Recommendations for Chemical Weed Control in Montana for 1949

by

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Recommendations for Chemical Weed Control in Montana

INTRODUCTION

The extensive use of 2,4-D (2,4-dichlorophenoxyacetic acid) in 1948 and the probable large use in 1949, combined with the comparative newness of this herbicide, make it necessary to present some of the information now available. This publication is intended to present information which will apply to Montana conditions in light of present known factors affecting probable results for the 1949 crop season.

ADVANTAGES OF 2,4-D

The advantages of 2,4-D are several. It is the least expensive selective herbicide which has been developed because very small amounts are required to kill weeds. 2,4-D is non-poisonous to animals and is non-inflammable. Normal applications of 2,4-D only temporarily affect the soil and does not build up from year to year. Very high rates of 15 pounds or more of parent acid have temporarily delayed the development of nitrate-producing bacteria. 2,4-D applied to the soil will remain effective for various lengths of time, but in most cases, not more than 90 days. Soil moisture, soil temperature, soil type and amount of organic matter seem to be the factors determining the period in which 2,4-D will remain dangerous.

DISADVANTAGES OF 2,4-D

Improper use of 2,4-D will damage most cereals. Accuracy of application is required, particularly when somewhat susceptible crops such as flax are being treated. Application by faulty spray equipment may result in some strips receiving dangerous amounts and others too little.

Since small amounts of 2,4-D will kill or seriously damage susceptible plants, drifting to vegetable or flower gardens, wind-breaks, sugar beets or other susceptible plants should be carefully avoided.

Certain plants become more palatable to livestock when treated with 2,4-D. When poisonous plants are treated, it appears possible that they too may become more palatable to livestock and
may cause poisoning as an indirect result of 2,4-D.

Small amounts of 2,4-D left in sprayers used for applying insecticides or other materials to susceptible plants may result in 2,4-D damage to those plants. This is so likely that some people recommend that equipment used for 2,4-D should not be used for any other purpose.

**COMPARISON OF FORMULATIONS**

The 2,4-D acid is highly insoluble in water. As a result, the acid has to be chemically reacted with various compounds so that it can be used effectively. The main classes in which 2,4-D is marketed are (1) the metallic salts of which ammonium and sodium are the most common, (2) the amine salts of which triethanolamine is the most common, and (3) the ester formulations which are usually marketed as ethyl, isopropyl or butyl esters of 2,4-D. Generally metallic salts are powders and the amines and esters are liquids. The esters, amines, and metallic salts however can be purchased as dusts.

2,4-D salt, amine and ester formulations act differently when applied on plants. All brands of the ester group act quickly; the amines are slower and metallic salts still slower.

The various formulations of ester and amines do not vary a great deal in effectiveness on young, vigorously growing, susceptible annual weeds. On most perennials, and on older or more resistant annuals, the difference in ability to damage plants is very evident. Similarly overdoses or improper application of esters are more apt to damage crops than the amines or salts.

Esters, largely because they have an oily base, are absorbed into plants most rapidly and are not as likely to be washed off by rain as amines or salts. The amine salts will be absorbed more rapidly than the metallic salts.

Metallic salts which come as a powder are soluble in water. However, sprayers without agitators have difficulty getting the powder completely into solution. The amines and metallic salts are soluble in water but not in oil. The esters are soluble in oil and emulsify or mix readily in water.

**CONDITIONS AFFECTING RESULTS**

Some of the conditions which affect results to be expected from 2,4-D are (1) Soil moisture, (2) Stage of growth of the plant, (3) Plant species, and (4) Environmental conditions before and after spraying.

The right amount of soil moisture usually results in rapidly growing succulent plants which are more susceptible to 2,4-D than those not growing rapidly. Consequently rapidly growing plants can be controlled with lower rates of 2,4-D. Most annual broad-
leaved weed species are much more sensitive to 2,4-D when small than after they have started to form seed pods and in many cases before they have reached full bloom.

There is considerable difference between various plant species in their degree of resistance to 2,4-D as is indicated in the following table:

**Classification of Weeds According to their Reaction to 2,4-D**

<table>
<thead>
<tr>
<th>Susceptible</th>
<th>Intermediate</th>
<th>Resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull thistle</td>
<td>Bindweed</td>
<td>Cactus</td>
</tr>
<tr>
<td>Burdock</td>
<td>Buckwheat</td>
<td>Cow cockle</td>
</tr>
<tr>
<td>Cocklebur</td>
<td>Canada thistle</td>
<td>Goatweed</td>
</tr>
<tr>
<td>Dandelion</td>
<td>Chickweed</td>
<td>Knapweed,</td>
</tr>
<tr>
<td>False Flax</td>
<td>Death camas</td>
<td>Russian</td>
</tr>
<tr>
<td>Fanweed</td>
<td>Goatsbeard</td>
<td>Leafy spurge</td>
</tr>
<tr>
<td>Locoweed</td>
<td>Goldenrod</td>
<td>Milkweed</td>
</tr>
<tr>
<td>Lupine</td>
<td>Larkspur</td>
<td>Wild rose</td>
</tr>
<tr>
<td>Tumbling mustard</td>
<td>Blue lettuce</td>
<td>Selaginella</td>
</tr>
<tr>
<td>Hare's ear mustard</td>
<td>Prickly lettuce</td>
<td>Grassweeds</td>
</tr>
<tr>
<td>Wild mustard</td>
<td>Tansy mustard</td>
<td></td>
</tr>
<tr>
<td>Stinging nettle</td>
<td>Perennial sow thistle</td>
<td></td>
</tr>
<tr>
<td>Plantain</td>
<td>Pig weed</td>
<td></td>
</tr>
<tr>
<td>Wild radish</td>
<td>Whitetop</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow trefoil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet clover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian thistle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(young)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamb's quarter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sow thistle (annual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shepherd's purse</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The foregoing table indicates the results likely to be obtained when the weeds are small and growing vigorously. When conditions are not favorable all plants will become more highly resistant. The increase in resistance will vary among weeds.

A hot wind and a drying soil for several days before application of 2,4-D will increase plant resistance. These factors all contribute to the success or failure of a spraying operation and their relative favorableness will determine the amount of 2,4-D required to do a specific job.

**Spraying Versus Dusting**

The question of whether or not dusting is better than spraying has been the topic of much discussion. Under conditions ideal for dusting, i.e., little or no wind and high humidity, the
dusts have been approximately equal in effectiveness on an acid basis with the sprays. However, these conditions exist all to seldom in Montana.

The dusts are somewhat more expensive than sprays because of the extra weight and bulk involved in shipping the material to Montana. For instance, an ester containing 3.34 pounds acid per gallon weighs approximately 8.5 pounds while the same amount of acid in a 4.2% dust will require approximately 80 pounds of material. The dusts are somewhat cheaper to handle because it is not necessary to haul water for application. The cost of hauling water is not generally considered important but does add some expense to the operation, especially if water has to be hauled for a distance of several miles. Dust will drift more than spray so dusting is considerably more dangerous when used near susceptible crops than is relatively high volume, low pressure spraying.

METHODS OF 2,4-D APPLICATION

The common methods of applying 2,4-D are with ground sprayers equipped with booms, airplanes with booms and ground operated turbines. Whatever method is used it is essential that the operator apply the herbicide uniformly and know exactly how much material he is applying per acre.

Several factors are involved in the amounts which will be applied by a nozzle. Changes in speed, and pressure will vary the actual amount applied and upon occasion bring rather disastrous results. For instance, if the sprayer has been calibrated at 4 miles per hour and the operator only travels 3 miles per hour, the result will be a one-fourth increase in the amount applied. When the sprayer is moving 5 miles per hour with the calibration set at 4 miles per hour, 20% less will be applied.

Differences in pressure also exert a marked influence on the amounts applied. For instance, a nozzle which will apply 5.3 gallons per acre at 4 miles per hour and 15 pounds of pressure, will apply 7.5 gallons at 30 pounds pressure and 13.6 gallons at 100 pounds pressure.

Sprayer Calibration

The following table indicates the time required to cover an acre at various boom widths and speeds. When using this table remember that a slight variation in speed can seriously affect the amount applied per acre.

Procedure for calibrating a sprayer with this table:
1. Determine boom width and exact speed and read time required to cover one acre in minutes on the table.
2. Determine the volume of material which will be discharged from the sprayer at the pressure which will
be used during the time required to cover one acre. Example: A 30-foot boom running at 4 miles per hour will require 4 minutes and 7 seconds to cover one acre.

Then measure the volume discharged by the boom in 4 minutes and 7 seconds. This will be the total volume applied per acre.

Where the table for either the speed or the boom width is not applicable use the figures given under a 1 foot boom or 1 mile per hour and divide either boom width or speed into the 1 figure.

Examples:
1. A 30-foot boom travelling at 2 miles per hour. 2 divided into the time required (16.5 minutes) for 1 mile per hour equals 8 minutes and 15 seconds to cover an acre.
2. A 37-foot boom travelling at 4 miles per hour. Divide 37 into 123.8 minutes. 3.38 minutes or 3 minutes and 23 seconds are required to cover one acre.

Time in minutes and seconds required to cover an acre at varying rates of speed and boom widths.

<table>
<thead>
<tr>
<th>Boom Width Feet</th>
<th>1</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
<th>5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>495.0*</td>
<td>198.0*</td>
<td>165.0*</td>
<td>141.4*</td>
<td>123.8*</td>
<td>110.0*</td>
<td>98.0*</td>
<td>90.0*</td>
</tr>
<tr>
<td>10</td>
<td>49.5*</td>
<td>19:48</td>
<td>16:30</td>
<td>14:08</td>
<td>12:45</td>
<td>11:00</td>
<td>9:54</td>
<td>9:00</td>
</tr>
<tr>
<td>15</td>
<td>33.0*</td>
<td>13:12</td>
<td>11:00</td>
<td>9:25</td>
<td>8:15</td>
<td>7:20</td>
<td>6:36</td>
<td>6:00</td>
</tr>
<tr>
<td>20</td>
<td>24.8*</td>
<td>9:55</td>
<td>8:16</td>
<td>7:05</td>
<td>6:12</td>
<td>5:30</td>
<td>4:58</td>
<td>4:31</td>
</tr>
<tr>
<td>30</td>
<td>16.5*</td>
<td>6:36</td>
<td>5:30</td>
<td>4:43</td>
<td>4:07</td>
<td>3:40</td>
<td>3:18</td>
<td>3:00</td>
</tr>
<tr>
<td>50</td>
<td>9.5*</td>
<td>3:48</td>
<td>3:10</td>
<td>2:43</td>
<td>2:23</td>
<td>2:07</td>
<td>1:54</td>
<td>1:44</td>
</tr>
</tbody>
</table>

*Starred figures are in minutes and tenths of minutes rather than minutes and seconds.

Another method for calculating gallons of spray used per acre is expressed in the following formula.

\[
\text{Amount used (gallons)} \times 66 = \text{volume in gallons per acre.}
\]

This formula has been worked out to give a simplified method of sprayer calibration. The formula itself is not difficult to understand but must be used correctly to give accurate results.

This method requires that the sprayer be filled to a certain specific point and then driven 40 rods (660 feet), using the speed and pressure which will be used in the field. Then measure the amount discharged. It is preferable to make the trial run over a soil which is the same as will be found in the field to be sprayed.
so that a constant throttle setting can be used to determine speed. A better method of determining speed is the use of a tachometer, but since they are not readily available on many tractors, careful timing will make the results quite accurate. When using this method it is desirable to make approximately three runs and measure the amount used each time and take an average of the three runs for the amount to be applied per acre.

When the volume which a certain sprayer will apply per acre at a constant speed and pressure has been determined, there still remains the problem of determining how much 2,4-D is required per unit of volume per acre. For instance, when it has been determined that a sprayer will apply 6 gallons per acre, it is then necessary to determine how much 2,4-D is needed for each acre volume of carrier. The following tables have been calculated to make this problem somewhat easier.

The first table has been worked out on the basis of weights of 2,4-D concentrates and the second on volumes needed per acre for specific rates of 2,4-D acid per acre.

Table for converting percent ACID EQUIVALENT to pounds or ounces of 2,4-D commercial chemical solution per acre.

<table>
<thead>
<tr>
<th>Percent 2,4-D ACID EQUIV. as listed on container</th>
<th>Lbs. of chemical for application of .1 lb. 2,4-D acid per acre*</th>
<th>Ounces of Chemical to get .1 lb. of 2,4-D acid per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>32%</td>
<td>.313</td>
<td>5.01</td>
</tr>
<tr>
<td>33%</td>
<td>.303</td>
<td>4.85</td>
</tr>
<tr>
<td>34%</td>
<td>.294</td>
<td>4.70</td>
</tr>
<tr>
<td>35%</td>
<td>.286</td>
<td>4.58</td>
</tr>
<tr>
<td>36%</td>
<td>.278</td>
<td>4.45</td>
</tr>
<tr>
<td>37%</td>
<td>.270</td>
<td>4.32</td>
</tr>
<tr>
<td>38%</td>
<td>.263</td>
<td>4.21</td>
</tr>
<tr>
<td>39%</td>
<td>.256</td>
<td>4.10</td>
</tr>
<tr>
<td>40%</td>
<td>.250</td>
<td>4.00</td>
</tr>
<tr>
<td>41%</td>
<td>.244</td>
<td>3.90</td>
</tr>
<tr>
<td>42%</td>
<td>.238</td>
<td>3.81</td>
</tr>
<tr>
<td>43%</td>
<td>.233</td>
<td>3.73</td>
</tr>
<tr>
<td>44%</td>
<td>.227</td>
<td>3.63</td>
</tr>
</tbody>
</table>

*Pounds solution obtained by dividing “percent ACID EQUIVALENT” into 10. The above table applies where the acid equivalent is given on a percent of weight basis.

Example: To apply .3 pound 2,4-D per acre when ACID EQUIVALENT” is 37%. Refer to the line with 37 in first column. Multiply the figure .270 (in the same line) by 3 = .810 pound (13 ounces), the amount to be mixed with any quantity of water or oil to be applied per acre.
The following table is based on the fact that many of the reputable brands available today have an almost equal amount of 2,4-D acid per gallon in each of the formulations. For this table to be of any value it must be determined beforehand that the material being used does contain the amount of acid which is stated in the “lbs.-acid-per gallon” column. If an amine formulation containing 2.5 “lbs. acid per gallon” is purchased the table will be of no value.

<table>
<thead>
<tr>
<th>Liquid Formulations</th>
<th>% acid</th>
<th>lbs. acid per gal.</th>
<th>lbs. acid per pt.</th>
<th>Pints required to apply the following lbs. acid per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Amines</td>
<td>40</td>
<td>4.00</td>
<td>.50</td>
<td>.40</td>
</tr>
<tr>
<td>Ethyl ester</td>
<td>42</td>
<td>3.00</td>
<td>.37</td>
<td>.54</td>
</tr>
<tr>
<td>Isopropyl ester</td>
<td>37</td>
<td>3.34</td>
<td>.42</td>
<td>.48</td>
</tr>
<tr>
<td>Butyl ester</td>
<td>33</td>
<td>2.64</td>
<td>.33</td>
<td>.61</td>
</tr>
</tbody>
</table>

*For rates not given in the table multiply the figure given for the proper formulation under this last column by the desired rate.

**Calibration of a Tank**

Some trouble has been noted in determining the amounts of 2,4-D required when partially filled tanks are refilled. One method of measuring the amount needed is to fill the tank with water and drain out 5 or 10 gallons at a time. As each unit of 5 or 10 gallons is drained out, the total amount should be marked on a measuring stick at the liquid level. For instance, when 20 gallons has been drained, the level in the tank should be marked on the measuring stick with the number 20. This method will give a quick accurate measurement of the amount required to fill the tank. The sprayer should be on level ground when measurements are made.

**Volumes of Carrier Needed**

For ground spraying on dryland, 5 gallons or more of water per acre are recommended. Under irrigated conditions, or on dryland where susceptible crops may be injured by drift, a minimum of 20 gallons per acre is suggested because a high volume, low pressure spray will reduce the danger of damaging drifts.

Tall, dense foliage will require higher volumes of carrier to obtain coverage than does a short, sparse growth.

**Cleaning Sprayers**

Cleaning sprayers is possible in many cases although occasionally these methods are not completely effective. Sprayers should be tested after cleaning by spraying sensitive plants such
as tomatoes. When a sprayer is also to be used for applying insecticides to crops susceptible to 2,4-D, an extra planting of tomatoes should be made for test purposes. If tomato plants show no effect of 2,4-D after 24 hours or more, it can be assumed that the sprayer is clean.

One method of cleaning a sprayer is to fill it with a one percent solution of household ammonia. If the tank holds 100 gallons, approximately 1 gallon of ammonia will be required. After filling the tank with water and ammonia, a small amount should be pumped through the hoses and booms so that they too will be cleaned. Then plug the nozzles if possible so that the solution will remain in contact with all internal parts of the sprayer. The solution should be allowed to stand in the sprayer for a period of approximately 24 hours, then drain and thoroughly rinse with clean water before testing or using for other purposes.

Activated charcoal in suspension in the sprayer will also do a good job of cleaning and is somewhat faster than the above method. However, the filled sprayer should stand for several hours before draining and rinsing. The amount of activated charcoal needed is approximately 1% of the total volume of the tank.

When 2,4-D esters have been used a thorough rinsing of the tank, pump, and booms may be made with kerosene or some light fuel oil before one of the above mentioned methods is used.

If wooden tank sprayers are to be used for 2,4-D, they should not be used for other purposes on susceptible crops because it is almost impossible to remove all 2,4-D from the tanks.

RECOMMENDATIONS FOR THE USE OF 2,4-D IN MONTANA FOR 1949

Pre-Emergence

The application of 2,4-D to the soil after planting but before emergence of crops has in some instances shown considerable promise as a weed control method. Pre-emergence application of 2,4-D has delayed germination of small seeded weeds varying for periods depending on the rate of application and on the soil type, the amount of moisture in the soil, temperatures, kinds of weeds present, etc.

An advantage of pre-emergence spraying with 2,4-D is that small seeded grass weeds as well as broad-leaved species would be controlled for a period of time. The weed seeds are not killed in most cases but their germination is stopped for a period of time varying from two weeks to three months depending on environmental factors. Present information indicates that seed size may be an important factor in pre-emergence work with 2,4-D and perhaps only the very large seeded crops such as corn can be treated.
safely by this method. There are also possibilities with beans and potatoes.

Post-Emergence Spraying

The following recommendations are those most likely to produce favorable results for the coming year. It should be borne in mind that these recommendations may be changed in another year and that the increasing amount of research information available may result in new recommendations in 1950.

There has been considerable use of the fuel oils as carriers for the ester formulations of 2,4-D, particularly with airplane application because oil can be effectively applied at much lower volumes per acre than water. In airplane operations there is a very distinct advantage in the use of oil since the number of acres they can cover on one flight determines to a large extent their cost of operation.

The use of fuel oils as carriers for the ester formulations must be handled with extreme care because oil is toxic or poisonous to cereals, although rates of one gallon per acre have not caused damage when applied accurately. Considerable damage to spring wheat has been noted in several of the northeastern Montana counties when oil was used as a carrier. Most, if not all, of the damage was due in a large part to poor distribution of the material, since the damage occurred in streaks through the field.

The combination of 2,4-D esters and diesel oil has proven itself considerably more dangerous to use on crops since the overdoses as a result of poor distribution did result in more damage than where esters or amines in water were used. When oil is the carrier it must be used much more carefully than water.

If the field is to be treated, the most significant value of spraying has been increased yields which show up as cash in the farmer's pocket at the end of the year. However, there are several other factors which do not show up as soon. It is certain that when no weed seeds have been returned to the soil for a number of years, the number of weeds in the soil will have decreased considerably. Although it is probably impossible to completely eliminate weeds from the field, in five or six years' operations, 2,4-D may cut the number of certain susceptible weeds down to such an extent that they no longer affect crop yields. One factor to watch for is an increase in grass weeds such as cheatgrass or pigeon grass. The use of 2,4-D may cause a large increase in these resistant weeds because of reduced competition from broad-leaved weeds.

Good farming practices such as planting clean seed, maintaining clean fallow and seeding in a weed-free soil are highly recommended and under no condition should clean tillage be slackened because of the availability of a product such as 2,4-D.
Weeds must be present in sufficient numbers to materially decrease yield before the cost of 2,4-D and its application can be turned into a profit when value received is being measured on increased income for the first year.

**Grain Yields**

2,4-D properly applied to a weedy grain crop will normally increase yields one to several bushels per acre. The amount of increase will depend on time of spraying, number and kind of weeds present, amount of rainfall, temperatures, etc.

**Test Weight**

An increase in test weight as a result of spraying with 2,4-D may occur. Some experimental results on wheat, oat and barley varieties have shown 1 to 3 pounds per bushel increase in the test weight. Other tests have shown no increase. Data available would indicate a decrease in test weight might be expected only when 2,4-D is applied in the early stooling (or tillering) or bloom stage or if too heavy applications are made.

**Protein Content**

2,4-D properly applied has not decreased the protein content of wheat, oats or barley and some investigators have reported an increase though in most instances the increase was small. However, results are so inconsistent spraying should in no instance be done for the increase in protein that might be obtained.

**Germination**

2,4-D increases the germination of some varieties of grain while in others it causes a slight reduction, according to one year’s data from the North Montana Experiment Station at Havre. Present information, however indicates that normal applications of 2,4-D is not likely to reduce the germination of any recommended variety of wheat, oat or barley enough to necessitate a heavier rate of seeding.

Seed for germination analysis should not be taken directly from the combine because some varieties require a “rest-period” after harvest before the seed will germinate normally. Delay at least a month after harvest before taking germination samples. Winter wheat also should be chilled to about freezing at least one week before taking germination samples. Then germinate seed in a cool place.

**Weed-Free Harvest**

A clean field of grain to harvest is considered by some operators the best recommendation for spraying. Weeds interfere
with combining by stopping the real, gumming up the cylinder and plugging the sieves, and causing storage troubles, dockage, etc. A clean field of wheat can be harvested in about half the time required for a weed-infested field. The wear on the combine will be greatly reduced and the grain delivered can be practically dockage-free.

**Spring Wheat, Oats and Barley**

The following recommendations are made for the use of 2,4-D on spring wheat, oats and barley.

Recommended rates of 2,4-D vary from .3 to .75 pound acid equivalent per acre. The amount to be used will necessarily vary with the amount of soil moisture, size and susceptibility of weed species, vigor of growth and other conditions prevailing at time of treatment. It is realized that rates lower than .3 pound acid equivalent per acre will give good kills on small, vigorously growing susceptible annual weeds when conditions are favorable. However, the rate of at least .3 pound of an ester is needed for all but the most susceptible weeds when conditions are not favorable.

To control perennial weeds in growing crops, a minimum of .5 pound of acid per acre should be used. Where a greater degree of control of the perennial weed involved is desired, rates should be increased but it must be remembered that some decrease in yield may result. Where perennials are in patches in fields, it is suggested that in crossing these areas the spray operator merely slow down to increase the rate of application.

**Winter Wheat**

Spring treatment of winter wheat with 2,4-D is recommended and the rates are the same (.3 to .75 pound acid per acre) as those for spring wheat, oats, barley or rye. Fall treatment of winter wheat has been tried in some areas with varying degrees of success though it is generally not advisable at that early a stage of growth. Furthermore, fall treatment will not control weeds which germinate in the spring.

The fall of 1948 was very dry in many areas of the state and as a result weeds and wheat did not make much growth before the freeze-up. If spraying is done before growth is well started in early May, many weeds may germinate after treatment. Also fall wheat which did not attain much growth last fall may be damaged severely by early spring treatment. Such winter wheat should be allowed to grow to 4 or 5 inches in height before treatment.

Wheat, oats, barley and rye should be sprayed between the stooling and boot stages. Treatment in the early stooling (or tillering) stage may result in a serious yield reduction due to de-
formation of plants parts and perhaps delayed maturity. Treatment should also not be applied in the boot or flowering stage because of increased plant susceptibility at those stages. 2,4-D applied in the dough stage to control green weeds in the crop and thus facilitate harvest, apparently does not decrease yields and in some cases may make harvesting possible.

**Flax**

The recommended rate of 2,4-D for flax is a maximum of .3 pound of acid per acre of an amine formulation. The use of esters in oil or water is not recommended. Lower rates are necessary in flax because it is more sensitive than other small grains. Also flax stands are more open than normal stands of the cereals, thus the lower rates of 2,4-D are more effective.

Of the Montana recommended varieties, Dakota, Arrow and Renew, Dakota is apparently the most resistant to 2,4-D. Montana tests indicated that Renew is the most susceptible of the three varieties. In general, yellow seeded varieties are not tolerant enough for 2,4-D treatment.

The best time for treatment of flax appears to be when plants are three to six inches in height. Treatments made after the early bud stage are apt to cause severe injury even to the more tolerant flax varieties.

**Corn**

Rates of 2,4-D recommended for corn are the same as those for the other cereals (.3 to .75 pound acid per acre). It is suggested that the grower wait until the corn is at least six inches high before treating.

The use of 2,4-D on corn is somewhat different than on the rest of the cereals in that corn is normally a cultivated crop and in many cases grass weeds are often the most troublesome weeds in corn. These two facts make it appear that the use of 2,4-D on corn in the state is more limited than on the close drilled cereals. However there are many cases where corn will benefit from 2,4-D treatment. Several of these cases might be (1) limited time to cover a large acreage, (2) lack of grass weeds in the crop, and (3) crop too wet for cultivation. In general where cultivation is practical the use of 2,4-D is limited.

The North Central Weed Control Conference has suggested that drops be attached to spray booms so that 2,4-D can be applied below the tops of the corn with a resultant reduction in the amount of 2,4-D deposited on the corn plant.

**Grass**

Most established grass crops can be successfully treated with 2,4-D for the control of broad-leaf weeds. There is some evi-
RECOMMENDATIONS FOR CHEMICAL WEED CONTROL

dence that the Bent grasses are susceptible and may be damaged by 2,4-D.

Seedling grasses are quite susceptible to 2,4-D until they become well established. The use of 2,4-D in pastures containing legume mixtures cannot be recommended at present, although there are indications that white clover, red clover and perhaps even alfalfa may be quite tolerant to reduced rates of 2,4-D.

Use of 2,4-D on Fallow*

Preliminary work with 2,4-D on fallow at Havre in 1948 gave poor control of Russian thistles and buckwheat with the result that very little moisture was stored on plots not cultivated. Plots initially sprayed and cultivated later, gave good control of all weeds. The soil had practically as much stored moisture as soil that was cultivated but not sprayed.

The use of herbicides for the control of weeds on fallow may have several points in its favor if it can be done effectively and economically. Some of the advantages may be (1) less soil pulverization and more residue left in the surface due to fewer tillage operations, (2) control of weeds by spraying when it is too wet to cultivate effectively, (3) more timely control of weeds because spraying is faster than cultivating, and (4) fall spraying might control weeds in stubble and still leave the stubble standing to hold winter snow.

Perennial Weeds

There are very few instances when perennial weeds have been completely eradicated by one treatment of 2,4-D. However, certain of the perennials can be controlled fairly satisfactorily for the crop year by one application. Combinations of 2,4-D and fallow or resistant competitive crops, such as annual or perennial grasses, appear to have some possibilities in control of perennial weeds. Where it is possible to cultivate before treatment with 2,4-D, it is suggested that at least one tillage operation be carried out before treatment. The use of soil sterilants, such as sodium chlorate, borax and combinations of the two, is still recommended, particularly for spot treatments, as are the cultivation methods for perennial weed control. Montana Experiment Station Bulletin 426 contains good information on control of perennial weeds by cultivation or soil sterilization. This bulletin is available in County Agents’ offices or can be obtained by writing to the Montana Agricultural Experiment Station Library at Bozeman, Montana.

As in annual weeds, perennial weeds must be growing rap-

*This section written by T. S. Aasheim, Project Supervisor, Soil Conservation Research.
idly for the best results to be obtained when 2,4-D is used.

**Bindweed**

Bindweed, morning glory or creeping jenny, as it may be called in some localities, has been the easiest of the perennials to control by the use of 2,4-D. Rates of one to two pounds of acid equivalent per acre have given good results in most cases. Time spraying should be after the plant has obtained a luxuriant foliage growth until full bloom stage. Rates of as low as .5 pound of acid per acre have resulted in good annual control when conditions at treating time are favorable.

For treatment when maximum root kill is desired recommended rates vary from 1 to 2 pounds acid per acre.

**Canada Thistle**

Canada thistle is not controlled as easily as bindweed, but it is “knocked down” with some decrease in root system obtained when treated with rates as low as .5 pound of 2,4-D acid per acre in cereal crops. Best results have been obtained when treatments are made on vigorously growing plants before they reach the early bloom stage. Rates of 2,4-D to be used when damage to yield is not a factor or on non-crop land will vary from 1½ to 2½ pounds per acre. The use of esters has generally given better results than the amine or salt formulations.

**White Top**

White top is generally considered to be quite resistant to 2,4-D. Time for spraying should be before the early bloom stage which often occurs in May. Rates to be used should be from 2 to 3 pounds of acid equivalent per acre. Fall treatment of white top growing from perennial roots has been quite successful in a few instances and where fall growth occurs, it appears that treatment at this time is feasible. Esters have given the best results on this weed.

**Leafy Spurge**

Leafy spurge is resistant to 2,4-D and although top kills have been obtained with rates of 1 to 2 pounds, root kills have generally been unsatisfactory. There is a small amount of evidence which indicates that high rates of 2,4-D (4 to 6 pounds of acid per acre) may be successful in decreasing the root system. This rate cannot be recommended at present because of the lack of adequate information.

**Russian Knapweed**

Russian knapweed has been considered to be the most resistant to 2,4-D of the perennial weeds listed. In general, 2,4-D treat-
ments on this weed have been unsatisfactory. However, in one instance knapweed was 95% controlled by one application of about 14 pounds of 2,4-D acid per acre.

2,4,5-T

2,4,5-T (2,4,5-trichlorophenoxyacetic acid) is a very close relative of 2,4-D and exhibits many of the same properties. 2,4,5-T is more effective than 2,4-D on certain woody plants. At present it should be limited to this use because it is considerably more expensive than 2,4-D. Mixtures of 2,4-D and 2,4,5-T on certain woody plants has reduced the amount of 2,4,5-T needed with a resultant decrease in cost. 2,4,5-T on whitetop and leafy spurge has not resulted in increased kills.

TCA

The sodium salt of trichloroacetic acid will be marketed to some extent in the state this year. TCA has shown some possibility as a quackgrass killer in limited testing. The best results obtained to date in Montana have been when the material was applied at rates of 300 pounds per acre to quackgrass stands immediately after cultivation.

TCA has been reported to be effective on cactus when applied as a spray. Thorough wetting of the plants with concentrations of 3/4 pound per gallon of water has given good results in the spring and early summer before blossom.

This herbicide will burn the skin when contact is prolonged, but it washes off easily with water. Other potential toxic effects are not known at present because of the newness of this herbicide.

The material is an oily powder which is highly soluble in water.

DINITRO HERBICIDES

Selective. The dinitro herbicides, such as Sinox and Dow Selective, are being used to a considerable degree on peas and flax. The dinitros will do a good job of selective weed control where conditions are right. However, they require better conditions than does 2,4-D, and are somewhat more expensive and require a larger volume of water per acre. These herbicides kill only on contact and as a result, the treated plants must be completely wet before the dinitros will do a good job.

Non-selective. The dinitro herbicides labeled as generals are contact herbicides which, when mixed with a fuel oil will kill all vegetation. There is considerable use for this type of a herbicide where it is desired to control all top growth. Directions for use are on the labels and should be followed with care. When
contact herbicides are used. It should be remembered that the effect on perennial roots is essentially the same as that accomplished by one mowing or tillage operation.

SOIL STERILANTS

Sodium Chlorate

Sodium chlorate is being recommended for small infestations even though it is expensive, and certain cautions must be taken in handling the material. Sodium chlorate will sterilize the soil for periods of from 1 to 3 years. Results obtained from sodium chlorate are generally very good and will give a satisfactory degree of control in most cases.

Borax

Borax is recommended along the same general lines as sodium chlorate. It will sterilize the soil for a somewhat longer period than chlorates but is somewhat cheaper. Borax is not inflamable or poisonous to livestock. In certain cases, mixtures of sodium chlorate and borax have given eradication more cheaply than has either of the two alone.

For a more thorough discussion of sodium chlorate and borax and other soil sterilants, refer to Montana Experiment Station Bulletin No. 426.

SUMMARY

2,4-D is a relatively new, potent, selective herbicide that, improperly applied, can damage or kill valuable crops as well as weeds. Great care should be exercised to apply 2,4-D uniformly and in the exact amounts recommended.

2,4-D is a relatively inexpensive chemical, non-inflammable, non-poisonous to livestock, and normally does not “carry over” in the soil for more than 3 months.

2,4-D, particularly in the ester and/or dust forms, can drift for long distances when used improperly and cause serious damage to vegetable or flower gardens, windbreaks, or susceptible crops such as sugar beets, beans, clovers, etc.

Sprayers must be carefully cleaned before they are used for applying other chemicals to susceptible crops.

2,4-D is marketed primarily as (1) metallic salts, (2) amine salts, and (3) esters. On most plants esters are the most rapid and potent killers; metallic salts are the slowest acting. The amines are intermediate but in action resemble the esters more closely than the metallic salts. The esters and amines differ little
in effectiveness on young, vigorously growing, susceptible annual weeds but on many perennials and on older more resistant annuals the esters are normally much more powerful in their herbicidal action.

Pre-emergence spraying is not advisable in light of present limited information.

Post-emergence spraying is advisable in the period following stooling (5" - 6") but prior to the boot stage. 2,4-D applied to weedy fields during this period will normally slightly increase grain yield but likely will have little effect on test weight, protein or germination. Only limited variation in reaction to 2,4-D is likely in wheat, oats, barley or rye varieties recommended for Montana.

A weed free crop to harvest may be the best recommendation for spraying.

Fall spraying of winter wheat is not recommended.

Fuel oil at 1 gallon per acre used as a carrier for 2,4-D has generally been satisfactory. Oil, is toxic or injurious to plants, so when used must be applied very uniformly and in exactly the recommended amounts.

For flax the recommended rate is .3 pound of an amine formulation per acre applied when plants are 3 to 6 inches high. Yellow seeded flax varieties are generally susceptible and are likely to be severely damaged by 2,4-D in any form at any stage of growth. Dakota is the most resistant of varieties recommended for Montana.

Most grass crops are sensitive to 2,4-D in seedling stage but are generally resistant when established.

Perennial noxious weeds are seldom killed by one application of 2,4-D; two, three or more treatments are normally required.

Sodium chlorate and borax are soil sterilants recommended for small patches of noxious weeds.

For questions not answered in this publication contact your County Extension Agent or Robert L. Warden, Montana State College, Bozeman, Montana.