PROGRESS REPORT of COMMITTEE on MOWING and HERBICIDES

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●IN the short time of less than a decade, a totally new field of vegetation management, concerned with right of way and roadsides, shows signs of being born as an integrated division of land management.

It is the purpose of this paper to discuss some of the problems of managing this type of vegetation and especially to assess the value of herbicides as a "tool" in this management.

THE ROADSIDES AND RIGHT OF WAY

Most people are only subconsciously aware of roadsides and right of way. A new type of acreage is becoming manifest in our national economy—narrow strips seem to be inevitable. What does all of this amount to, acreage-wise? The state of Ohio has over 18,000 miles of state highways and over 70,000 miles of secondary roads, involving, together, 330,000 roadside-acres.

Possessing high values for the public and for the nation, in addition to immediate use, such tracts can be managed for multiple purpose or they can be subjected to practice detrimental to their owners as well as to the public. It is the unmowed strip that offers excellent opportunities for rational management techniques. Basically it must satisfy the needs of the highway department.

The needs involve the elements of traffic safety. Locally, there is the problem of snow fences, for which shrubs are valuable in some places but unwanted in others. Not of minor importance is the matter of fire hazard. Both noxious weeds and insect pests present local problems that must be solved independently. From another point of view, ornamental values rank high in roadside management, and most state departments have their own landscape divisions often involved in planting shrubs. It has sometimes seemed inconsistent to find miles of native shrubs destroyed.

CHEMICALS

Chemically, the materials now mostly used are derivatives of both 2,4-D and 2,4,5-T. The latter was found effective against certain species for which 2,4-D was useless. Now various mixtures of D and T, or T alone, are promoted. Salts, amines, and the acids themselves have yielded their place to esters. The original esters were methyl, butyl, proyl, ethyl, and other so-called high-volatility compounds. Because of extraordinary damage suits, industry developed the so-called low-volatility esters.

SPRAYING

Techniques of D-T spraying are sharply divided into opposing groups. There is dormant season vs. growing-season spraying; pack-sack vs. power-spraying. Most treatments are either summer foliage vs. basal spraying or winter basal selective pack-sack spraying. (1)

INFORMATION

An increased interest in herbicides expressed by landscape architects and maintenance engineers of various state highway departments challenges this committee to make available to them more information about this subject. Some states have had rather extensive programs of control of roadside weeds and brush with

herbicides, but many others are just starting limited field trials or merely giving initial consideration to the use of herbicides in highway maintenance.

The committee's preliminary report last year was an endeavor to stimulate interest, to exhibit what has been done in a few specific states, and also to acquaint those states anticipating such work with various methods that had been employed, materials used, rates of application, costs, and recommendations.

WEED CONTROL CONFERENCES

To continue to function adequately we believe that we should take full advantage of the services of the various weed control conference research coordinating committees, utilizing these organizations to select and screen material for presentation at the Highway Research Board. Work actually done along highways and similar areas would be reported to the weed control conference, particularly if the agencies concerned were urged to do this through the medium of the Highway Research Board.

The weed control conference research coordinating committees would recommend a policy on the various phases of highway herbicidal control based on such reports and specifically directed at highway needs. By this procedure we could be assured of a competent analysis, by the best men in the country, of reports of work by individuals and individual agencies which would give assurance that presentation at the Highway Research Board would not be merely the opinion of one, or of a few men, whose conclusions might be erroneous.

The officers of the four weed control conferences were contacted and they have indicated their willingness to cooperate in directing more attention of the conference to herbicide work on highways and their agreement to have the research coordinating committee establish policies for such work. The value of this procedure will depend largely upon the amount of work or tests reported to the weed control conferences.

The following is New York State's report to the Northeastern Weed Control Conference: (2)

HERBICIDE WORK ON NEW YORK STATE HIGHWAYS

Broad-Leaf Weed Control

The control of dandelion and broad-leaved plantain in a turf predominantly red fescue by one application of 2,4-D has been found to reduce materially the amount of mowing necessary on state highways on Long Island.

Two lb. of the acid equivalent of 2,4-D in the ester form were applied with water on each acre treated. Two rates of application were used, 35 gal. of mixture being used on each of about 5 acres and 15 gal. of mixture on each of about 70 acres. The spraying was done with a small pump operating at 30 psi., using OC tips, at a rate of travel of 5 or 10 mph.

Results were satisfactory with both treatments.

Control of broad-leaved weeds by hormone spraying was started on June 22, 1954, in the Hornell area on 185 miles of highways. Two lb. of the acid equivalent of 2,4-D in 15 gal. of water were applied to an acre with a small pump operating at 30 psi., using OO tips, at a speed of travel of about 11 mph. A swath approximately 10 feet wide was sprayed.

Chicory, which was almost in the flowering stage, and ragweed were satisfactorily controlled. A later spraying was required to control Queen Ann's lace.

Cost of the work was found to be $5.04 for material and $1.14 for labor, a total of $6.18 for each mile (both sides) treated. One mowing was eliminated in the areas treated.

Brush Control

Poison ivy was sprayed along 207 miles of highways in 1949 and 1950, using 2,4-D ester and fuel oil No. 2 in the proportion of 1:22. All leaves were thoroughly wetted with the mixture. Over 90 percent kill was obtained. No retreatment has been necessary.

Poison ivy was sprayed with 2,4-D ester in water or oil in the proportion of 1:22 in July and August, 1951. Oil was used as the carrier on about 12 miles of highway and water as carrier on about 7 miles. All leaves were thoroughly wetted with the mixture. Over 90 percent kill was obtained, and no retreatment has been necessary.

Poison ivy was sprayed with 2,4-D ester in water in the proportion of 1:22 in the summer of 1953. All leaves were thoroughly wetted with the spray. Over 90 percent kill was obtained.

Poison ivy was sprayed in August and September, 1954, with 2,4-D and water in the proportion of 1:200. A top kill of over 90 percent was observed in October. Further observations will be made to determine root kill.

From July 6 to July 30, 1953, heavy growth of poison ivy along about 20 miles of highway on Long Island was sprayed, using knapsack equipment. Three different mixtures were used, each in about the same total area and in sufficient amounts to wet all leaves.

Mixes Used

	Fuel oil #2	Water	Ester of 2,4-D	Ester of 2,4,5-T
Mix 1	48 gal.	---	1 gal.	1 gal.
Mix 2	---	48 gal.	1 gal.	1 gal.
Mix 3	---	48 gal.	2 gal.	---

Both hormone materials contained 4 lb. of the acid equivalent per gallon. On August 10, 1954, the effect of mix 1 was judged to be satisfactory and the effect of mixes 2 and 3 unsatisfactory. Additional treatment was required even in the area treated with mix 1.

This job required 58 man-days of work. A similar job done July 15, 1954, with relatively poor motorized equipment on about 4 miles of highway required two man-days of work. From these figures it may be judged that knapsack-equipment type of spraying requires almost six times as much labor as spraying with motorized equipment. However, selective spraying can more readily be done with the knapsack equipment.

Test treatments of brush to prevent snowdrifting were made near Cranberry Lake in 1949. About 17 acres of heavy brush had been cut during the summer months, and the stumps and stubble were sprayed during mid-October. Every effort was made completely to saturate each brush stump. The material used was the ester form of 2,4-D in fuel oil. The amount of 2,4-D applied to an acre was varied, the least amount being 1.45 gal. per acre and the greatest amount 4.70 gal. per acre. Using a small pump giving pressure of 30 psi. on a truck, two men sprayed about 1.75 acres in a day, using 50 gal. of spray mixture.

There was little apparent difference in results due to the different treatments. All were considered unsatisfactory.

Northwest of Watertown a heavy stand of brush and small trees consisting of chokecherry, gray dogwood, staghorn sumac, arrowwood, elm, sugar maple, ash, and thornapple was cut along 5 miles of road during February and March of 1953. This brush was about 25 feet in width on each side of the road. The stumps were sprayed in April of that year, using 12 gal. of 2,4,5-T ester, 26 gal. of 2,4-D ester, and 760 gal. of fuel oil. A foreman, truck driver, and four laborers accomplished the job in five working days, using knapsack sprayers.

There was complete kill of 50 percent of existing stumps, and some effect on the remainder was evident. The effect on staghorn sumac was unsatisfactory because of root sprouting. Repeated applications are necessary to control it.

Based on the work done in this area on brush control, the following conclusions are drawn:

Follow-up foliage spray treatments were found to be essential to obtain satisfactory control.

Control of such susceptible species as chokecherry, especially when the spray is applied to foliage, can be obtained with 2,4-D and fuel oil in the ratio of 1:20, but for average brush control in the area equal parts of 2,4,5-T and 2,4-D are required for basal dormant and stump treatment. Stump treatment may be made immediately after cutting or at any time before sprout growth starts.

Brush cutting followed by stump treatment is preferred to avoid "brownouts." However, this method and basal treatment require more materials and more expensive materials, more labor and care in application, and seem to have been less effective than the foliage-spraying method.

Foliage spraying is effective from the time leaves are fully developed until late August, with best results from May and June treatments. All leaves must be thoroughly wetted. The hazard to vegetable gardens in the Watertown area is at a minimum in May.

A mixture of two parts 2,4-D and one part 2,4,5-T with 20 parts of carrier is apparently as effective as equal parts of the two materials for average brush control by foliage spraying. Water mixtures have not been quite as effective as oil mixtures.

Less material is used in spraying spotty or intermittent growth with knapsack sprayers than by blanket treatment by power equipment. Labor costs are higher. Selective control is possible with knapsack sprayers.

Chemical Mowing

This term is used to mean the reduction of top growth or kill by chemicals of all vegetation to reduce or eliminate mowing by hand or equipment.

Weedkiller 7B

Weedkiller 7B and oil, the material found to be most satisfactory in those tests, have been used each subsequent year to control vegetation along guardrails, posts, and similar structures. Two treatments each year have been required, the first being made about the first of May, before top growth has developed very far, and the second treatment about the first part of July as required by regrowth or new growth.

This material, manufactured by General Chemical Co., is an aromatic oil

containing 5 lb. of trichloroacetic acid and 0.75 lb. of pentachlorophenol. The standard treatment was 5 gal. of this material mixed with 35 gal. of fuel oil supplied to an acre. A 3-foot swath along structures was sprayed. A light vehicle with a small pump providing about 30-psi. pressure was used to permit sharp turns necessary to spray signs at intersections. The speed of operation while spraying was generally about 15 mph., although successful results were obtained at 30 mph., a speed considered too fast for safety.

Control has been satisfactory in the treated areas for the four years of chemical treatment except in areas of silt loam first treated in May, 1954, and except that weeping lovegrass was found to be very resistant. Cost of the material and labor has been about $25 per treated mile per season. Hand mowing to provide comparable results would have cost about $100.

In July, 1954, three different treatments of the silt loam areas were tried as follows:

Amounts per acre

Gal. 7B	Gal. Fuel oil #2	Gal. mix
10	10	20
10	20	30
10	30	40

Control was satisfactory with each treatment.

Weedkiller 7B was used along about 90 miles of highways. The mixture consisted of one part of 7B, seven parts of fuel oil, and 1½ lb. of the acid equivalent of 2,4-D and was applied at about 40 gal. per acre and at a speed of about 15 mph. The first application was made on May 17 and 18 and gave satisfactory control until the last part of June when the second application was made to control regrowth which had reached an average of 6 to 8 inches in height. In the second treatment 2,4-D was not used, and the mixture was applied at about 47 gal. per acre. The second treatment gave satisfactory control for the remainder of the year. No mowing was necessary except where the dead tops of orchard grass which were higher than 8 inches at the time of the first spraying were considered unsightly.

Staklor

On December 8 and 9, 1953, Staklor was applied at rates of 100, 200, and 430 lb. per acre to test its value for chemical mowing. On April 30, 1954, and during the following summer, results were judged unsatisfactory.

Staklor was applied at rates of about 100, 200, and 430 lb. per acre in the vicinity of Roslyn, L. I., on April 30, 1954, and in the Hornell area on April 28, 1954. At the end of September, control was judged unsatisfactory in both areas.

Telvar W (CMU)

Telvar W was applied at rates of 10 and 20 lb. per acre in the vicinity of Jericho, L. I., on December 8 and 9, 1953, and at about the same time in the Hornell area. Considerable difficulty in application was experienced in the Hornell area because of the low temperature at that time. Control at the higher rate was judged satisfactory in both districts in the spring and during the following summer. Control at the lower rate was unsatisfactory.

Telvar W was applied at the rates of 10 and 20 lb. per acre in the vicinity of Roslyn, L. I., on April 30, 1954, and in the Hornell area at about the same time. At the end of September, 1954, control at the higher rate was judged

satisfactory. Control at the lower rate was unsatisfactory in both areas.

From July 6 through 9, 1953, Telvar W was applied around 650 traffic signs on 100 miles of road in the Hornell area at the rate of about 50 lb. per acre. In the spring of 1954, the result was still satisfactory, and an additional 1,940 signs on over 400 miles of highway were treated at a similar rate. During the summer of 1954 a few weeds, such as dandelion, began to come into the 1953 treated areas but the control was still satisfactory. Control by the 1954 treatments was satisfactory.

Cost data using Telvar W have not been obtained, but it is believed that this material might prove practical because only one spraying operation a season is required. Therefore, an overall saving might result even though the cost of material at the 20-lb. rate would probably be about $60 for each acre treated.

Dalapon

Dalapon was applied at rates of about 3, 6, 9, and 18 lb., together with 2 lb. of the acid equivalent of 2,4-D, an acre in the Babylon area on June 15, 1954. The turf which had been mowed shortly before treatment consisted, for the most part, of red fescue. Unfortunately, in error, some mowing was done subsequently within the test area, but on September 28, 1954, the topgrowth of vegetation in the area treated with 18 lb. of Dalapon per acre was still brown and no high regrowth had occurred. Therefore, the results of this treatment were considered satisfactory.

Dalapon was applied at rates of 3, 6, 9, and 18 lb. an acre in the Hornell area on June 21, 1954. These areas had been mowed on June 7 and 8. The grass population included orchard grass, red fescue, Kentucky blue, redtop and quack grass. Browning of the grass leaves occurred soon after treatment at all rates. At the lowest rate the tips of leaves seemed to be affected and recovery was apparent 10 days later. At the 18-lb. rate, practically all the topgrowth seemed to be killed.

Two subsequent treatments with 2,4-D were made to control broad-leaved weeds.

Forty-three days after application, red fescue was still completely brown but appeared to be alive. Kentucky blue and redtop had not been affected as severely. Orchard grass was affected the least and appeared to be two-thirds of the way back to normal.

At the end of September, about 100 days after treatment with Dalapon, the results from treatments at 3 and 6 lb. per acre were unsatisfactory, while the results from treatments of 9 and 18 lb. per acre were satisfactory. The areas treated at 9 and 18 lb. per acre were still browned in appearance. All grasses were recovering in the area of the 9-lb. treatment, while only orchard grass and timothy were recovering in the area of the 18-lb. treatment.

Since these tests were installed late in the season, comparison with the results of the treatment with Weedkiller 7B and Telvar W cannot be made, but the satisfactory results obtained, together with the low cost for material, indicate the desirability of further study with Dalapon. Even at the rate of 18 lb. per acre, the cost of material would be only $9 an acre at present prices.

The fact that Dalapon is soluble in water is a definite advantage in the practical application of this material as a spray.

Maleic Hydrazide

Maleic hydrazide (40 percent) was applied at rates of 6 and 10 lb. per acre, together with 2 and 3 lb. of the acid equivalent of 2,4-D per acre on April 23, 1952, in the Babylon area. On May 13, 1952, another treatment at rates of 10, 20, and 30 lb. per acre was made on a nearby highway. Mowing on these highways had

been done when top growth of turf had reached a height of about 6 to 8 inches, and the height of cut had been 3 to 4 inches. There was no reduction in the number of mowings due to the reduction in growth of grass. However, where 2,4-D had been used, the control of broad-leaved weeds did result in a reduction in number of mowings required.

Maleic hydrazide (40 percent) was applied at rates of 18, 36, and 72 lb. per acre in the Hornell area on April 14 and 15, 1953. It had been customary to mow about two or three times a year. The vegetation was predominantly red fescue with some Kentucky blue, redtop, and clover. Temporary browning of the grass was caused by the 72-lb. rate. A very wet spring followed. Subsequently there was some retarding of grass growth but this was so slight that it did not reduce the number of mowings required.

Borascu --- Polyborchlorate

In the Hornell area, test installations of Borascu and Polyborchlorate were made in July, 1954. Although results were satisfactory, the large amounts required made application impractical with the equipment available in the district. Costs of the treatment would be excessively high when compared with the use of other materials reported.

WEED CONTROL PROGRAM

Members of this committee have been successful in getting on only the Northeastern Weed Control Conference program this year. Harry Iurka presented the following paper which we hope will serve as a pattern to other weed control conferences as to the type of topic we would like presented in each of the other conferences and also as a guide for the kind of summaries we would like from the Research Coordinating Committee. (3)

HIGHWAYS AND HERBICIDES

"Greater efficiency is being demanded of responsible highway personnel today. This is due to increased labor costs and to the enormous increase in roadside areas on our constantly growing highway systems, most particularly in the construction of modern primary highways with wide rights of way. The development of chemicals to control vegetation in recent years has provided the means for more efficient roadside maintenance. Use of these chemicals by state highway departments in the northeastern section of the United States has not, however, kept pace with their widespread use in agriculture and industry.

"In considering the use of chemicals to control vegetation on roadsides, highway officials are concerned about three factors—safety, economy, and appearance. Of these, the safety of not only the traveling public but also of personnel is of primary importance and warrants greater rather than less expenditures for any specific improvement. Highway safety can be improved by efficient control of vegetation interfering with sight distances on horizontal curves, by efficient control of vegetation to assure continuing visibility of signs and guardrails, and by control of poisonous plants.

"Considerable cost data indicating the economies made possible by the proper use of chemicals for roadside maintenance have been published. (4, 5, 6, 8).

"Mowing is a continuing and costly operation. One excellent cost study (4) reports 4.3 acres mowed in a 9-hr. day by a sickle-bar tractor mower and 1.75 acres by a small power mower. At $1.50 per hr. for labor, this would be a cost of over $3 per acre for the former and over $7 for the latter for labor alone. One spraying of 2,4-D has been done for less than $3 and acre for labor and materials (5, 6).

The effect of this treatment which materially reduced the number of mowings necessary lasted more than one year.

"Brush can be controlled by chemicals at a cost comparable to that for one or two cuttings by hand, the cost of subsequent control being negligible when chemicals are used and continuing when cutting is practiced (6).

"Mowing of vegetation around structures such as guardrails and posts, whether by hand or by equipment, is expensive. Hand mowing has cost almost $100 an acre (4) or $35 for a swath 3 feet wide along one mile of guardrail. At least three such mowings at a labor cost of over $100 for one season would be required to give results comparable to those obtained with chemicals (5, 6). Since reporting tests of several materials for this purpose to the Northeastern Weed Control Conference (7), one agency has used the highest rated material during the past four years at a cost of less than $25 a season for labor and materials for each mile treated (6). Additional study is needed in this field because of the development of new materials such as Telvar W, Telvar DW, and Dalapon.

"Appearance, although least important, is actually improved by intelligent use of available chemicals for improving safety and reducing costs. 'Brownouts' are not necessary.

"Recent reports from the state highway departments of 12 and 13 states included in the Northeastern Weed Control Conference area indicate that nine of those reporting have a herbicide control program, that four have programs embracing broad-leaf weed control, brush control, and chemical mowing. Five report investigational work.

"In one of the states included within this conference a board of water supply has forbidden the use of 2,4-D to control broad-leaved weeds within a watershed area because of the hazard of water pollution. It is believed that such an objection to the use of plant hormones is similar to the objections voiced by beekeepers and some conservationists to the control of roadside vegetation with herbicides. An authoritative statement of policies on these subjects is needed.

"There is at present a lack of agreement on necessary procedures. One agency has used 100 gal. of water an acre as a carrier for 2 lb. of 2,4-D acid equivalent for the control of broad-leaved weeds, while another agency has reported satisfactory control with as little as 12 gal. of water an acre. There is also a lack of suitable inexpensive equipment for use on the various phases of herbicide work along highways.

"There appears to be need for an aggressive educational program to acquaint highway officials with the value of intelligent use of herbicides on roadsides. Tests have been made and work has been done on a large scale which can be used to show that safety can be improved, maintenance costs lowered subsequently, and appearance improved. There is need for continued study of new materials and for the development of more efficient methods and equipment."

EXCERPTS

The committee felt that excerpts from the reports of the various weed control conferences should be made available in this report, noting those phases of herbicide work which are related to roadside requirements. Here again, information pertaining to highway use was very meager.

The summation of such excerpts from the Northeastern Weed Control Conference practically covers all that is to be found (5).

HERBICIDES

Herbicides have been proved a useful tool in performing certain roadside maintenance operations satisfactorily and economically. These chemicals fall into two main classes: (1) contact, which affects all kinds of vegetation, e.g., Ammate and oil; and (2) translocated, which in certain concentrations affect certain species and leave others unharmed. In this last class are the hormone-type materials, 2,4-D and 2, 4, 5-T. They are not poisonous to animals. Since minute quantities, even of the vapor carried in the atmosphere while using volatile forms, can injure nearby susceptible plants, low-volatile forms should be used. Even these should not be used in the vicinity of valuable susceptible plants during the growing season. Small particles of sprayed mixtures may be air-borne considerable distances. Proper precautions should be observed to avoid drift of the spray by wind; pressures and spray tips should be selected to prevent mist. Equipment used for spraying herbicides should not be used for other spraying unless all the precautions recommended by the manufacturer of the material for cleaning equipment are observed.

The following data on brush and weed control have been developed not only from actual study under this project but from recommendations of the Research Coordinating Committee of the Northeastern Weed Control Conference. The data on chemical mowing are based on studies by the Department.

A. Brush

(1) Costs. Brush-control cost data are necessarily indefinite since sites and character of vegetation vary. Comparative cost data, however, have been assembled by this study and are presented herewith:

COMPARISON OF COSTS PER ACRE OF VARIOUS BRUSH-CONTROL METHODS

Method	Cost per acre
Bulldozing	$ 10 to 25
Hand cutting, each year	25 to 150
Ammate spraying	300 to 600
Hormone spraying	
1st year, 75% control	75 to 150
Retreatment 2nd year, 95% control	75 to 150
Subsequent retreatment when necessary	10 to 15

Ammates spraying requires large quantities of water, and it is corrosive. It affects all plants sprayed, while the hormone-type materials such as 2,4-D and 2,4,5-T used at the appropriate rates do not kill grass. Two treatments with these hormone-type materials give control for at least five years. Based on the above cost data, one hand cutting followed by two sprayings during the next two years, which would result in 75 percent control the first year and 95 percent control each of the next four years, would cost from $175 to $450. Annual hand cutting for five successive years would cost $125 to $750. Moreover, the cost of control after the five-year period with the hormone-spray system would be a fraction of the cost of continual hand cutting.

(2) Equipment. The character of the vegetation and the requirements of the site dictate the type of equipment to be used. High-pressure and large-volume spraying equipment may be used for large areas where control of the spray is not important. Low-pressure (less than 75 psi.) equipment may be used where careful control of the spray and avoidance of drift are important and where distance of spraying is short. Knapsack equipment may be used for spot spraying and in areas

not easily reached by power machines. Small carbon dioxide cylinders provide an economical, convenient means of obtaining pressure for knapsack tanks.

(3) Material. The low-volatile ester forms of 2,4-D and 2,4,5-T should be used. Most of the materials commercially available contain 4 lb. per gal. of acid equivalent, i.e., the active ingredient.

(4) Method. Low brush and plants such as poison ivy may be treated with herbicides without cutting. Tall brush, however, requires unnecessarily large amounts of chemicals, and the dead brush looks unsightly and is harder to cut than when green. It has proved more economical to brush out such larger material before applying the herbicides.

The herbicide may be sprayed either on the foliage during the growing season or as a basal spray on stems and stumps during the dormant season. Foliage spraying should be done when plants are in full leaf and actively growing, preferably during June and July, although the season may be extended two weeks each way. Application should be thorough, wetting all leaves, stems, and trunks. Basal and stump spraying may be done at any time of the year. The material may also be brushed on stubs and stumps. For brush up to a height of 6 feet, the stems should be thoroughly covered to a height of 12 inches above the ground, being sure to cover exposed roots and crowns. For taller brush, the treatment should be proportionately higher. The entire treated areas of leaves, stems, and trunks should be so thoroughly wetted that some of the spray runs off. Although availability of labor should determine largely which system to use, consideration must be given to neighboring susceptible plants. It would, for example, be disastrous to use a foliage spray on brush adjoining a field of tomatoes, beans, or peas. A dormant basal spray would cause no damage since the volatile material would have dispersed by the time these crops were growing.

The following table gives the formulations for the several methods outlined above. The quantities of 2,4-D and 2,4,5-T which are given in pounds refer to the amount of the contained acid equivalent.

HERBICIDE FORMULATIONS FOR BRUSH CONTROL

Method	Materials & Quantities per Acre			
	Herbicides		Carrier	
	2,4-D lb.	2,4,5-T lb.	Fuel Oil #2 gal.	Water gal.
Foliage sprayed by power equipment	2	2	--	100
Foliage sprayed by knapsack equipment	2	2	25	
Basal spraying	--	12-20	100	
Stump treatment	4-12	4-12	100	

B. Weed Control

(1) Costs. Although broad-leaved weeds often necessitate mowing not required by a growth of grass, they may be controlled by herbicides. This would cost less than $3 per acre, a fraction of the cost of one mowing, with the effect lasting more than one year.

(2) Equipment. Any available low-pressure power equipment may be used for spraying. Low pressure is essential to avoid drift of air-borne particles.

(3) Material. Use of 2,4-D is effective for the control of most broad-leaved

weeds. The ester form penetrates the leaves more quickly than other forms and therefore is not so apt to be washed off by rain following treatment.

(4) Method. Two pounds of the contained acid equivalent of 2,4-D should be applied per acre. The material should be thoroughly mixed in water and the solution, if distributed evenly, may be sprayed on at a rate as low as 5 gal. per acre. Any reasonable speed of application is satisfactory.

WEED CONTROL IN MICHIGAN

E. C. Eckert reports that, in reviewing the proceedings of the North Central Weed Control Conference and also the research report, there was practically no material dealing with the topic of weeds along highways.

As a means of summarizing the weed-control work done along highways in Michigan, four principal objectives are considered.

1. Substitution of chemical spraying for machine mowing, thereby reducing mowing frequency with resultant financial saving.

2. The elimination of weeds as an aid to farmers in the matter of contaminating field crops from weed seed originating in the highway right of way.

3. The improved appearance of the roadsides. In this connection, it is their attitude that mature grass free of uneven-height weeds presents a satisfactory appearance.

4. Reduction in the competition between grass and weeds permitting a more vigorous growth of a grass turf.

To summarize the results of their program, the following points are mentioned:

1. It is their feeling that there is considerable room for improvement in the selective type of herbicides now available. This impression is based on the fact that some weeds are quite resistant to the present type of material and that either a stronger solution must be used or the strength of the concentrated material must be increased. It appears that the most positive control results from early-spring or summer operations. Michigan is experimenting with varying strengths of spray solution and also with combinations of materials; for instance, there appears to be some improvement in the effectiveness of the amine formula of 2,4-D when approximately 1 pt. of 2,4,5-T is added to 100 gal. of water.

2. The equipment used is an hydraulic-type spray rig having a 500-gal. tank and a 35-gpm. pump adapted in such a way as to operate at reduced pressures but still maintain the volume desired. What is needed is a piece of equipment which will spray a wider width without breaking up the spray material too fine and creating greater drift.

3. It has been Michigan's observation that a thorough coverage of the weed is required in order to effect a positive kill.

4. It is the feeling of the majority of road engineers that tall grass should be cut in the autumn to eliminate the possibility of the grass starting a snowdrift situation which might result in excessive snow-removal costs.

OHIO'S HERBICIDE WEED-CONTROL PROGRAM

The 1954 herbicide weed-control program in Ohio included the application of 2,4-D and 2,4,5-T to 6,356 miles of roadside (both sides), or 69 percent of the 9,166.26 miles of rural state highways in 49 of Ohio's 88 counties.

Contract Spray Program

The 1954 contract spray program included three spray applications to the rural mileage in eight counties, plus the same number of applications to US routes 30-30S-30N and 25 across Division 1, for a total of 1,698.12 miles by contract. Contract costs were $43,918.91 plus a $3,750.32 cost to the department for inspectors. This is an average cost of $9.36 per mile per single application, or $28.08 per mile per complete program of three applications.

Mowing on these roads in 1954 cost $106,148.98, or an average of $62.51 per mile per season. In 1953, mowing these same roads cost $147,135.58, averaging $86.65 per mile. Adding the cost of the spray program to the mowing costs in 1954, the total charge is an average of $90.59 per mile for the season with an increase of $3.94 per mile or a net increase of $6,682.83.

Force-account Spray Program

In 41 counties the spray program was carried on by force account and included applications to 4,657.99 miles of state-highway roadsides.

Cost of this program was $76,716.96, or $12.15 per mile per application (both sides).

Mowing these roads in 1954 cost $611,362.54, or $91.42 per mile. In 1953 the mowing costs of the same roads were $627,271.41, or $93.80 per mile. However, adding the cost of the spraying to the mowing increased the 1954 costs by $26,135.36 over those of 1953 for an average increase of $5.61 per mile.

Comments

Even though mowing has been reduced after the first or second year of weed-spray application, the combined costs of mowing and spraying were greater in 1954, on the average, than the straight mowing program of previous years. This may be due to any, or all, of the following reasons:

1. Labor rates were increased approximately 5 percent over 1953.

2. Lack of coordination of mowing and spraying program with resulting failure to reduce mowing.

3. Shortage of equipment of proper design for a large-scale spray program.

4. Inexperienced spray operators and too much supervisory charges.

5. Improper spray mixture. In 1954, 4 lb. of acid equivalent material was purchased for the first time. Spray mixture may have been mixed on the old formula, resulting in the use of too much costly material.

However, for any long-range predictions, reference must be made again to Knox County. Here the fourth year of spraying was completed in 1954. Mowings have been reduced from the standard mowing practices for several years, but this year it has been possible to reduce the amount of spraying too. In a long-range spray program this must be the ultimate goal.

Within the department there is a mild controversy as to which is better—contract spraying or force account spraying.

Summarizing:

For Contract Spraying:

1. Lower spray costs (on the average for a three-spray program)
2. Greater savings on mowing costs for counties sprayed by contract

3. Speed of application (about three days per application)
4. Claims for damage handled by contractor

Against Contract Spraying:
1. Spotty application (first-year complaints)
2. Failure to cover entire right of way
3. Percentage of kill not as high as by force-account work

For Force-account Spraying:
1. Closer control of operation
2. Application to all needed parts of right of way
3. Heavier applications where needed

Against Force-account Spraying:
1. Higher costs
2. Longer tie-up in operation with men and equipment involved
3. Lack of proper equipment

Maleic Hydrazide

The area treated was a heavy bluegrass sod consisting of 3.4 acres. MH40 at the rate of 10 lb. per acre was applied, plus 1½ gal. of 2,4-D. A portion of this area was treated at the rate of 15 lb. per acre with very little visual difference in results.

The area was treated on April 14 and was not mowed until the middle of August and then only to eliminate some weeds which were not present at the time of application. However, most weeds were kept under control by the 2,4-D in the initial mixture. In the past season it had been necessary to mow this area from five to seven times.

Some browning was noticeable but it was not objectionable. With the fall rains this area began to grow again and had a very healthy grass color. This gave effective control for approximately four months.

The total cost was $102.50 ($72.05 for material). Even at this rate there is a definite saving as men and equipment used on mowing can be used for other duties. Mowing cost on other sections of this road was $95.00 per mile. With MH40 remaining at its present price, we feel that it is feasible and economical to use it only on areas that require more than four mowings per season or on areas inaccessible to mowing equipment.

HIGHWAY WEED CONTROL IN CALIFORNIA

Cooperative agreements is another phase of highway weed control. From a practical standpoint, it has been found in many cases that our county department of agriculture can more satisfactorily accomplish the control of noxious weeds on state highways than the state department of highways.

The county agricultural commission can enter into a cooperative agreement with other agencies such as the state highway.

PERMITS AND POLICIES

Problems have arisen in the relation of roadside vegetation to herbicide work of wire-using utilities on lines parallel to highways.

Permits in states such as Louisiana, Virginia, North Carolina, and Ohio are required by any agency desiring to do any spraying within the highway right of way. The use of chemicals on our highways is a serious undertaking; companies should know and agree to assume responsibility, and such permits should be signed by the

proper officials. In Louisiana the permit is merely a detailed program of the specific work to be done although it does embody the points of the policy agreement.

In North Carolina a policy was adopted after a series of conferences was held with various civic organizations, utility representatives, and other interested parties.

SUGGESTION

It is suggested that at least one individual familiar with weed research and development from each of the four regions in the United States be added to our committee, either as a member or as associate member to assist us in our weed-control problems associated with highway maintenance.

REFERENCES

1. "Vegetation Management for Right-of-Way and Roadsides," Frank E. Egler, Department of Conservation and General Ecology, American Museum of Natural History, Smithsonian Institute, Washington, D. C.

2. "Herbicide Work on New York State Highways," Curtis, Iurka, Moller, Secor, and Ward.

3. "Highways and Herbicides," H. H. Iurka, New York State Department of Public Works.

4. "Connecticut Highway Maintenance Production Study," Highway Research Board Special Report 8 (1952).

5. "Roadside Vegetative Cover Research Project," Progress Report, Landscape Bureau, New York State Department of Public Works (March, 1954).

6. "Roadside Vegetative Cover," Final Report, Landscape Bureau, New York State Department of Public Works March 31, 1954 (On press).

7. "Progress Report on the Use of Herbicides to Eliminate Hand-Mowing under Guardrails and around Traffic Signs along New York State Highways," Iurka and Pridham, "Proceedings," Fifth Annual Meeting, Northeastern Weed Control Conference (January, 1951).

8. "Preliminary Report of Project Committee on Mowing and Herbicides," Wilbur J. Garmhausen, Chairman, Annual Report, Committee on Roadside Development, Highway Research Board, Washington, D. C., (1954).

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