CONTROLLING VEGETATION IN ASPHALT PAVEMENTS

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PREFACE

A weed is a plant growing where it is not wanted. Highway engineers have specifications for using various plants along the roadways, and bermudagrass is a plant which has great utility in erosion control on the right of way and its slopes. Bermudagrass also has long been considered a weed when it grows in asphalt pavements. This problem was intensified with the adoption and widespread use of paved shoulders. In most cases the existing base material was used to support the shoulder pavement. Plant remnants within this base material grew, penetrated the asphalt surface, and caused an early deterioration of the asphalt pavement.

Highway engineers are establishing and using progressively higher standards of maintenance. Combined with the higher maintenance requirements is the continually increasing cost of labor. Chemicals have been developed and used for controlling weedy plants in agriculture, industrial installations, and many other situations. It seems reasonable that a knowledge of these herbicides, together with the necessary research background will permit the highway engineer to increase his maintenance efficiency.

The research reported here was supported initially by the Texas Highway Department, with the U. S. Bureau of Public Roads joining in the cooperative effort beginning September 1, 1962. The authors are indebted to the Texas Highway Department, especially the Maintenance Division and the Landscape Section, for support and valuable suggestions. The field work of the research would have been impossible to conduct without the active participation of several cooperating districts.

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Controlling Vegetation in Asphalt Pavements

Highway engineers have many problems with vegetation, whether it grows inside or outside the travelway. Unwanted plants hasten the break-up of asphalt pavement, interfere with sight distance, and require tedious and costly hand mowing under guard rails and around structures. At the same time, engineers use a functional cover of desirable vegetation on the unpaved portion of the roadway to stabilize the soil on faces of cut and fill slopes and in roadside ditches.

Specifications have been developed in agricultural research for the control of a number of weeds by using herbicides. A cooperative research project was activated to adapt this agricultural technology to highway requirements and thus aid in enabling engineers to meet the increasingly higher standards of construction and maintenance required in the evergrowing system of transportation arteries (Figure 1). The cooperating agencies in the research were the Texas Transportation Institute (with the Texas Agricultural Experiment Station), the Texas Highway Department, and the Bureau of Public Roads.

The work was initiated September 1, 1959. The objectives were to:

1. Adapt recommended chemical methods of plant control to highway requirements, and investigate other plant control techniques which might apply to certain highway vegetation control problems.

2. Develop techniques for establishing a desirable vegetation on cuts and fills, drainage channels and other areas having a soil erosion hazard.

Work was accomplished under each of these objectives, but this report will deal only with the recommendations developed for chemical methods of plant control. This project has been continued, but major emphasis under the extended research is on the establishment of vegetation.

THE PROBLEM

The problem vegetation requiring control grows over the entire roadway, but this report will deal only with the plants infesting asphalt pavement. Vegetation is a problem in asphalt pavement only when the traffic volume is low. The most important and widespread problem plant in pavements is bermudagrass, *Cynodon dactylon* (L.), Pers., but other grasses and herbaceous weeds may occur as scattered plants or become locally abundant (Figure 2).

Asphalt pavements such as those on farm-to-market roads and on the shoulders of primary highways often become infested with bermudagrass and other plants. Medians separating travel lanes and islands at highway intersections often are surfaced with asphalt. When these asphalt surfaces become infested with weeds, the plants usually are pulled by hand.

The continual extension of the amount of pavement, higher standards of maintenance, increasing labor costs, and more numerous structures placed within the roadway place a premium on hand trimming operations done concurrently with mowing. Also, pavements costing from $3,000 to $20,000 per mile and having a life expectancy of 20 years can be damaged so greatly by invading plants that replacement is necessary as soon as three years after paving. Judicious use of herbicides offers promise for increasing the efficiency of highway maintenance, but the requirements are strict. Not only must the chemical be effective, but it must be safe for personnel to use and not damage adjoining property.

Plants become established in pavement: (1) from seeds or other plant parts contained in the base material underneath the asphalt, (2) from the encroachment or extension of plants rooted outside the asphalt and (3) from seeds lodging in the cover stone or in cracks or seams. The problem is twofold: (1) to prevent the emergence of plants through new pavement, and (2) to neutralize plants which have invaded a pavement. Systematic treatment will be needed to control future establishment or encroachment on pavements already in place.

REVIEW OF LITERATURE

A number of chemicals have been developed for weed control and classified as to their herbicidal action (Crafts and Robbins, 1962; Klingman, 1961). Herbicidal action ranges from selective control of weeds to general control of weeds. Selective weed control means that only certain plants are killed by a specified herbicide application; general weed control means that all plants are killed by a specified application. A soil sterilant herbicide is one which prevents the growth of any plants within the treated area. A systemic herbicide is one which is absorbed through the roots, the top, or other part of the plant and translocated within the plant to the point of killing action.

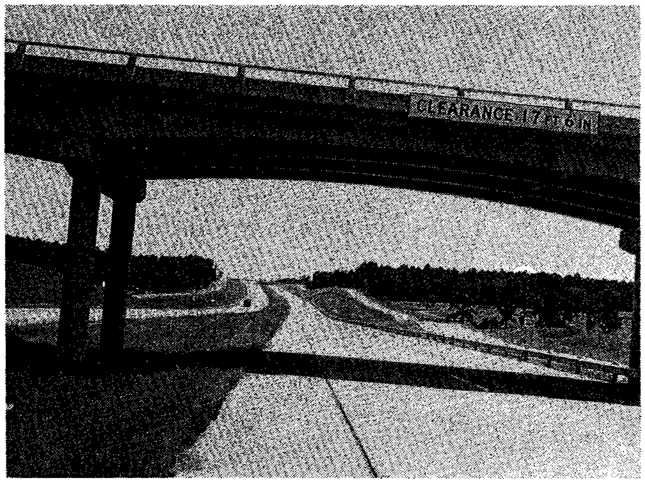


Figure 1. Roadside vegetation must be both functional and ornamental. Functionally, it delineates the travel surface, and stabilizes the soil on the unpaved portion of the roadway. Ornamentally, the esthetic qualities of green plants growing along roadsides together with the contrast offered from different kinds of plants make driving a pleasure.

Both systemic and soil sterilant herbicides are used in California (Harvey, 1953). In Connecticut soil sterilants are used under guard rails, and systemic materials are used to control other weeds and grass (Greene, 1958). In Ohio systemic herbicides have been studied for the control of both woody and herbaceous plants (Garmhausen, 1958). Soil sterilants have been used in Texas to control plant growth around sign posts and guard posts at an annual cost of 13¢ per post (Greene, *et al.*, 1959). The experiences of Greene and his coworkers was a major factor influencing the Texas Highway Department to undertake a systematic evaluation of sterilants and other herbicides for the control of plants growing in pavements.

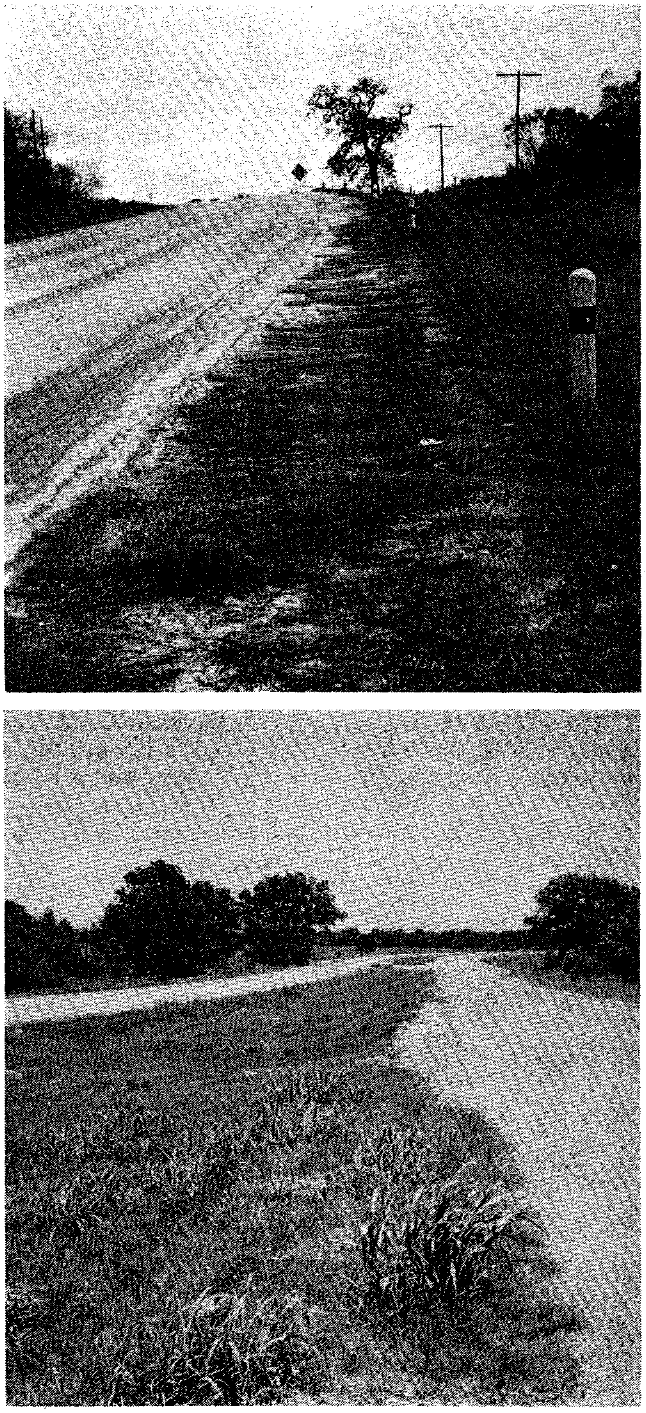


Figure 2. (Top) Bermudagrass has nearly covered this asphalt shoulder, and the shoulder will probably need to be repaved. Vegetation around each guard post must be mowed by hand. (Bottom) This shoulder is obscured intermittently by a mixture of bermudagrass and Johnsongrass.

Grasses are the major weed problem in asphalt pavements. Green, *et al.*, (1959) utilized "Borascu"[1] and "Polyborchlorate" as soil sterilants. Several reports (Friesen, 1949; McCall and Zahnley, 1949; Stamper, 1961) indicate that dalapon and TCA effectively control perennial grass. At higher rates sodium TCA will induce soil sterility for 60 to 90 days (McCall and Zahnley, 1949). Various other materials including the substituted ureas also are effective soil sterilants for controlling grassy weeds (Klingman, 1961).

The wide range of plants affected, the activities of these herbicides at relatively low rates together with the selectivity induced by the nature of the chemical itself or the manner in which it is applied requires careful selection and application of the weed killing herbicide. Precautionary statements are common in reports dealing with the use of herbicides along highways (Jennings, 1955; Garmhausen, 1958; Kress, 1955; Woodford, 1953).

PROCEDURE

Experimental applications of herbicides were made as replicated treatments to the base material just prior to surfacing (pre-paving) or to plants growing in an existing pavement (post-paving). The granular materials were broadcast mechanically (Figure 3), and the

[1]Chemicals are identified in Appendix A.

Figure 3. The distribution of granular herbicides can be done by hand or with larger equipment. During the experimental applications, air movement from passing traffic carried the granules away from the intended area of application.

liquid materials were applied through a spray bar (Figures 4 and 5). Plot width was equivalent to the width of the shoulder pavement, and length varied from 400 feet to approximately one mile.

The response of vegetation to the imposed treatment was evaluated systematically, and the reaction of each plant species was noted. Initially, the entire width of the shoulder pavement was considered as a single unit in sampling, but stratification was imposed in later sampling to assess the influence of location on the shoulder to control achieved.

RESULTS

Both pre-paving and post-paving applications of herbicides were effective in controlling bermudagrass in asphalt pavement. Control using pre-paving treatment was achieved with a single application, but a spray program involving scheduled post-paving chemical applications was needed for adequate control.

Pre-paving applications

The Texas Highway Department initiated a screening program to compare various herbicides for pre-paving use in 1959. These tests were continued and expanded under a cooperative agreement with the Texas A&M University in 1960. The results of these tests have been published (Pruett and McCully, 1960).

TABLE 1. MATERIALS USED AND APPROXIMATE COST OF PRE-SURFACE TREATMENT BASED UPON TESTS APPLIED IN 1959 AND 1960

Herbicide	Unit Price (Estimated)[1]	Rate per foot-mile[2]		Cost per foot-mile[1]
1959				
"Polyborchlorate"	$ .11	212.5	lbs.	$23.37
Sodium TCA	.35	12.5 25.	" "	4.37 8.75
Dalapon	.92	10.	"	9.20
Monuron	2.60	7.5	"	19.50
"Chlorax Liquid"	.35	20.80 31.25	gal. "	7.28 10.94
Erbon	4.99	5.	"	24.95
1960				
"Polyborchlorate"	$ .11	200.	lbs.	$22.00
Sodium TCA	.35	12.50 25.0	" "	4.37 8.75
Dalapon	.92	10.	"	9.20
MonuronTCA (Granules)	.75	12.50	"	9.37
Diuron	2.65	5.	"	13.25
Monuron	2.60	5.	"	13.00
"Chlorax Liquid"	.35	24. 32.	gal. "	8.40 11.20
"Garlon"	6.60	2.5	"	16.50
MonuronTCA (Liquid)	12.00	0.917	"	11.00

[1]These estimated retail prices were furnished by various herbicide manufacturers during the winter of 1960-1961 and may not coincide with present quotations. The extended costs per foot-mile are for the herbicide and do not include mixing and applying any material.

[2]An area 1 foot wide and 1 mile long; 8.25 foot-miles are equivalent to 1 acre.

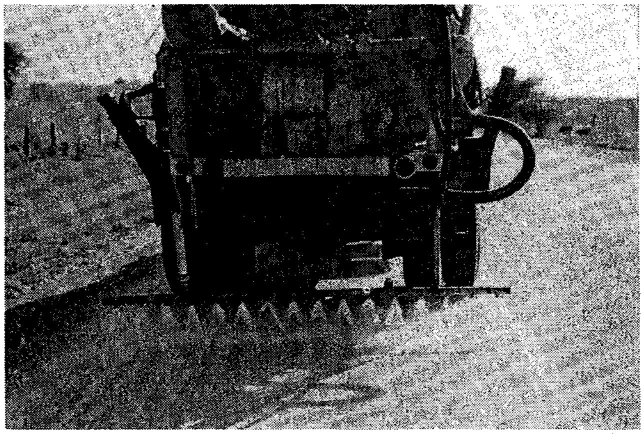


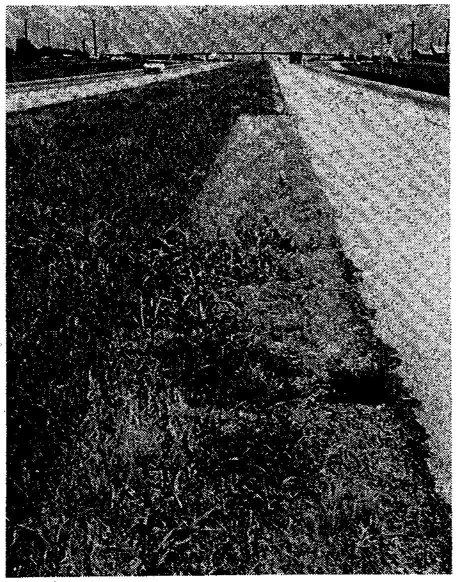
Figure 4. Pre-paving applications were made satisfactorily by pumping the herbicide mixture from a standard water truck through a boom fitted with asphalt nozzles. The material should be applied so that it covers the joint between the pavement and the shoulder.

One location near Gonzales was treated in 1959, and experimental locations were established near Lott and near Tyler in 1960. The materials listed in Table 1 were applied just ahead of the prime or seal coat. The granular material was broadcast and then watered until the blue color faded (Figure 3). The other herbicides were applied in water (Figure 4), but 5 percent (by volume) of diesel oil was used with monuronTCA to reduce foaming.

All treatments prevented the emergence of vegetation through the asphalt pavement. In the 1959 test "Chlorax Liquid," monuron, erbon, and "Polyborchlorate" from under the pavement kept some of the frontslope bare of plants, often as far as the ditchline. Monuron affected trees growing across the ditchline and beyond the top of the backslope. The same materials applied in 1960 showed some movement away from the edge of the pavement, but the largest sterile areas were beside shoulders treated with diuron and monuronTCA. The granular application of monuronTCA induced more soil sterility farther down the frontslope than did the same material applied as a liquid spray.

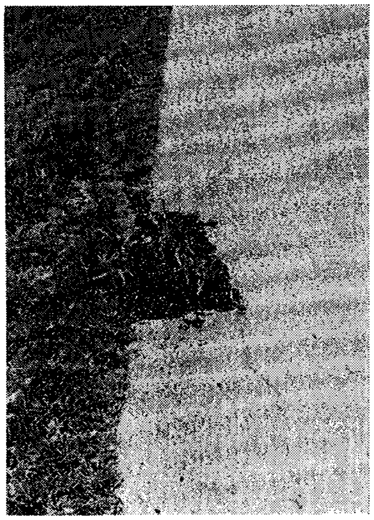
The application rates used were those specified on the labels. The lower rates of both sodium TCA and "Chlorax Liquid" appeared to be marginal, based upon the tendency for plant encroachment from the pavement edge.

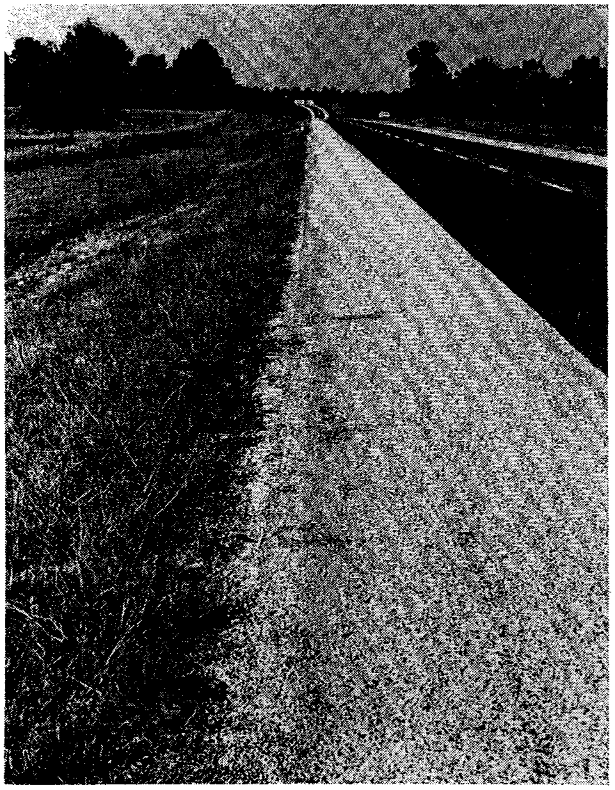
Results from these tests indicate that plant germules usually contained in base material can be neutralized by applying any of several herbicides just prior to sealing the surface preparatory to surfacing. Of the nine materials tested, only sodium TCA and dalapon failed to damage grass growing on the frontslope adjacent to the treated shoulder. However, this lack of residual action adjacent to the pavement edge probably will permit more rapid encroachment from the open soil of plants such as bermudagrass. If the engineer will accept some soil sterilization along the edge of the pavement as a deterrent to encroachment, then the borate-chlorate materials can be used. The data given in Table 1 show that "Chlorax Liquid," sodium TCA, and dalapon are nearly equivalent in cost at the recommended rates of treatment.



(Left) Sodium TCA controls bermudagrass very well, but Johnson-grass and some broadleaf plants are not so susceptible.

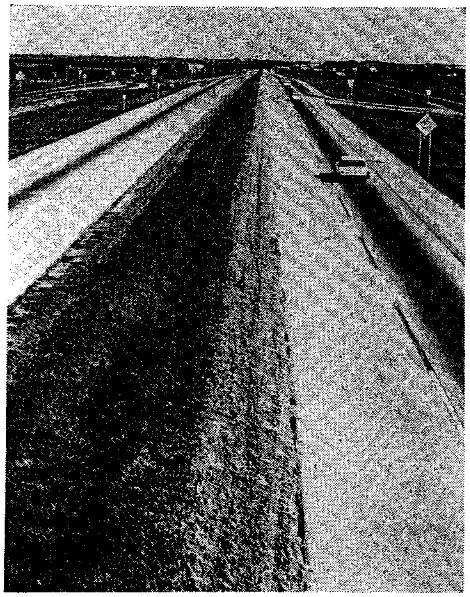
(Below) Materials which leave an unattractive ragged edge of vegetation along a pavement cannot be recommended for highway use.

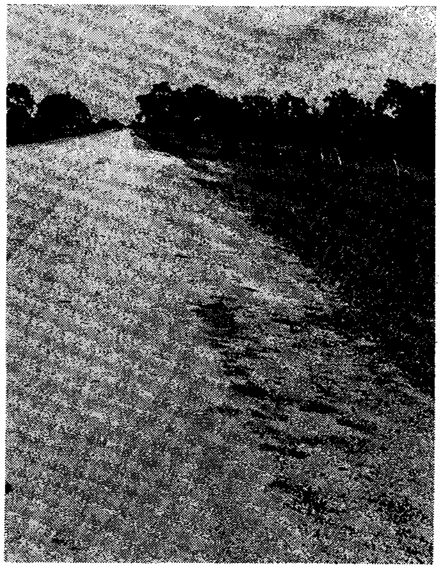


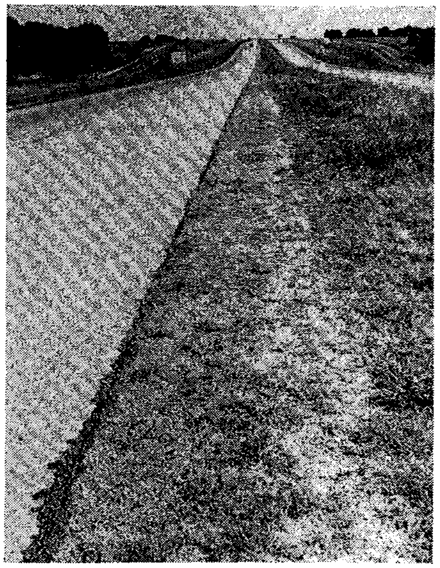


(Right) This shoulder pavement was treated pre-surface six months previously. Pre-surface treatment at the time patching is done (above) will prevent offending vegetation from growing in the patch.

(Right) The initial post-surface treatment to vegetation growing on these inside shoulders using the recommended rate of sodium TCA gave a uniform browning of the treated area.







The bermudagrass stand on a paved shoulder is thinned by a single post-surface treatment (center right). Earlier research (center left) showed that a second treatment when the remaining grass started to grow, usually about one month following the initial treatment, gave a much cleaner pavement as shown in the background than the single treatment portrayed in the foreground.

(Right) Some touchup treatment may be needed, but two post-surface applications, properly applied, usually control bermudagrass and many other plants growing in an asphalt pavement.

TABLE 2. MATERIALS AND RATES APPLIED AS POST-SURFACE TREATMENTS IN 1960

Material	Rate per foot-mile
Dalapon	1 lb. 4 lbs.
"Garlon"	0.75 gal. 1.00 gal.
2,3,6-TBA	0.75 lb. 1.50 lbs.
Sodium TCA	12.50 lbs. 25.00 lbs.
MonuronTCA	2.75 lbs. 4.125 lbs.
*Diuron (3(3,4-dichloropheny 1)1,1-dimethylurea)	6.25 lbs.
"Polyborchlorate"	200.00 lbs.

*Applied at Austin only.

Post-paving Treatments

Pre-paving treatments stressed the application of materials having soil sterilant properties, but post-paving applications seem to require herbicides which are translocated. Five materials, listed in Table 2, were applied in June 1960 to pavement shoulders near Austin, Gonzales, Lufkin, and Tyler. Diuron and "Polyborchlorate" were also applied at Austin (Figure 5).

Definite effects were registered by the treated vegetation four to six weeks following application of all materials except 2,3,6-TBA. After four months the treated vegetation showed the greatest response to sodium TCA and monuronTCA, but the best treatment at this time was sodium TCA. MonuronTCA was nearly as effective, but both oak and pine trees growing within the right-of-way showed considerable damage from this material. Bermudagrass and other plants were beginning to regrow in all treatments four months following application. "Polyborchlorate" was less effective than sodium TCA in the single comparison.

Figure 5. Post-surface applications were made using a sprayer developed by the Texas Highway Department. This spray unit utilizes a water tank as a herbicide container and incorporates a system which includes a pump, a pressure regulator, a bypass, and a boom with nozzles for distribution of the spray solution.

In 1961 dalapon, a borate-chlorate mixture ("Chlorax Liquid"), and sodium TCA were applied to shoulder pavements infested with bermudagrass at Crockett, Gonzales and Pleasanton. The test section at Pleasanton was discontinued after July when it was repaved. Dalapon was applied at rates of 3, 5, and 7 pounds per foot-mile. Each rate of dalapon was applied as 10, 15, and 20 gallons of spray per foot-mile. TCA was applied at rates of 12, 18, and 24 pounds in volumes of 40, 60, and 80 gallons per foot-mile. Liquid chlorax was used at rates of 16, 24, and 32 gallons of concentrate in volumes of 32, 48, and 64 gallons per foot-mile. Water was the diluent for each material. A wetting agent was used in the amount of three pints per 100 gallons of spray.

Applications were begun in mid-March and continued at monthly intervals through July. One-half of each plot was retreated one month following the initial treatment using the same rate and volume of spray solution. The initial plots were 600 feet in length, and width of the shoulders varied from 3 to 6 feet. Plant-growth conditions were only fair at the time of the first treatment, and became progressively drier until mid-June when general rains fell. Growing conditions were best at Crockett and worst at Pleasanton during the period in which applications were made.

The first evaluations were made at the time of the May treatment for the applications initiated in March and April. The apparent kills for all materials at all locations at the highest rates of application equaled or exceeded 75 percent. The evaluations made in June disclosed that the response to sodium TCA remained very high, but some inconsistencies developed in the plant response to the "Chlorax Liquid" and dalapon. The dalapon treatment applied in March at Pleasanton showed a rather short residual, although the apparent kills at the other two locations remained quite high. The readings in June for "Chlorax Liquid" showed a variation in response by location. The best control was found at Crockett, the least at Pleasanton, while that at Gonzales was intermediate.

The same relative plant response to the three herbicides was noted in July (Figure 6) as had been registered in June. There was relatively little control with dalapon except at Crockett where growing conditions were considerably better than at the other two locations. The sodium TCA, particularly in the retreated portion of each area, showed 95 percent or better control. The response to "Chlorax Liquid" continued to vary strongly by location. In August, observations made at Crockett and Gonzales showed an increase in the effectiveness of "Chlorax Liquid" at each location and a depression in the control achieved with sodium TCA compared with that for the previous month. Rains totaling five to nine inches fell during late June and July. When the final observations were made in October the "Chlorax Liquid" showed a greater apparent kill than TCA for each of the treatment dates at both Crockett and Gonzales except for the final treatment at Crockett. The differences were greater at Gonzales than at Crockett. Apparent kills ranged from 50 to 85 percent with two applications of

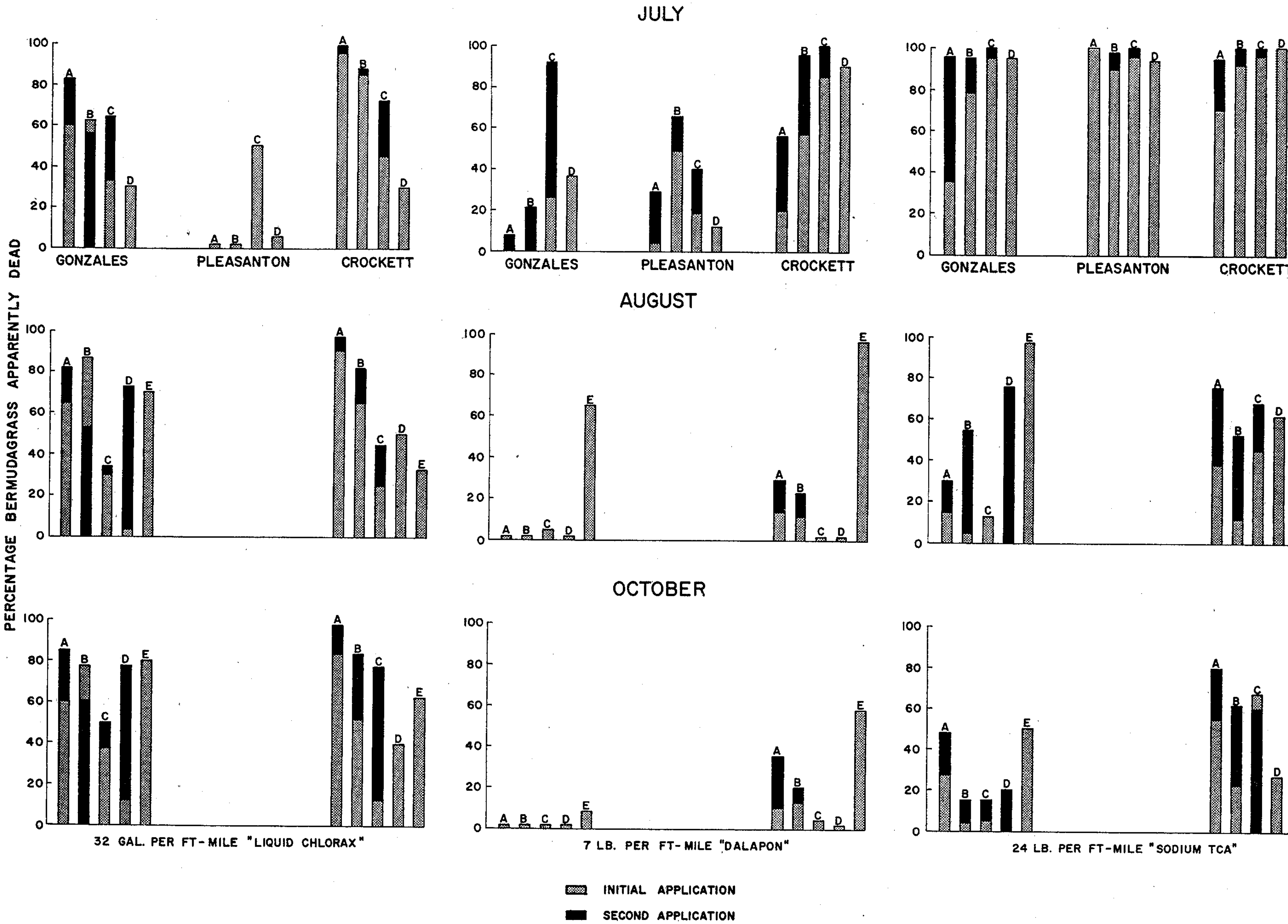


Figure 6. Percentage of apparently dead bermudagrass measured in July, August, and October, 1961, for one or two treatments of "Liquid Chlorax," of dalapon, and of sodium TCA applied initially in March (A), April (B), May (C), June (D), or July (E), 1961. Experimental locations were at Gonzales (GON), Pleasanton (PLT), and Crockett (CKT).

"Chlorax Liquid" at Gonzales, and from 62 to 97 percent at Crockett

At the conclusion of the growing season the apparent kills of bermudagrass ranged from 50 to 97 percent with two applications of 32 gallons per foot-mile of "Chlorax Liquid," and from 15 to 80 percent following two applications of 24 pounds of sodium TCA. The most effective treatment with either material at the end of the season was the one made in March. Application made soon after bermudagrass initiated growth in the spring would precede the heavy work period of maintenance sections. Live bermudagrass was present in all treated areas in March, 1962.

The results from these tests showed that a single application from any of the three materials was not sufficient for adequate control of bermudagrass. The second application of TCA or dalapon usually improved the degree of control achieved with the initial application, but the initial treatment using the "Chlorax Liquid" was as good or better in several instances than a repeated treatment. Dalapon was more demanding of good plant growth conditions as shown by the higher degree of control at Crockett than at either of the other test locations. This, combined with the relatively short residual of this chemical after application, eliminated it from further consideration. Complete control with either "Chlorax Liquid" or sodium TCA was not attained consistently within a single season. In the portions of Texas where bermudagrass is a problem, systematic treatment probably will be necessary to control encroachment of this plant onto the pavement.

Three volumes of diluent were used in applying each of the herbicides. At the volumes used there was no consistent advantage within any of the three materials. The minimum volume, especially for "Chlorax Liquid" and sodium TCA, was relatively high, so the foliage of the treated plants should have been thoroughly wetted.

The relatively consistent performance of sodium TCA at several locations, the high degree of control achieved, together with an apparent cost advantage per unit of treated area indicated that this material should be tested further during 1962. A series of standard applications were made at Beaumont, Dallas, and Gilmer to compare rates and number of applications of sodium TCA required for satisfactory control of vegetation growing in shoulder pavements. The initial application was 24 pounds per foot-mile, and subsequent treatments were applied at rates of 12, 18, or 24 pounds per foot-mile. At Beaumont and Dallas the applications were made to inside shoulders along a divided highway; at Gilmer outside shoulders along a two-lane highway were treated. The test sections at Beaumont and at Gilmer supported nearly pure stands of bermudagrass, but the shoulders at Dallas had a covering of bermudagrass together with a number of other plants. Among the associated plants at Dallas were Johnsongrass, *Sorghum halepense* (L.), Pers.; puncturevine, *Tribulus terrestris* L.; carelessweed, *Amaranthus* spp.; prostrate milkweed, *Euphorbia prostrata* Ait.; bur-clover, *Medicago* spp. as well as other miscellaneous plants.

These tests were initiated in early May, and subsequent applications were made at monthly intervals. Growing conditions remained good throughout the treatment period at both Dallas and Gilmer, but were dry at Beaumont. Because of the variety of plants growing in the shoulders at Dallas four applications were made, but two treatments effectively controlled the bermudagrass at Gilmer. Two complete applications were made at Beaumont, followed by a directed spray on the seam between the road and shoulder pavements. The shoulders at Beaumont and Gilmer were essentially free of live bermudagrass in April of the year following treatment. The shoulders at Dallas had a very light stand of bermudagrass the spring following treatment, but the associated plants were not controlled to any degree by the four applications of sodium TCA.

At both Gilmer and Beaumont, retreatment with 12 pounds per foot-mile of sodium TCA was as effective as 24 pounds. At Dallas, there was a definite advantage in retreating with 24 pounds of sodium TCA compared with lower rates (Figure 7).

The shoulders at Dallas had an accumulation of soil approximately four inches thick over the original pavement. Prior to the second application a portion of the test section was cleaned using a rotary broom, and the residual vegetation was permitted to resume growth before the treatment was applied. The brooming did not influence the ultimate control of bermudagrass, but removal of some existing plants as well as germinating seedlings by the sweeping action effectively reduced the stands of these associated plants (Figure 8).

Trichloroacetic acid is available in several forms including a liquid acid, an ester and a sodium salt. The acid has a relatively short shelf life compared with the other two forms. The forms of TCA were tested at College Station and at Lufkin, and an analysis of variance for the comparisons showed no difference in the response of bermudagrass to various forms of TCA (Figure 9).

Surfactants improve the performance of some herbicides. A replicated test using a marginal rate (18 pounds per foot-mile) of sodium TCA applied in June and evaluated in August compared three volumes of application and several increments of wetting agent (Du Pont "Spreader Sticker"). The apparent kill sixty days following treatment ranged from 80 to 100 percent, but no consistent response to wetting agent could be shown. The added cost of using a surfactant in sprays where sodium TCA is the herbicide cannot be recommended on the basis of these comparisons.

Combinations of herbicides often are more efficient than a single material. A replicated test compared the response to sodium TCA, fenac, and these two materials together on bermudagrass growing in paved shoulders near Lufkin. Observations made thirty and ninety days later disclosed that the addition of one pound of fenac per foot-mile to each of three rates of sodium TCA was superior to the sodium TCA alone (Figure 10). The regrowth of the bermudagrass where the highest rate of sodium TCA was used with fenac was chlorotic, but eventually recovered. Although this line of research was not pursued further, it would appear to offer a possible field of investigation for improving the efficiency of sodium TCA on bermudagrass and to better control plants commonly found growing in association.

The chemical "tools" for controlling undesirable vegetation are no better than the application. The Texas Highway Department has designed and built a

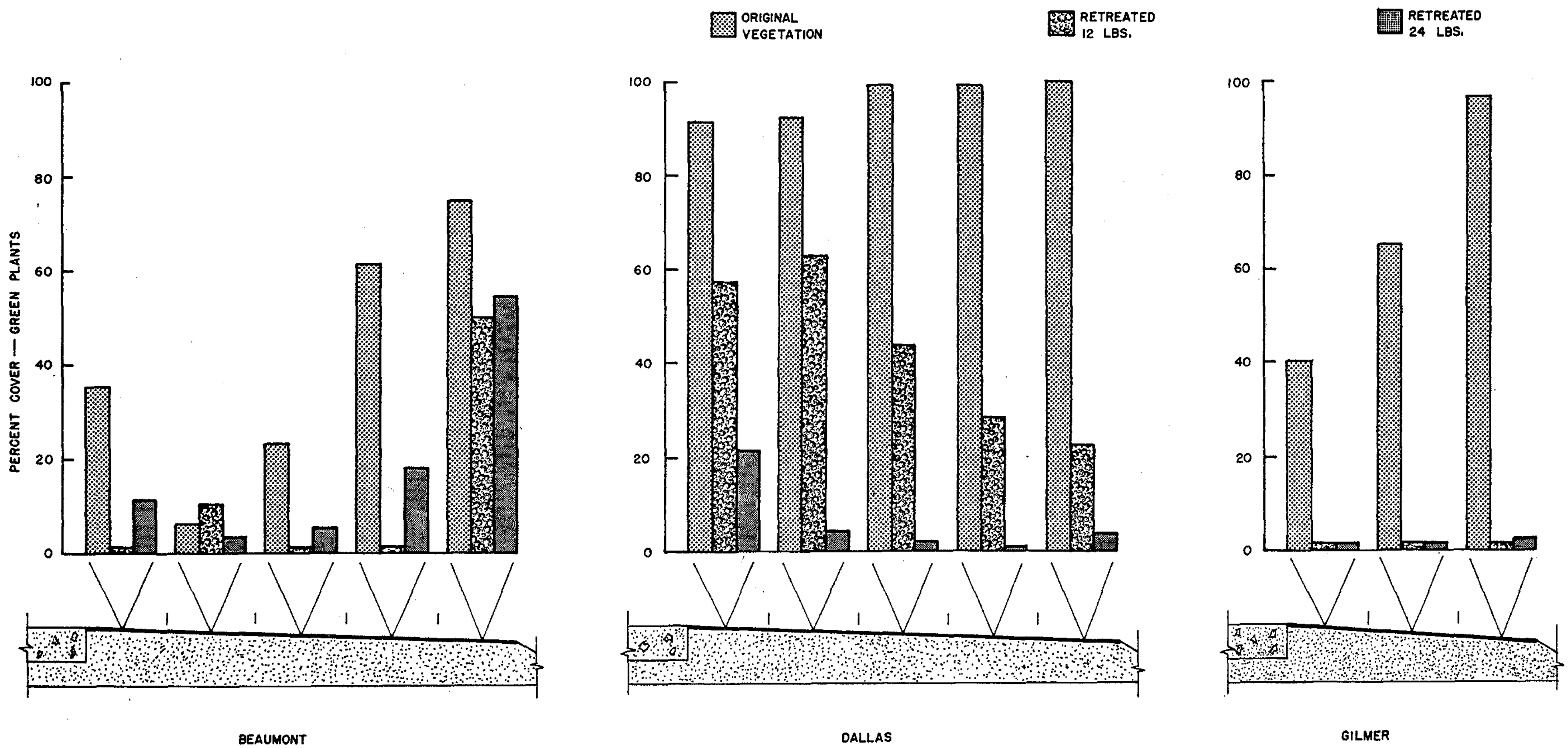


Figure 7. Response of bermudagrass to subsequent treatment with two rates of sodium TCA following initial uniform application of 24 pounds of TCA per foot-mile. Measurements are shown for one-foot segments of shoulder pavement three or five feet wide, beginning at the edge of the road surface at the left.

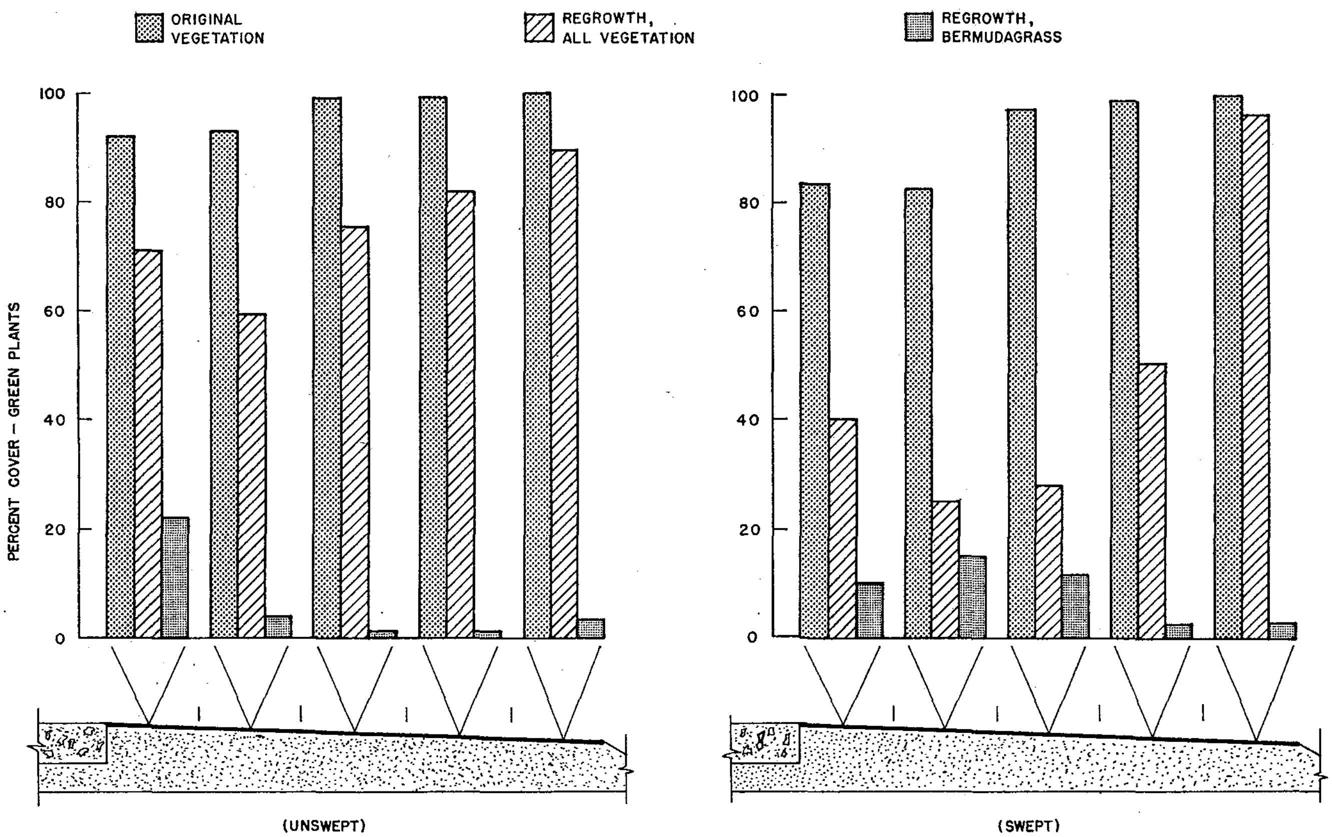


Figure 8. Sweeping removes the seed source of many of the plants associated with bermudagrass, but some of these plants are not susceptible to sodium TCA. Measurements are shown in one-foot segments for a shoulder five feet wide, beginning at the edge of the road pavement on the left.

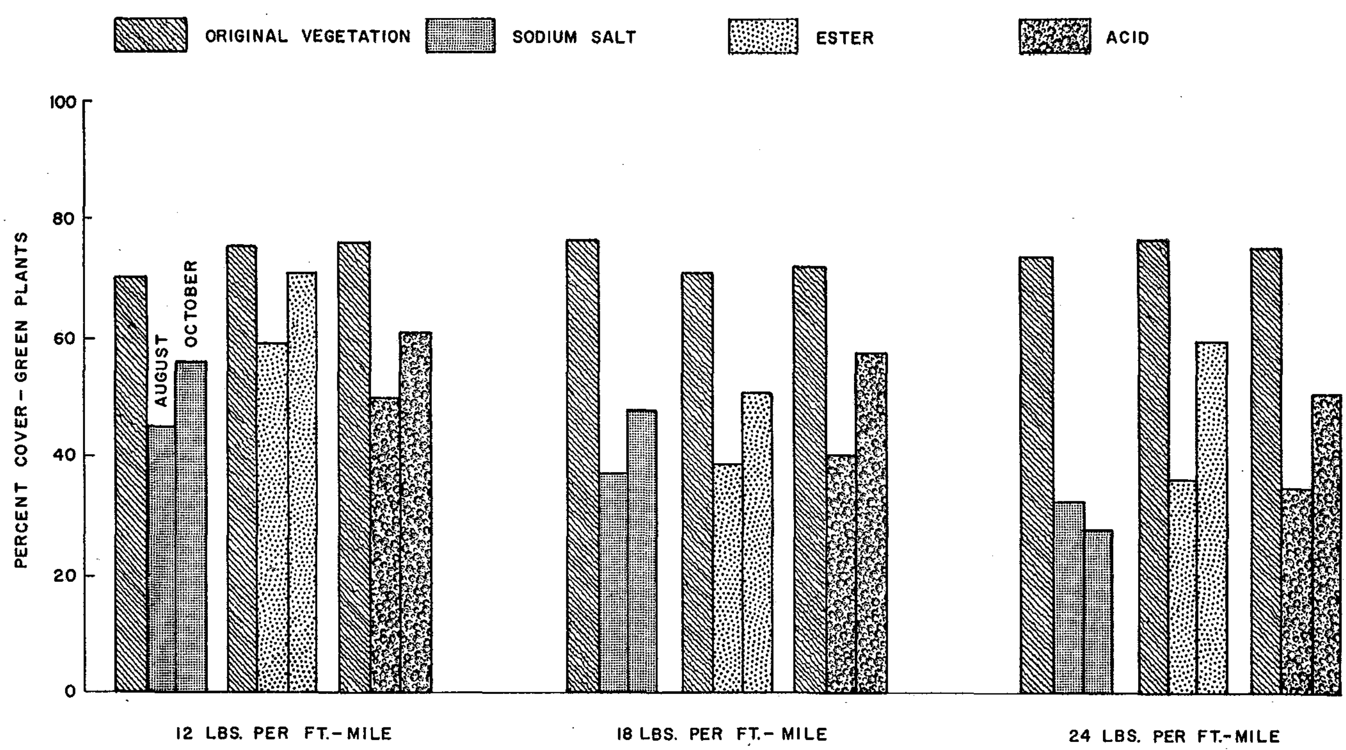


Figure 9. Percentage cover of green plants of bermudagrass in asphalt shoulders following a single treatment in June with three rates of different forms of TCA. The evaluations were made in August (left) and October (right).

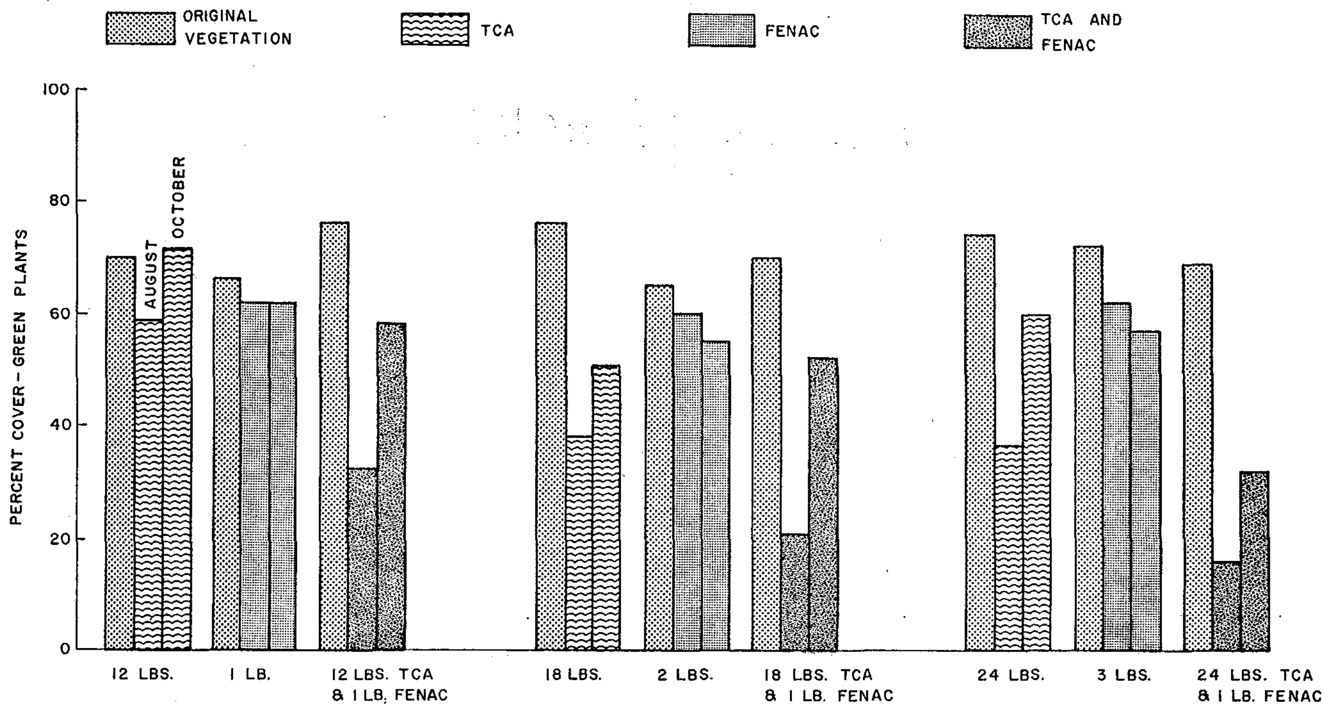


Figure 10. The effects of TCA and fenac individually and combined on bermudagrass growing in asphalt pavement. Rates of application are pounds per foot-mile.

spray unit which can be attached to a standard water truck for application of herbicides. This sprayer will accommodate application equipment ranging from a boom to a handgun, and other modifications can be made to meet specification requirements. A description of this spray unit is contained in an operator's handbook (McCully and Hill, 1961).

SUMMARY AND CONCLUSIONS

Plants growing in asphalt surfacing cause a rapid deterioration of the pavement. Common bermudagrass is the most prevalent problem plant over much of Texas, but other plants such as Johnsongrass, prostrate milkweed, several bunchgrasses, as well as other herbaceous and grassy weeds occur as scattered plants or become locally abundant.

Several herbicides were compared for application (1) prior to paving (pre-paving) or (2) to emergent plants growing in existing pavement (post-paving). From these tests conducted over a wide range of climatic conditions it was determined that sodium TCA applied as a water spray at a rate of 24 pounds per foot-mile is an effective treatment in either pre- or post-paving application. Following are some considerations and suggestions for applying sodium TCA:

1. For pre-paving treatments the material should be applied just prior to the prime or seal coat. Following the application of the herbicide, the surface of the base material should not be swept nor worked further before sealing.

2. Control of vegetation with a post-paving treatment should be regarded as a program application requiring at least two treatments. The initial application should be made when the bermudagrass is beginning growth in the spring with retreatment approximately one month later. The second treatment should be applied when the bermudagrass begins to show green again rather than specifically according to the calendar. Applications of sodium TCA made through the summer months generally are not as effective as those made under more favorable conditions for plant growth. Applications during the winter dormant period were not considered in this research. They are not recommended since sodium TCA is quite soluble, and is easily washed from the treated surface.

3. Soil and other debris should be bladed or broomed from the pavement surface and the residual vegetation allowed to begin growth before spraying.

4. Occasionally, trees may show some effect of sodium TCA absorption, but these effects usually are not serious nor long lasting.

5. The best chemical is no better than the application. Too little material yields unsatisfactory results, and an excessive application is wasteful. A spray application using a boom combines nozzle delivery at a stated pressure with speed of travel to obtain the prescribed treatment. Effective treatment with a handgun depends on the judgment of the applicator.

6. The results of this research are most applicable to bermudagrass in asphalt pavements. Other plants may respond to sodium TCA, but a number of plants growing in association with bermudagrass are not controlled using the specified treatment.

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APPENDIX A. COMMON AND CHEMICAL NAMES OF HERBICIDES

Common name or other designation	Chemical name*
"Borascu"**	A refined sodium borate or containing 63 percent boron trioxide
"Chlorax liquid"**	A liquid mixture containing approximately 18 percent sodium chlorate and 10 percent sodium metaborate
Dalapon	2,2-dichloropropionic acid
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
Erbon	2-(2,4,5-trichlorophenoxy)ethyl-2,2-dichloropropionate
Fenac	2,3,6-trichlorophenylacetic acid
"Garlon"**	A combination of the esters of dalapon and silvex
Monuron	3-(p-chlorophenyl)-1,1-dimethylurea
MonuronTCA	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate
"Polyborchlorate"**	A mixture containing 73 percent disodium octoborate and 25 percent sodium chlorate
Silvex	2-(2,4,5-trichlorophenoxy) propionic acid
2,3,6-TBA	2,3,6-trichlorobenyoic acid
TCA	trichloroacetic acid

*The name indicates the basic chemical. It may be formulated as an ester, a salt or in some other form to facilitate application. The actual formulation may be indicated; for example, sodium TCA indicates the sodium salt of TCA.

**Brand names for which no common designation exists.