HERBICIDES for ROADSIDES

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The continuing rapid progress in the field of weed control by herbicides has been characterized by C. J. Willard thus: "If any of you are waiting to learn about modern weed control until the situation clears up and settles a bit, I can assure you that no such comfortable period is anywhere in sight."

Increasing interest by state highway agencies is indicated by the data gathered in a recent survey of the northeastern states for a report to the Weed Control Conference of that area. Ten of the 13 states are doing herbicide work, and a majority of them report large amounts of work done. However, there has been little reporting of this work. There is a much greater volume of work being done in agriculture, together with much experimental study, and this is being reported to the weed control conferences. Much of this information is applicable to the use of herbicides on roadsides in the three main categories in which highway engineers are interested. These are brush control, broad-leaf weed control, and "chemical mowing," which for the present purposes may be considered the economical control of all vegetation to eliminate expensive mowing, particularly along structures, either by suppression of growth or by elimination of growth.

Highways present certain special problems which are not being studied satisfactorily by others. Generally, the weed population along any highway is composed of various species. Material and method for control must take this into consideration. In many cases, control of weeds to keep the tops down below desired mowing height, rather than to kill, may be considered satisfactory. Chemical mowing is perhaps peculiar in its use to roadsides. Ideal equipment for herbicide treatment of roadsides is not presently generally available. Highway requirements are quite different from those for agricultural, turf, and commercial line-clearance requirements.

Each of the weed control conferences in the country would welcome the participation of highway personnel in its program. No special invitations are necessary. If highway agencies would avail themselves of this opportunity, the exchange of information would make available to all the valuable studies of each, and there would also be available the aid of experts in allied fields. Less duplication, more effective work, and greater efficiency would be a natural result. Until such time as highway agencies can and will take an active part in the weed control conferences, it would seem that this committee must serve directly for such cooperation.

The author has been provided to date with the preliminary reports of the coordinating committees of only two of the weed control conferences of this year, that of the northeastern states and that of the Western Weed Control Conference, the latter in excerpt form. Because of the lack of information, this report must, of necessity, be limited in scope. However, the purpose here is to report on general considerations on which there is wide agreement and recommend that, for specific considerations, reference be made to local weed control conferences, experiment stations, and other accredited sources with experience of the particular problems of their area.

GENERAL

Present Situation

The economies possible by the proper use of chemicals for weed control are

generally accepted. For those few who have not had their own proof, it is suggested that reference be made to the data presented in this committee's report of 1955. More and more new chemicals are being supplied, each with its specific purpose or use. It is no longer the solution to spray broadcast the now well-known 2,4-D. Consideration should first be given to the species of plants, whether herbaceous or woody, which are to be controlled; the timing of spraying in relation to stage of development of plants; the specific soil and climatic conditions; the time of year of treatment; the susceptibility of adjacent plants; the degree of control desired; and the relative costs before deciding on which material or materials are to be used and the method to be chosen for control. Even more specific considerations may be expected in the future.

Precautions

Any one herbicide will almost always fail to kill some weeds. There is an added responsibility not to upset the balance of nature to such an extent that a surviving weed which cannot be controlled will take possession of the vegetation. Long-accepted cultural methods will always be a necessity. At many past meetings and in informal discussions consideration has been given to the importance of the necessary precautions in the use of the new powerful herbicides to prevent undesirable damage to vegetation, and yet there are now several state highway agencies prohibiting the use of these materials for commercial line-clearance purposes along highways. The results of improper treatments along highways, have probably been noticed. This is quite unnecessary. There are materials and methods which may be effectively used without sacrificing economy or appearance along the highway and without damage to adjacent vegetation. Two of the most important factors in preventing this damage and in assuring effective control are adequate planning and adequate supervision by informed and alert personnel. If there is brush to control along a roadside adjacent to an orchard, it would be damaging to spray with the phenoxy materials during the blossoming period. Yet it has been done. The necessary control would have been more effectively achieved, in all probability, without such damage by means of winter basal or stump treatment.

BRUSH CONTROL

With the experience gathered from the past 10 years, there is now available general agreement on the procedures and materials for effective and economical control of brush. It is now generally accepted that there are several methods, each with its own value and application. It is generally agreed that a combination of these methods is probably the most effective means of control.

In planning a program, certain factors must be considered. First and most important is an analysis of the species which is to be treated. A growth of alder will certainly not be treated the same as a growth of scrub oak. The material and method used for alder would not touch the scrub oak; the material and method for scrub oak would be too expensive for treatment of alder.

Second is the necessity of considering the precautions required to assure no damage to adjacent vegetation. Spraying in summer obviously should not be done if there is danger of drift or of the volatility causing damage. If there are nearby very susceptible plants, it will be necessary to limit the treatment to dormant stump or basal treatment.

Third is resulting appearance. If it is desirable to prevent any "brown-out" at all, foliage spraying will definitely be out, and it might be that basal treatment would be eliminated by this consideration. It should be noted here that a

treatment in late summer, resulting in the dying of leaves, might well be correlated with the normal fall period of coloration.

Fourth is a consideration of economy not of just a treatment but of the treatment or treatments necessary for the degree of control desired. There is general agreement that foliage spraying is cheaper than other types of spraying and that cutting and stump treatment is more expensive than either of the other two methods. Data presented by Dr. Bramble in this symposium indicate the difference between the several treatments.

Fifth is consideration of such other miscellaneous factors as availability of labor, equipment, and weather.

Regardless of the method used, successful results will be directly proportional to the care and thoroughness of application. There is general agreement that the concentration of the mixture is not as important as the volume of material applied. The recommendations of the Northeast Weed Control Conference on the basis of biological activity have not changed greatly since 1953. A summary is given in the following table.

WOODY PLANT CONTROL

Type of Application	Chemical	Lb.*/100 gal. unless Specified	Comments
Foliage spray	2,4-D 2,4,5-T or D+T	4 in H_2O	Limit water sprays to growing season.
Cane foliage spray	See above	6+10-25 gal. oil+H_2O	All of lower 4/5 of stems must be wet by emulsions.
Basal spray	2,4-D + 2,4,5-T 2,4,5-T	8-16 in fuel or diesel oil See above.	Any season. Apply to runoff from base up to 10-12 in. See above.
Stump treatment	2,4-D+ 2,4,5-T or T	8-16 in oil	Any season. Spray over-all to runoff.
	Ammate	4-6 lb./gal.H_2O	
Frill girdle	Ammate	Place in overlapping notch cut around base.	For trees 3-4 in. d.b.h. or over.
	2,4,5-T	See above. 4 in fuel oil.	See above.

*Of active ingredient.

Foliage sprays are usually applied with power equipment at high pressure. They are less costly than other methods, particularly where dense brush is to be treated. The relationship of quantity of spray mixture applied to degree of control obtained is demonstrated by reports of work involving this method. As little as 5 gal. per acre has given a top kill of hardwoods considered satisfactory for the release of young evergreen plantations. Root kill, however, requires a thorough saturation of leaves and stems, which means volumes of the order indicated hereinafter. Early regrowth of cut brush is harder to kill with foliage spray than when it has reached some larger sizes after cutting. Spraying should not be done until the leaves reach full development and should not continue beyond two weeks

before the first frost. Brush 4 to 6 feet high will require, approximately, for heavy density, 150 to 200 gal. per acre; for light density, 75 to 100 gal. per acre.

Oil-water mixtures are considered more effective. Some authorities consider the oil-water as a form of basal spraying and state that this is the most versatile type and gives as good control as any of the other methods. With this method, full coverage of base, stem, and lower four-fifths of each plant is essential. The spray should completely encircle the plant, with particular care being exercised to spray the stems until runoff occurs. One authority recommends 4 to 6 lb. of the mixed hormones in an acid form in 10 gal. of oil and 90 gal. of water, which is applied at high pressure to brush from 4 to 6 feet high at the rate of approximately 175 to 250 gal. for brush of heavy density and 75 to 125 gal. for brush of light density.

Basal sprays should be applied to the bases of stems 10 to 12 in. up from the ground line so that the entire circumference of each stem is wetted with an amount to ensure runoff. This treatment may be made at either the dormant or the growing season, but summer treatment appears to be best for root-suckering species. This is one of the most effective techniques for root kill on most woody species. It is also highly selective and therefore desirable for use where certain species are to be saved. Basal spray in summer is better than in winter because it is obvious which plants are dead and which are alive. Several authorities state that this method is commonly used as a follow-up spray when heavy brush population has been reduced by foliage spray. Application is at low pressure (50 to 75 psi.) and, for brush 4 to 6 feet tall, heavy density, at a rate of 90 to 125 gal. per acre; light density, 30 to 50 gal. per acre.

Stump treatment. Tops and sides of stumps should be soaked until runoff occurs. This method is effective on most species and is particularly promising on white ash. Effective stump treatment in winter time is very difficult because of the problem of seeing not only stumps but also seedlings and sucker growth of small sizes.

One authority states that stump application can be made at any time of the year but that best results at lowest cost are obtained when treatment follows immediately after cutting and that better results are obtained on stumps cut very low. Application is made at low pressure. Recommendations for volume of application are lacking, but it is known that enough should be applied to ensure runoff on all sides of the stump to the crown.

New materials. A new herbicide, amino triazole, shows considerable promise, although observations are limited, for the control of specific plants including basswood, ash, oaks, particularly scrub oak, and poison ivy. Unfortunately, results have not been satisfactory when this material was mixed with 2,4-D and 2, 4, 5-T. Other chemicals which may become more important to us for brush control are Ammate X, which is an oil-water emulsion; HC 1281; Telvar; Kuron; Propon 4; and sodium 2,2-Dichloropropionate, which is promising as a control for coniferous species.

BROAD-LEAF WEED CONTROL

It is assumed that the purpose of broad-leaf weed control on roadsides is primarily the reduction of the number of mowings necessary. If this is the case, the reports from the weed control conferences on the control of "Herbaceous Perennial and Biennial Weeds," "Permanent Pastures," and "Turf" may be referenced for agreement as to materials and the best methods of control of those plants which are

found on the roadsides to be treated. There is general agreement that 2,4-D and MCP (2,methyl-4-chlorophenoxyacetic acid) used at the rate of from $\frac{1}{4}$ to $1\frac{1}{2}$ lb. per acre provides control of most of the perennial and annual weeds. It is beyond the scope of this report to itemize the exceptions in detail. It may be desirable to increase this amount somewhat to allow for faulty application or the occasional more resistant species encountered along roadsides. The Northeast Weed Control Conference does not recommend any specific quantity of a carrier to deliver this quantity of material per acre. One state highway agency uses 15 gal. per acre; another, 100 gal, per acre. Certainly enough material must be applied to give adequate coverage. Type of equipment, density and height of growth, availability of water, and wind velocity will all be determining factors.

One commercial agency sprays three times a year. Others believe that one spraying a year is satisfactory, particularly when the time of that spraying is varied from year to year to care for weeds which develop at different seasons. Again, the specific requirements of the job will dictate the procedure.

Amino triazole is promising for the control of milkweed, a weed which heretofore has not been affected by the usual concentrations and volumes of herbicides used.

CHEMICAL MOWING

Chemical mowing is one category of roadside herbicide work which has not been studied per se by others in the general field of weed control. A considerable amount of study has been done by the New York State Department of Public Works and has been reported to the Northeast Weed Control Conference and the Highway Research Board. It is believed that all the chemicals commercially available in 1951 and subsequently which might restrain growth to a height of 18 inches or less for a period of at least six weeks, or eliminate vegetation for a period of six weeks or more, have been studied, with the exception of the arsenicals, which were considered impractical because of the hazard to animal life. Only one chemical, maleic hydrazide, is known which, it was claimed, would restrain the growth of grass satisfactorily. Although other agencies have reported successful use of this material, it was not successful in trials in several sections and years in New York State. The other type of material is, in effect, a soil sterilant, and the weed control conferences have specific panels on this particular subject. The recommendations of the Northeast Weed Control Conference for the use of boron, chlorates, borate-chlorate combinations, and TCA can be eliminated for the particular purpose because of the relatively high cost and difficulty of application of these materials.

Until this year only one material had been found satisfactory and recommended. This was General Chemical Company's Weedkiller 7B, an aromatic oil containing pentachlorophenol and trichloroacetic acid which, used with oil and applied twice in a season, gave adequate control of all vegetation along structures such as guard rails, posts, etc. Studies of the use of Dalapon and Telvar in the past two years have shown that these new materials are effective. Telvar W and Telvar DW applied shortly before growth begins are recommended by the Northeast Weed Control Conference for soil sterilants at rates of 20 to 60 lb. per acre. Telvar DW is recommended for sandy soils and areas of high rainfall. The Northeast Weed Control Conference and the Western Weed Control Conference also recommend the use of Dalapon for the control of various grasses for several purposes. The New York State Department of Public Works has found that Dalapon, applied at from 20 to 30 lb. per acre in the spring, together with 2,4-D, controls vegetation for the season. The addition of 2,4-D is necessary to control broad-leaf weeds, and in some cases a second application of 2,4-D to control fall weeds may be necessary. Telvar, at 20

lb. per acre applied in the early spring, has successfully controlled all vegetation for one year. A comparison of the costs and characteristics of materials is given in the following table:

	Telvar W	Dalapon+2,4-D		Weedkiller 7B+011	
Cost of material per lb. or gal.	(lb.) $2.94*	(lb.) $0.78**	(gal.) $2.75*	(gal.) $3.89*	(gal.) $0.14*
Pounds or gal. per acre per year	20	30	½	7 x 2	28 x 2
Cost per acre	$58.80	$24.78		$62.30	
Cost per mile 3 ft. wide	$21.34	$ 9.00		$22.56	
Number of treatments per year	1	1		2	
Corrosive, hazardous to personnel, discolors paint and metal	no	no		yes	
Requires agitation	yes	no		no	
Hazardous in application to other plants	yes	yes***		no	
Convenient to reload	yes	yes		no	
Time of application	April	May		May and July	

*Quotations on a New York State letting of 1955.
**Quotation by Dow, June 1955.
***2,4-D fraction.

It may be seen from the foregoing that Dalapon and 2,4-D are outstanding in low cost of material. It may be that the application of Telvar at a higher rate in one year (Telvar W at 20 lb. did not control two years) might provide control for more than one year or that repeated applications would permit eventual lower rate of application so that the cost over a period of years might be less with Telvar than with Dalapon. The second treatment with 2,4-D, which might be required where Dalapon is used, might well be combined with the treatment of shoulders and/or backslopes for broad-leaf weed control in July, thereby eliminating a separate application for the purpose of chemical mowing.

This treatment has been made efficiently at speeds as high as 30 mph., which is of importance in consideration of control along roads with high speed or volume of traffic.

The coordinating committee of the Northeast Weed Control Conference lists a new chemical, Baron, for soil sterilization on early growth at 25 to 40 gal. per acre in sufficient water to wet thoroughly all vegetation and soil. This material is discussed by the New York State Department of Public Works in its report on herbicides this year to the Highway Research Board.

EQUIPMENT

There is a definite need for equipment designed for roadside herbicidal spraying. Other sections than highways of the Northeast Weed Control Conference note

similar needs. Because of lack of more extensive information, this report gives information on New York State Department of Public Work's recent determination of specifications for the purchase of equipment considered satisfactory for the several operations included in herbicide work.

For brush control it is considered necessary to have a unit which will provide high pressure, a pump capacity of at least 35 gpm., a tank holding at least 500 gal. of mixture equipped with agitator and a pressure control valve, live hose reels, and a refiller.

For foliage spraying and basal spraying, high-pressure guns of the quick-shut-off type with quickly adjustable nozzles were considered essential. This equipment will also serve at reduced pressures for the treatment of broad-leaf weeds, with off-center nozzles which will deliver material in an even pattern a distance of 30 ft., provided there is no wind interference. It should be recognized that this is an ideal that cannot be assured. However, the impracticality of boom operation where obstructions are so frequent as along roadsides determines the choice of the lesser of two evils. This equipment operating at lower pressures will also be used for stump spraying, using light 3/8-in. hose and small guns similar to those provided by Spraying Systems Incorporated with cone jet tips.

For chemical mowing along guard rails a small pump of low-pressure capacity is required, the complete unit being small enough to be handled by a light vehicle so that easy maneuverability is obtained. For materials like Dalapon which go into solution readily, agitation is not necessary. However, materials such as Telvar do require agitation. Inasmuch as the future may bring other materials which are suspensions rather than solutions, it was considered wise to obtain a piece of equipment which provides agitation as well as a tank to hold the solution. Tank size is limited to 100-gal. capacity because of weight considerations. A pump delivering 7 gpm. is required to assure delivery of approximately 40 gal. per acre while traveling at a speed of 15 mph. with the tips and pressures generally used. These requirements were satisfied by a commercial sprayer having a piston pump. It should be noted that considerable study has been given to the characteristics of several designs of pumps by Cornell University; this was reported to the Northeast Weed Control Conference in 1955. It was found that, when suspensions are used, roller vane and rotary pumps rapidly deteriorated in performance and that centrifugal, diaphragm, and piston pumps were each superior.

For the accurate application of herbicides the average speedometer, particularly on trucks, is not satisfactory. A low-speed speedometer is a desirable accessory.

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COMMENTS

Ralph I. Kauffman:

Foliage water-borne sprays are satisfactory for the control of woody species susceptible to this method, but it should be stressed that this method will not kill the more resistant species of brush, and its use on these plants instead of the more effective oil-water, basal, and stump-spray methods is false economy.

Our considerable experience indicates that there is probably some 75 percent

more exposure to damage either from drift or volatility when using the foliage spray as compared with the much safer summer basal sprays.

Dormant or basal spraying will not in itself, without observation of the necessary precautions, assure no damage to adjoining susceptible plants. Damage has been done to plants by this type of treatment, indicated by bud blasting and stem twisting, from the careless use of these materials.

The statement that basal treatment might be eliminated by the consideration of prevention of "brown-out" is not quite true. The selective basal treatment will brown-out only the brush treated. Consequently, if there is 50 percent brush which is treated, there will be only a 50 percent brown-out, and any spot selective treatment done by basal application will certainly not cause anywhere nearly as noticeable a brown-out as broadcast sprays of any kind.

Although it is possible that the coloration of leaves by foliage sprays used in late August or September can be correlated with the normal fall coloration, it is generally recognized that less effective control may be expected from application so late in the summer.

Frank H. Brant:

The importance of an analysis of the species to be treated has been mentioned and the example given of alder not being treated the same as scrub oak. How far is individual treatment of individual species likely to develop? Could there be just a few methods specified, each method to cover a considerable number of species?

Iurka:

It is doubted that anyone can say at this time just how far individual treatment of individual species is likely to develop. This will certainly be dependent upon the commercial availability of new herbicides. Today the picture is not so complicated. There are five separate methods given in this report, and there are four important materials. If a growth of brush to be controlled consists of species susceptible to 2,4-D, (as, for example, alder and birch), it would be most economical to use the one material. If the growth is made up of a mixed stand including plants susceptible and resistant to 2,4-D, a mixture of D and T would be used. If a stand were entirely oak, ash, or poison ivy, amino triazole would be the most effective material.

Torbert Slack:

What pressure is recommended and what size orifice for spraying foliage in order to eliminate drift hazard?

Iurka:

Drift cannot be entirely eliminated, but it can be reduced by the appropriate combination of nozzle tip and pressure. Higher pressure will, of course, give finer spray droplets with any given tip, and smaller tips will give finer droplets with any given pressure.

W. C. Bramble:

With the basal and cane foliage techniques, drift could be reduced to a minimum, as they direct the spray low. In the oil-water sprays we use a No. 8 nozzle tip with 300-lb. pressure, while for the basal sprays we use a No. 5 nozzle tip with 50-lb. pressure.

Torbert Slack:

What maximum height of brush would you recommend spraying in order to eliminate or alleviate drift?

W. C. Bramble:

The lower the brush, the less hazard there would be of drift, as the spray can be directed down on the foliage. A 5- to 6-ft. height should be about the maximum for spray in order to reduce drift and to get efficient application.

W. H. Simonson:

Are the hormone sprays as recommended for roadside use a hazard to animal life?

Iurka:

Exhaustive studies by S. N. Fertig, College of Agriculture, Cornell University, show that in all cases which have been carefully surveyed, even though the herbicide has been associated with the trouble, it has in no case been directly or indirectly related to the deaths reported.

W. J. Garmhausen:

What is the effect of herbicides on bees? Does it kill them when they come in contact with the spray? Does the herbicide that clings to their bodies affect the young in the hive or produce other undesirable effects?

Iurka:

The Entomology and Agronomy Departments of Cornell University have never found any evidence to show that the hormones of either D or T form will directly affect bees or bee larvae when used at the concentrations normal for roadside or other spraying purposes.

A COMPARISON of the EFFECTS of CHEMICAL BRUSH-CONTROL TECHNIQUES on PLANT COVER

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In the spring of 1953, a large-scale test of common brush-control techniques was instituted on a 3-mile section of a power-line right-of-way paralleling US 322 in central Pennsylvania. In the winter of 1951-1952 this line had been given an initial capital clearance through an upland oak forest containing species typical of the extensive oak-chestnut forest region of the northeastern United States.

The six treatments applied originally in this study were selected as brush-control techniques commonly employed in right-of-way maintenance. A commercial power sprayer and crew applied the spray. One year following the initial treatments, a follow-up basal spray was given to one-half of each area of four of the original treatments. Original treatments and follow-up sprays may be briefly described as follows:

A. No spray: to be compared, as a control, with sprayed areas and not to be