OKLAHOMA PROJECT

No. 63-03-3

# ROADSIDE DEVELOPMENT AND EROSION CONTROL

Final Report

(Part III of III Parts)

## Weed Control and Eradication

## on

## Oklahoma Highways

by

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in cooperation with

The Oklahoma Department of Highways

and

The United States Department of Commerce

Bureau of Public Roads

Oklahoma Agricultural Experiment Station

Oklahoma State University

Stillwater, Oklahoma

## Acknowledgements

The research personnel from Oklahoma State University working on this project express their appreciation to the personnel of the Oklahoma Department of Highways and the Bureau of Public Roads for their continued interest and cooperation in these investigations. Special recognition is due Mr. R. T. Sutton, Mr. H. B. McDowell, and Mr. B. C. Hartronft of the Oklahoma Highway Department, and Mr. J. E. Stewart of the Bureau of Public Roads. The assistance of Dr. Paul W. Santelmann, Professor, Department of Agronomy, Oklahoma State University in planning and supervising the weed control research in 1963 during the absence of the project director is gratefully acknowledged. We are grateful to the following chemical companies which furnished the herbicides and surfactants for the research: Allied Chemical, Amchem Products, Inc., American Paint, Ansul Chemical Co., Chevron Chemical Co., Chipman Chemical Co. Inc., Diamond Alkali Co., Geigy Agricultural Chemicals, Hooker Chemical Corp., Naugatuck Chemical, Stauffer Chemical Co., Thompson-Hayward Chemical Co., U.S. Borax, Velsicol Chemical Corp., and Vineland Chemical Co.

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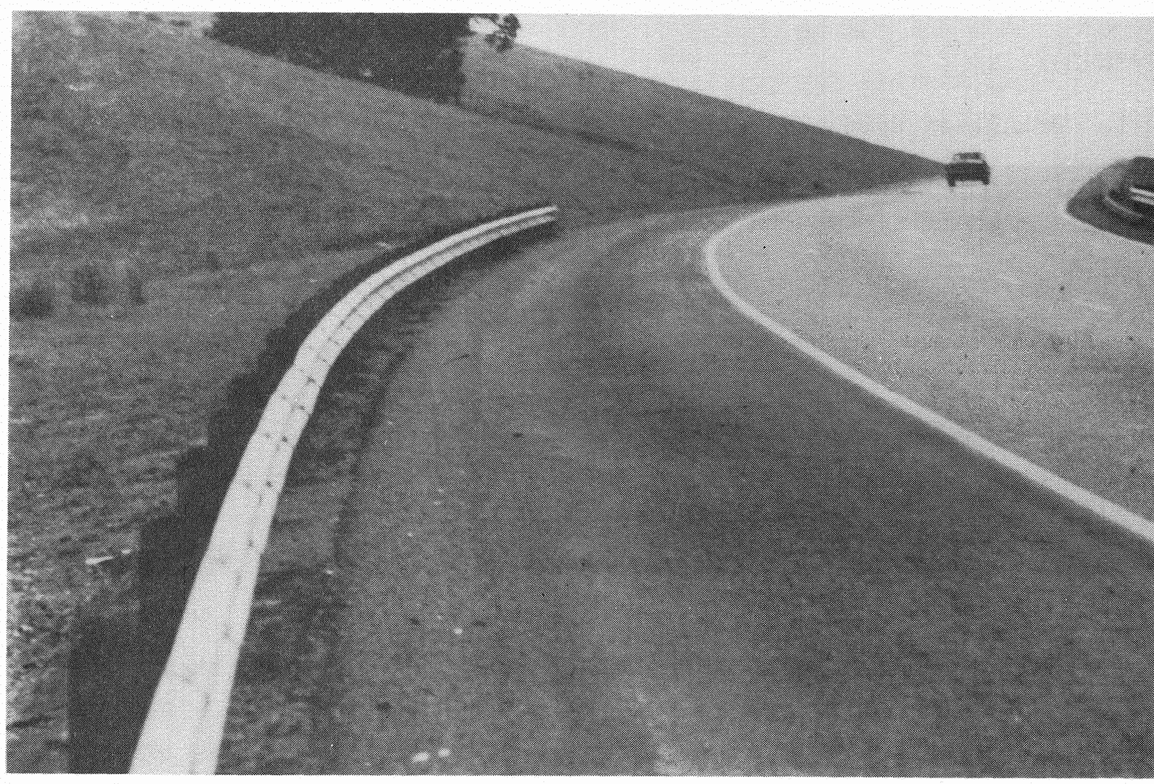

Weed control on the highway system enhances the beauty of the state and provides additional safety for the motoring public.

WEED CONTROL AND ERADICATION

ON

OKLAHOMA HIGHWAYS

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## RECOMMENDATIONS*

The evaluation of herbicides for the most effective and economical means of weed control on the highway system is a continuous process. Numerous herbicides currently available and combinations of these have been only partially evaluated, some of which could be more effective and economical than the ones currently recommended. Each year new herbicides are developed and should be evaluated immediately if maximum efficiency and economy in weed control on the highway system is to be achieved. Recommendations for weed control and eradication based upon these initial findings must be subject to revision with the accumulation of additional data. The evaluations of various herbicides for weed control and eradication on Oklahoma highways obtained in these preliminary investigations serve as the bases for these recommendations. All chemicals currently recommended for weed control and eradication on Oklahoma highways are listed in the tables at the end of this section.

### BROADLEAF WEED AND ANNUAL GRASS CONTROL

1. Sandbur control. The post-emergence herbicides ammonium methanearsonate (AMA), calcium acid methyl arsonate (CMA), monosodium acid methanearsonate (MSMA), and disodium methanearsonate (DSMA) each with one retreatment 7 to 20 days after the initial application are equally effective in the control of sandburs on Oklahoma highways. A surfactant should be added at the rate of one percent by volume to those materials that do not contain a surfactant in the manufacturers formulation. These herbicides

should be applied in enough water to make 40 gallons of solution per acre plus 0.4 gallon of surfactant as needed. In these experiments only MSMA was formulated with a surfactant by the manufacturer. Based upon actual plant count in these investigations, although not statistically different AMA consistently seemed to be more effective than the other organic arsonates. If competitive with the other herbicides in cost per acre AMA would be suggested for sandbur control on Oklahoma highways.

2. General Broadleaf Weed and Annual Grass Control. The pre-emergence application of atrazine is recommended first for the control of both broadleaf weeds and annual grasses commonly found on Oklahoma highways. Diuron, although not as widely effective in these experiments, is the second pre-emergence herbicide recommended for both broadleaf weed and annual grass control. To control only broadleaf weeds the herbicides Banvel-D (dicamba), 2,4-D amine, and 2,4,5-T amine are recommended. Based on cost per acre for effective bradleaf weed control 2,4-D generally would be the least expensive. Caution should be exercised in the use of the phenoxy compounds particularly such as 2,4-D, and 2,4,5-T in areas where sensitive crops or trees are growing to avoid drift. It would be advisable to apply these herbicides when there is no wind or at least when the wind velocity is less than 10 miles per hour.

3. Alfalfa and Sweetclover Control. The herbicides recommended for the control of these plants on the highway system are 2,4-D amine, 2,4,5-T amine, and Banvel-D (dicamba).

JOHNSONGRASS CONTROL

The organic arsonate herbicides disodium methanearsonate (DSMA), and monosodium acid methanearsonate (MSMA) are recommended for the selective control of johnsongrass on Oklahoma highways. These herbicides should be applied two or three times per year in enough water to make 40 gallons of solution per acre plus a surfactant at the rate of one percent by volume with those materials that do not contain a surfactant in the manufacturers formulation. In these experiments 0.4 gallon of surfactant was added to the DSMA solution only as MSMA was formulated with a surfactant by the manufacturer. Plants that appear the year following treatment are primarily from seed and will require repeated applications of the herbicide as before for control. The most effective control of johnsongrass will be obtained with these herbicides when the plants are treated when 12 to 18 inches tall and actively growing, and when the sun is bright and the temperature is 80$^{\circ}$F or higher.

SOIL STERILIZATION

The herbicides recommended for the suppression of all plant growth especially bermudagrass on shoulders and under guardrails of the Oklahoma highway system are bromacil, borocil, TCA Inhibited, Borea T-10, and a combination of TCA and bromacil.

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* In order that the information in this publication may be more useful, it was sometimes necessary to use tradenames of products, rather than complicated chemical identifications. As a result it is unavoidable in some cases that similar products which are on the market under other tradenames may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

SUGGESTED CHEMICALS
FOR
BROADLEAF WEED AND ANNUAL GRASS CONTROL

| Herbicide* | Chemical | Form | % Active Ingredient | Pounds or gallons of Commercial Material Per Acre |
|---|---|---|---|---|
| Atrazine +++ (Pre-Em) | 2-chloro-4-Ethyl-amino-6-isopropyl-amino-5-triazine | wp** | 80 | 3.75 |
| Picloram + (Tordon) (Pre-Em) | 4-Amino-3,5,6-trichloropicolinic acid | Liquid | 4 lbs. per gal. | 1 pint |
| Diuron +++ (Pre-Em) | 3(3,4-dichlorophenyl)-1,1-dimethylurea | wp | 80 | 3.75 |
| Banvel-D + (Post-Em) | 2-methoxy-3,6-di-chlorobenzoic acid | Liquid | 4 lbs. per gal. | 1 quart |
| 2,4-D Amine + | Dimethylamine salt of 2,4-dichlorophenoxy acetate | Liquid | 4 lbs. per gal. | 1 quart |
| 2,4,5-T Amine + | Triethylamine salt of 2,4,5-trichlorophenoxy acetate | Liquid | 4 lbs. per gal. | 1 quart |
| CMA ++ | Calicum acid methanearsonate | Liquid | 1 lb. per gal. | 3.7 gal. |
| MSMA ++ | Monosodium acid methanearsonate | Liquid | 2 lbs. per gal. | 1 gal. |
| A M A ++ | Ammonium methanearsonate | Liquid | 1.4 lbs. per gal. | 2.7 gal. |
| DSMA ++ | Disodium methanearsonate | wp | 63 | 4.0 |

* In order that the information in this table may be more useful, it is sometimes necessary to use trade names of products, rather than complicated chemical identifications. As a result it is unavoidable in some cases that similar products which are on the market under other tradenames may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

** WP = Wettable Powder

All herbicides are to be applied in 40 gallons of solution per acre.

+ Broadleaf weed control
++ Annual grass control
+++ Broadleaf weed and annual grass control

SUGGESTED CHEMICALS
FOR
COMPLETE PLANT SUPRESSION ON OKLAHOMA HIGHWAY RIGHTS OF WAY

| Herbicide* | Chemical | Form** | % Active Ingredient | Pounds of Commercial material | |
|---|---|---|---|---|---|
| | | | | Acre | Foot Mile |
| Borocil | Disodium Tetraborate Pentahydrate, & Disodium tetraborate decahydrate, and Bromacil | G | 98 | 334 | 40.4 |
| Bromacil | (5-bromo-3-sec-butyl-6-methyluracil) | WP | Hyvar X-Ws 50<br>Hyvar X 80 | 48 | 5.8 |
| TCA Inhibited | Sodium Trichloroacetate | SP | 91 | 165 | 20.0 |
| TCA & Bromacil | (See Above) | SP & WP | (See Above) | 88 &<br>20 (of 50%)<br>88&<br>12.5 (of 80%) | 10.6 &<br>2.4<br>10.6 &<br>1.5 |
| Borea T-10 | Sodium metaborate and monuron | WP | 58 | 862 | 104.3 |

* In order that the information in this table may be more useful, it is sometimes necessary to use tradenames of products, rather than complicated chemical identifications. As a result it is unavoidable in some cases that similar products which are on the market under other tradenames may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

** G = Granular
WP= Wettable Powder
SP = Soluble Powder

All herbicides are to be applied in a minimum of 100 gallons of water per acre.

COST PER ACRE OR FOOT MILE OF RECOMMENDED
HERBICIDES BASED ON CURRENT WHOLESALE PRICES
FOR SMALL QUANTITIES*

| Herbicide | Percent Active | Amount of Commercial Material/Application | | Cost | |
|---|---|---|---|---|---|
| | | Acre | Foot Mile | Acre | Foot Mile |
| SELECTIVE WEED CONTROL** | | | | | |
| Atrazine | 80% | 3.75 pounds | | $9.26 | |
| Picloram | 4 lbs/gal. | 1.0 pints | | $7.75 | |
| Diuron | 80% | 3.75 pounds | | $9.56 | |
| Banvel-D | 4 lbs/gal. | 1.0 quart | | $6.25 | |
| 2,4-D amine | 4 lbs/gal. | 1.0 quart | | $0.75 | |
| 2,4,5-T amine | 4 lbs/gal. | 1.0 quart | | $2.41 | |
| CMA | 1 lb/gal. | 3.7 gallons | | $12.40 | |
| MSMA | 4 lbs/gal. | 3.0 quarts | | $3.56 | |
| AMA | 1.4 lbs/gal. | 2.7 gallons | | $16.17 | |
| DSMA | 63% | 4.0 pounds | | $1.44 | |
| SOIL STERILANTS*** | | | | | |
| Borocil | 98% | 334 lbs. | 40.4 lbs. | $140.28 | $16.97 |
| Bromacil | Hyvar X-WS 50% | 48 lbs. | 5.8 lbs. | $165.60 | $20.01 |
| | Hyvar X 80% | 30 lbs. | 3.6 lbs. | $154.50 | $18.54 |
| TCA Inhibited | 91% | 165 lbs. | 20.0 lbs. | $ 58.58 | $ 7.10 |
| TCA & Bromacil | (See above) | 88 lbs & 20 lbs. 50% | 10.6 lbs. & 20 lbs. 50% | $31.24 & $69.00 = $100.24 | $ 3.76 + $8.28 =$12.04 |
| | | 88 lbs & 12.5 lbs 80% | 10.6 lbs & 1.5 lbs 80% | $31.24 & $64.38 = $95.62 | $ 3.76 & 7.73 = $11.49 |
| Borea T-10 | 58% | 862 lbs. | 104.3 lbs. | $2.4.98 | $26.06 |

* Cost per pound generally is much less when purchases are made of truckload, carload, or tank car lots.

** These herbicides should be applied in enough water to make 40 gallons of solution per acre.

*** These herbicides should be applied in water in a minimum of 100 gallons of solution per acre or 12.1 gallons per foot mile.

# WEED CONTROL AND ERADICATION
# ON
# OKLAHOMA HIGHWAYS

by

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## INTRODUCTION

The highway program in Oklahoma requires modern, efficient methods of establishment and maintenance of desirable vegetation on the rights-of-way if it is to provide maximum services with a minimum of expenditure. Herbicides are being used successfully in most areas to minimize hand labor in the maintenance programs around guardrails and signposts, to reduce the frequency of mowing, and to improve the effectiveness and reduce the costs of weed control on grass-covered areas. Current maintenance programs in some states utilize herbicides for the control of broadleaved plants and weedy grasses, sometimes in combination with growth inhibitors. These modern programs commonly reduce maintenance costs while improving the stand of grass.

A problem common to many states is the infestation of roadsides with johnsongrass (Sorghum halepense L.). This plant, considered a noxious weed on most crop land, spreads by seeds and underground stems (rhizomes), and is detrimental to both the appearance of roadsides and the drivers' safety. To combat this problem highway maintenance divisions frequently employ mechanical mowing of johnsongrass as a means of control. Mowing newly established lawns regularly with a lawn mower and at the usual low height of clip, will require one or more years to effectively reduce or eliminate johnsongrass from the area. Such a frequency of mowing applied to the vast highway system would make the cost for the control of johnsongrass prohibitive in most cases even with maximum effectiveness.

Soil sterilization, or complete plant suppression, is currently employed in many highway maintenance programs for more effective and economical maintenance of guardrails and shoulders. The complete suppression of plant growth is used for the protection of highways where severe damage could result if plant growth in the asphaltic surface or shoulders were not controlled.

## METHODS OF WEED CONTROL

Two methods are generally available for the control of weeds in grass-covered areas, these are mechanical or chemical. Both methods have been used with success. The principal objective here is to use the most satisfactory and economical method for weed control on the various highway areas.

Successful weed control by mechanical methods generally is restricted to those weeds that perpetuate themselves by seed. With careful timing of the mowing operations to coincide with the flowering periods of the many weeds, the repeated removal of the flowers, preventing seed production should ultimately eliminate the weeds from an area. Failure to remove all flowers however, enables the common roadside weeds to produce enough seed to perpetuate the problem for many years. Weeds that reproduce vegetatively must be mowed frequently enough to prevent flowering, and the normal production and accumulation of foodstuffs to ultimately lead to starvation and death of the plant while preventing seed production for future infestation. A proposed mowing schedule for weed control on Oklahoma highways where mechanical methods are deemed best is included in the appendix.

The improper use of mechanical equipment for supposedly weed control purposes adds greatly to the maintenance costs of the highway system. The exposure of bare soil on slopes from the tearing action of the tractor, and the destruction of desirable grasses on the flats from frequent and low mowings, permits and encourages weed invasion and growth along the highway. Soil erosion is accelerated by these practices also.

Weed control with chemicals has become a common practice in recent years. Generally this is the most satisfactory and economical method of weed control. These weed-killing chemicals, or herbicides are classified according to their effects on plants. Contact herbicides kill those plant parts that are covered with the chemical. They are effective against annual weeds but only burn off the tops of perennial plants. Herbicides such as 2,4-D that can be absorbed by either the roots or above-ground parts and moved throughout the plant system upsetting the plant's growth and metabolic processes are referred to as systemic herbicides, growth regulators, or translocated herbicides. Chemicals that prevents the growth of green plants when present in the soil are referred to as soil sterilants.

## WEED CONTROL AND ERADICATION

The principal objectives of this part of the research project were to find the most satisfactory and economical methods to control weeds on the Oklahoma highway system. To achieve these objectives several factors were to be evaluated. The major items of concern involved chemical and mechanical means of weed control, and were to concentrate on:

A. Chemical control of weeds.

1. The evaluation of selective herbicides for weed control.
2. The evaluation of non-selective herbicides for soil sterilization.
3. The evaluation of chemical growth regulators as a substitute for mowing.

B. Mechanical control of weeds.

1. Determination of proper time to mow for weed control in each geographical area of the state.
2. Determination of height and frequency of mowing required for weed control in various highway areas.

## FINDINGS AND CONCLUSIONS

The research results in this report, even though involved with a common investigation, will be presented as three separate studies for the purpose of clarity and convenience.

## PART I

### BROADLEAF WEED AND ANNUAL GRASS CONTROL

More than 15,000 miles of state and federal highways and roads are presently maintained by the Oklahoma Department of Highways. Mowing represents one of the major maintenance costs annually for this highway system. In the five-year period 1960-1964 an average of

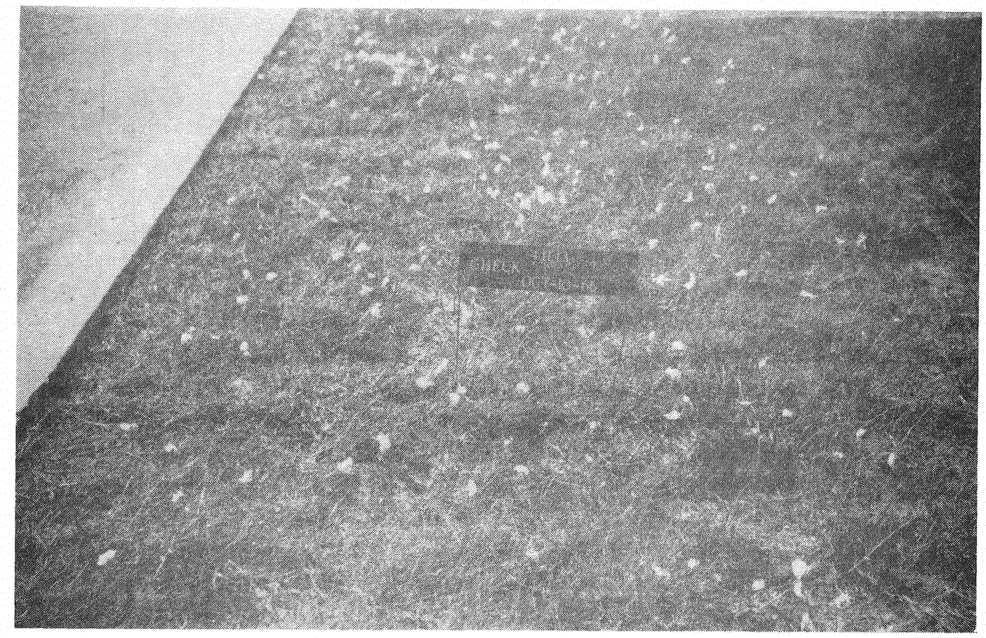
244,608 acres were mowed annually at an average cost of more than $843,000.00 per year. The loss of life in mowing accidents each year is of even greater importance.

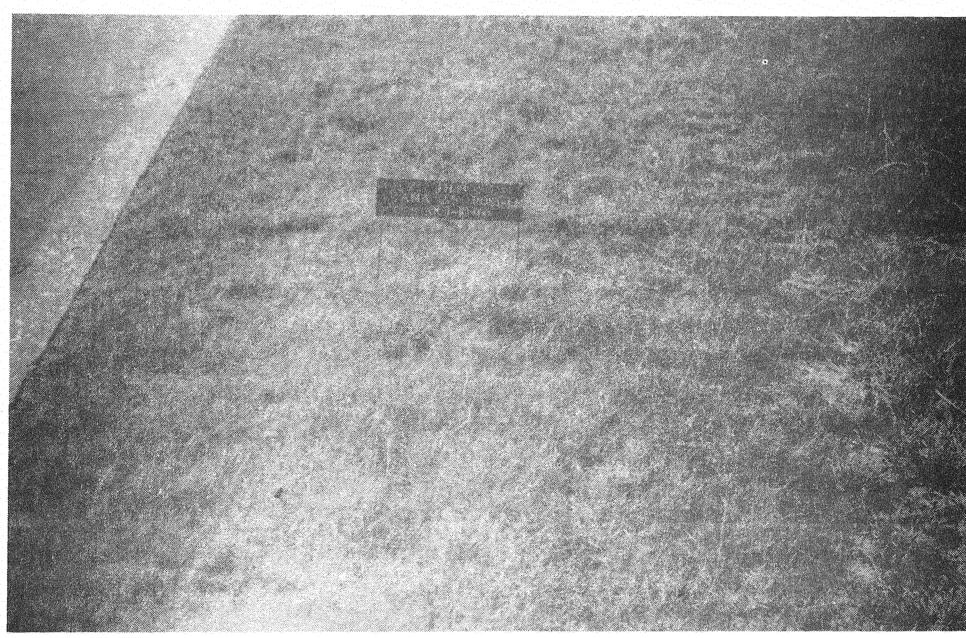
The availability of herbicides that are effective in the selective control of many plants, offers possibilities for their successful and economical use in the maintenance of Oklahoma's highways. The use of chemicals for weed control in combination with an effective fertilization program (see Part I, "Causes and Control of Soil Erosion on Oklahoma Highways," and Part II of this research report, "Maintenance of Vegetative Ground Covers on Oklahoma Highways") would enhance soil stabilization for erosion control and beautification while substantially reducing costs of highway maintenance.

With tourism being encouraged in Oklahoma, all aspects of our highway system must be considered if the program is to be successful. As our state and federal roads and highways are increasingly used, the rest areas and roadside parks will be visited more frequently. Roadsides also will be utilized to a greater extent either from intentional rest stops or for emergency purposes.

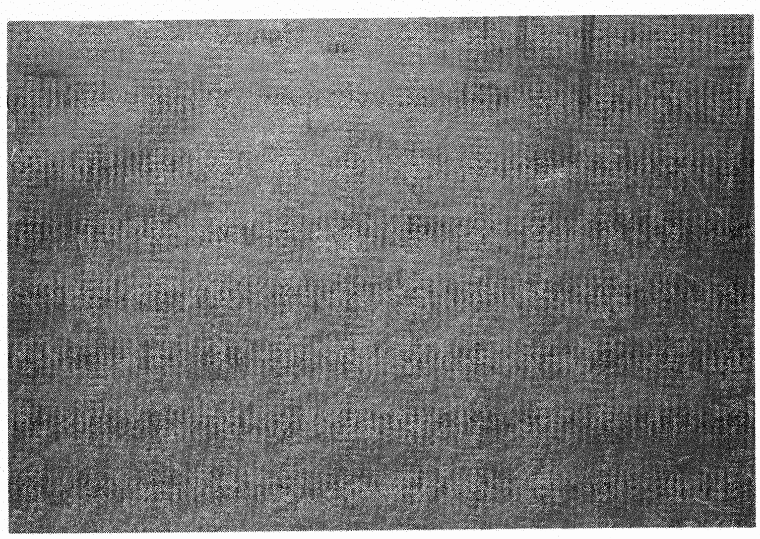
Weeds which are to be found on the highway rights-of-way generally detract from the overall beauty of the area, or may inflict physical pain if brought into contact with a person. One such plant of this nature is the sandbur (Cenchrus pauciflorus Benth.) which produces numerous spiny burs that virtually renders an area unusable by man or animal.

In 1966 the first of several experiments was initiated to evaluate pre-emergence and post-emergence herbicides and their combinations for the selective control of sandburs on the roadside in





Sandburs (white marks in top photo) that infest roadsides and rest areas can be effectively controlled (bottom photo) with selective herbicides that permits the erosion resistant bermudagrass to take over.

Broadleaf weeds and annual grasses (top photo) can be effectively controlled on the highway system (bottom photo) with selective herbicides that permits the erosion resistant grasses to thrive and reduces the total costs of maintenance.

bermudagrass turf.[1] The results of these herbicide evaluations for the selective control of sandburs in bermudagrass turf are shown in Figures 1 through 5.

The post-emergence herbicides were significantly more effective than the pre-emergence materials tested, or a combination of the two for sandbur control as shown in Figure 5. The organic arsonates, AMA (ammonium methanearsonate) at 3.8 pounds active ingredient (a.i.)/acre showed complete sandbur control with MSMA (monosodium acid methanearsonate) at 2.0 lbs., DSMA (disodium methanearsonate) at 2.5 lbs., and CMA (calcium acid methyl arsonate) at 3.7 lbs. a.i./acre equally as effective.

Only the post-emergence herbicides from the initial investigation were evaluated in subsequent studies along with two other post-emergence materials, another organic arsonate DSMA (disodium methanearsonate) at 2.5 lbs., and Monex (MSMA plus Diuron [3(3,4-dichlorophenyl)-1,1 dimethylurea] at 1.2 lbs. a.i./acre. The post-emergence herbicides used in 1966 and 1967 were all satisfactory in the control of sandburs in bermudagrass turf with only slight differences indicated between materials or rates.

An experiment was initiated in 1966 to evaluate several pre-emergence and post-emergence herbicides for the control of broadleaf weeds and annual grasses in central Oklahoma at the intersection of

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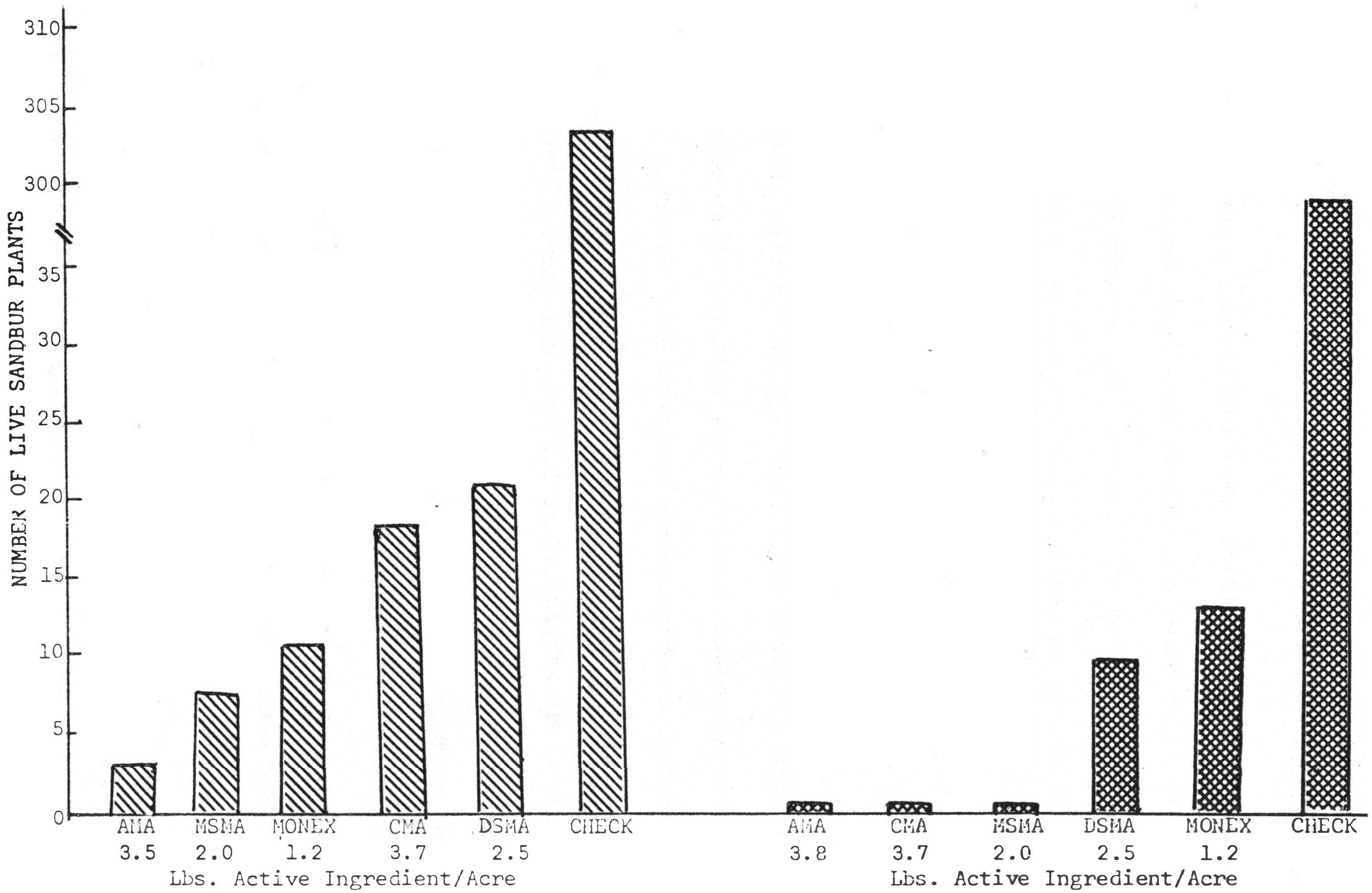
[1]Roach, Gary W. 1968. Herbicide Evaluation for the Selective Control of Sandbur in Bermudagrass Turf. Unpublished M.S. Thesis. Oklahoma State University.




SH-152 8¼ miles west of Binger July 12, 1967 SH-152 8 miles west of Binger July 25, 1967

Figure 1. The effect of various post-emergence herbicides on the control of sandbur in established bermudagrass on SH-152 shoulders west of Binger, Oklahoma.

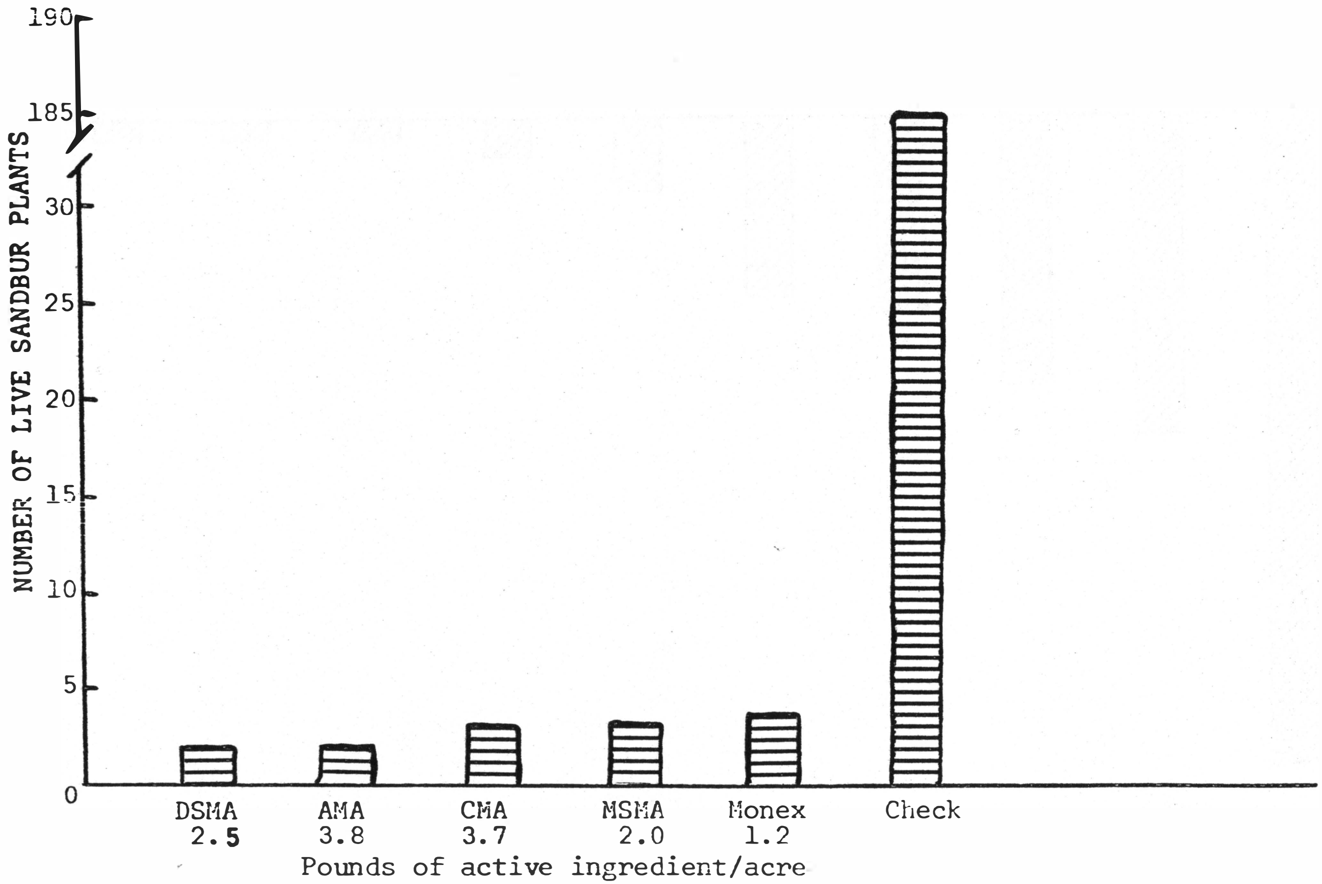



**Figure 2.** The effect of various post-emergence herbicides applied June 15, 1967 and retreated July 10, 1967, on the control of sandbur in established bermudagrass on SH-33 shoulders 3.5 miles west of US-177 near Perkins, Oklahoma, on July 24, 1967.

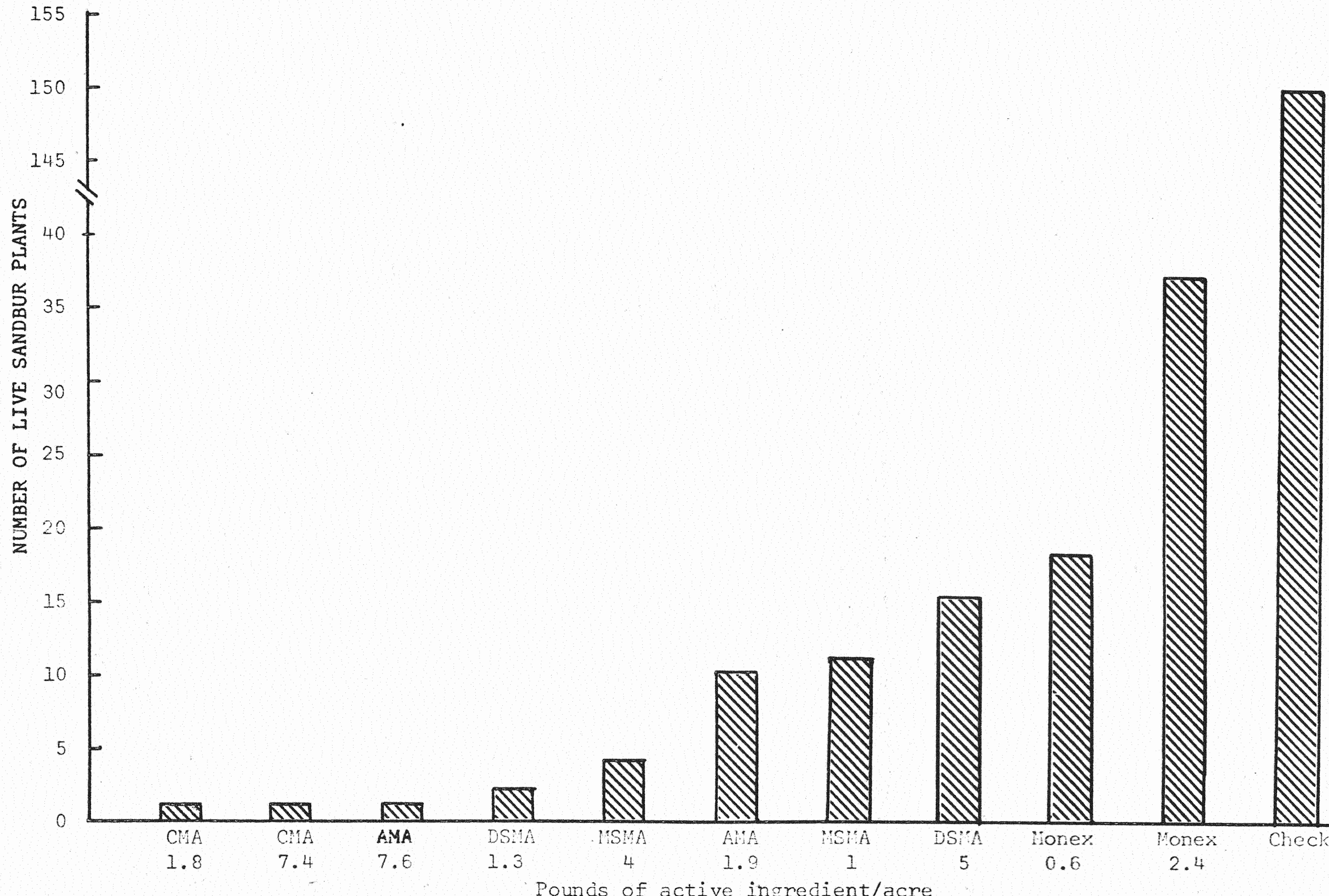



**Figure 3.** The effect of various post-emergence herbicides applied June 21, 1967, and retreated June 30, 1967, on the control of sandbur in established bermudagrass on SH-152 shoulders nine miles west of Binger, Oklahoma, on August 16, 1967.

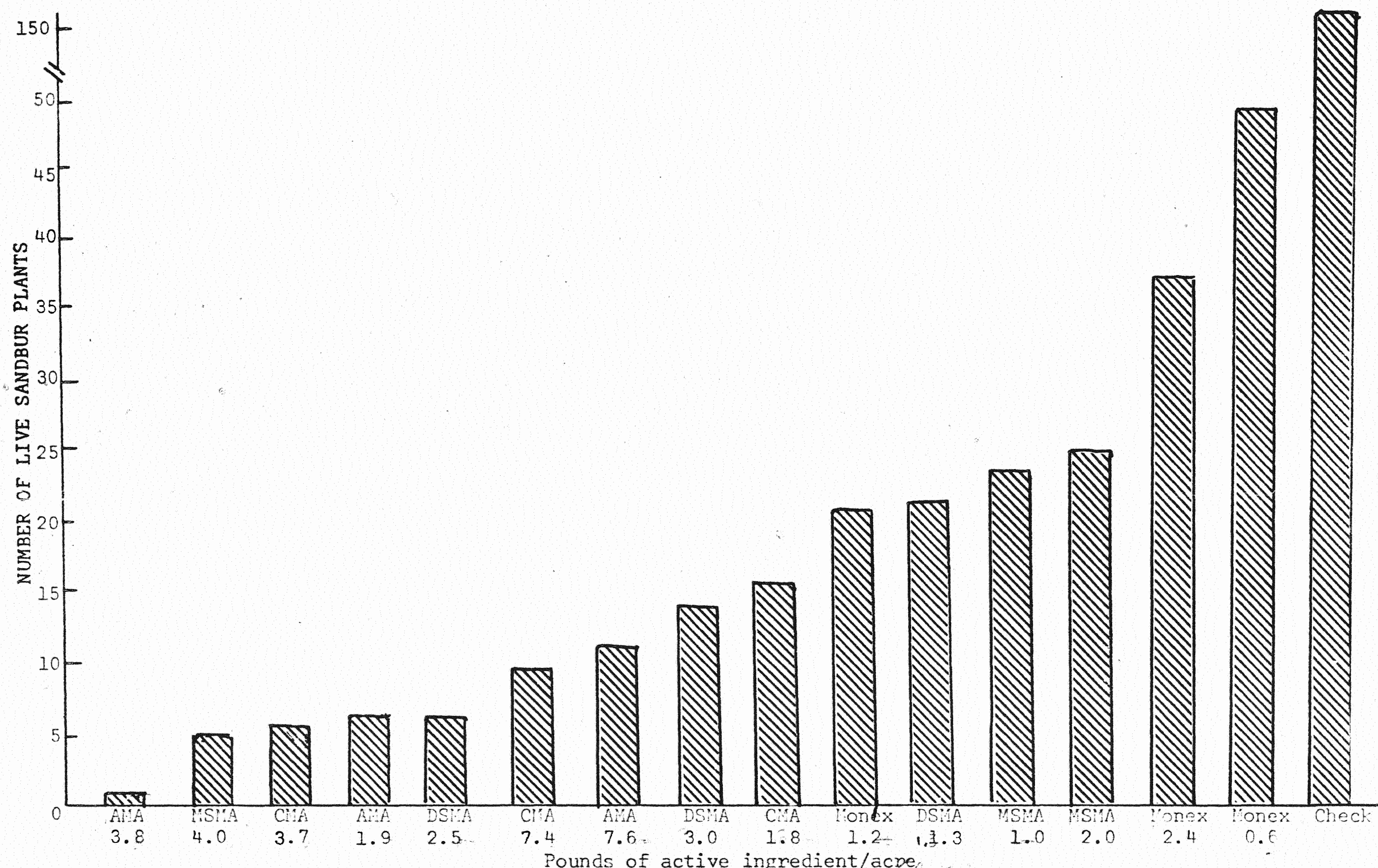



**Figure 4.** The effect of various post-emergence herbicides applied August 25, 1967, on the control of sandbur in established bermudagrass on SH-152 shoulders **nine** miles west of Binger, Oklahoma on September 7, 1967.

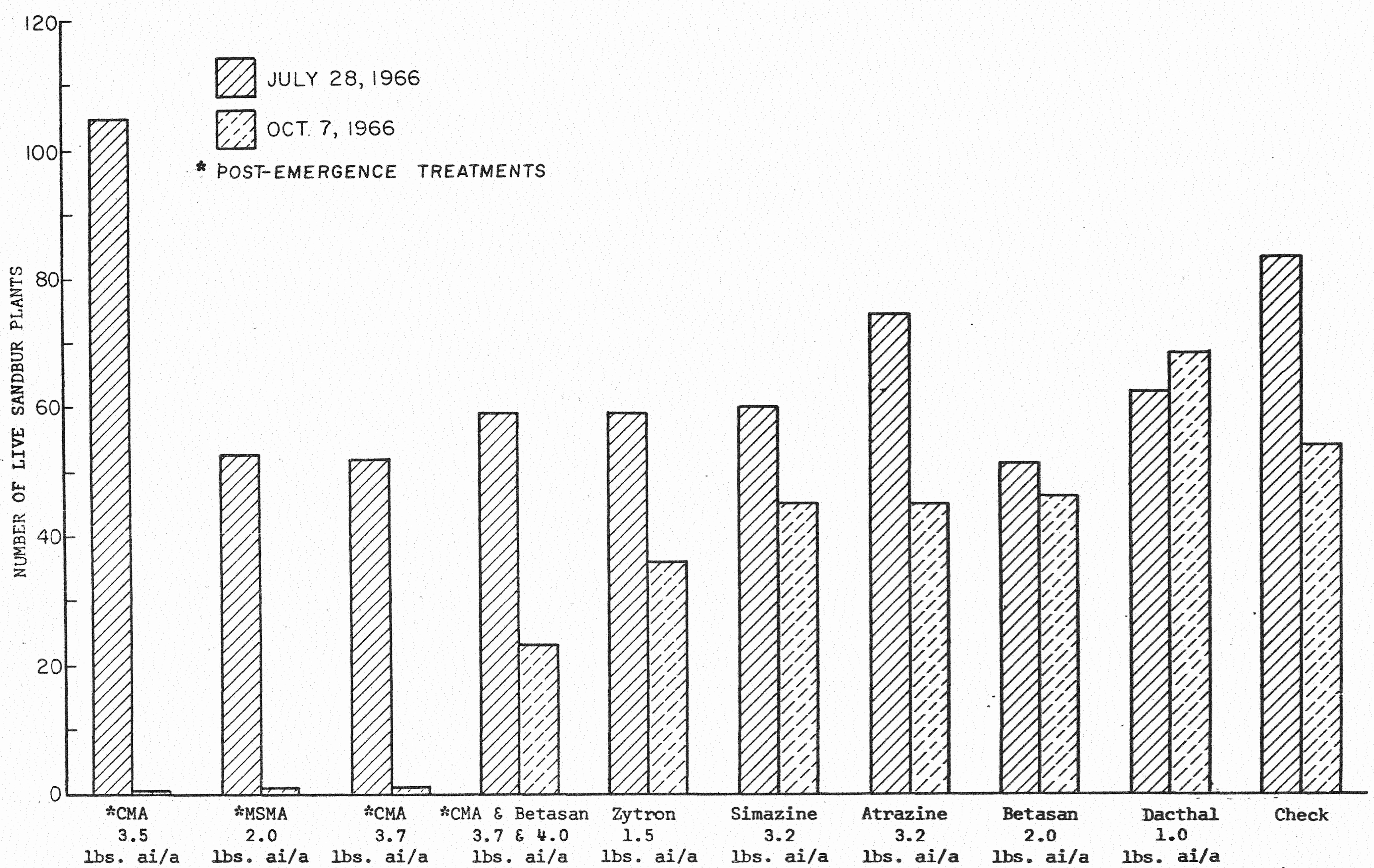



Figure 5. The effect of various herbicides applied pre-emergence March 30, 1966, and post-emergence May 25, September 1, and September 19, 1966, on the control of sandbur on SH-33 shoulders 7.8 miles west of US-177 near Coyle, Oklahoma.

US-177 and US-62 west of Meeker. The results of this investigation are shown in Figures 6,7, and 8. The pre-emergence herbicides Tordon (picloram), Tritac-D, Diuron, Fenac, and Simazine applied in March 1966, and the post-emergence material Banvel-D (dicamba) applied two months later in May produced more than 75% control of all broadleaf weeds when evaluated several months later in mid-August. The control of annual grasses was not as good as expected with a 72% control with Diuron at 3 lbs. ai/acre as the most effective treatment.

A similar experiment to the one described above was started a year earlier (1965) on US-270 near Shawnee. The objectives of this experiment were to evaluate pre-emergence and post-emergence herbicides for broadleaf weed and annual grass control, and to measure residual activity if any of the herbicides to determine the application frequency required for satisfactory weed control. Each experimental unit or plot was entirely treated with its respective herbicide in 1965, but in 1966 only two-thirds of the original area was treated making a total of two treatments for this portion and in 1967 one-third of the original treatment area was retreated making a total of three successive annual treatments on this part. The results of these evaluations are shown in Figures 9 through 21. The treatments were evaluated twice in each of the years 1965 (two bars at the left for each entry), and 1966 (two center bars), but only once in 1967 as indicated by the one bar at the extreme right for each entry. An arbitrary figure of 90% was established as the minimum for satisfactory broadleaf weed and annual grass control.

Atrazine at 3 lbs. ai/acre applied as a pre-emergence herbicide in early April as shown in Figure 9, provided about 96% control of

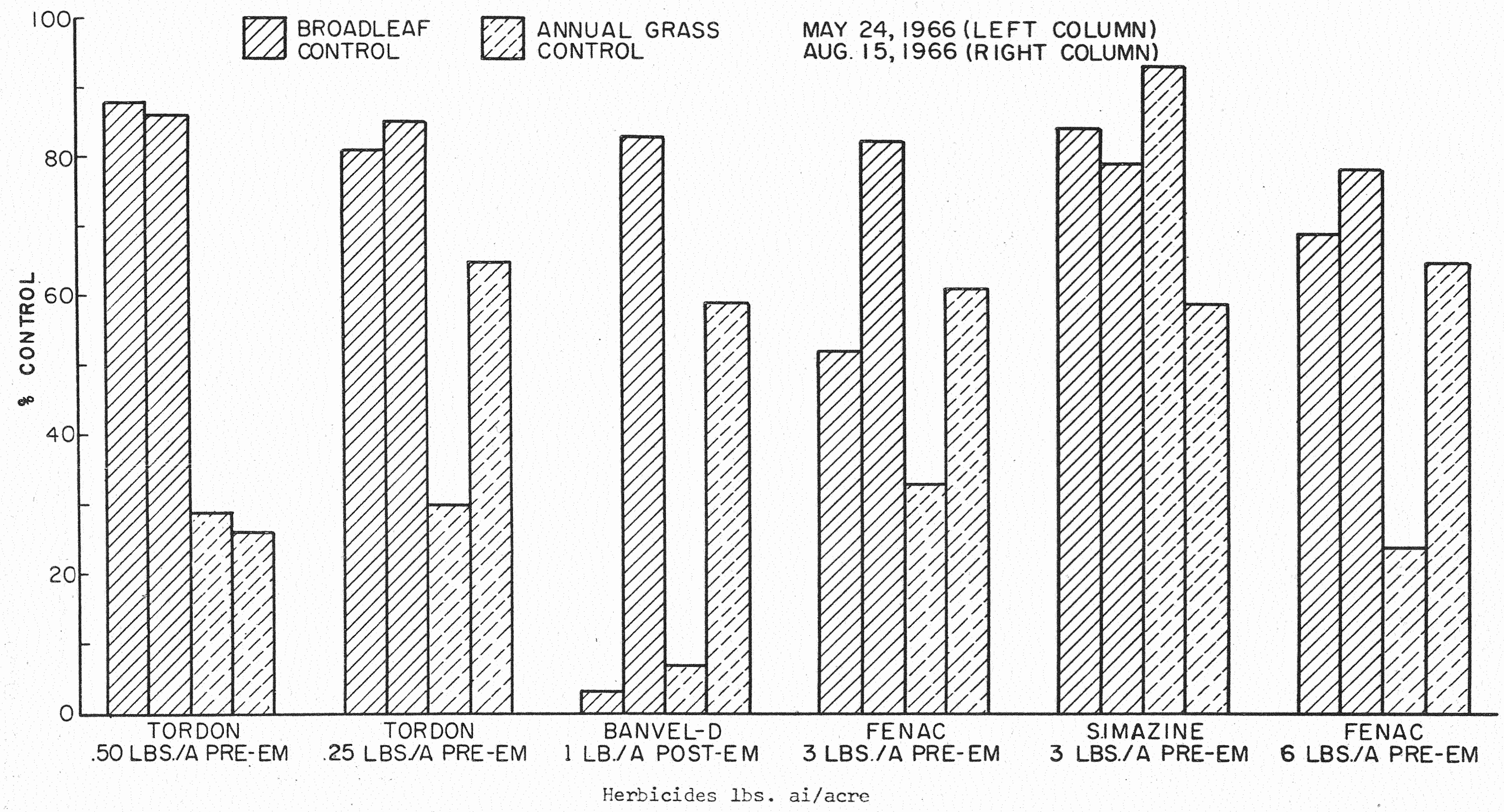
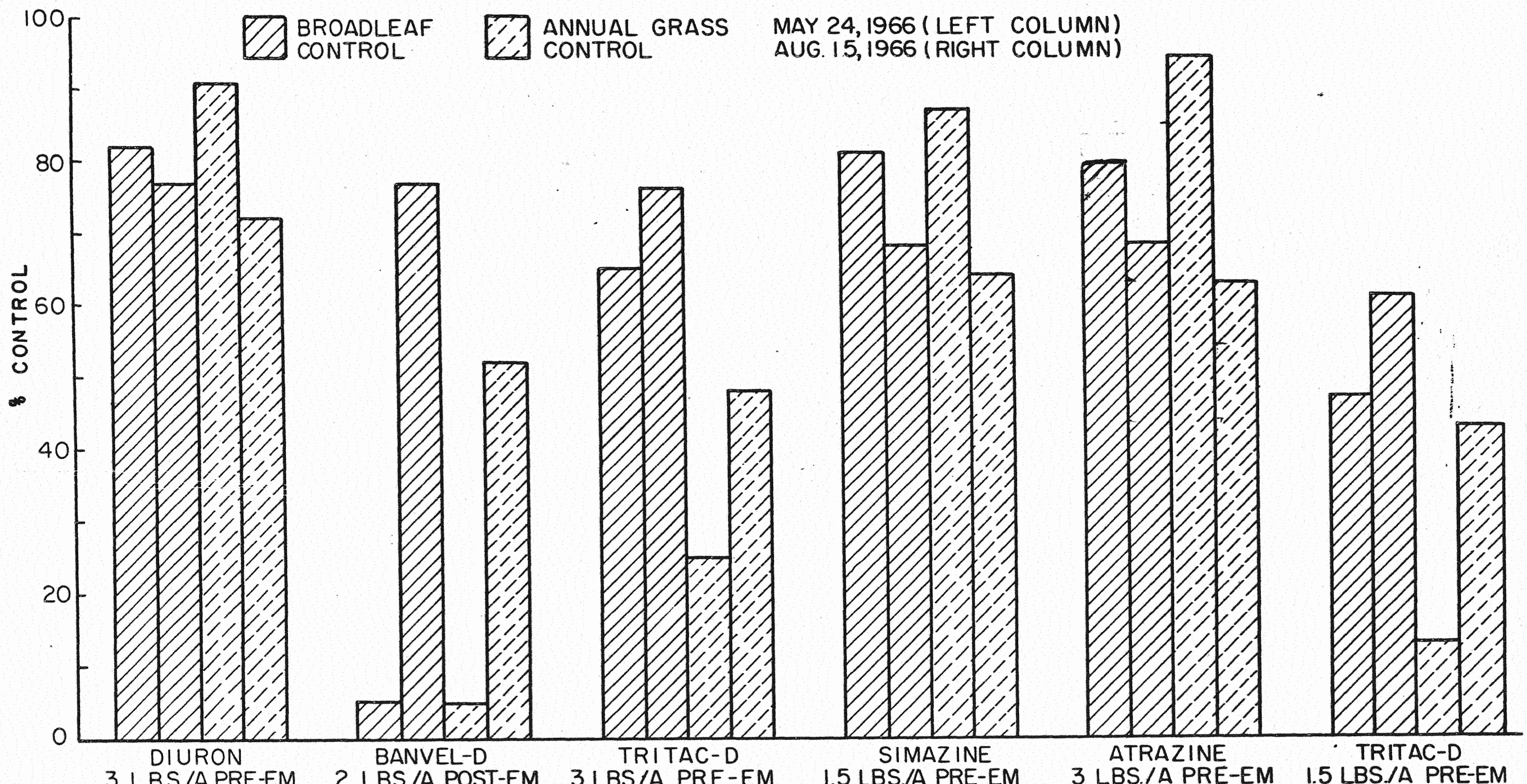



**Figure 6.** The effect of various chemicals applied March 29, 1966 (Pre-emergence) and May 25, 1966 (Post-emergence) on the control of broadleaf weeds and annual grasses near the junction of US-177 and US-62 west of Meeker, Oklahoma.




Herbicides lbs. ai/acre

**Figure 7** The effect of various chemicals applied March 29, 1966 (Pre-emergence) and May 25, 1966 (Post-emergence) on the control of broadleaf weeds and annual grasses near the junction of US-177 and US-62 west of Meeker, Oklahoma.

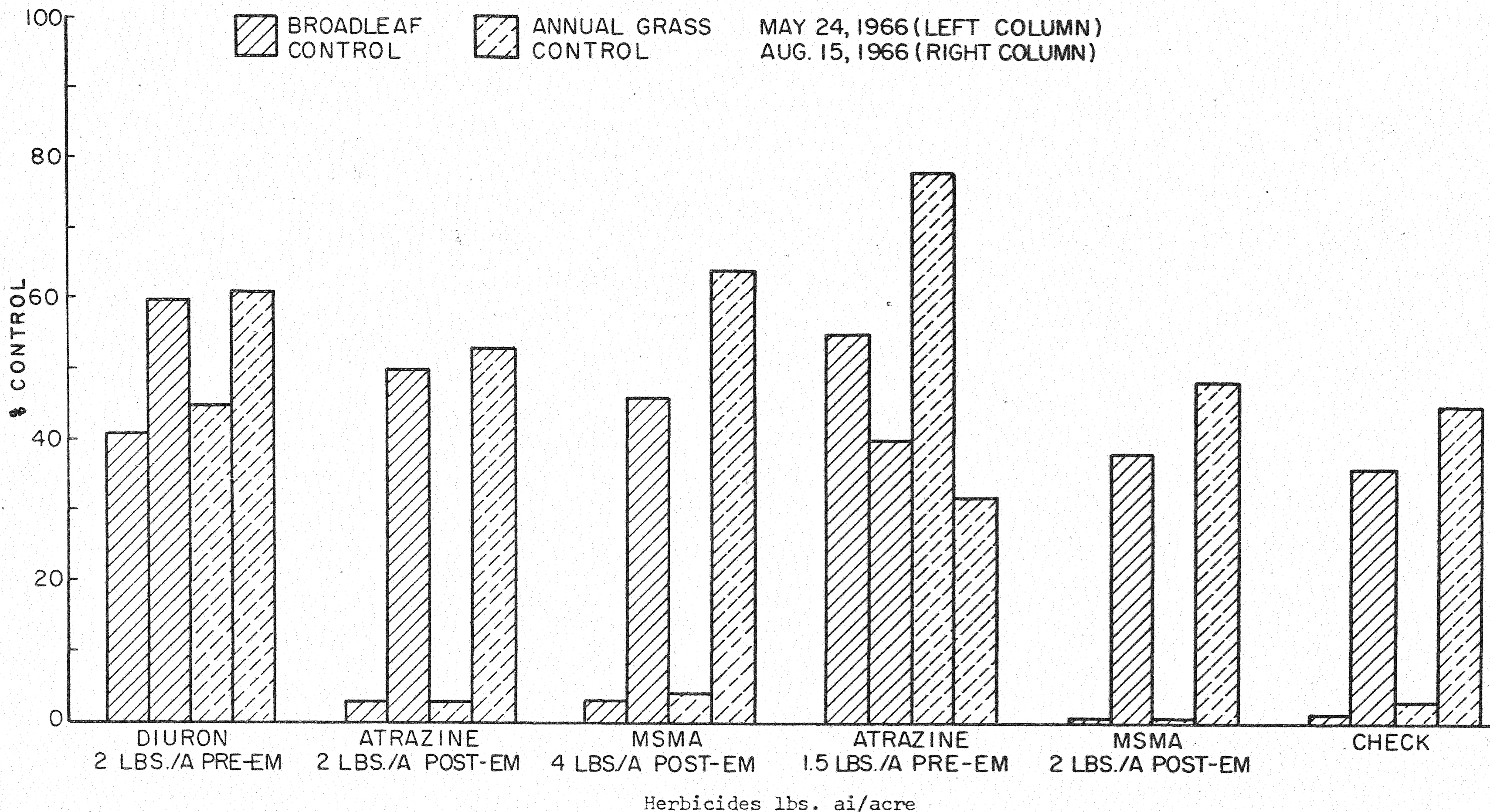



Figure 8. The effect of various chemicals applied March 29, 1966 (Pre-emergence) and May 25, 1966 (Post-emergence) on the control of broadleaf weeds and annual grasses near the junction of US-177 and US-62 west of Meeker, Oklahoma.

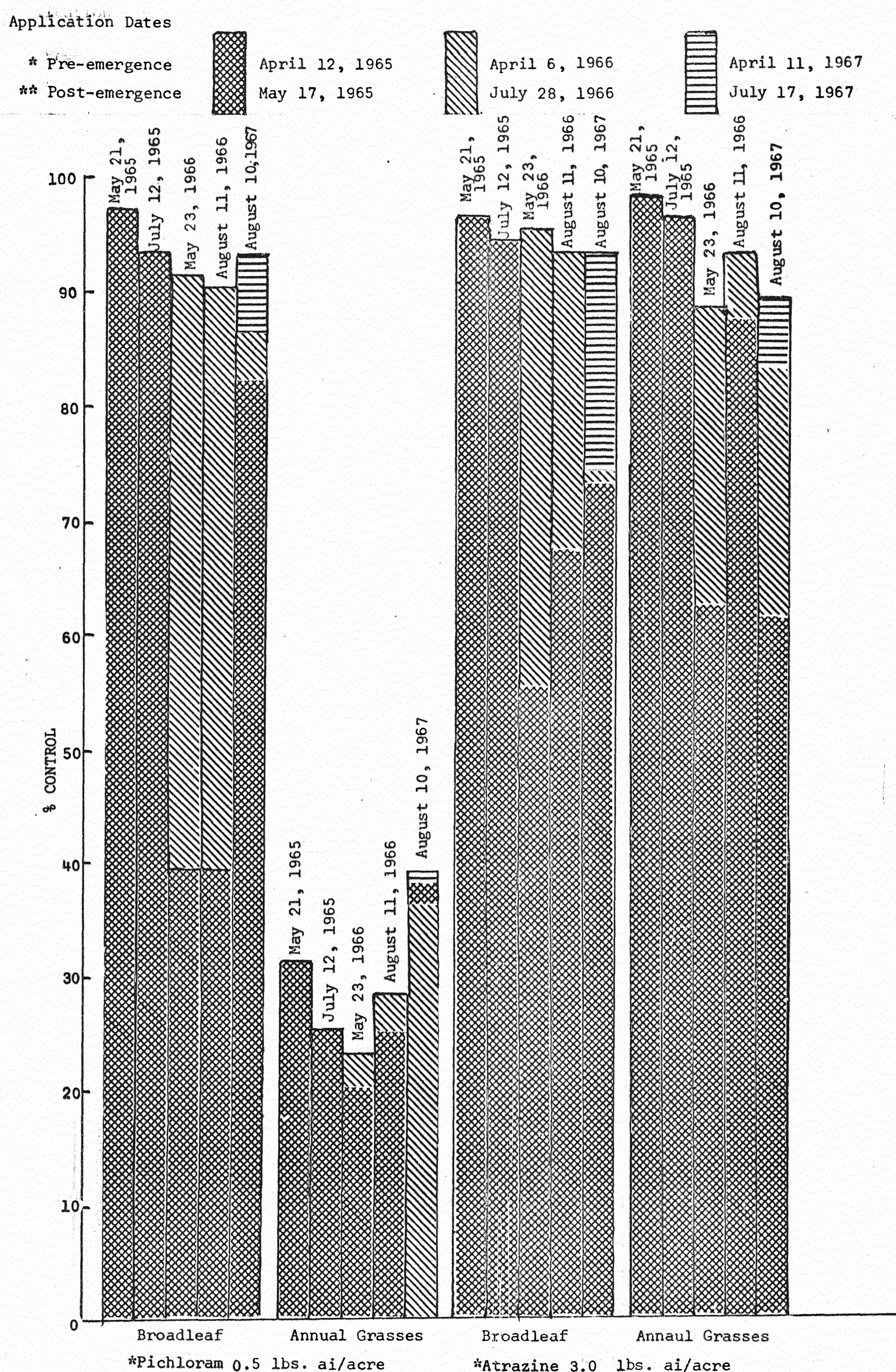



Figure 9. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

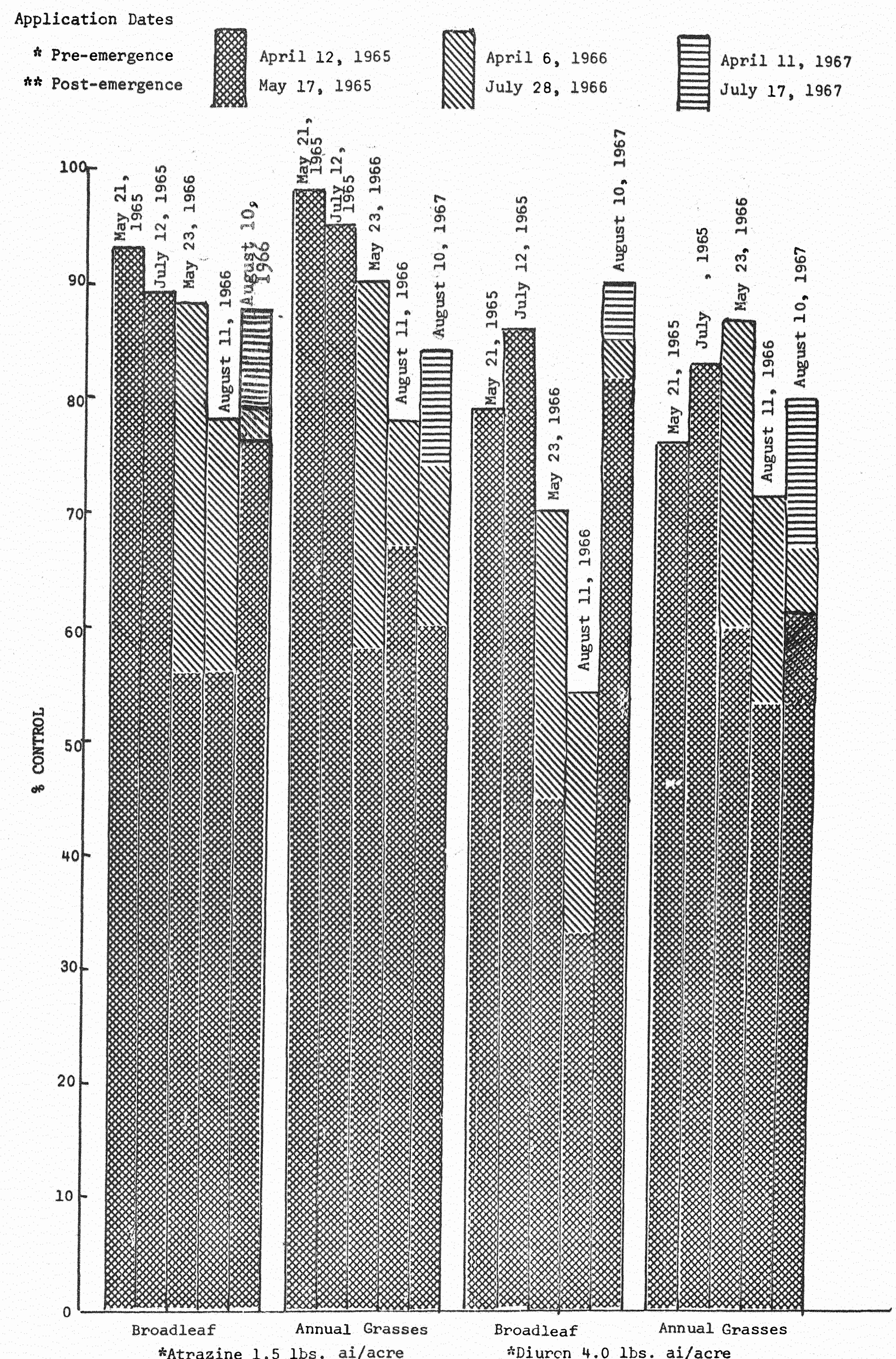



Figure 10. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

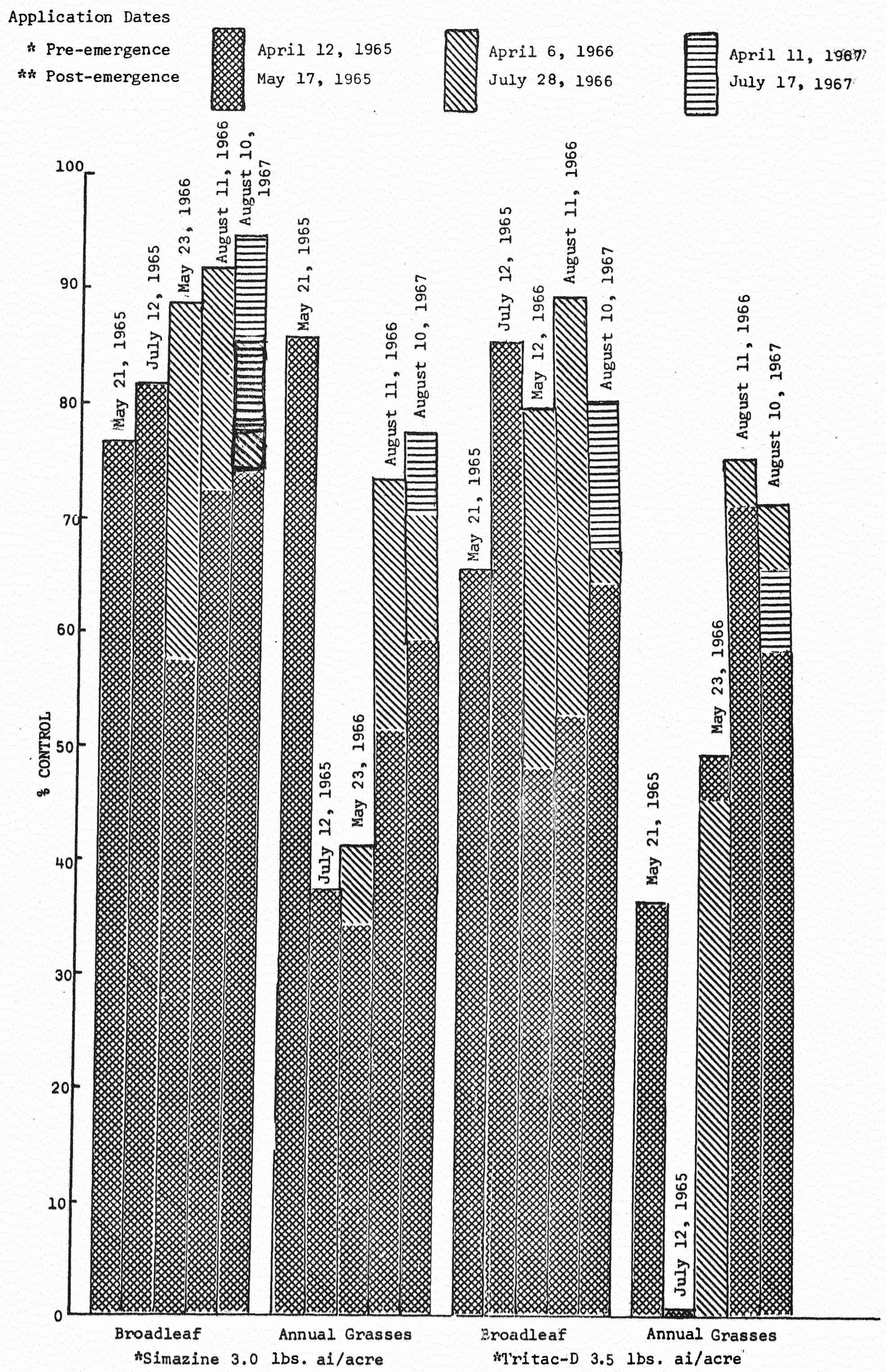



Figure 11. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

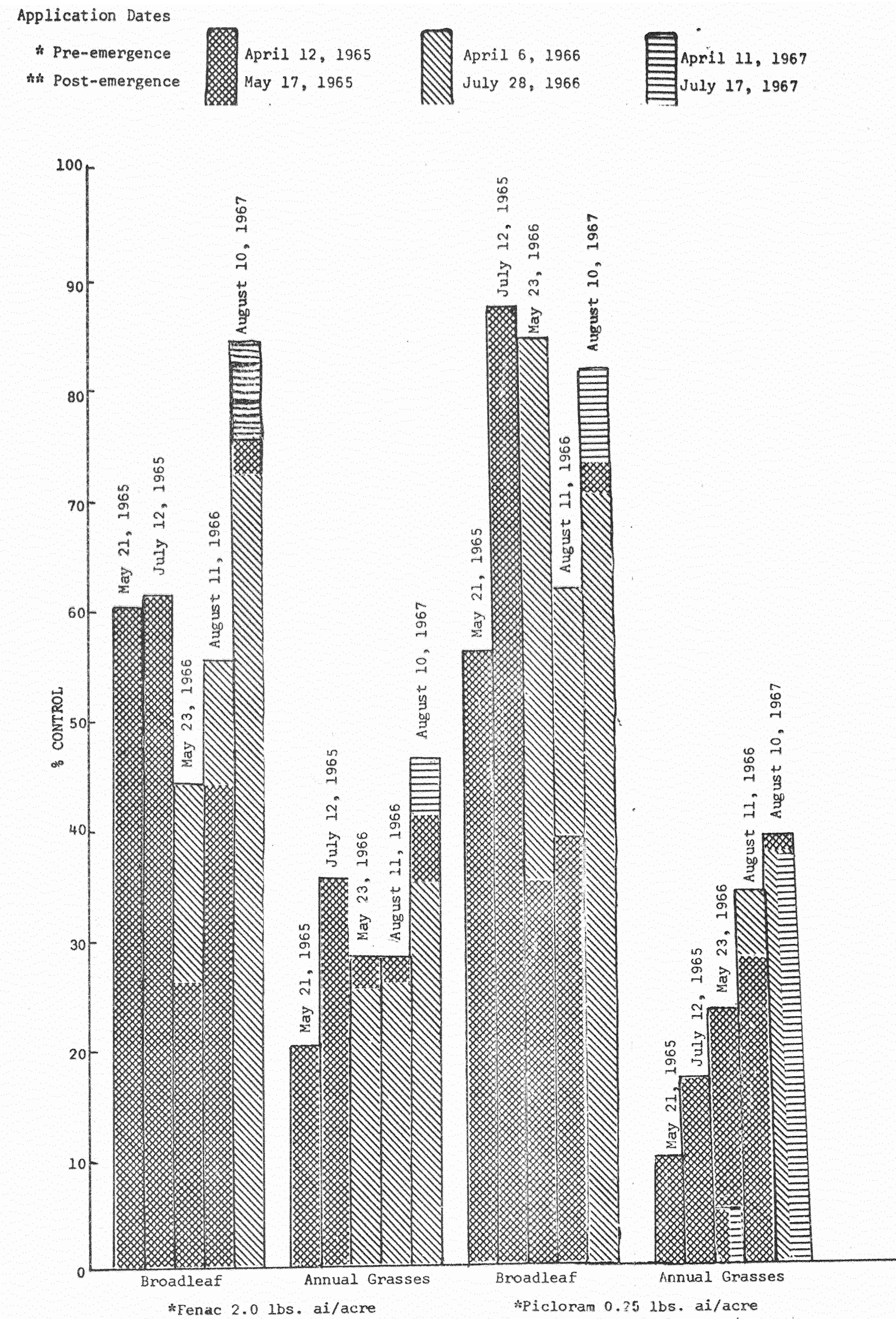



Figure 12. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

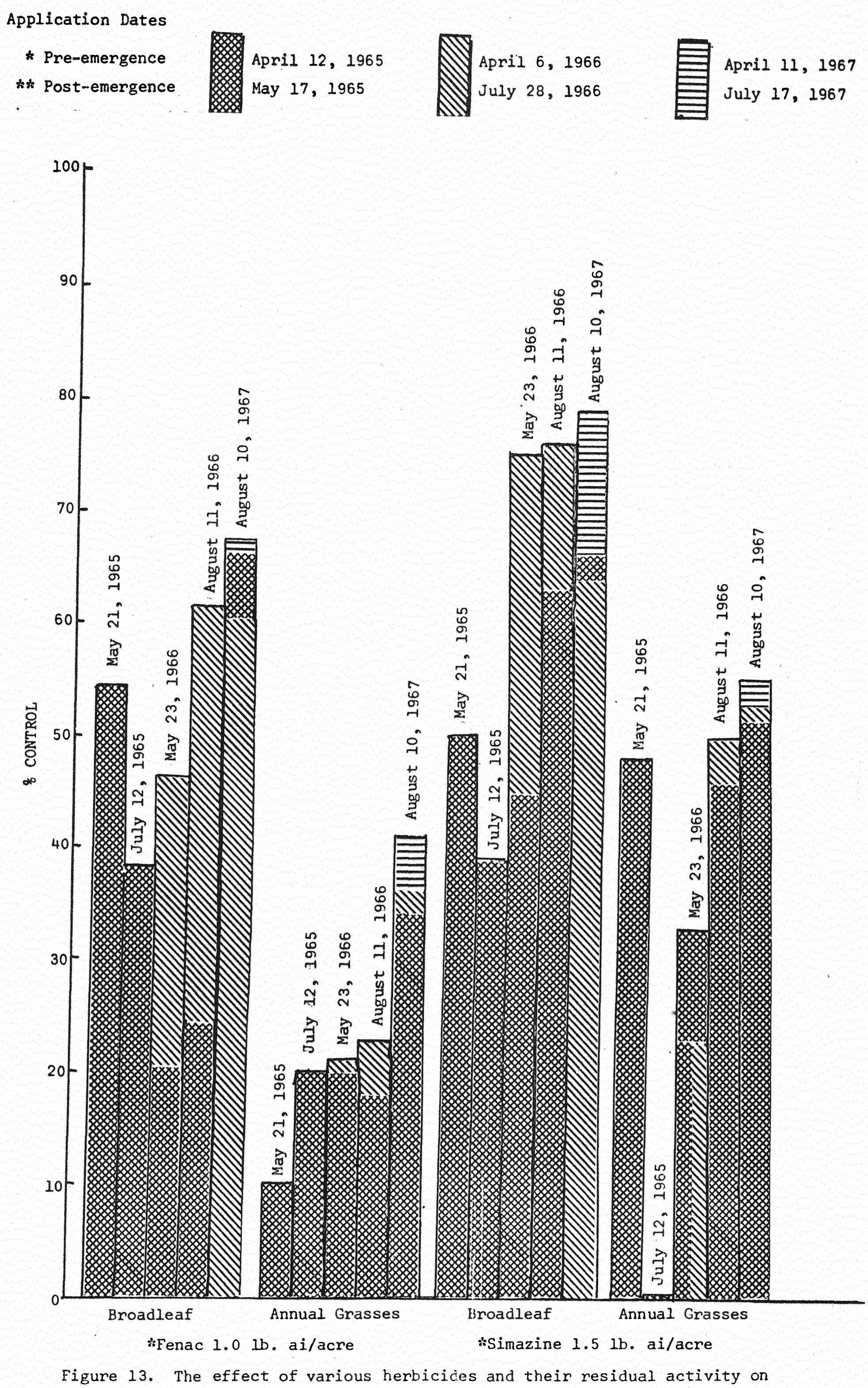



Figure 13. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967 on US-270 just south of I-40 near Shawnee, Oklahoma.

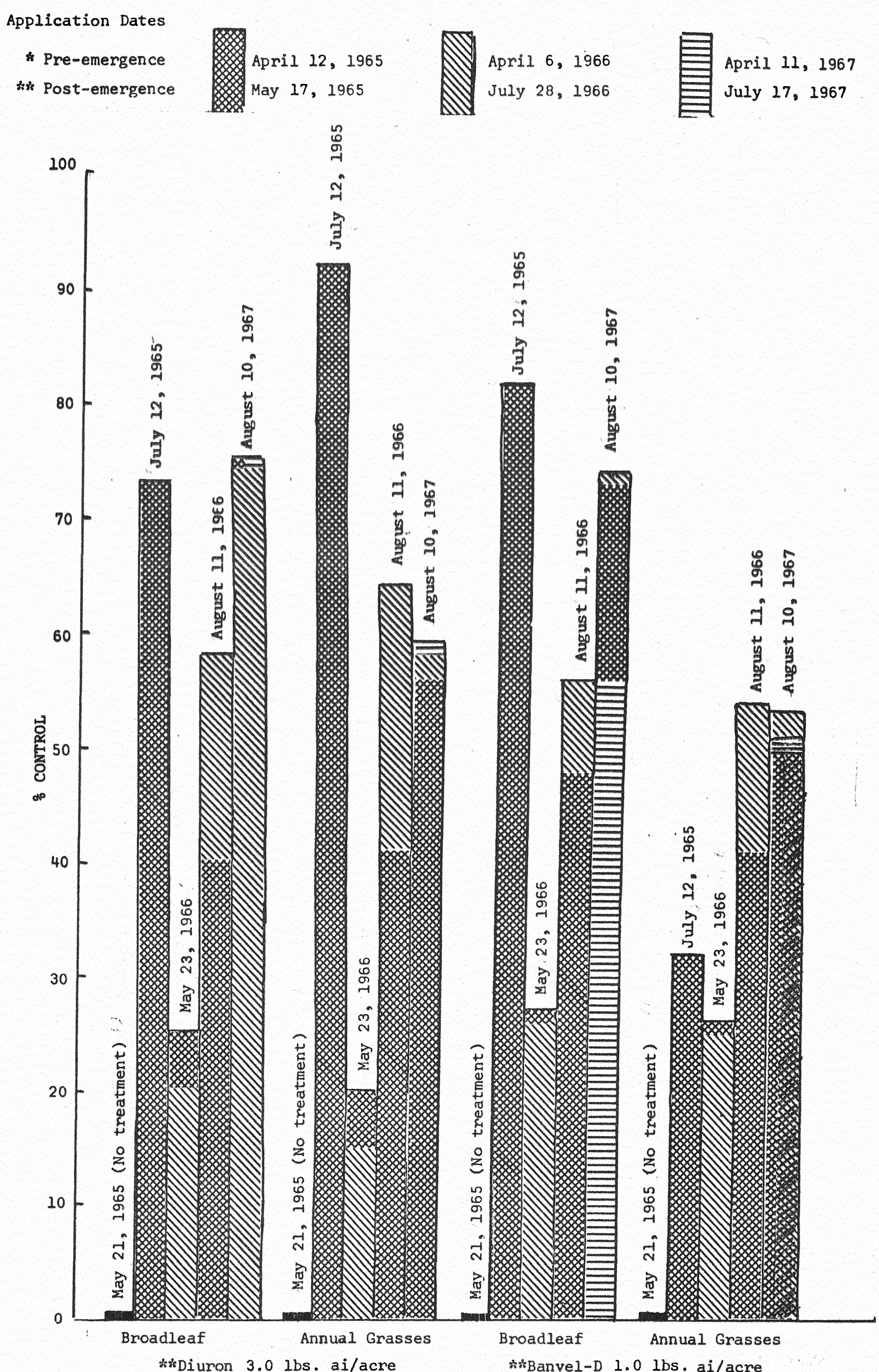



Figure 14. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1967, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

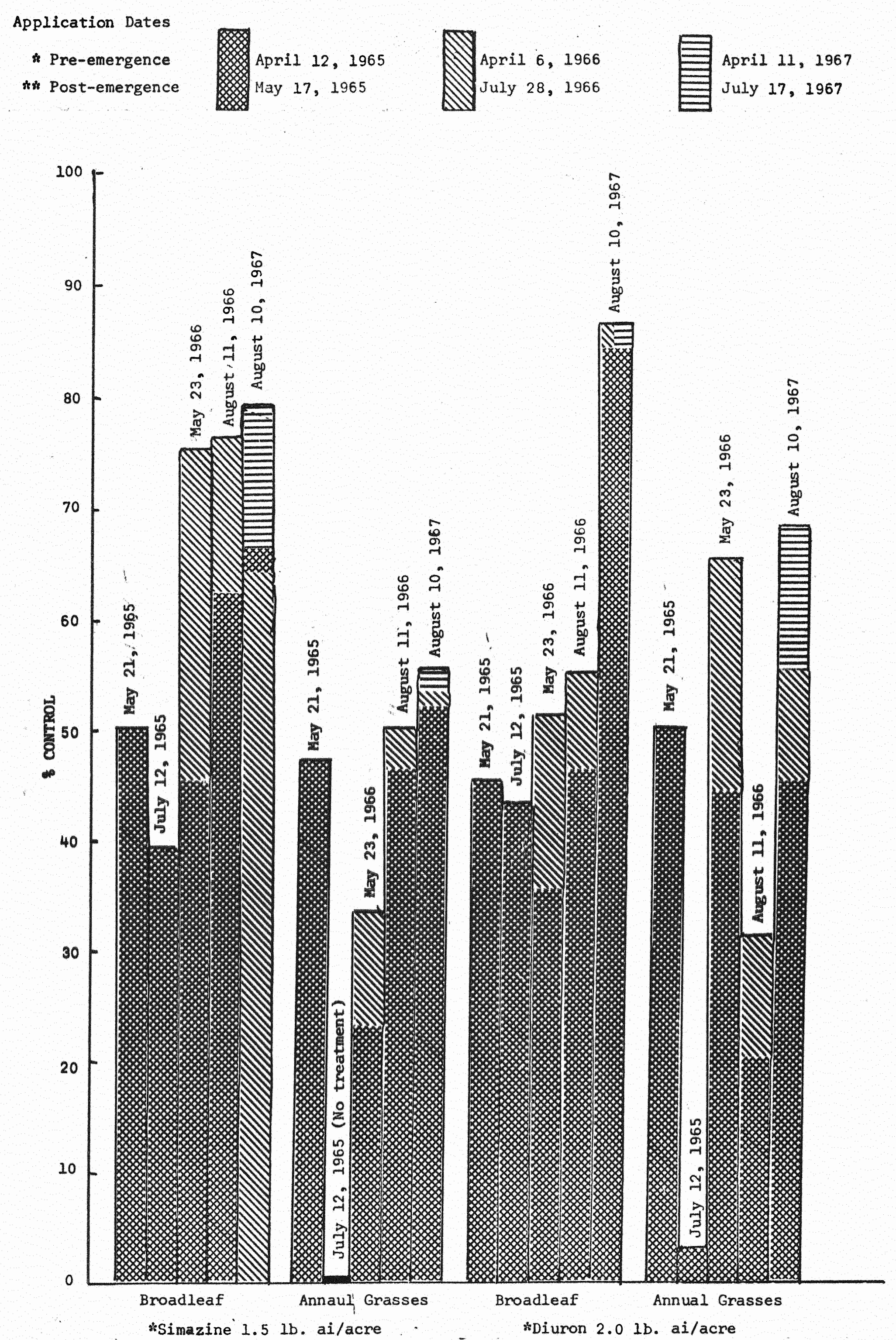



Figure 15. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

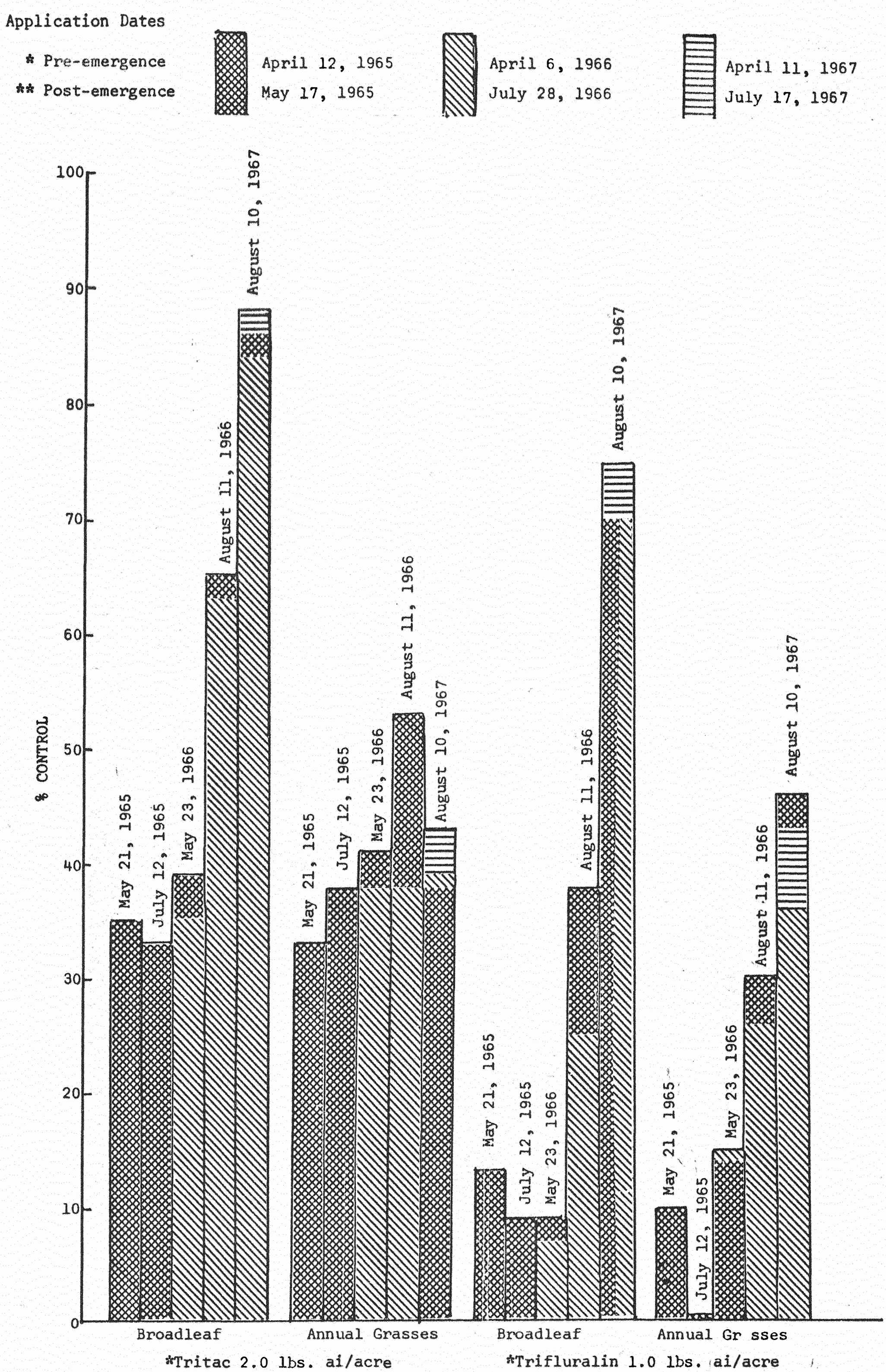



Figure 16. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

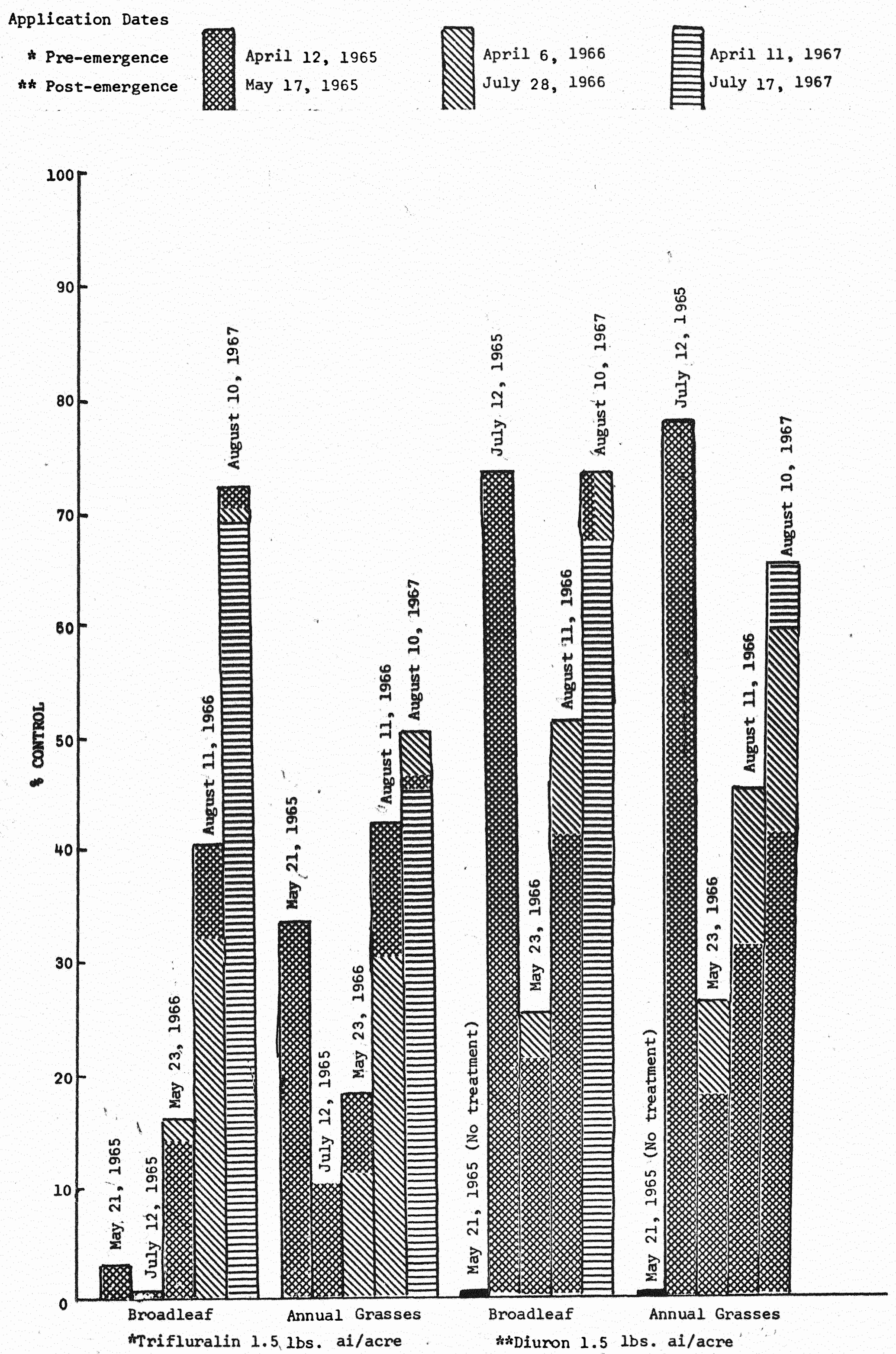



**Figure 17.** The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma

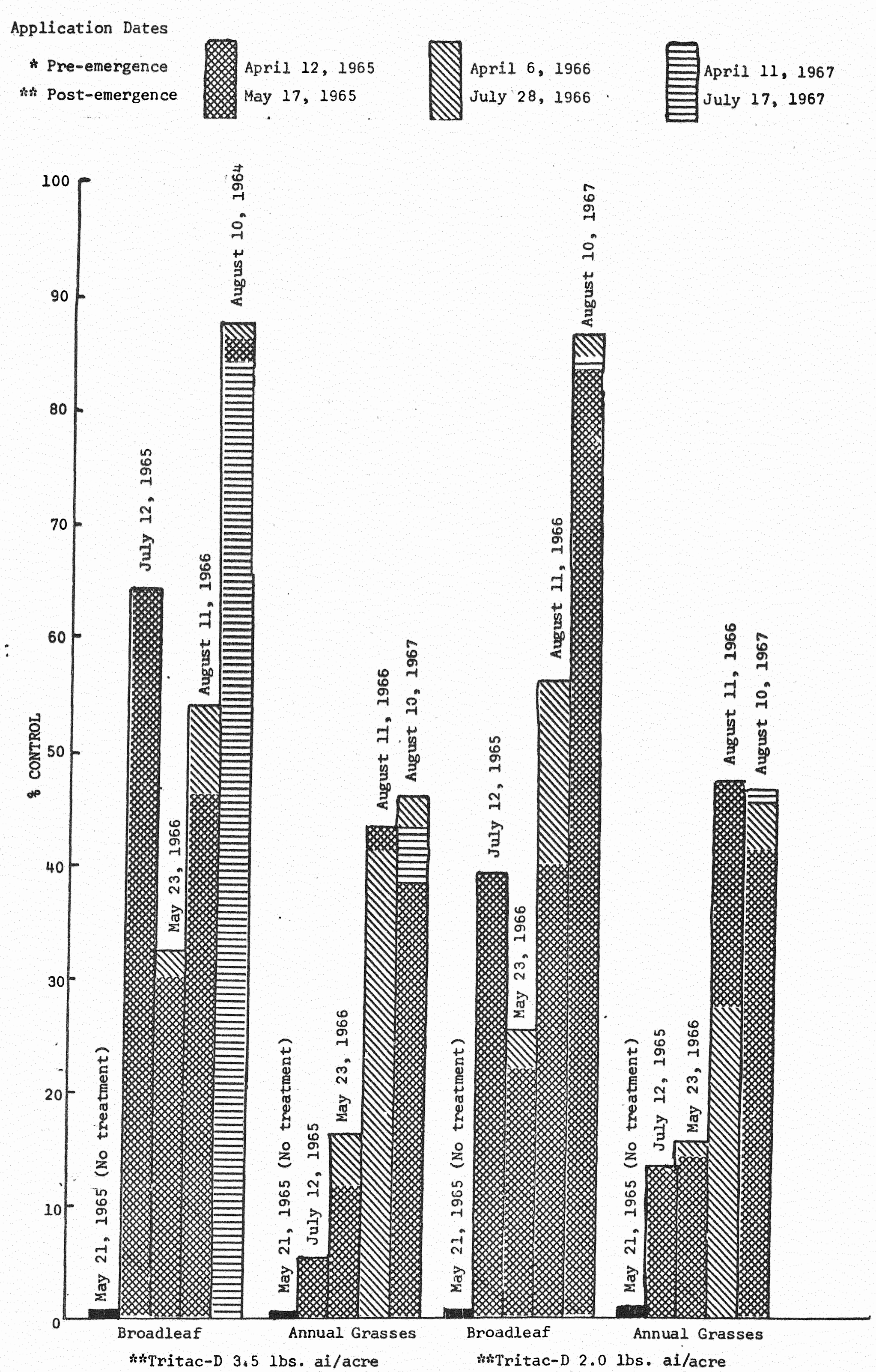



Figure 18. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

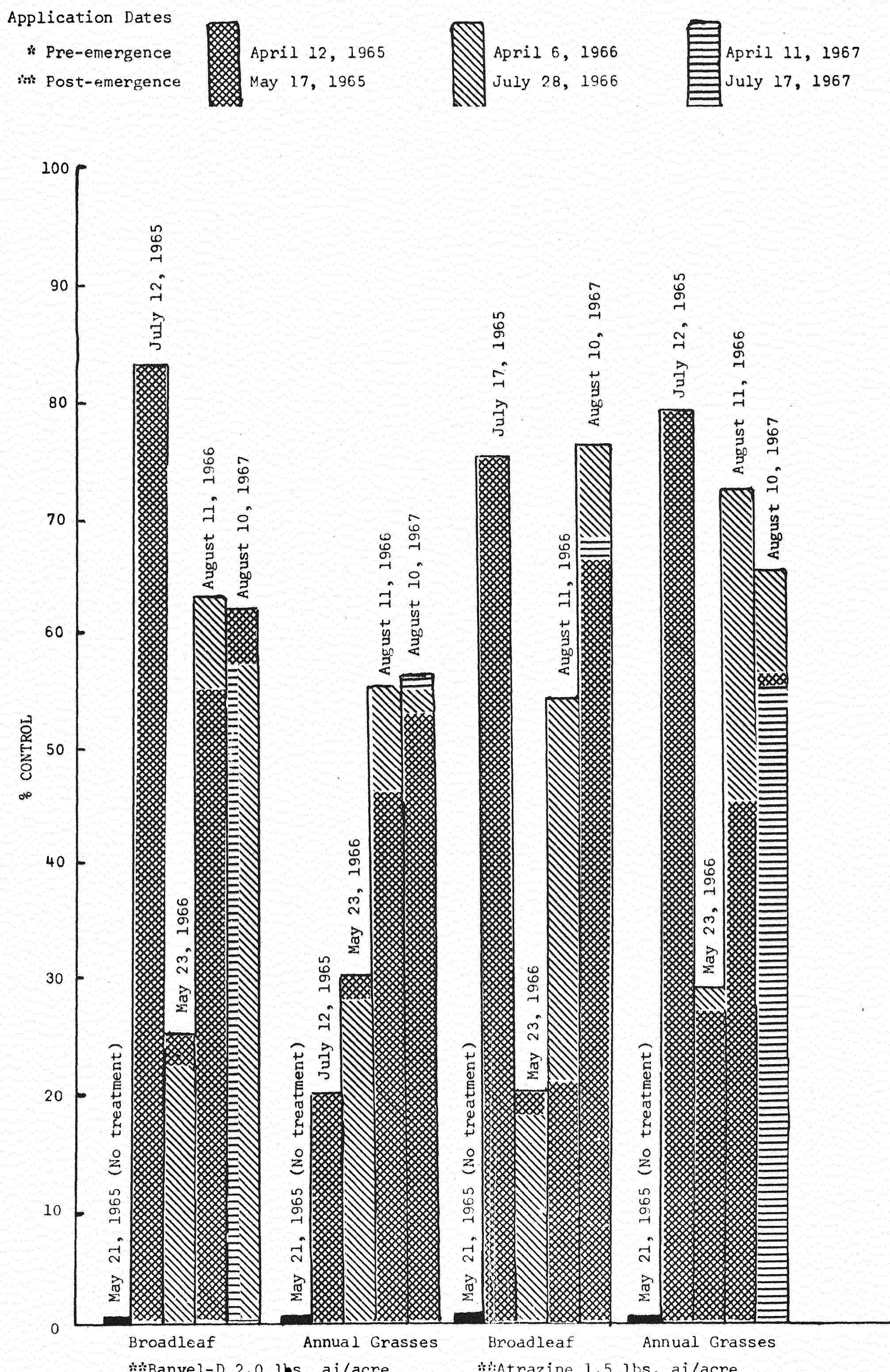



Figure 19. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

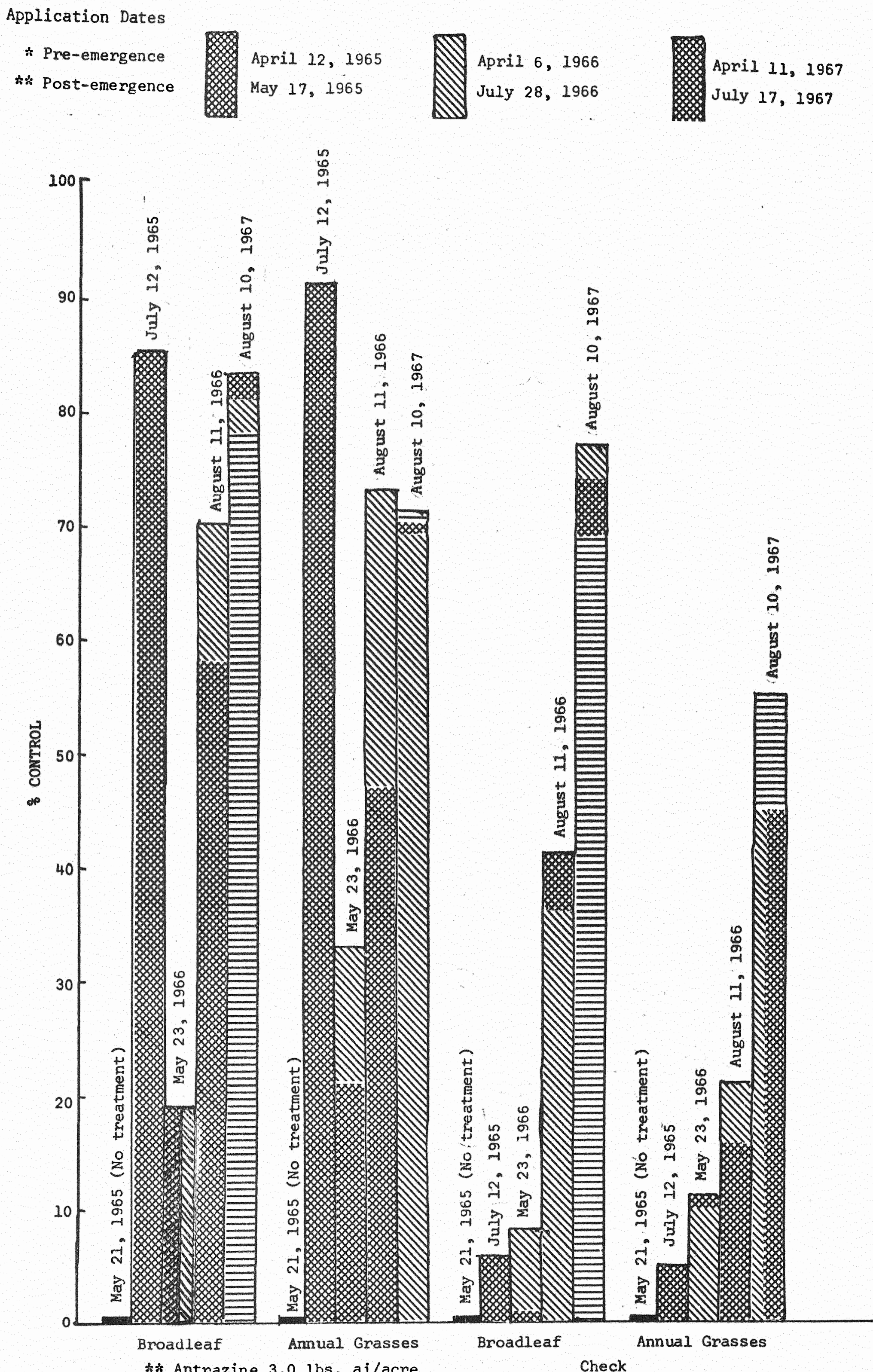
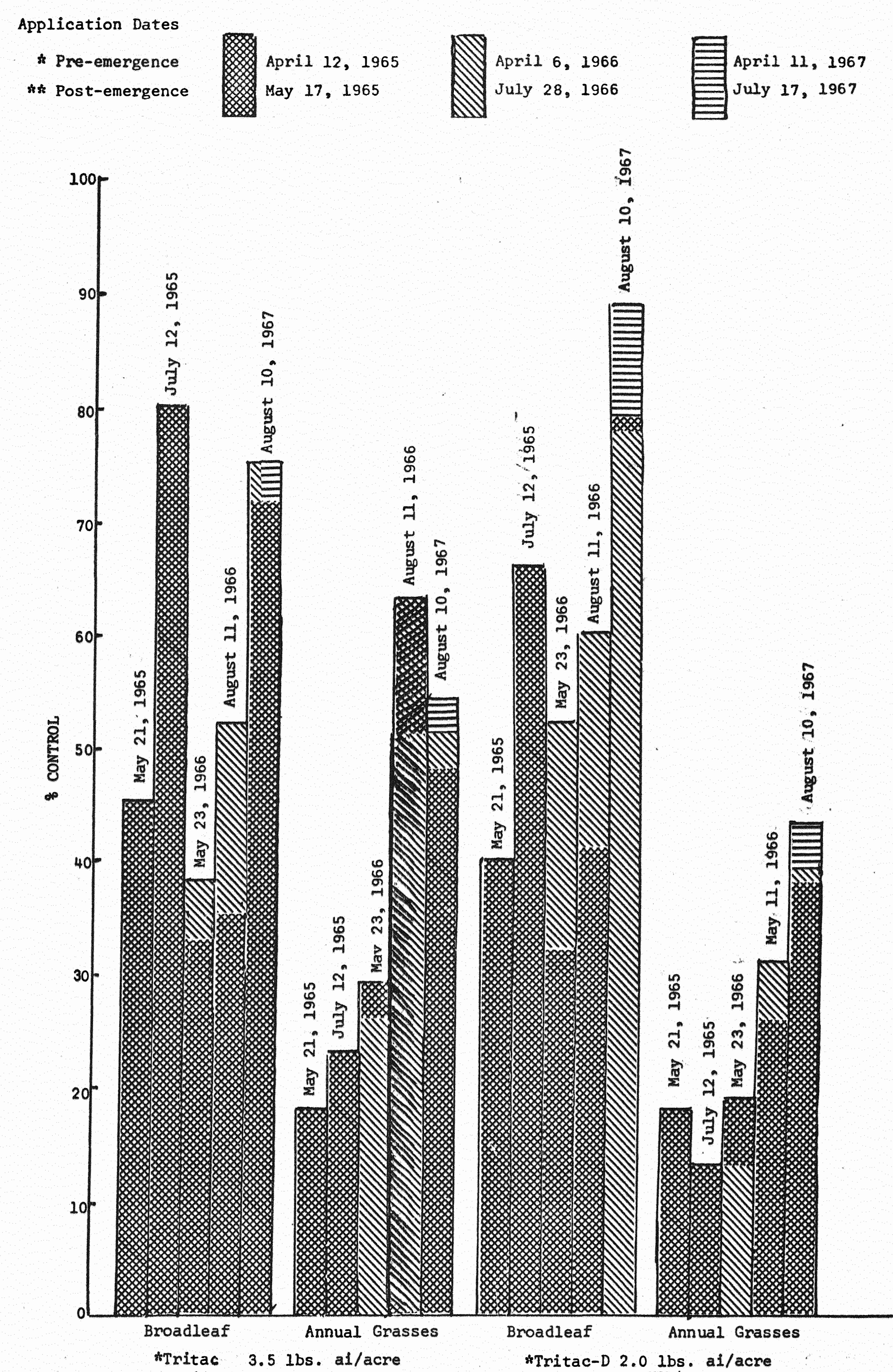



Figure 20. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.




Figu e 21. The effect of various herbicides and their residual activity on the control of broadleaf weeds and annual grasses applied pre-emergence on April 12, 1965, April 6, 1966, and April 11, 1967, and the post-emergence treatments on May 17, 1965, July 28, 1966, and July 17, 1967, on US-270 just south of I-40 near Shawnee, Oklahoma.

all broadleaf weeds and 97% control of the annual grasses as shown by the bar graph at the left for each plant group when first evaluated in May 1965. Some seven weeks later 92% of the broadleaf plants and 96% of the annual grasses had been controlled as shown by the second bar graph from the left for each plant group. One year later this herbicide still controlled 55% of the broadleaf weeds and 62% of the annual grasses when evaluated on May 23, 1966 as shown by the lower portion of the center bar graph for each entry. That portion of the experimental unit (two-thirds of the original area) that was retreated about six weeks earlier provided control for 95% of the broadleaves and 88% of the annual grasses as shown by the upper portion of the central bar graph. When these two areas were again evaluated in August 1966 that area treated 16 months earlier showed 67% control of the broadleaf weeds and 87% of the annual grasses as shown by the lower portion of the second bar graph from the right. The retreated portion of this plot provided 93% control each for the broadleaf plants and the annual grasses as shown in the upper portion of the second bar graph from the right. In 1967 the area treated two years before still exhibited about 73% broadleaf weed control and 61% of the annual grasses as shown in the lower portion of the right-hand bar graph. The area treated in April of the two previous years showed a control of 74% of the broadleaves and 83% of the annual grasses as depicted by the middle portion of the bar graph on the right. Treatment in April for three consecutive years provided 93% control of the broadleaf weeds and 89% of the annual grasses as shown by the upper portion of the right-hand bar graph.

The pre-emergence application of atrazine at 3.0 lbs. a.i./acre generally is adequate for the control of 90% or more broadleaf weeds and annual grasses as indicated by these data. A possibility exists of building-up enough residual activity after 3 or more annual treatments to permit treatments on alternate years or perhaps even less frequently. The full evaluation of the residual activity of these herbicides could not be achieved in the three years of this experiment. Picloram at the rate of 0.5 lbs. a.i./acre will provide 90% or better control of the broadleaf weeds commonly found on the highway system as indicated by these data. After three consecutive applications of atrazine at 1.5 lbs. a.i./acre, simazine at 3.0 lbs., or diuron at 4 lbs. a control of 90% or more of the broadleaf weeds was attained just as produced by one application of atrazine at 3.0 lbs. a.i./acre, or 0.5 lbs., of picloram. Two of the most effective herbicides for the selective control of broadleaf plants and weedy grasses that Sinkler[2] found in his preliminary investigation, tritac and tritac-D were closely approaching the 90% level of broadleaf weed control after three annual applications of 2.0 lbs. a.i./acre. The post-emergence application of those herbicides at the rates evaluated in this experiment was generally not satisfactory for the control of broadleaf weeds or annual grasses on the highway system.

The weeds found to be most common in early spring in the experiment on US-270 near Shawnee in central Oklahoma were henbit (<u>Lamium amplexicaule</u>), woolly plantain (<u>Plantago purshii</u>), and vetch (<u>Vicia</u> spp.). The weeds most commonly found in mid-summer at this location were

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[2] Sinkler, Max Dee, 1966. Herbicide Evaluation for Weed Control on Oklahoma Highways. Unpublished M.S. Thesis. Oklahoma State University.

perennial ragweed (Ambrosia psilostachya), haplopappus (Haplopappus ciliatus), lespedeza (Lespedeza japonica), buttonweed (Diodia teres), conyza (Conyza canadensis), buffalo bur (Solanum rostratum), annual bromegrasses (Bromus spp.), hairy crabgrass (Digitaria sanguinalis), and triple-awned grass (Aristida oligantha).

Two plants that are common in appearance on the roadsides and medians of numerous Oklahoma highways are alfalfa (Medicago sativa), and yellow sweetclover (Melilotus officinalis). These important forage and pasture legumes are becoming weed problems for the Highway Department and serve to justify frequent and costly mowing of the highway system.

In 1967 two investigations were initiated to evaluate several herbicides for the selective control of alfalfa and sweetclover.[3] One experiment was located on SH-51 west of Stillwater in north-central Oklahoma, the other was on SH-81 south of Kingfisher. The materials found to be most effective in this preliminary investigation for the control of alfalfa and sweetclover were 1.0 lb. a.i./acre of 2,4-D or 2,4,5-T, 7.5 lbs. of Fenac, or 0.75 lbs. of Banvel-D (dicamba).

The herbicides found to be most effective for the control of sandburs on the Oklahoma highway system are the post-emergence materials the organic arsonates, AMA (ammonium methanearsonate) at 3.8 lbs. a.i./acre, MSMA (monosodium methanearsonate) at 2.0 lbs. a.i./acre, DSMA (disodium methanearsonate) at 2.5 lbs. a.i./acre, and

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[3]Bhrommalee, Narong. 1968. The Effect of Six Herbicides on the Control of Alfalfa and Sweetclover on Oklahoma Highways. Unpublished M.S. Thesis. Oklahoma State University.

CMA (calcium acid methyl arsonate) at 3.7 lbs. a.i./acre. These herbicides must be reapplied at least once at a 7 to 20 day interval for the most effective control.

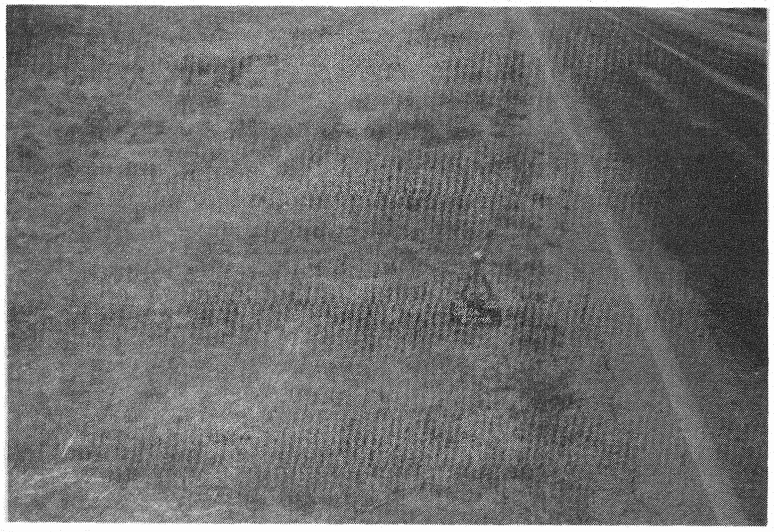
The pre-emergence application of atrazine at the rate of 3.0 lbs. a.i./acre was found to be effective for the control of both broadleaf weeds and annual grasses commonly found on Oklahoma highways. Broadleaf weeds were effectively controlled also with the pre-emergence herbicides picloram (Tordon) at 0.5 lbs. a.i./acre, and diuron at 3.0 lbs. a.i./acre. The post-emergence herbicide dicamba (Banvel-D) at 1.0 lbs. a.i./acre, was effective in the control of broadleaf weeds in these experiments. Diuron applied as a pre-emergence herbicide at the rate of 3.0 lbs. a.i./acre was found to be effective in the control of annual grasses on the highway system.

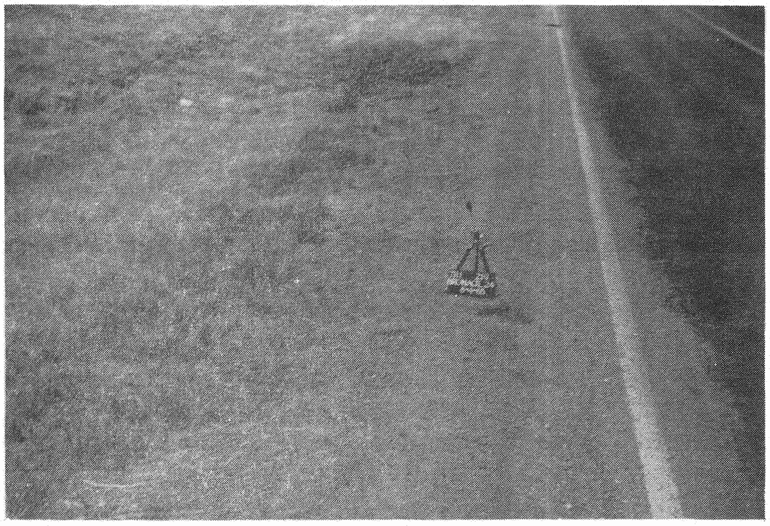
Alfalfa and sweetclover were effectively controlled with the post-emergence applications of 1.0 lb. a.i./acre of 2,4-D or 2,4,5-T, 7.5 lbs. a.i./acre of Fenac, or 0.75 lbs. a.i./acre of dicamba (Banvel-D).

## PART II

## SOIL STERILIZATION

Soil sterilization is commonly used in several state highway maintenance programs for more efficient and economical maintenance of guardrails, signposts, and shoulders. In these areas all plant growth is suppressed for the safety of the motoring public, and the preservation of the highway through the protection of the asphaltic shoulders. The potential benefits of these chemicals are offset in some cases by the improper application of the materials, or by the





Vegetative growth in asphaltic shoulders (top photo) and under guardrails can be effectively controlled with herbicides (bottom photo) that sterilize the soil.

downslope movement from the place of application, killing all vegetation, thereby leaving the soil exposed to erosion and perhaps ultimate loss of the highway at that point.

The plant species commonly found and oftentimes quite difficult to control on Oklahoma highways are common bermudagrass (Cynodon dactylon) and johnsongrass (Sorghum halepense). These become troublesome on the highway shoulders particularly when the rhizomes or shoots break through the asphaltic surface and open a channel for water penetration into the roadbed.

Six experiments were conducted to evaluate various soil sterilants for the elimination of all vegetation, especially bermudagrass on highway shoulders and around guardrails. These investigations were located generally through the central portion of the state. One experiment was located near Chickasha on the shoulders of SH-92. Twelve chemicals were applied initially in March 1965 and the plots retreated in June 1966 at one-half the initial rate. The results of this investigation are shown in Figures 22 through 28. Although the complete evaluation of these chemicals could not be made in the brief period of this investigation the results tend to indicate the most effective materials for the suppression of bermudagrass are: bromacil at the rate of 24 lbs. a.i./acre, TCA at 150 lbs., urox at 300 lbs., Monobor-chlorate at 1740 lbs., borocil at 327 lbs., Borea T-10 at 500 lbs., and a combination of 80 lbs. a.i./acre of TCA and 5 lbs. of bromacil. These data are generally in agreement with those obtained by Sinkler[2] who found the most promising herbicides for soil sterilization to be chlorea, Monobor-chlorate,ureabor, Borea T-10, borocil, prometone, and TCA. He also noted that lateral movement from

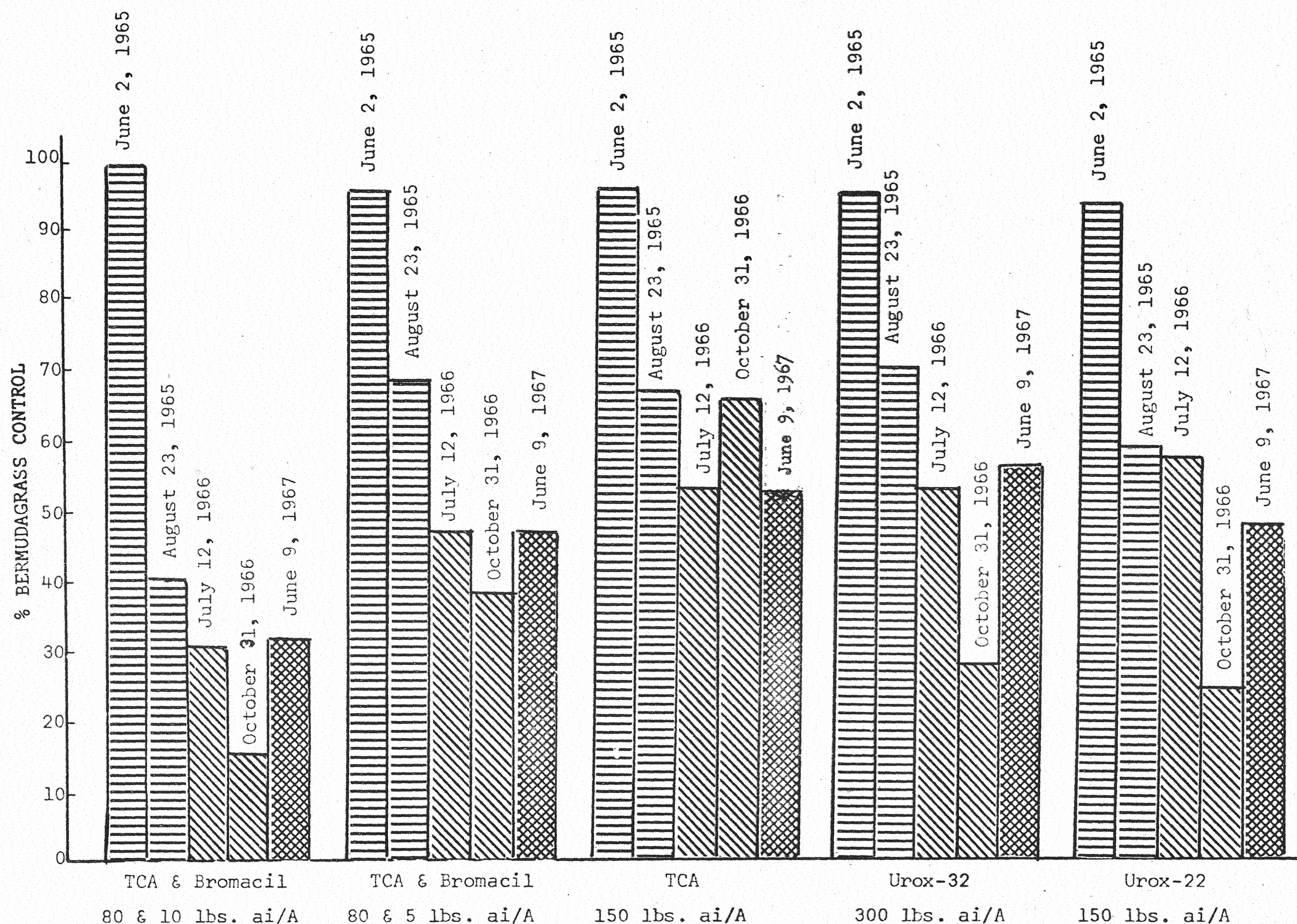



Figure 22. The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH-92 shoulders near Chickasha, Oklahoma.

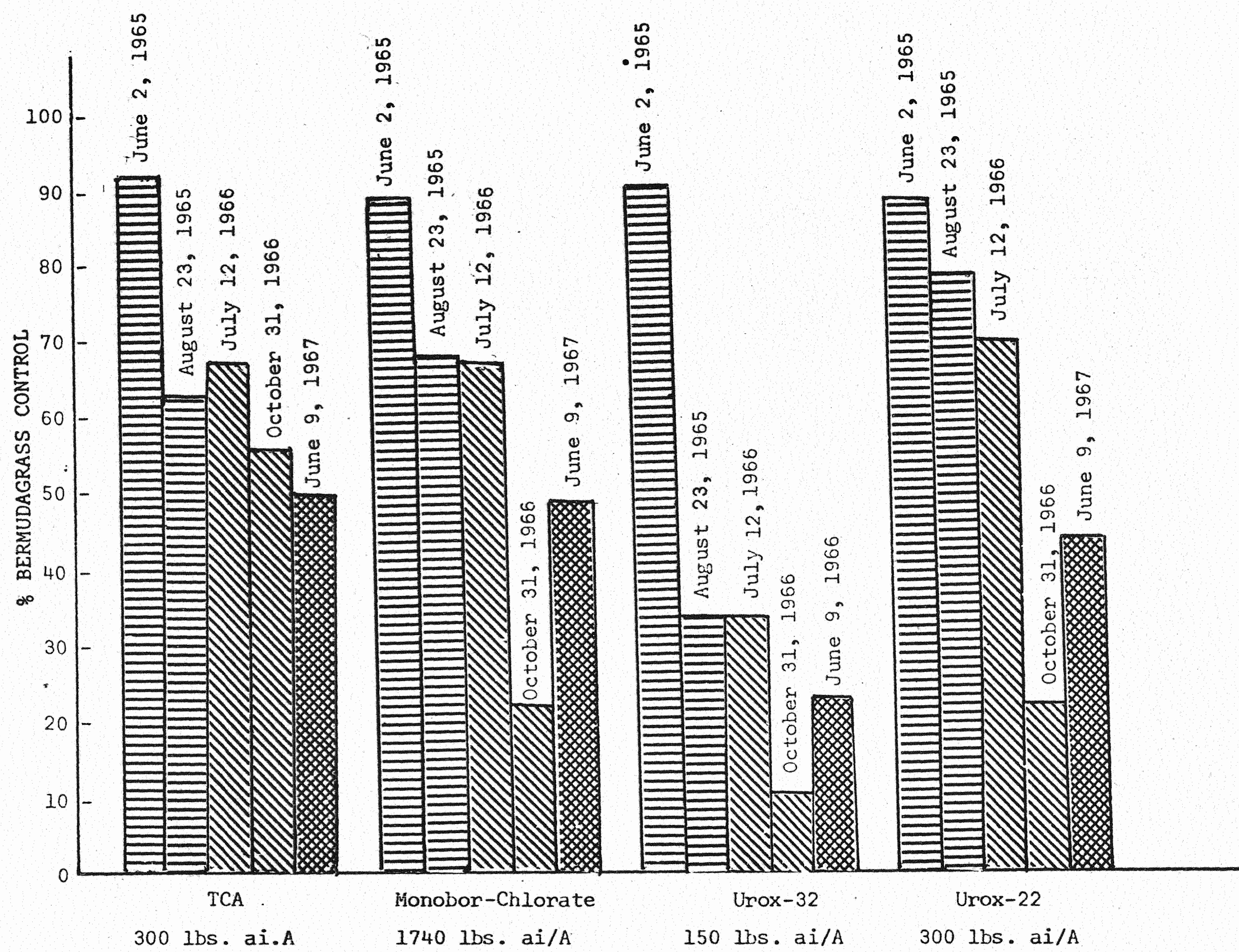



**Figure 23.** The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH-92 shoulders near Chickasha, Oklahoma.

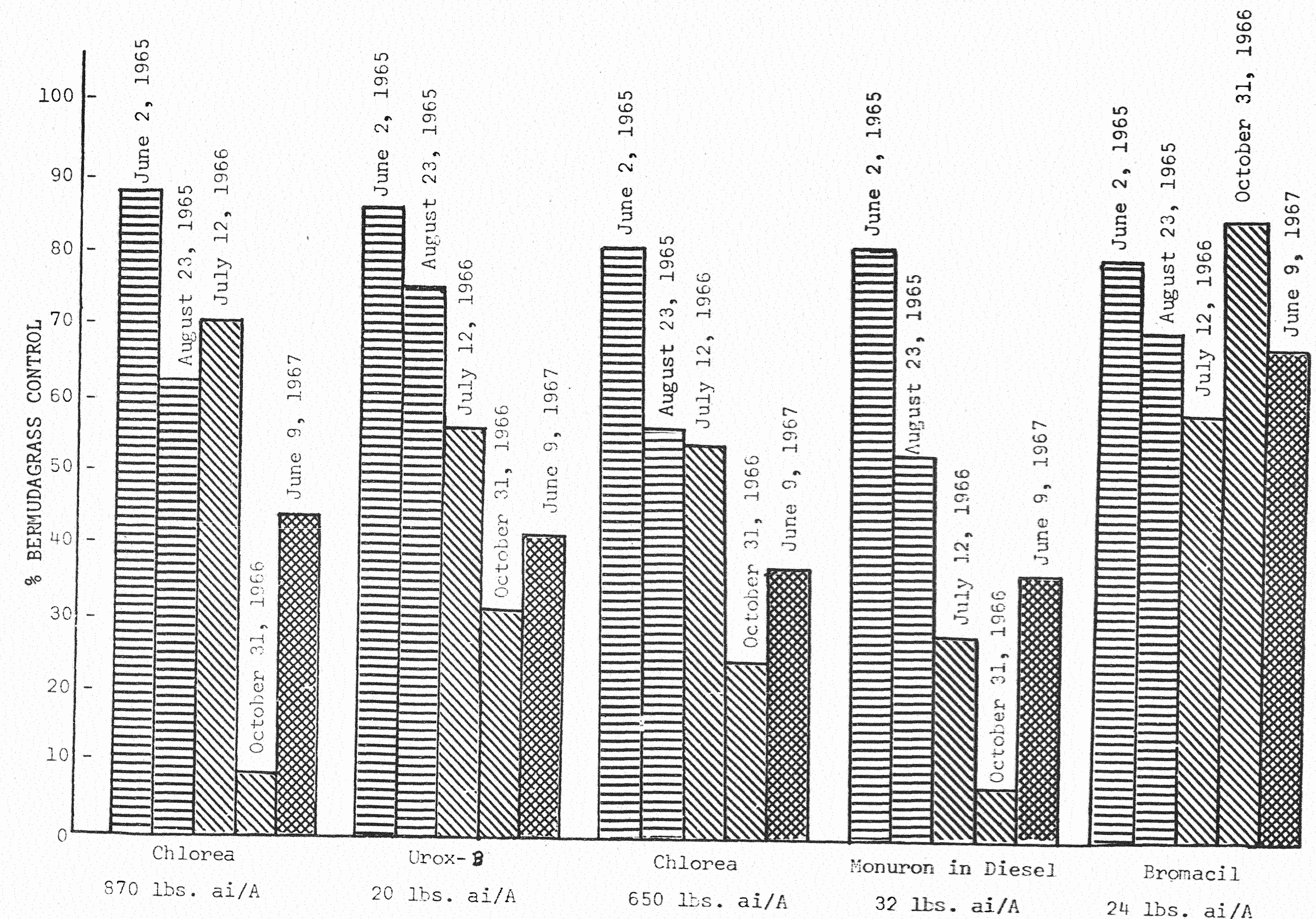



Figure 24. The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH-92 shoulders near Chickasha, Oklahoma.

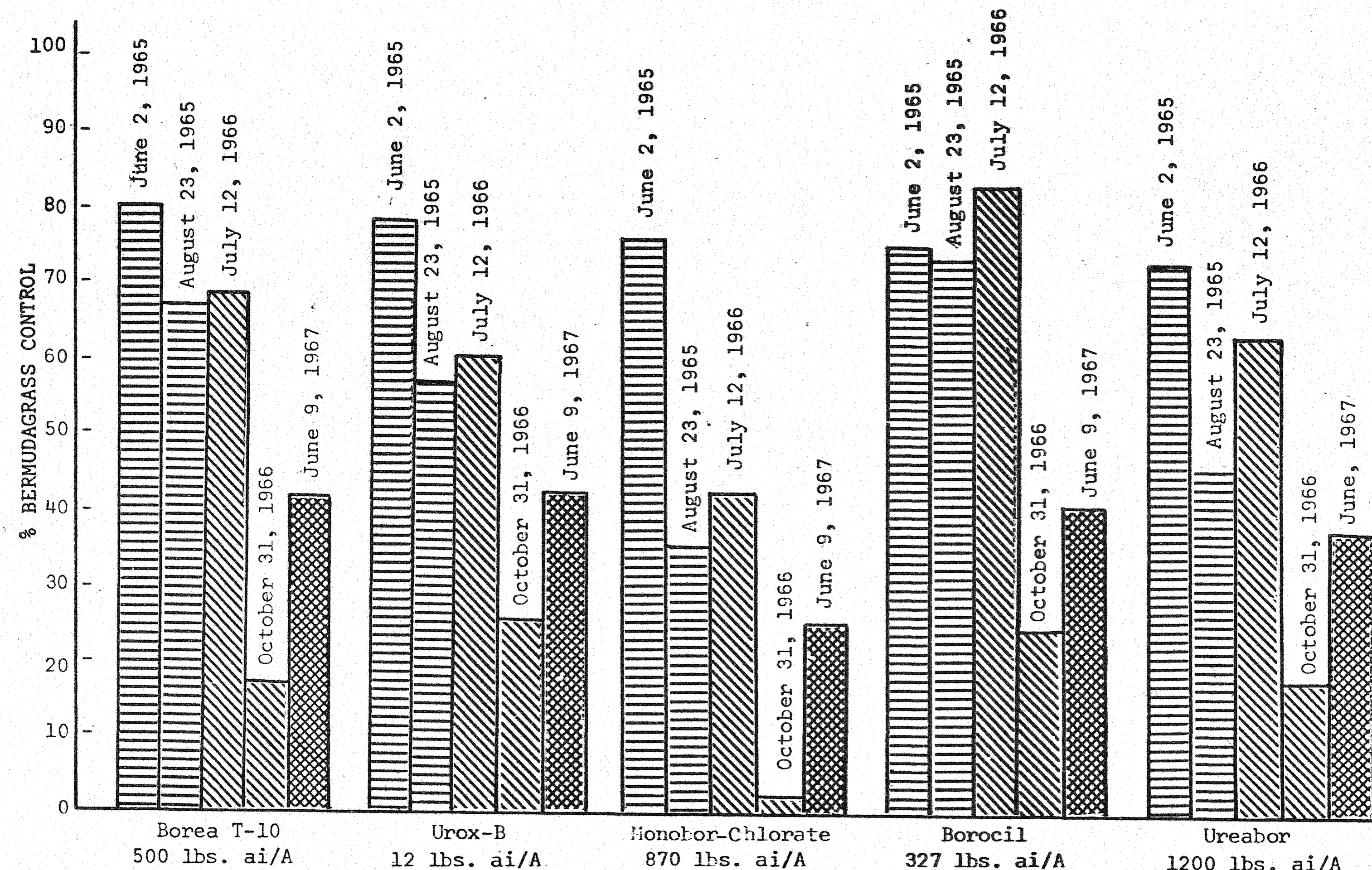



Figure 25. The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH 92 shoulders near Chickasha, Oklahoma.

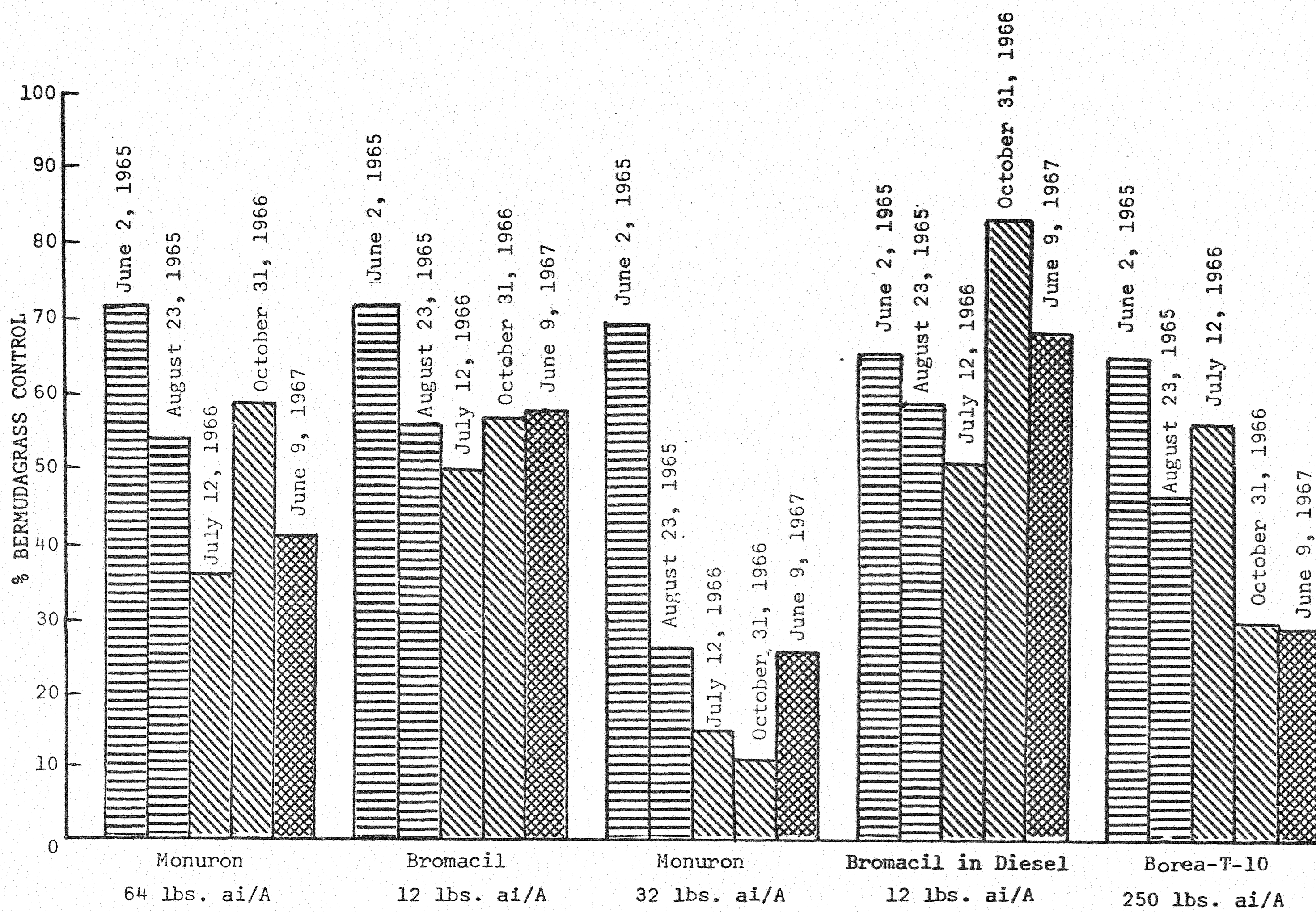



Figure 26. The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH 92 shoulders near Chickasha, Oklahoma.

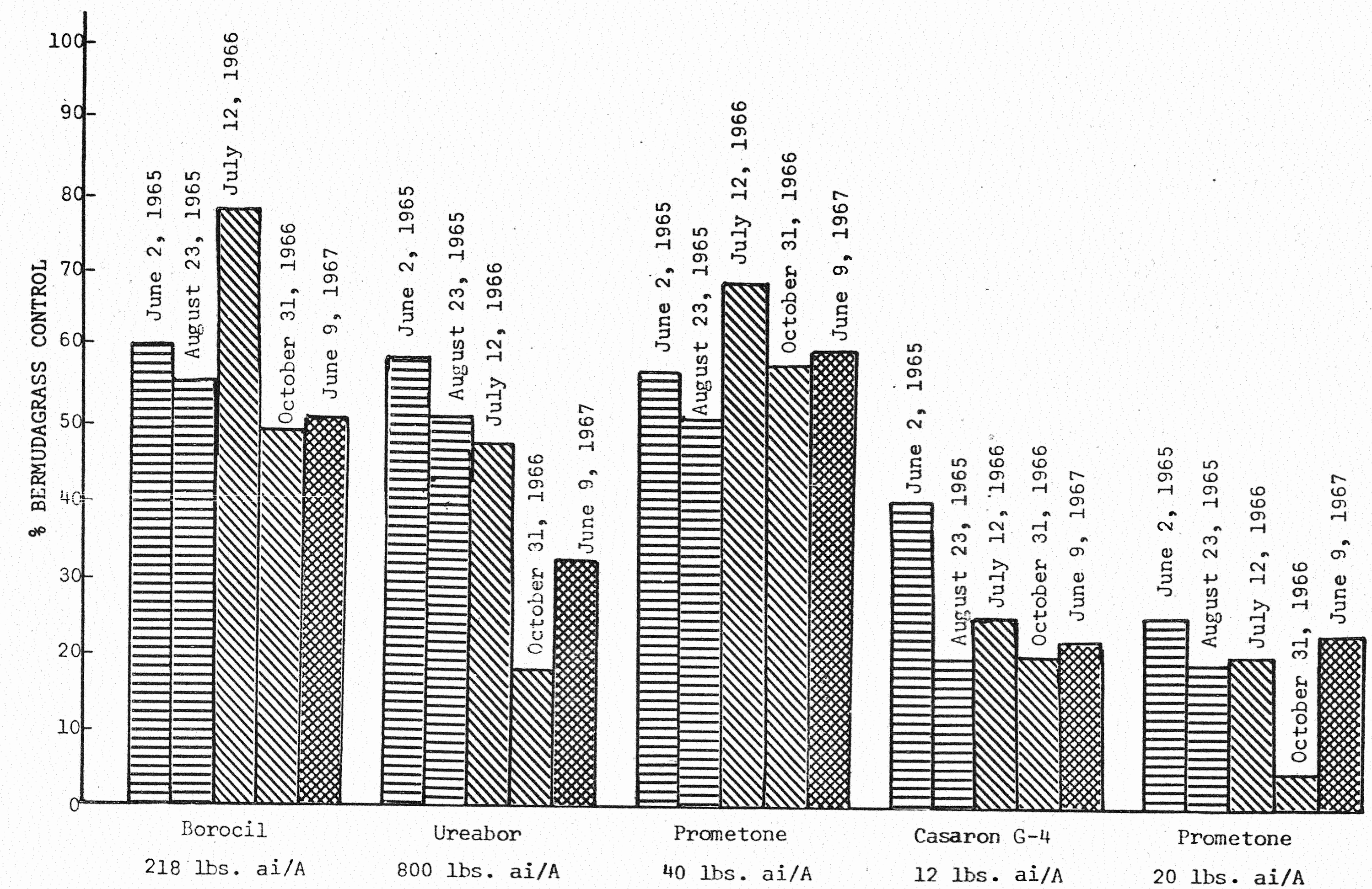



**Figure 27. The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH-92 shoulders near Chickasha, Oklahoma.**

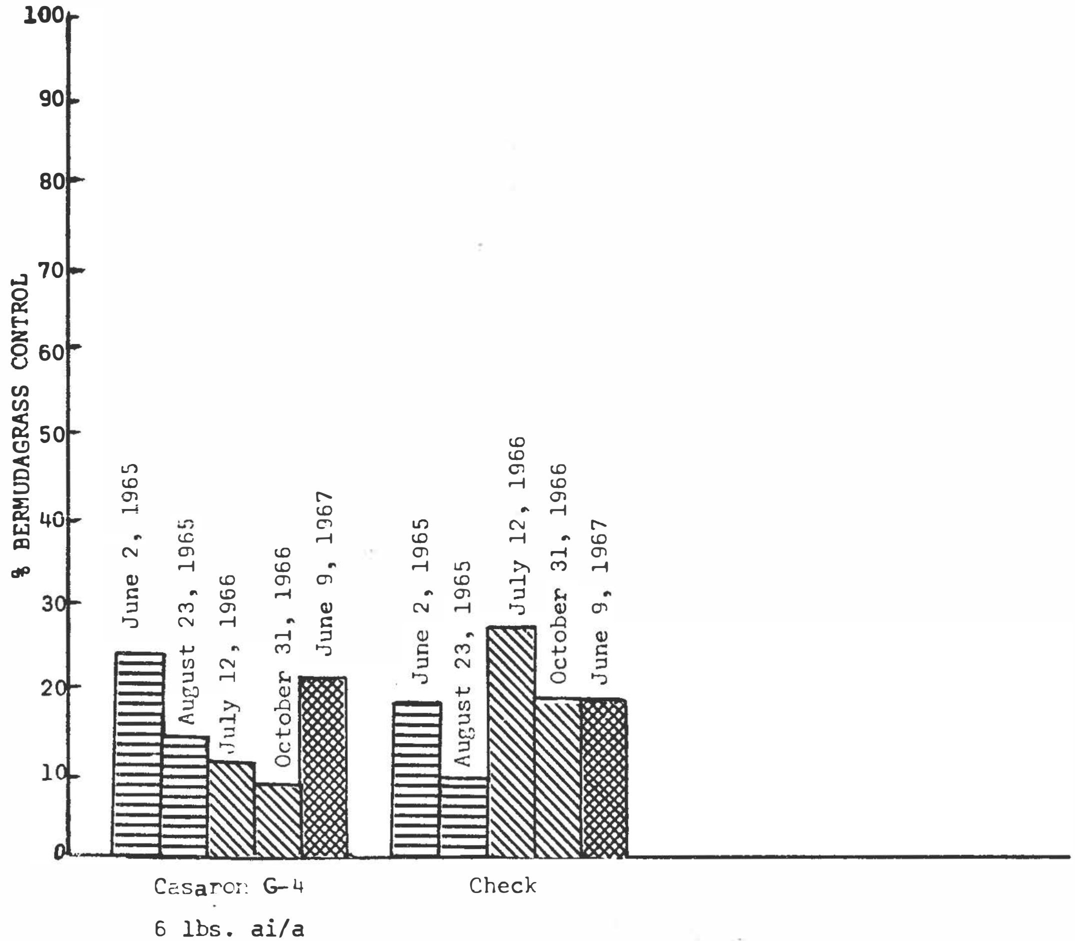



Figure 28. The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH-92 shoulders near Chickasha, Oklahoma.

the treated band occurred consistently with chlorea, Borea T-10, monuron, bromacil, urox, and ureabor.

An evaluation of chemicals for the complete suppression of plant growth under guardrails was initiated in June 1964 on US-270 near Wewoka. The results of these evaluations are shown in Figures 29 through 36. Little precipitation occurred at this location in 1964 until August, after which a total of 15 inches was recorded by the middle of November[2]. These data although only preliminary for the complete evaluation of these materials indicate those treatments and rates that were most effective in the kill of bermudagrass also moved downslope killing an area larger than the originally intended band of soil sterilization with the exception of TCA at the rate of 250 lbs./acre. The chemicals that seemed to be the most effective were Borea T-10 at 250 lbs. a.i./acre, urox at 300 lbs., monuron at 52 lbs., ureabor at 1200, bromacil at 20 lbs., boracil at 218 lbs., and a combination of 65 lbs. of TCA and 8 lbs. a.i./acre of bromacil.

An experiment was initiated in June 1964 to evaluate various chemicals as soil sterilants for the control of bermudagrass principally on SH-51 west of Stillwater in north-central Oklahoma. The results of these evaluations are shown in Figures 37 through 49. Although the chemicals have not been fully evaluated the most effective materials as indicated by these data were: bromacil at 24 lbs. a.i./acre, urox at 300 lbs., prometone 40 lbs., ureabor 1200 lbs., chlorea 1920 lbs., borocil 218 lbs., the combination of 80 lbs. TCA and 10 lbs. bromacil, and TCA alone at 300 lbs. a.i./acre.

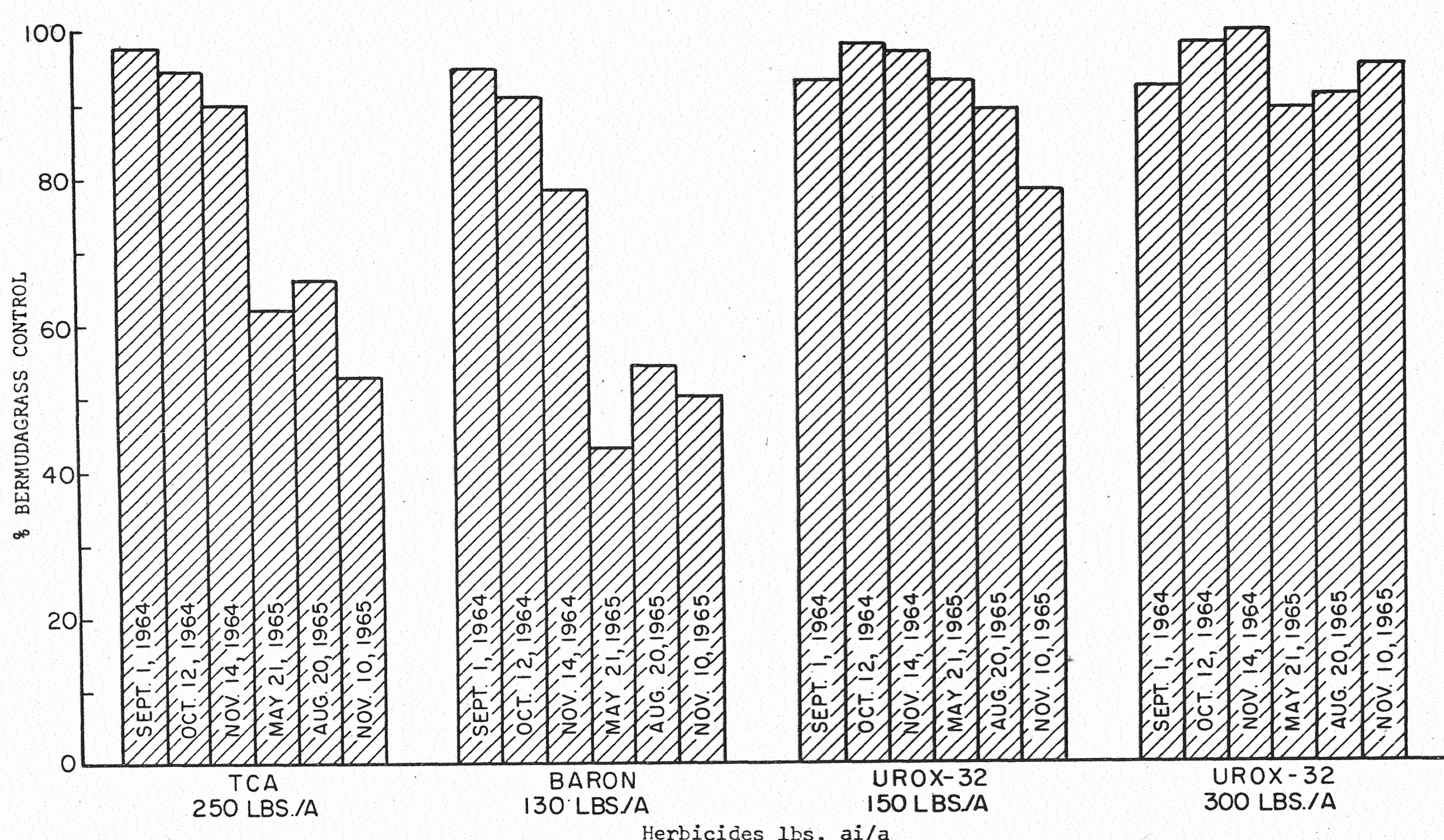



Figure 29. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

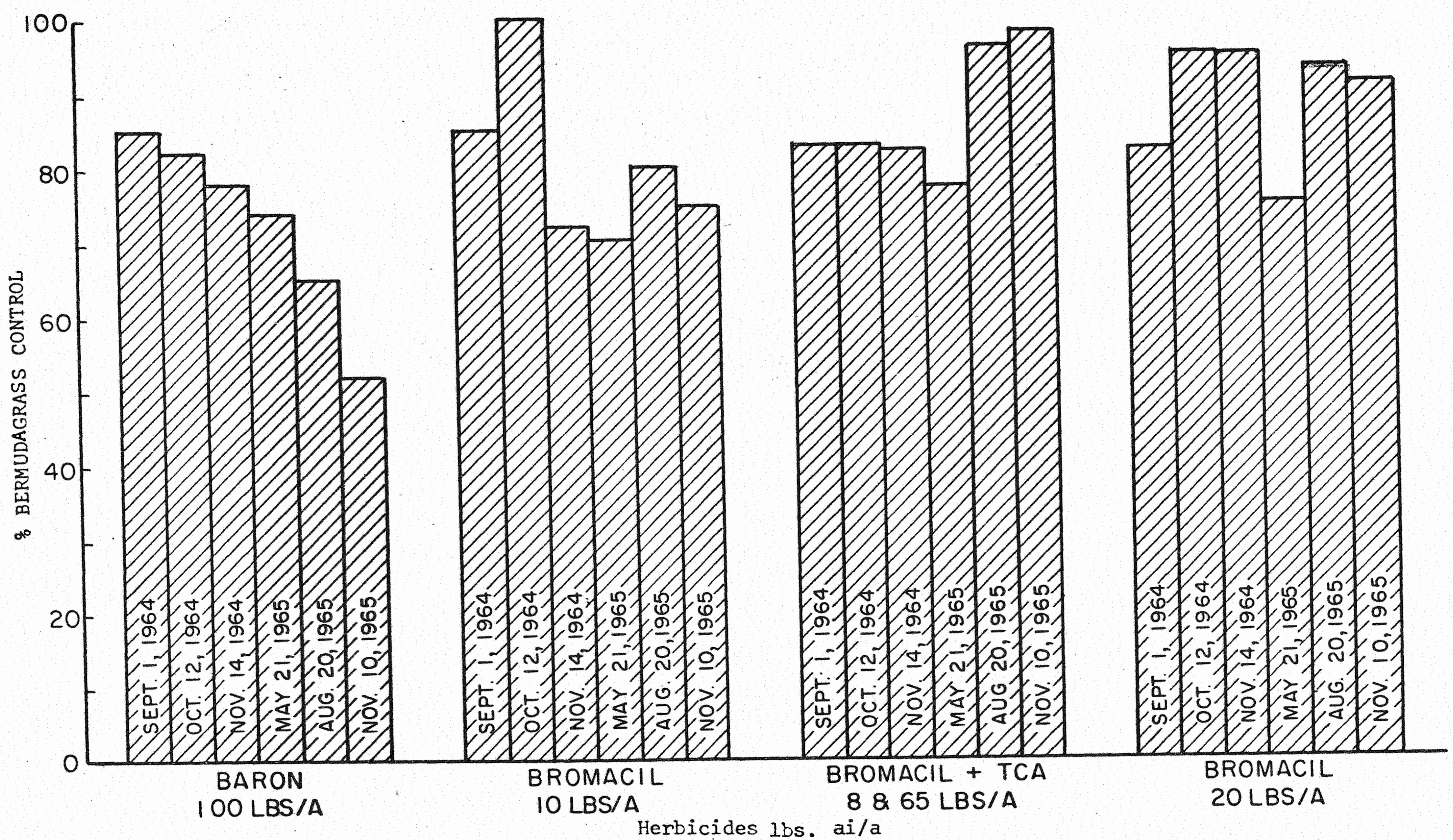



Figure 30. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

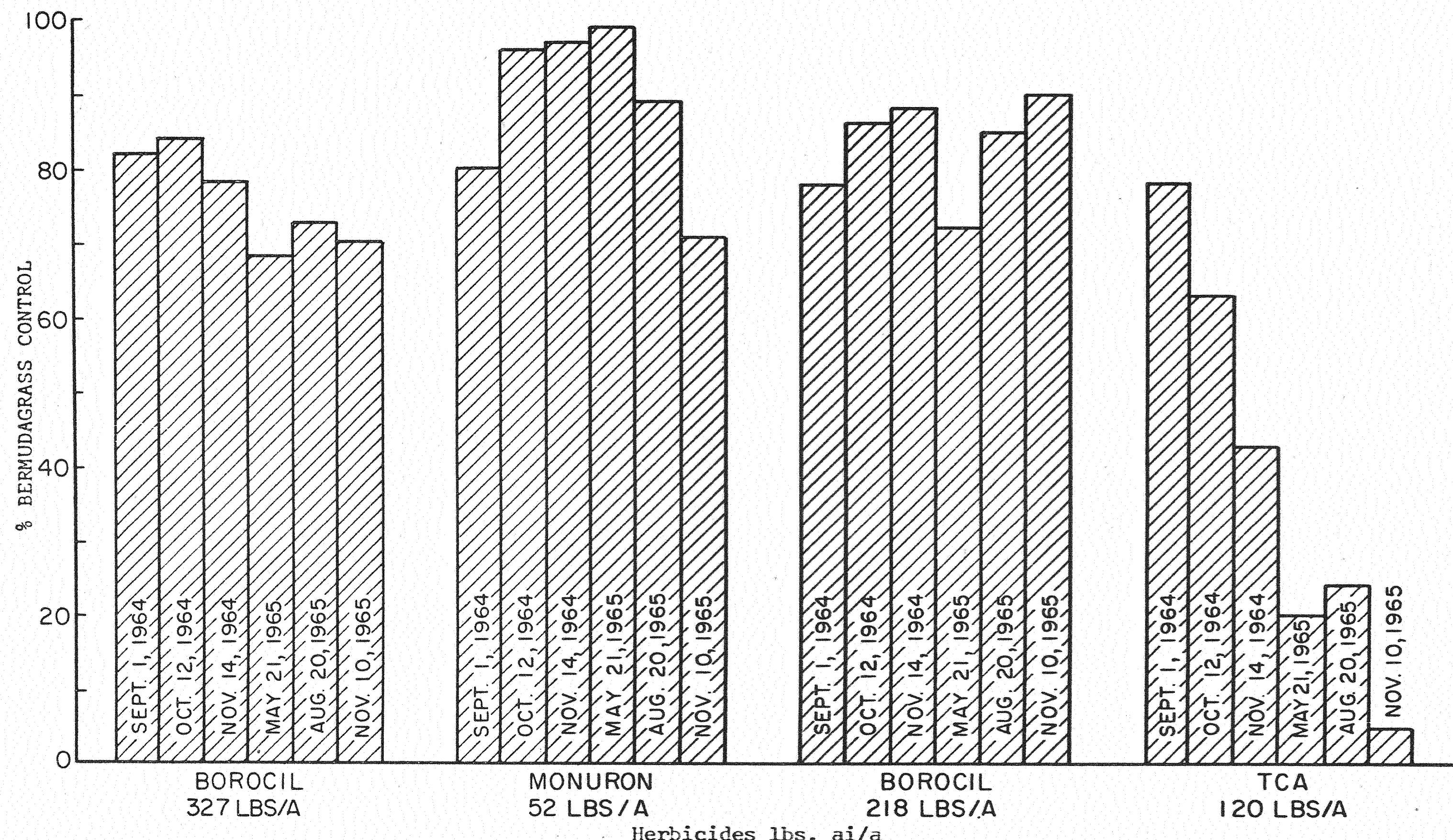



Figure 31. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

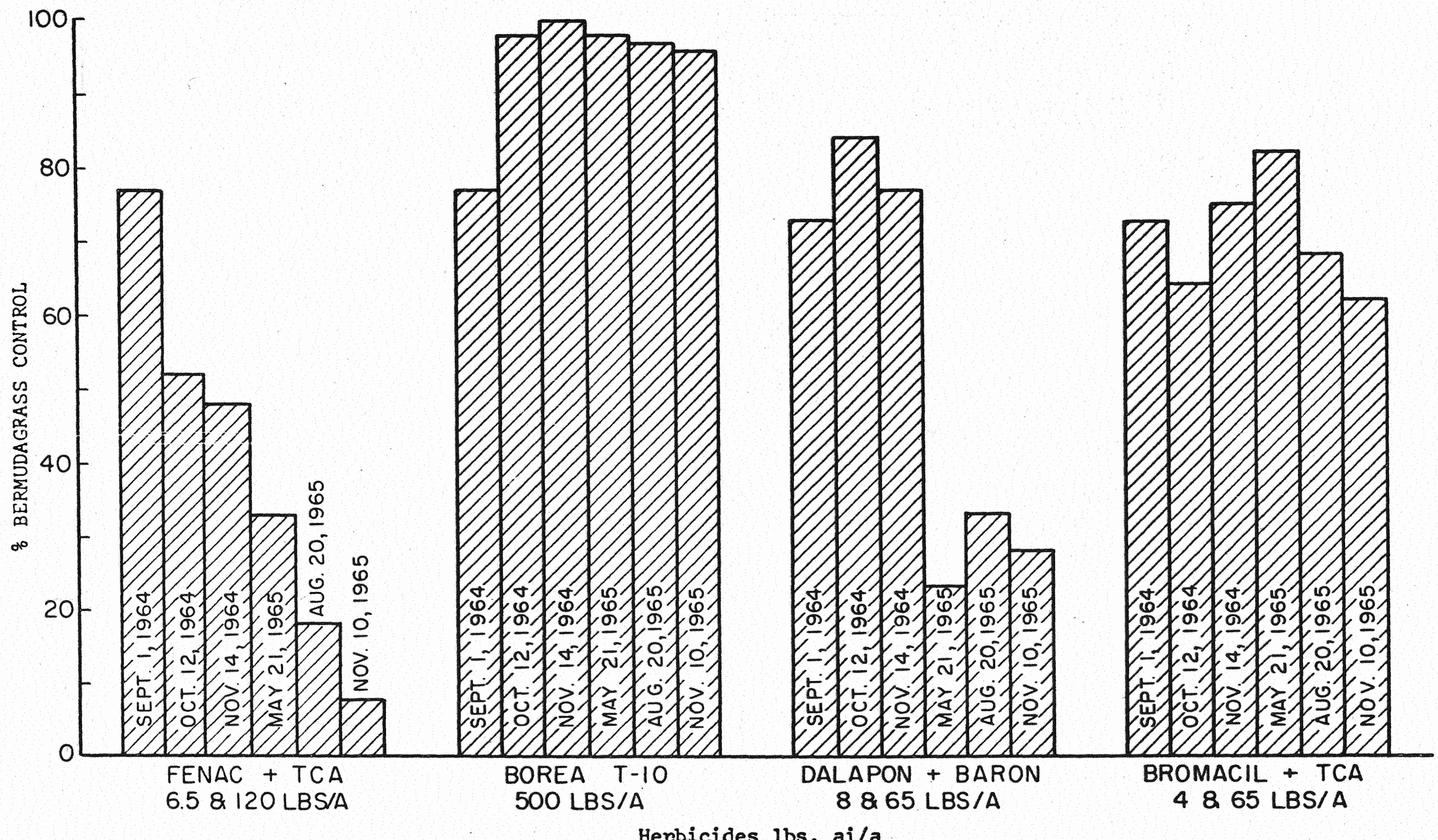



Figure 32. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma

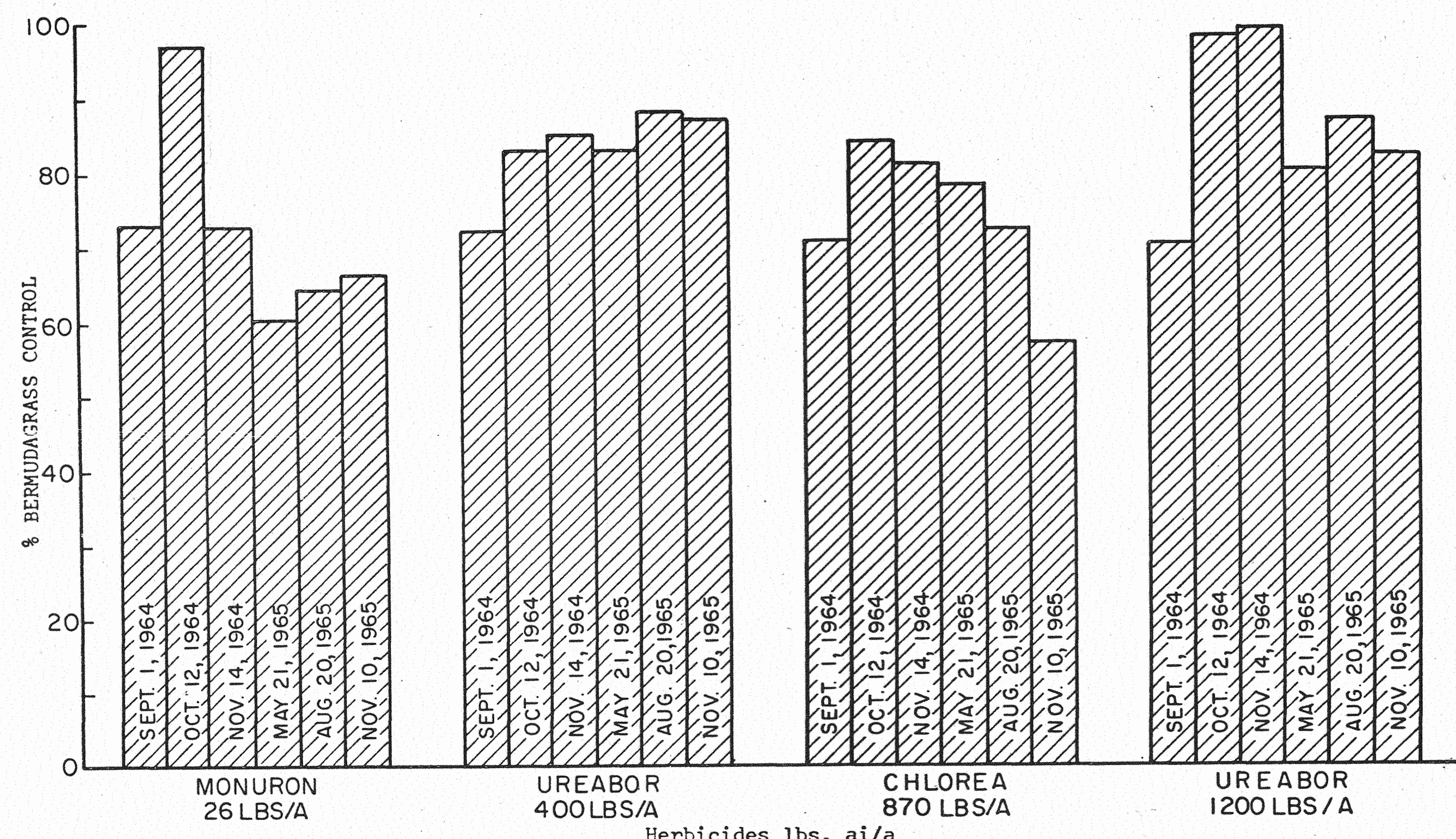



Figure 33. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

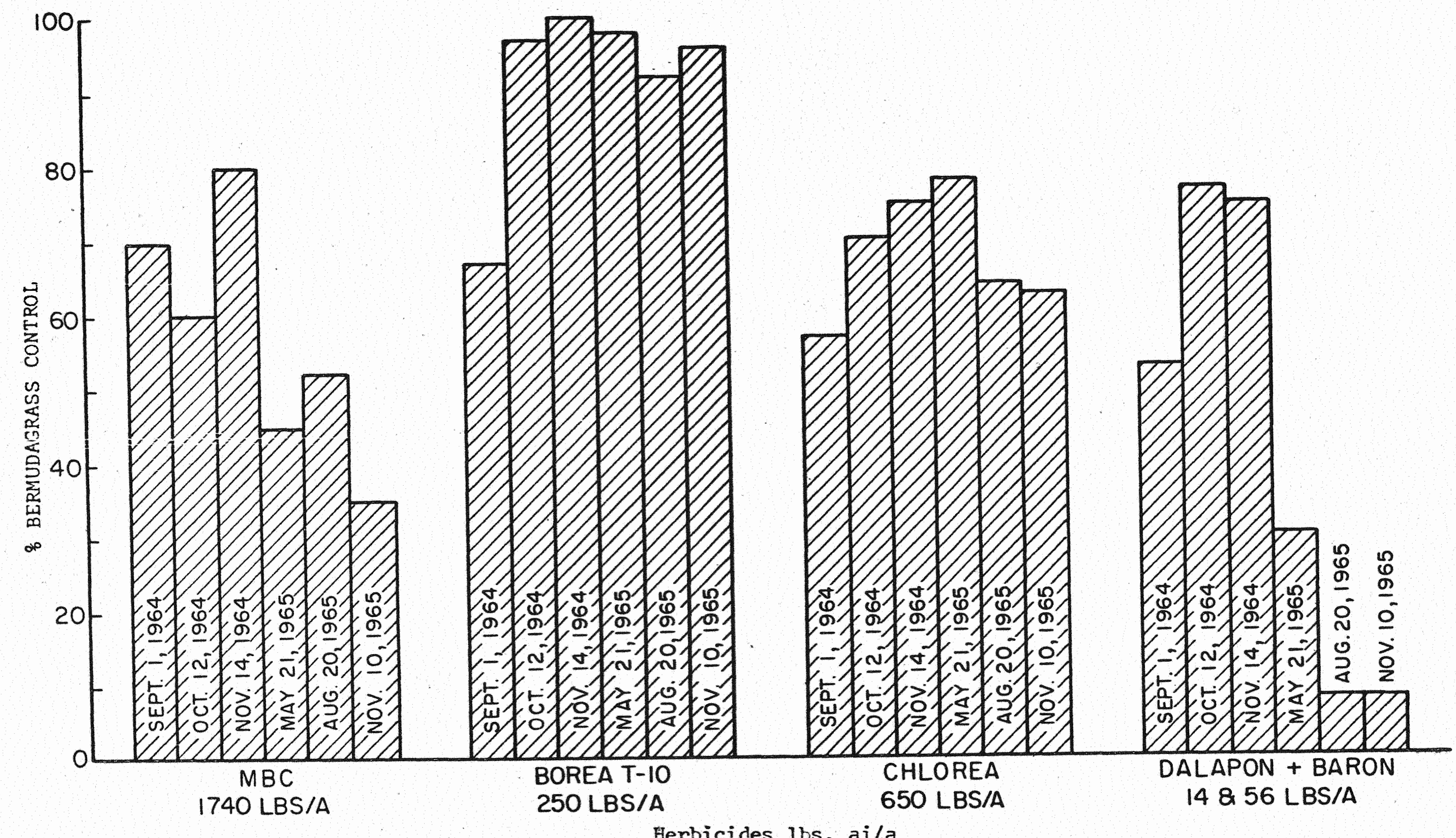



Figure 34. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

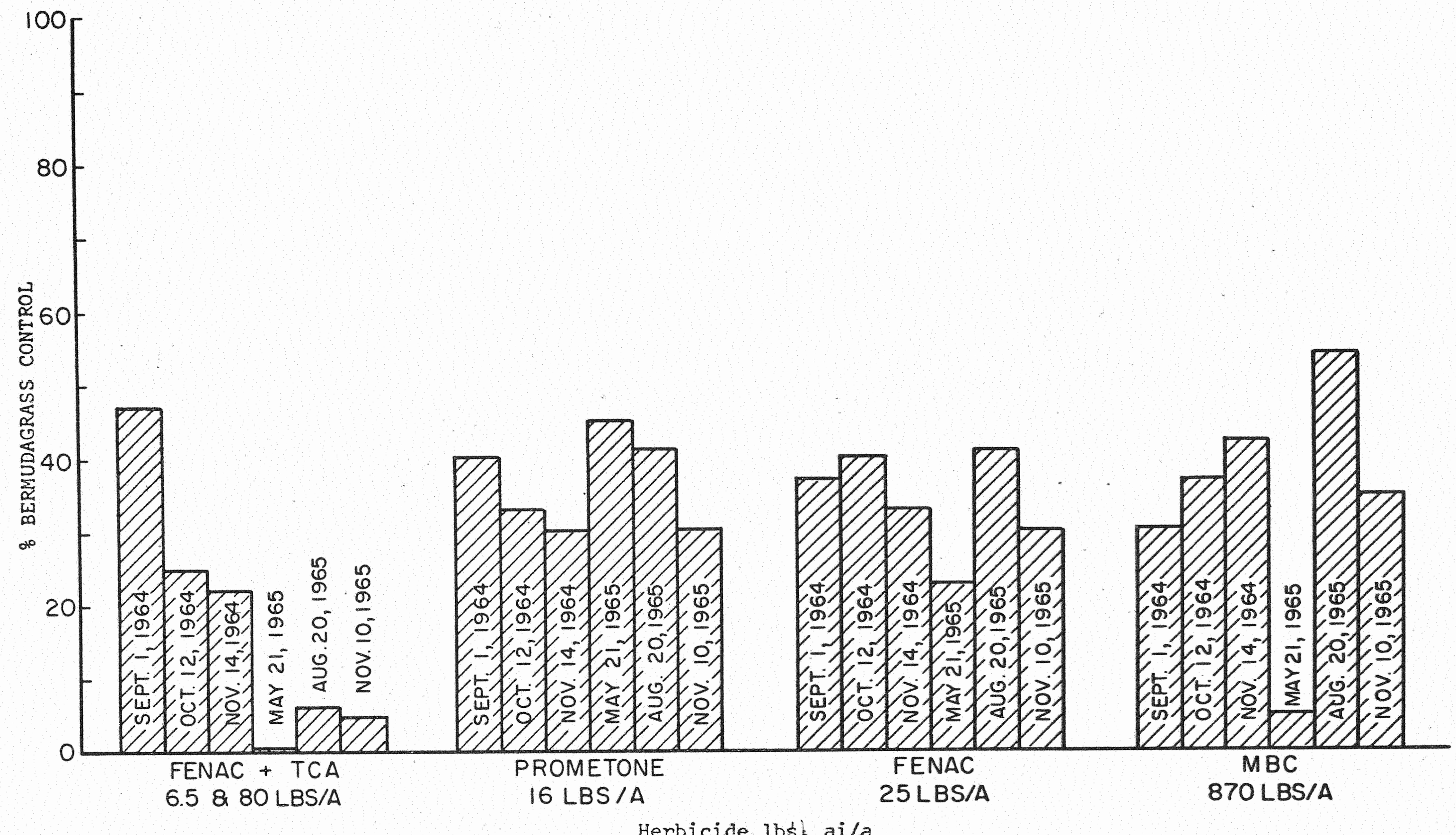



Figure 35. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

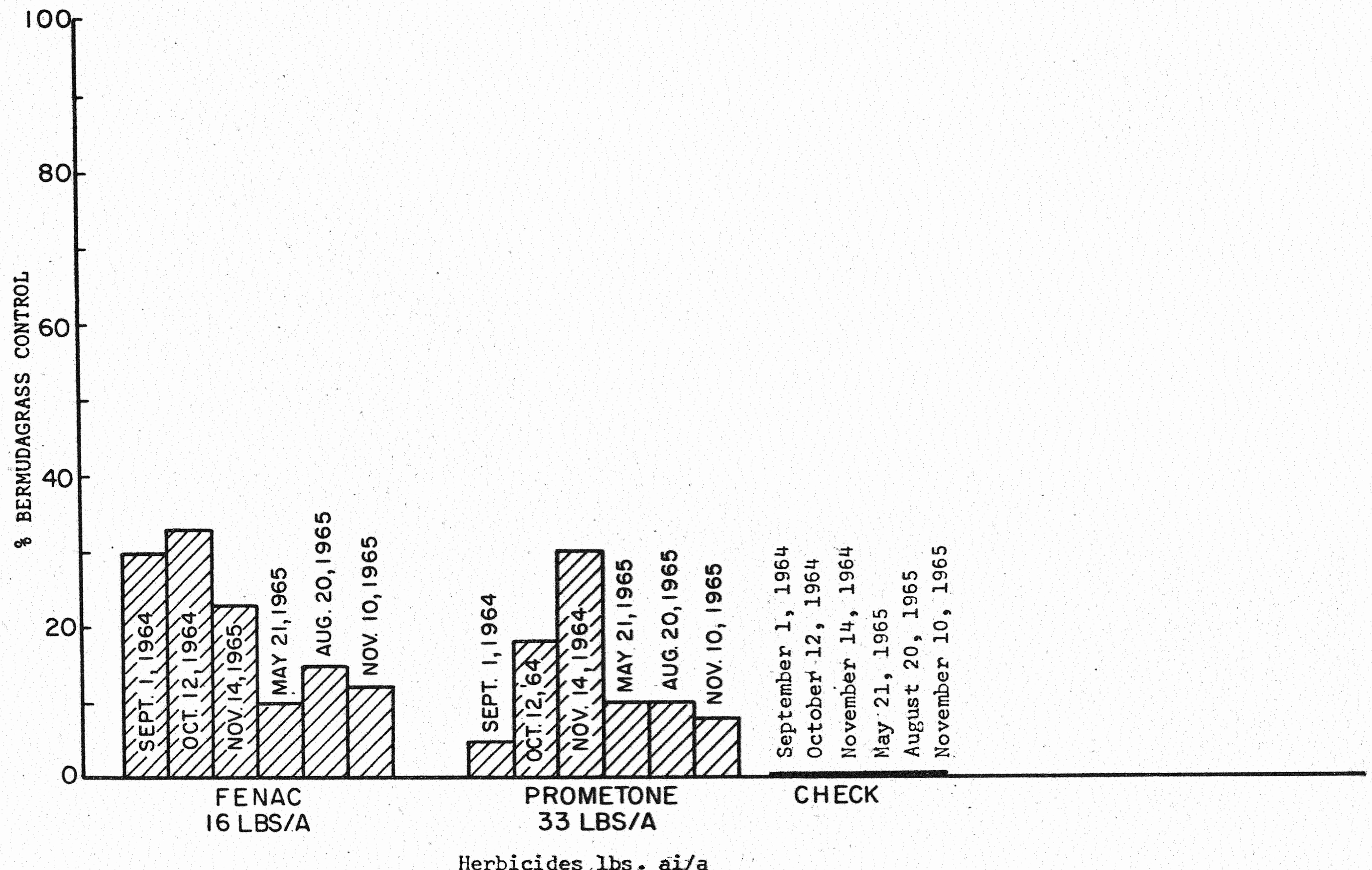



Figure 36. The effect of various chemicals applied June 29, 1964, on the control of bermudagrass around guardrails on US-270 near Wewoka, Oklahoma.

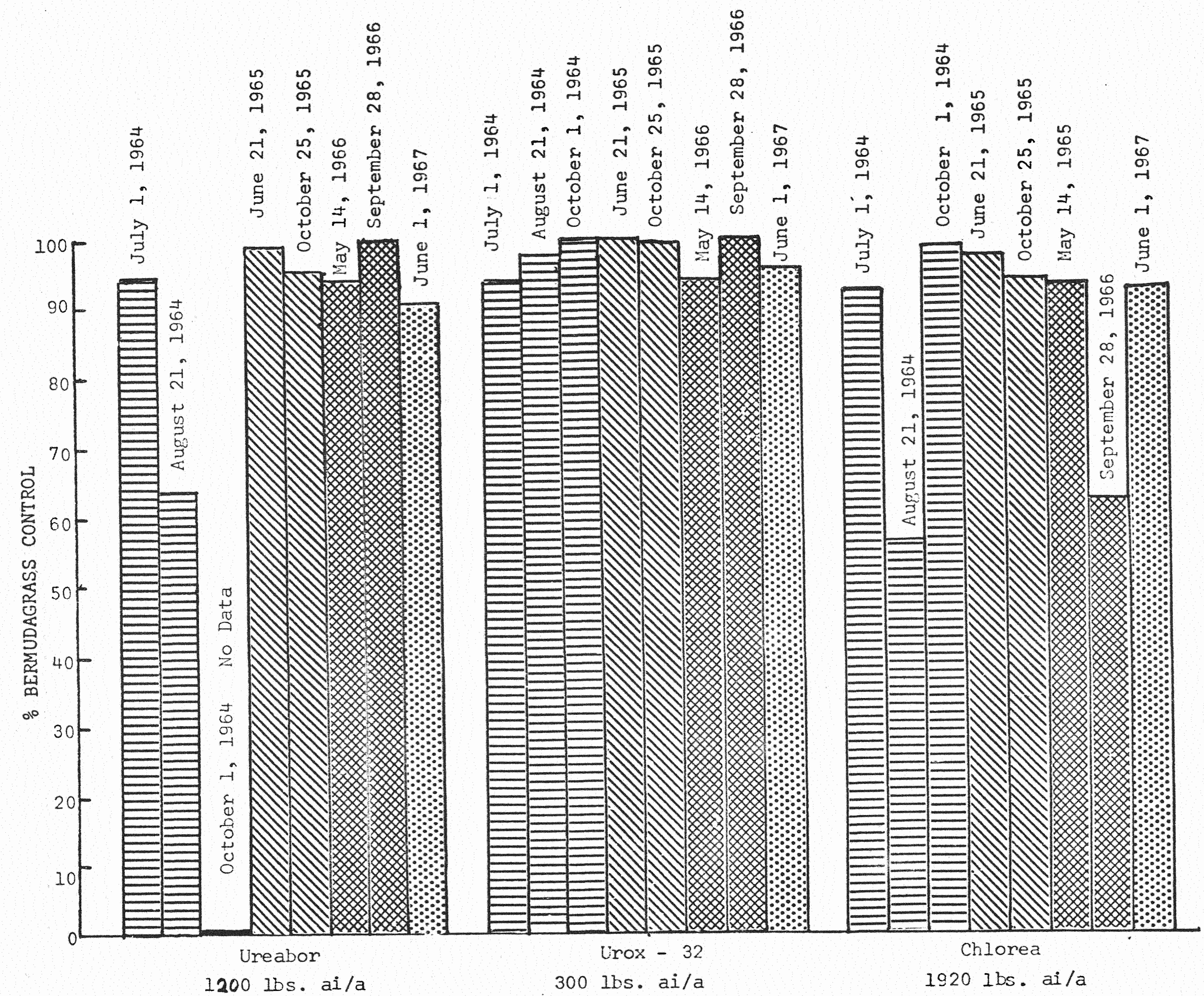



Figure 37. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

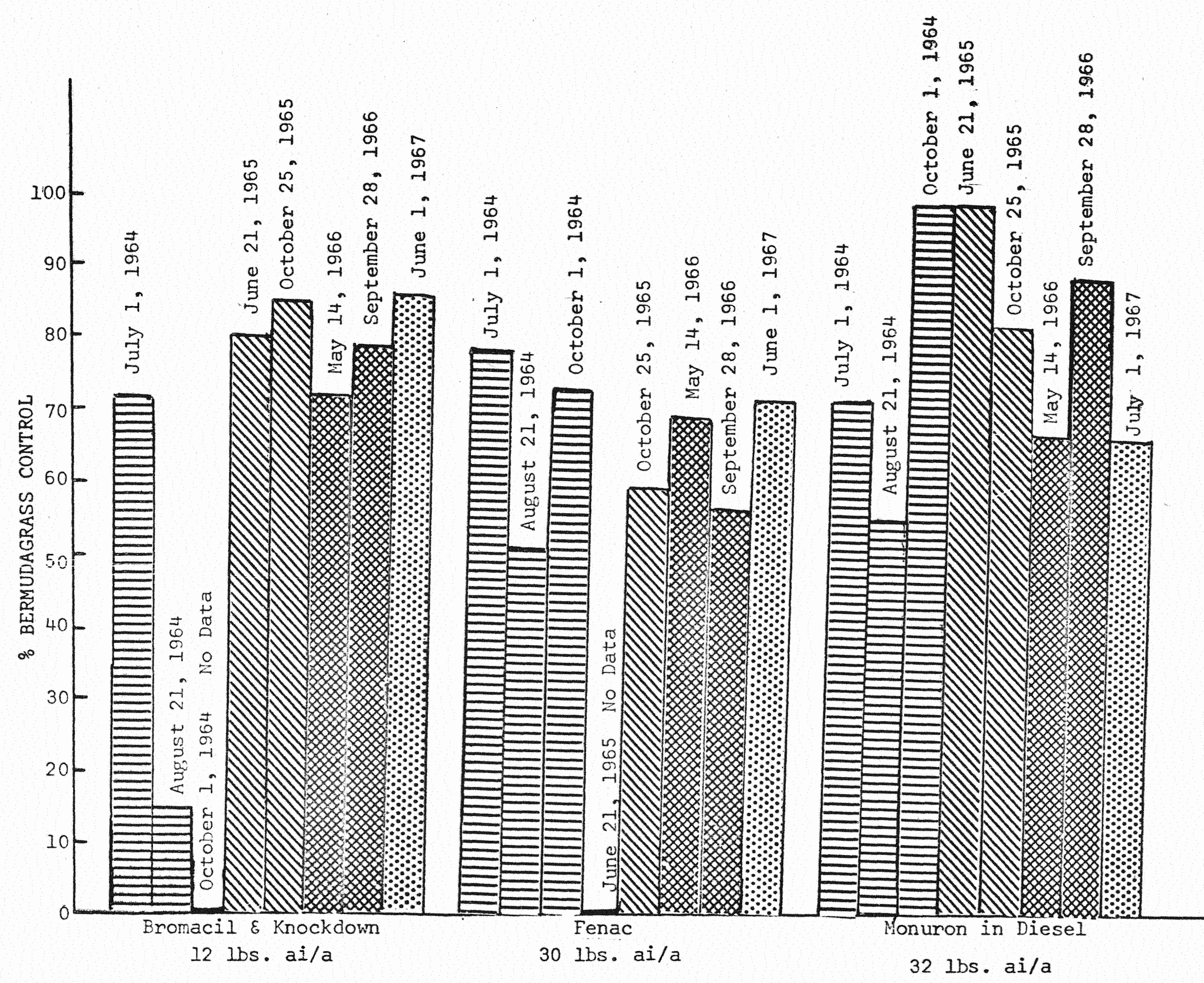



Figure 38. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

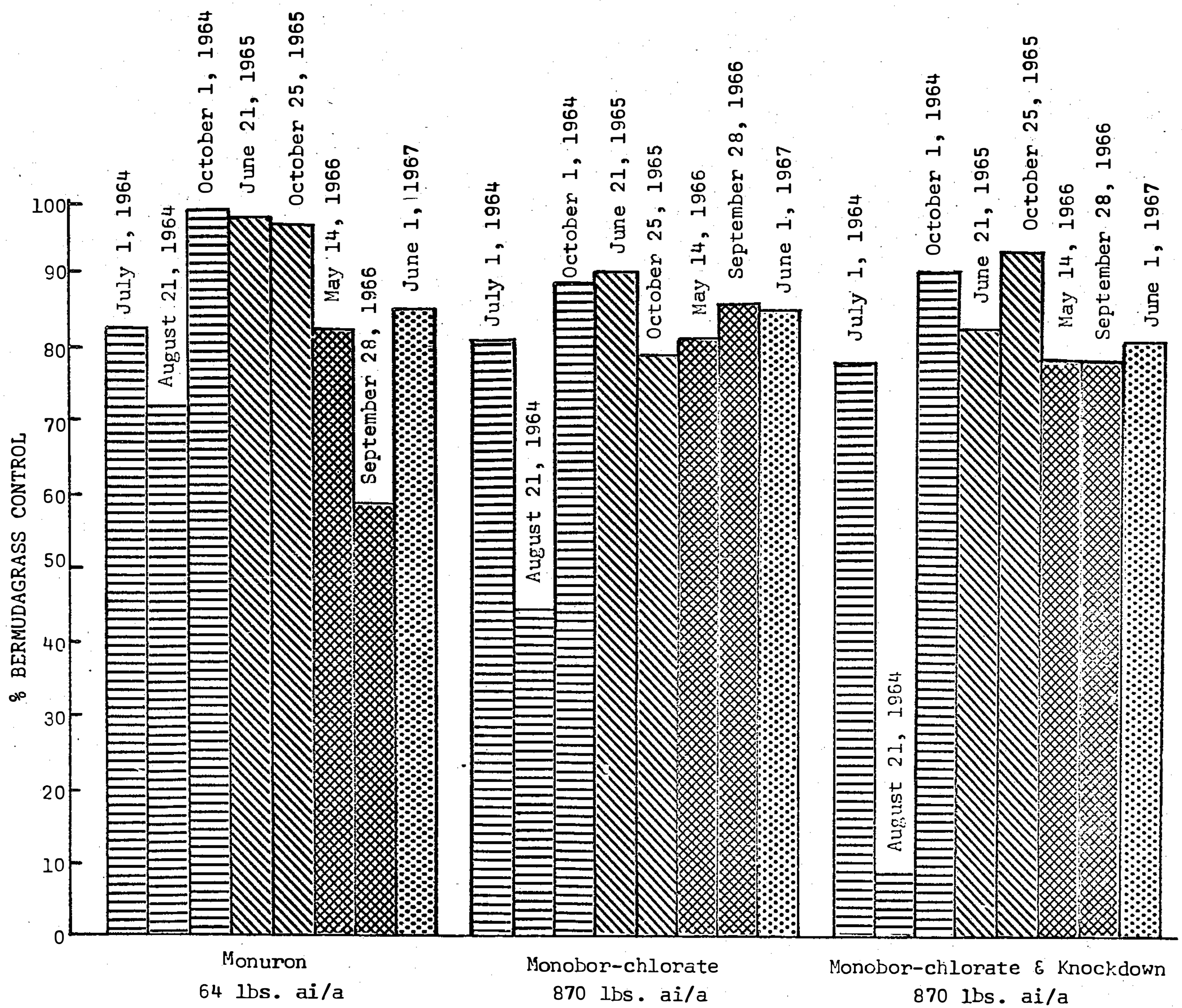



Figure 39. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma

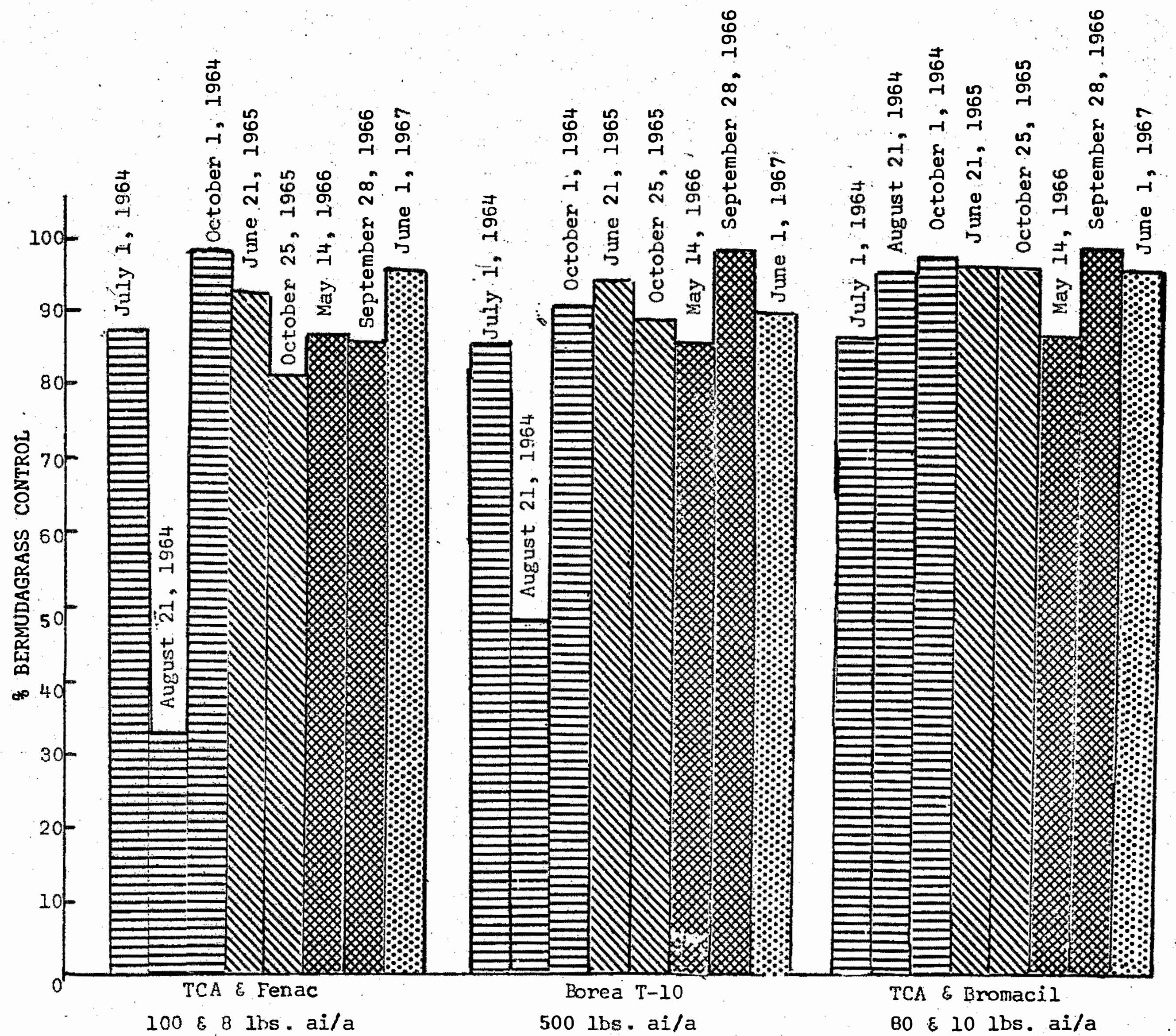



Figure 40. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

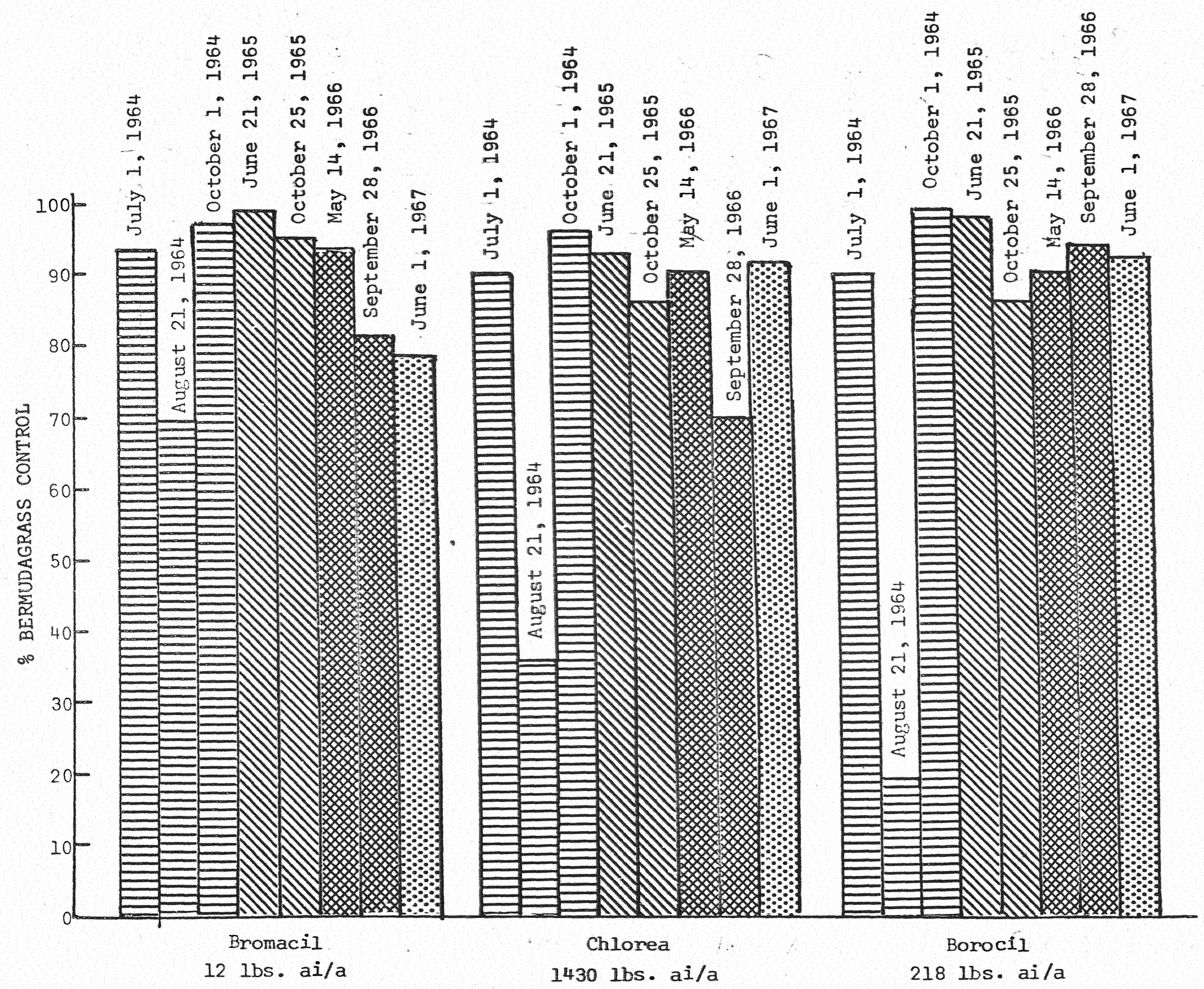



Figure 41. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

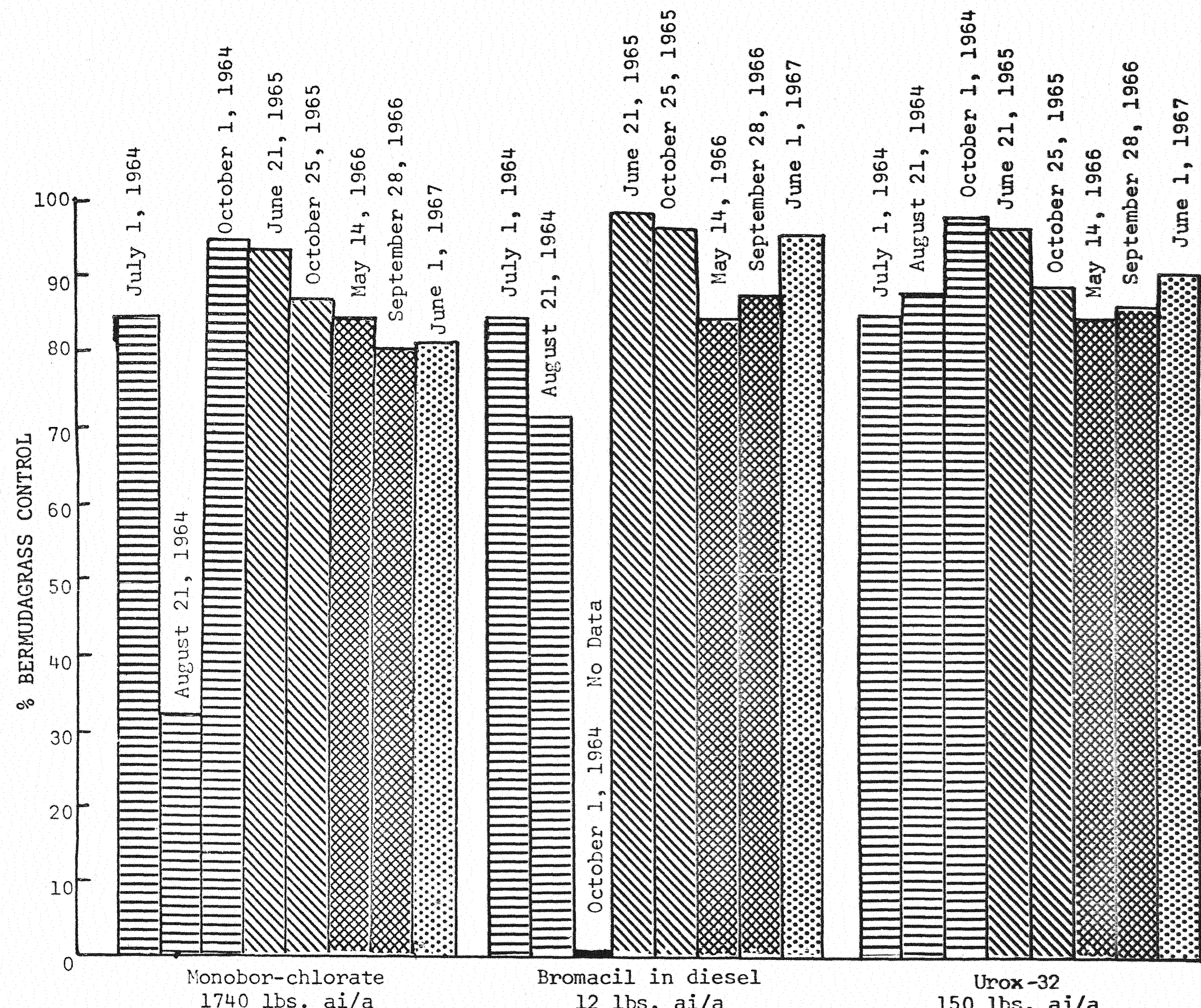



Figure 42. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

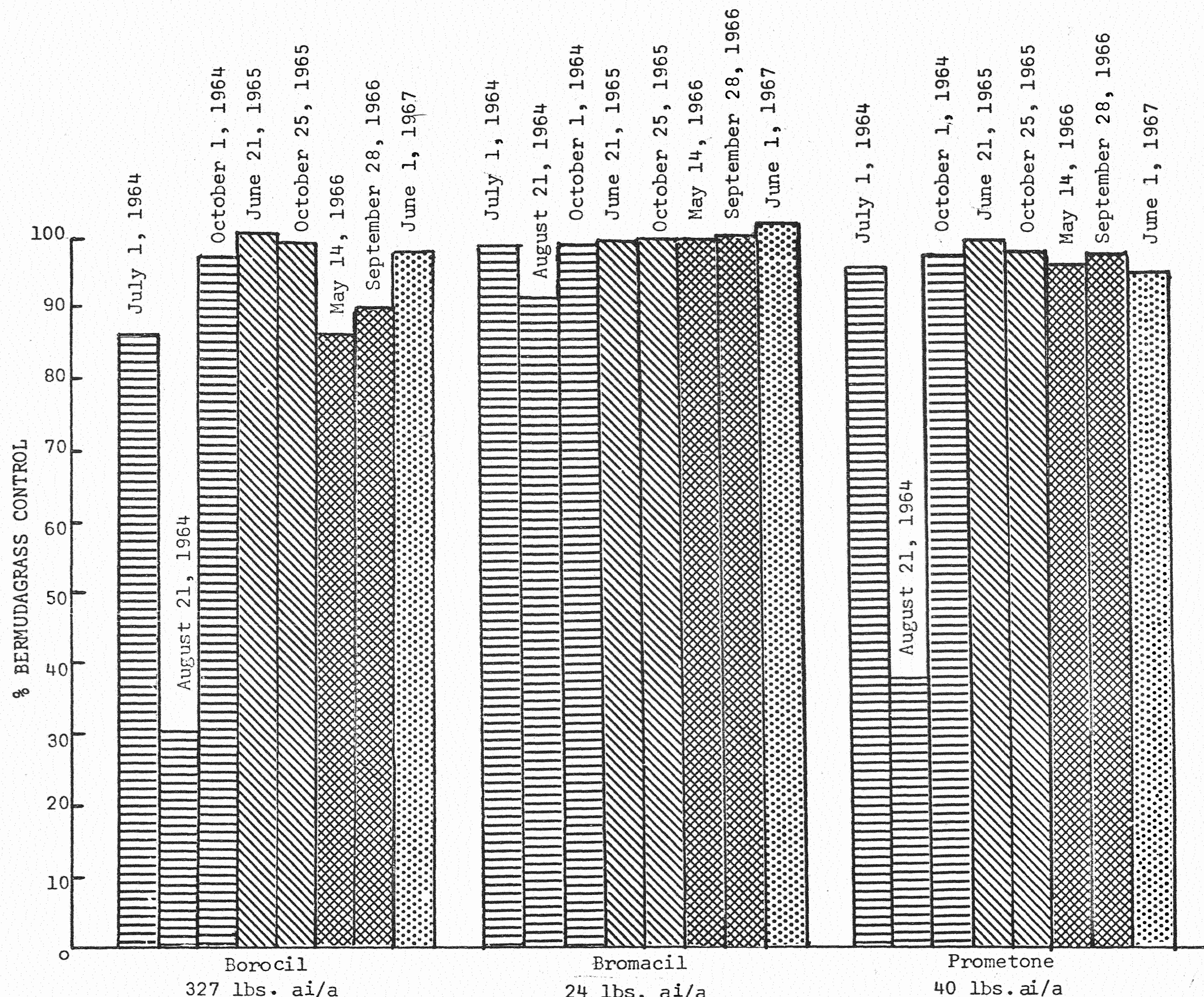



Figure 43. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

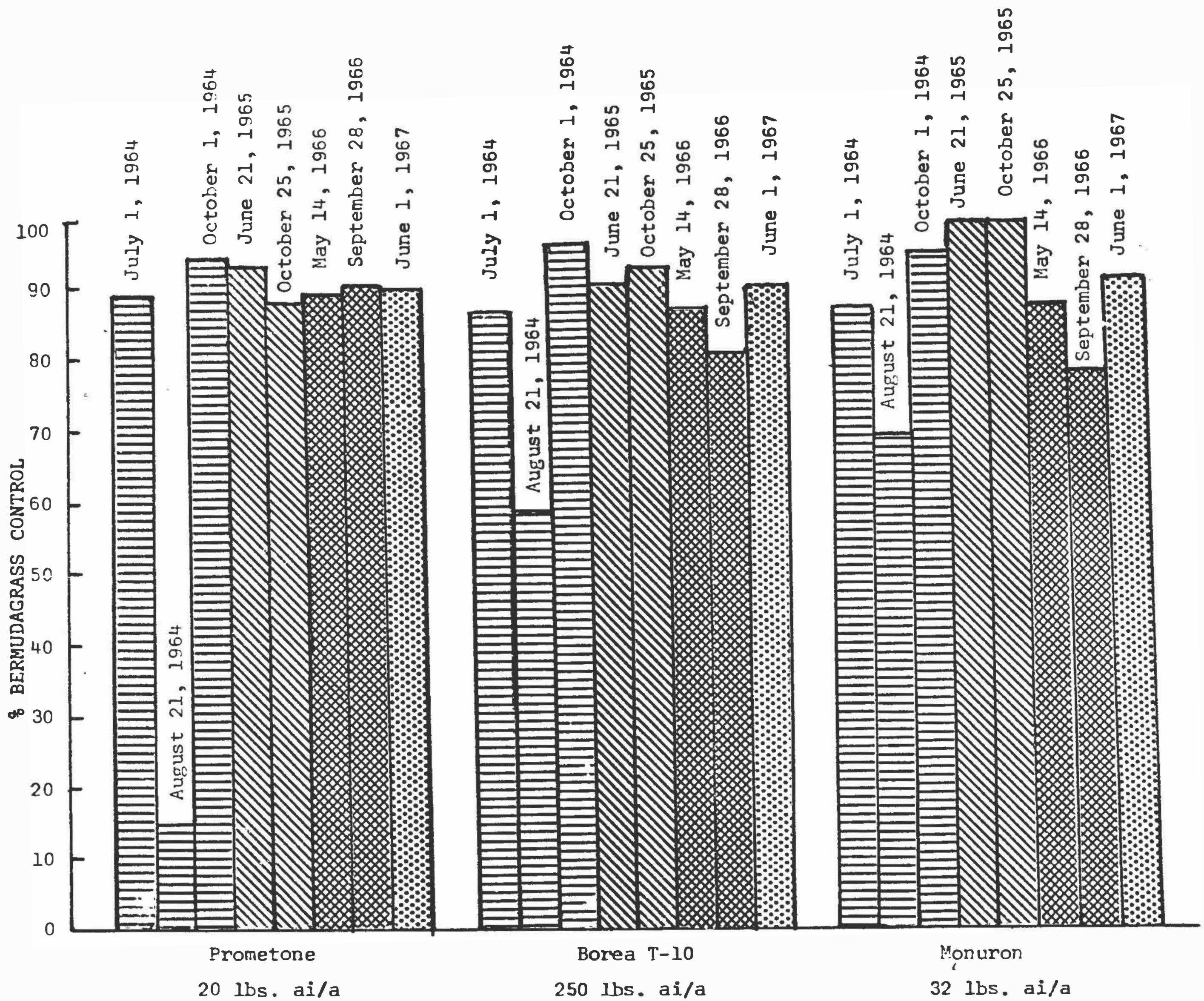



Figure 44. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

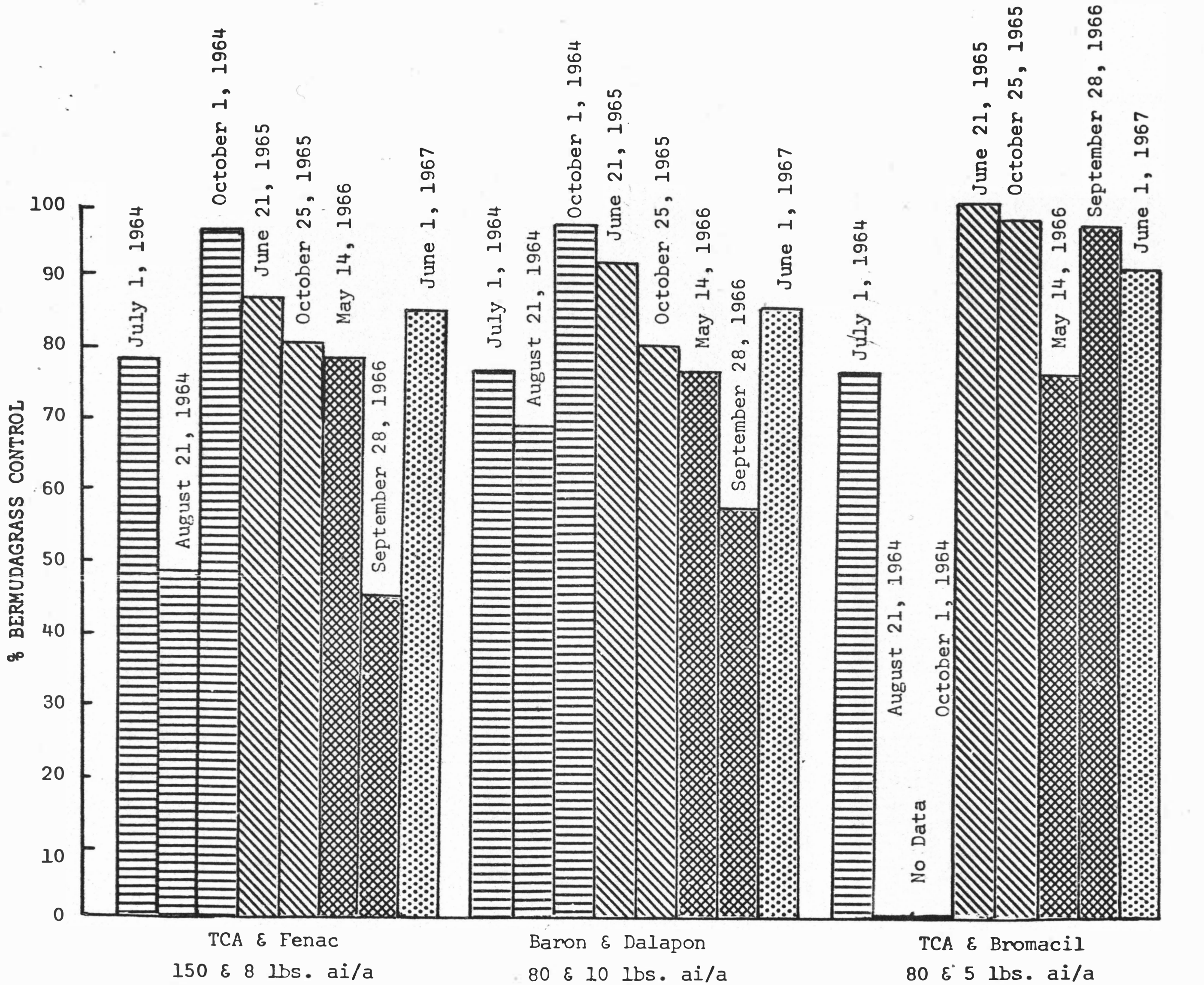



Figure 45. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma

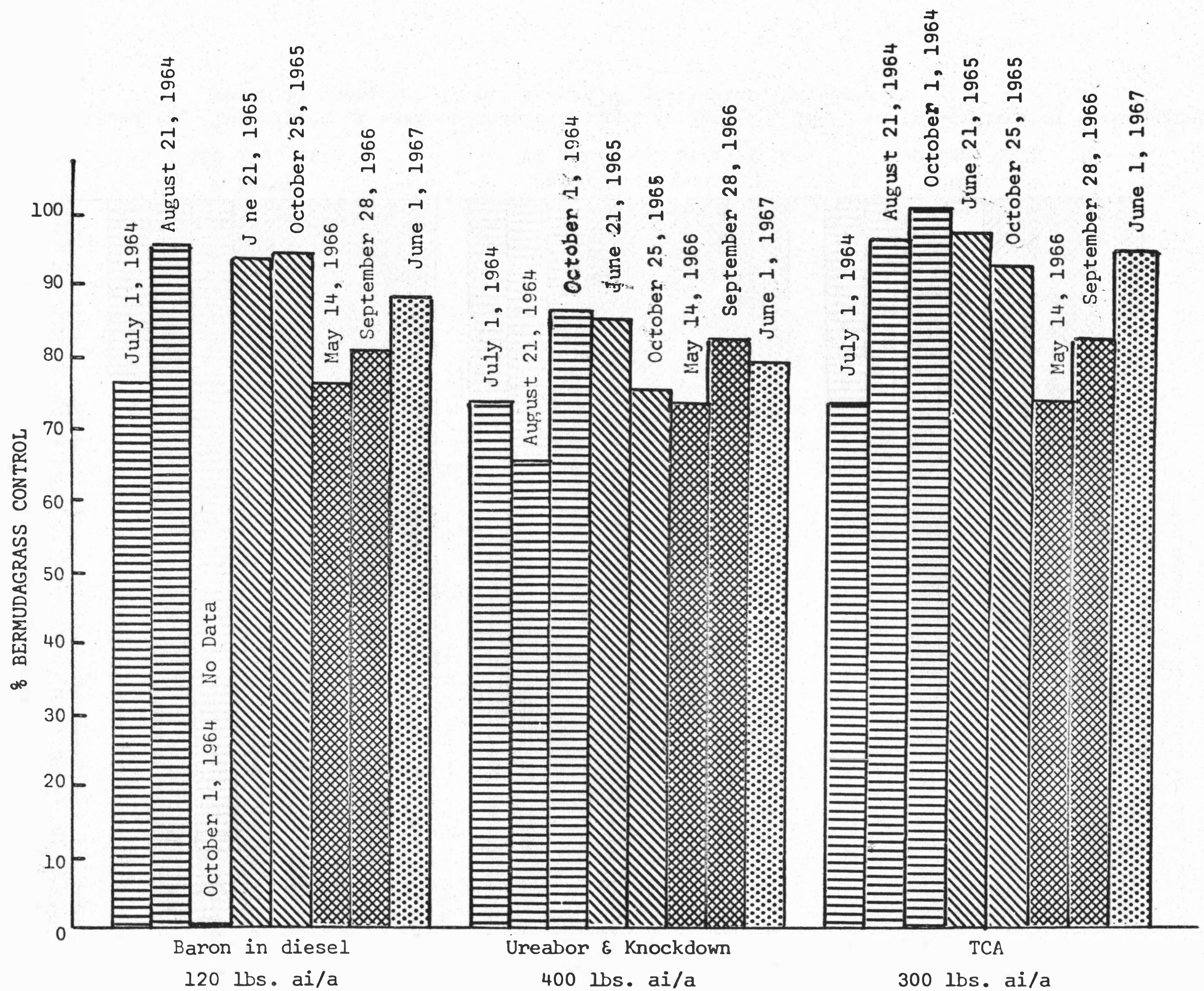



Figure 46. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

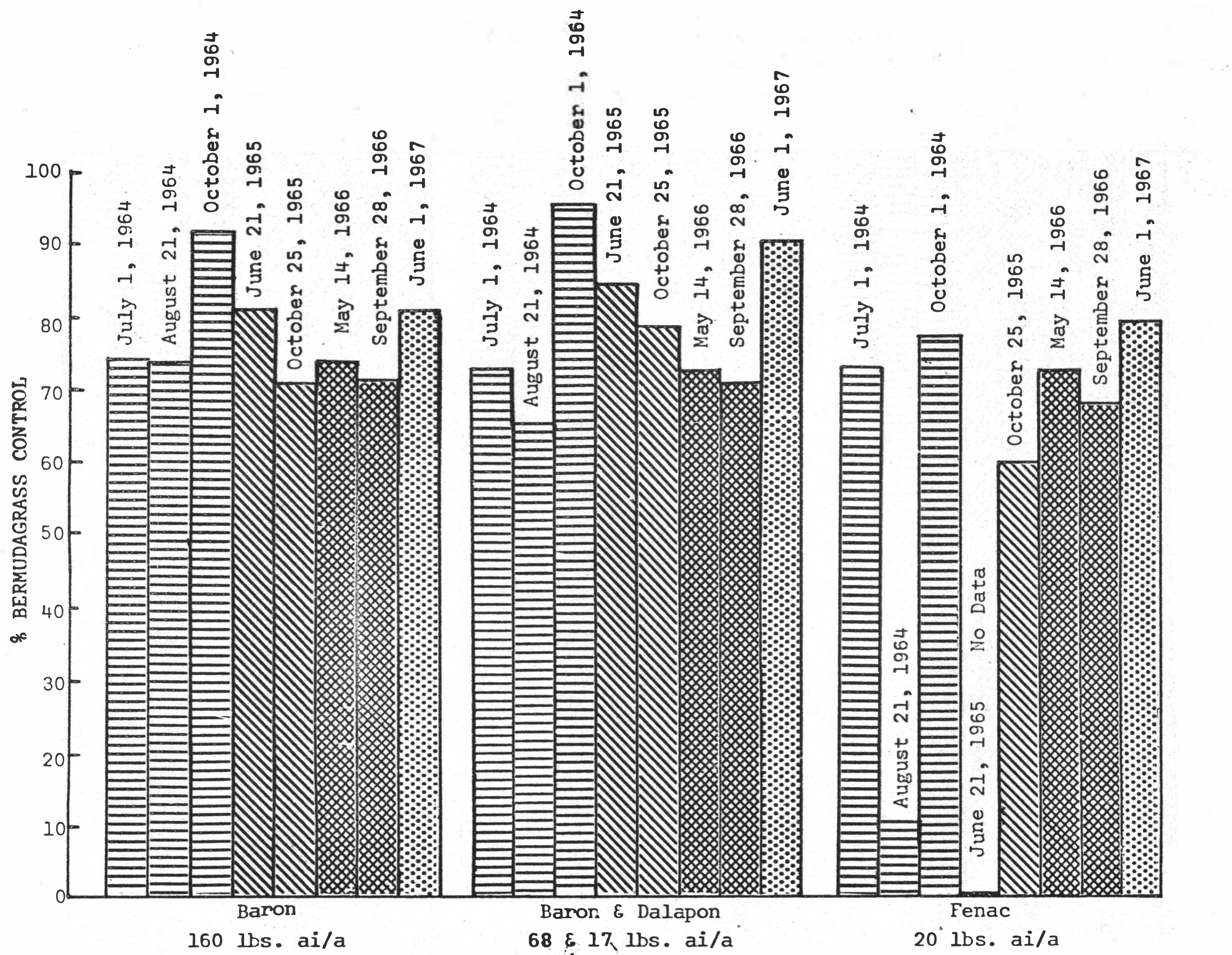



Figure 47. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

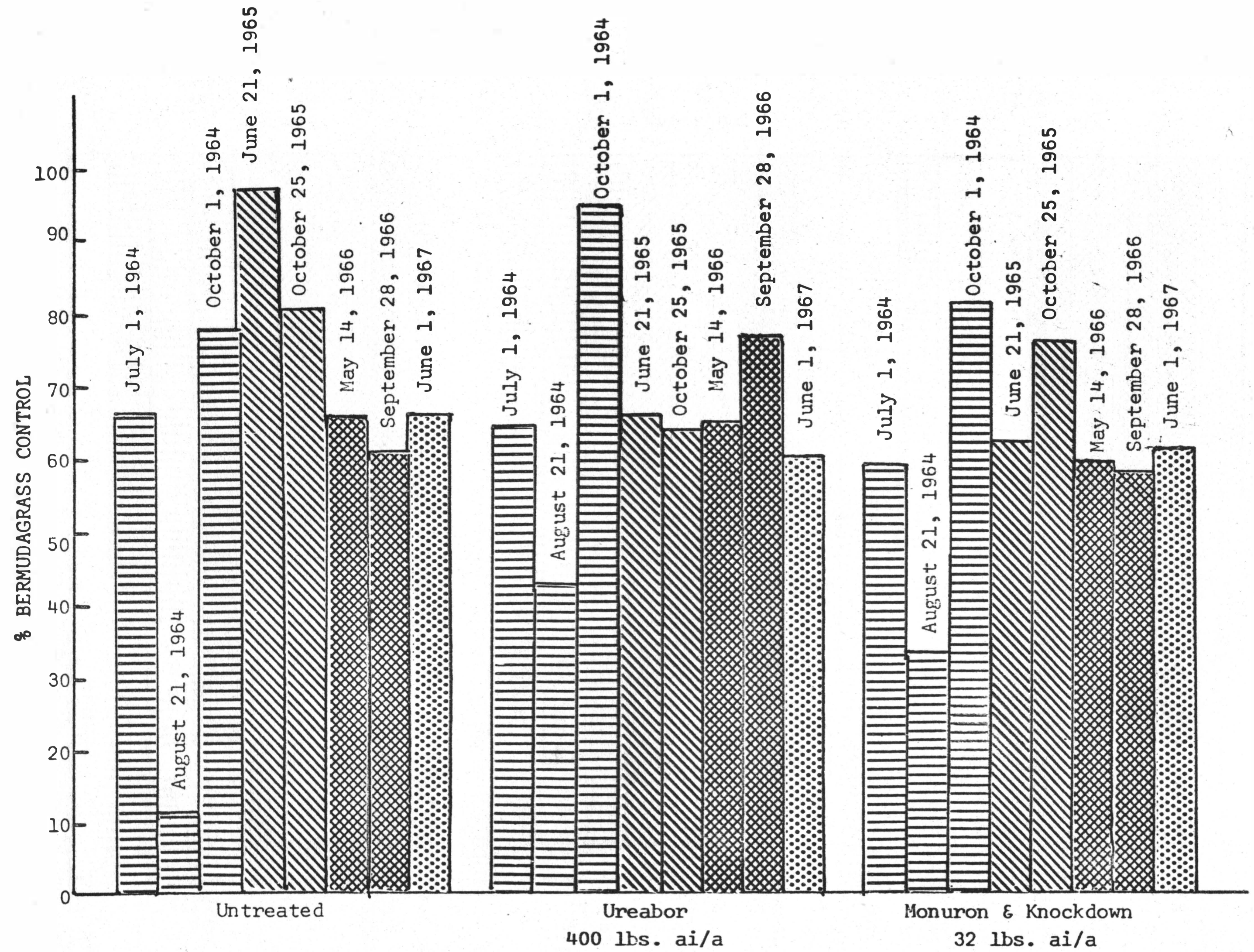



Figure 48. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

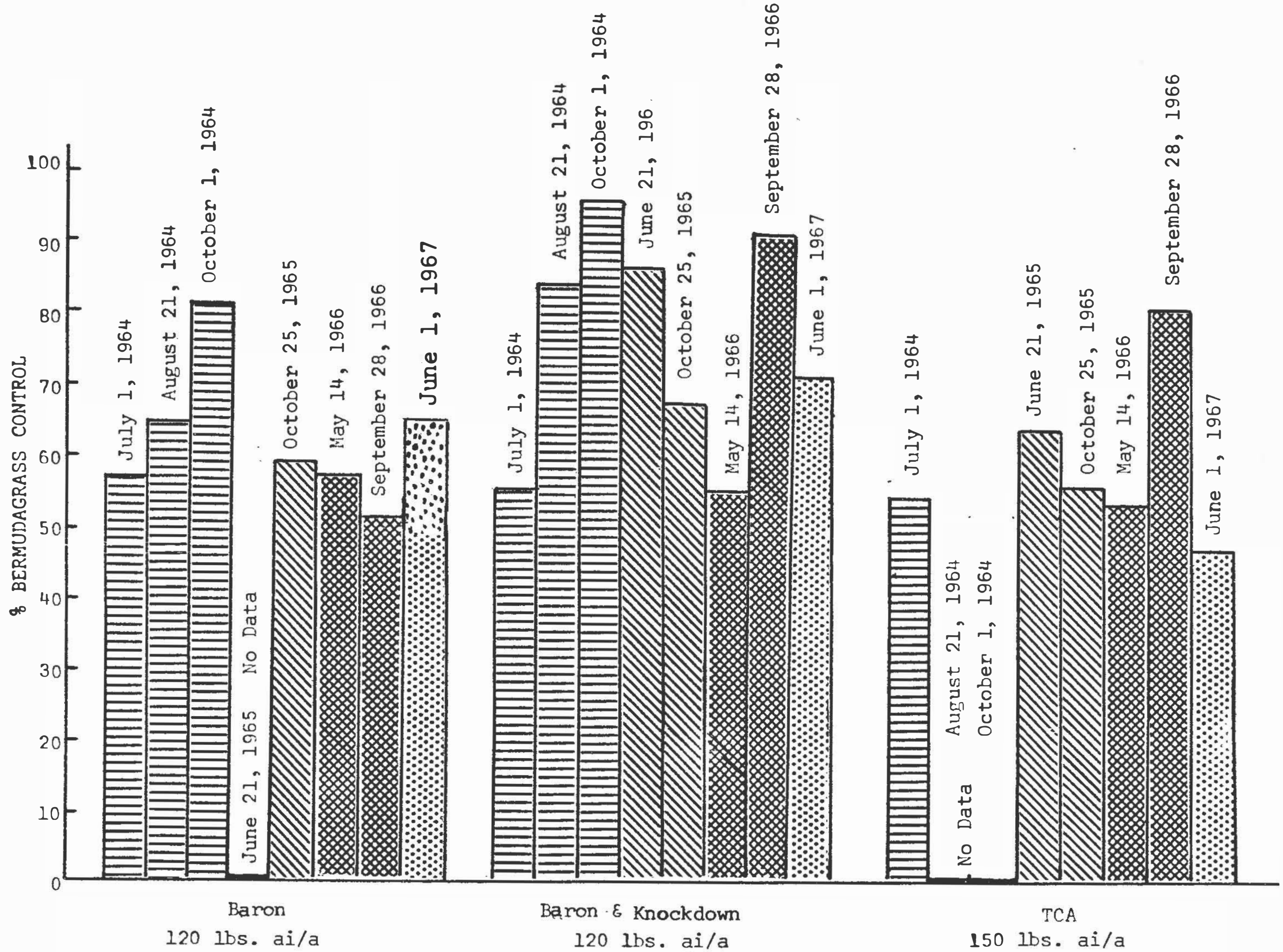



Figure 49. The effect of various chemicals applied June 10, 1964, on the control of bermudagrass on SH-51 shoulders 13 miles west of Stillwater, Oklahoma.

A similar investigation to the one described above was initiated in June 1964 on the shoulders of SH-99 near Drumright. The results of these evaluations are shown in Figures 50 through 54. Although these chemicals were not fully evaluated these data tend to indicate even though effective in killing bermudagrass in the treated band, the herbicides chlorea, borocil, and urox at all rates tested and the high rate of 1740 lbs. a.i./acre of Monobor-chlorate, monuron, Borea T-10, bromacil, ureabor, prometone, and the combination of bromacil and TCA would be arbitrarily considered unsatisfactory for use on highway shoulders because of the excessive downslope movement that created potential erosion problems. In this experiment prometone at 40 lbs. a.i./acre, urox at 398 lbs., monuron at 24 lbs., and a combination of 12.3 lbs. a.i./acre of bromacil and 98.7 lbs. of TCA all exhibited good plant suppression two years after the initial application.

Another experiment was initiated on SH-99 in June 1965, this one near Wynona in north-central Oklahoma to evaluate several herbicides for use as soil sterilants on highway shoulders. A second application of these materials at one-half the original rate was made in 1966, one year later. The results of these evaluations, although not complete are shown in Figures 55 through 65. These data indicate the most effective herbicides for the control of bermudagrass particularly in this area are TCA at 150 lbs., urox at 300 lbs., and bromacil at 24 lbs. a.i./acre. The downslope movement of urox at this rate was considered excessive and would be undesirable on slopes such as these.

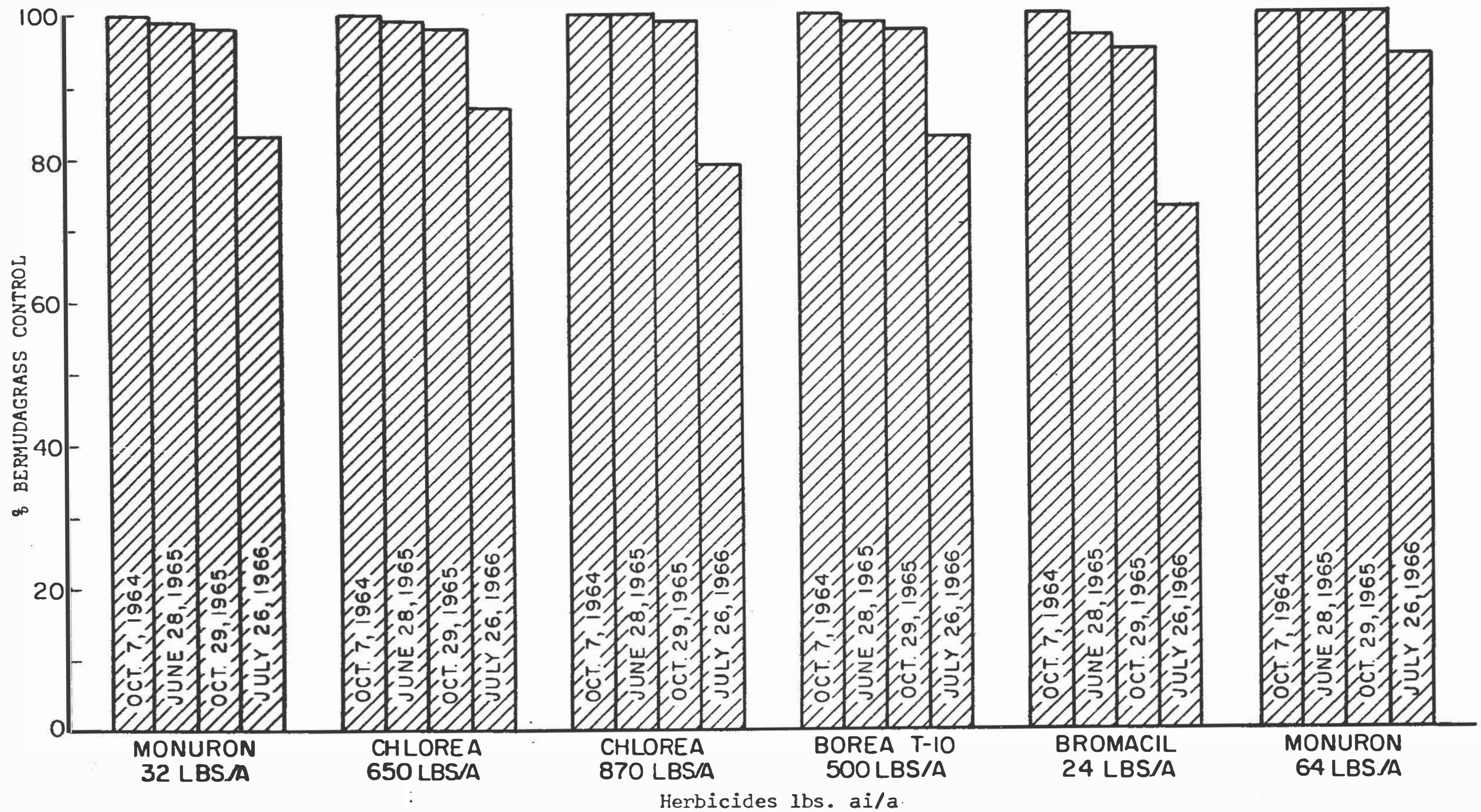



**Figure 50.** **The effect of various chemicals applied on June 2, 1964, in the control of bermudagrass on SH-99 shoulders near Drumright,** Oklahoma.

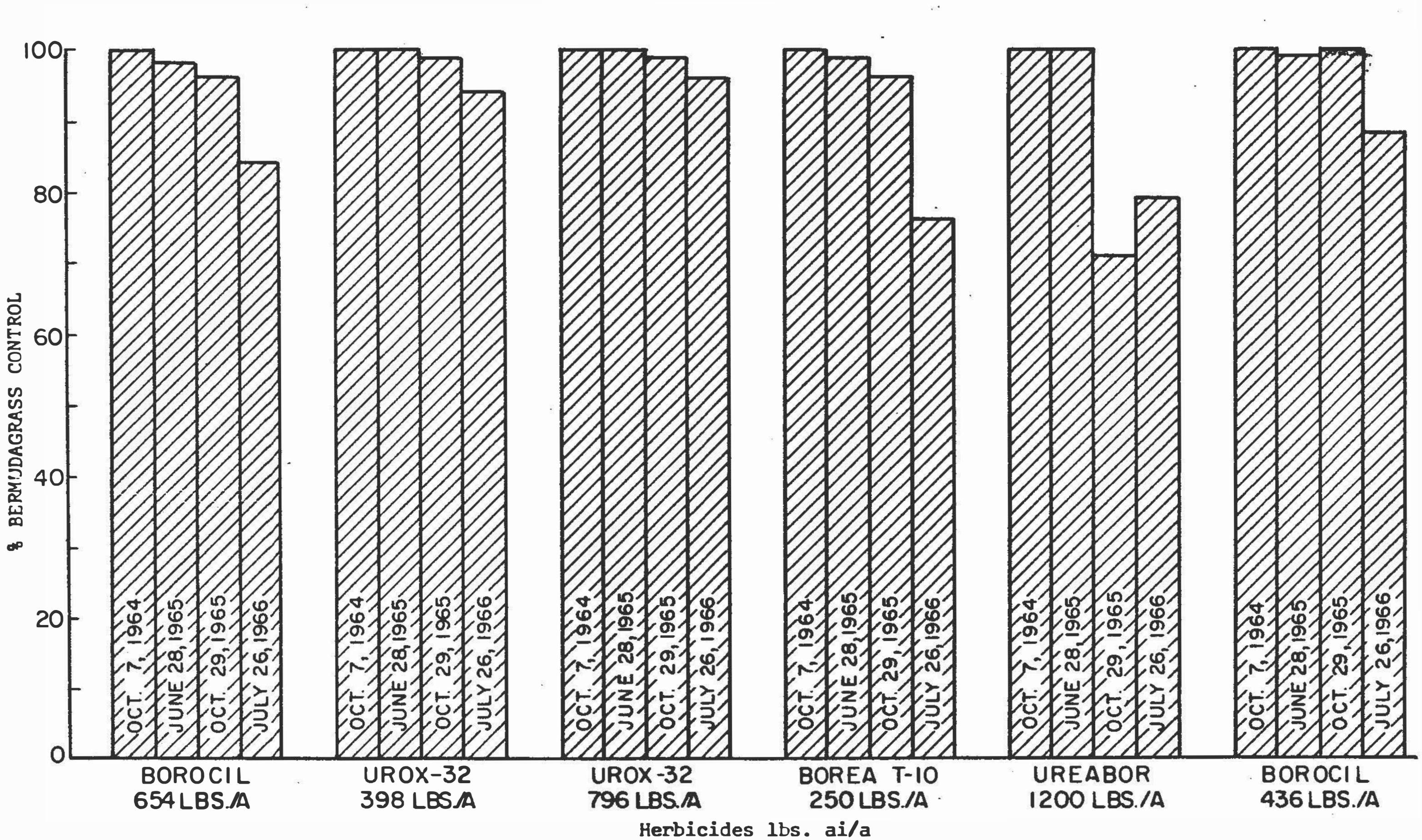



Figure 51. The effect of various chemicals applied on June 2, 1964, in the control of Bermudagrass on SH-99 shoulders near Drumright, Oklahoma.

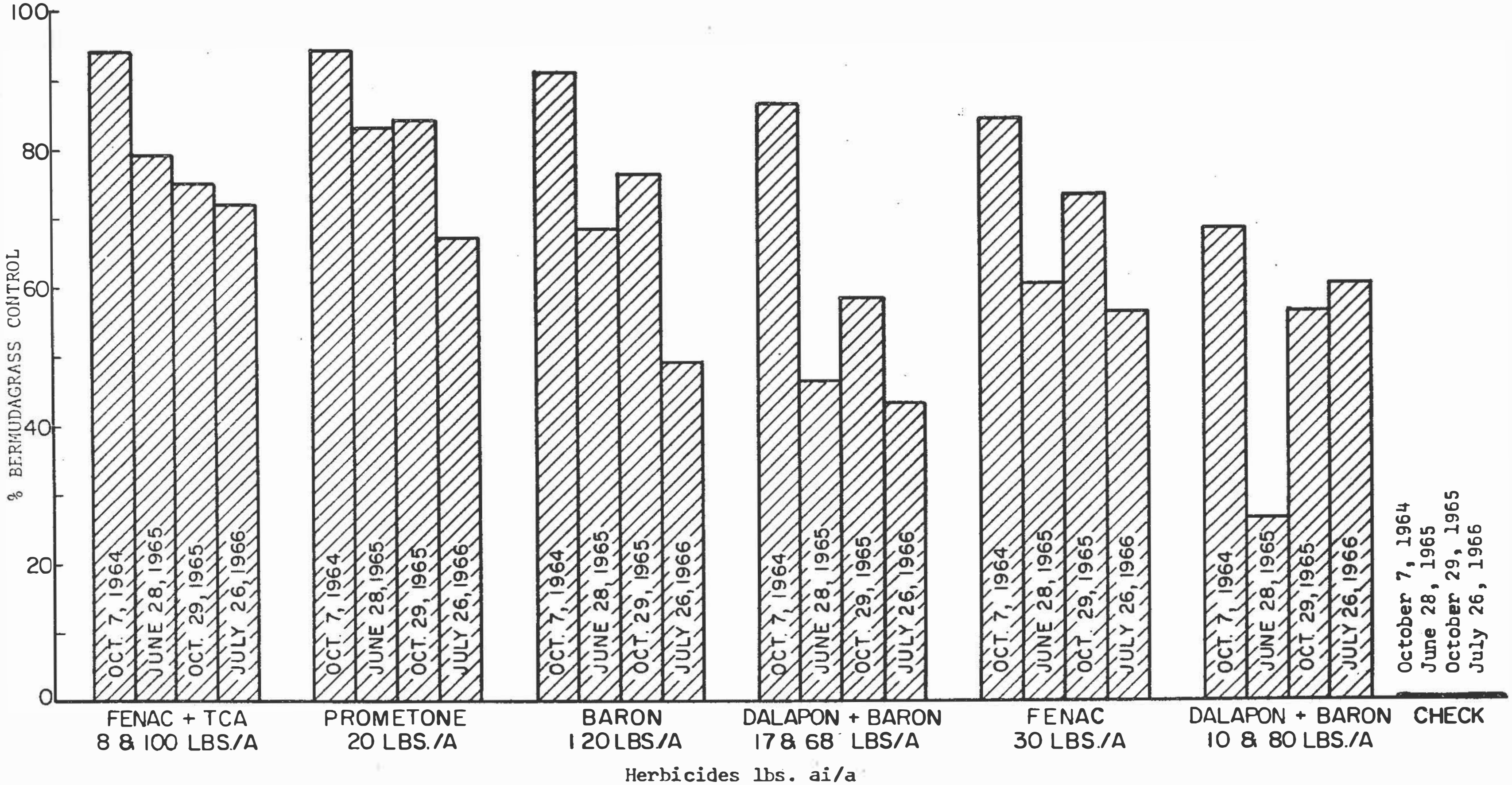



Figure 54. The effect of various chemicals applied on June 2, 1964, in the control of Bermudagrass on SH-99 shoulders near Drumright, Oklahoma

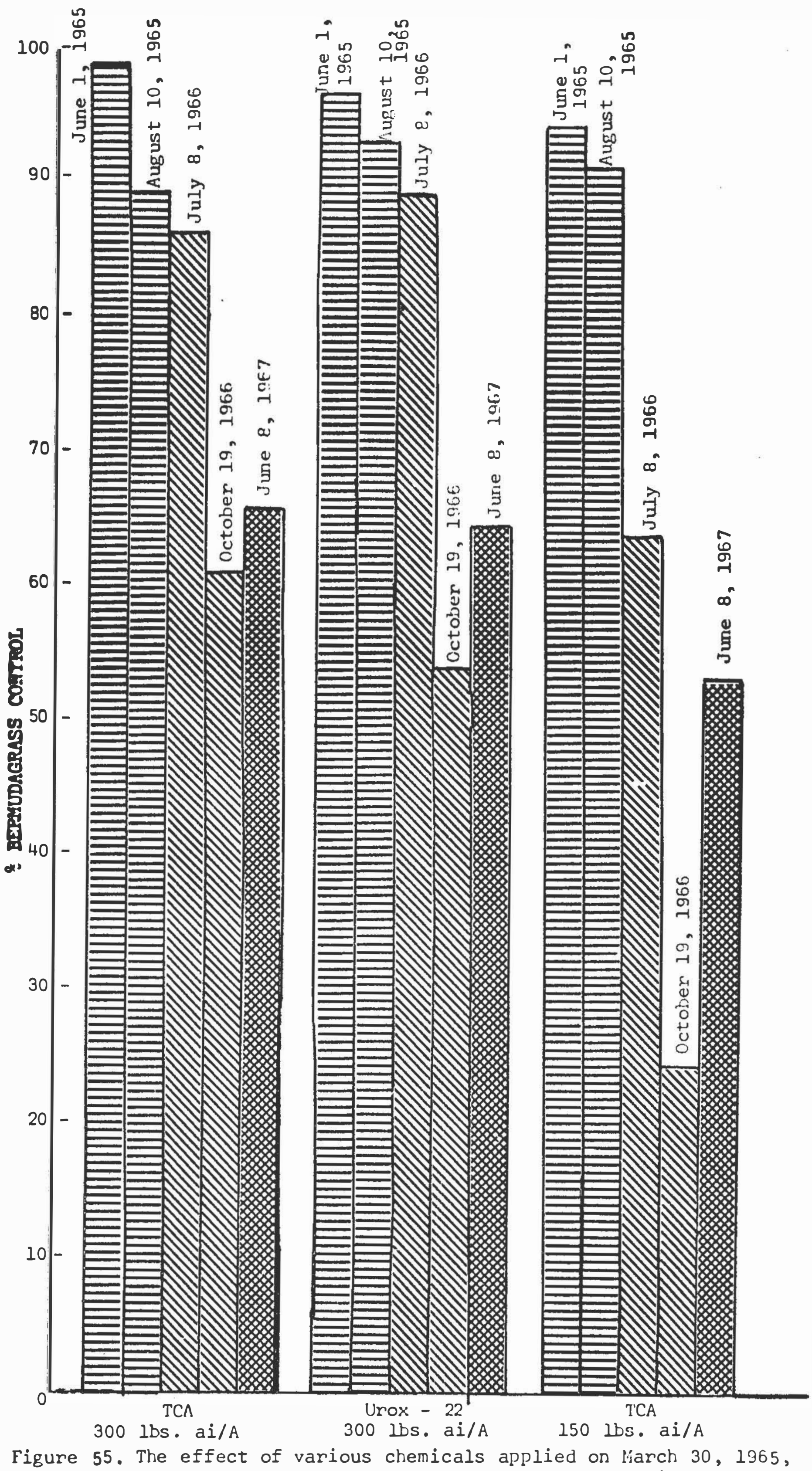



Figure 55. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

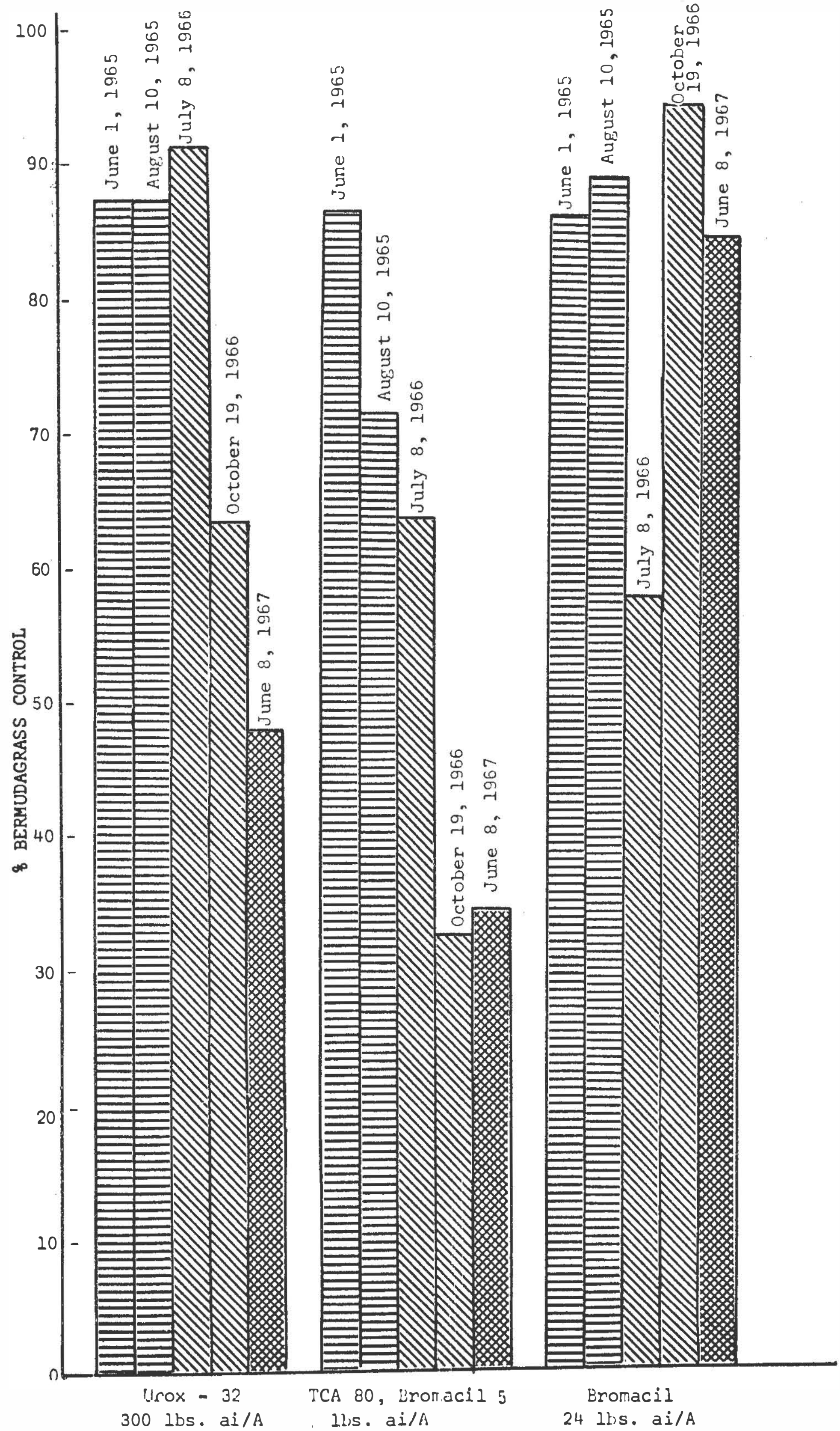



Figure 56. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

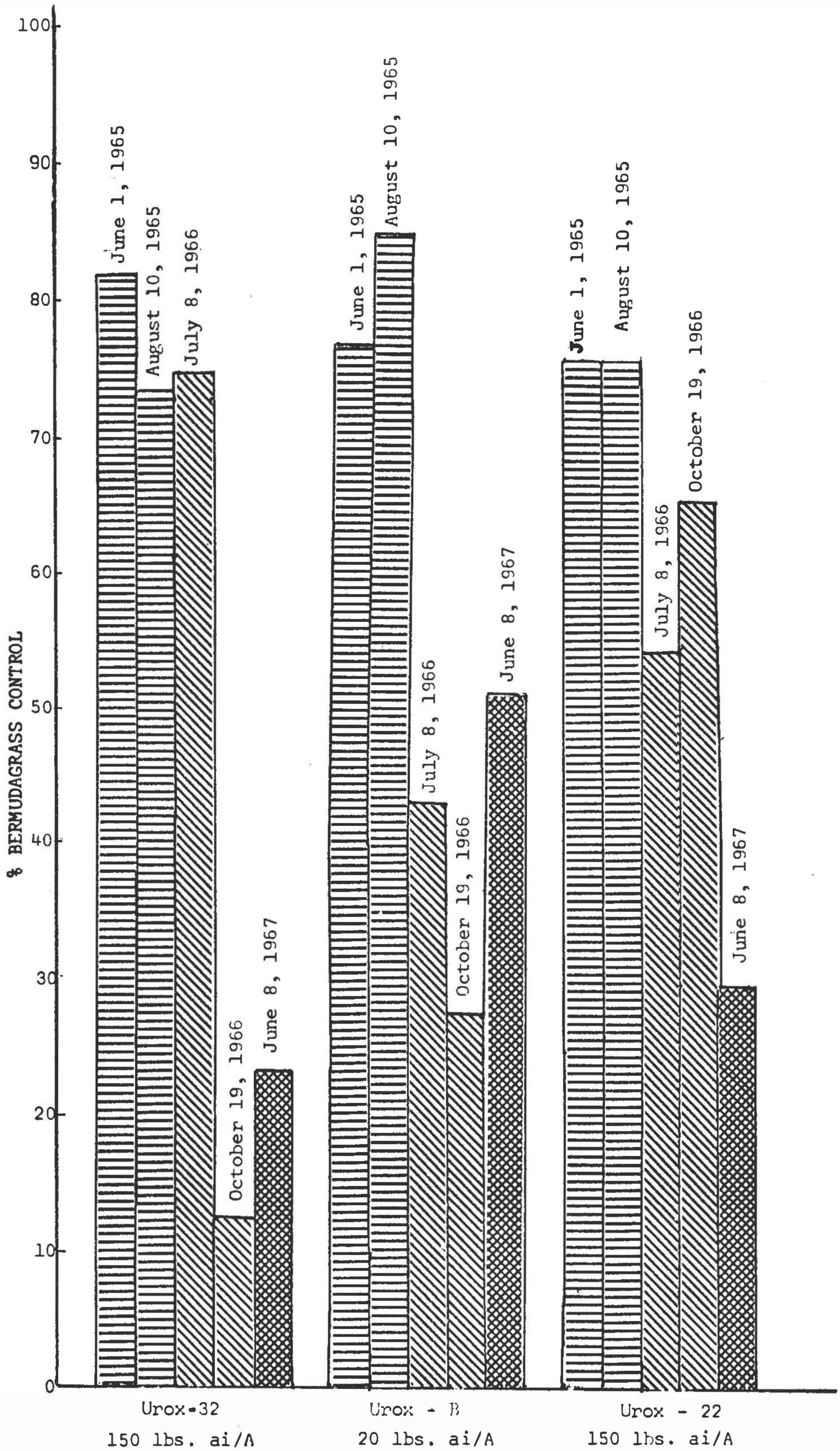



Figure 57. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

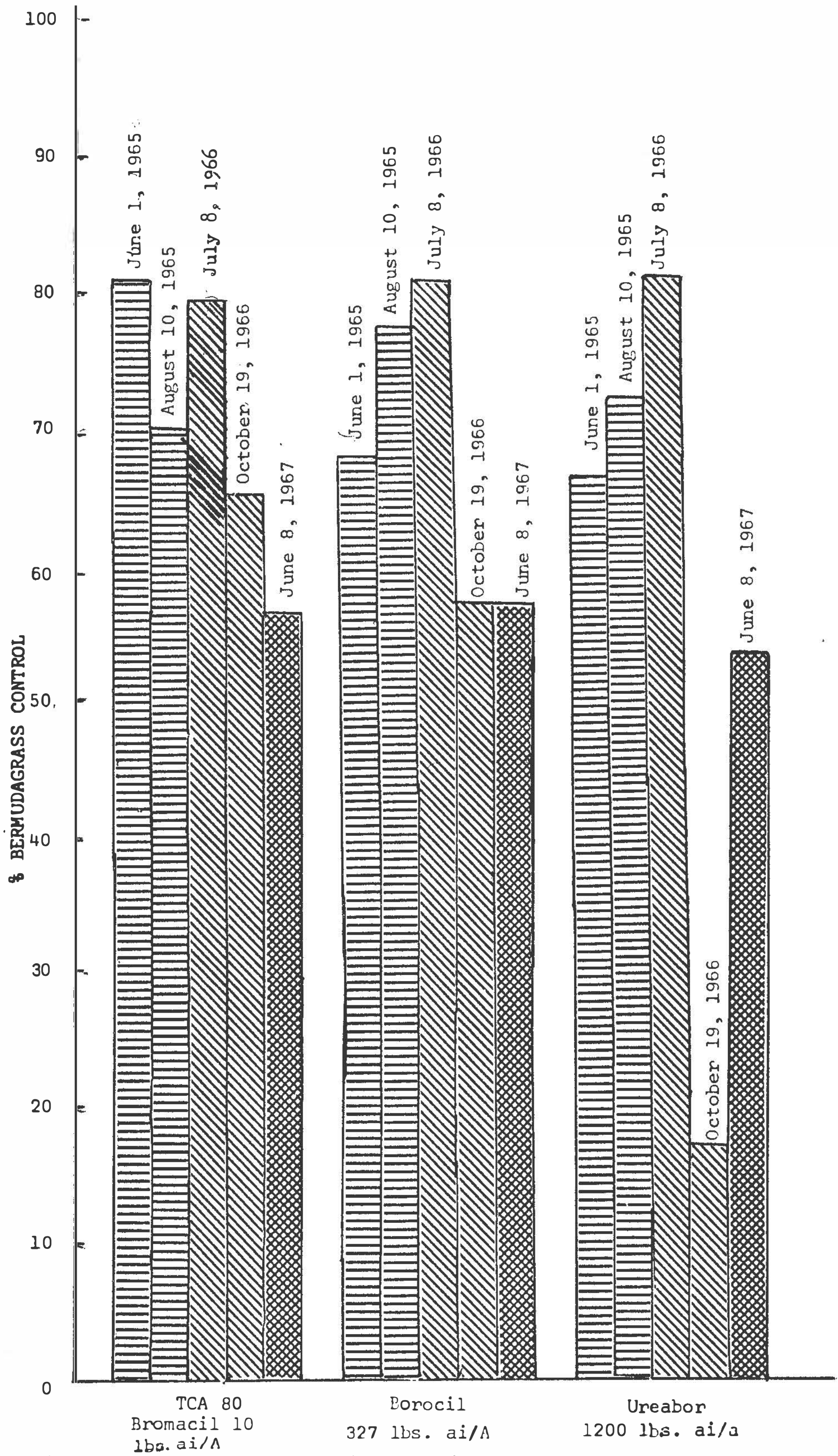



Figure 58. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

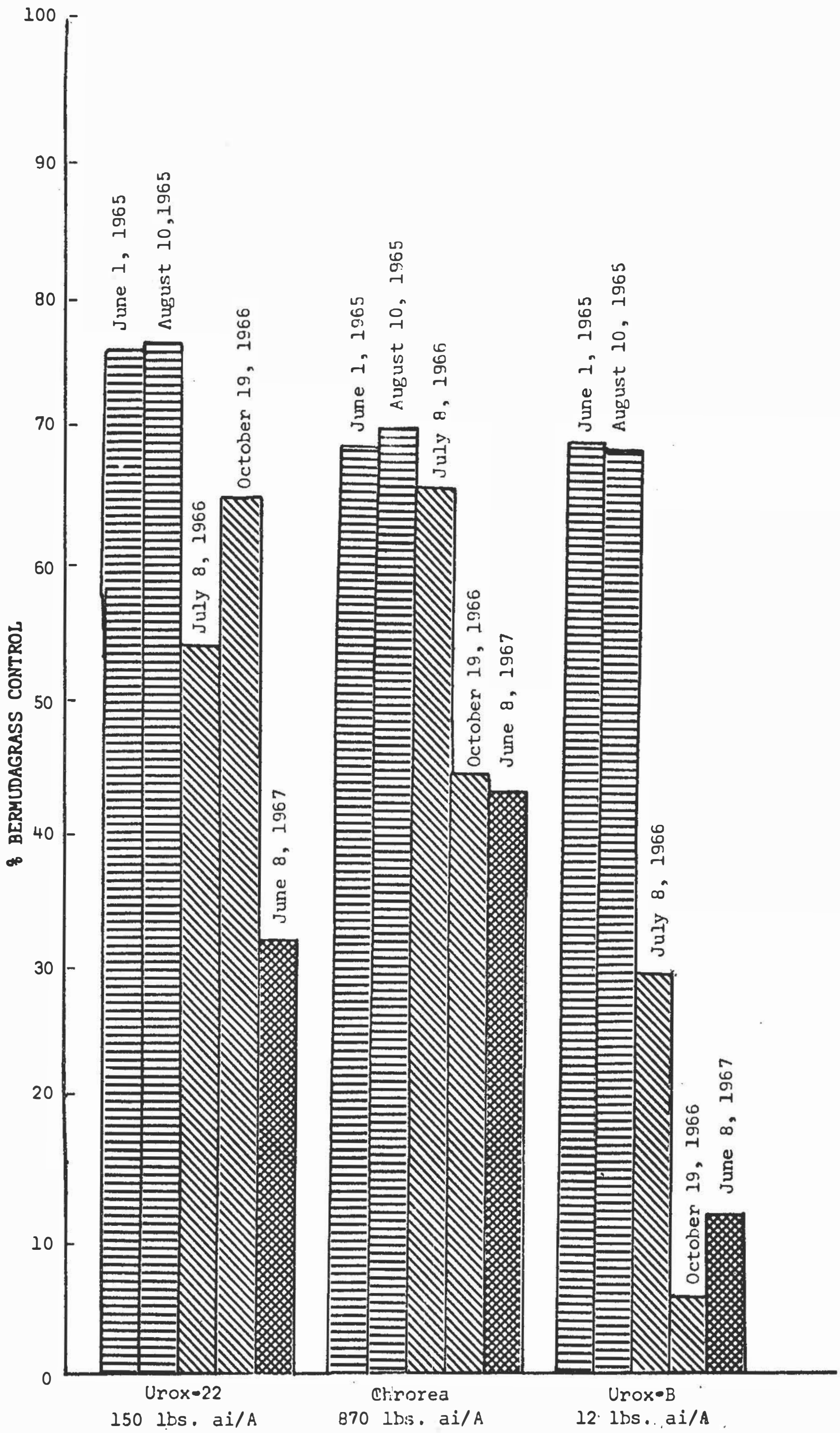



Figure 59. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

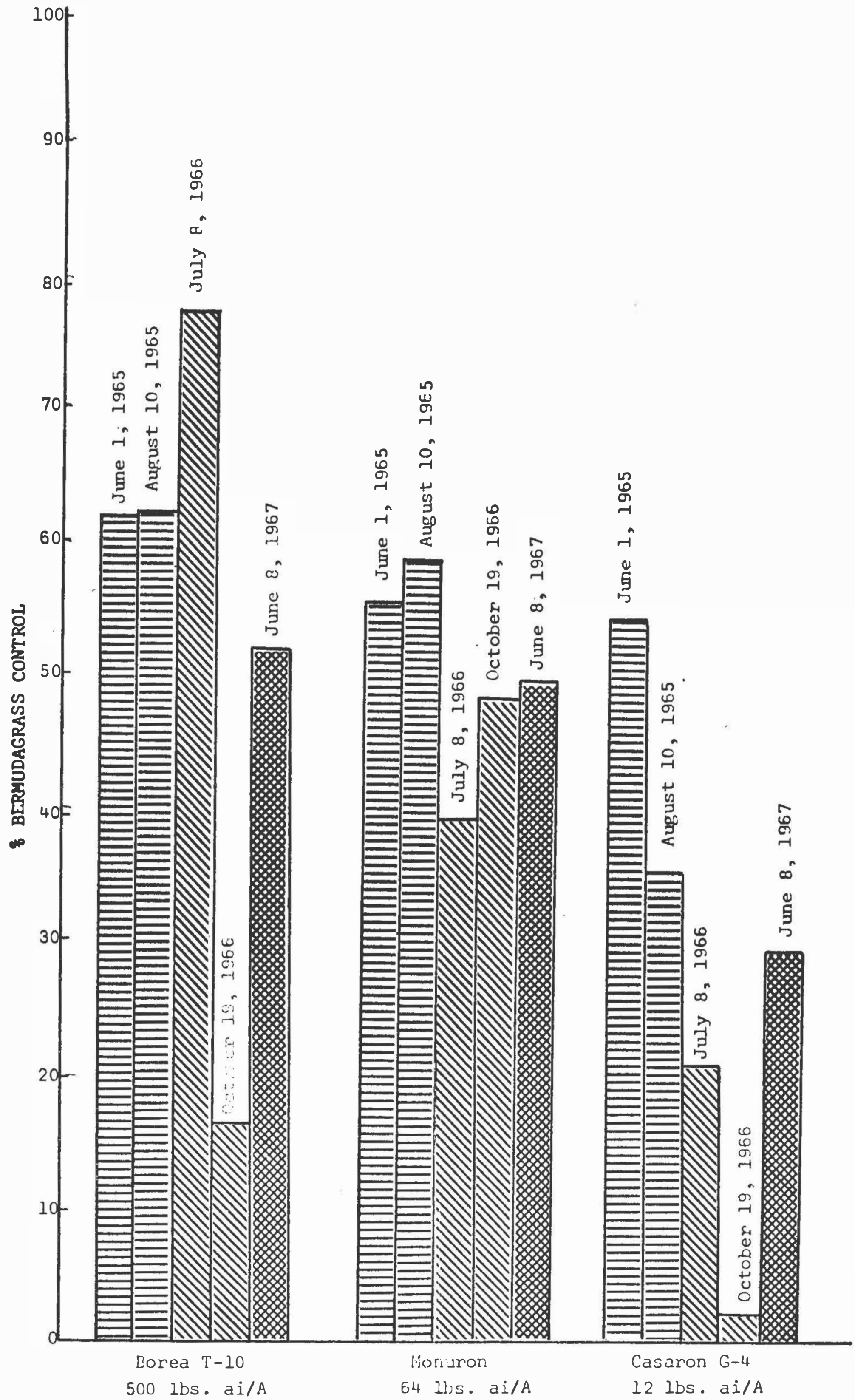



Figure 60. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH 99 shoulders near Wynona, Oklahoma.

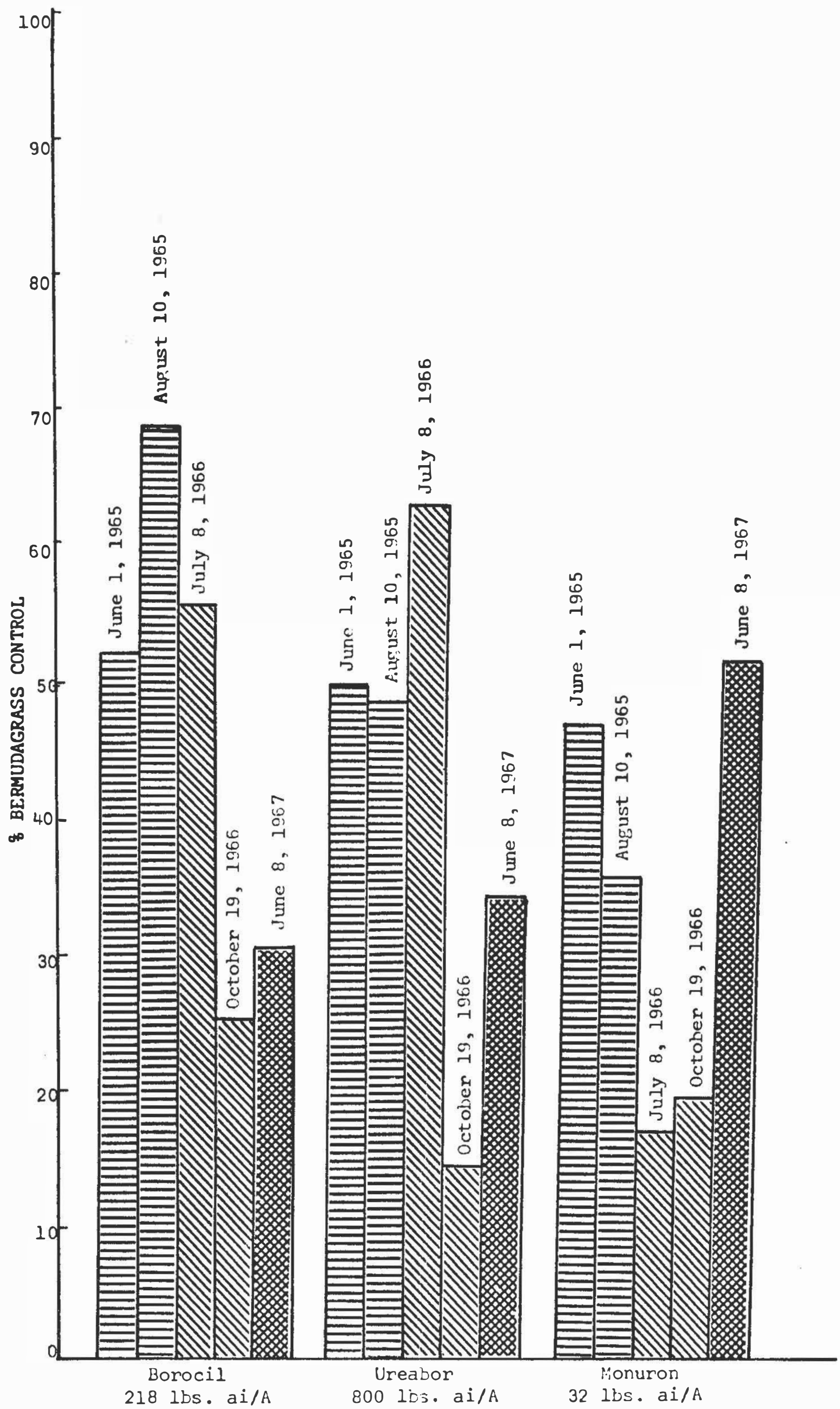



Figure 61. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH 99 shoulders near Wynona, Oklahoma.

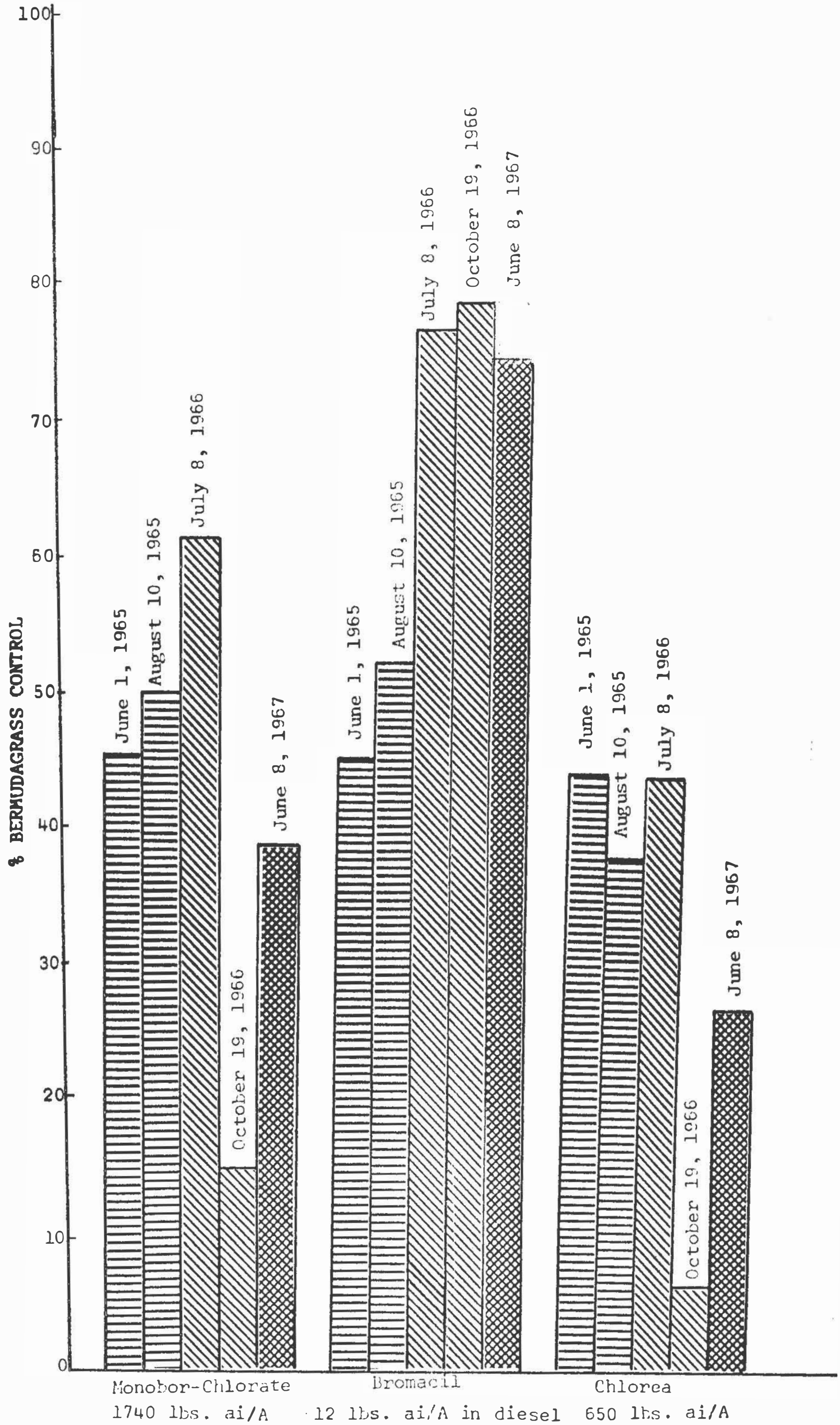



Figure 62. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

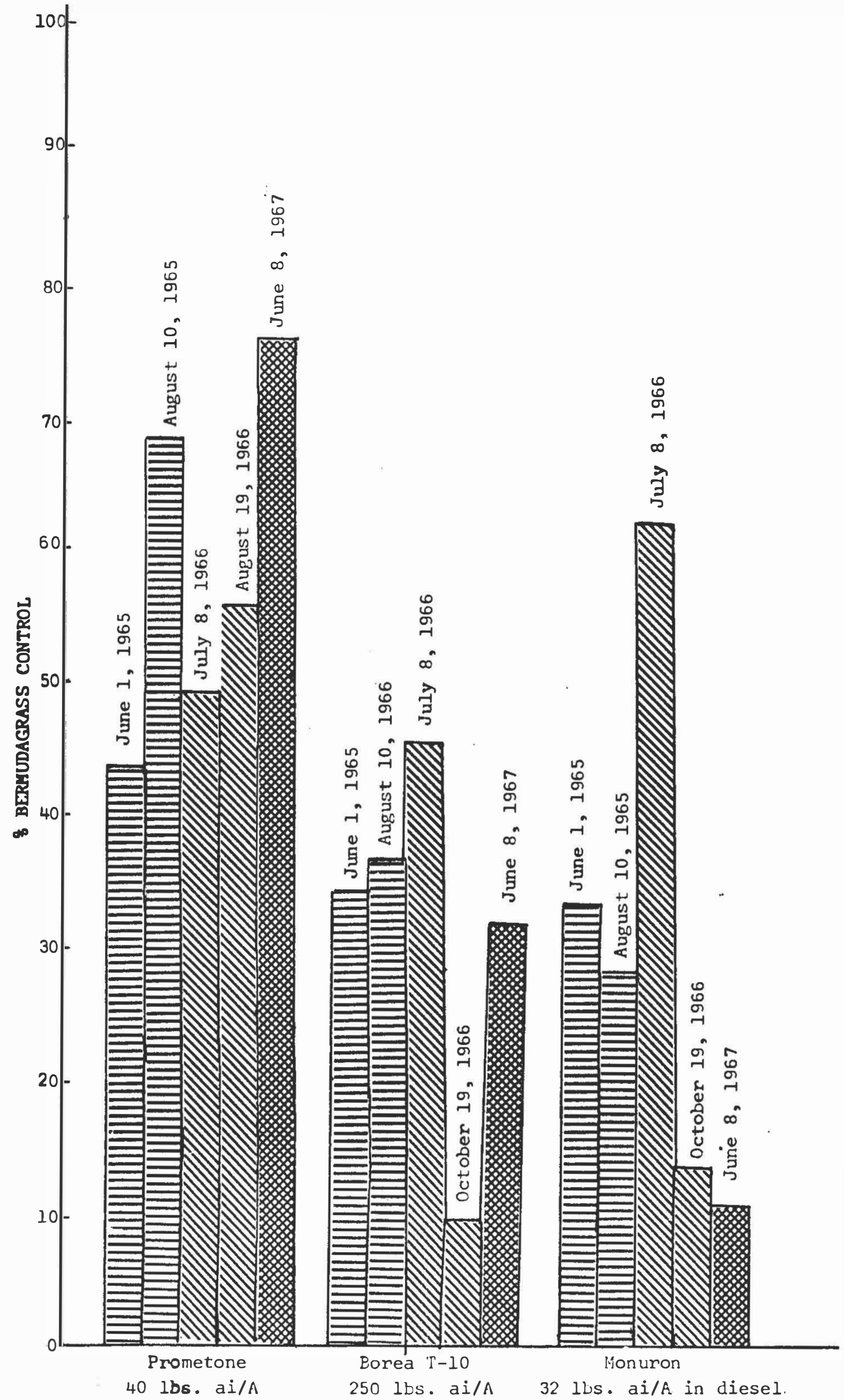



Figure 63. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

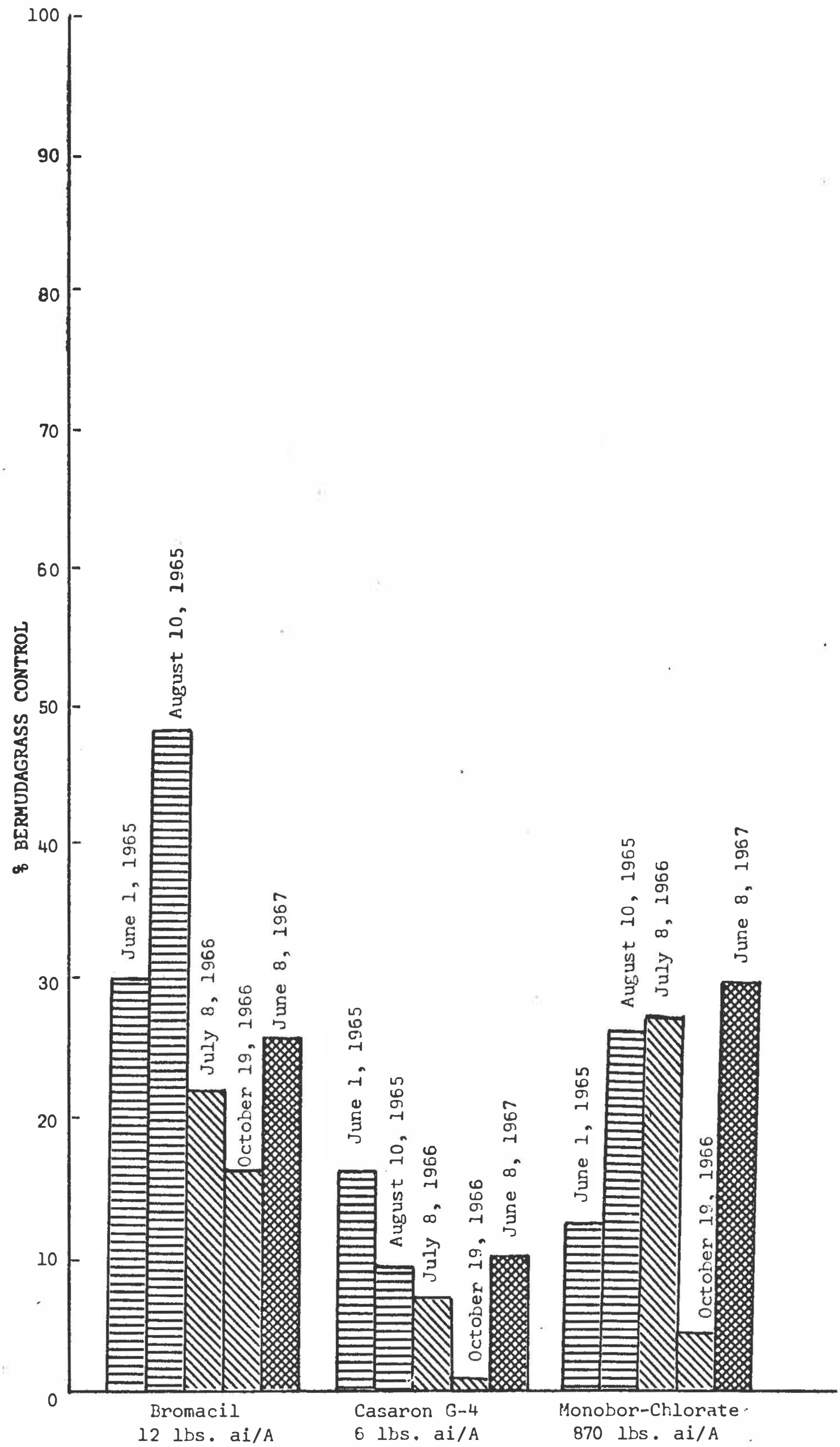



Figure 64. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

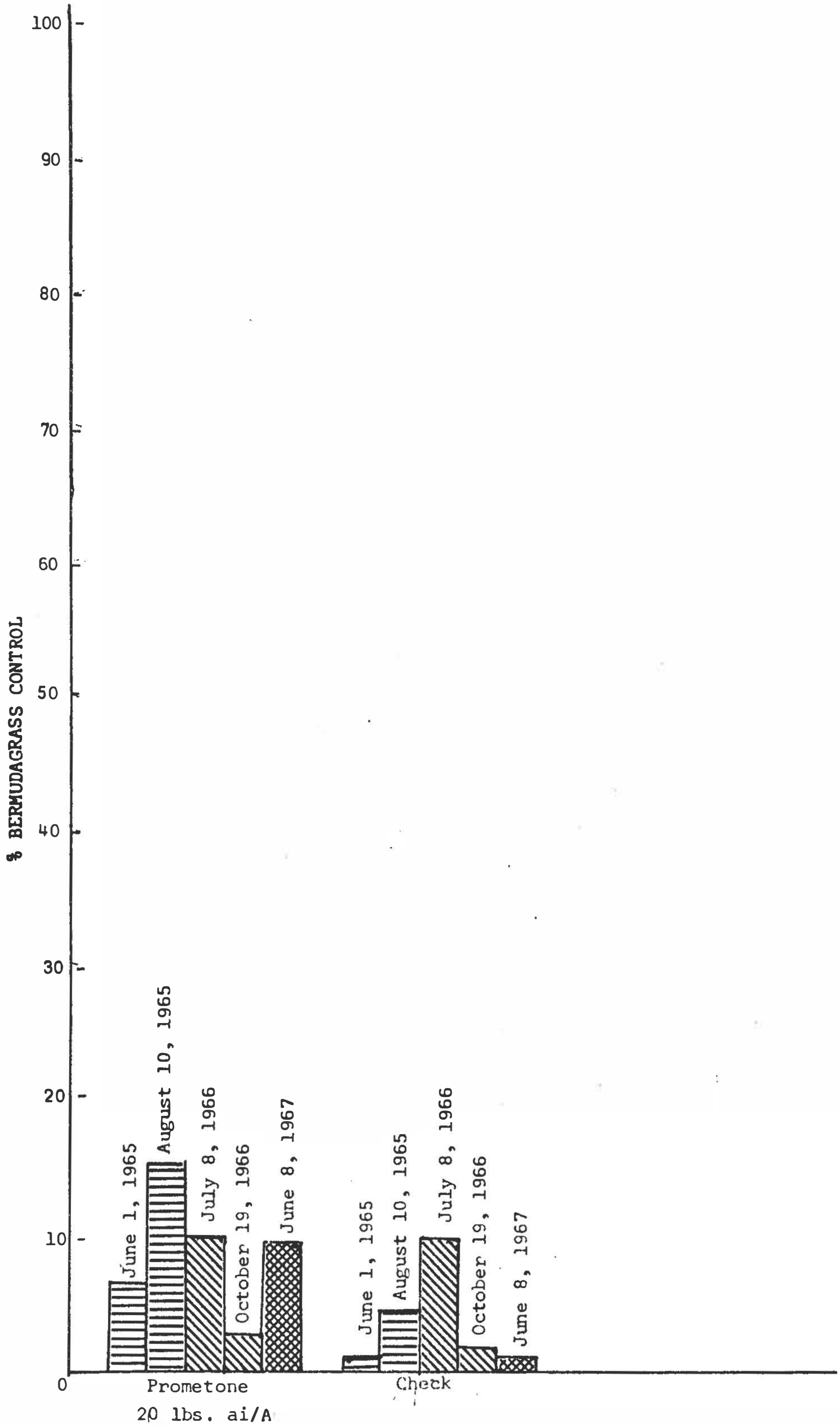



Figure 65. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of Bermudagrass on SH-99 shoulders near Wynona, Oklahoma.

In December of 1965 an experiment was initiated on US-177 about five miles south of the intersection with US-66 west of Chandler in central Oklahoma to evaluate several chemicals as soil sterilants on highway shoulders and their application in mid-winter. The results of these evaluations although not complete are shown in Figures 66 through 71. These data indicate the most effective herbicides for the eradication of bermudagrass when applied near the first of the year are Urox HX at 16 lbs. a.i./acre, bromacil at 24 lbs., borocil at 327 lbs., monuron at 64 lbs., and ureabor at 800 lbs. The most downslope movement of chemicals seemed to occur with Borea T-10, ureabor, bromacil, borocil, monuron, urox, and prometone. Sinkler[2] reported chemical movement downslope similar to that found in this experiment.

The herbicides found to be the most effective in the suppression of plant growth especially bermudagrass on shoulders and under guardrails of the Oklahoma highway system are bromacil at 24 lbs. a.i./acre, boracil at 327 lbs., TCA at 150 lbs., Borea T-10 at 500 lbs., and a combination of 80 lbs. TCA and 10 lbs. bromacil. These chemicals and rates alone and in combination possibly will change with further evaluation.

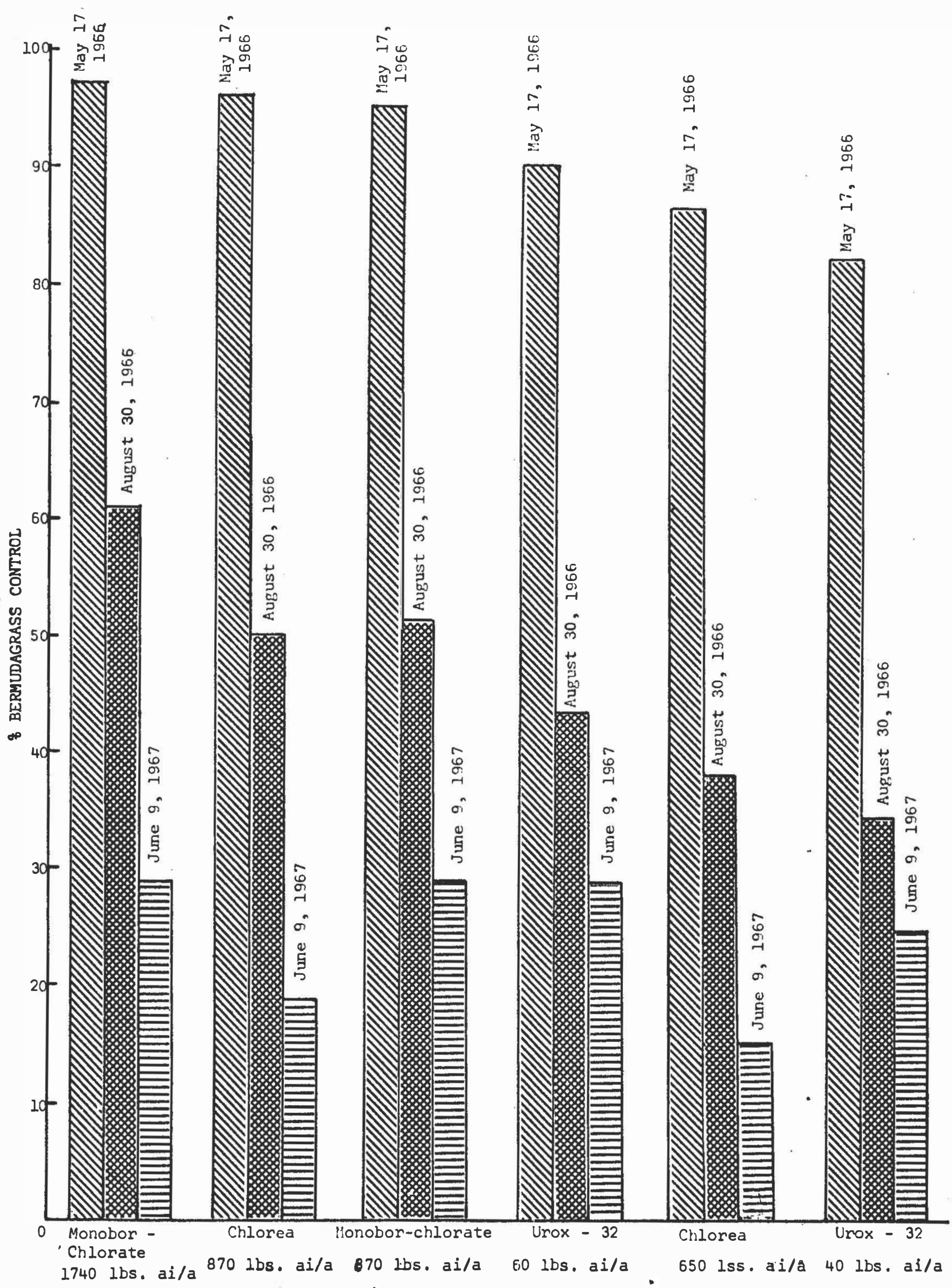



Figure 66. The effect of various chemicals applied November 30, 1965, on the control of bermudagrass on US-177 shoulders 4.8 miles south of US-66 junction in central Oklahoma.

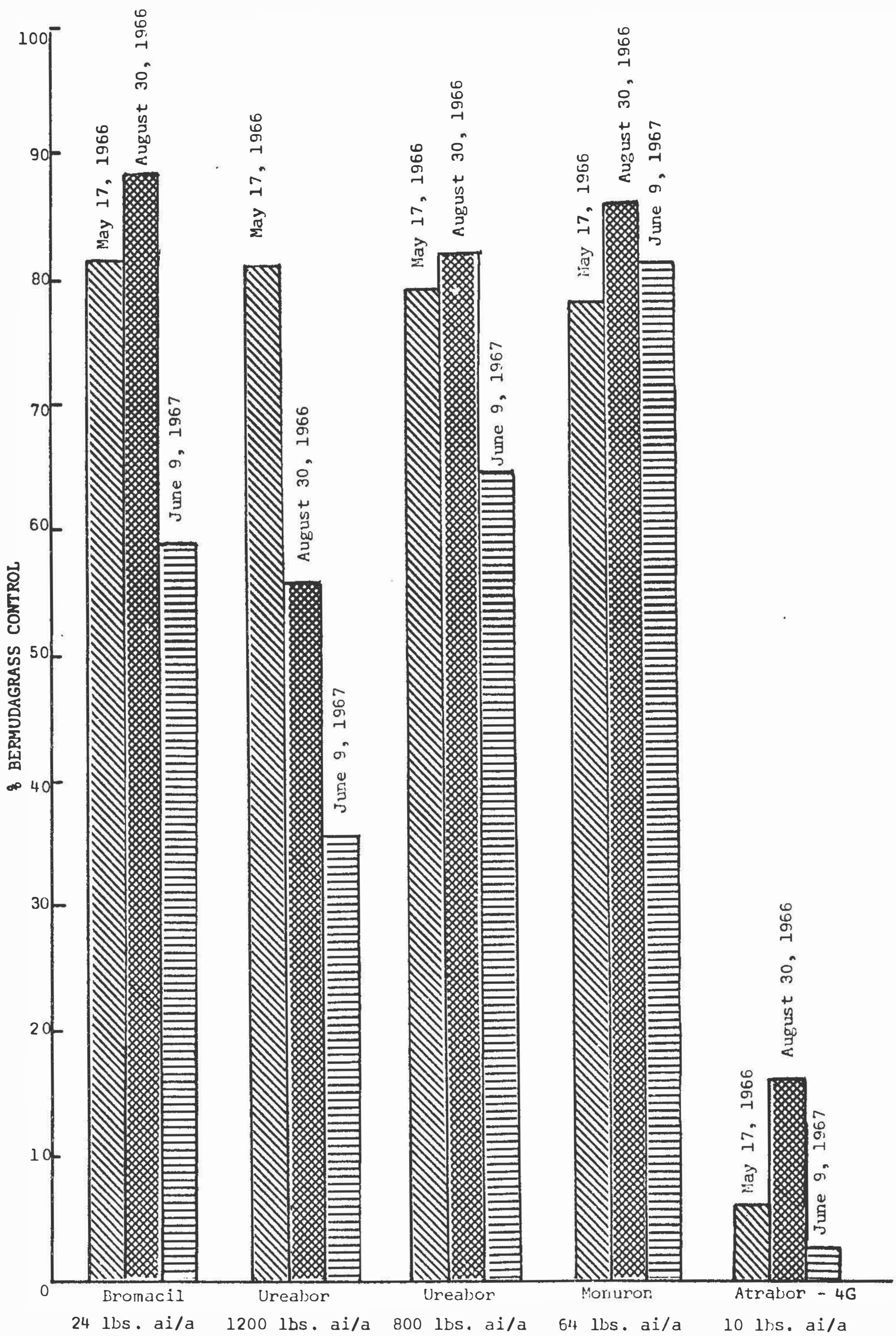



Figure **67.** The effect of various chemicals applied November 30, 1965, on the control of bermudagrass on US-177 shoulders 4.8 miles **south of** US-66 junction in central Oklahoma.

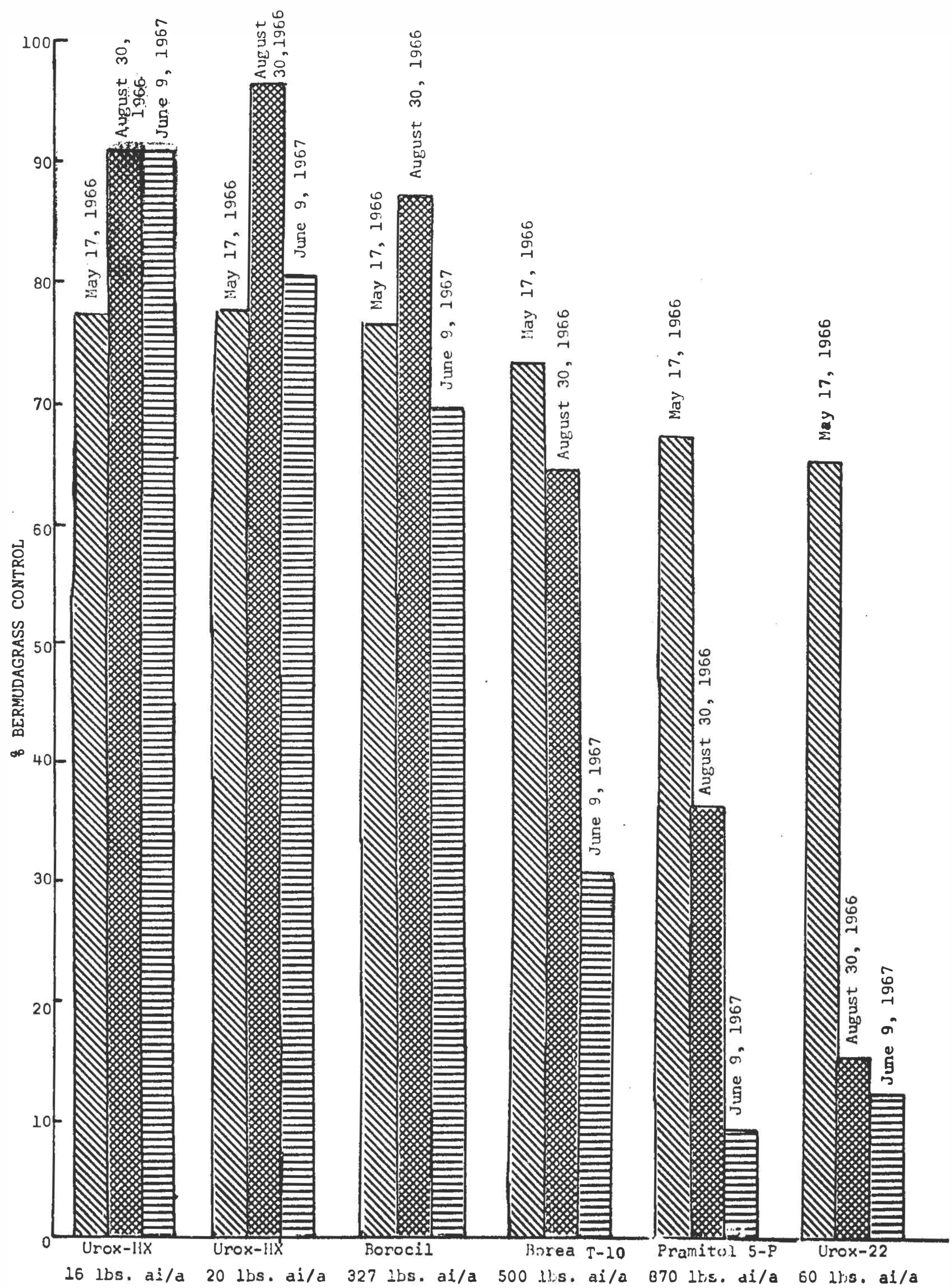



Figure 68. The effect of various chemicals applied November 30, 1965, on the control of bermudagrass on US-177 shoulders 4.8 miles south of US-66 junction in central Oklahoma.

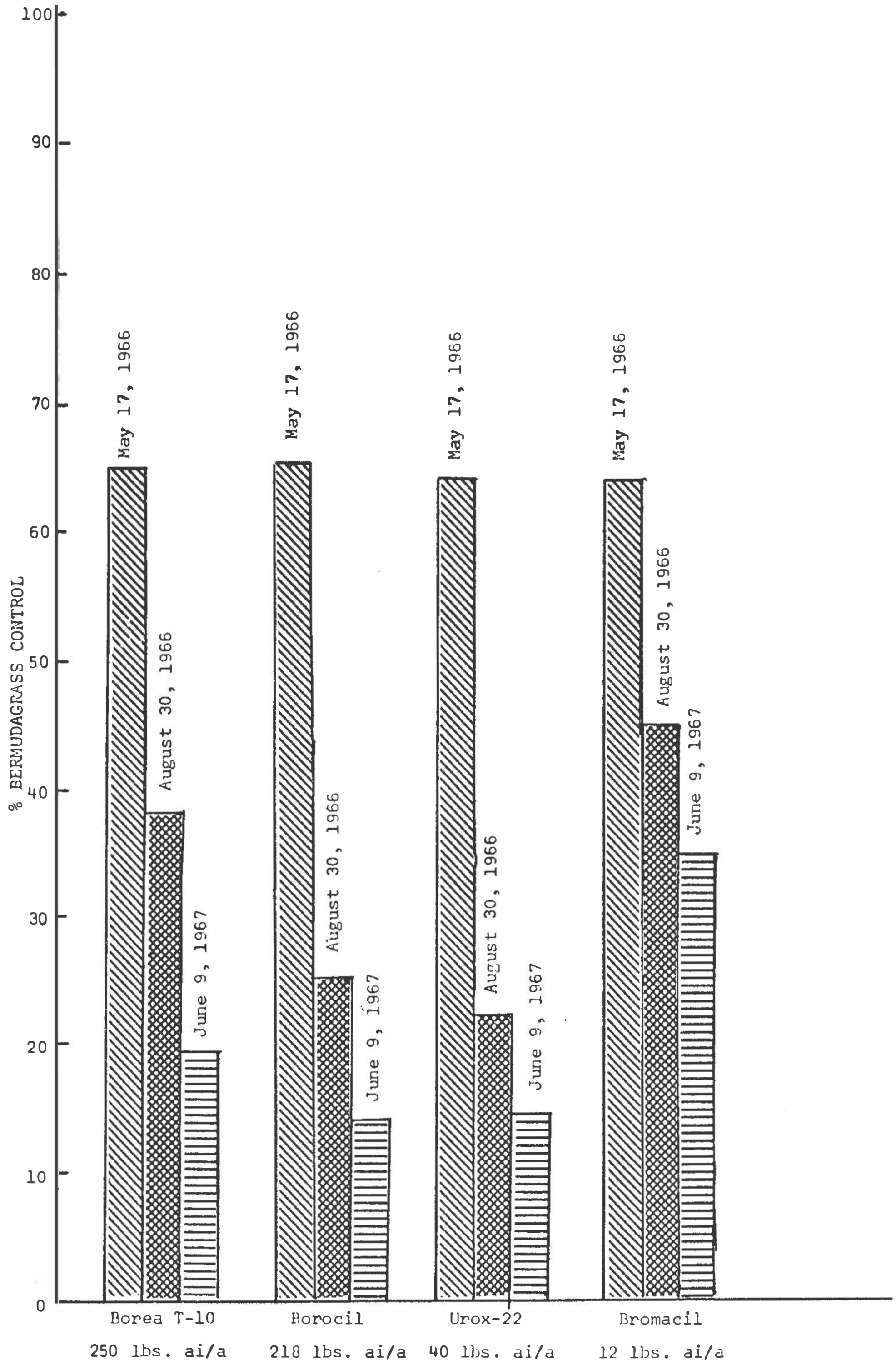



Figure 69. The effect of various chemicals applied November 30, 1965, on the control of bermudagrass on US-177 shoulders 4.8 miles south of US-66 junction in central Oklahoma.

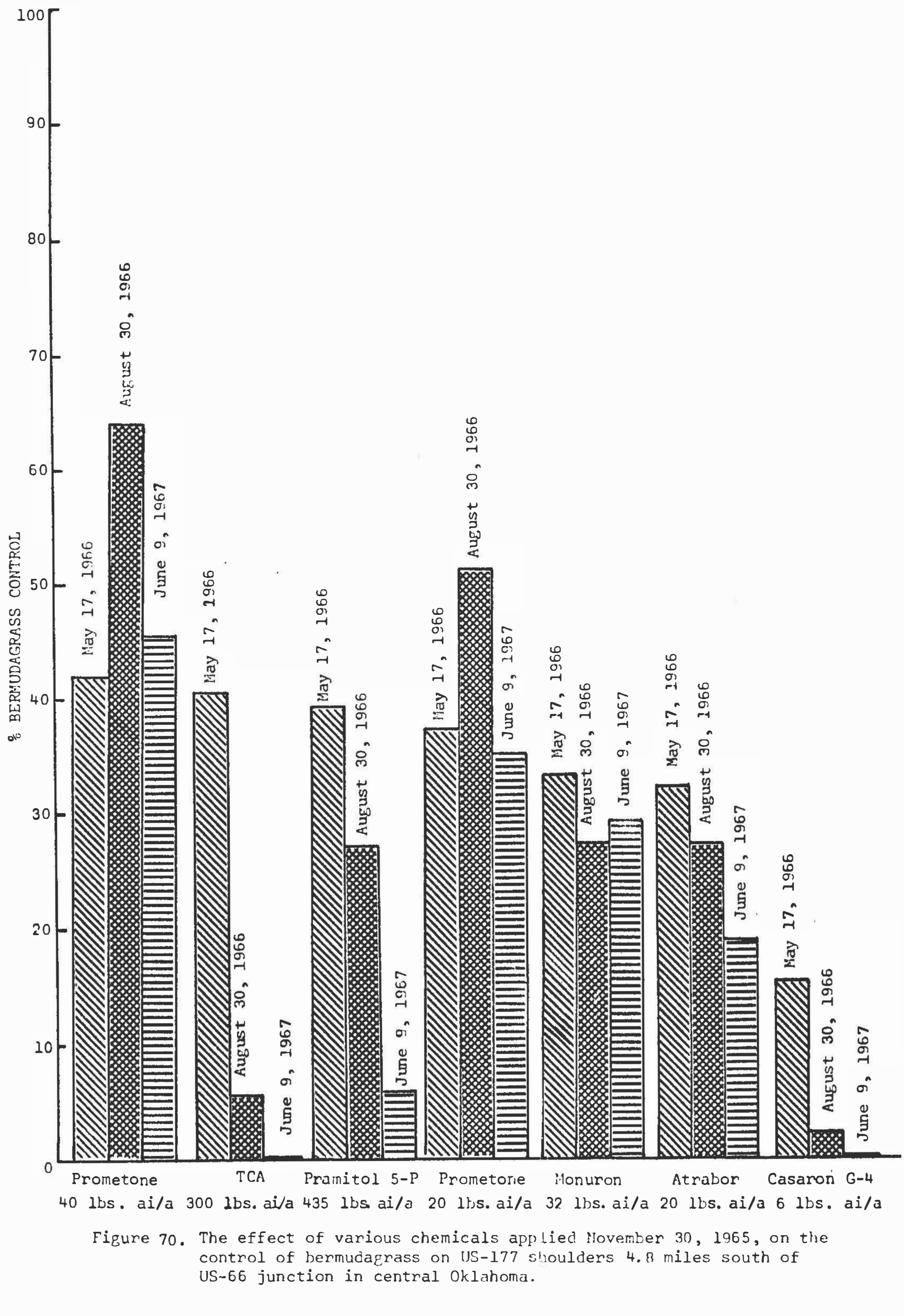



Figure 70. The effect of various chemicals applied November 30, 1965, on the control of bermudagrass on US-177 shoulders 4.8 miles south of US-66 junction in central Oklahoma.

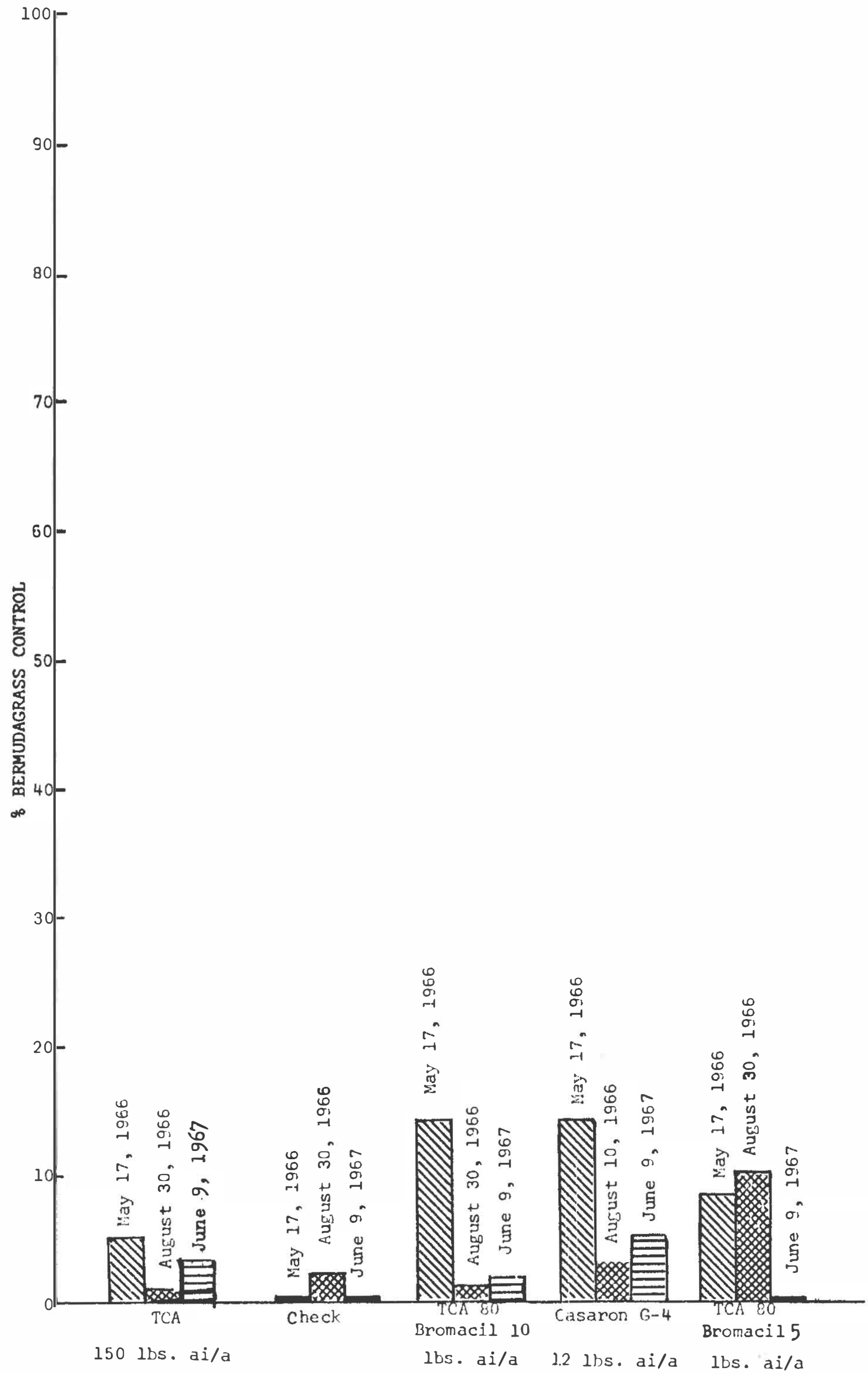



Figure 71. The effect of various chemicals applied November 30, 1965, on the control of bermudagrass on US-177 shoulders 4.8 miles south of US-66 junction in central Oklahoma.

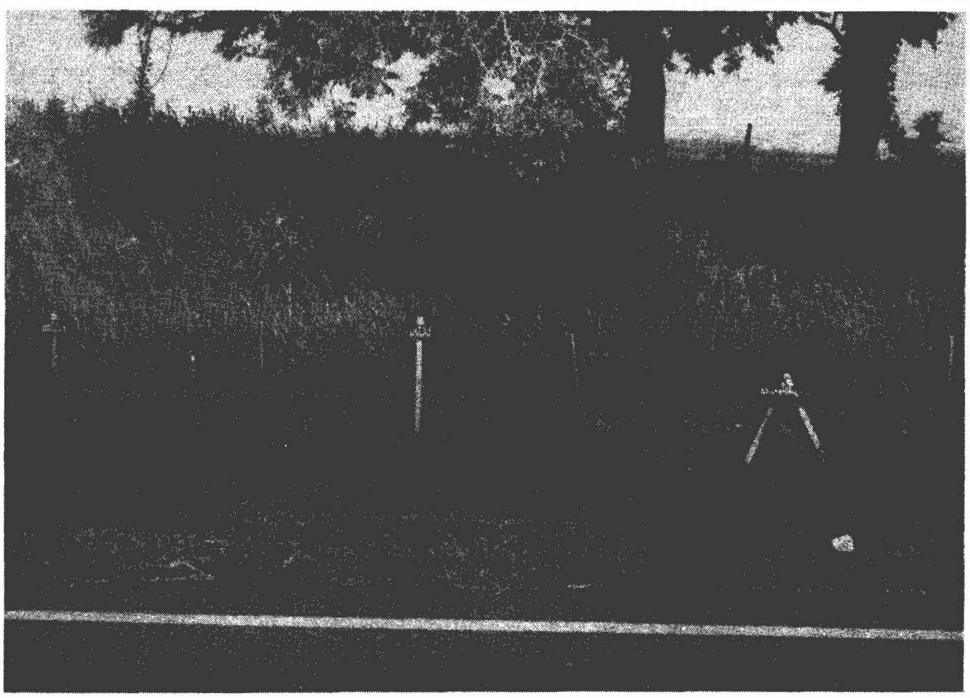
# PART III

## JOHNSONGRASS CONTROL

The abundance of johnsongrass seems to increase each year along Oklahoma highways. When allowed to grow, the plants may become so tall and dense as to restrict the drivers' view on curves, crossings, and intersections. In addition to the driving hazards that may be created by johnsongrass, the plants detract from the general beauty of the area, and serve as a source of infestation into adjacent cropland of this noxious weed. A substantial portion of the mowing costs on Oklahoma highways is expended for the intended control of johnsongrass. Even though this could be accomplished eventually by frequent mowing at low heights, the expense would be prohibitive. The rhizomes ordinarily become extensive and repeatedly send new growth above ground for a long period even when the plants are mowed.

The nature of the rhizomes (underground stems) of johnsongrass is such as to make the plant a persistant perennial. It spreads both by seeds and rhizomes. The control of johnsongrass with a herbicide would normally require either that the herbicide be translocated throughout the plant system, or that the soil be completely sterilized. Although there are several soil sterilants which will kill the rhizomes of johnsongrass, they also will kill the desirable erosion resistant bermudagrass commonly found growing in close association even though sparse.

Two experiments were initiated in August 1963 to evaluate three herbicides for the selective control of johnsongrass on the Oklahoma highway system. The herbicides Monobor-chlorate-D at the rates of 643 and 1089 lbs. a.i./acre, dalapon at 10 and 15 lb. rates,

Johnsongrass (top photo) commonly found in some areas of the highway system can be effectively controlled with selective herbicides (bottom photo) that permits the erosion resistant bermudagrass to grow up and take over (left center-lower photo).

and DSMA at 1.9 and 3.2 lbs. ai./100 gallons of water applied at a rate to completely wet the foliage were used in the experiments on I-35 south of SH-51 near Mulhall, and on SH-33 west of US-177 intersection near Coyle, both in north central Oklahoma. These were retreated four times in 1964 as deemed necessary for the most effective control. The chemicals and rates used in each experiment are shown in Table I. In 1964 two additional experiments were initiated. One that was discarded before evaluations could be made was located on SH-18 north of SH-51 intersection near Pawnee in north central Oklahoma. The other was located on US-64 west of Sand Springs in the northeast part of the state. One retreatment was made in the fall of 1964 on the experiment located near Sand Springs. None was made on the experiment located near Pawnee.

The results of these preliminary evaluations of herbicides for the selective control of johnsongrass are shown in Tables II, III, and IV. These data as reported by Sinkler[2] indicate the most effective control of johnsongrass was obtained with treatments of Monobor-chlorate, or Monobor-chlorate-D. All herbicide treatments tended to cause a substantial reduction in johnsongrass stands at the end of the treatment period. Mowing did not consistently enhance or inhibit the effectiveness of these herbicides.

TABLE I

DATES OF HERBICIDE APPLICATION AND SURFACTANTS USED IN 1963 FOR THE CONTROL OF JOHNSONGRASS ALONG STATE HIGHWAY 33 AND INTERSTATE 35

| Application Date | Herbicide | Rate/Acre Lbs. A.I. | Surfactant | Rate | Experiment |
|---|---|---|---|---|---|
| Aug. 22-25,1963 | Monobor-chlorate-D | 643 & 1089/acre | None | -- | SH-33 |
| | Dalapon | 10 & 15/acre | Dow's Dynawet | 0.5% | SH-33 |
| | DSMA | 1.9 & 3.2/100 gal. | Dow's Dynawet | 0.37% | SH-33 |
| Aug. 26-28,1963 | Same herbicides | Same rates | Same | Same | I-35 |
| October 6, 1963 | Dalapon | 1/10 gal. | Dow's Dynawet | 1% | I-35 |
| | DSMA | 1.9/100 gal. | Dow's Dynawet | 0.32% | I-35 |
| October 11, 1963 | Same | Same | Same | Same | SH-33 |
| May 16, 1964 | Dalapon | 1/10 gal. | Dow's Dynawet | 1% | SH-33 |
| | DSMA | 1.9/100 gal. | Dow's Dynawet | 0.37% | SH-33 |
| June 23, 1964 | DSMA | 1.9 & 3.2/100 gal. | Dow's Dynawet | 0.37% | I-35 |
| | Dalapon | 10 & 15/acre or spot treatment | Dow's Dynawet | 1% | I-35 |
| Aug. 6, 1964 | DSMA | 1.9 & 3.2/100 gal. | Depester Herbicide Surf. | 0.2% | SH-33 |
| | Dalapon | 10 & 15/acre or spot treatment | Depester Herbicide Surf. | 1% | SH-33 |
| | Monobor-chlorate | Spot treatment | None | -- | SH-33 |
| August 8,1964 | Same as SH-33 | Same as SH-33 | Same as SH-33 | -- | I-35 |
| Sept. 16, 1964 | DSMA | 1.9 & 3.2/100 gal. | Dow's Dynawet | 0.2% | I-35 |
| Sept. 17, 1964 | Dalapon | 10 & 15/acre | Dow's Dynawet, except plots 1, 13, & 24 with Depester Herbicide Surf. | 1% | I-35 & SH-33 |
| | Monobor-chlorate | 214 & 428/acre | None | -- | I-35 & SH-33 |
| Sept. 22, 1964 | DSMA | 1.9 & 3.2/100 gal. | Depester Herbicide Surf. | 0.2% | SH-33 |
| October 17, 1964 | DSMA | 1.9 & 3.2/100 gal. | Emulsifying Agent A | 1% | I-35 & SH-33 |
| | Dalapon | 1 & 2/10 gal. | Emulsifying Agent A | 1% | I-35 & SH-33 |

TABLE II

THE EFFECT OF THREE HERBICIDES ON THE RELATIVE STAND OF JOHNSONGRASS REPORTED IN PERCENT IN MOWED AND UNMOWED PLOTS FOLLOWING RETREATMENTS IN 1964 (TWO RETREATMENTS WITH DALAPON AND DSMA, AND ONE WITH CBM) AS SCORED ON SEPTEMBER 18, 1964 IN THE TEST ON I-35 NEAR MULHALL ROAD.

| HERBICIDE | RETREATMENT RATE LBS. A.I./ACRE AUGUST 6 & 8, 1964 | RELATIVE DENSITY IN PERCENT** | |
|---|---|---|---|
| | | Mowed | Unmowed |
| Check | -- | 100 | 81 |
| DSMA | 1.9 lbs./acre | 75 | 58 |
| DSMA | 3.2 lbs./acre | 92 | 67 |
| Dalapon | 10 lbs./acre | 67 | 50 |
| Dalapon | 15 lbs./acre | 67 | 33 |
| CBM | Spot treatments | 62 | 69 |
| CBM | Spot treatments | 25 | 50 |

**Treatment differences are significant at the one percent level of probability.

TABLE III

THE EFFECT OF THREE HERBICIDES ON THE RELATIVE STAND OF JOHNSONGRASS REPORTED IN PERCENT IN MOWED AND UNMOWED PLOTS FOLLOWING RETREATMENTS IN 1964 (TWO RETREATMENTS WITH DALAPON AND DSMA, AND ONE WITH CBM) AS SCORED ON SEPTEMBER 22, 1964 IN THE TEST ON SH-33 NEAR COYLE.

| HERBICIDE | RETREATMENT RATE AUGUST 6, 1964 LBS. A.I./ACRE | RELATIVE DENSITY IN PERCENT** | |
|---|---|---|---|
| | | MOWED | UNMOWED |
| Check | -- | 20* | 43 |
| DSMA | 1.9 lbs./100 gal. | 22 | 30 |
| DSMA | 3.2 lbs./100 gal. | 13 | 33 |
| Dalapon | 10 bls./acre or spot | 20 | 9 |
| Dalapon | 15 lbs./acre or spot | 12 | 22 |
| CBM | Spot treatment | 10 | 1 |
| CBM | Spot treatment | 8 | 4 |

* Only two plots, one of which was damaged in 1963.

** The treatment differences are significant at the one percent level of probability.

TABLE IV

THE EFFECT OF FOUR HERBICIDES ON THE RELATIVE STAND OF JOHNSONGRASS REPORTED IN PERCENT IN MOWED AND UNMOWED PLOTS ON OCTOBER 15, 1964, FOLLOWING ONE RETREATMENT WITH DALAPON, DSMA AND CMA ON OCTOBER 7, 1964, IN THE TEST ON US-64 NEAR SAND SPRINGS.

| HERBICIDE | INITIAL RATE LBS. A.I./ACRE | RELATIVE DENSITY IN PERCENT | |
|---|---|---|---|
| | | MOWED | UNMOWED |
| Check | -- | 100 | 93 |
| DSMA | 1.9 lbs/100 gal. | 108 | 6 |
| DSMA | 3.2 lbs/100 gal. | 88 | 7 |
| Dalapon | 10 lbs/acre | 4 | 2 |
| Dalapon | 15 lbs/acre | 1 | 0 |
| CBM | 643 lbs/acre | 5 | 1 |
| CBM | 1089 lbs/acre | 3 | 0 |
| CMA | 1.5 lbs/acre | 100 | 10 |
| CBM | 2.5 lbs/acre* | 100 | 4 |

* There are only two replications.

In June 1965 three additional experiments were initiated to further evaluate these and other chemicals for the selective control of johnsongrass. One was located in central Oklahoma on US-177 near Meeker, another near Fort Gibson on SH-80 in eastern Oklahoma, and one on US-64 near Alva in northwest Oklahoma. Two similar investigations were begun in August 1965, one in southeast Oklahoma near Ada on SH-3, and the other in south central Oklahoma on US-270 near Texoma. In June 1966 an experiment was initiated on SH-51 west of Stillwater to evaluate combinations of Monobor-chlorate and bromacil as possible materials for selective, long-lasting control of johnsongrass while permitting the erosion-resistant bermudagrass to survive. The chemicals used and dates of application since 1965 at each location are shown in Table V.

The results of these evaluations of chemicals for the selective control of johnsongrass indicate that many of the herbicide treatments used, such as DSMA, MSMA, dalapon, Monobor-chlorate, and the bromacil-Monobor-chlorate combination produced significant control of johnsongrass, but when considered on the basis of toxicity to the bermudagrass, it was concluded from these data that the organic arsonate herbicides DSMA and MSMA are best suited for the selective control of johnsongrass on Oklahoma highways. The effectiveness of these materials is shown in Table VI. These materials caused only a brief yellowing of the bermudagrass that soon disappeared as new growth was produced.[4] The herbicides DSMA plus 1% surfactant, applied at the rate of 2.5 lbs a.i./acre, or MSMA at 3 lbs. a.i./acre, each applied two or three times per year, will produce 90% or more

[4] Schneider, Ri~hard John. 1968. The Evaluation of Various Herbicides for the Selective Control of Johnsongrass (Sorghum halepense L.) on Oklahoma Highways. Unpublished M.S. Thesis. Oklahoma State University.

TABLE V

HERBICIDES AND RATES USED AT TEN LOCATIONS SINCE 1965

| Herbicide | Rates lbs. a.i. | Location* | Years Applied 1967 | 1966 | 1965 |
|---|---|---|---|---|---|
| Bromacil & MBC | 12 & 960/A | Alva | | * | * |
| MBC | 500 & 1000/A | Fort Gibson | * | * | * |
| DSMA | 2.5 & 5.0/A | Meeker | * | * | * |
| Dalapon | 10 & 15/A | | | | |
| CMA | 1.5 & 2.5/A | | | | |
| Diuron | 2.0 & 4.0/A | | | | |
| Prometone 25E | 40/A | Ada | * | * | |
| Dalapon & TCA | 12.5/A | Texoma | * | * | |
| Dalapon | 7.5/A | | | | |
| DSMA | 2.5 & 5.0/A | | | | |
| MSMA | 2 & 3/A | | | | |
| Bromacil & DSMA | 3 & 5/A | | | | |
| Bromacil & MSMA | 3 & 3/A | | | | |
| Diuron & DSMA | 3 & 5/A | | | | |
| Diuron & MSMA | 3 & 3/A | | | | |
| Bromacil & MBC | 0 & 250/A | Stillwater | | * | |
| Bromacil & MBC | 2 & 250/A | | | | |
| Bromacil & MBC | 4 & 250/A | | | | |
| Bromacil & MBC | 6 & 250/A | | | | |
| Bromacil & MBC | 8 & 250/A | | | | |
| Bromacil & MBC | 0 & 500/A | | | | |
| Bromacil & MBC | 2 & 500/A | | | | |
| Bromacil & MBC | 4 & 500/A | | | | |
| Bromacil & MBC | 6 & 500/A | | | | |
| Bromacil & MBC | 8 & 500/A | | | | |
| DSMA | 3 & 5/100 gal. | Mulhall | | | * |
| Dalapon | 10 & 15/A | Perkins | | | * |
| MBC | 1.5 & 2.5/100 sq.ft. | | | | |
| CMA | 1.5 & 2.5/A | Pawnee | | * | * |
| DSMA | 3 & 5/100 gal. | Sand Springs | | | * |
| Dalapon | 10 & 15/A | | | | |
| MBC | 1.5 & 2.5/100 sq. ft. | | | | |

* All herbicides in each group were applied at each location in the years shown.

TABLE VI

THE PERCENT CONTROL OF JOHNSONGRASS PRODUCED BY THE TWO RATES OF DSMA FOR ONE OR MORE YEARS AT NINE LOCATIONS

| Location | Rate a.i. | Mowed | | | Unmowed | | |
|---|---|---|---|---|---|---|---|
| | | 1967 | 1966 | 1965 | 1967 | 1966 | 1965 |
| Ada | 2.5/A | 92 | | | 65 | | |
| | 5.0/A | 98 | | | 94 | | |
| Alva | 2.5/A | | 70 | 78 | | 82 | 86 |
| | 5.0/A | | 93 | 87 | | 62 | 85 |
| Fort Gibson | 2.5/A | 93 | 68 | 89 | 99 | 90 | 79 |
| | 5.0/A | 99 | 92 | 85 | 99 | 94 | 76 |
| Mulhall | 3/100 gal. | | 55 | 56 | | 16 | 63 |
| | 5/100 gal. | | 52 | 78 | | 36 | 73 |
| Meeker | 2.5/A | 95 | 97 | 93 | 88 | 98 | 77 |
| | 5.0/A | 90 | 99 | 91 | 90 | 98 | 83 |
| Sand Springs | 3/100 gal. | | 49 | 54 | | 13 | 55 |
| | 5/100 gal. | | 41 | 44 | | 56 | 59 |
| Pawnee | 2.5/A | | 82 | 88 | | 88 | 86 |
| | 5.0/A | | 91 | 74 | | 88 | 77 |
| Perkins | 3/100 gal. | | 55 | 53 | | 52 | 41 |
| | 5/100 gal. | | 64 | 81 | | 53 | 70 |
| Texoma | 2.5/A | 72 | 88 | | 57 | 53 | |
| | 5.0/A | 93 | 93 | | 89 | 81 | |

control of the existing johnsongrass plants. The plants that appear the year or more after the area was treated are primarily from seed and will require repeated applications of the herbicide as before for control. Bermudagrass that was present even though sparse under the johnsongrass cover and in adjacent areas began to flourish soon after the johnsongrass foliage had been removed. The most effective control of johnsongrass will be obtained when the plants are treated, when 12 to 18 inches tall and actively growing, and when the sun is shining and the temperature is 80$^{\circ}$ or higher.

## PUBLICATIONS

1. Sinkler, Max D., Wayne W. Huffine and Paul W. Santelmann. 1965. Evaluation of Four Herbicides for the Selective Control of Johnsongrass (*Sorghum halepense*) on Oklahoma Highways. Proc. SWC Abstracts. p. 417.

2. Roach, Gary W., and Wayne W. Huffine. 1967. Herbicide Evaluation for the Selective Control of Sandbur in Bermudagrass Turf. Amer. Soc. Agron. Abstracts p. 57.

## FILM

HIGHWAY MAINTENANCE. Description of maintenance problems created by mowing, and suggested means of selective weed control and soil sterilization based upon research findings. Methods are presented for herbicide applications and the calibration of equipment. (25 minutes on sound. Black & White. 16 mm.).

# APPENDIX

Some Chemicals Included in the Weed Control Experiments

| Herbicide | Chemical, Form, and Concentration |
|---|---|
| Urox | 3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate |
| Urox HX | Bromacil (5-bromo-3 sec-butyl-6-methyluracil) granular 4% |
| Urox-22 | (Same as urox)<br>granular 22% |
| Tordon | 4-amino-3,5,6-trichloropicolinic acid<br>liquid 2 lbs. per gallon |
| Betasan 4E | S-(0,0-diisopropyl phosphorodithioate) of N-(2-mercaptoethyl) benzenesulfonamide<br>liquid 4 lbs. per gallon |
| Betasan | (Same as Betasan 4E)<br>granular |
| Banvel-D | 2-methoxy-3,6-dichlorobenzoic aicd<br>liquid 4 lbs. per gallon |
| Chlorea | Sodium chlorate 40%<br>Sodium metaborate 51%<br>Monuron 2.4%<br>granular 93.4% |
| Prometone | 2-methoxy-4,6-bis-(isopropylamino)-S-triazine<br>liquid 2 lbs. per gallon |
| Dacthal | dimethyl 2,3,5,6,-tetrachloroterephthalate<br>wettable powder 75% |
| Atrabor 8p | atrazine<br>granular |
| Fenac | 2,3,6-trichlorophenylacetic acid<br>liquid 2 lbs. per gallon |
| TCA | trichloroacetic acid<br>soluble powder to be applied with water<br>Inhibited 91% |
| Simazine | 2-chloro-4,6-bis (ethylamino)-S-triazine<br>wettable powder 80% |
| Atrazine | 2-chloro-4-ethylamino-6-isopropylamino-S-triazine<br>wettable powder 80% |

| | |
|---|---|
| Monuron | 3-(4-chlorophenyl)-1,1-dimethylurea<br>wettable powder 80% |
| Diuron | 3-(3,4-dichlorophenyl)-1,1-dimethylurea<br>wettable powder 80% |
| Dalapon | 2,2-dichloropropionic acid<br>wettable powder 85% |
| Casoron | 2,6-dichlorobenzonitrile<br>granular |
| MSMA | Monosodium acid methanearsonate<br>liquid 2 lbs. per gallon |
| MBC | Sodium metaborate 68%<br>Sodium chlorate 30%<br>(Boron trioxide 23%) |
| Ureabor | Disodium tetraborate pentahydrate 63.2%<br>Disodium tetraborate decahydrate 30.0%<br>(Boron trioxide 41.4%)<br>Monuron 2% |
| Borocil | Disodium tetraborate pentahydrate 71.2%<br>Disodium tetraborate pentahydrate 22.8%<br>Bromacil 4.0%<br>granular |
| Borea T-10 | Sodium metaborate 50%<br>Monuron 8%<br>granular |
| AMA | Ammonium methanearsonate<br>liquid 1.4 lbs. per gallon |
| DSMA | Disodium methanearsonate<br>Wettable powder 63% |
| 2,4D | Dimethylamine salt of 2,4-dichloroacetic acid<br>liquid 4 lbs. per gallon |
| 2,4,5T | Triethylamine salt of 2,4,5-trichloroacetic acid<br>liquid 4 lbs. per gallon |

# APPENDIX

## PROPOSED
## MOWING SCHEDULE
## FOR
## MECHANICAL WEED CONTROL

The flowering dates for many common weeds along Oklahoma Highways are in the months of May to September. Weed control solely by mechanical means perhaps would be a questionable practice from the practical and economical standpoint, but when judiciously used could compliment other weed control practices. It is suggested that 2 or 3 mowings a summer be used where weed control is to be done in part by mechanical means.

Since the majority of the plants listed will flower in 2 or more of the months of June, July and August it is suggested that mowing of the highway rights-of-way be scheduled for at least 2 and preferably all 3 months to clip off the flowers before seed can be produced. This practice along with other maintenance operations such as periodic fertilization to stimulate growth of the desired grass and chemical weed control should produce a more weed-free roadside area within a short period of time. It must be remembered that weeds are not the cause of poor turf but are the result of!! All maintenance practices for good turf must be employed at the same time. MOWING ONCE IN EACH OF THE MONTHS OF JUNE AND JULY AND AUGUST IF POSSIBLE WILL PREVENT MOST SEED-SET AND IN TIME WILL LEAD TO A PRACTICALLY WEED-FREE ROADSIDE.

PROPOSED MOWING SCHEDULE FOR THE CONTROL OF SOME WEEDS FOUND ON OKLAHOMA HIGHWAYS

| Common Names<br>Scientific Names | Duration | Mowing Dates* | | | | | | Method of<br>Propagation | Division<br>Infested |
|---|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | August | September | | |
| Dogbane<br>Apocynum cannabimum | perennial | | | X | X | X | X | Seeds, roots, or rhizomes | all |
| Stiff Goldenrod<br>Solidago rigida | perennial | | | | X | X | X | Seeds | all |
| Common Ragweed<br>Ambrosia elatior | annual | | | | X | X | X | Seeds | all |
| Giant Ragweed<br>Ambrosia trifida | annual | | | | X | X | X | Seeds | all |
| Ironweed<br>Vernonia baldwinii | perennial | | | | X | X | X | Seeds | all |
| Tall Ironweed<br>Vernonia altissima | perennial | | | | X | X | X | Seeds | all |
| Rough Buttonweed<br>Diodia teres | annual | | | | X | X | X | Seeds | all |
| Velvetleaf<br>Abutilon theophrasti | annual | | | | X | X | X | Seeds | all |
| Flower-of-the-Hour<br>Hibiscus trionum | annual | | | | X | X | X | Seeds | all |
| Russian Thistle<br>Salsola kali | annual | | | | X | X | X | Seeds | 3,4,5,6,7 |
| Cocklebur<br>Xanthium pennsylvanicum | annual | | | | X | X | X | Seeds | all |
| Prickly Lettuce<br>Lactuca scarriola | annual or winter annual | | | | X | X | X | Seeds | all |
| Woolly Plantain<br>Plantago purshii | annual | X | X | X | | | | Seeds | all |

*These correspond essentially with flowering dates

| Common Names<br>Scientific Names | Duration | Mowing Dates*<br>April | <br>May | <br>June | <br>July | <br>August | <br>September | Propagation | Division Infested |
|---|---|---|---|---|---|---|---|---|---|
| Horsenettle<br>Solanum carolinense | perennial | | X | X | X | X | X | Seeds | all |
| Prickly Pear<br>Opuntia species | perennial | | X | X | X | | | Seeds &<br>Stems | all |
| Fleabane or Daisy Fleabane<br>Erigeron strigosus | annual or biennial<br>winter annual | X | X | X | X | | | Seeds | all |
| Buckhorn Plantain<br>Plantago lanceolata | perennial | | X | X | X | X | X | Seeds | 8 |
| Ground Cherry<br>Phsalis Heterophylla | perennial | | X | X | X | X | | Seeds | all |
| Silverleaf Nightshade<br>Solanum elaeagnifolium | perennial | | X | X | X | X | | Seeds | all |
| Buffalo Bur<br>Solanum rostratum | annual | | | X | X | X | | Seeds | all |
| Peppergrass<br>Lepidium virginianum | annual or<br>winter annual | X | X | X | X | | | Seeds | all |
| Wild Pumpkin or Wild Gourd<br>Cucurbita foetidissima | perennial | | X | X | X | X | X | | 4,5,6,7 |
| Prickly Sida<br>Sida spinosa | annual | | X | X | X | X | X | Seeds | 1,2,3,4,8 |
| Carolina Cranesbill<br>Geranium carolinianum | annual or | X | X | | | | | Seeds | all |
| Evening Primrose<br>Cenothera spp. | perennial | X | X | | | | | Seeds | all |
| Curlycup Gumweed<br>Grindelia squarrosa | biennial | | X | X | | | | Seeds | all |
| Western Yarrow<br>Achillea lanulosa | perennial | | | X | X | X | X | Seeds & under-<br>ground root-<br>stocks | all |

| Common Name<br>Scientific Name | Duration | Mowing Dates* April | May | June | July | August | September | Method of Propagation | Division Infested |
|---|---|---|---|---|---|---|---|---|---|
| Western Ragweed<br>Ambrosia psilostachya | perennial | | | X | X | X | X | Seeds | all |
| Snow-on-the-Mountain<br>Euphorbia marginata | annual | | | | X | X | X | Seeds | all |
| Blackeyed Susan<br>Rudbeckia hirta | perennial | | X | X | X | X | | Seeds | all |
| Russian Knapweed<br>Centaurea repens | perennial | | | X | X | X | | Seeds &<br>Roots | 6 |
| Curled Dock<br>Rumex crispus | perennial | | | X | X | X | X | Seeds | all |
| Sand sunflower or Plains sunflower<br>Helianthus petiolaris | annual | | | X | X | X | X | Seeds | all |
| Mare's Tail or Horseweed<br>Erigeron canadensis | annual | | | X | X | X | X | Seeds | all |
| Prickly Poppy<br>Argemons intermedia | annual | | X | X | X | X | X | Seeds | all |
| Wild Blue Lettuce or<br>Perennial Lettuce<br>Lactuca pulchella | perennial | | | X | X | X | | Seeds &<br>creeping roots | 6 |
| Rugel or Blackseed Plantago<br>Plantage rugelii | perennial | | | X | X | X | X | Seeds | 1,2,3,4,8 |
| Stinging Nettle<br>Vroica procera | perennial | | | X | X | X | X | Seeds or under-<br>ground rootstock | 1,2,3,4,8 |
| Rough Pigweed<br>Amaranthus retroflexus | annual | | | X | X | X | X | Seeds | all |
| Lamb's Quarters<br>Chenopodium album | annual | | X | X | X | X | X | Seeds | all |
| Bracted Plantain<br>Plantago aristata | annual or<br>winter annual | | | X | X | X | X | Seeds | 1,2,3,4,7,8 |

| Common Name<br>Scientific Name | Duration | April | May | June | July | August | September | Method of Propagation | Division Infested |
|---|---|---|---|---|---|---|---|---|---|
| | | Mowing Dates* | | | | | | | |
| Mullen<br>Verbascum thapsus | biennial | | | X | X | X | X | Seeds | 1 & 8 |
| Prairie Rose<br>Rosa suffulta | perennial | | | X | X | X | | Seeds & under-ground roots | 8 |
| Woolly Croton<br>Croton capitatus | annual | | | | X | X | X | Seeds | all |
| Field Thistle or Tall Thistle<br>Cirsium altissimum | perennial | | | X | X | X | X | Seeds | 1,2,4,5,6 |
| Kochia, Burning Bush<br>or Mexican Fireweed<br>Kochia scoparis | annual | | | X | X | X | X | Seeds | 5,6,4,8 |
| Salt Bush or Orache<br>Atriples patula | annual | | | | X | X | | Seeds | 4,5,6 |
| Spiny Pigweed<br>Amaranthus spinosus | annual | | | | X | X | X | Seeds | all |
| Pennsylvania Smartweed<br>Polygonum pennsylvanicum | annual | | | X | X | X | X | Seeds | all |
| Wild Sunflower<br>Helianthus annus | annual | | | X | X | X | X | Seeds | all |
| Frect Knotweed<br>Polygonum erectum | annual | | | X | X | X | X | Seeds | all |
| Yellow Sweet Clover<br>Melilotus officinalis | biennial | | X | X | X | X | | Seed | all |
| White Sweet Clover<br>Melilotus alba | biennial | | X | X | X | X | | Seed | all |
| Jerusalem Artichoke<br>Helianthus tuberosus | perennial | | | | | X | X | Seeds, rhizomes & tuber | 1,2,3,4,8 |
| Thoroughwort<br>Eupatorium altissimum | perennial | | | | | X | X | Seeds | 1,2,3,4,<br>7,8 |