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16. Abstract

This report presents technology developed in cooperative research to facilitate the establishment of vegetation for soil stability and to control unwanted vegetation in pavement and on the roadside. Work on erosion control dealt with critical slopes where excessive acidity and plastic soil materials limited vegetation establishment. Lime can be used to reclaim existing acid slopes, but subsequent maintenance liming will be required. Removal of the offending material and backfilling is suggested as a construction practice. Plastic soil materials can be treated in many cases, but present construction requirements make the salvage and immediate use of topsoil possible.

The use of chemicals for maintenance of unwanted vegetation can be summarized as follows:

1. Addition of a "polymer activator" to TCA solutions may significantly reduce the TCA requirement. Cost data for the activator are not firm to aid in decision making.

2. A satisfactory chemical treatment has not been found for maintenance of median plantings where the offending vegetation is perennial. Annual plants can be controlled with simazine.

3. A program treatment for perennial weeds is available, but the spray mixture contains growth-regulating chemicals similar to 2,4,-D. This practice should not be used where susceptible plants may be affected.

4. It is recommended that herbicides not be applied at soil sterilant rates in highway facilities.

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ROADSIDE VEGETATION STUDIES, 1969-1973

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Research Report 142-4 (Final)
Establishment and Management of Roadside Vegetation
Research Study 2-18-69-142

Sponsored by
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TEXAS TRANSPORTATION INSTITUTE
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SUMMARY AND CONCLUSIONS

Vegetation demands considerable attention from the engineer in highway design, construction and maintenance. Roadside vegetation stabilizes the roadside, provides a pleasing traveling environment and assists in channeling traffic.

This report presents technology developed in cooperative research to facilitate the establishment of vegetation for soil stability and to control unwanted vegetation in pavement and on the roadside. Our earlier work established the need for an orderly sequence of site preparation, plant material selection and seeding installation. Specifications have been issued earlier for using Sodium Trichloroacetate (TCA) to control unwanted vegetation.

Present work on erosion control dealt with critical slopes where excessive acidity and plastic soil materials limited vegetation establishment. Lime can be used to reclaim existing acid slopes, but subsequent maintenance liming will be required. Removal of the offending material and backfilling is suggested as a construction practice. Plastic soil materials can be treated in many cases, but present construction requirements make the salvage and immediate use of topsoil possible.

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4. It is recommended that herbicides not be applied at soil sterilant rates in highway facilities.

RESEARCH IMPLEMENTATION

These studies on establishment and maintenance of desirable vegetation and control of unwanted vegetation have produced results which should be considered in the following categories:

1. Plantings for erosion control are feasible to a line extending southward from the western boundary of the Texas Panhandle. Seedings should be restricted to sandy soils which are not salty.

2. Hay and straw used as mulch should not contain seeds which will germinate and compete with permanent grass.

3. Buffalograss should be continued as a component of seeding mixture in northwestern Texas. Treated seed should be specified if the cost premium is not great.

4. Treatments specified for perennial weeds should not be used where crops or other plants may be damaged by spray drift.

5. Soil sterilant herbicides other than sodium TCA should not be applied to roadsides.

6. Where acid soil materials are known or suspected in construction, the acid material should be removed to a depth of at least two feet and backfilled with quality topsoil. Also, the acid material removed should be placed in the center of fill sections to prevent damage to vegetation planted on fill slopes.

Work is continuing on the following:

1. Acceptable materials for treating perennial weeds.

2. Evaluation of performance and relative cost of polymerized TCA compared with the standard formulation now in use.

3. Materials and techniques of reclaiming slopes containing acid materials restrictive to plant establishment and growth.

4. Evaluation under roadside conditions of experimental herbicides, such as "Spike", "Roundup" and "Asulox".

DISCLAIMER

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INTRODUCTION

The entire right of way of a finished highway is an engineering concern. Concrete or asphalt pavements support vehicular traffic on the travelway; the remaining portion of a right-of-way is covered with living plants for erosion control and to present a pleasant and safe environment to the motorist. On the other hand, plants growing in an asphaltic pavement accelerate breakup of the surface, or they become nuisances in other ways. Consequently, establishment, maintenance and control of vegetation within the highway facility are management operations based on judgments derived from research and experience.

Interim reports for this study (12, 13, 14) describe the use of various amendments on denser soil materials, the efficacy of a wide range of soil sterilant herbicides for highway use, and the use of a "polymer activator" in herbicidal solutions of sodium trichloroacetate (TCA).

This report describes results from tests installed to establish a cover of desired plants and to control unwanted vegetation.

PROBLEM BACKGROUND

Development and maintenance of vegetation over the highway facility have received increasing emphasis in recent years. Improved technology reflects the increasing research interest at both the State and Federal levels. Overviews and guidelines are available (8, 9).

Specific research is available from several states (2, 3, 4, 6) as the pertinent part of a large volume of technology for vegetation establishment. Our own cooperative research effort has produced several reports which are summarized by McCully and Bowmer (11).

Special problems bring a refinement in technology, as in the case of acid soil materials. This condition extends across the South near the edge of the Coastal Plain and has prompted work in several states (7, 15). Oxidation and hydration of pyritic materials may yield a ph as low as 1.8; plant survival is rare below ph 4.5. These pyritic materials are present in specific geologic strata, so the system is perpetual. If the acid stratum is relatively high on the slope, all of the slope face below the outcrop is kept scoured by acid surface water.

Using chemical energy to control unwanted vegetation also has received attention. Soil sterilants were considered early (1, 5, 16). Our cooperative work has stressed safety and then effectiveness in the development of specified practices for both pre- and post-paving application (10). TCA has been specified in Texas for both pre- and post-paving vegetation control because it is effective, relatively inexpensive, and safe to use. Adequate vegetation control requires recurring applications of TCA, and more treatments are needed in areas receiving higher rainfall.

There also is a large source of research information from agricultural research which can be mobilized into this cooperative research effort. This information is general or is specific for focusing on particular problems dealing with vegetation.

PART A: VEGETATION ESTABLISHMENT

PROBLEMS

Soil materials encountered in road construction which possess objectionable physical or chemical properties will not support plant growth. Specific soil conditions under study were:

1. Dense soil materials having a plasticity index (PI) greater than 15 support only a marginal stand of vegetation at best. These plastic materials were encountered in scattered locations throughout Texas.
2. Acid materials having a pH lower than 4.5 will not support plant growth. The acidity of some materials encountered in northeastern Texas has measured as low as pH 1.8.

PROCEDURES

Problem sites were selected in consultation with the Contact Study Representative, and specific test locations were organized following on-site inspection and preliminary measurements. Individual tests were installed and conducted using appropriate research procedures. Equipment together with needed materials and services were provided by the local maintenance section of the Texas Highway Department.

1. Modification of soil physical problems. A soil material functioning as a plant growth medium should possess a granular structure to properly supply moisture and aerate plant roots. A sharp contrast is offered by massive clayey or shaly materials on the faces of cut or fill

slopes which have not been subjected to the weathering processes which condition most surface soils.

Granulation of these dense subsurface materials can be induced by tillage with a pulvi-mixer or scarifier, but the soil granules puddle back into an amorphous soil mass upon wetting.

Materials tested (Table 1) were those which would perpetuate aggregate identity or lines of weakness generated by tillage. Ten tests were installed over a four-year period.

RESULTS AND DISCUSSION

Dense, massive subsurface soil materials lack the pore spaces which are the basis for good plant-soil-water relations and the aeration so necessary for plant growth. Materials selected for testing were those usually involved in natural soil granulation, or would either maintain granular identity or perpetuate lines of weakness generated by tillage. Grass hay, composted garbage, calcitic lime and agricultural gypsum are examples of organic and inorganic materials which favor granulation. The synthetic polymers listed in Table 1 are representatives of a vast array of similar materials which have been used as anti-crusting agents. Urethane, gravel and reclaimed rubber were admixed in the soil matrix.

These tests have been discussed in detail in earlier reports (McCully and Stubbendieck, 1972; McCully, Bowmer and Stubbendieck, 1970). A number of materials offer some utility in modifying properties of dense soil materials to better support grass plants. The most spectacular increases in stand occurred when topsoil was used to plate a slope face. Present construction practices, often utilizing short haul distances, may permit

Table 1. Effectiveness of various soil amendments relative to the plant stand secured without treatment. [a/]

Material	Rate/ acre	1968			1969			1970		1971	
		Taylor	Brazos	Rusk	Burleson	Hidalgo	Webb	Brazos	Grayson	Grayson	Washington
Aggregate	300 cu ft									+	+
	600 "									+	–
	1200 "									+	+
AP30	100 lbs	0	+	0							
Aqua-gro	17 gal	0	+	–	–	0	0	0	+		
CMC	100 lbs	0	+	0	0	0	0	0 1/	0 1/		
	200 "	0 2/	+	0	+	+	0	0 3/	0 3/	+	+
	400									+	+
Gelgard	100 lbs				0	+	0	0	0		
	200 "				0	+	+	0	0	+	+
	400 "									+	+
Ground bark	300 cu ft									+	0
	600 "									+	+
	1200 "									+	–
Gypsum	1 T				0	0		0	0		
	2 "		+	+	0	+		0	0	+	+
	4 "									+	+
Hay	4 T		0	–							
	8 "		0	0							
Lime	1 T							–	+		
	2 "							0	0		
Metroganic	2.5 T							0	0		
	5.0 "							0	0		
	7.5 "							–	0		
Reclaimed rubber	300 cu ft									+	–
	600 "									+	–
	1200 "									+	–
Reten 210	100 lbs	0	+	–	–	0	0	0	+		
	200 "				0	+	0	0	+	+	+
	400 "									+	+
Topsoil	unincorporated									+	+
	incorporated								+		0
Urethane (pre-till)	300 cu ft									+	–
	600 "				+	0	0	0	0	+	–
	1200 "				+	0	0			+	0
	1800 "				+	0	0	0	0		
(post-till)	600 cu ft				0	0	+				
	1200 "				0	0	+				
	1800				0	0	+				

a/ + = establishment improved; 0 = no advantage; – = establishment depressed
1/ 75 lbs. 2/ 150 lbs. 3/ 125 lbs.

greater use of topsoiling at considerably less cost than when the common practice was to stockpile and haul relatively great distances.

2. Modification of soil chemical problems. Soil materials more acid than pH 4.5 will not support a plant cover for erosion control. Soil materials have been uncovered during construction in northeastern Texas which were as acid as pH 1.8. These acid materials are found in Weches and associated formations of the Claiborne geologic group (Miller, et al., 1969). The acidity of the surface layer on cut slopes is intensified upon exposure to atmospheric conditions, so the acidity system is self-perpetuating as erosion of the surface material progresses.

The experimental approach was reclamation of acid soil material (first action), monitoring pH on the treated site, and maintenance liming (second action). Application of lime in the first action was based on total acidity by potentiometric titration (Kamprath, 1967). Initiation of second action came with a definite increase in acidity and pH 5.7.

Plant tolerance of acidity and the high rates of lime applied were determined for bermudagrass, kleingrass and weeping lovegrass.

RESULTS AND DISCUSSION

Most plants thrive in a nearly neutral (pH 7.0) soil and show varying tolerances for deviations in pH toward either acidity or alkalinity. A pH of 4.5 seems to be an acidity threshold below which plants do not survive. Acid toxicity is not due to hydrogen ion alone (Coleman and Thomas, 1966) but involves low amounts of calcium and magnesium, increased solubility (and toxicity) of aluminum, iron and manganese, and organic toxins (Kamprath, 1967). The essential growth elements, nitrogen and phosphorus, are lacking. Massive applications of lime correct pH and ion solubility problems, but nutritional problems remain.

The pH of extremely acid materials is not a valid measure of lime requirement (Miller, et. al., 1968). Total acidity, determined by potentiometric titration against a standard base, integrates active acidity of pH and exchangeable acidity (not registering as pH) into a lime requirement. These relationships are shown in Table 2.

Color of soil material can be related to problem status. Materials containing the yellow oxidized iron fragments have a very low lime requirement. Materials having a gun-metal color or containing lignite beds are highly suspect.

Calcitic lime was applied at rates ranging from 5 to 50 tons/acre. Results from these tests can be summarized as follows:

1. Lime requirement should be based on total acidity.

2. Several grasses can be grown on soils treated with high rates (100 tons/acre) of lime.

3. The applied lime does not modify acidity below the level of incorporation. Consequently, soil pH may become acid enough for maintenance liming in three to five years.

4. Grass stands were not as good where the total amount of lime was applied in two increments over successive years as where a single lime application was made.

Additional lime was applied in mid-July 1971 as a topdressing over existing stands of grass on an adjacent study slope that was limed and seeded in 1968. These earlier lime treatments have been monitored since the test was installed, and acidity readings fell below pH 5.8 for all samples. Six, twelve or twenty-four tons of agricultural lime per acre together with 300 pounds of 16-8-8 fertilizer were broadcast over areas originally treated with either 25 or 50 tons of lime per acre.

The cover of bermudagrass on these test slopes at the time of reliming reflected the acidity status. Plant frequencies, measured as the

Table 2. Some comparisons of pH, and total and exchangeable acidity in sediments exposed by construction along IH 20.

Site No.	Depth in.	pH	Exchange-able acidity	Total acidity
A-1	0-10*	5.9	0.0	0.1
	24-30	2.9	10.0	21.0
	54-60	2.5	17.8	28.8
A-2	0-6	2.5	16.1	27.4
	12-18	2.5	26.6	44.0
	48-54	3.7	2.5	23.8
A-4	0-6	2.9	21.1	47.8
	12-18	2.6	18.2	40.0
	36-42	4.0	1.2	14.4
A-5	0-6	2.9	26.1	46.8
	12-18	4.6	1.0	18.8
	24-30	2.8	16.6	40.0
	48-54	4.9	0.5	13.4
A-6	0-6	2.6	23.8	37.2
	18-24	2.6	4.7	8.8
	30-36	2.6	6.1	12.0
A-7	0-6	2.4	7.5	18.4
	12-18	2.8	3.5	6.4
	48-54	2.7	3.3	6.1

*Brown sandy loam topsoil from previous mulch sod.

relative number of square-foot samples containing live plant material, were 80% for the original 50 tons of lime, 57% for 25 tons, 19% for 5 tons and 8% for the unlimed control. The bare areas gradually increased in size, so that liming and seeding were planned for 1974.

3. Plant materials for dry climates. Buffalograss seed treated with potassium nitrate during cold storage together with seed from the U. S. Soil Conservation Plant Materials Program were included in various scheduled seedings. Plant materials included several introduced and native bluestems, whiplash pappasgrass and alkali sacaton. Details are listed in an interim report by McCully, Bowmer and Stubbendieck (1970).

Buffalograss enjoys a wide geographic distribution, is a component of the natural vegetation in northwestern Texas and forms a low sod. Because it is slow to cover, it should be a component of any seeding mixture for that region.

Of the plant materials tested only Old World bluestem showed promise and only in the more humid portions of Texas.

The one seeding to establish a western limit of seeding was unsuccessful because of competition from wheat germinating from grain in the straw mulch.

PART B: VEGETATION CONTROL

Tedious and costly vegetation control using such methods as hand hoeing are being replaced by more efficient chemical energy in the form of herbicides. Herbicidal technology for highway engineering use is highly oriented to management situations. This report will consider studies to selectively control unsightly plants in median plantings; to eradicate a mixture of perennial plants from asphaltic plants in northwestern Texas; to investigate the efficacy of a "polymerizing" agent to enhance the herbicidal properties of TCA; to compare a wide range of soil sterilants for maintenance use; and to screen new materials for further testing.

Herbicidal materials are listed as officially designated by the Weed Society of America.*

1. Maintenance of plant screens for headlight glare. A multiflora rose hedge planted in the median of IH 10 eastward from Winnie (THD District 20) to reduce headlight glare has become infested with a number of broadleaf weeds and grasses as well as with a woody shrub, eastern baccharis. These unsightly plants are most prevalent in thin hedge plantings, and are difficult to control with routine mowing operations.

   The treatment strategy was to apply a contact herbicide (cacodylic acid or MSMA sodium cacodylate) followed by a number of materials with pre-emergence potential (Table 3). Individual treatments were applied in duplicate on three dates to a strip four feet wide centered on the

*Mention of a specific trade name is for convenience only, and does not imply endorsement over other materials which may be equally effective.

Table 3. Relative effectiveness of various herbicides for controlling weedy plants in multiflora rose plantings along highway medians.

Material	Rate (Lb/A ai)	Date of Treatment							
		January a/				March			May
		(Relative control - weeks following treatment)							
		7	13	19	30	6	12	24	11
Chlorpropham	2.0								4.5
(Furloe 20G)	4.0								4.5
	6.0								5.0
Cpd 9789 (80WP)	1.0								4.5
(Sandoz-Wander)	2.0								5.0
Cpd 13638	2.0	3.0	3.0	3.0	1.0	2.5	1.5	1.0	
(Geigy)	4.0	3.5	3.5	3.0	1.5	3.0	2.5	1.0	
Cpd 17623	1.5								5.0
(Chipman)	3.0								5.0
Diphenamid	5.0	3.0	3.5	2.5	1.0	2.5	2.0	1.0	
(Dymid 80-WP)	10.0	2.0	3.0	1.5	1.5	3.0	2.5	1.5	
MSMA/Cacodylic acid	6.0								2.0
(Ansul)	8.0								4.5
Norea	4.0	2.5	3.5	1.0	1.0	2.5	1.5	1.0	
(Herban 80-WP)	6.0	2.0	3.0	2.0	1.0	3.0	2.0	1.0	
	8.0	2.0	3.0	2.5	1.0	4.0	2.0	1.0	
Sesone	4.0	3.5	3.5	3.0	1.5	4.0	3.0	1.0	
(Sesone 90-WP)	6.0	3.0	2.5	2.5	1.0	3.5	2.5	1.0	
	8.0	2.0	2.5	2.5	1.0	3.0	2.0	1.0	
Simazine	2.0	4.0	4.5	4.0	2.0	2.5	2.5	2.0	
(Princep 4-G)	4.0	4.5	5.0	4.5	2.5	3.5	3.5	2.5	
	6.0	4.0	5.0	5.0	2.5	3.5	4.5	2.5	5.0
	8.0								5.0
	12.0								5.0
(Princep 80-WP)	2.0	3.5	4.0	3.5	1.0	4.0	2.5	1.0	
	4.0	4.5	4.5	3.5	1.0	4.5	4.0	1.5	
	6.0	4.5	4.0	4.0	1.5	4.5	3.5	1.5	5.0
	8.0								5.0
	12.0								5.0
Trifluralin	4.0	3.0	3.5	3.0	1.0	2.0	2.0	1.0	
(Treflan 5-G)	6.0	3.5	3.5	3.5	1.5	3.0	2.0	1.0	
	8.0	3.0	3.5	3.0	2.0	4.0	3.0	1.5	
VCS-438 (75-WP)	4.0								5.0
(Velsicol)	8.0								5.0
(3G)	4.0								4.5

a/ 1= 0 - 20% control
2=20 - 40% control
3=40 - 60% control
4=60 - 80% control
5=80 - 100% control

hedge row aggregating 0.05 A. Plants present at the time of treatment and for each evaluation were listed.

The plants encountered were a wide assortment of both warm- and cool-season annual or perennial weeds and grasses. Generally, the annual plants were controlled more easily by the pre-emergence treatments than were the perennials.

None of the treatments affected the roses. Simazine, as in 1970, was the most effective material in the January and March treatments. Granules of simazine were somewhat superior to sprays, and the effective treatment life was approximately 20 weeks.

The most common perennial plants were bermudagrass, johnsongrass and showy verbena. Of these, johnsongrass stands were reduced by the heavier rate of Cpd 17623. Also, showy verbena was controlled with simazine, and stands were reduced with Cpd 17623 and VCS-438.

In summary, annual plants in median plantings of roses can be controlled with pre-emergence application of simazine. If growth has started, a contact spray will be necessary. None of the treatments tested controlled johnson grass or bermudagrass infesting these plantings.

2. Control of perennial weeds infesting asphalt shoulders. Several experimental materials were compared with the mixtures of prometone/fenac/dicamba and bromanil/fenac/dicamba for controlling bindweed and other cropland weeds. None of the materials tested was superior to the above mixtures.

3. Polymerization of TCA. TCA alone or combined with ammonium sulfamate ("Ammate") are standard treatments for vegetation maintenance on pavements as well as on open soil. TCA and TCA/"Ammate" are easy to use because they are soluble in water, but this solubility limits their treatment life. Combining TCA with a patented activate has been suggested to yield a polymerized form consisting of a chain of TCA molecules. In theory the TCA polymer would retain the herbicidal effectiveness of the original material and the decreased solubility would enhance treatment longevity.

Treatments were installed in each of three districts of the Texas Highway Department in 1972 and 1973. The locations were in THD District 2, 11, 13 and 20, and covered a wide range of soil and climatic conditions. Polymerized TCA at rates ranging from 12 to 24 pounds/foot-mile were compared with the standard TCA at 24 pounds or 140 pounds of TCA and 60 pounds of "Ammate". Polymerized "Ammate" was discarded after the first year.

Results from field tests can be summarized as follows:

1. Using the polymer form the rate of TCA may be reduced as much as one-half the rate now specified in the standard treatment.
2. The initial kill on most plants is more complete with polymer than with standard TCA. The treatment effect lasts longer but not for an entire season.
3. The polymer form used was quite effective for controlling plants on paved surfaces but was inferior to standard TCA on open soil.

Controlled laboratory tests were run to measure the effects of heat and ultraviolet radiation on standard TCA and two polymerized forms (Figures 1 and 2). These materials were also applied to three general types of asphalt. The results of these tests can be interpreted as follows:

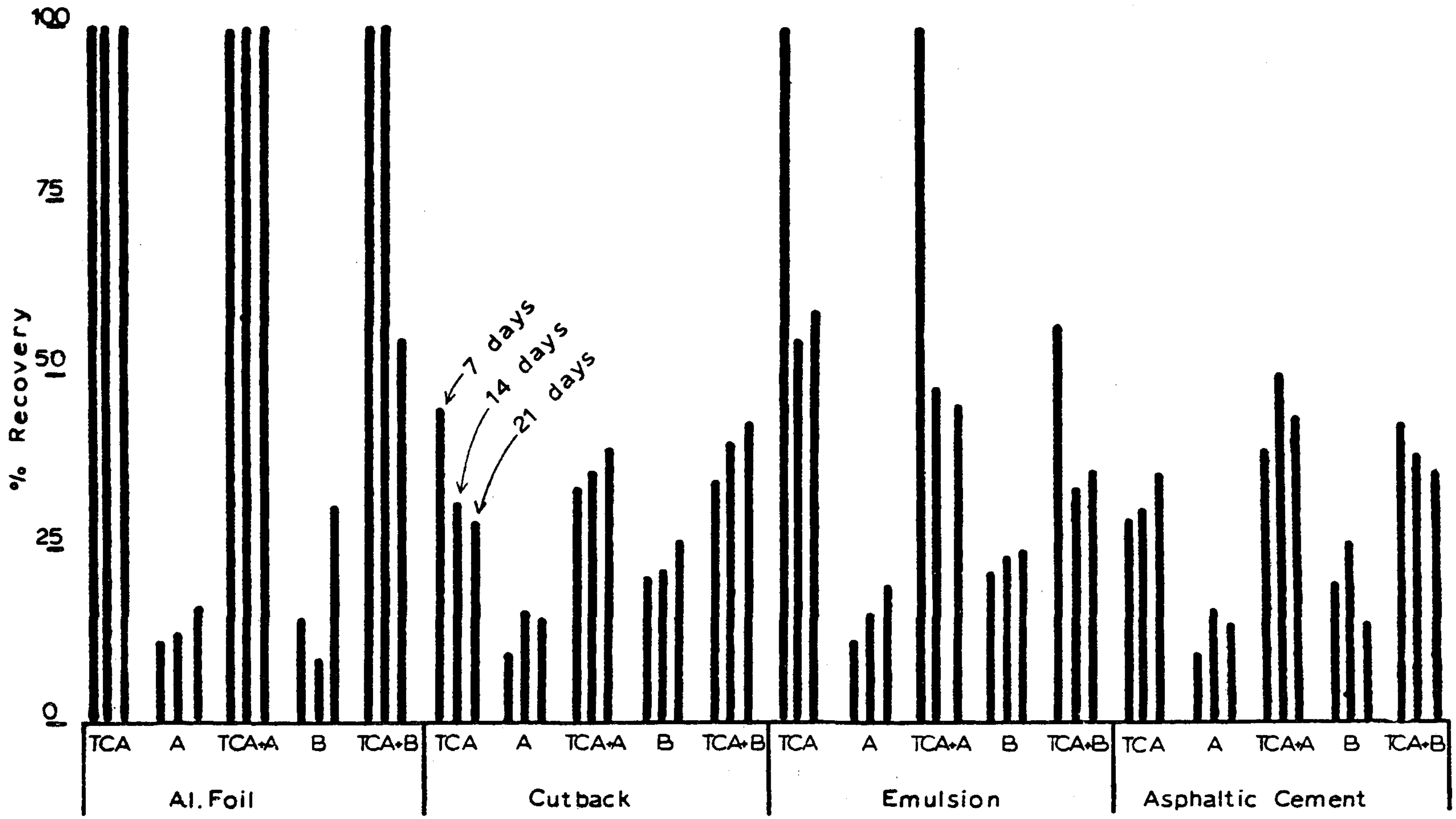

Fig. 1. Percentage recovery of sodium TCA, polymer activates A and B, and polymerized TCA applied to asphaltic or aluminum foil surfaces and subjected to 140°F for varying periods of time.

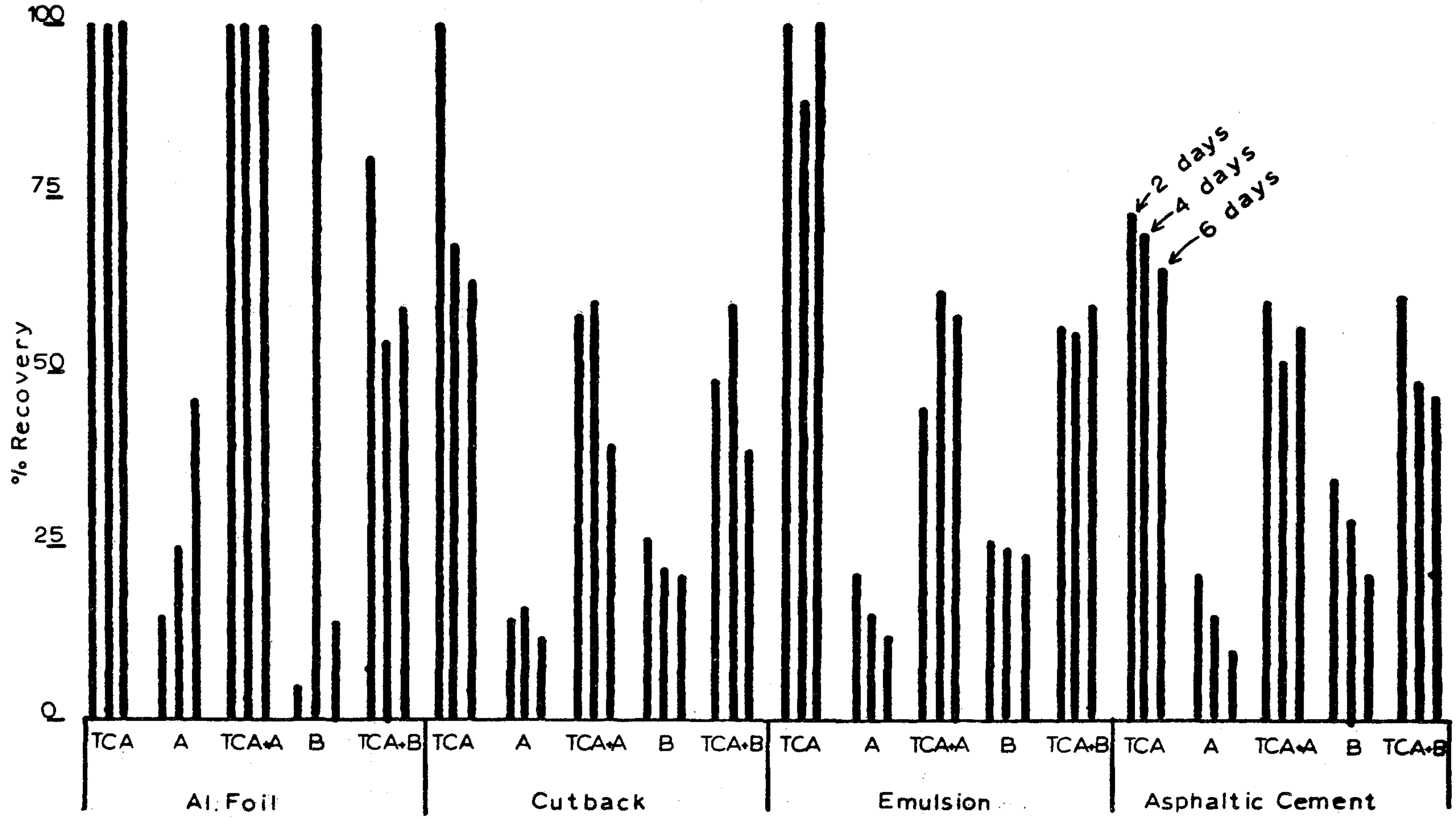

Fig. 2. Percentage recovery of sodium TCA, polymer activates A and B, and polymerized TCA applied to asphaltic or aluminum foil surfaces and subjected to 700 μW/cm² ultraviolet radiation for varying periods of time.

1. Both standard and polymerized forms are quite stable under the imposed environmental conditions, as shown from their recovery from the soil surface.

2. Recovery of both forms of TCA varied with the nature of the asphaltic surface. This probably represents a physical or chemical affinity between the TCA material and asphalt rather than degradation of the TCA from heat or ultraviolet. This theory is supported in part by results from field tests.

4. Soil Sterilants. Using soil sterilant herbicides to maintain areas around sign posts, under guard rails and in other situations interfering with high-speed mowing has been proposed as a maintenance treatment.

Forty-four herbicides were applied alone and in various combinations (McCully and Bowmer, 1971) over a two-year period. The following findings can be summarized from the Interim Research Report:

1. Even though soil sterilant herbicides are considered "general purpose", a wide variation in plant response was noted. Annual plants were more susceptible than many perennials, and perennials varied in susceptibility.

2. The control achieved with the more residual materials such as bromacil, CBMM, karbutilate and Monuron TCA lasted for 10 months (Tables 4 and 5).

3. Materials which gave the best vegetation control moved out of the treatment area (Tables 4 and 5). This shift downslope from the place of application damaged turf and erosion resulted. Several operational procedures such as increasing the volume of solution applied, incorporating the herbicide into an asphalt emulsion or placing the herbicide under an asphalt layer failed to prevent damage to untreated vegetation downslope.

5. Experimental herbicides. Three materials tested are apparently being developed by the manufacturer. Then include "Asulam" of Rhodia-Chipman, "Spike" of Eli Lilly and "Roundup" of Monsanto.

"Asulam" is specific for controlling established johnsongrass, but more than one application is needed.

"Spike" is a form of substituted urea. Combined with a contact material it gives effective vegetation control for as long as four months. The main disadvantage for roadside use is a tendency to shift from the place of application, particularly at higher rates.

"Roundup" gives excellent control of many plants, but it lasts for only 4 to 8 weeks. Combined with persistent materials such as "Spike", it gave excellent early control of vegetation.

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