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Perennial and Annual Weed Control in South Dakota

L. A. Derscheid
South Dakota State University

L. R. Wilson
South Dakota State University

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PERENNIAL and ANNUAL *Weed* CONTROL IN SOUTH DAKOTA

Above: Patch control now, prevents large weed infestations later. Center: One method of controlling large infestations is to spray. Below: Cultivation is another satisfactory control measure.

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BROOKINGS

Contents

This publication discusses cultural and chemical methods of controlling some of the most troublesome weeds in South Dakota. It replaces C75, *Cultural Methods of Noxious Weed Control* and C94 *Chemical Control of Weeds.*

Other publications discussing *Chemical Control of Woody Plants, Equipment Used for Weed Control* and *Weed Control in Lawns and Gardens* are available at your county agent's office or at the Bulletin Department, South Dakota State College, College Station, South Dakota.

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PERENNIAL AND ANNUAL

Weed Control in South Dakota

LYLE A. DERSCHEID and LLOYD R. WILSON[1]

CLEAN SEED, good crop rotations and sound soil management practices are means of preventing weeds from infesting the land. Once they become established, however, special practices are needed to eliminate them. These practices include the use of special cultivation, competitive crops and chemicals. One application of any one of the practices seldom eliminates all perennial weeds now present and never eradicates a weed. Even though the top growth is eliminated, new weeds come from the seeds in the soil. Some of these seeds remain viable for as long as 20 years and many years of diligent work are required to eradicate them.

The major portion of this circular is devoted to a discussion of special cultural and chemical practices needed to eliminate weed infestations. The recommendations are based on results of research work done in South Dakota and on recommendations made by the North Central Weed Control Conference.

The tests in South Dakota include over 50 sets of plots established throughout the state in addition to work conducted at the Field Bindweed Research Farm near Scotland (1946–1950), work conducted on the Leafy Spurge Research Farm near Gary (1949–1953), results obtained on the Quackgrass Research Farm near Gary (1951–1953), trials conducted on the Russian Knapweed Research Farm near Brentford (1952–1953) and experiments conducted on the Agronomy Farm at Brookings since 1947.

[1]Associate Agronomist, South Dakota Agricultural Experiment Station and Extension Weed Specialist, South Dakota Extension Service, respectively.

Perennial Weed Control

SPECIAL CULTURAL or chemical practices are needed to eliminate perennial weed infestations. The objectives of these practices are to deplete the food reserves in the roots. Plants manufacture food as illustrated in Fig. 1. Food not needed by the plant for growth or seed production is stored in the roots in the form of root reserves. Reserves can be depleted or reduced in several ways: (1) by shading the leaves of the plants to reduce the amount of sugar produced, (2) by depriving the plants of soil nutrients so that less of other foods are produced, (3) by forcing the plants to use up the reserves already in the roots, or (4) by using a combination of these methods.

Competitive crops shade the plant so that less sugar is made. They also compete for soil nutrients so that less of the other plant foods are produced. Consequently, there is less food to store in the roots.

Cultivation is used to cut the roots of plants 4 inches below the soil surface. Experiments have shown that after such a cultivation, it takes about one week for the plants to emerge. It takes another week or more before there are enough leaves to produce food faster than it is being used for growth. Therefore, very little food is stored and reserves from the roots are used for plant growth during a period of about two weeks. Each cultivation has a similar effect. If repeated cultivations are continued long enough, the root reserves are eventually used up and the plant dies.

Chemicals used in weed control either completely deplete the root reserves or decrease them to the point where competitive crops or cultivation will kill them.

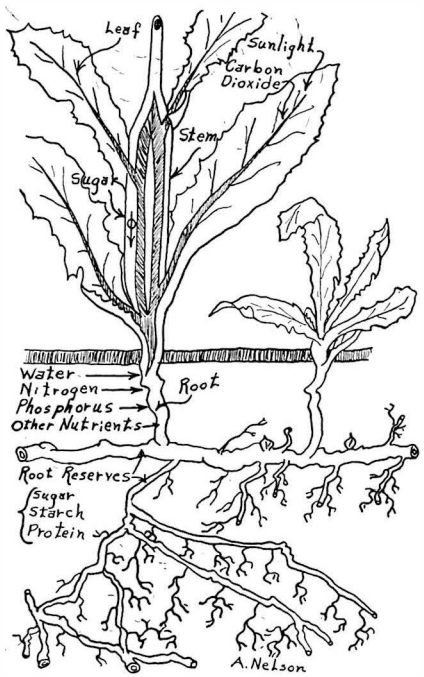


Fig. 1. Lower portion of a perennial weed with stem enlarged to show the translocation system. Carbon dioxide is taken through the leaves, while water, nitrogen, phosphorus and other plant nutrients are taken into the roots. With the aid of sunlight, sugar is produced in the leaves and moves to the roots if not needed for growth. Other plant foods not needed for growth are also stored in the roots. These are called the root reserves.

Control Measures

Control of Patches

Patch treatment is an important part of a perennial weed control program, as it is easier to control weeds on a small area than it is to control them after they spread over a large area. Intensive cultivation, 2,4-D, MCP, 2,4,5-T, TCA, MH[2] or any of the soil sterilants (chlorate, borax compounds, borate-chlorate mixtures, amate or CMU) may be used, depending upon the situation. The amount of each chemical needed is given for many of the weeds on the following pages.

Soil sterilants can be used to good advantage on patches because the proper application of the right chemical will give almost complete elimination of many species of perennial weeds (Fig. 2). However, weed seeds in the soil generally are not killed. When the effect of the soil sterilant wears off, these seeds will germinate and produce a new infestation if the seedlings are not killed. They can usually be eliminated with cultivation or one of the chemicals that does not sterilize the soil.

If 2,4-D, MCP, 2,4,5-T, TCA or MH are used, it is just as important that the right amount of chemical be applied to small patches as it is on large fields. If too little is applied, the weed will not be controlled; if too much is applied, the tops may be killed without injuring the roots. The amount of chemical needed for a square rod area for several rates of application is given in Table 1.

[2]2,4-D 2,4-dichlorophenoxyacetic acid
MCP 2-methyl-4-chlorophenoxyacetic acid
2,4,5-T 2,4,5-trichlorophenoxyacetic acid
TCA trichloroacetic acid
MH maleic hydrazide
CMU 3-p-chlorophenyl-1-1-dimethyl urea

Fig. 2. ***Right:*** **The effects of sodium chlorate applied to a small patch of perennial weeds.** ***Left:*** **Applying the chemical to an area that had previously not been treated.**

Table 1. Amount of Chemical Needed on 1 Square Rod When Treating Patches

If Pounds of Acid Equivalent Per Acre to Be Used Are:	This Much Chemical Should Be Used on a Square Rod (16½ ft. x 16½ ft.)				
	2,4-D, MCP or 2,4,5-T		TCA		MH
	Contains 4 Lbs. per Gallon	Contains 3 Lbs. per Gallon	Powder (90% Sodium Salt)	Liquid (6.3 Lbs. 90% Sodium Salt per Gallon)	40% Sodium Salt
½	⅔ teaspoonful	⅞ teaspoonful			
¾	1 teaspoonful	1⅓ teaspoonsful			
1	1⅓ teaspoonsful	1¾ teaspoonsful			
1½	2 teaspoonsful	2⅔ teaspoonsful			
2	2⅔ teaspoonsful	3½ teaspoonsful			
5			⅔ cupful	4½ teaspoonsful	1 cup
7½			1 cupful	6¾ teaspoonsful	1½ cups
10			1⅓ cupsful	3 tablespoonsful	2 cups
25	⅜ cupful	11/12 cupful	3½ cupsful	½ cupful	
50			7 cupsful	1 cupful	
100			3⅓ quarts	2 cupsful	

These chemicals can be applied in 1 quart to 1 gallon of water per square rod, depending on the size of the nozzle and the speed that the operator walks. It is best to mark out a square rod plot (16½ feet by 16½ feet) and measure the amount of water required to cover it. If 2 quarts are needed, the amount of chemical for a square rod (Table 1) should be measured into each 2 quarts of water used. The same is true for any other amount of water.

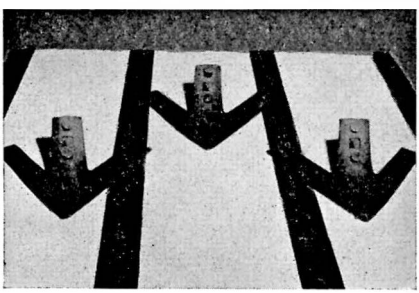
Cultural Methods

Cultural practices include the use of intensive cultivation alone or with competitive crops. Intensive cultivation alone may not be advisable in areas where soil erosion is a problem.

Intensive cultivation. Proper cultivation will eliminate a high percentage of most perennial weed species. For use on field bindweed, leafy spurge, Russian knapweed, hoary cress or horse nettle, a duckfoot field cultivator equipped with wide sweeps (12 to 24 inches) is essential (Fig. 3). The sweeps must be sharp, must overlap 3 to 4 inches, must be flat when in the soil and should operate at a uniform depth of 4 to 5 inches in order to cut every shoot at every cultivation. Although a duckfoot cultivator is preferred for Canada thistle and perennial sow thistle, a wheatland (one-way) disk may be substituted if operated at a depth of 4 to 5 inches.

The first operation is to plow 5 inches deep with a moldboard plow three weeks after the weeds emerge

Fig. 3. Duck-foot sweeps recommended for use in cultivating perennial weeds. Notice how the duck-foot sweeps overlap.



(about May 15 for leafy spurge, Russian knapweed or hoary cress; about June 1 for field bindweed and about June 15 for Canada thistle, perennial sow thistle or horse nettle). Field bindweed, leafy spurge, Russian knapweed, hoary cress and horse nettle should then be cultivated every two weeks until fall. Canada thistle and perennial sow thistle should be cultivated or "one-wayed" every three weeks until fall.

For quackgrass the first operation should be done at a depth of 2 inches about July 1 after a crop is removed or after the top growth of quackgrass is removed by mowing or grazing. A sharp wheatland (one-way) disk is preferred, but a moldboard plow will do if the area is disked sufficiently to cut up the sod. Succeeding operations should be done with a field cultivator equipped with spring shanks and bull-tongue points (shovels) to bring quackgrass rhizomes (underground stems) to the surface where they will dry out in a dry year. This also starves the plant. These later operations should be done when the quackgrass regrowth is about 2 inches tall.

One year of intensive cultivation will generally eliminate 90 percent of Canada thistle or perennial sow thistle plants and a high percentage of quackgrass in a dry year. Fewer plants of field bindweed, leafy spurge, Russian knapweed, hoary cress or horse nettle will be eliminated. A second year of intensive cultivation will usually eliminate the remaining plants, but it is seldom advisable to do this.

Competitive grain crops. Winter wheat or rye used with cultivation has proved to be effective for controlling field bindweed, Canada thistle, perennial sow thistle, leafy spurge, Russian knapweed, hoary cress and toadflax. Spring barley also has been an effective crop for curbing bindweed. Rye is the best of the three crops, as winter wheat often winterkills and barley, being a spring crop, leaves the ground uncovered over winter.

The area should be plowed shortly after weeds emerge in the spring and cultivated at 2-week intervals (3-week intervals for the thistles) until September when winter wheat or rye is seeded. If barley is used, the cultivation should be continued another month in the fall and one cultivation should be done in the spring before the crop is seeded. The area should be plowed as soon as the crop is combined. Cultivation should be carried on until the next crop is seeded. With this system at least two or three crops are generally required to eliminate any of these weeds.

Summer crops. Forage sorghum, sudan grass and soybeans have proved effective for the control of field bindweed, Canada thistle, or perennial sow thistle. Buckwheat, proso millet, or German millet have helped control quackgrass. The area should be plowed deep (5 to 6 inches) about June 1 (quackgrass should be plowed 2 inches deep when the weed is 2 inches tall) and cultivated at 2-week intervals.

If sufficient moisture is available about July 1, the crop best adapted

to the location and for controlling the weed should be seeded at a heavy rate with a grain drill. The crop should be harvested for forage (except proso millet and buckwheat which may be harvested for seed) before the first frost. The area should then be plowed deep in early November just before the soil freezes. If there is not sufficient moisture on July 1 to produce a crop, intensive cultivation can be continued until fall.

Perennial forage crops. Perennial grass and alfalfa give a high degree of control of field bindweed, Canada thistle or perennial sow thistle, especially when used with intensive cultivation. This method is particularly adapted to areas subject to erosion or areas too rough or rocky to permit regular cropping or cultivation.

If possible, the area should be intensively cultivated for one year. A crop of alfalfa or a mixture of alfalfa and an adapted perennial grass should be seeded in August when moisture is ample, or early the next spring. The date of seeding will depend on the area, but should be set when the chances of getting a good stand are best. A heavy stand is essential to successful control. The crop may be grazed or harvested for hay. Five years, generally, will eliminate 95 to 100 percent of bindweed, but less time is required for thistles.

Intensive cultivation and 2,4-D. The application of 2,4-D to perennial weeds in small grain, followed by intensive cultivation after harvest, has proved to be effective for the control of several species, especially Canada thistle and perennial sow thistle. The amount of 2,4-D required to control the weed should be applied to the weeds in the small grain, preferably barley or wheat. The crop should be combined so that the area can be tilled immediately after harvest. The field should be cultivated intensively at 2- or 3-week intervals, depending on the weed present, until fall.

Grazing. Large areas of leafy spurge can be controlled by pasturing with sheep with no harmful effects upon the sheep. The degree of control is dependent upon the intensity of grazing that the grass will stand. Sheep should be turned into the pasture when spurge plants are 6 to 8 inches tall. Good pasture management practices should be followed. If sheep do not keep the grass down, cattle can be rotated ahead of the sheep.

Field bindweed has been controlled with grazing sheep. A satisfactory system is to plant winter rye in the fall and graze it early the next spring. Then the land should be plowed 5 inches deep in early June. If there is enough moisture, sudan grass can be seeded at a heavy rate. It can be grazed from the time it gets 15 to 18 inches tall until September. If there is not sufficient moisture for a crop of sudan grass, the area should be cultivated intensively. A second crop of rye should be seeded in September and can be grazed or combined. The area should be plowed and cultivated intensively until fall.

Mowing. Many perennial weeds can be controlled by mowing at the right time for two, three or four years. This method has been especially effective for weed control in pastures. Such weeds as ironweed, ragweed and similar weeds should be mowed when budding or starting to bloom.

Chemical Control

One application of 2,4-D, MCP or 2,4,5-T seldom eliminates all perennial weeds present and it never eradicates an infestation. However, these chemicals do control many species by preventing the production of seed and by stunting top growth so that harvesting operations are facilitated.

These chemicals in conjunction with the special cultural practices previously described usually increase the effectiveness of such practices and decrease the length of time that they will have to be used. However, time should be allowed for 2,4-D to get into the roots of the weeds before any cultivation is done after spraying. This may take three weeks.

The heavy applications of chemicals required to control perennial weeds may cause some damage to the crop, especially at certain stages of growth. The farmer has two choices: (1) to risk injuring his crops in order to get good weed control or (2) get poor weed control with less chance of injuring his crop. The advantage gained by good weed control often offsets damage caused to the crop. Also the reduced infestation in the following crops usually makes it more practical to get good weed control.

Field bindweed, creeping jenny, *(Convolvulus arvensis* L.) 2,4-D is more effective than 2,4,5-T or MCP. Three-fourths pound of 2,4-D acid per acre will control this weed whether growing in small grain, perennial grasses or in areas that are not cropped. Sometimes when there is plenty of soil moisture, one-half pound of 2,4-D acid per acre will give satisfactory control of the weed growing in crops. In the more humid portions of the state, the most practical control is obtained by applying an amine form when the bindweed is starting to bloom. In drier areas, best results have been obtained by applying an ester form as soon as all plants are up in the spring, or by leaving the land idle for a year and spraying when the weeds are in bloom. Cultivation can then be started three weeks after spraying.

The high rate of application of 2,4-D may damage small grain, and early spring treatments increase this risk as then the small grain is in a more susceptible stage of growth. If re-treatments are necessary they should not be made until the remaining weeds have recovered from the first application, which is generally one year or more after the original treatment.

Small patches may be eliminated by the use of soil sterilants. Five pounds of sodium chlorate or 15 pounds of the borate-chlorate mixtures per square rod is recommended. However, 25 pounds of "Boras-

cu" or 15 pounds of the other borax compounds per square rod are often effective. Applications should be made between July 1 and October 1. One-half pound of CMU containing 80 percent active ingredient applied in 2 to 4 gallons of water per square rod also may be used on noncropland if there is an abundance of soil moisture.

Canada thistle (*Cirsium arvense* L.) and **perennial sow thistle** (*Sonchus arvensis* L.). 2,4-D is superior to 2,4,5-T or MCP for the control of perennial sow thistle, but in some cases, MCP has been equal to or slightly better than 2,4-D on Canada thistle. The amine form of 2,4-D or MCP generally gives a better kill of Canada thistle, since the esters kill the tops too quickly. There seems to be little difference in the effectiveness of esters or amines of 2,4-D on sow thistle.

Three-fourths pound of 2,4-D or MCP acid per acre is needed to give satisfactory kill of these weeds, although seed production can be prevented with one-half pound. One application should be made when the thistles are starting to bud, and can be done in small grain. To get best results the grain should be combined, the stubble tilled immediately and the area intensively cultivated at 3-week intervals until fall. If it is impossible to cultivate after harvest, a second application of 2,4-D or MCP should be made early in September. Late fall plowing just before the soil freezes adds to the effectiveness of the earlier treatments.

Two applications of chemical a year will kill most of the susceptible plants in grasslands or non-cropland. Other measures will have to be adopted to eliminate any remaining plants.

Small patches can be eliminated with 5 pounds of sodium chlorate or 15 pounds of a borate-chlorate mixture per square rod. Twenty pounds of "Borascu" or 10 pounds of the other borax compounds or 5 pounds of amate per square rod are also effective. Applications should be made between July 1 and October 1. CMU may be used on noncropland at the rate of one-fourth pound per square rod if there is an abundance of soil moisture.

Leafy spurge (*Euphorbia esula* L.). On leafy spurge 2,4-D is more effective than 2,4,5-T or MCP. The ester forms of 2,4-D give better results than the amine forms as the amines do not readily get into the plant. Top growth is retarded and usually prevented from setting seed in small grain by an application of one-half pound of 2,4-D acid equivalent per acre. After harvest, the area should be tilled and cultivated intensively at 2-week intervals in order to get best results. However, a fall application of one-half pound of 2,4-D acid will prevent the production of seed. A fall application of 1 pound will reduce the stand somewhat.

Where possible, large infestations should be seeded to an adapted perennial grass as its competitive effect increases the effectiveness of the 2,4-D. Applications of 1 pound of 2,4-D acid per acre twice a year on leafy spurge growing in a

Fig. 4. Borax compounds eliminate leafy spurge

bromegrass sod will sometimes eliminate this weed in three years. Quicker elimination can be obtained if the area is intensively cultivated at 2-week intervals for one season before the grass is seeded.

Several repeat applications of 1 pound per acre made when the upper bracts are beginning to turn yellow will greatly weaken or thin out stands of leafy spurge not growing in a crop, but two or three years are required to give appreciable elimination.

Limited trials indicate that one application of 25 to 30 pounds of 2,4-D acid per acre made in late September will eliminate a high percentage of the spurge plants. This method is especially adapted to infestations that are 1 to 10 acres in size.

Small patches can be eliminated with soil sterilants applied between July 1 and October 1. The borax compounds are the most effective and will generally give complete elimination (Fig. 4). "Borascu" should be applied at the rate of 15 pounds and the other borax compounds at the rate of 10 pounds per square rod. The borate-chlorate mixtures at a rate of 10 pounds or amate at 5 pounds or sodium chlorate at 5 pounds per square rod also are often effective. Seedlings that grow from seeds in the soil can be eliminated with 2,4-D.

Quackgrass *(Agropyron repens* L.). TCA in both liquid and pow-

dered forms has proved to be effective for the control of this weed. Fairly good control can sometimes be obtained by spraying quackgrass sod with 40 pounds of TCA acid (50 pounds of 90 percent sodium salt) per acre in the fall. At least 100 pounds (125 pounds of 90 percent sodium salt) are needed at any other time of the year. Best results can generally be obtained by applying 20 pounds of TCA acid (25 pounds of 90 percent sodium salt) per acre after the area has been plowed 2 or 3 inches deep. Applications should be made in September or May.

The effect of TCA remains in the soil for some time—longer in heavy soils than light soils. However, flax, oats or corn can generally be grown the spring after fall treatments are made. Wheat, soybeans, red clover, and alfalfa are more sensitive and may not grow so soon after TCA is applied.

MH has been found to give good temporary suppression of quackgrass. The suppression generally lasts at least one year and often results in a permanent kill of the weed. Five to 8 pounds should be applied when quackgrass is 4 to 8 inches tall, and the grass should be plowed under three to six days after spraying. The area should then be planted to a crop, as it increases the effectiveness of the chemical. Crops do not seem to be affected by the chemical.

Sodium chlorate at the rate of 5 pounds per square rod will give almost complete elimination of quackgrass. CMU at the rate of one-fourth pound per square rod is also effective and can be used on non-cropland. The borate-chlorate mixtures at the rate of 12 to 15 pounds per square rod will sometimes eliminate this weed, but the straight borax compounds are ineffective at rates normally used on other weeds. Amate has not been tested on this weed.

Russian knapweed (*Centaurea repens* L.). 2,4-D is more effective than 2,4,5-T or MCP for controlling this weed and an ester form of 2,4-D gives better results than an amine form. Application of 1½ pounds of 2,4-D acid per acre will kill top growth and prevent seed setting. However, only slight stand reductions can be obtained from repeated treatments.

Limited trials in South Dakota indicate that one application of 16 pounds of 2,4-D ester late in September will eliminate most of the Russian knapweed growing in a first-year stand of Crested wheatgrass without injuring the grass. More extensive trials in Nebraska indicate that 30 pounds per acre are needed to get consistently good elimination. This method is particularly adapted to this weed because most of the infestations in South Dakota are less than 10 acres in size.

Small patches can usually be eliminated with one application of 5 pounds of sodium chlorate or 15 pounds of a borate-chlorate mixture applied between July 1 and October 1. However, lighter rates of these chemicals, or 20 pounds of "Borascu," or 15 pounds of the other borax compounds, or 5 pounds of

amate per square rod sometimes give complete elimination. CMU at a rate of one-fourth pound per square rod gave good results on plots that were flooded, but CMU was ineffective even at much higher rates on plots that had less moisture.

Hoary cress, perennial peppergrass, white top *(Cardaria draba* L.). 2,4-D is more effective than 2, 4,5-T or MCP. An ester form of 2,4-D should be used. One-half to 1 pound per acre will control the top growth of hoary cress in growing crops when applied at the time the weeds are budding. Re-treatment of fall rosettes with 1 to 2 pounds per acre will give substantial stand reductions. Such a combination of treatments will give almost complete elimination in two or three seasons.

Limited trials indicate that a fall application of 30 pounds of 2,4-D acid per acre will give almost complete elimination of this weed.

Small patches can be eliminated with 5 pounds of sodium chlorate or 15 pounds of borate-chlorate mixtures per square rod. On non-cropland one-third pound of CMU per square rod can be used during a wet season to eliminate this weed.

Horse nettle *(Solanum carolinense* L.). On horse nettle 2,4,5-T is more effective than 2,4-D or MCP. Repeat applications of 1½ to 2 pounds of an ester form per acre will greatly reduce the stand. Treatments should be applied between the time the weed blooms and the time it sets fruit.

Bur ragweed *(Franceria discolor* Nutt.) and *(F. tomentosa* Gray). Two pounds of 2,4-D acid per acre in an ester form will effectively control these weeds if the application is made before the plants start to bud. Small patches can be eliminated with 4 pounds of sodium chlorate or 6 pounds of a borate-chlorate mixture per square rod.

Toadflax, butter and eggs *(Linaria vulgaris* Hill.). Repeated applications of 2 pounds of 2,4-D ester per acre in a perennial grass sod will reduce the stand of this weed. Two or more applications are needed each year for two or more years. Best results have been obtained when the area was intensively cultivated for a season before the grass was seeded. Sodium chlorate at 5 pounds or a borate-chlorate mixture at 10 pounds per square rod will eliminate this weed. CMU at one-half pound per square rod has also been effective in areas of high rainfall.

Poverty weed *(Iva axillaris* Pursh.). Two pounds of 2,4-D acid per acre applied in an ester form when the plants were budding have controlled this weed. Elimination is seldom achieved, even with repeated applications.

Reaction of Perennial Weeds to Chemicals

The Research Committee of the North Central Weed Control Conference has classified numerous species of perennial weeds according to their reactions to 2,4-D, MCP, 2,4,5-T, TCA, and some of the soil sterilants. The 2,4-D classification is given below. Numerals after the names of several species indicate the sensitivity of the weed to other chemicals. The meaning of these numerals is explained in footnotes following the list.

Group I. Weeds that can be killed with one application of 1 pound or more of 2,4-D acid per acre.

Austrian field cress
Dandelion (*)
Plaintain
Sunflower, perennial

Group II. Weeds which can be retarded in growth and prevented from setting seed by one application of 1 pound or more of 2,4-D acid per acre. Repeated applications are needed to give elimination.

Aster
Bindweed, hedge
Bindweed, field (2)
Buttercup, tall (2) (3)
Cress, western yellow
Chickweed, mouse ear
Daisy, oxeye (2)
Dock, curled
Garlic, wild
Hawkweed, orange
Ironweed (*) (2)
Lettuce, blue (*)
Mallow, round-leaved
Nettle
Nettle, stinging (2) (3)
Pucoon, hoary
Ragweed, bur
Ragweed, perennial (2)
Sage, pasture
Sage, prairie
Tansy
Thistle, bull
Thistle, Canada (2) (3)
Thistle, perennial sow (3)
Vervain, hoary (2)
Yellow rocket

Group III. Weeds which can be retarded in growth and prevented from setting seed with one application of 1 pound or more of 2,4-D acid per acre. Complete elimination is seldom accomplished even with repeated applications of 1 to 4 pounds of 2,4-D acid per acre.

Avens, three-flowered
Bedstraw, northern
Bladder campion
Blueweed
Bracken
Cockle, white
Geranium
Goldenrod
Hoary cress (2)
Horsetail
Leafy spurge
Licorice, wild
Milkweed, climbing (*)
Milkweed, common
Milkweed, whorled
Poverty weed
Russian knapweed
Sheep sorrel
Tanweed
Toadflax
Yarrow

Group IV. Weeds that are not controlled by as much as 4 pounds of 2,4-D acid per acre.

Boneset
Brier, sensitive
Cacti (1) (4)
Ground cherry
Horse nettle (2)
Johnson grass (4)
Mallow, alkali
Quackgrass (4)

*Weeds that belong in the next higher classification if treated as late as at the budding stages of growth.

(1) Weeds that can be killed with one application of 1 pound or more of 2,4,5-T acid per acre.

(2) Weeds which can be retarded in growth and prevented from setting seed by one application of 1 pound or more of 2,4,5-T acid per acre. Repeated applications are needed to give elimination.

(3) Weeds which can be retarded in growth and prevented from setting seed by one application of 1 pound or more of MCP acid per acre. Repeated applications are needed to give elimination.

(4) Weeds that can generally be killed with one application of TCA.

Annual Weed Control

ANNUAL WEEDS use soil moisture and soil nutrients for growth. Many of them require more water and plant food to produce a pound of dry matter than our common crops. Since they use some of the moisture and nutrients needed by crops, the yield of the crop is reduced. Table 2 shows how the yield of flax is reduced by three different types of annual weed infestations. It also shows the number of pounds of weeds produced per acre by a light infestation of weeds. There were 1400 pounds of broad-leaved weeds on one acre, 540 pounds of grassy weeds on another, and 1860 pounds on an acre when broad-leaved weeds and grassy weeds were grown together.

Table 3 shows the number of bushels of crop that could be produced with the amount of water required to grow 1000 pounds of weeds, for instance, 1000 pounds of cockleburs require enough water to produce 8 bushels of oats, or 7 bushels of barley, or 4 bushels of wheat, or 9 bushels of corn. If 1000 pounds of weeds are grown on an acre of land in a dry year, these figures represent the decrease in yield per acre that is caused by weeds. Actually, 1000 pounds of weeds would be a light infestation, as shown by the

Table 2. Bushels of Flax and Pounds of Weeds per Acre of Weed-free and Weedy Flax at Brookings, 1950

Weed Infestation	Flax Yields	Weed Yields
	Bu.	Lbs.
None	23.6	
Lamb's quarters, mustard, ragweed	14.4	1400
Foxtail	18.9	540
All four species	14.5	1860

Table 3. The Bushels of Crop That Could Be Grown with the Amount of Water Required to Produce 1,000 Pounds of Several Species of Annual Weeds

Weed	Oats	Barley	Wheat	Corn
	Bu.	Bu.	Bu.	Bu.
Cocklebur	8	7	4	9
Sunflower	13	12	6	14
Lamb's quarters	15	13	7	16
Russian thistle	6	5	3	7
Pigweed	5	5	2	6

PERENNIAL WEED CONTROL RECOMMENDATIONS

Weed	*Cultural Methods**	*Chemical Methods*		
		Large Infestations†	*Large Patches (1-10 Acres)*	*Small Patches‡ (Chemical per Sq. Rd.)*
Field Bindweed (Creeping Jenny)	Intensive cultivation Cultivation and rye Perennial hay crops Summer crops Grazing	2,4-D amine—¾ pound when blooming		5 lbs. sodium chlorate 15 lbs. borate-chlorate mixture 25 lbs. "Borascu" 15 lbs. other borax compounds ½ lb. CMU
Leafy Spurge	Intensive cultivation Cultivation and rye Perennial hay crops Summer crops Grazing	2,4-D ester—½ lb. in grain and 1 lb. or cultivation after harvest; 1 lb. twice a year in grass	25-30 lbs. 2,4-D late in September	15 lbs. "Borascu" 10 lbs. other borax compounds 15 lbs. borate-chlorate mixture 5 lbs. amate 5 lbs. sodium chlorate
Russian Knapweed	Intensive cultivation Cultivation and rye	2,4-D ester—1½ lbs. spring and fall	30 lbs. 2,4-D during late September	5 lbs. sodium chlorate 15 lbs. borate-chlorate mixture 20 lbs. "Borascu" 15 lbs. other borax compounds 5 lbs. amate ¼ lb. CMU
Hoary Cress (Perennial Peppergrass or White Top)	Intensive cultivation Cultivation and rye	2,4-D ester twice a year—1 lb. in spring and 1 lb. in fall	30 lbs. 2,4-D during late September	5 lbs. sodium chlorate 15 lbs. borate-chlorate mixture ⅓ lb. CMU
Canada Thistle and Perennial Sow Thistle	Intensive cultivation Cultivation and rye Perennial hay crops Summer crops Late fall plowing	2,4-D amine or MCP on Canada thistle 2,4-D amine or ester on sow thistle ¾ lb. at bud and in September or ¾ lb. in crop and intensive cultivation after harvest		5 lbs. sodium chlorate 15 lbs. borate-chlorate mixture 20 lbs. "Borascu" 10 lbs. other borax compounds 5 lbs. amate ¼ lb. CMU
Quackgrass	Intensive cultivation Summer crops	TCA—100 lbs. on sod TCA—20 lbs. on plowing in September or May MH—5 to 8 lbs., plow 3 to 6 days later and seed crop		5 lbs. sodium chlorate 12 to 15 lbs. borate-chlorate mixture ¼ lb. CMU
Horse Nettle	Intensive cultivation	2,4,5-T—1½ to 2 lbs. when blooming		

*Intensive cultivation refers to cultivation at 3-week intervals for thistles and at 2-week intervals for other species. Cultivation should be used with all cropping methods listed before seeding and after harvesting rye or summer crops, and before seeding perennial forage crops.

†Recommended rates of application are in pounds of 2,4-D, MCP, 2,4,5-T or TCA acid equivalent per acre.

‡CMU should be used only on non-cropland when there is an abundance of soil moisture. Sodium chlorate is inflammable and can be applied as a spray, but is less dangerous if applied dry. Borate-chlorate mixtures, amate, CMU and "Polybor" (a borax compound) should be applied as sprays. "Borascu" and "Concentrated Borascu" (other borax compounds) should be applied dry.

yield of weeds in Tables 2 and 5.

Table 4 shows that the amount of nitrogen and phosphorus required to grow 1000 pounds of weeds would produce several bushels of grain, for instance, the amount of plant food needed to grow 1000 pounds of foxtail (pigeongrass) is sufficient to produce 16 bushels of oats, or 13 bushels of barley, or 8 bushels of wheat, or 11 bushels of corn. If 1000 pounds of weeds are grown on an acre of land with a low fertility, the yields in Table 4 represent the yield decrease per acre that may be caused by weeds. Since data in Tables 2 and 5 indicate that 1000 pounds of weeds would be a light infestation, it is probable that weeds decrease the yield even more.

Table 4. The Bushels of Crop That Could Be Grown with the Amount of Nitrogen and Phosphorus Required to Produce 1,000 Pounds of Several Species of Annual Weeds

Weed	Oats	Barley	Wheat	Corn
	Bu.	Bu.	Bu.	Bu.
Foxtail	16	13	8	11
Lamb's quarters	24	19	12	16
Mustard	37	30	18	25
Wild oats	31	25	15	21
Pennycress	32	25	16	21

Table 5. Flax and Weeds per Acre in Western Minnesota, 1952, after 1951 Cropping Methods*

Cropping System in 1951	Flax Seed Yields 1952	Dry Weed Yields 1952
	Bu.	Lbs.
Small grain stubble plowed in August	21.7	646
Small grain stubble plowed in September	19.8	859
Corn, cultivated three times	15.0	1860
Corn, cultivated and hand hoed	20.1	864

*Data obtained at Minnesota Experiment Station located at Morris and presented in Flax Facts.

Control Measures

By planting clean seed and by using good crop rotations that include the use of row crops, forage crops and fall tillage, annual weed infestations can be almost eliminated over a period of years. Where these practices are not followed, or where they are not well done, it will be necessary to use 2,4-D or MCP and perhaps TCA to keep the weeds to a minimum. In such cases, advance planning for the use of the chemicals should be done. Too often people decide to spray when the weeds have over-taken the crop. Generally they are dissatisfied with the results because it was done too late. Few who plan on using chemicals at the beginning of the year complain.

Cultural Methods

There are several special cultivation practices, that can be incorporated into the regular cropping system, that will help eliminate infestations and prevent re-infestation.

Fall tillage. Plowing or one-waying in August induces many species of annual weeds to germinate in the fall (wild oats is an exception). These weeds are generally killed by frost. However, if they start to set seed before frost, they should be killed by cultivation or spraying. Most of the seeds that are in the upper 2 inches of soil will germinate. The area should be worked shallowly the following spring to keep from bringing any seeds from lower

depths up to the soil surface where they will germinate. The usual crops may be seeded, but flax is the crop most commonly handled in this manner. The data in Table 5 show how such a practice has decreased weeds and increased flax yields.

Delayed seeding. Shallow fall tillage will cover up weed seeds so that those that do not germinate in the fall will be ready to germinate next spring (wild oats is one of the weeds that acts this way). The area should be harrowed and packed early in the spring to induce early germination. Weeds that grow in the spring should be killed with cultivation just before the crop is seeded. But since these weeds do not grow early enough to permit the seeding of small grains at the normal seeding date, crop yields will suffer. Therefore, late seeded crops, such as soybeans, corn, sudan or sorghum, or early maturing varieties of small grain or flax should be used to partially offset this low yield. A stand of wild oats has been reduced 85 to 90 percent by this system. After several years, most of the seeds in the soil will germinate.

Perennial forage crops. Seeding to perennial grasses or legumes is helpful in controlling annual weeds, including wild oats, since the frequent cutting or grazing prevents weed seed production. In a few years the weed seeds in the upper levels of the soil germinate and if no seeds are returned, these upper levels eventually become free of weed seeds. When these crops are plowed up weed seeds from lower depths are brought to the surface and a new infestation results. To clean this up a second crop of grasses and legumes will be necessary to eliminate the infestation. Wild oats have been eliminated by including two years of grasses and legumes in a 4- or 5-year rotation for several rotations.

Mowing. Many annual weed infestations can be eliminated by mowing often enough to keep the weeds from setting seed for several years. This may be done in a hay crop or in non-cropland such as fence rows, feed lots, roadsides, and other rights of way.

Chemical Control

2,4-D (2,4-dichlorophenoxyacetic acid) and MCP (2-methyl-4-chlorophenoxyacetic acid) can be used to control many species of broadleaved annual weeds, such as sunflowers, cockleburs, mustards, kochia and others. In most cases, the chemical should be applied before the weeds are 6 inches tall in order to get best results. The amount of chemical needed to kill seedling weeds generally will not affect the crop. The maximum amount of chemical that crops will tolerate is given later under a discussion for each crop.

TCA (trichloroacetic acid) will control several species of grassy annual weeds, such as foxtail and barnyard grass (not wild oats). However, the chemical must be applied before the weed is more than 2 inches tall. Small grain crops are injured by TCA, but flax is not damaged by rates needed to control the annual grassy weeds.

Reaction of Annual Weeds to Chemicals

In 1952 research workers of the North Central Weed Control Conference classified many annual and biennial species of weeds according to their reactions to 2,4-D, MCP and TCA. The classification of weeds as to their reaction to 2,4-D is presented below in a modified form. The reaction to MCP and TCA is indicated with numerals after the name of the weeds. The meaning of these numerals is explained in footnotes following the list.

Group I. Weeds that can generally be killed at any stage of growth before flowering time with one-fourth to one-third pound of 2,4-D acid per acre.

Annual sow thistle
Annual vetch
Dragonhead mint (1)
False flax
Goose foot (1)
Henbit
Jewelweed
Lamb's quarters
Marsh elder
Morning glory (1)
Mustards (1)
Plantains
Puncture vine (1)
Ragweed, common (1)
Ragweed, giant (1)
Radish, wild (1)
Wormwood, bitter

Group II. Weeds that can generally be killed before they are 6 inches tall or stunted at later stages with one-third to one-half pound of 2,4-D acid per acre.

Bachelor's button
Blue bur
Carrot, wild (b)
Cinquefoil
Cocklebur (2)
Evening primrose (b) (2)
Goatsbeard (b) (2)
Lettuce, wild (2)
Mustard, hare's ear (2)
Mustard, tansy
Parsnip, wild (b)
Pennycress (2)
Peppergrass, annual (2)
Purslane (2)

Group III. Weeds that can be stunted and seed production sometimes prevented if treated at early stages of growth with one-third to one-half pound of 2,4-D acid per acre.

Buckwheat, wild (3)
Chickweed, common
Flixweed
Mare's tail
Mat spurge
Mayweed
Pigweed, rough (3)
Russian thistle (3)
Smartweeds, annual (3)
Speedwells
Sunflower, wild (3)
Velvet leaf (3)

Group IV. Weeds that are not readily controlled with one-half pound of 2,4-D acid per acre.

Barnyard grass (3) (4)
Bedstraw (3)
Black Medic (3)
Bluegrass, annual (4)
Bromegrass, downy (4)
Buffalo bur
Burdock (b) (3)
Catchfly, night flowering (3)
Chess, Japanese (4)
Cockle, corn
Cockle, cow
Cockle, white (3)
Corn spurry (3)
Crab grasses (3) (4)
Cucumber, wild
Flower of an hour (3)
Foxtails (3) (4)
Goose grass (4)
Hemp, wild (3)
Knotweed
Mallow (3)
Mullein (b) (3)
Nettle, hemp (2)
Nightshade, black
Sandburs (4)
Shepherd's purse (3)
Wild barley (4)
Wild oats (5)
Witch grass (4)

(b) a biennial species (germinates one year and sets seed the next).

(1) Weeds that can generally be killed at any stage of growth before flowering with one-fourth to one-third pound of MCP acid per acre.

(2) Weeds that can generally be killed before they are 6 inches tall or stunted at later stages with one-third to one-half pound of MCP acid per acre.

(3) Weeds that are not readily controlled with one-half pound of MCP acid per acre.

(4) Weeds that can generally be killed before they are 2 inches tall with 5 to 8 pounds of TCA acid per acre.

(5) Grassy weeds that are not readily killed with 10 pounds of TCA acid per acre.

Effects of Chemicals on Crops

APPLICATION of chemicals to crops will cause more damage at certain stages of growth than at others. This is particularly true when the rates of application required to control perennial weeds are used. If the most tolerant stage of the crop does not occur when the weeds are most susceptible, the farmer has two choices: (1) to risk injuring the crop in order to get good weed control, or (2) get poor weed control with less chance of injuring the crop. The advantage gained by good weed control often offsets damage caused to the crop.

The maximum rates of application that crops will tolerate at varius stages is discussed on the following pages. However, one should not use more chemical than is required to control the weeds.

Small Grains

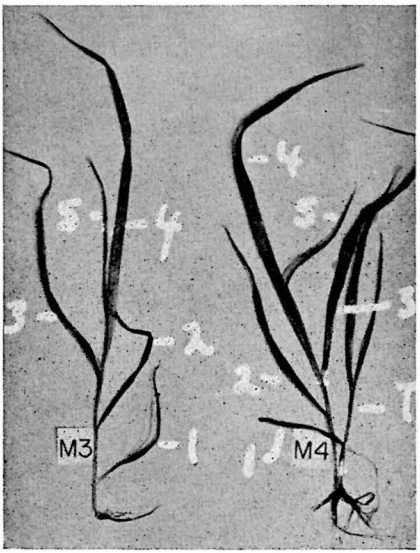
The ester forms of 2,4-D consistently cause more damage to these crops than do the amine forms if the same amount of 2,4-D acid per acre is applied. TCA cannot be used in wheat, barley, oats or rye.

Spring wheat and barley. These crops are most sensitive to 2,4-D before two leaves are formed. They are still sensitive between the 2-leaf stage of growth and the 5-leaf stage (Fig. 5), but are relatively tolerant to 2,4-D between the 5-leaf stage and the time that the growing head inside the plant begins to swell the boot (Fig. 6). They are again sensitive between the early-boot stage of growth and the time that milk is formed in the seeds. After the seeds become doughy, these crops are quite resistant to 2,4-D.

Any application of 2,4-D during the sensitive periods of growth may cause injury to the crop. However, one-third pound of an ester or one-half pound of an amine generally does not cause any yield reduction if applied between the 5-leaf and early-boot stages of growth. Likewise, an application of 1 pound of either form seldom causes damage after the grain is in the dough.

Wisconsin 38 has proved to be more susceptible to 2,4-D than such

Fig. 5. Five-leaf stage of growth in grain. Plant at left has five leaves. Plant at right has five leaves and a tiller (T) which emerged immediately above the first leaf. This leaf dropped off shortly after this picture was taken; therefore, it is necessary to count one leaf for each tiller whether the leaf is on the tiller or not.



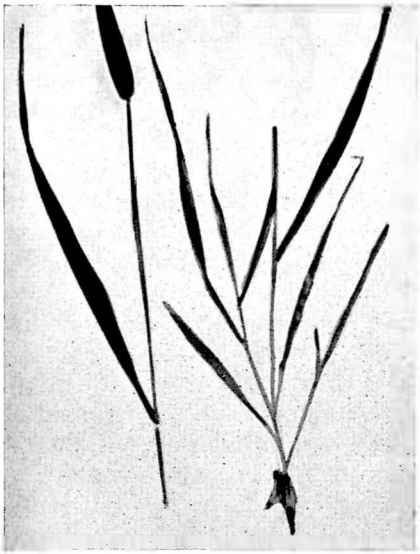


Fig. 6. Early-boot stage of growth in grain. Note how the boot is swelling on the stem of the plant shown at the left.

barley varieties as Plains, Feebar, Spartan, Odessa and Kindred. Likewise, Canadian workers have found that Montcalm, Prospect and Vantage are more susceptible than several other Canadian varieties.

Only a few wheat varieties have been tested, but there is some indication that Rescue, Thatcher and Regent are more sensitive than some of the other varieties.

Oats. Varieties of oats differ more in their reactions to 2,4-D than do varieties of barley or wheat. Mindo and Marion are two of the most sensitive varieties—they are sensitive until after they are headed. Nemaha and Cherokee are also sensitive varieties, but they become tolerant shortly after the boot begins to swell. Clinton, Bonda and Ajax appear to be relatively tolerant between the 6-leaf stage and boot stages, while Andrew and Brunker are most tolerant between the 5-leaf and boot stages of growth. Canadian workers have reported Anthony and Vanguard as being more susceptible than other Canadian varieties. All varieties are sensitive before the 2-leaf stage and quite resistant after the seeds become doughy.

Small dosages of 2,4-D may decrease yields during sensitive periods of growth, but rates up to one-third pound of an ester or one-half pound of an amine applied during tolerant periods do not generally reduce the yields. As much as one pound of 2,4-D may be applied after the grain is in the dough. Oats are more tolerant to MCP than 2,4-D. Therefore, in some cases it may be desirable to use MCP in oats if the weeds present can be controlled with this chemical.

Winter wheat and rye. These crops are susceptible to 2,4-D treatments made in the fall of the year. However, up to one-third pound of an ester form or one-half pound of an amine form can be applied after the crop is fully stooled in the spring and before the boot begins to swell, without causing any material decrease in yield (Fig. 7). Heavier rates can be applied after the grain is doughy, but rates of 1 pound or more per acre may cause some yield reduction even at this late period of growth.

Flax. To control some annual broad-leaved weeds in flax, one-fourth pound of an amine of 2,4-D

Photo courtesy of Walter Enlow, U. S. Indian Service

Fig. 7. Unsprayed field of wheat at the left and a sprayed field at the right.

or one-fourth pound of either an amine or a sodium salt of MCP may be used. The grassy weeds may be controlled with 5 pounds of TCA acid (6¼ pounds of 90 per cent sodium salt) per acre.

The chemicals may be applied as mixtures containing TCA and either 2,4-D or MCP in the amounts given above for controlling mixed species of weeds (Fig. 8). None of these treatments reduce the yield materially. The 2,4-D or MCP will control or eliminate such weeds as lamb's quarters, pigweed, ragweed, cocklebur and pennycress, if applied when the weeds are very young. Less chemical is needed for most of the mustards. TCA will control the foxtails and barnyard grass (not wild oats), if applied before the weeds are 2 inches tall. Mixtures containing TCA and 2,4-D or MCP will control both types of weeds when they are young. Therefore, flax should be sprayed as soon as the weeds are up.

Although the chemicals do not reduce the yield of flax and will control weeds, flax will do better on weed-free land. In experiments, weed-free flax has yielded 25 bushels per acre, while weed-free flax that had been sprayed yielded 24 to 25 bushels per acre. Flax infested with broad-leaved weeds (mustard, pigweed, kochia, and lamb's quarters) yielded only 14.4 bushels, and flax infested with foxtail yielded 18.9 bushels per acre. By using 2,4-D on flax infested with both types of weeds, the yield of weedy flax was increased to 18.2 bushels (an increase of about 4 bushels per acre). However, more flax was produced on weed-free land than on weedy land even though the weeds were killed.

MCP is less toxic to flax than either 2,4-D or TCA. It seldom delays maturity, while the other chemicals may result in a delay of three to seven days. The later date of maturity does not directly affect yield, but some varieties that would normally escape disease infection may be delayed long enough to become infected. The yield is sometimes reduced materially by the diseases. Therefore, MCP should be used instead of 2,4-D if it will control the weeds. This is particularly true if used in a mixture with TCA.

Sprayed flax often appears wilted for several days after spraying and the stems are often curved, but this does not necessarily mean that the yield is reduced.

Spraying flax with 2,4-D or MCP right after the bolls are set may result in reduced germination. Therefore, flax grown for seed should not be treated at this stage of growth.

Row Crops

Cultivation of row crops is essential for the liberation of nutrients needed for the crops. Chemicals may be used to control weeds that cannot be controlled by cultivation. Therefore, chemicals may be used in the place of one cultivation, but should not replace all cultivations.

In one test, corn that was culti-

Fig. 8. Plots of flax sprayed with (from left to right) MCP, MCP and TCA mixed, TCA, 2,4-D and TCA mixed, and 2,4-D alone. Annual weeds were controlled and flax was not injured by chemicals used.

Photo courtesy of Glenn Schrader, S. D. Extension Service

Fig. 9. *Left:* corn infested with sunflower. *Right:* Portion of same field that had been sprayed with 2,4-D—sunflowers were eliminated but foxtail was not.

vated three times yielded 63.8 bushels per acre, while corn that was hoed around the plants in addition to being cultivated yielded 77 bushels. Corn that was cultivated twice yielded 56 bushels; whereas, corn that was sprayed and not cultivated only produced a yield of 25.6 bushels.

Corn. 2,4-D can be used to control many broad-leaved weeds in this crop. An application of one-fourth pound of an ester or one-half pound of an amine per acre seldom has any pronounced effect on yield unless it is applied the week before silking commences (Fig. 9). However, stalks often become brittle after treatment with 2,4-D and a strong wind or cultivation may break many of them (the larger the corn at time of treatment, the greater chance of getting breakage). Brace roots may also be damaged, and severe injury may allow the corn to lodge.

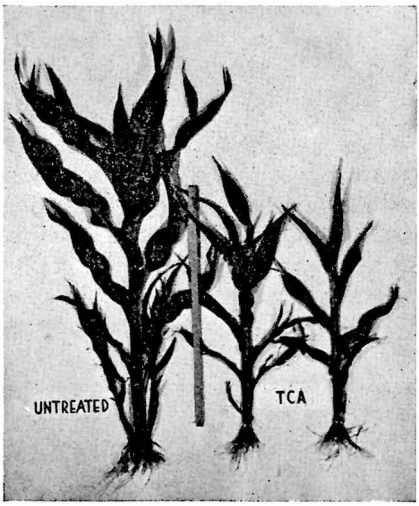
Corn is more susceptible to 2,4-D after a period of hot weather. After several days of 85° or above, corn is much more susceptible than it is after a similar number of days at 65° F. The temperature during the period before treatment is more important than the temperature at the time of treatment.

Limited trials indicate that TCA can be used at lay-by time to control grassy weeds if drop nozzles are

used and if the chemical touches the base of the stock, only. If the chemical is sprayed over the leaves, the corn will be severely damaged (Fig. 10). In Minnesota the application of 1 to 2 pounds of a 2,4-D ester and 5 pounds of TCA per acre at lay-by time with drop nozzles, has proved to be an effective method of cleaning up the land for flax the next year. This treatment is suggested for use on a trial basis, only.

Sorghum. Forage sorghums are, in general, more tolerant to 2,4-D than grain sorghums. Both types may be injured severely and may be killed if treated before they are 3 inches tall. They are most tolerant when 4 to 8 inches tall—they usually have 3 to 5 leaves. Applications of one-fourth pound ester or one-half pound amine per acre during this period seldom reduces the yield. However, brace roots may be slightly injured. Plants treated after they are 8 inches tall may be dwarfed and may suffer brace root injury to the extent that they will lodge. Plants treated at heading time may not produce a full crop of seed.

Fig. 10. ***Left:*** **untreated corn plant.** ***Right:*** **two corn plants that had been sprayed with 5 pounds TCA acid per acre over the tops when they had three to four leaves.**



Sugar beets. Neither 2,4-D nor MCP should be used on this crop. However, TCA can be used to control grassy weeds such as foxtail or barnyard grass (not wild oats). To get best results, 5 to 7 pounds of TCA acid (6¼ to 8¾ pounds of 90 per cent sodium salt) per acre should be applied just before the beets come up. In order to reduce the cost, the chemical should be sprayed in a swath over the row only. The weeds between the rows can be removed more cheaply with a cultivator.

Forage Crops

Legumes. The use of herbicides on new plantings of legumes should be avoided unless the crop is seriously threatened by weeds. However, seedling stands of ladino clover, alsike clover, red clover and alfalfa may be sprayed with an amine of 2,4-D or an amine or sodium salt of MCP at rates of one-fourth pound or less per acre without serious losses of crop stands. Sweet clover usually will not tolerate either 2,4-D or MCP.

TCA can be used at a rate of 5 pounds (6¼ pounds of 90 per cent sodium salt) per acre in seedlings of alfalfa or sweet clover for the control of annual grassy weeds. This

chemical will severely damage alsike or red clovers and it will kill small grains used as a companion crop. It can be used if flax is the companion crop. Less injury is produced by any of the chemicals if the companion crop or weed canopy is 10 to 15 inches high. Seedlings are more sensitive to 2,4-D or MCP if they are shaded, therefore, too much canopy is just as undesirable as too little cover.

The use of 2,4-D or MCP on established legume stands should be considered an emergency weed control measure. The safest time for treatment is in early spring before any growth is made, or immediately after a crop of hay is harvested. TCA at a rate of 5 pounds TCA acid per acre can be used to control grassy weeds in established stands of alfalfa or sweet clover.

Grass crops. Application of three-fourths pound of 2,4-D, or MCP can be applied to perennial grasses, such as bromegrass, bluegrass or the wheatgrasses, after the grass has reached the 4-leaf stage of growth, without injuring the grass. Broad-leaved annual weeds can readily be controlled in new plantings of perrenial grasses. However, the removal of these broad-leaved weeds favors the development of grassy weeds.

Established stands of perennial grasses will tolerate as much 2,4-D, MCP or 2,4,5-T as is needed to control the weeds. However, rates of 12 to 15 pounds per acre or more, used to eliminate some perennial weeds may cause some damage to the crop.

Pastures. Heavy rates of 2,4-D, MCP or 2,4,5-T may be used to control weeds in pastures. A single spraying in June gives better control of more kinds of weeds than a single mowing. However, two applications a year are often required for two or more years for some perennial weeds. This generally results in increased production of desirable forage and improvement in grass stands. These materials may reduce the stand of some legume species present in the pasture, but many native legume species, have a rather high tolerance to the chemicals.

Good pasture management with controlled grazing will prevent an infestation of weeds. Once the pasture is overrun with weeds, however, chemicals, or mowing, or a complete pasture renovation is needed to eliminate them. Pasture renovation on land where it can be done is perhaps the best method. Renovation is done by preparing a seed bed, seeding and protection of the grass until established.

WHEN TO SPRAY

Crop	*Safest Time to Spray (Most Tolerant Stages of Growth)*
Spring Wheat and Barley	Between 5-leaf and early-boot stages After grain is in the dough
Oats	
Andrew and Brunker	Between 5-leaf and early-boot stages
Clinton, Bonda and Ajax	Between 6-leaf and early-boot stages
Nemaha and Cherokee	After boot stage
Mindo and Marion	None
All Varieties	After grain is in the dough
Winter Wheat and Rye	Spring; fully stooled to boot After grain is in the dough
Flax	As soon as weeds are up Grassy weeds 2 inches high or shorter
Corn	Before silking and after several cool days; earlier the better
Sorghum	When 4 to 8 inches tall (3 to 5 leaves)
Sugar Beets	Just before beets come up
Legumes	
Alfalfa; Red, Alsike and Ladino Clovers	Seedlings when companion crop or weed canopy is 10 to 15 inches high, or established stands right after mowing
Alfalfa and Sweet Clover	Seedlings in flax or established stands after mowing
Grasses	Seedlings after they have 4 leaves
Bromegrass, blue grass and wheatgrasses	Established stands any time except heading time for seed fields
Pastures	Best weed control in June

°Rates of application are in pounds of 2,4-D, MCP, 2,4,5-T or TCA acid equivalent per acre

WEEDS IN CROPS

Maximum Pounds of Chemical That Can Be Applied Per Acre at Tolerant Stages of Growth Without Undue Risk of Reducing the Yield of the Crop°	*Type of Weeds That Can Be Controlled*
2,4-D: ⅓ lb. ester or ½ lb. amine	Broad-leaved
2,4-D: up to 1 lb.	Broad-leaved
MCP less toxic than 2,4-D	Broad-leaved
2,4-D: ⅓ lb. ester or ½ lb. amine	Broad-leaved
2,4-D: ⅓ lb. ester or ½ lb. amine	Broad-leaved
2,4-D: ⅓ lb. ester or ½ lb. amine	Broad-leaved
2,4-D: ¼ lb. ester or ⅓ lb. amine	Broad-leaved
2,4-D: up to 1 lb.	Broad-leaved
2,4-D: ⅓ lb. ester or ½ lb. amine	Broad-leaved
2,4-D: up to 1 lb.	Broad-leaved
MCP or 2,4-D: ¼ lb. amine	Broad-leaved
TCA: 5 lbs. (6¼ lbs. 90% sodium salt)	Grassy annuals
2,4-D: ¼ lb. ester or ½ lb. amine	Broad-leaved
2,4-D: ¼ lb. ester or ½ lb. amine	Broad-leaved
TCA: 5 to 7 lbs. over the row (6¼ to 8¾ lbs. 90% sodium salt)	Grassy annuals
2,4-D or MCP: ¼ lb. amine	Broad-leaved
TCA: 5 to 7 lbs. (6¼ to 8¾ lbs. 90% sodium salt)	Grassy annuals
2,4-D or MCP: ¾ lb. ester or amine	Broad-leaved
2,4-D, MCP or 2,4,5-T: up to 2 lbs.	Broad-leaved
2,4-D, MCP or 2,4,5-T: up to 2 lbs.	Broad-leaved

Recommended Chemicals

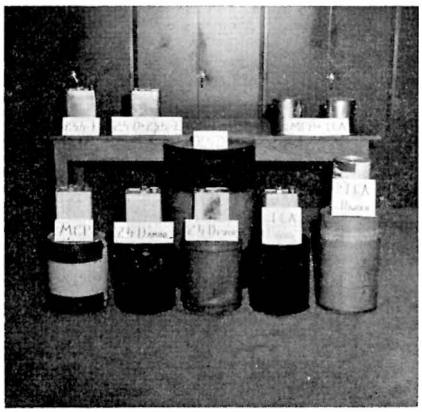
In South Dakota, over 100 chemical forms have been tested in the greenhouse or in the field for their effectiveness in controlling weeds. (Fig. 11). 2,4-D is effective for controlling many broad-leaved weeds, but for some weeds 2,4,5-T or MCP are superior. TCA and MH are effective for controlling grassy weeds, but their cost prohibits their use on large acreages. Soil sterilants are useful in eliminating small patches, but are impractical for large areas of cultivated land.

2,4-D, MCP and 2,4,5-T

2,4-D (2,4-dichlorophenoxyacetic acid) is the best chemical available for the control of large infestations of perennial weeds. It can be used selectively in many of our field crops. If applied properly it often controls the weeds without injuring the crops. MCP (2-methyl-4-chlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) are closely related to 2,4-D and have limited use in controlling perennial weeds.

All three chemicals are insoluble in water, but are made soluble by treatment with other chemicals. This results in the manufacture of ester and amine forms of all three chemicals. However, 2,4,5-T is generally used in an ester form while MCP is most common in the amine form. Emulsifying agents, stickers and spreaders are added to help get the ester or amine into solution or emulsion with water or oil. They also tend to help make the spray droplets spread in a thin layer on the leaf of the plant so that it will stick until it gets into the plant. Each formulating company uses different compounds or different amounts of the same compounds as emulsifiers, stickers and spreaders.

Fig. 11. The chemicals recommended for controlling large infestations of weeds.



Aside from the differences in these added agents, one ester form of 2,4-D is about as effective for controlling weeds as another when the same amount of 2,4-D acid is used. Likewise, several esters of 2,4,5-T seem to be equally effective. The same is true for the various amine forms of 2,4-D or MCP. These emulsifiers, stickers and spreaders are important, especially if water is used as a carrier. In formulations containing 6 or more pounds of 2,4-D acid per gallon, these additives may be deficient.

The ester forms can be applied in either oil or water as carriers, but the amine forms must be applied in

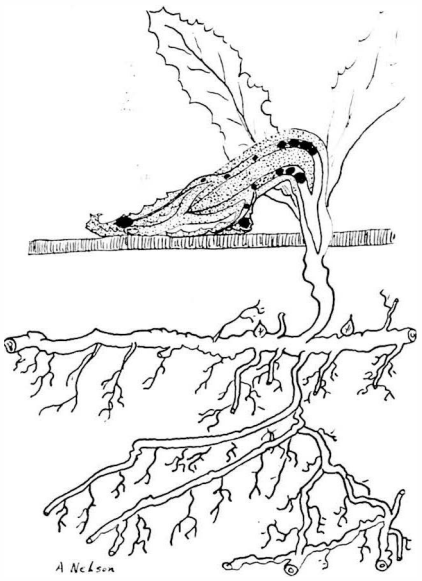


Fig. 12. Lower portion of a perennial weed showing how 2,4-D works when too much chemical is applied, or when an ester form is applied. Weeds such as field bindweed or canada thistles are relatively easy to penetrate. The chemical moves into the plant so rapidly that a high concentration is built up in the translocation system (stem enlarged to show system). The top is killed but the roots are not affected. Consequently, the weed recovers.

water. The ester forms are, as a general rule, more injurious to crop plants. They appear to get into the plant quicker than the amine forms. They also will penetrate some plants such as leafy spurge, Russian knapweed or hoary cress, that the amines do not appear to enter. This means that esters will control some weeds that amines will not affect. However, the chemicals must move from the leaves to the roots of perennial weeds in order to kill them. If an ester enters a plant too fast, as it sometimes does in field bindweed or Canada thistle, it builds up a high concentration in the top of the plant; thus killing the top without killing the roots (Fig. 12). Amines seem to penetrate plants more slowly than esters and trickle down into the roots where they build up a toxic concentration and kill the roots (Fig. 13). In such cases, the amines give a slower kill of the top growth, but the kill of the entire plant is more complete.

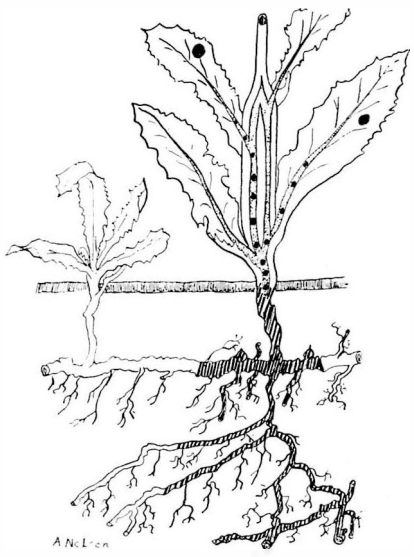


Fig. 13. Lower portion of a perennial weed showing how 2,4-D works when used properly. The chemical is applied to the leaf where it slowly penetrates the plant. It gets into the translocation system (stem enlarged to show this system) and moves slowly to the roots where it moves down to kill the roots directly beneath.

TCA

TCA (trichloroacetic acid) is a grass killer and is effective for the control of quackgrass and other grassy weeds. It is generally sold in the sodium salt form which can be purchased as a powder or as a liquid. Both forms can be applied in water as a carrier. Slightly over 1 pound of the powder will dissolve in a gallon of water. Both forms have strong caustic properties—they will irritate the skin and corrode aluminum or copper fittings with which they come in contact. Liquid forms may eat through metal in which they are sold; therefore, it is not advisable to plan to store liquid TCA more than 90 days.

MH

MH (maleic hydrazide) is a growth inhibitor that has proved to be effective for the control of quackgrass and some other weeds. It is formulated as sodium and amine salts. The sodium salt is a powder that is soluble in water and has a wetting agent and stickers added. The amine form is a liquid that also is water soluble, but does not contain a wetting agent. Therefore, two-thirds of an ounce of Dreft should be added to every 10 gallons of spray containing the amine form of MH.

Soil Sterilants

Soil sterilants (heavy chemicals) such as sodium chlorate, several borax compounds, borate-chlorate mixtures, amate and CMU are recommended for the elimination of small patches of perennial weeds (Fig. 14). Soil sterilants will leave the soil unproductive for a period of one or more years.

Fig. 14. The chemicals recommended for eliminating patches of perennial weeds.

Sodium chlorate. This chemical is handled commercially as "Chlorate of Soda" or as "Atlacide." Both chemicals are equally effective for weed control and both are inflammable. Both chemicals are granular compounds that are soluble in water. Approximately 3 pounds can be dissolved in a gallon of water. They may be applied as spray or in the dry form. However, the spray applications are greater fire hazards. Clothing and foliage that have been wet with spray of these chemicals and then dried are highly inflammable.

Borax. There are several borax compounds. The most important are "Borascu,""Concentrated Borascu" and "Polybor." Both forms of "Borascu" are granulated and are insoluble in water. They must be

applied dry. "Polybor" is a powder that will dissolve in water at the rate of approximately 3 pounds in a gallon. It should be applied as a spray to get best results. All three forms are equally effective if the same amount of boron trioxide (active ingredient) is applied. Ten pounds of "Concentrated Borascu" or "Polybor" are equal to about 15 pounds of "Borascu." "Polybor" is the fastest acting chemical followed in order by "Concentrated Borascu" and "Borascu."

Borate-chlorate mixtures. Borax compounds and sodium chlorate are formulated into mixtures known as "Polybor-chlorate" and "Chlorax." Both are soluble in water. About 1 pound of "Polybor-chlorate" or one-half to three-fourths pound of "Chlorax" will dissolve in a gallon of water. They may both be applied as sprays. The main difference is the relative proportion of borates and chlorates. Chlorax contains a higher amount of sodium chlorate.

Amate (ammonium sulfamate). This chemical is a granulated compound that can be applied as a spray. About 5 pounds will dissolve in a gallon of water. It will leave the soil unproductive for a shorter period of time than any of the other soil sterilants. It is the easiest of the soil sterilants to apply. It is corrosive to metals.

CMU (3-p-chlorophenyl-1-1-dimethyl urea). CMU is a fine powder that is slightly soluble in water. About one-half pound will dissolve in a gallon of water. It should be applied as a spray. CMU is not effective for weed control unless an abundance of rain falls after the chemical is applied. It is recommended for use on non-cropland only, as there is some danger of it accumulating below the soil surface in concentrations strong enough to kill crops.