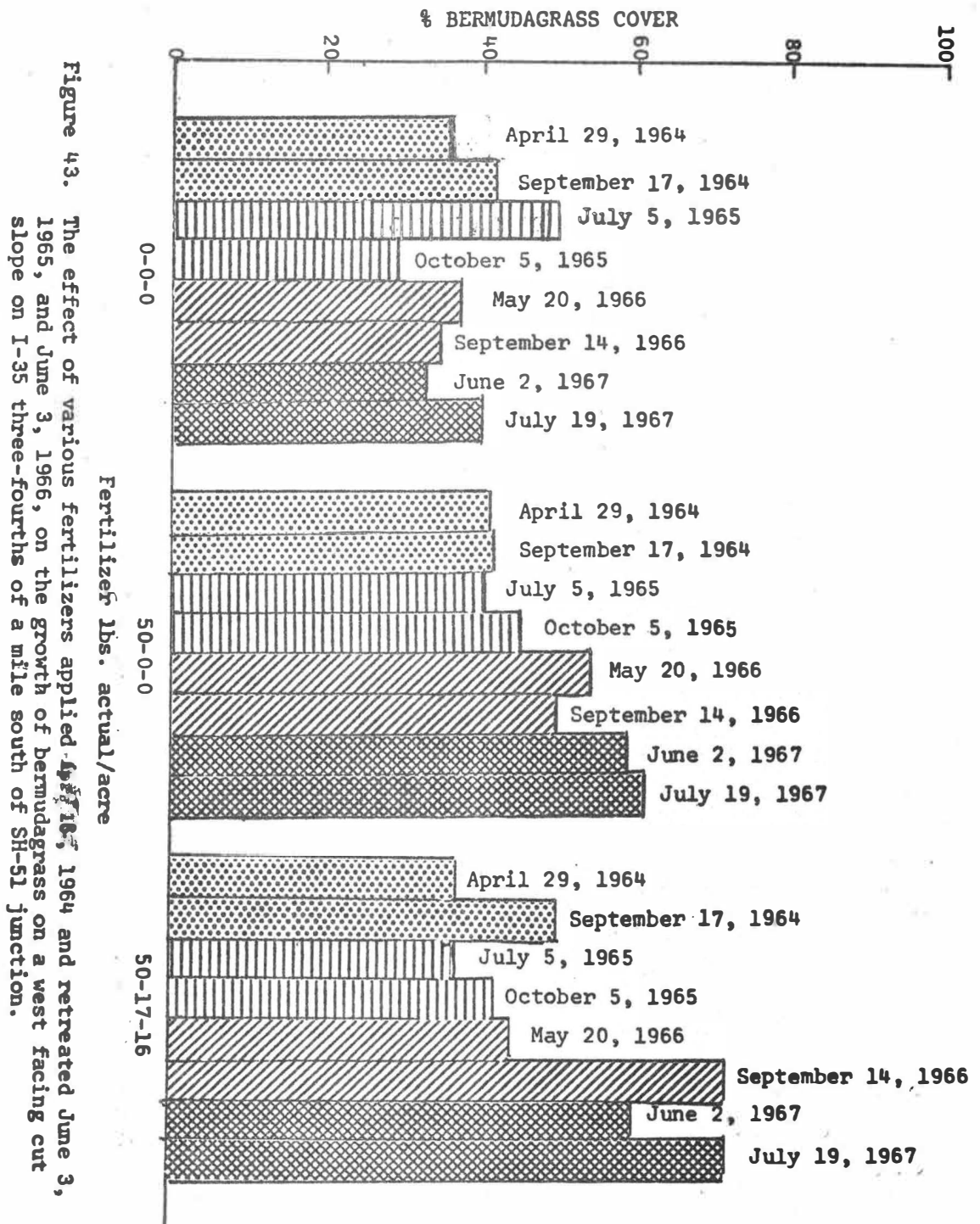


Figure 42. The effect of various fertilizers applied April 10, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of bermudagrass on a west facing cut slope on I-35 three-fourths of a mile south of SH-51 junction.





was in a poor condition. The percent ground cover from all grasses declined during this short period of time in the unfertilized areas but had increased at the end of three years from all fertilizer treatments. The greatest increase in percent ground cover occurred in those areas that recieved only nitrogen. The preliminary results of these fertility treatments are shown in Figures 44 through 49. Sideoats grama made its greatest increase in percent ground cover when fertilized with the high rate of nitrogen, phosphorus, and potassium. The 100-34-32 (pounds of actual) fertilizer produced twice as much ground cover from sideoats grama as did 100 pounds of nitrogen alone. Weeping lovegrass however, just as all grasses combined, produced the most ground cover when fertilized with only nitrogen.

On a north-facing fill slope one-half mile west of the above experiment on I-40, bermudagrass declined in percent ground cover from June 1964 to October 1966 in all except one fertilizer treatment. The preliminary evaluations of these six fertilizer treatments on the growth and persistence of bermudagrass are shown in Figures 50 and 51. The fill soil is a sandy loam, with an occassional ditch beginning to form when the investigation started in 1964. Considerable water from the elevated slope of the highway pours down over the fill surface. The application of 100-17-16 pounds of actual N-P-K per acre in each of the three years 1964 to 1966, increased the percent ground cover slightly, whereas all other treatments showed a definite decline in the amount of bermuda. These data tend to indicate that the application of a complete, high analysis fertilizer is not enough to maintain bermudagrass (a full-sun loving grass), on the shaded, colder slopes of a north-facing fill area.

Further west about one-quarter mile from the above experiment on I-40, six fertilizer treatments were applied initially in May 1964 on a moderately eroded 3:1 backslope with a fair, but inadequate cover of sideoats grama, weeping love, and switchgrass. The soil is a sandy loam with some sandstone exposed near

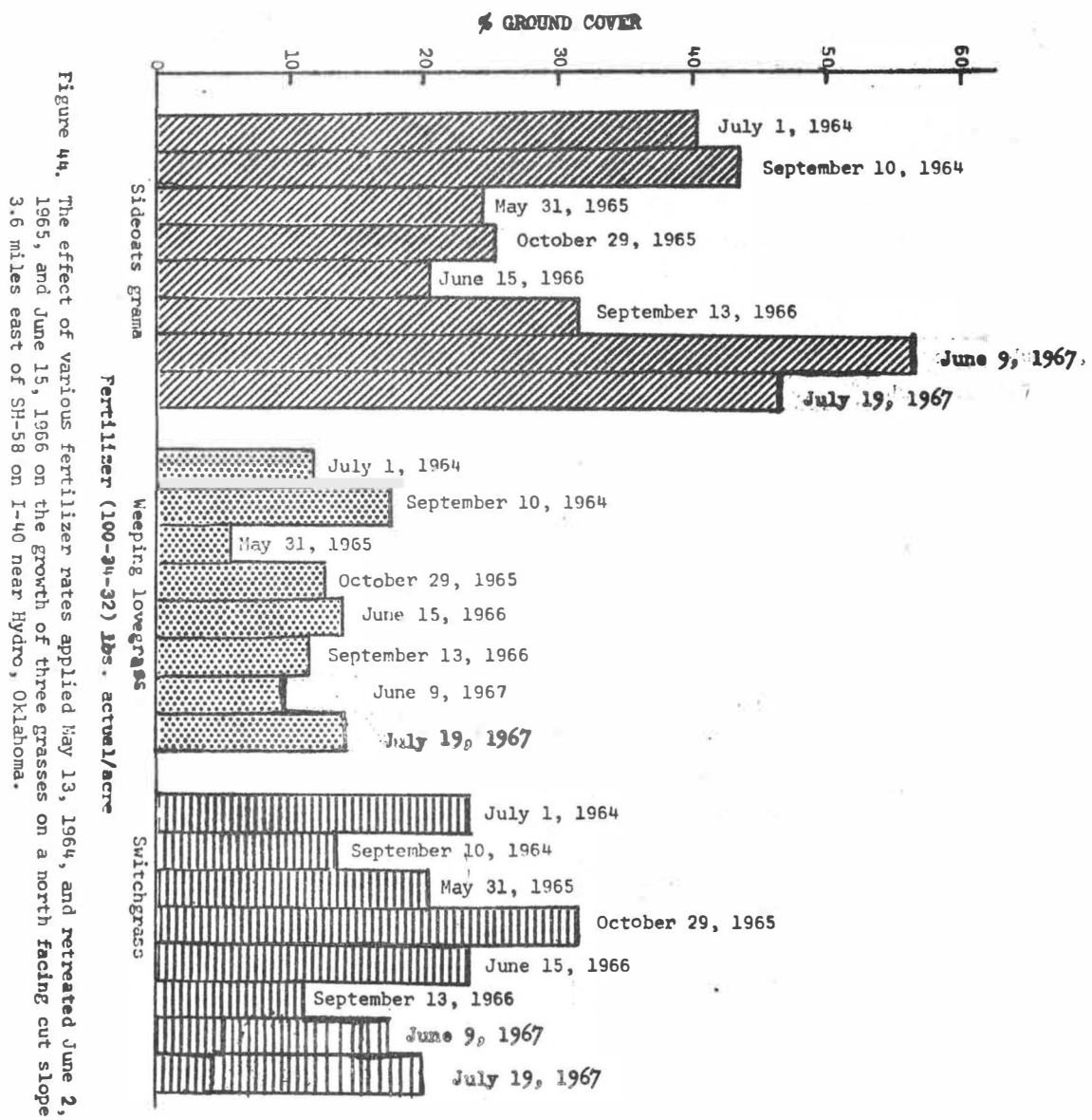
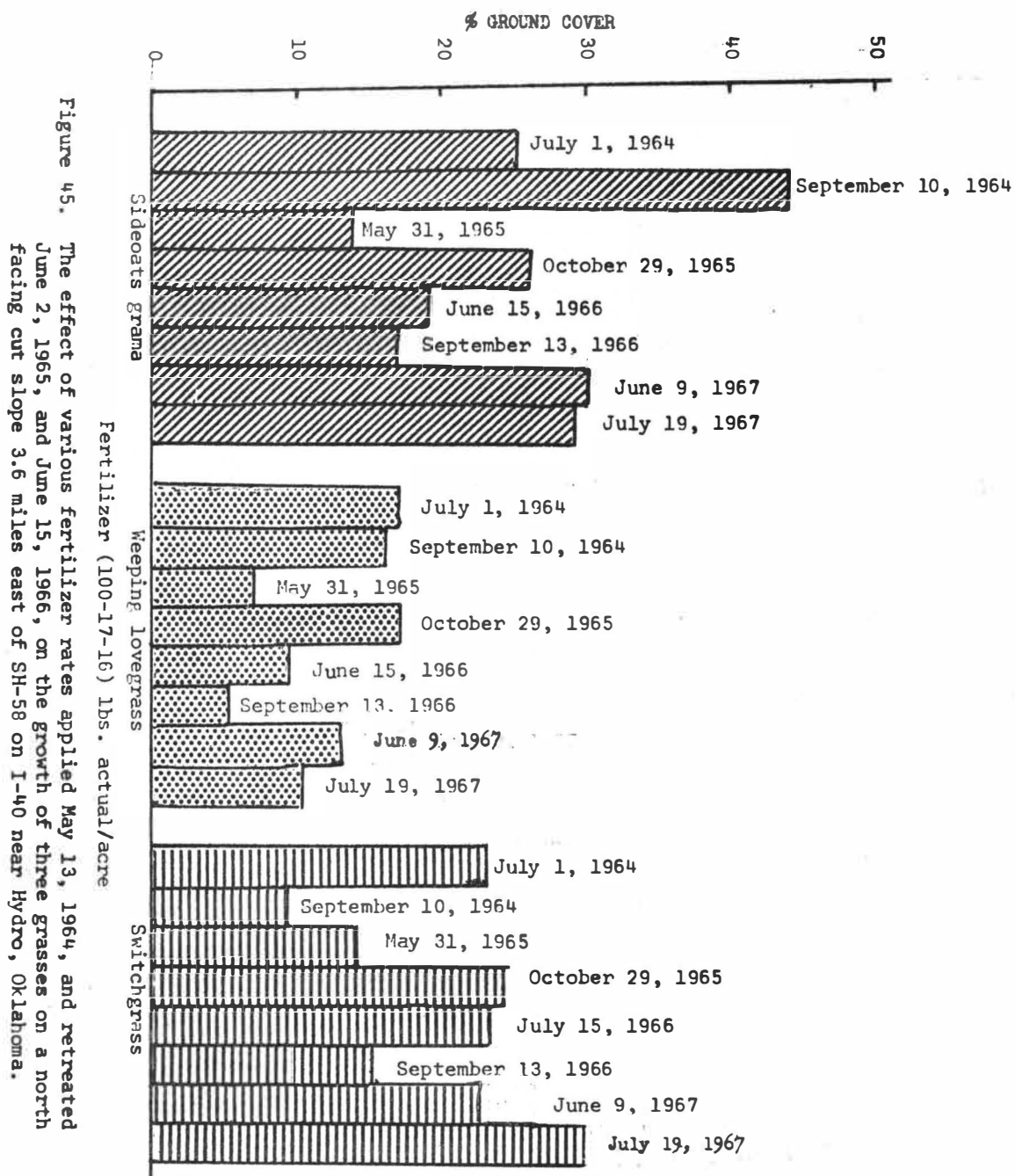
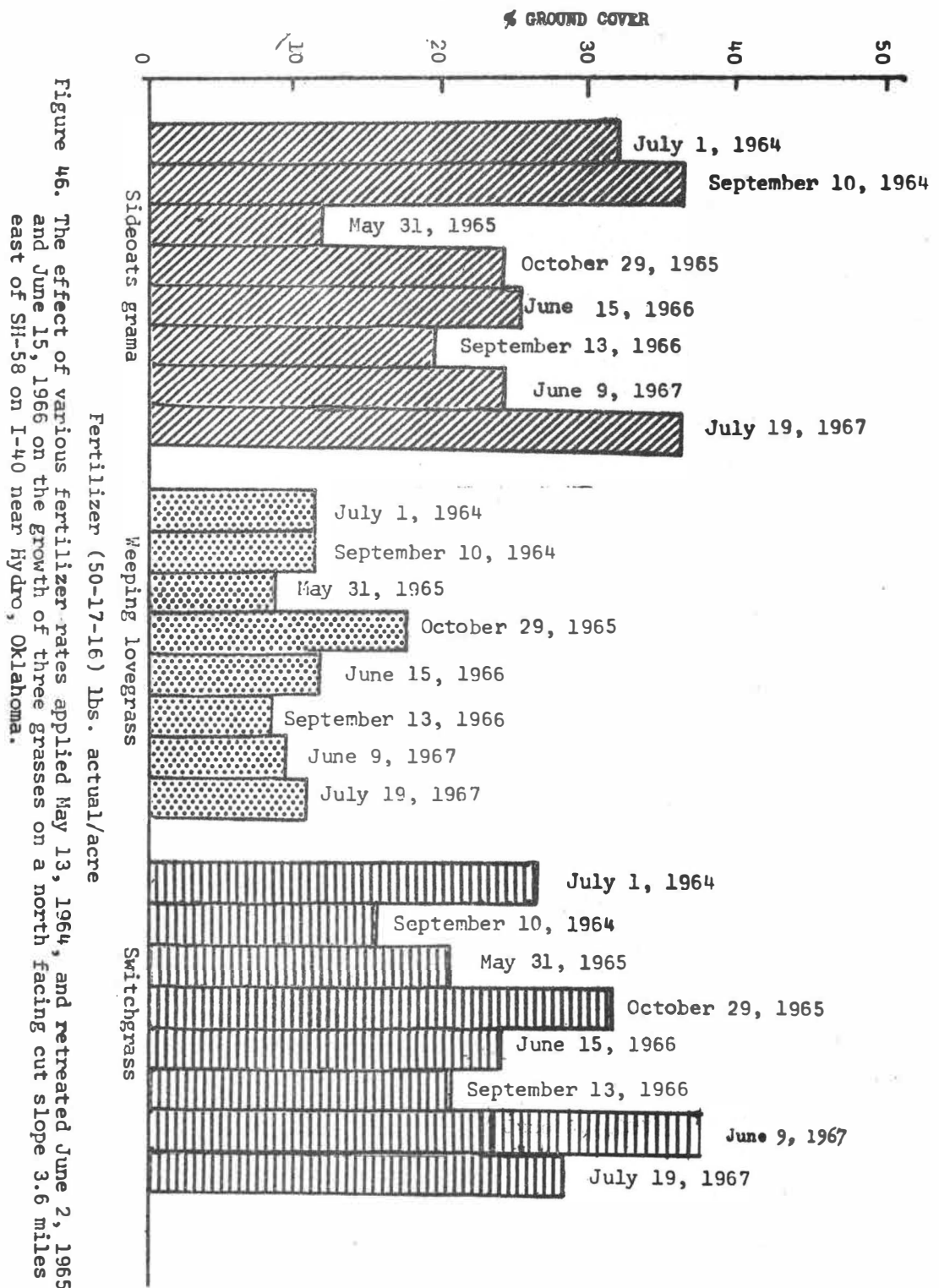
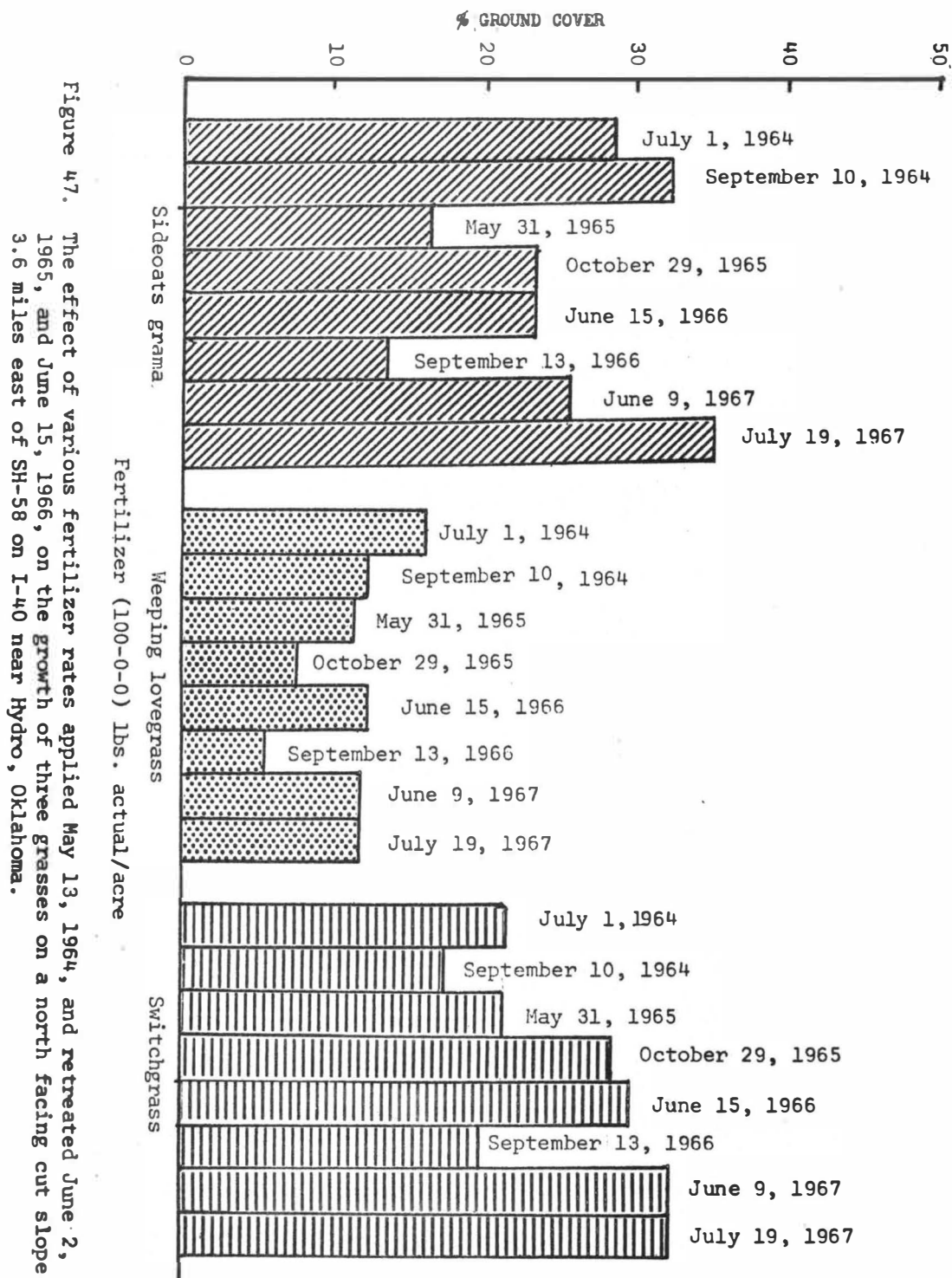
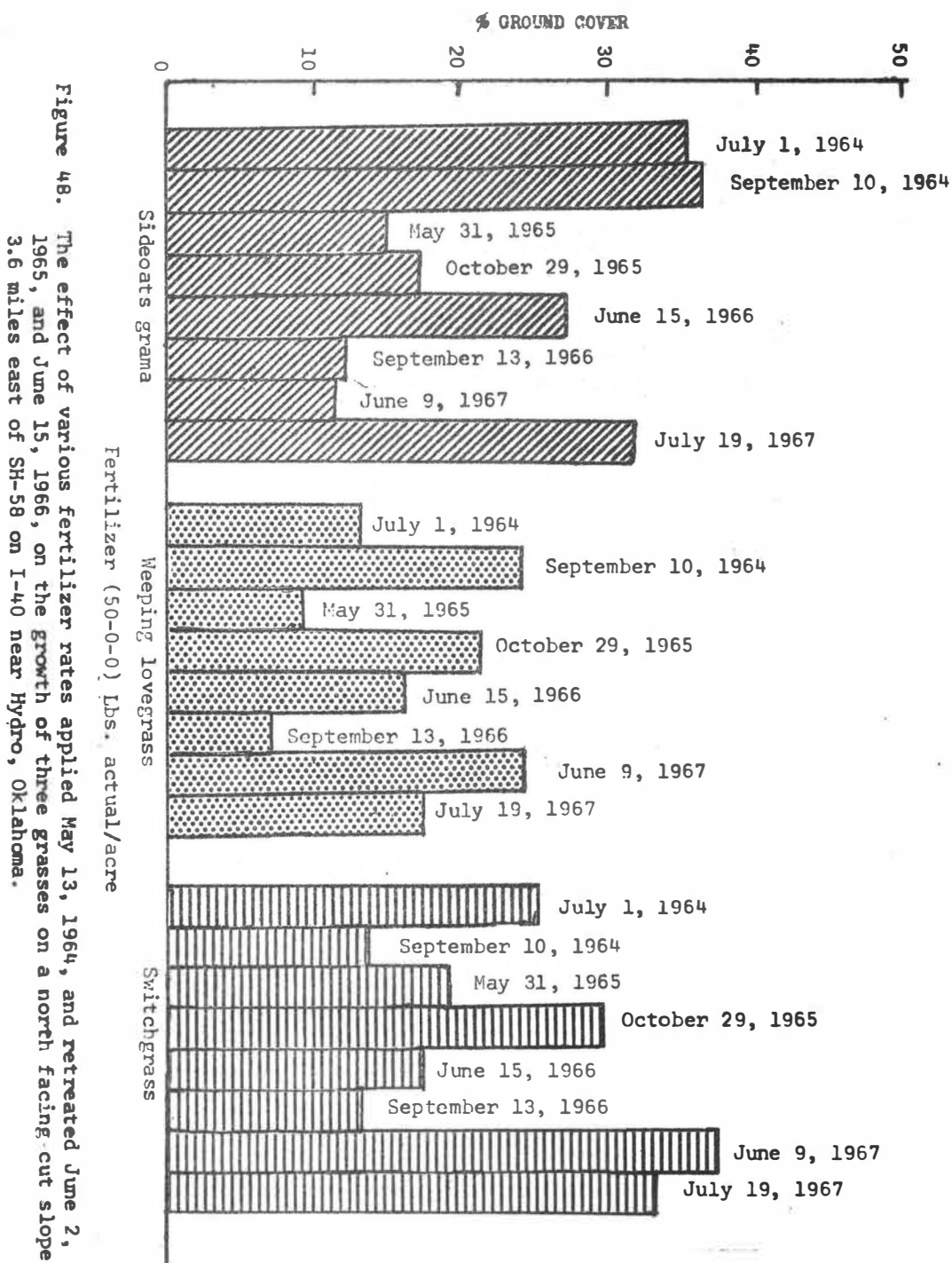


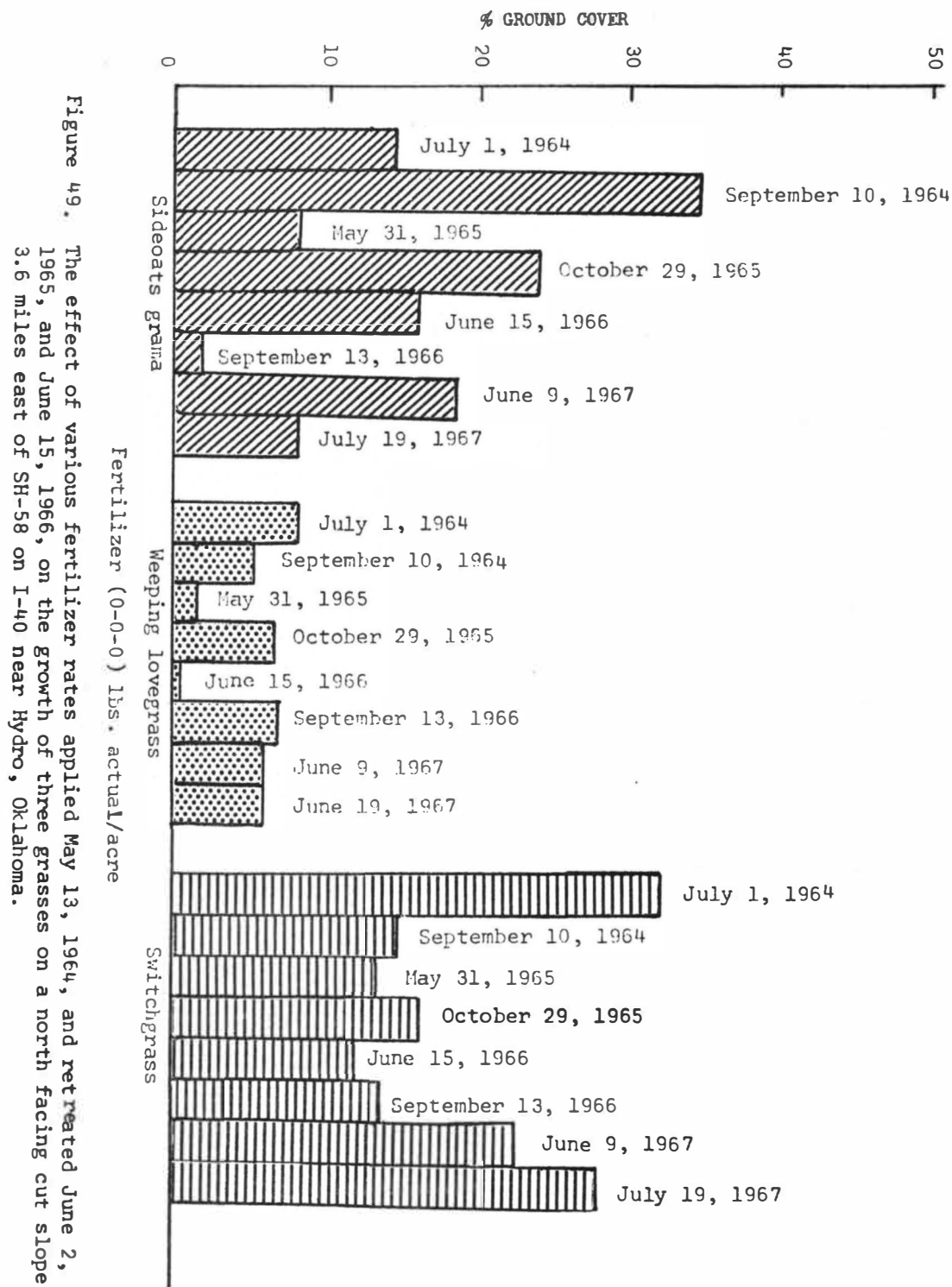
Figure 44. The effect of various fertilizer rates applied May 13, 1964, and retreated June 2, 1965, and June 15, 1966 on the growth of three grasses on a north facing cut slope 3.6 miles east of SH-58 on I-40 near Hydro, Oklahoma.











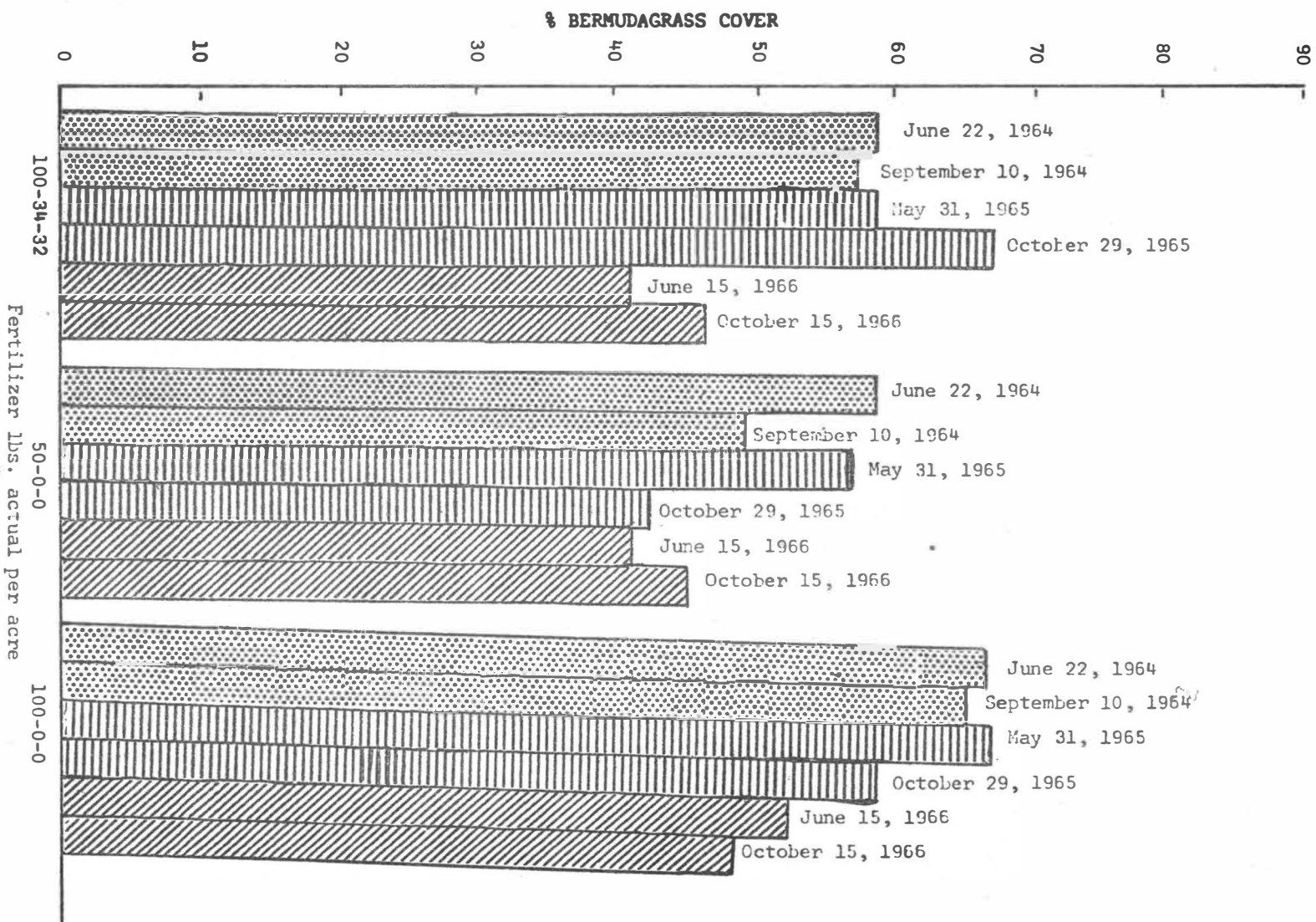


Figure 50. The effect of various fertilizer rates applied May 20, 1964, and retreated June 2, 1965, and June 15, 1966, on the growth of bermudagrass on a north facing fill slope 4.2 miles east of SH-58 on I-40 near Hydro, Oklahoma.

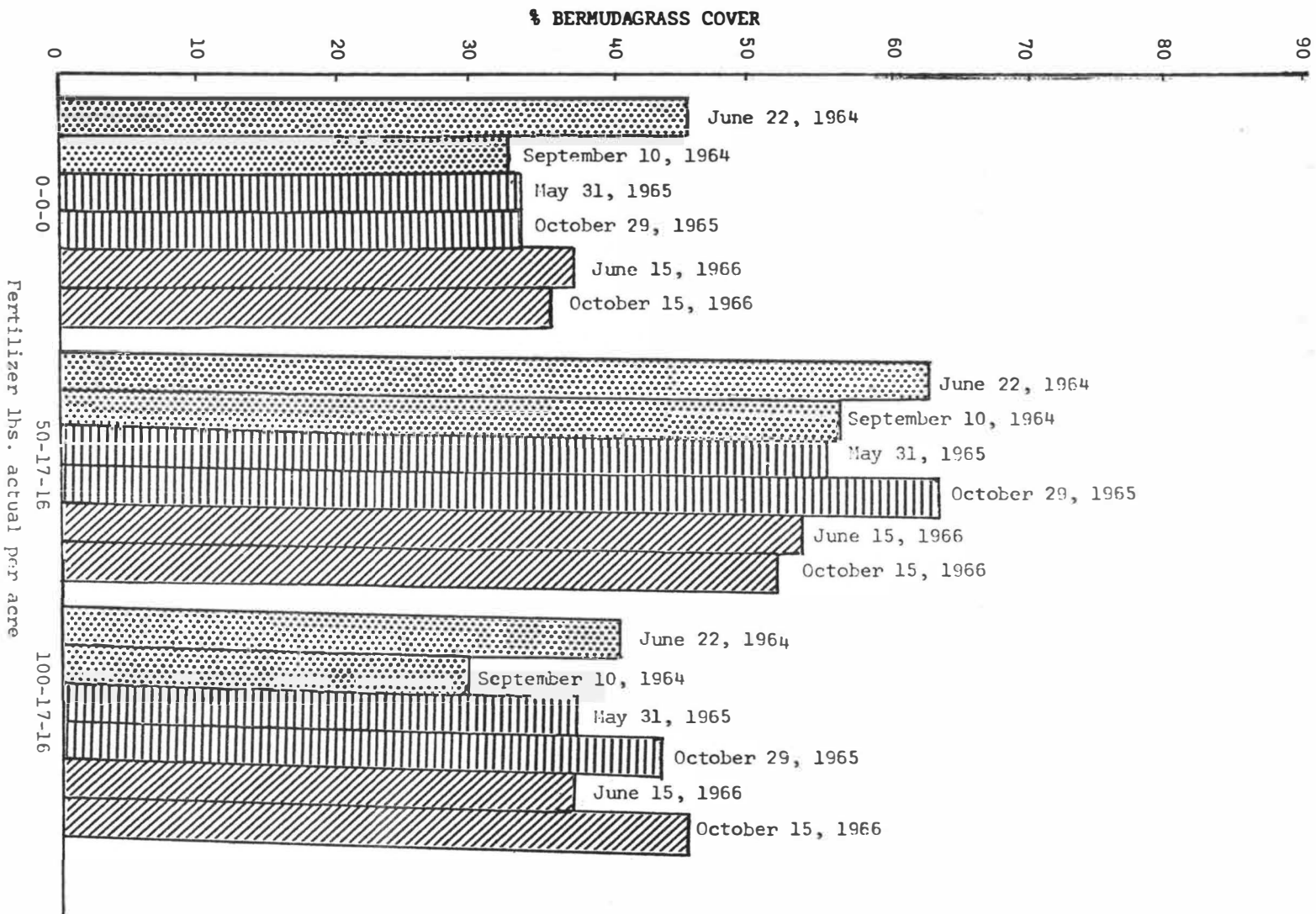
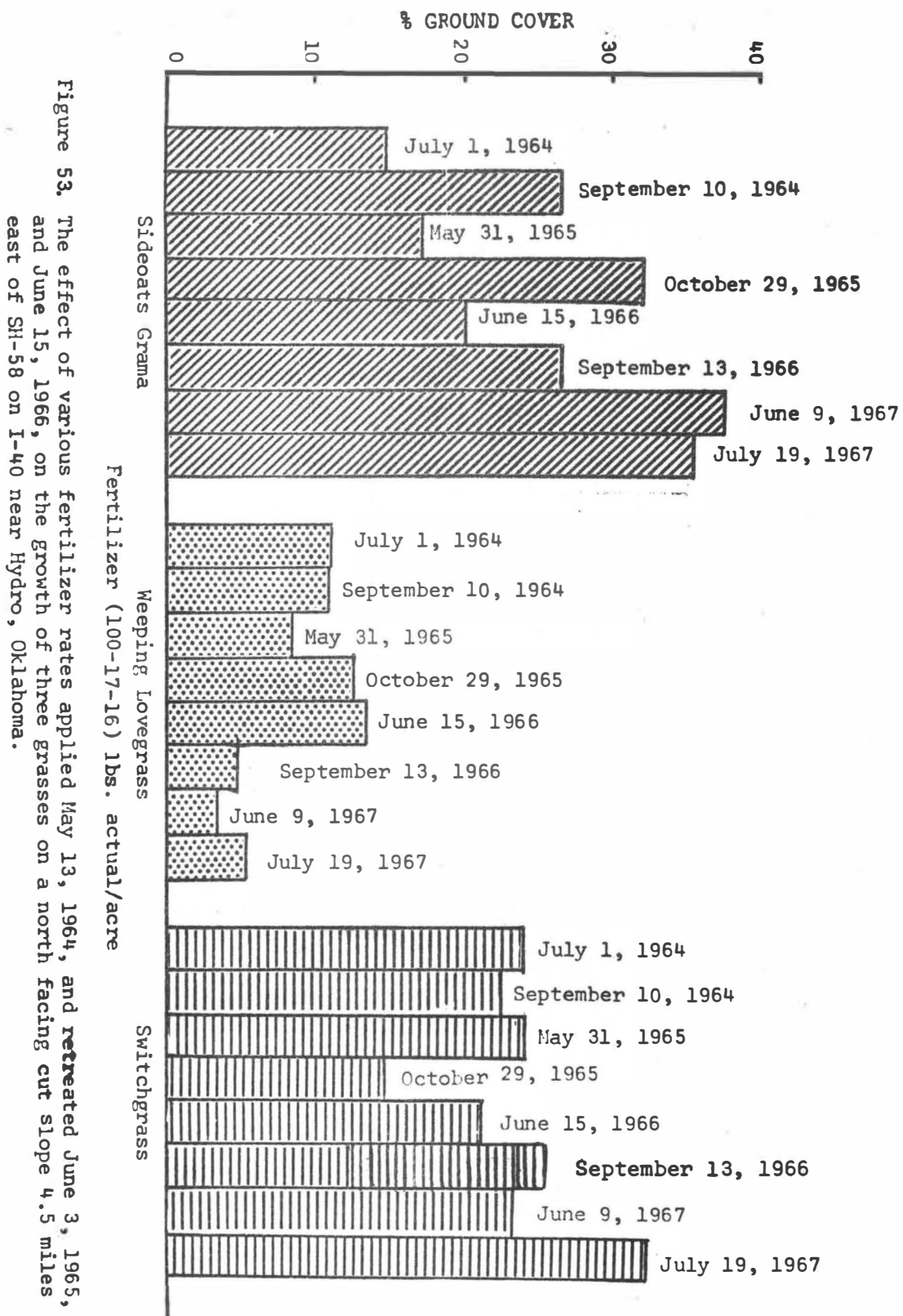
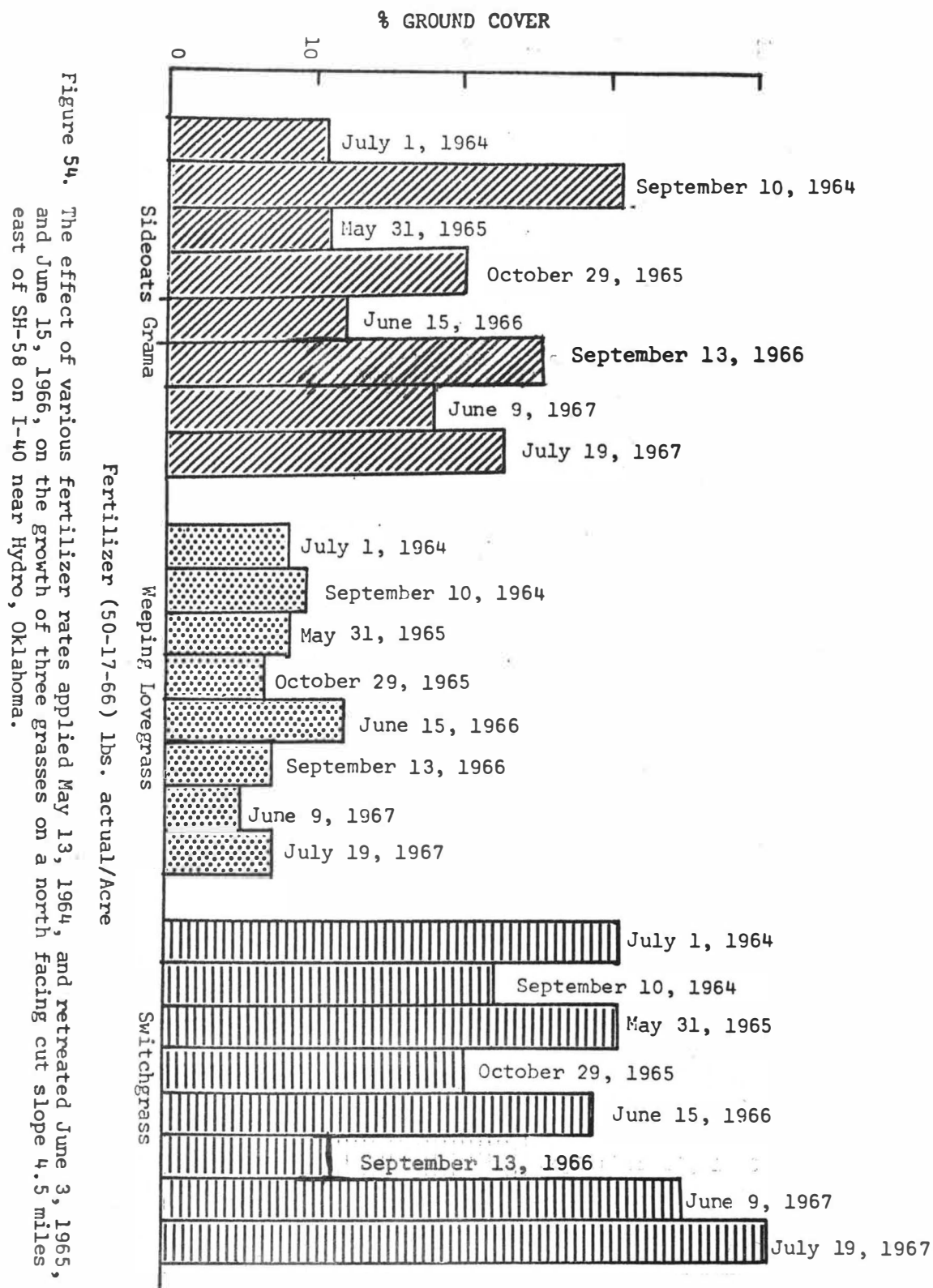


Figure 51. The effect of various fertilizer rates applied May 20, 1964, and retreated June 2, 1965, and June 15, 1966, on the growth of bermudagrass on a north facing fill slope 4.2 miles east of SH-58 on I-40 near Hydro, Oklahoma.





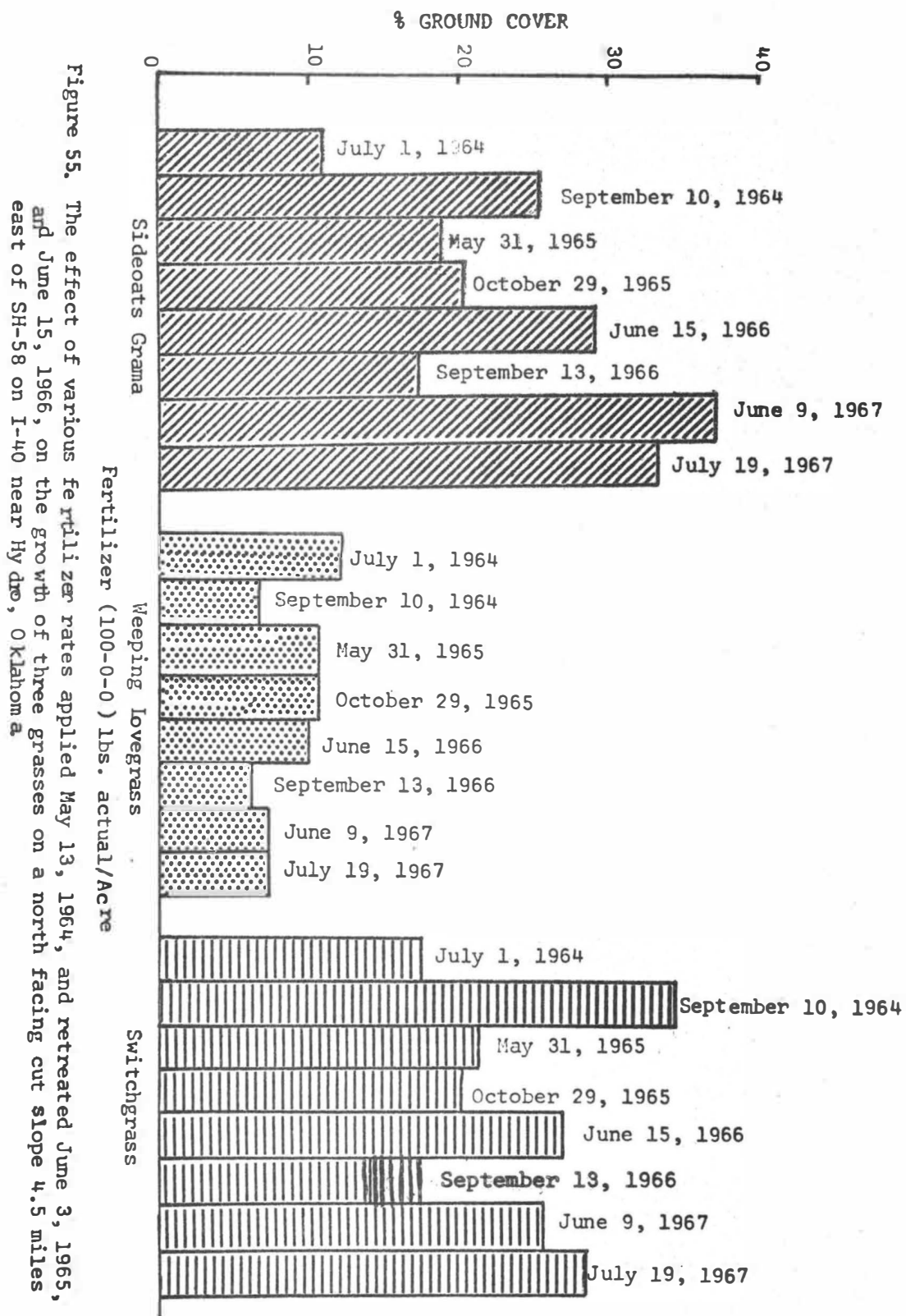
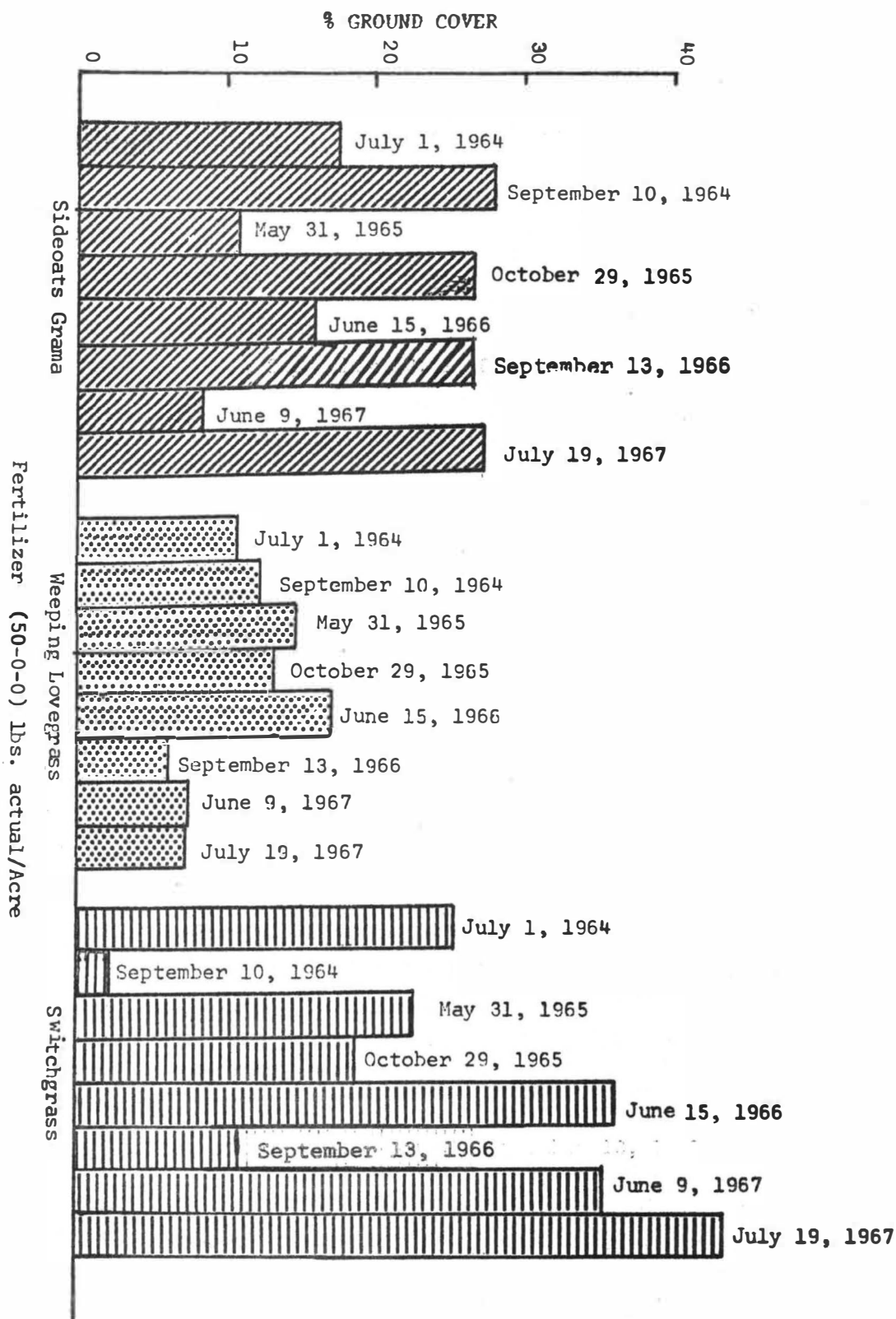
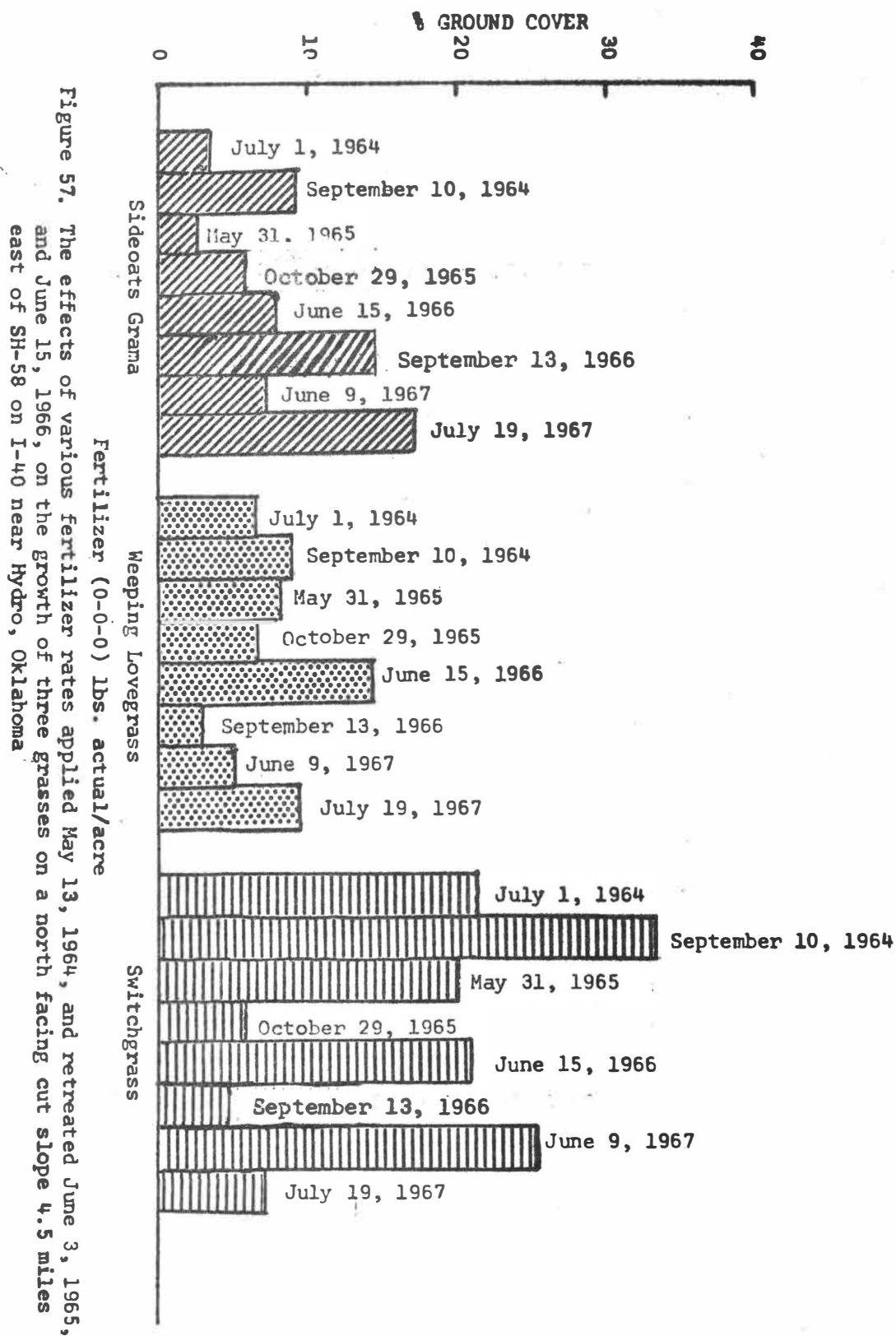
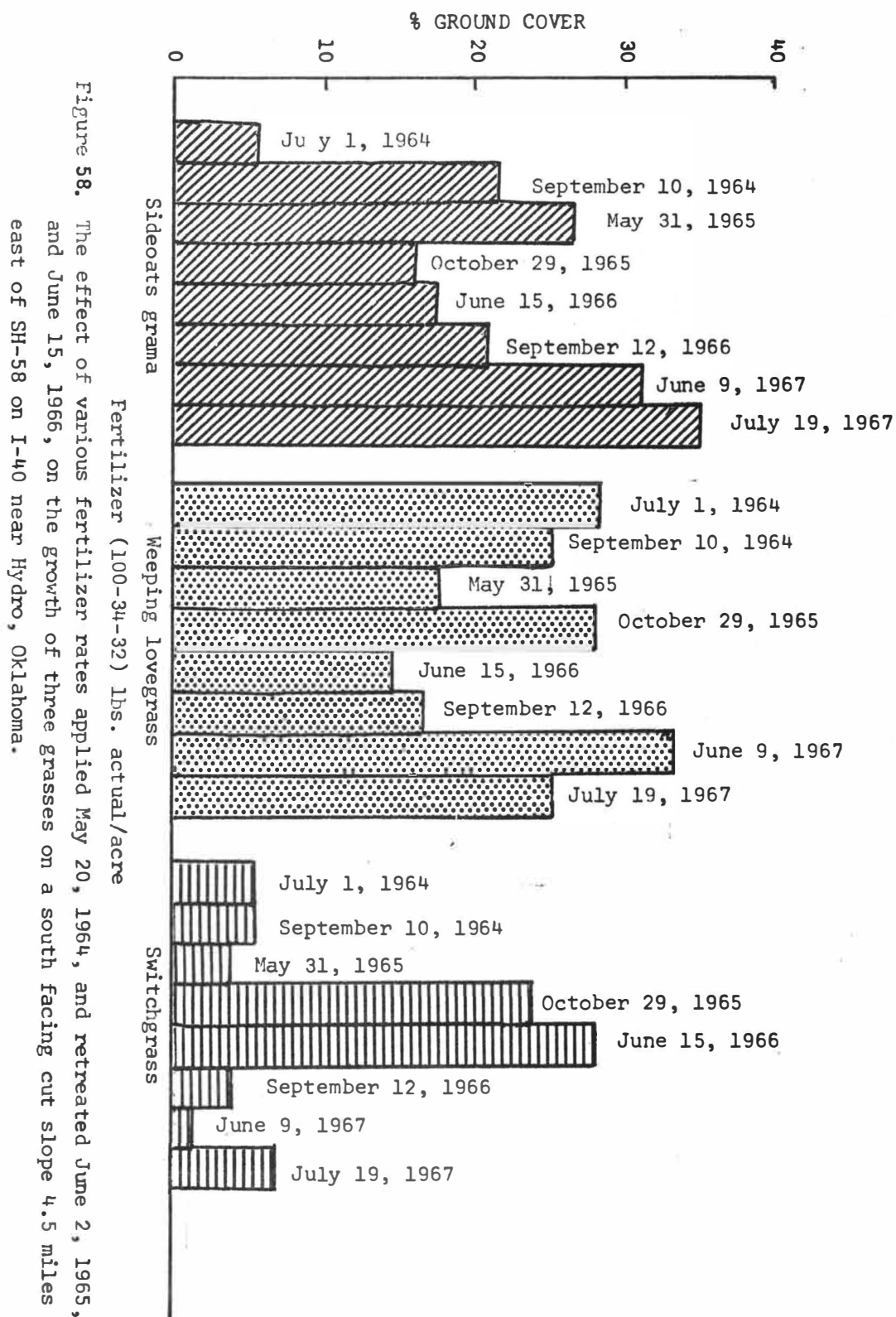
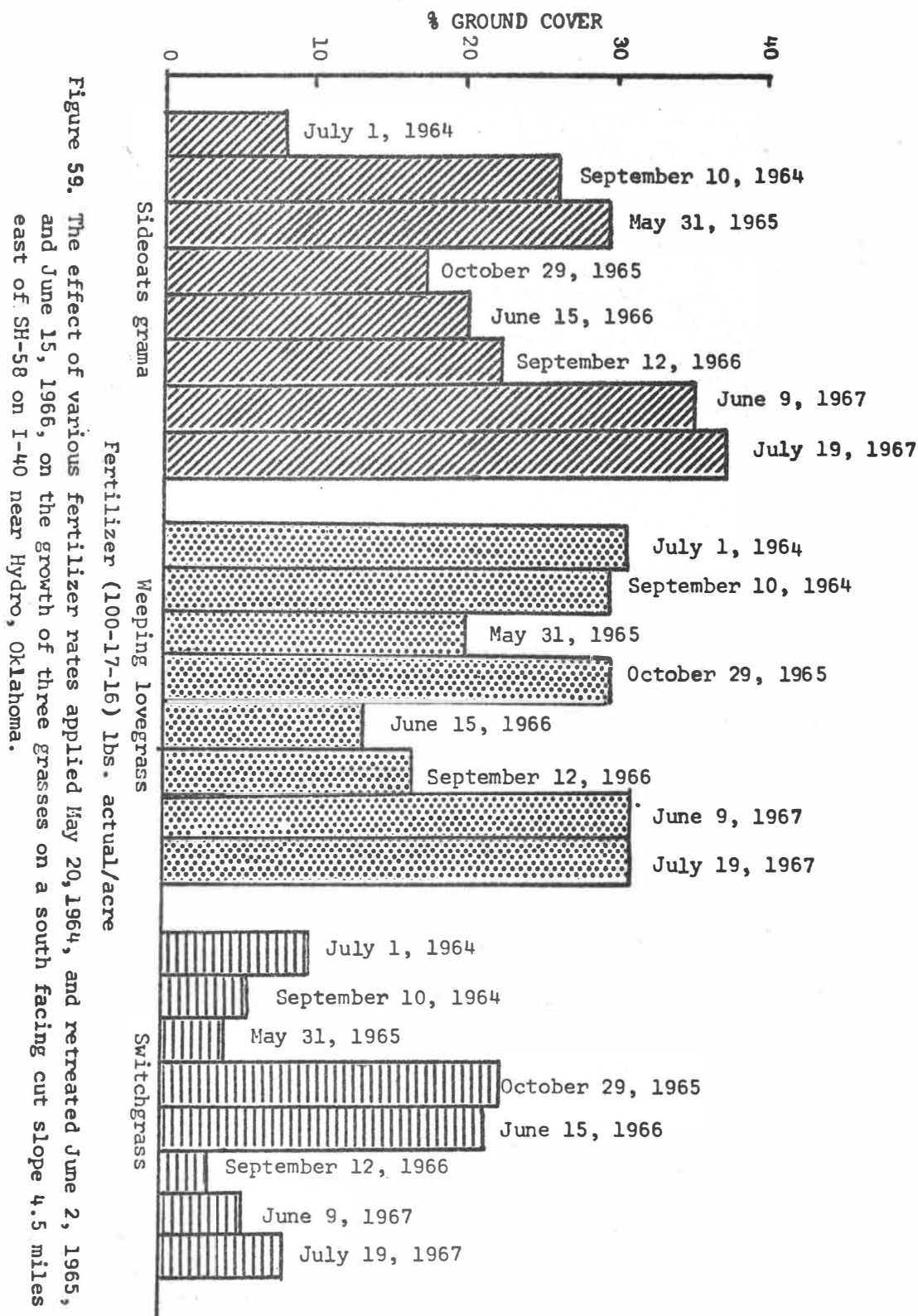


Figure 56. The effects of various fertilizer rates applied May 13, 1964, and retreated June 3, 1965, and June 15, 1966, on the growth of three grasses on a north facing cut slope 4.5 miles east of SH-58 on I-40 near Hydro, Oklahoma.









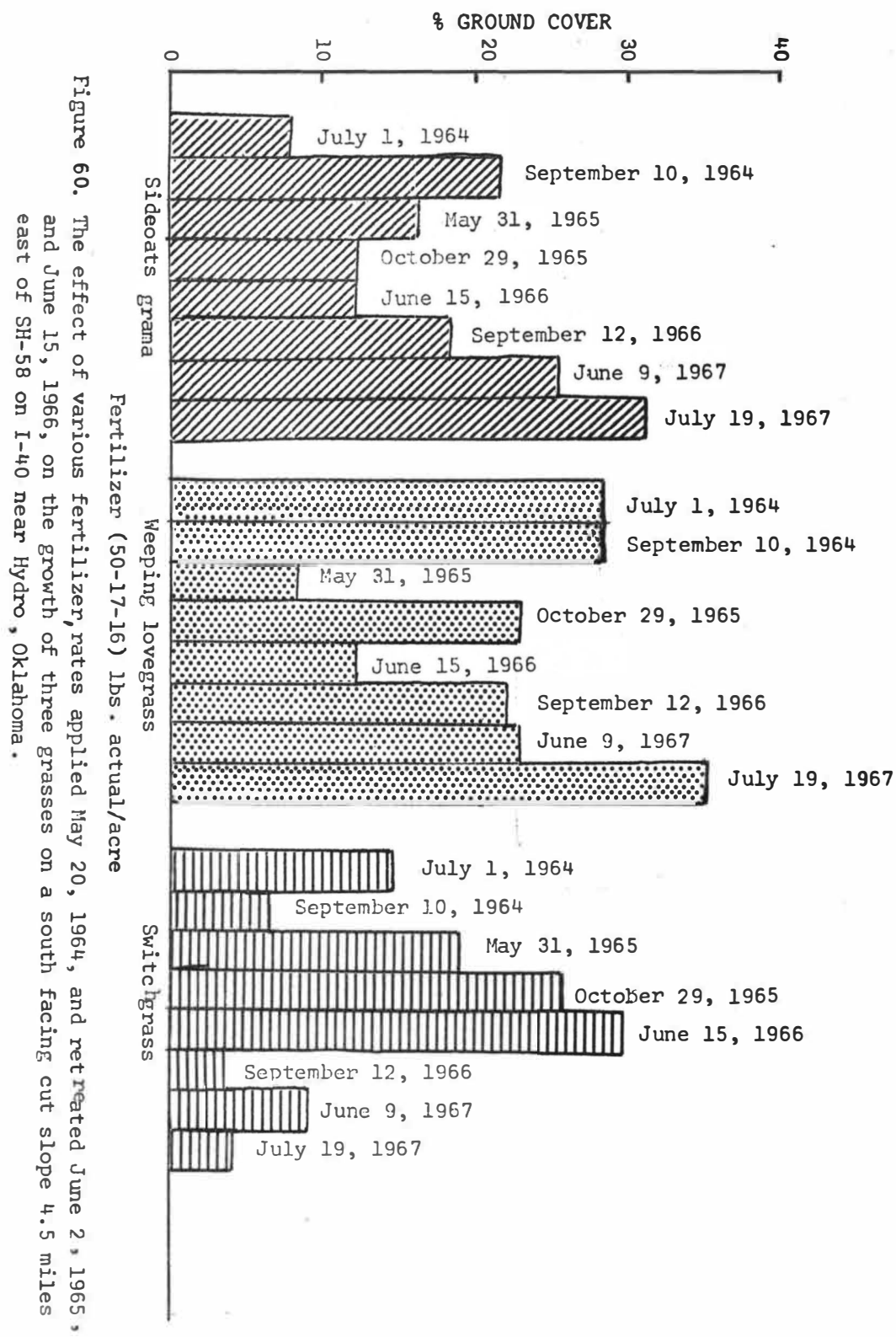


Figure 60. The effect of various fertilizer rates applied May 20, 1964, and retreated June 2, 1965, and June 15, 1966, on the growth of three grasses on a south facing cut slope 4.5 miles east of SH-58 on I-40 near Hydro, Oklahoma.

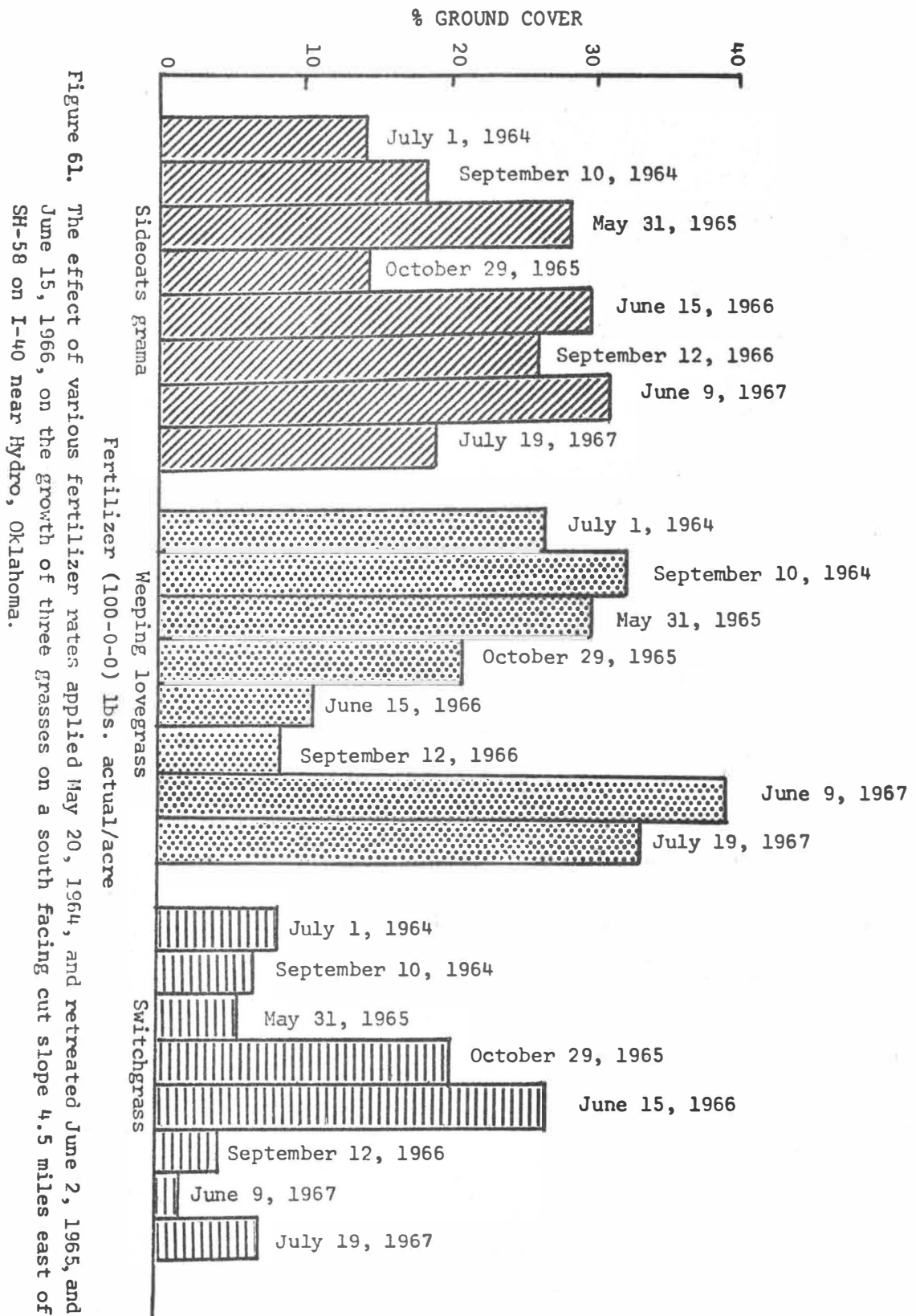


Figure 62. The effect of various fertilizer rates applied May 20, 1964, and retreated June 2, 1965, and June 15, 1966, on the growth of three grasses on a south facing cut slope 4.5 miles east of SH-58 on I-40 near Hydro, Oklahoma.

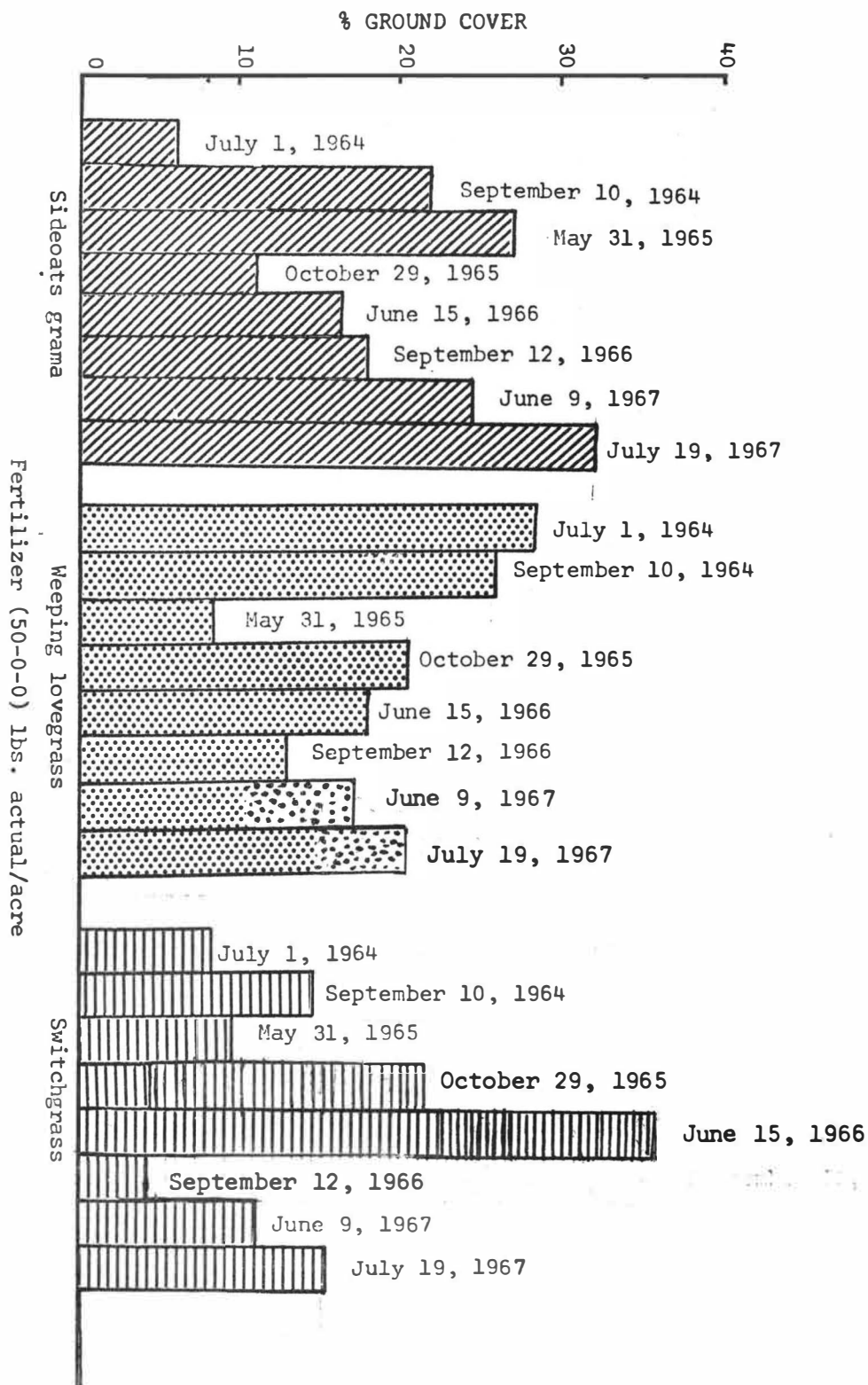
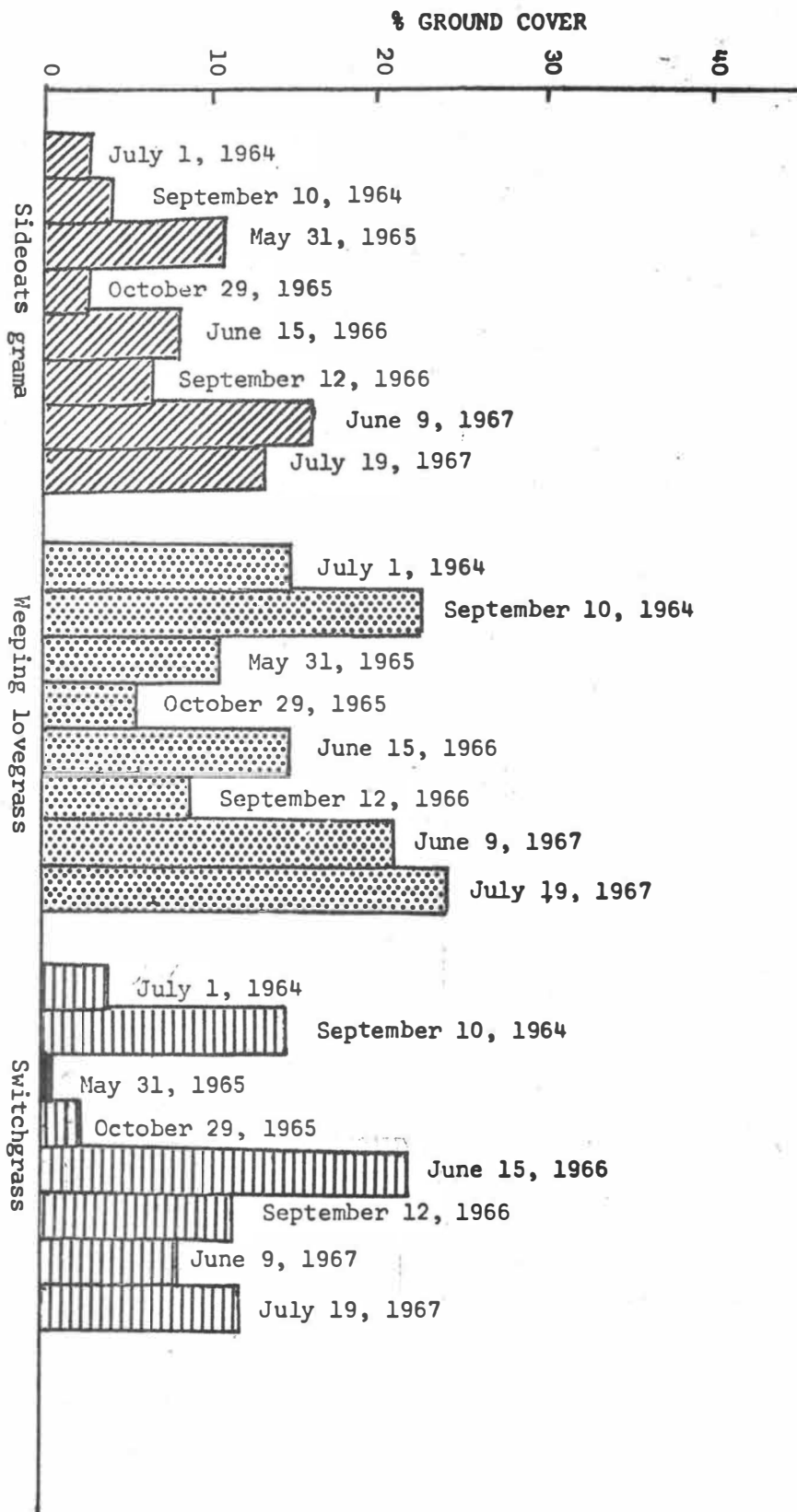
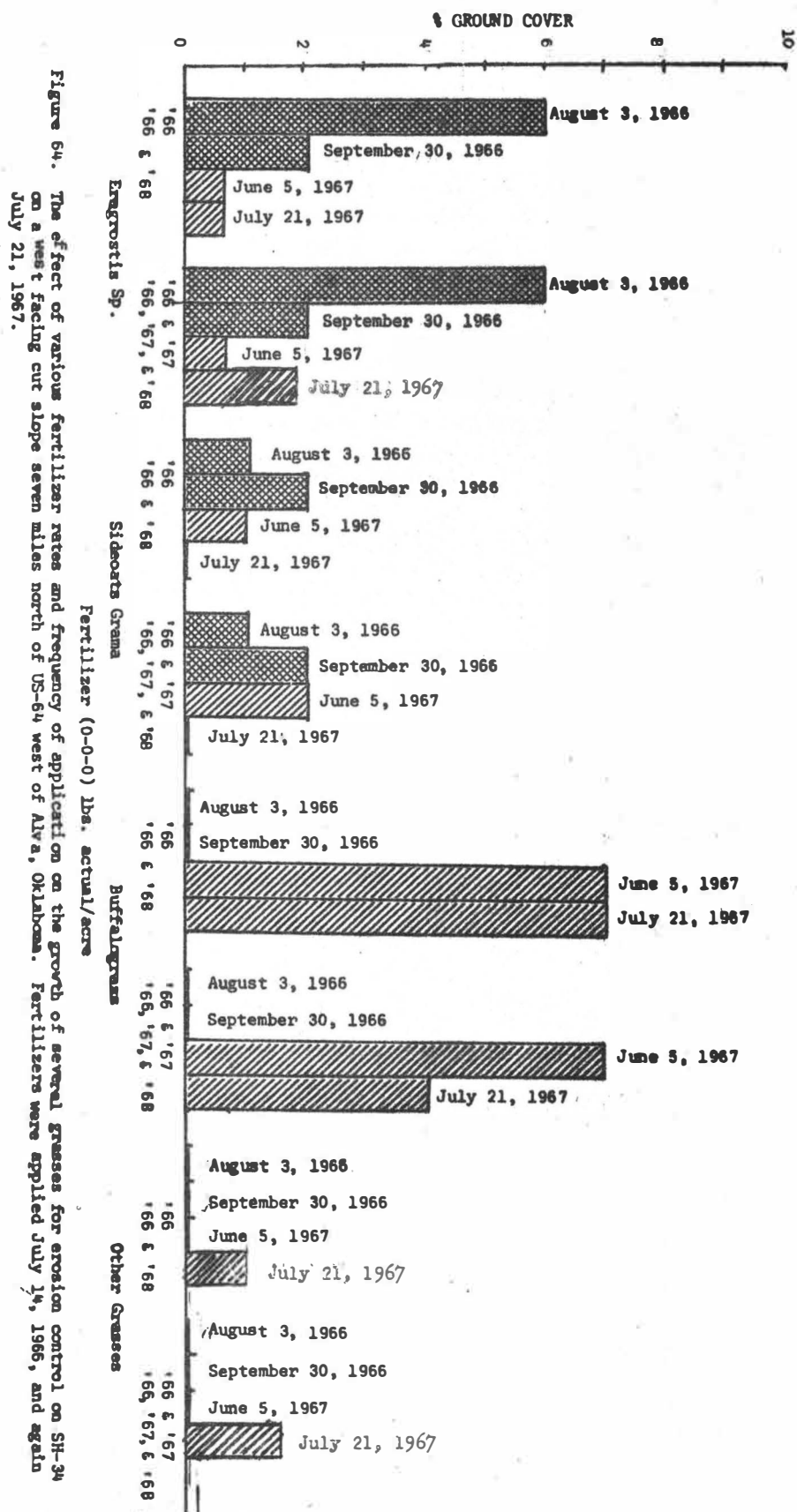


Figure 63. The effect of various fertilizer rates applied May 20, 1964, and retreated June 2, 1965, and June 15, 1966, on the growth of three grasses on a south facing cut slope 4.5 miles east of SH-58 on I-40 near Hvdro, Oklahoma.



experiments, with the exception of slope exposure, on sandy loam backslopes in northwest Oklahoma on State Highway 34 (some seven miles north of US-64 intersection), northeast of Buffalo. The east and west facing slopes were originally seeded in the summer of 1964 when 200 pounds of 13-13-13 per acre was applied, and the area was seeded with weeping lovegrass and mulched with hay. A sparse and chlorotic stand of weeping lovegrass and sideoats grama existed on the slopes at the start of this investigation in 1966. The preliminary evaluations of fertilizers, and frequency of application, for maintenance and erosion control of vegetative ground covers are shown for the west-facing backslope in Figures 64 through 67, and in Figures 68 through 71 for the area on the opposite side of the road with an east exposure. Neither weeping lovegrass, nor sideoats grama showed a significant increase in percent ground cover from two applications of nitrogen, one in each of the two years 1966 and 1967. The complete evaluation of these fertilizer treatments and planned frequency of application could not be achieved in the brief period of only two years.² Neither the east or west slope exposure exhibited a significant influence on the vegetative cover in the first two years of the experiment.

In the same area as the above experiments on SH-34, but on east and west facing fill slopes sprigged to bermudagrass in 1964, four fertilizer treatments were applied initially in July 1966, and re-applied in June 1967. The sandy loam soil used in the fill exhibited only slight traces of erosion when this experiment started. The bermudagrass, at that time, was thin and slightly chlorotic, but showing signs of spreading. The incomplete evaluations of these fertility treatments are shown for the east-facing fill slope in Figure 72, and for the duplicate treatments on a west exposure in Figure 73. The application of 100 pounds of nitrogen per acre significantly increased the percent ground cover of bermudagrass the first year it was applied in both experiments but showed only a slight, although definitely important increase from a similar application the second year. Neither the east or west slope exposure exhibited any influence on the vegetative cover on these fill slopes in this short period of time.



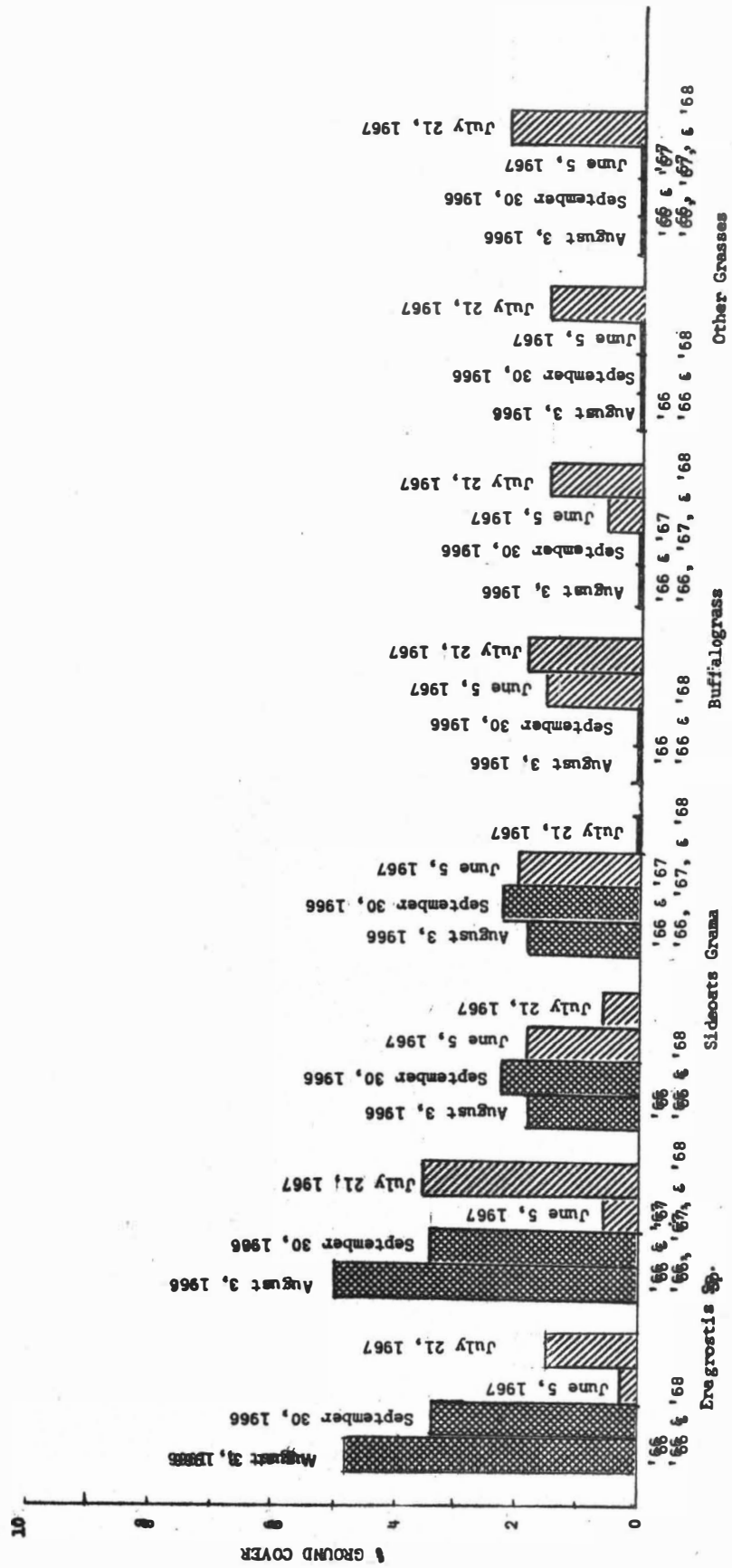
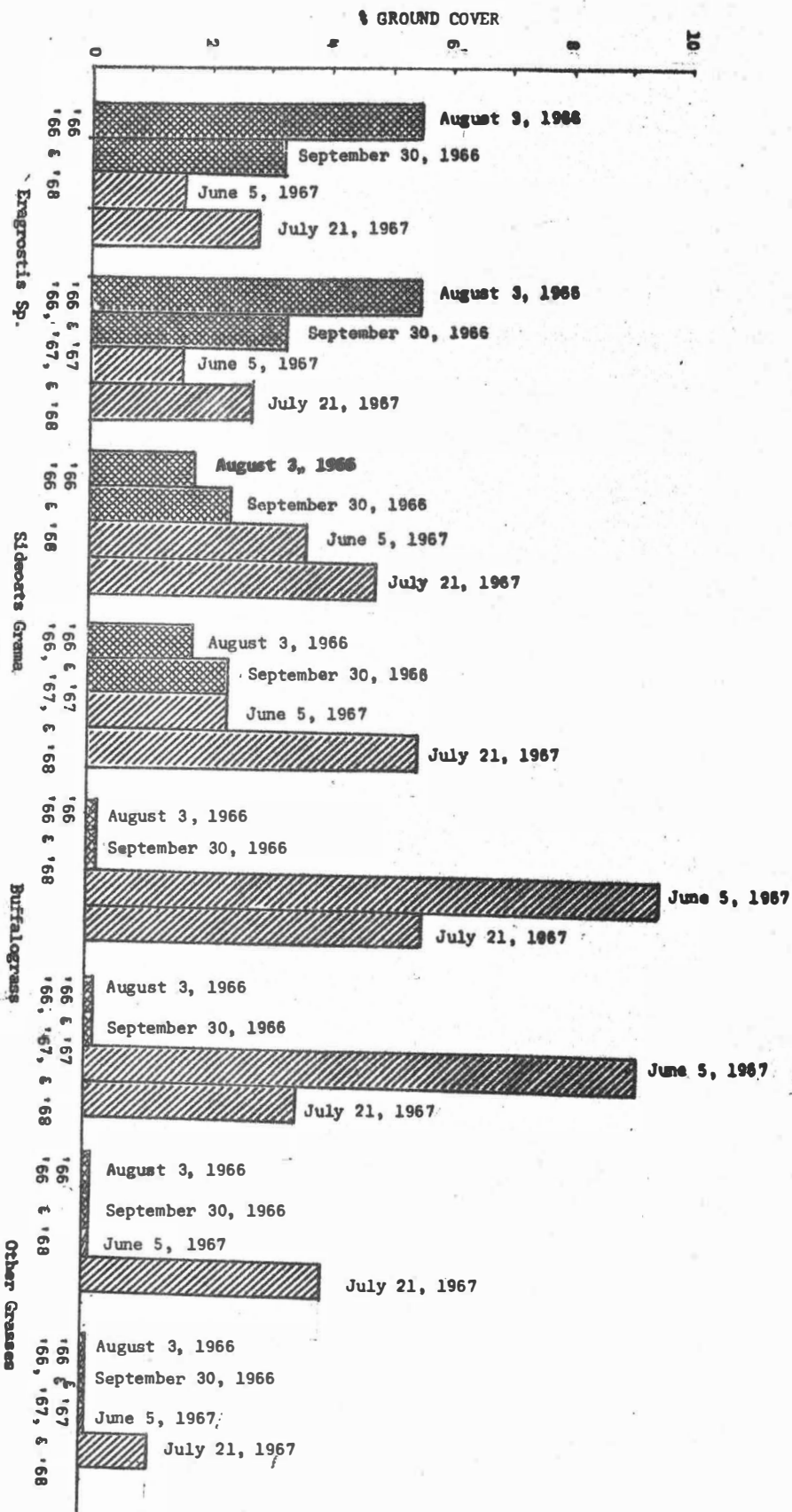


Figure 65. The effect of various fertilizer rates and frequency of application on the growth of several grasses for erosion control on SH-34 on a west facing cut slope seven miles north of US-64 west of Alva, Oklahoma. Fertilizers were applied July 14, 1966, and again July 21, 1967.

Figure 66. The effect of various fertilizer rates and frequency of application on the growth of several grasses for erosion control on SH-34 on a west facing cut slope seven miles north of US-64 west of Alva, Oklahoma. Fertilizers were applied July 14, 1966, and again July 21, 1967.



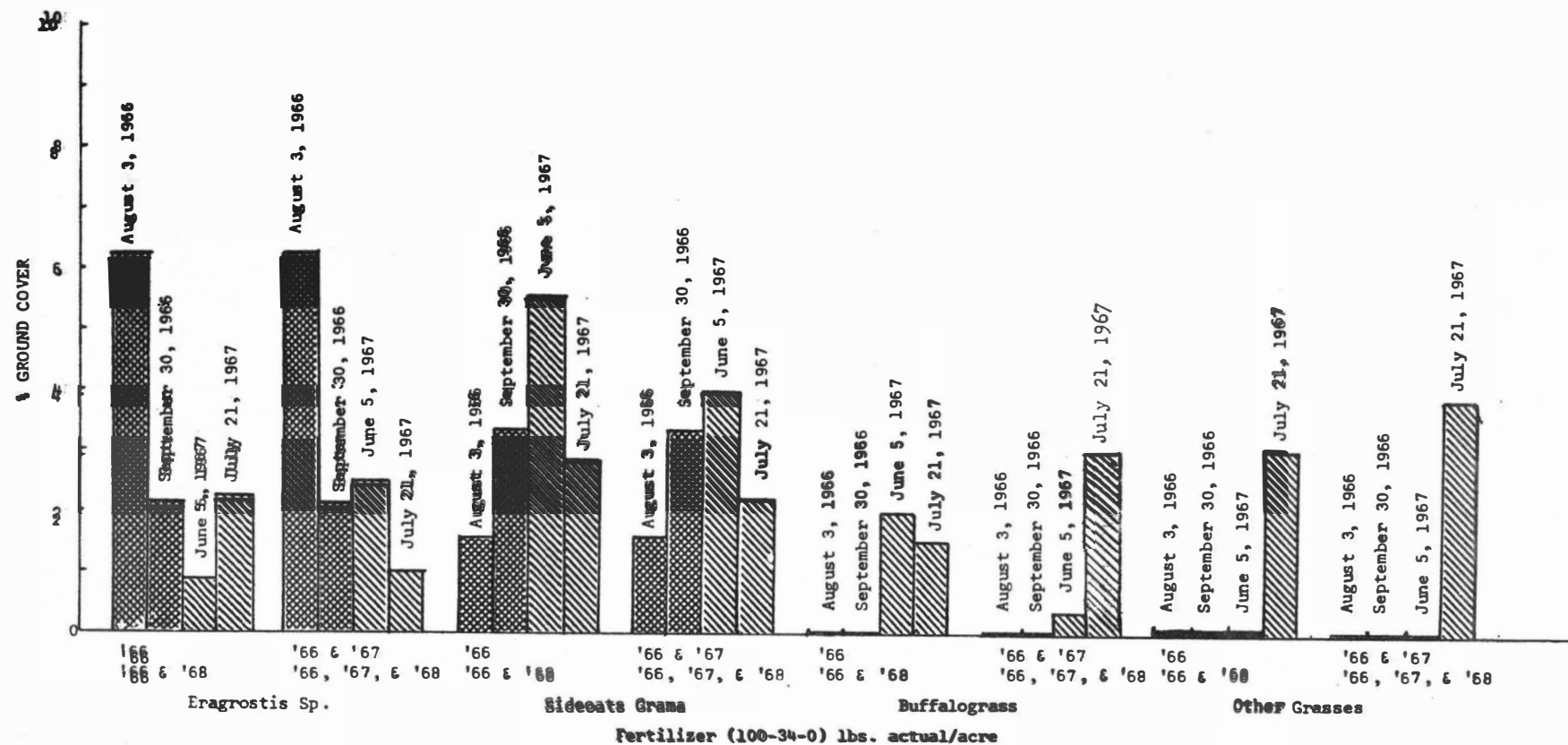


Figure 67. The effect of various fertilizer rates and frequency of application on the growth of several grasses for erosion control on S4-34 on west facing cut slope seven miles north of US-64 west of Alva, Oklahoma. Fertilizers were applied July 14, 1966, and again July 21, 1967 —

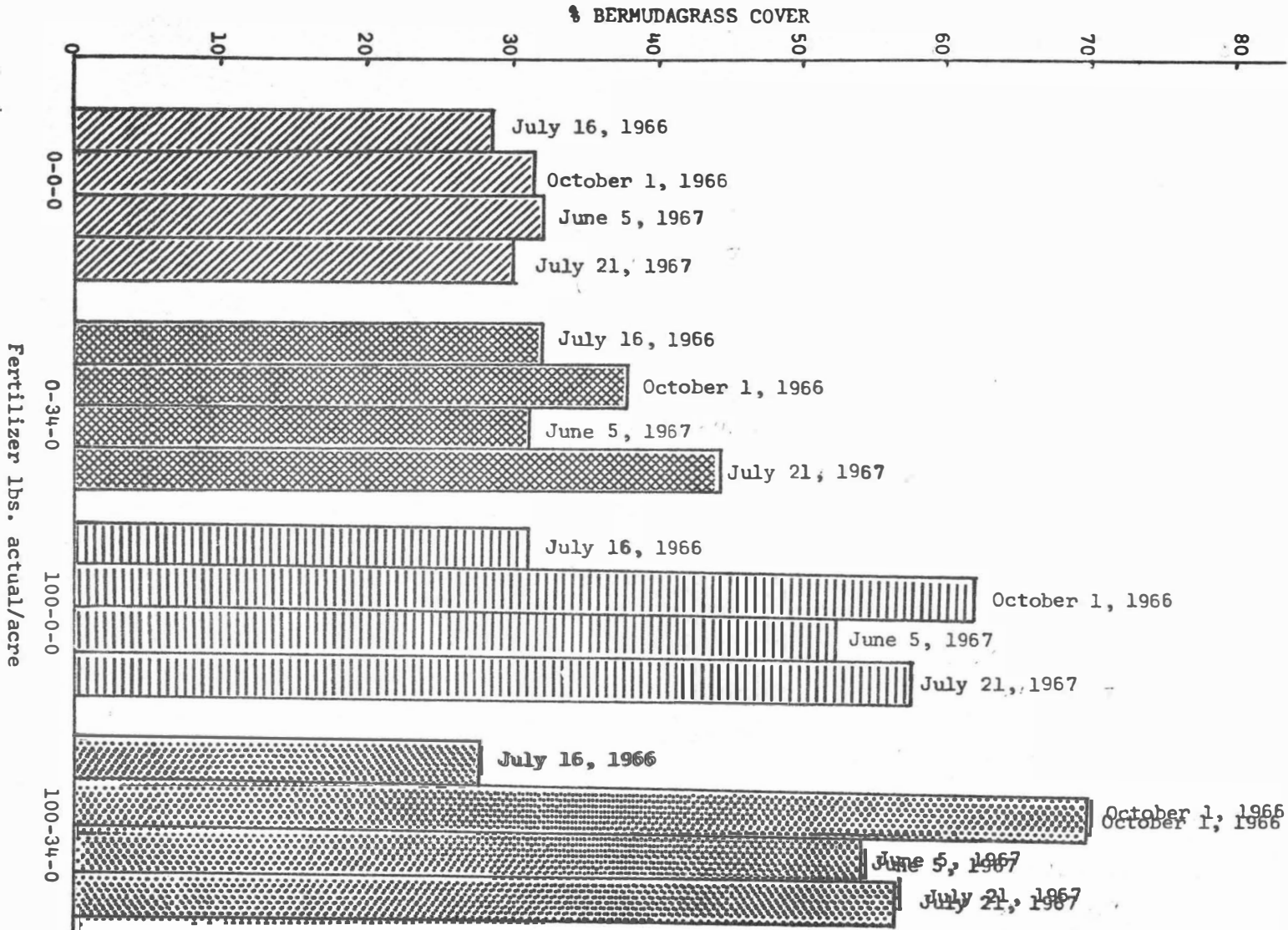


Figure 72. The effect of various fertilizers applied July 14, 1966, and again on July 21, 1967, on the growth of bermudagrass on an east facing fill slope on SH-34, 6.8 miles north of US-64 west of Alva, Oklahoma.

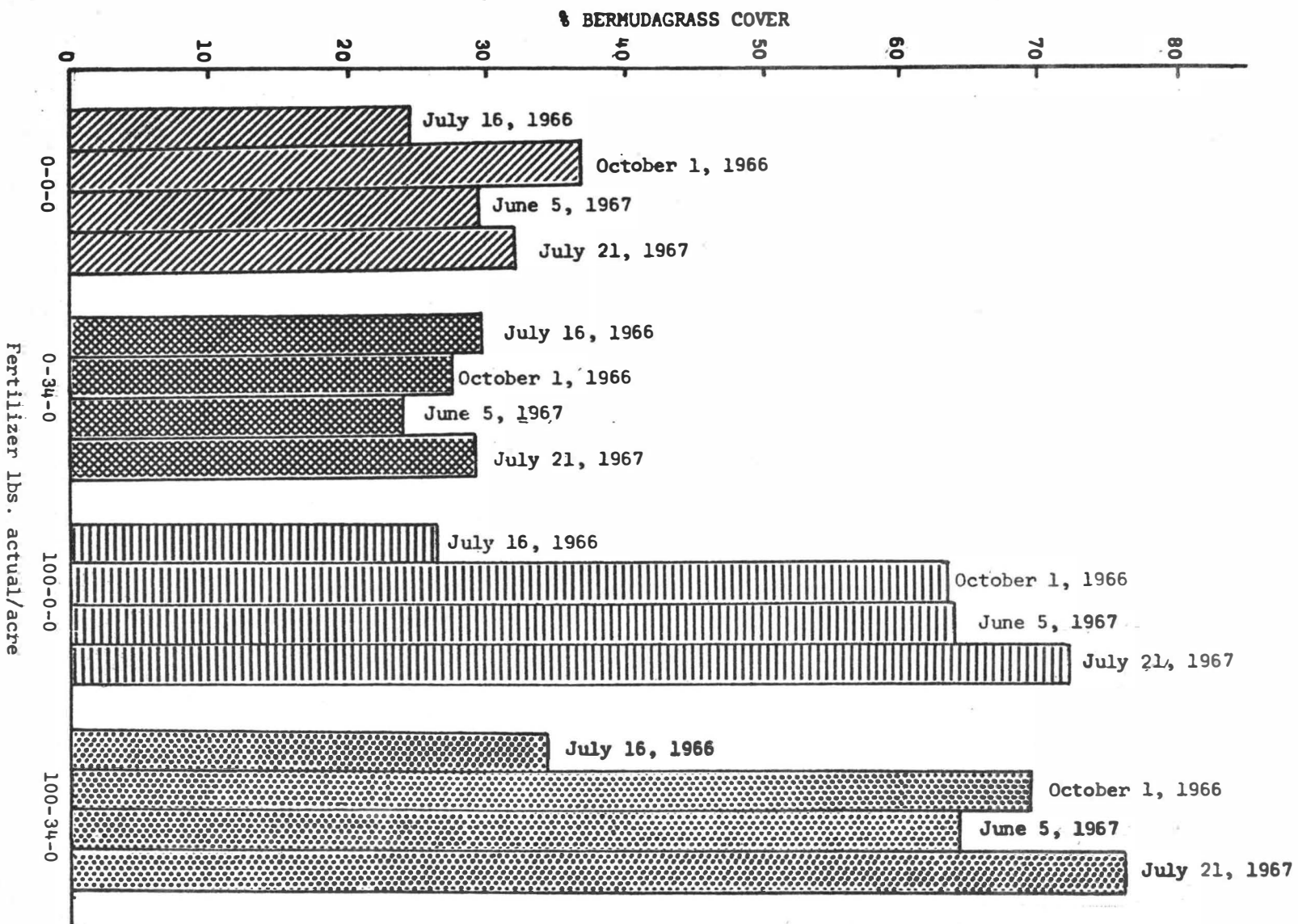


Figure 73. The effect of various fertilizers applied July 14, 1966 and again on July 21, 1967, on the growth of bermudagrass on a west facing fill slope on SH-34, 6.8 miles north of US-64 west of Alva, Oklahoma.

