Bsmt

Extension Folder 212
Revised

Cultural and Chemical WEED CONTROL

in Field Crops 1968

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXTENSION SERVICE

Cultural and Chemical Weed Control in Field Crops—1968

Information in this publication summarizes research at the Minnesota Agricultural Experiment Station and elsewhere on the effectiveness of using chemicals for controlling weeds. Application rates listed herein are broadcast rates and refer to acid equivalent or active ingredient rather than the amount of commercial product.

In general, the problems that might result from residues remaining on agricultural commodities from the use of these chemicals have not been investigated at this experiment station. Therefore, no claims or representations are made by the University of Minnesota or its officers or employees that the chemical pesticides discussed will or will not have residues. *Consequently, any person who uses any of the chemicals discussed in this publication does so at his own risk.*

This position is necessary because of the enactment in July 1954 of Public Law 518, an amendment (commonly known as the Miller Amendment) to the Federal Food, Drug, and Cosmetic Act. This law makes liable for seizure any raw agricultural commodity moving in interstate commerce which carries a pesticide residue (1) for which no exemption or tolerance has been established or (2) which exceeds the tolerance established by the Food and Drug Administration. Similar state regulations cover intrastate shipments.

After December 31, 1967, registration under the Federal Insecticide, Fungicide, and Rodenticide Act for pesticides previously registered for use in a manner involving food or feed on a "no residue" or "zero tolerance" basis will be cancelled unless: (1) finite tolerance or exemptions from the requirement of tolerances have been established by the Food and Drug Administration or (2) progress reports have been submitted to the Pesticide Registration Division, U.S. Department of Agriculture, showing that studies are being conducted to obtain data to support finite tolerances. *Therefore, registrations for some uses suggested in this bulletin could change by planting time.* New information will be available from county agents as changes occur.

Also observe label directions; they should be read and followed carefully. For information on specific problems contact your county agent.

Safety precautions—Always follow carefully the precautions on the label in order to help protect the operator, avoid crop injury, and prevent harmful residues in food and feed crops. Use herbicides only on crops for which they are specifically approved and recommended. Use only recommended amounts; applying too much of an herbicide may damage the crop, may be unwise if the crop is to be used for food or feed, and is costly. Apply herbicides only at times specified on the label; observe the recommended intervals between treatments and pasturing or harvesting of crops. Wear goggles, rubber gloves, and other protective clothing as recommended on the label. Guard against possible injury to nearby susceptible plants.

Revised for 1968 by G. R. Miller, associate professor and extension agronomist, and R. Behrens, professor, Department of Agronomy and Plant Genetics. Other staff members concerned with field crop weed control include H. J. Otto, professor and extension agronomist; R. G. Robinson, associate professor, Department of Agronomy and Plant Genetics; O. E. Strand, assistant extension agronomist; and R. N. Andersen, plant physiologist, Agricultural Research Service, United States Department of Agriculture (USDA).

Trade names are sometimes used in this publication to clearly identity the herbicide under discussion. Omission of other trade names of similar herbicides is unintentional. The inclusion of a trade name does not imply endorsement and exclusion does not imply nonapproval.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Roland H. Abraham, Acting Director, Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55101.

35M—12-67

Follow label instructions carefully when using agricultural chemicals.

Contents

Chemical Weed Control Practices

The terms listed below are used in this folder to describe herbicide applications:

Acid equivalent—A term used to express a rate or quantity of an acid herbicide.

Active ingredient—A term used to express a rate or quantity of a nonacid herbicide.

Band application—Herbicide applied to a narrow strip centered over the crop row.

Broadcast application—Herbicide applied over entire area.

Directed spray application—Herbicide applied to a band over the row that includes the base of crop plants and the weeds in the row. Spray is directed across the row from nozzles positioned near ground level on each side of the row. This type of application allows use of chemicals that will injure the crop plant if more than a small part of the plant is contacted by spray. Special units that guide from the ground or mount on cultivators must be used.

Drop-nozzle application—Herbicide applied by means of nozzles mounted on extensions below the spray boom to avoid spraying upper parts of the crop plant.

Postemergence application—Herbicide applied to the crop and weeds after they emerge.

Pre-emergence application—Herbicide applied after a crop is planted but before it or weeds emerge.

Preplanting application—Herbicide applied before the crop is planted.

Preplow application—Herbicide applied to soil and/or foliage of weeds before plowing.

Rate—The amount of active ingredient or acid equivalent of an herbicide applied to the area treated, i.e., on a broadcast basis.

Soil incorporation—Mechanical mixing of the herbicide with the soil. Chemicals may be incorporated 3 to 4 inches with a disk or rotary tiller, 1 to 2 inches with a harrow or rotary hoe, or slightly covered with planter attachments. The desired depth of incorporation depends on characteristics of the chemical being used.

Diallate, EPTC, triallate, trifluralin, and vernolate require some incorporation. Incorporation of linuron usually reduces its effectiveness. Incorporation of atrazine by disking has resulted in weed control equal to or, under dry conditions, slightly better than pre-emergence applications.

Pre-emergence Applications

Several excellent herbicides are now available for use as pre-emergence applications. These herbicides generally give good weed control. But results may vary depending on the kinds of weeds present, weather conditions, and soil type. Established perennials are usually not controlled with pre-emergence herbicides. Control of some deep-germinating and tolerant annual species may not be adequate with pre-emergence treatments. The surviving species vary with the herbicide used. Weed control may be poor if there is no rainfall soon after treatment. Or, if rainfall is very heavy, some herbicides will move downward in the soil, resulting in poor weed control and/or crop injury. Soil type can affect weed control. Use the rates given in instructions on the herbicide label for the soil type.

Numerous tests have been conducted in Minnesota to determine the overall effectiveness of pre-emergence applications of herbicides. Table 1 shows the performance of uncultivated plots of pre-emergence herbicides in corn for several years in county demonstrations. Table 3, page 10, gives similar information for herbicides in soybeans. Figures in Tables 1 and 3 are the percentage of trials in which weed control was rated good (more than 75 percent of the weeds controlled), fair (50 to 75 percent of the weeds controlled), or poor (less than 50 percent of the weeds controlled). Evaluations were made about 5 weeks after application. Herbicides not included in these tables have not been adequately tested or have performed poorly under Minnesota conditions.

Table 1. Early evaluations of herbicides in weed control demonstrations in uncultivated corn

Chemical	Pounds per acre active ingredient or acid equivalent broadcast	Years in trial	Number of trials		Percent of trials in each class					
					Grasses			Broad-leaved weeds		
			Grasses	Broad-leaved weeds	Good	Fair	Poor	Good	Fair	Poor
Amiben	2	1965-66	124	122	49	27	24	51	25	24
Atrazine	2	1960-64	294	274	54	27	19	68	20	12
Atrazine	3	1959-67	513	489	76	16	8	85	9	6
Atrazine (early postemergence)	3	1961-67	398	374	73	14	13	87	7	6
Atrazine + linuron	1½ + 1½	1965-67	179	174	74	16	10	85	9	6
Atrazine + oil (early postemergence)	2	1966-67	121	120	93	3	4	91	6	3
Atrazine + prometryne (Caparol)	1½ + 1½	1964-65	130	125	73	19	8	81	10	9
CDAA (Randox) granular	4	1959-64	333	313	40	35	25	11	26	63
CDAA (Randox) granular	5	1963-66	252	236	48	30	22	15	21	64
CDAA-T (Randox-T) granular	3½ + 7	1960-66	417	397	48	33	19	46	31	23
Dicamba (Banvel-D)	1	1966-67	119	117	19	20	61	63	17	20
EPTC + 2,4-D (Knoxweed)	2 + 0.8	1964-65	131	127	21	31	48	34	31	35
Linuron (Lorox)	2	1963-65	189	179	52	26	22	61	21	18
Propachlor (Ramrod)	5	1965-67	180	176	75	17	8	39	31	30
Propachlor (Ramrod) granular	5	1965-66	123	119	73	19	8	41	29	30

Granular Versus Spray Forms of Herbicides

Several herbicides are available in granular or spray forms which may or may not perform equally in either form. Granular forms require no mixing and they can be used directly from the package. The cost of granules is usually higher than the cost of an equal amount of the spray form. Distribution of chemicals with granule applicators is sometimes not as uniform as with sprayers, especially on rough ground. In some instances this has resulted in variable weed control. Chemicals that cause irritation, such as CDAA and CDAA-T, are safer in the granular form than in the spray form.

Herbicide Mixtures

Some herbicide mixtures are in use and several new herbicide mixtures show promise for overcoming limitations of single chemicals. Certain mixtures may (1) control more kinds of weeds, (2) give more consistent performance with different soils and weather conditions, (3) lessen soil residue problems, (4) increase persistence enough to give full-season weed control, (5) reduce crop injury, or (6) reduce costs.

Only those mixtures that have been field tested under local conditions and registered for use by the U.S. Department of Agriculture should be used. Use of unregistered mixtures may result in poor weed control, crop injury, or accumulation of illegal chemical residues in the crop. Growers are responsible for residues resulting from use of unregistered mixtures.

CONTROL OF WEEDS IN FIELD CROPS

Corn

Weed control in corn is based on a combination of cultural practices and herbicides applications.

Cultural Practices—Cultural practices include seedbed preparation, establishment of an adequate stand, and timely, effective cultivations.

Early germinating weeds can be destroyed with a disk, field cultivator, or harrow before planting if conventional tillage is used. Minimum tillage methods that leave the space between the rows rough discourage weed growth.

Early cultivations are most effective for killing weeds. The rotary hoe or harrow works best if used after weed seeds have germinated and before or as soon as the weeds appear above the soil surface. Row cultivators should also be used while the weeds are still very small. Set the shovels for shallow cultivation to prevent root pruning and to bring fewer weed seeds to the surface. A rotary hoe or cultivator should be used as soon as weeds appear even if pre-emergence applications have been used.

Herbicides—Table 2 indicates corn tolerance to herbicides suggested for use in corn and relative efficiency of these herbicides in controlling common annual weeds. This is a general comparative control rating based on field observations. Under unfavorable conditions any of the herbicides may give unsatisfactory results. Under favorable conditions control may be better than indicated.

Pre-emergence applications of atrazine at 1 to 4 pounds per acre have given fair to good kill of annual weeds with no injury to corn. A 4 pound per acre rate of atrazine should be used on heavy soils or those high in organic matter. One to 2 pounds per acre of atrazine is adequate on sandy soils. Atrazine may remain in some soils for more than one season. Toxic residues are more likely to persist if soil moisture or temperatures are low.

In limited trials, fall and early spring applications of atrazine controlled weeds as well as or better than pre-emergence applications. Preplanting incorporation of atrazine by disking has resulted in weed control equal to or, under dry conditions, slightly better than pre-emergence applications without incorporation. Broadcast applications, necessary when preplanting treatments are used, may increase the potential of atrazine carryover.

Atrazine sometimes affects small grains, flax, sugar beets, soybeans, and other legumes planted the following spring. Recent label changes require that small grains, flax, sugar beets, and small-seeded legumes not be planted in the year following atrazine application. Soybeans cannot be grown the year following atrazine use if the rate of atrazine application was more than 2 pounds per acre of active ingredient in western Minnesota or 3 pounds in eastern Minnesota. Residue can be minimized by using the lowest rate of chemical consistent with good weed control, use of band applications rather than broadcast applications, and plowing or thorough tillage of the soil prior to planting soybeans.

Used in pre-emergence applications at 4 to 5 pounds per acre, CDAA (Randox) controls annual grasses but is not effective on most annual broad-leaved weeds. Annual grasses are controlled for about 4 weeks. CDAA has performed better on soils high in organic matter than on light-colored soils. It should not be used on sandy soils because of injury potential and lack of weed control.

Propachlor (Ramrod), chemically related to CDAA, gives slightly longer weed control. It has given better grass control than CDAA but is not effective against most broad-leaved weeds. Some combinations of propachlor with effective broadleaf herbicides looked promising in research trials. Suggested rates are the same as for CDAA. Corn is very tolerant to propachlor. The chemical is less irritating than CDAA, but should be handled cautiously.

Pre-emergence applications of linuron (Lorox) at one-half to 2½ pounds per acre control most annual broad-leaved and grass weeds. In a few instances severe stunting and stand reduction of corn have occurred. It is extremely important to use the rates recommended on the label for your soil type.

Pre-emergence applications of 2,4-D as granules or sprays are not recommended in Minnesota. The control of annual grasses has been erratic, and injury to the

corn is likely if moderate or heavy rains occur shortly after treatment. This herbicide gave fair to good grass control in 27 percent of the county demonstration tests and fair to good broad-leaved weed control in 48 percent.

Dicamba (Banvel-D) as a pre-emergence treatment at one-half to 1 pound per acre has given good broad-leaved weed control but poor grass control and some severe corn injury.

Amiben is cleared for use on corn as a pre-emergence application at 2 pounds per acre. In research trials this rate has given erratic weed control and caused some injury on the corn. Severe stunting occurred following heavy rains in 1965.

R1910 (Sutan) is a recently developed herbicide for corn. In limited trials, R1910 has given good annual grass control, but has not controlled broadleafs. R1910 is applied before planting and incorporated by disking.

Caution: As of December 1967, R1910 is not cleared for use on corn.

Pre-emergence herbicide mixtures—Several mixtures are registered for use as pre-emergence applications on corn. Soil residues of atrazine can be reduced by using a lower rate of atrazine in a mixture with linuron, propachlor, or prometryne.

Caution: As of December 1967, prometryne is not cleared for this use.

Weed control with atrazine mixed with linuron or prometryne has been about the same as with equivalent rates of atrazine alone. A 1-to-1 ratio of active ingredients of an atrazine-linuron mixture has given weed control comparable to an equivalent rate of atrazine alone and has reduced residue problems. Using linuron in combination with atrazine reduces the likelihood of corn injury and usually improves weed control compared with linuron alone. Rates vary from one-half to 1½ pounds per acre of each chemical according to soil type. In pre-emergence applications, corn tolerance to this mixture is not as great as to atrazine alone. Do not use this mixture for postemergence application. Also, this mixture is less effective than atrazine alone on quackgrass.

The mixture of atrazine and propachlor controls broad-leaved weeds better than propachlor alone and gives more consistent control on high organic matter soils or with limited rain than atrazine alone.

A mixture of linuron and propachlor is now registered for pre-emergence use in corn. The mixture has consistently controlled annual grasses and broad-leaved weeds. There is less potential for injury with the mixture than with linuron alone, since lower rates of linuron are used. The mixture controls broadleafs better than propachlor alone. Suggested rates are 1 to 1½ pounds per acre of linuron with 3 pounds per acre of propachlor. Do not use the mixture on sandy soils because of possible crop injury from linuron.

CDAA-T (Randox-T) contains an additive that kills some broad-leaved species not controlled by CDAA.

Table 2. Effectiveness on major annual weeds of herbicides used in corn

	Pre-emergence				Postemergence		
	Atrazine	CDAA	Propachlor	Linuron	2,4-D	Dicamba	Atrazine and oil
Corn tolerance	G	G	G	F	G	G	G
Grasses							
Giant foxtail	F	F	G	F	N	N	F
Green foxtail	G	G	G	F	N	N	G
Yellow foxtail	G	G	G	F	N	N	G
Barnyardgrass	F	F	F	F	N	N	F
Crabgrass	P	G	G	G	N	N	P
Broadleafs							
Cocklebur	F	N	P	P	G	G	F
Lambsquarters	G	P	P	G	G	G	G
Mustard	G	N	P	G	G	F	G
Pigweed	G	F	F	G	G	G	G
Ragweed	G	P	P	G	G	G	G
Smartweed	G	N	P	F	P	G	G
Velvetleaf	F	N	P	F	G	G	F
Wild sunflower	P	N	P	P	F	G	F

G—Good
F—Fair
P—Poor
N—None

Soybeans may be affected by soil residues if planted in areas treated with CDAA-T the previous crop season. Take special care to avoid getting CDAA or CDAA-T in contact with the skin and eyes. Both materials cause considerable irritation and discomfort.

A mixture of EPTC and 2,4-D (Knoxweed) has given erratic performance as a pre-emergence herbicide, depending on rainfall, soil moisture, and soil type.

Postemergence—Annual broad-leaved weeds have been controlled with broadcast postemergence applications of one-fourth to one-half pound per acre of 2,4-D amine when the corn is less than 8 inches tall. The one-fourth pound rate has been adequate for susceptible weeds and is less dangerous to corn. The one-half pound rate has been satisfactory for moderately resistant weeds, but corn has usually been injured by this rate.

If 2,4-D esters are used, reduce application rates about one-third. Since the ester forms are volatile, vapor injury to nearby susceptible crops is a possibility. The use of amines eliminates the danger of vapor injury because amines are not volatile. Spray drift from either amines or esters of 2,4-D will injure susceptible plants.

To reduce the danger of 2,4-D injury when the corn is more than 8 inches tall, avoid spraying the upper leaves and leaf whorl of corn by using drop nozzles between the rows when the corn is sufficiently tall. However, adequate spray coverage of the tops of the weeds is necessary for maximum weed control. If nozzles are directed toward the row from both sides, the herbicide concentration must be reduced to compensate for the double coverage.

Some injury may result when corn is sprayed with 2,4-D. Brittleness followed by bending or breaking of stalks is the most serious type of injury, and it may result in severe stand losses when applications of 2,4-D are followed by a storm or careless cultivation.

Several factors influence the degree of injury resulting from 2,4-D. Hybrids vary in tolerance to 2,4-D. Corn growing rapidly is more susceptible than corn developing under less favorable growth conditions. When temperatures exceed 85° F. just before or at the time of 2,4-D application, the corn is more likely to be injured. At the rates of application commonly used, the stage of growth at which treatment is made during the period from emergence to tasseling is less critical than the effects of environmental factors.

If broad-leaved weed control is necessary after layby, 2,4-D ester at one-half pound per acre or 2,4-D amine at three-fourths to 1 pound per acre may be applied using drop nozzles. Do not apply 2,4-D from tasseling to dough stage; 2,4-D can be applied after the early dough stage if necessary, but it is more beneficial to control weeds earlier.

MCPA can be used on corn, but it has not proved less injurious to corn than 2,4-D.

Dicamba (Banvel-D) as a postemergence spray in corn has given better control of Canada thistle and smartweed than 2,4-D with less effect on the corn. But when used, dicamba drift has usually affected soybeans in the vicinity of treated cornfields. Dicamba also controls other broad-leaved weeds except mustard, but does not control grasses.

Dicamba can be used in corn at one-eighth to one-fourth pound per acre either alone or in mixtures with 2,4-D amine at one-fourth to one-half pound per acre. Applications can be made only until corn is 3 feet tall. Use drops after corn is 8 inches tall.

Caution—Soybeans and other broad-leaved plants are very sensitive to dicamba. Dicamba effects have been observed on soybeans considerable distances from treated corn fields and in some cases soybean yield losses have occurred. Users of dicamba should take special precautions to avoid drift. Drift can be minimized by reducing sprayer pressure, increasing water volumes with larger nozzles and using drop nozzles to keep the spray release as low as possible and still give weed coverage. Drift potential is greater with windy or high temperature conditions. Do not graze or harvest for dairy feed prior to the milk stage of the grain if corn is treated with dicamba.

Early postemergence sprays of atrazine effectively control most annual weeds in corn. Broad-leaved weed control is especially good. Grass control is less consistent. It is important to apply early postemergence treatments at the proper time or results may be poor. Apply atrazine within 3 weeks of planting while the weeds are less than 1½ inches tall. The addition of 1 to 2 gallons per acre of special oils with an emulsifier to the spray increases the effectiveness of early postemergence applications of atrazine. Use only the oils that are labeled for this purpose. Suggested atrazine rates for postemergence application with oil are 1 to 3 pounds per acre. When atrazine is used, early postemergence treatments are preferred to pre-emergence if the soil is high in clay or organic matter and in western Minnesota where rainfall is less certain. These are the areas where pre-emergence applications of atrazine have given less satisfactory weed control. Do not mix other chemicals with atrazine and oil. Severe corn injury has resulted from the addition of 2,4-D to this mixture.

Directed sprays—Specially designed equipment has been developed to make directed spray applications in corn. When applying directed sprays, the nozzles should be mounted so that wheels, skids, cultivator shanks, or similar devices control the nozzle height. To minimize spray contact with corn leaves, use attachments to lift the corn leaves because the spray is directed to the base of corn plants and onto weeds in the row.

Directed sprays of dalapon-2,4-D mixtures at rates of 1½ pounds of dalapon and one-half pound of 2,4-D per acre can be used when corn height to the whorl is 8 to 16 inches. This mixture will stunt or kill most weeds in the row that are hard to control by cultivation. If excessive amounts of dalapon contact the corn leaves, plants become stunted and deformed. Twisted leaves and undeveloped ear husks are typical injury symptoms.

Directed sprays of linuron at 1½ pounds per acre can be applied when the corn is not less than 15 inches tall. The addition of a wetting agent is necessary for effective weed control. Care must be taken in application to minimize spray on the corn leaves while covering most of the weed foliage with the linuron spray. Linuron will kill corn leaf tissue it contacts and, if leaf kill is extensive, corn yields may be reduced.

Cypromid (Clobber) controls both broad-leaved weeds and grasses when applied as a directed spray, but results have been erratic. In some cases corn stunting has occurred. *Caution*—Do not use treated foliage or stalks for silage or livestock feed.

Flame weeding of corn is a practice that can be used in the same manner as directed sprays. Special equipment using LP-gas as fuel has been developed for flame weed control after corn is 8 inches tall. Flaming must be carried out carefully by experienced operators to avoid corn injury. Several flamings are usually required within 5 to 10 days to give adequate weed control with slight effect on the corn in most instances. Serious corn leaf burn can occur when the flame weeder is improperly adjusted or the operating speed is too slow. Searing of the bottom two or three leaves of corn commonly occurs and may slightly depress the corn height but has no apparent effect on corn yield. Corn yields in flame-weeded plots have often equalled those obtained using herbicides for weed control. A disadvantage of flame weeding is the necessity of flaming several times to obtain adequate weed control.

Flame weeding or directed sprays cannot be used on small corn. Therefore, early season weed growth must be controlled by some other means (use of rotary hoe, harrowing, pre-emergence herbicides, or cultivation) to prevent yield losses from early weed competition. Directed sprays and flame weeding are considered emergency measures to control heavy weed stands that have become established within corn rows.

Dry Edible Beans

Before emergence, bean fields can be spike-tooth harrowed to kill emerging weeds. After beans emerge, use such implements as the weeder, rotary hoe, spike-tooth harrow, or coil spring harrow to kill weeds. Only small emerging weeds in the "white" stage can be uprooted and killed without injury to the larger beans. It may pay to harrow the field several times before the first cultivation if weeds emerge.

Beans are generally cultivated twice before the vines cover the middles. Hand hoeing is desirable when economically feasible.

Herbicides cleared for use on beans and tested by the University of Minnesota include EPTC (Eptam) trifluralin (Treflan), amiben, DCPA (Dacthal), and DNBP amine.

EPTC at 3 pounds per acre or trifluralin at three-fourths pound per acre on sandy soil to 1 pound per acre on finer textured soils are applied preplanting and incorporated into the soil. Incorporation must be accomplished within minutes after application to avoid loss of the herbicide. If a disk is used for incorporation, the field should be disked twice, once in each direction. The second disking need not be done the same day.

Amiben, DCPA, or DNPB amine are applied pre-emergence at 2, 10½, or 9 pounds per acre, respectively. Weed control at these rates may be less satisfactory than that obtained from the herbicides suggested for preplanting application.

DNBP amine may be applied when beans are emerging (not later than crook stage) at a rate of 3 to 4½ pounds per acre. This is primarily a contact killer for small and germinating weeds. Weather often makes treatment at this time impractical.

Flax

Cultural practices—Weeds are generally more of a problem in flax than in small grain; therefore growers should sow flax on relatively clean land. To prepare land for flax, practice early afterharvest tillage of small grain stubble—except where such tillage results in serious wind erosion—to control perennial weeds, prevent weed seed production, and stimulate annual weed seed germination in late summer and fall.

Another desirable weed control practice is to prevent weed seed production in the preceding corn, soybean, or other cultivated crop and prepare the seedbed for flax by shallow tillage. Delayed sowing of flax to permit spring tillage for wild oat control has been successful in some areas although the delay is sometimes detrimental to the flax. For delayed sowing, use early maturing varieties such as Bolley, Summit, or Windom.

Herbicides—MCPA is less likely to injure flax than 2,4-D. Weed control is most effective when spraying is done as soon as most of the weeds have emerged. MCPA sprays may reduce yield of flax seed and straw unless weed competition is reduced sufficiently to offset injury from the chemical.

Susceptible weeds like wild mustard are killed by 2 to 3 ounces per acre of MCPA. Lambsquarters, field pennycress, cocklebur, marshelder, and ragweed require 4 ounces. From 5 to 8 ounces per acre of MCPA amine are required for control of wild buckwheat, thistles, smartweed, and redroot pigweed. At these rates flax may be injured and a good kill of these weeds seldom results, though their growth is usually checked and seed production reduced.

Time of application of herbicides is very important on flax. Flax is likely to be seriously hurt if sprayed during the period between bud stage and when 90 percent of the bolls have formed. Germination of the seed may be reduced by spraying between full bloom and the stage when seeds are colored.

TCA at 5 pounds per acre or dalapon (Dowpon) at three-fourths pound per acre will kill green, yellow, and giant foxtail in young flax. Best results have followed application when the flax was 2 to 6 inches tall and the weeds less than 2 inches. TCA or dalapon can be applied in a mixture with MCPA to kill susceptible grass weeds and susceptible broad-leaved weeds with one application—but spraying must be done before early bud. Neither TCA nor dalapon should be used unless a serious annual grass population is present. Flax varieties recommended for use in Minnesota are approximately equal in tolerance to MCPA and TCA. However, varieties differ in their tolerance to dalapon. Most tolerant to least tolerant varieties are: Redwood, B-5128, Bolley, Windom, and Summit.

When flax is used as a companion crop to establish alfalfa, red clover, alsike clover, ladino clover, birdsfoot trefoil, timothy, meadow fescue, bromegrass, or crested wheatgrass, use MCPA as directed for susceptible weeds in flax except that legume seedlings should be at least 2 inches tall. Sweetclover seedlings are likely to be killed and other legumes injured by MCPA. TCA or dalapon can be used on flax sown with alfalfa, sweetclover, or birdsfoot trefoil but will probably kill forage grasses and seriously injure red and alsike clovers.

Use 10 to 20 gallons per acre of spray solution when spraying with TCA, dalapon, or more than 4 ounces per acre of MCPA amine.

For chemical control of wild oats in flax see section on WILD OATS control on page 15.

Forages—Alfalfa, Clover, and Grasses

Seedling legumes generally are poor competitors with weeds. Management practices in preceding crops such as use of intertilled crops and afterharvest tillage to make the land as weed free as possible for the legume seedlings are desirable.

Clipping of seedling legumes (except sweetclover) when sown alone, mowing the stubble of companion crops, and patch mowing of perennial weeds aid in weed control.

Preplant incorporation treatments at 2 to 3 pounds of EPTC (Eptam) per acre have given effective control of annual broad-leaved and grass weeds in alfalfa, red clover, sweetclover, alsike clover, and birdsfoot trefoil when these legumes were sown without a grass in the mixture or a companion crop.

Postemergence treatments with 2,4-DB at one-half to 1½ pounds per acre can be used to control broad-leaved weeds in seedling alfalfa, birdsfoot trefoil, red clover, alsike clover, and ladino clover when sown alone or with small grains. Spray when weeds are less than 3 inches tall, when the legumes are 2 to 3 inches tall, and small grains are 6 to 8 inches tall. Wild mustard is not effectively controlled by 2,4-DB. *Caution:* To avoid residues do not graze or harvest forage for livestock feed for 30 days after treatment.

Small grass weeds can be controlled in seedling alfalfa (2 to 3 inches tall) with dalapon at 1 pound per acre. *Caution:* Do not feed first-year crop to dairy animals or animals being finished for slaughter. First-year crop should not be sold commercially or shipped interstate.

Dalapon-2,4-DB mixtures may be used to control weeds in alfalfa sown without a forage grass or companion crop.

Seedling stands of ladino clover, alsike clover, red clover, and alfalfa sprayed with the sodium or amine salt of 2,4-D or MCPA at rates of one-fourth pound per acre or less have not been seriously injured, especially if a canopy of companion crops or weeds has been present. Reduced sprayer pressure helps minimize damage.

Seedlings of perennial grasses may be treated with 2,4-D when broad-leaved weeds are a problem. Up to three-fourths pound per acre of 2,4-D may be used after the grass seedlings have reached the two- to four-leaf stage.

Mowing is the recommended practice for controlling many kinds of weeds if done at the right time and if repeated for 2, 3, or 4 years. In general, mow herbaceous weeds in the early bud to blossom stage.

In established legumes, the amine sale of 2,4-DB can be applied at one-half to 2 pounds per acre or the ester of 2,4-DB can be applied at one-half to 1 pound per acre in 15 to 30 gallons of water per acre. Do not use more than three-fourths pound of the ester per acre on red clover. Apply when the annual broad-leaved weeds are 2 to 3 inches tall or when perennials are 6 to 8 inches tall. The same feeding restrictions apply that were mentioned above.

Use of 2,4-D or MCPA is often hazardous to legumes. Either herbicide should be applied in the dormant stage of the legume—late fall or very early spring—to control weeds that are present at this time. MCPA or 2,4-D amine at 4 to 8 ounces per acre may be used during legume dormancy to control yellow rocket, a weed that is sometimes troublesome in legumes. White cockle is not controlled by 2,4-D or MCPA. Harvest of the legume before white cockle seed matures will reduce the rate of spread by seed.

Legumes grown for seed present some different weed control problems than do forage legumes. Weeds cannot be controlled by grazing or clipping. Also, weed seeds are a more serious problem.

Several herbicides can be used on seed fields if the forage is not fed to livestock. Herbicide residues in milk or meat prohibit the use of some of these compounds on forages grown for feed.

EPTC can be used to establish legumes without a companion crop (see suggestions above). TCA at 5 to 7 pounds per acre controls annual grasses in seedling stands of alfalfa, sweetclover, and birdsfoot trefoil if applied when the grass is less than 2 to 3 inches tall. TCA cannot be used on alsike, red clover, or on a small grain companion crop.

Dalapon has given no injury and good grass control in seedling stands of alfalfa or birdsfoot trefoil when applied at 1 or 2 pounds per acre soon after emergence of grassy weeds. (Note feeding restrictions mentioned above.)

Established stands of alfalfa, sweetclover, and birdsfoot trefoil have been sprayed with TCA at 5 to 7 pounds per acre for control of many annual grasses (not wild oats) without permanent injury to the legumes. Do not treat ladino clover, alsike clover, and red clover with TCA.

A 2 pound per acre dalapon application will suppress quackgrass in birdsfoot trefoil seed fields during the growing season. Treat early in the spring soon after quackgrass growth starts.

One to 1½ pounds per acre of 2,4-DB will control many broad-leaved weeds in legumes with little or no injury to the legumes. *Caution:* forage harvested within 30 days of treatment cannot be fed to livestock.

DNBP dried the foliage of crop and weeds, including Canada and perennial sow thistle, when alfalfa, red clover, and alsike clover were sprayed preharvest with 1.87 pounds per acre. Two applications may be necessary for complete drying of the vegetation.

For timothy grown for seed, early spring applications of dicamba (Banvel-D) at one-quarter to one-half pound per acre look promising for controlling young nightflowering catchfly and white cockle. The chemical should be applied after weeds start to grow and when timothy is 2 to 4 inches tall. Timothy injury is more likely if dicamba is applied late or at the higher rate. When applied in the spring, silvex at 1 to 2 pounds per acre gave good control of nightflowering catchfly and white cockle with little injury to the timothy. Combinations of dicamba with MCPA or 2,4-D give better control of mustards and other weeds resistant to dicamba. If Canada thistle or sow thistle is a problem, a later application of 2,4-D or MCPA may be required.

Caution: Do not graze areas treated with dicamba or feed treated forage or threshings to livestock.

In established pastures good management and controlled grazing are most important in any attempt at weed control.

In very weedy pastures where good perennial grasses are thin, reseeding may be the most important practice. To be successful, prepare a firm seedbed for

any reseeding and add lime and fertilizer by soil test. Protect new seedlings from grazing until they are established and graze moderately thereafter. Plowing (or intensive surface tillage) and seeding to adapted grasses, where practicable, will usually eliminate many of the perennial pasture weeds.

Spraying with 1 to 2 pounds per acre of 2,4-D, 2,4,5,-T or a mixture of the two gives better control of many weeds with a single application than is obtained with a single mowing treatment. The weeds should be sprayed when growing actively. Repeated treatment for 2 or more years is usually necessary. In general, these chemicals have been used at rates necessary for weed or brush control without appreciable injury to grasses, but legumes will be eliminated.

MCPA can be used at low rates of about one-fourth pound per acre where legumes are present. Some 2,4-D-resistant weeds such as buttercup are controlled better with MCPA.

Caution: Do not graze dairy cattle on pastures treated with 2,4-D for 7 days after treatment.

Small Grains—Spring Wheat, Oats, and Barley

Wheat and barley are less sensitive than oats to 2,4-D applications made during the growing season. All three crops are sensitive as seedlings. Wheat and barley are relatively tolerant from the time five full leaves appear until the early-boot stage. During this period one-sixth to one-half pound of 2,4-D ester or one-fourth to two-thirds pound of 2,4-D amine will control most broad-leaved weeds without serious injury to crops. Some injury to oats should be expected, but weed control generally will more than offset losses resulting from 2,4-D injury.

Avoid spraying wheat and barley in the boot stage of development. Varietal differences in wheat and barley have been unimportant. Oat varieties differ in their response to 2,4-D.

Small grains are more tolerant to MCPA than to 2,4-D. Using MCPA permits spraying in the 2- to 5-leaf stage of the small grains, whereas using 2,4-D in this early stage would usually result in excessive crop injury. MCPA rates of one-fourth pound per acre of amine or one-sixth pound per acre of ester will control small mustard plants. For other broad-leaved weeds or larger mustard, up to two-thirds pound per acre of amine and one-half pound per acre of ester may be required.

Weeds more easily controlled by MCPA than 2,4-D are hemp nettle, horsetail, buttercup, tartary buckwheat, corn spurry, and perennial peppergrass. Those more easily controlled by 2,4-D than MCPA are Russian thistle, falseflax, velvetleaf, jimsonweed, smartweed, redroot pigweed, ball mustard, tansy-mustard, and hemp.

Bromoxynil is a recently-developed herbicide that controls most annual broad-leaved weeds, including 2,4-D-resistant weeds, in wheat and barley when applied at three-eighths to one-half pound per acre as an early postemergence treatment. Bromoxynil does not control annual grasses or perennials.

Dicamba at one-eighth pound per acre controls hard-to-kill broad-leaved weeds such as wild buckwheat and smartweed in oats and wheat when used alone or in mixtures with one-fourth pound per acre MCPA. The combination of dicamba and MCPA gives better control of mustard than dicamba alone. Oats are most tolerant, followed by wheat, with barley being least tolerant. Applications made at the two- to five-leaf stage of small grain growth are the least injurious to the grains.

Caution: As of December 1967 dicamba has received clearance for use on wheat and oats, but not for spring barley. Do not graze or feed to livestock forage or threshings from small grains treated with dicamba.

Applications of 2,4-DB at one-half to 1½ pounds per acre made when small grains are 6 to 8 inches tall will control many broad-leaved weeds with no injury to legumes, except sweetclover. Mustard is not usually controlled by 2,4-DB, and other weeds require higher rates than used for MCPA or 2,4-D. *Caution:* Grain should not be harvested for 30 days after treatment.

For control of wild oats in small grains see section on WILD OATS control (page 13).

Small Grains—Winter Wheat and Rye

Many annual broad-leaved weeds can be controlled in winter wheat and rye by spraying with 2,4-D—using the ester at one-fourth to one-half pound per acre or the amine at one-half to three-fourths pound per acre in the spring, after the grain is fully tillered but before it is in the boot. Do not spray winter wheat or rye in fall.

Grain Sorghum

Sorghum will not germinate or grow in cold soil. Therefore, late planting in warmer soil, May 25 to June 10, is necessary if sorghum is to grow rapidly enough so that weeds can be controlled by cultivation. Later planting would be still more desirable but the short Minnesota growing season will not allow later planting if maximum grain production is desired.

Treatment with CDAA (Randox), propachlor (Ramrod), norea (Herban), propazine, or atrazine is usually necessary to prevent drastic reduction in sorghum yield due to weed competition. These herbicides control annual grasses (not wild oats) in sorghum. Propazine, atrazine, and norea also kill broad-leaved annual weeds. CDAA or propachlor at 4 pounds per acre, norea at 2.4 pounds per acre, or propazine at 2 pounds per acre are applied pre-emergence. Propachlor (Ramrod) is chemically related to CDAA and was better than CDAA in recent tests. Atrazine at 2 pounds per acre should be applied after the sorghum has emerged and as soon as a few annual grass weeds have started to emerge. Atrazine kills both emerged and nonemerged susceptible weeds, if grasses are less than 1½ inches tall when treated. Addition of special emulsifiable oils at 2 gallons per acre to atrazine at 1 or 2 pounds per acre gives better weed control than atrazine alone at the same rates. Slight reduction of sorghum height was observed in some trials. A mixture of norea at 1.6 pounds per acre and atrazine at 0.8

Table 3. Early evaluations of herbicides in weed control demonstrations in uncultivated soybeans

Chemical	Pounds per acre active ingredient or acid equivalent broadcast	Years in trial	Number of trials		Percent of trials in each class					
					Grasses			Broad-leaved weeds		
			Grasses	Broad-leaved weeds	Good	Fair	Poor	Good	Fair	Poor
Amiben	2	1963-66	149	137	54	27	19	56	25	19
Amiben	3	1959-67	319	310	71	19	10	72	19	9
CDAA (Randox) granular	4	1959-64	219	199	54	29	17	15	27	58
CDAA (Randox) granular	5	1963-67	185	168	58	30	12	22	26	52
Linuron (Lorox)	2	1962-67	232	227	50	26	24	63	19	18
Propachlor (Ramrod) granular	5	1965-66	65	61	80	14	6	41	33	26
Propachlor (Ramrod)	5	1965-67	100	96	75	18	7	43	36	21
Trifluralin (Treflan)	1	1965-67	68	64	79	18	3	59	25	16
Vernolate (Vernam)	3	1965-66	61	58	40	16	44	33	19	48

pounds per acre is approved for pre-emergence application. *Caution:* Do not graze or feed forage within 60 days after application of the norea-atrazine mixture.

These herbicides have not seriously injured adapted grain sorghum varieties in Minnesota. Occasionally CDAA has caused injury, but the sorghum has recovered and outyielded unsprayed sorghum. Atrazine or propazine should not be used on sandy soils, as injury to sorghum may occur.

For the control of broad-leaved weeds, 2,4-D may be used at one-fourth to one-half pound per acre. However, injuries similar to those of corn may occur. Sorghum is most susceptible to 2,4-D in seedling, early boot, and pollination stages of growth. It is most tolerant when 4 to 12 inches tall but injury may occur at this stage of growth also.

Soybeans

Cool soil temperatures slow the germination and growth of soybeans considerably so that weeds may gain a competitive advantage. However, in warm soils, soybeans are good competitors of weeds because germination and growth are rapid.

Several cultural practices control annual weeds in soybeans. Fall and early spring plowing plus tillage prior to sowing of the crop can kill many weeds. Post-emergence cultivation with the rotary hoe or harrow is effective if done when the weeds are small and soil conditions are favorable.

Table 3 shows the performance of some pre-emergence herbicides in uncultivated soybeans during several years of county demonstrations. Figures show the percent of trials in which weed control was rated good (more than 75 percent of the weeds controlled), fair (50 to 75 percent of the weeds controlled), or poor (less than 50 percent of the weeds controlled). Evaluations were made about 5 weeks after application.

Table 4 indicates soybean tolerance of herbicides suggested for use in soybeans and efficiency of these herbicides in controlling common annual weeds. This is a general comparative control rating based on field observations. Under unfavorable conditions any of the herbicides may give unsatisfactory results. With favorable conditions control may be better than indicated.

The chemicals DNBP, CIPC, NPA (Alanap), and PCP have occasionally caused injury to soybeans and have given erratic weed control.

Pre-emergence applications of CDAA at 4 to 5 pounds per acre have usually given satisfactory control of grasses with little or no injury to soybeans. CDAA has performed better on soils high in organic matter than on light-colored soils. It should not be used on sandy soils because of injury potential and lack of weed control. Take special care to avoid getting CDAA in contact with the skin and eyes. The chemical causes considerable irritation and discomfort especially in liquid form.

Propachlor (Ramrod), chemically related to CDAA, gives slightly longer weed control. It has given better grass control than CDAA but is not effective against most broad-leaved weeds. Suggested rates are 4 to 5 pounds per acre. Although the chemical is less irritating than CDAA, it should be handled cautiously. *Caution:* As of December 1967 propachlor has received clearance for use on soybeans grown for seed for replanting only. Do not use seed for food, feed, or oil.

Pre-emergence applications of amiben at 3 pounds per acre control most annual broad-leaved and grass weeds. Performance has been consistent on all soil types where rain occurred before weeds emerged. In a few instances stand reductions and slight stunting of soybeans treated with amiben have been noted. However, yields did not appear to be reduced.

Pre-emergence applications of linuron at one-half to 2½ pounds per acre control most annual broad-leaved weeds and grass in soybeans. In a few instances severe stunting and stand reduction of soybeans have occurred. It is extremely important to use the rates recommended on the label for your soil type.

Vernolate (Vernam) has given erratic performance as a pre-emergence or preplanting herbicide on soybeans in Minnesota. Grass control is usually better than

broadleaf control. Crop tolerance is not as good as desired and occasionally soybean injury has occurred. Vernolate must be incorporated with a disk before planting or with a rotary hoe immediately after planting.

In soybeans, trifluralin (Treflan) applied at one-half to 1 pound per acre preplanting and incorporated has given good control of annual grasses, pigweed, and lambsquarters, but has given little control of most other broad-leaved weeds. Proper incorporation can be accomplished by double disking twice in opposite directions or by other methods which thoroughly mix the chemical with the top 3 inches of soil. Incorporation with a spike-tooth harrow after planting has caused trifluralin injury to soybeans in some trials.

Applications 2 to 3 weeks before planting have given equal weed control and less soybean injury compared with applications at planting time. With early application one disking can be done at application time, followed by an additional disking at planting.

Nitralin (Planavin), chemically related to trifluralin, has not given satisfactory weed control in soybeans under Minnesota conditions.

DCPA (Dacthal) is cleared for pre-emergence use on soybeans at rates up to 10.5 pounds per acre. In Minnesota trials, the maximum rate of 10.5 pounds per acre has given fair control of annual grasses, but poor broadleaf control. Soybean tolerance is good except there is an occasional plant broken over near the soil surface. *Caution:* Do not graze treated areas or feed forage to livestock.

In limited trials, norea (Herban) and a mixture of amiben and norea have shown promise for pre-emergence use on soybeans for broadleaf and grass control. Label approved rates for norea alone are 1.44 to 2.4 pounds per acre, the lower rate for fine sandy loam soils and the higher rate for clay soils. Rates for the amiben-norea mixture are 1 to 1.5 pounds per acre of amiben and 0.8 to 1.2 pounds per acre of norea. There is some soybean injury potential with norea alone or the norea-amiben mixture. Do not use either on sands or sandy loams with low organic matter. As of December, 1967, norea is not cleared for use on soybeans.

Cocklebur can be controlled by applying 2,4-DB to soybeans from 10 days before bloom up to mid-bloom growth stages at 0.2 pound per acre. Cockleburs may develop regrowth and produce burs after a good initial dieback. The burs produced will germinate. Stunting of the soybeans may occur and appears to be more severe under hot, dry conditions.

Chloroxuron (Tenoran) is cleared for use as an early postemergence application on soybeans at one-half to 1½ pounds per acre with a wetting agent. This treatment has shown promise in Minnesota trials, but results have varied. Further work is needed to determine optimum timing and weed species controlled before general usage is suggested. Generally, broad-leaved weeds, but not grasses, are controlled. Soybean injury and delayed maturity are sometimes problems. *Caution:* Do not graze treated fields. Do not cut forage within 90 days after treatment.

Table 4. Effectiveness on major annual weeds of herbicides used in soybeans

	Amiben	CDAA	Propachlor	Linuron	Trifluralin	2,4-DB
Soybean tolerance	G	F	G	F	F	P
Grasses						
Giant foxtail	G	F	G	F	G	N
Green foxtail	G	G	G	F	G	N
Yellow foxtail	G	G	G	F	G	N
Barnyardgrass	G	F	F	F	G	N
Crabgrass	G	G	G	G	G	N
Broadleafs						
Cocklebur	P	N	P	P	P	F
Lambsquarters	G	P	P	G	G	P
Mustard	F	N	P	G	P	P
Pigweed	G	F	F	G	G	P
Ragweed	G	P	P	G	N	P
Smartweed	F	N	P	F	P	P
Velvetleaf	F	N	P	F	P	P
Wild sunflower	P	N	P	P	N	P

G—Good
F—Fair
P—Poor
N—No control

Sugar Beets

Herbicides may be used in sugar beets to supplement conventional cultivation practices. Hand labor, mostly hoeing, is still needed but can be reduced by timely cultivations and herbicide applications.

Annual grasses, except wild oats, may be controlled by TCA at 6 pounds per acre applied pre-emergence. *Caution:* TCA is not cleared for use on sugar beets if the tops are to be fed.

Propachlor (Ramrod) is cleared for pre-emergence application on sugar beets at 3.9 pounds per acre. Propachlor controls primarily annual grasses, but under certain conditions has controlled some broad-leaved weeds. Compared with TCA, propachlor has worked more consistently under a wider range of rainfall conditions and sometimes controlled more kinds of weeds. Some sugar beet injury, primarily stand reduction, has occurred. No sugar beet yields have been determined in these trials. *Caution:* Do not graze or feed forage from treated areas.

Dalapon at 3 pounds per acre will control most emerged annual grasses. For best control, grasses should be sprayed before they are 3 inches tall. Late-emerging grasses can be controlled with directed sprays of dalapon at 2 to 3½ pounds per acre until sugar beets are 14 inches tall. If repeated applications are used, no more than 6 pounds per acre can be applied in any single growing season.

A combination of EPTC (Eptam) at 2 pounds per acre incorporated into the soil before planting plus TCA at 6 pounds per acre pre-emergence has given excellent control of annual grasses particularly foxtail and some broadleaf control in several years of testing. The combination has given satisfactory control under climatic conditions in which the single chemicals gave poor results. The treatment has at times given stand reduction and temporary stunting of beets. This combination treatment has given more severe injury in some years than in others.

Diallate (Avadex) at 1½ to 2 pounds per acre as a preplanting soil-incorporated treatment may be used to control wild oats in sugar beets. Barban (Carbyne) at five-eighths to three-fourths pound per acre may be used to control emerged wild oats. Wild oats should be sprayed in the two-leaf stage.

Certain broad-leaved weeds—annual smartweed, wild buckwheat, and marshelder—may be controlled by a postemergence application of endothall at three-fourths to 1½ pounds per acre. When beets and weeds have recently emerged the lower rate should be used. Application of endothall at temperatures below 60° F. may give poor results. Temperatures in excess of 80° F. at time of treatment may cause excessive injury, particularly in very small beets. Endothall may cause leaf burn on the beets but recovery is usually rapid. Endothall will generally give disappointing results on most broad-leaved weeds not mentioned above.

Sunflowers

Sunflowers are often a weedy crop. They compete well with weeds, but do not develop ground cover quickly enough to prevent weeds from establishing.

Weeds frequently emerge before sunflowers. Thus many weeds can be killed by spike-tooth or coil spring harrowing about 1 week after planting but before sunflowers germinate.

After sunflowers emerge such implements as the weeder, rotary hoe, spike-tooth harrow, or coil spring harrow may be used to kill weeds. Sunflower seedlings are strongly rooted so small emerging weeds in the "white" stage can be uprooted and killed without injury to the larger sunflowers. Setting of the harrow or weighting of the rotary hoe to do most damage to the weeds and least to the sunflowers can be accomplished on a "try-and-adjust" basis. It might pay to harrow the field several times if weed emergence warrants it.

Cultivation to kill weeds between the rows is the major method of weed control. Sunflowers are more easily damaged or broken by the cultivator than is corn.

EPTC (Eptam) at 3 pounds per acre applied before planting and incorporated into the soil has controlled many grass and broad-leaved annual weeds. Disking or other incorporation must be accomplished within minutes after spraying to avoid loss of the herbicide. Spraying plowed ground followed immediately by seedbed preparation or cross-disking (twice at right angles), spike-tooth harrowing once, and planting has given good weed control and no sunflower injury. EPTC has been ineffective on wild mustard or smartweed and only occasionally effective on wild oats.

Sunflowers are also tolerant to several other herbicides, but only EPTC is cleared at this time.

SPECIAL WEED PROBLEMS

Cultural Practices for Controlling Perennial Weeds

Perennial weeds such as Canada thistle, perennial sowthistle, field bindweed, leafy spurge, and quackgrass are difficult and expensive to control. Control is usually accomplished best with a combination of cultural practices, cropping systems, and chemicals.

These persistent perennial weeds spread vegetatively as well as by seed. Underground parts of the plants store food and produce new growth. Control programs should be planned to (1) prevent seed production; (2) destroy top growth repeatedly, thereby depleting food reserves; (3) kill underground parts by exposure to drying and freezing at the soil surface; and (4) eliminate small seedlings before they form rhizomes or other reproductive organs.

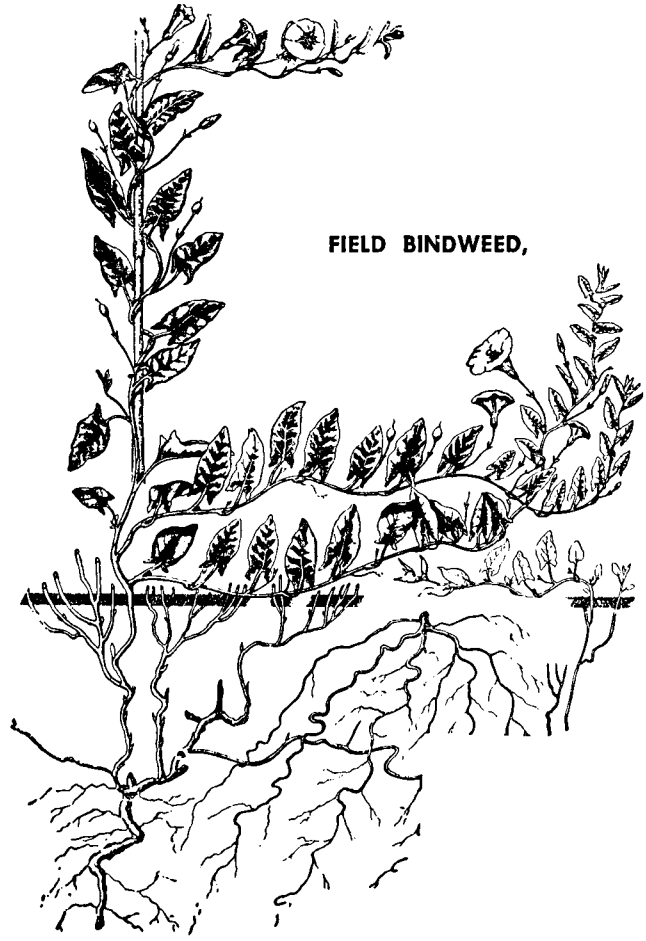
The following practices have been used successfully in Minnesota. Each farmer may need to adapt these ideas to fit his particular cropping system and soils.

Tillage—Properly timed repeated destruction of top growth by plowing followed by cultivation at regular

intervals or fallowing will eventually exhaust underground food storage organs. Underground parts exposed to the surface will dry and die. Quackgrass is especially susceptible to surface exposure because roots do not extend below the plow layer and can be pulled to the surface by spring-tooth tillage implements. Cultivation must be frequent and continued over a long enough period, usually two or more seasons, to free the soil of all underground rootstocks or rhizomes. Fallowing is effective in dry years but is not very successful in wet years or on poorly drained soils. When the soil is wet, underground parts do not dry when exposed to the surface. Also, under wet conditions, it may be impossible to repeat tillage operations at the proper time to destroy regrowth. The possibility of erosion may prevent the use of this control method on certain fields. If the weed is limited to scattered patches, till these patches separately or use a disk to avoid dragging rootstocks to clean parts of the field.

Tillage practices may be effectively combined with growing winter small grains or short-season, late-planted summer annuals such as forage sorghums, sudangrass, sorghum-sudangrass hybrids, or millet. Various combinations of the following suggested cultural practices should effectively control perennial weeds when used with chemicals.

Fall plow and cultivate at 2- to 3-week intervals until freezeup. A field cultivator equipped with overlapping sweeps operated at a 4-inch depth works well for this job.



FIELD BINDWEED,

CANADA THISTLE

In the spring, begin cultivation again as soon as 2 to 3 inches of top growth appears and repeat the cultivations whenever there is 2 to 3 inches of regrowth. Continue cultivations until:

a. Freezeup in the fall.
b. About July 1, when forage sorghums, sudangrass, sorghum-sudangrass hybrids, or millet can be planted. After harvest, cultivate until freezeup.
c. September, when winter rye or winter wheat can be sown. After harvest cultivate until freezeup.

These practices may be repeated, used in sequence, or the land fallowed as needed to eliminate the problem weeds. Chemicals should be used in the crops to control the weeds while a crop is growing.

Cultivation—Infestations of perennial weeds can be reduced in row crops by frequent cultivations. Timing cultivations to kill top growth when it is not more than 2 inches tall and to eliminate small seedlings before they develop rhizomes or other storage organs will increase the effectiveness of cultivations. Best results are obtained in corn by check planting and cross cultivating. However, if check planting is used it may be impossible to plant corn populations high enough for optimum yields without overcrowding the corn hill.

Mowing—Frequent mowing will weaken and suppress perennial weeds. Weeds should be mowed by the time the first flowers appear so that seeds will not form and then clipped whenever top growth warrants it.

Areas infested with perennial weeds may be planted to hay crops and cut for hay over several years to weaken the weeds and keep them from spreading.

Management—Good management in growing all crops will help control perennial weeds. Using quality seed of adapted varieties and proper seeding rates helps establish good stands to compete with weeds. Adequate preparation of the seedbed prior to planting eliminates existing vegetation and gives crops at least an even start. Narrower rows may help control weeds by shading the row middles sooner. But the row width should be wide enough to cultivate so problem weeds can be controlled by cultivation.

Chemicals for Controlling Perennial Broad-leaved Weeds in Crops

Perennial broad-leaved weeds such as Canada thistle, perennial sowthistle, field bindweed, and leafy spurge can be suppressed with 2,4-D or MCPA in tolerant crops. Use 2,4-D on wheat, barley, or corn; MCPA is less injurious to oats. These chemicals may also be used in conjunction with the tillage and cropping practices mentioned above or in grass pastures.

Proper timing of the spray applications is very important for getting good results. Usually two or more applications during the growing season and retreatment for several years are necessary. The chemicals are most effective if applied when the weeds are just starting to grow in the spring and again near the bud stage of the weeds. Timing will also be influenced by the tolerance of the crop being sprayed. Avoid spraying small grains before the five-leaf stage and in the boot stage. Do not spray corn with 2,4-D from tasseling to the dough stage.

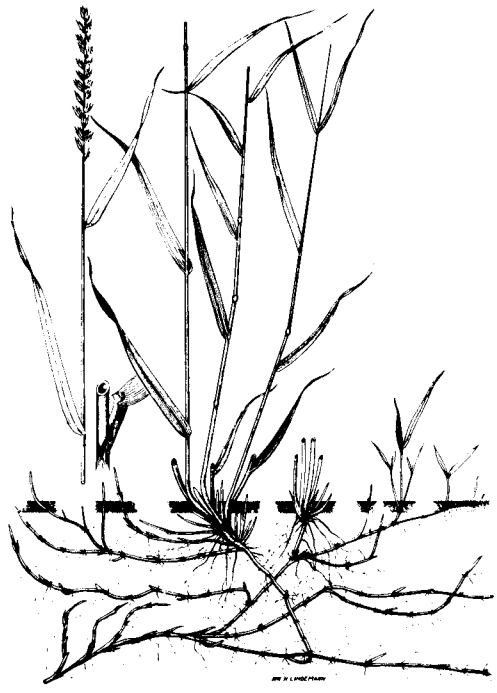
The amount of chemical used should be that recommended for the crop being sprayed. Higher rates may cause crop injury. These rates will not eradicate perennial weeds, but the treatments will usually reduce or kill top growth and prevent seed production.

Perennial broad-leaved weed infestations can be effectively reduced by applying 1 to 2 pounds of 2,4-D per acre after harvest of small grains, flax, or other early maturing crops. This treatment will kill legumes. Mow the area after harvest, allow regrowth to reach 6 to 8 inches, and spray while the weeds are still growing vigorously.

In grass pastures, perennial broad-leaved weeds have been controlled with one to two applications per year of 2,4-D at 1 to 2 pounds per acre. Spray when the weeds are growing rapidly and before the bud stage. Repeated treatment for 2 or more years is usually necessary. *Caution:* Do not graze dairy cattle for 7 days after treatment.

Dicamba will suppress Canada thistle in small grains and corn. Use the maximum rate of dicamba listed for the specific crop. Drift may damage soybeans or other broad-leaved plants.

QUACKGRASS



Amitrole or amitrole-T will control Canada thistle when applied either in the fall after harvesting crops or in the spring prior to planting corn. The suggested rate is 4 pounds per acre in 30 or more gallons of water. It is important that a full stand of thistles emerges before spraying. Best results follow treatment just before bud stage or when regrowth is 6 to 8 inches tall. If thistles have been spring-plowed, delayed in emergence, are blooming or mature, or if treatment follows harvesting in late summer or fall, it is best to mow and spray the regrowth when it is 6 to 8 inches tall. Plowing or cultivating after spraying is not necessary, but, if done, should be delayed at least 2 weeks after treatment.

Corn may be planted 2 weeks after amitrole or amitrole-T treatments without danger of injury to the corn from residue. *Caution:* Treated areas should not be planted to other crops, grazed, or cut for hay for 8 months after treatment.

For control in small areas, spot treatment in cropland, or where soil sterility is not objectionable, see the section on complete vegetation control. Benzabor; dicamba; fenac; picloram; TBA; sodium chlorate, borate, or various mixtures of the two; and mixtures with 2,4-D or monuron can be used. But at the rates needed these chemicals will kill crops, and residues will remain in the soil for at least 1 year.

Chemicals for Controlling Quackgrass

It is possible to greatly reduce or eliminate quackgrass infestations with chemicals. Weather conditions, soil type, timing of treatments, and accompanying tillage will influence the results.

Atrazine is the most effective herbicide for quackgrass control. Preplow applications of 2 to 4 pounds

per acre to quackgrass sod in the fall, September to freezeup, or spring, after the frost is out until mid-May, have resulted in nearly complete elimination of quackgrass stands. The low rate is adequate on sandy soils but higher rates are necessary on heavier soils. Treated areas should be plowed and planted to corn only. Other crops are likely to be injured. If 3 to 4 pounds per acre are used, plant corn 2 years to avoid possible carryover injury.

Split applications, 2 pounds per acre of atrazine on quackgrass sod in the fall or early spring and 1 to 2 pounds per acre on the corn as a pre-emergence treatment, have the advantage of controlling annual weeds in the corn as well as eliminating the quackgrass.

TCA applied at the rate of 22 pounds per acre in September or early October on land that has recently been plowed or thoroughly cultivated has given fair quackgrass control. The next year, if the land is cropped make a second application of 18 pounds per acre after harvest to eradicate the quackgrass.

PERENNIAL SOWTHISTLE

Normal growth of crops sown or planted in the spring following a fall application of 22 pounds of TCA can be expected from flax, potatoes, sugar beets, oats, corn, and strawberries if normal rainfall has occurred. If it has been dry following the application of TCA, all crops may be injured.

Dalapon (Dowpon) will give results similar to those obtained with TCA when applied to the soil or areas of scanty foliage. It is more effective than TCA when applied to a good growth of foliage. Fall treatment of 12 to 15 pounds per acre followed in a week or two by plowing or other similar soil preparation gives good control of quackgrass the following year. Repeated treatments are necessary for eradication. Control is best when rain occurs between treatment and plowing. Response of spring-sown crops to residues of dalapon in the soil is similar to that for TCA.

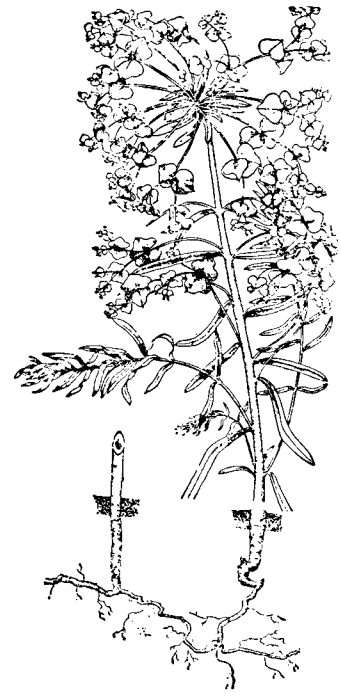
Dalapon may also be applied to quackgrass in the spring. An application of 5 pounds per acre, when quackgrass leaves are about 6 inches tall, followed in 2 or 3 weeks by plowing or other soil tillage has proved most satisfactory. Crops should not be planted until 4 weeks after the application. Corn, wheat, and soybeans are especially sensitive to small amounts of dalapon in the soil.

Wild Oats

There are two major reasons for the difficulty in controlling wild oats: (1) its habit of shattering its seed before most small grain crops are harvested, and (2) its delayed germination characteristic. Unless the crop in which the wild oats occurs is cut for hay, enough seed is shattered to infest the soil for years. The germination of the seed and the length of time it can remain viable depend on several factors.

Favorable temperature and moisture for germination are most common in fall and spring; very little seed germinates between June and September. Some seeds require afterripening or a rest period in which the seed coat becomes more permeable to oxygen, which is necessary for germination. Seeds requiring this afterripening germinate the next spring after they have been produced or the following fall.

Seeds kept under favorable conditions usually germinate in 2 or 3 years. However, when seeds are plowed



LEAFY SPURGE

under they may remain dormant and viable for a long time.

The following cultural methods of control are suggested:

1. Do not plow under seeds that have shattered from the current crop of wild oats. They may remain alive for many years when buried. Weathering helps break dormancy if seeds stay near the soil surface.

2. Cultivate shallow in the spring to break the soil crust and cover seed. Cultivate later to kill the wild oats that have germinated, and to bring up other seed that is no longer dormant. Late spring and summer cultivation should be shallow. About the middle of June sow a crop adapted to late sowing—such as early varieties of flax, potatoes, corn, sugar beets, proso millet, buckwheat, sudangrass, and soybeans.

3. Cultivate as in (2) and sow barley late. Use fertilizer and heavy sowing rate.

4. Sow tame oats early and cut for hay before wild oats form seed. Plow immediately after hay crop.

5. More than 1 year of early tillage and delayed sowing or cutting of tame oats for hay is necessary on badly-infested fields.

6. Wild oats can regrow after cultivation. Avoid this by cultivating not earlier than the three-leaf stage, completely uprooting the plants.

Several herbicides are now available which may be used to control wild oats in a number of crops.

Preplant or pre-emergence incorporated applications of diallate (Avadex) at 1½ to 2 pounds per acre will control wild oats in flax with no injury to the crop. This compound may be used for the control of wild oats in barley if applied after planting at 1¼ pounds per acre. Triallate (Fargo), a related compound, appears somewhat safer to barley and may be applied at the same rate either before or after seeding the barley. Triallate, but not diallate, may be used for the control of wild oats in hard red spring or durum wheat if applied at a lower application rate, 1 pound per acre, after seeding. Lower application rates, afterseeding applications, and greater depth of planting of the grain tend to reduce the possibility of crop injury from diallate or triallate. However, the degree of wild oat control usually decreases as the application rate is reduced. Diallate and triallate require incorporation immediately to prevent losses by evaporation.

Fall applications after October 15 of diallate before sugar beets or flax and triallate before barley have been used successfully in northern areas. Excessive injury has occurred from fall applications prior to spring wheat. A good seedbed free of trash should be prepared before application and the chemical incorporated as above. Soil should be worked no more than 2 to 2½ inches in spring. Fall applications are not advised on soils subject to wind or water erosion.

Alfalfa and clovers may be underseeded in crops treated with diallate. Trials indicate that diallate will control wild oats in corn without injury to the corn.

Barban (Carbyne) should be applied to wild oats in the two-leaf stage from 4 to 10 days after emergence to obtain the greatest degree of control. Application rates of 4 to 6 ounces per acre will usually control wild oats in flax, wheat, and barley. Flax is more sensitive to barban than wheat, and barley is least sensitive. Spraying thin crop stands may result in unsatisfactory wild oat control. Thick stands of crop plants aid in suppression of wild oats and enhance the degree of control obtained with barban. Do not spray barban after wheat or barley is in the 4-leaf stage, flax in the 12-leaf stage, nor later than 1 month after sugar beets emerge. *Caution:* Do not allow livestock to graze treated barley, wheat or sugar beet fields until after the crop is harvested. Do feed treated flax straw to livestock.

Barban is cleared for early postemergence application in soybeans at rates up to 6 ounces per acre. Apply when most of the wild oats are in the 2-leaf stage. Do not apply after the first trifoliolate leaf stage of the soybeans nor later than 14 days after soybean emergence. *Caution:* Do not allow livestock to graze treated fields until after crop harvest and do not feed treated forage to livestock.

For information on the control of wild oats in sugar beets, see page 12.

Complete Vegetation Control

Several herbicides are available for controlling small areas of perennial weeds or for complete vegetation control. These herbicides may prevent the growth of plants for a few weeks to more than 2 years, depending on the chemical and rate of application. Most chemicals do not control all weed species, so read the label for weeds controlled by a specific product. The cost on an acre basis may be rather high for these chemical treatments. Use of chemicals for this type of weed control must also comply with the provisions of the Miller Amendment to the Federal Food, Drug, and Cosmetic Act (see page 2).

Be sure the treatment you select agrees with your planned future use of the area. Larger dosages than those suggested below will give better and more lasting control. Higher rates are usually more necessary on low than on high, dry locations. Lower rates and less water or other carrier are needed if applications are made before plant growth is large and dense.

Short-term control—For a temporary kill, use 5 to 10 pounds per acre of dalapon plus 1 to 2 pounds per acre of 2,4-D ester. This treatment works best if applied when the weeds are small and controls both grasses and broad-leaved weeds.

Long-term control—To control vegetation for at least 1 year, the compounds and rates described below may be used for spot spraying or in areas where residues are not objectionable. Numerous mixtures of these materials are available.

Picloram alone at 1 to 3 pounds per acre or mixed with 2,4-D gives excellent control of perennial broad-leaved weeds such as Canada thistle, field bindweed, Russian thistle, Russian knapweed, and leafy spurge in nonagricultural lands or for spot-treatment in cropland if the spots actually treated are removed from production.

Dicamba may be used at 5 to 10 pounds per acre for control of broad-leaved perennials. It should be applied to the foliage or soil when the weed is actively growing. Crops will be killed by this rate of dicamba.

Trichlorobenzoic acids are effective in controlling perennial broad-leaved weeds when applied at 15 to 20 pounds acid equivalent per acre. Mixtures of dichloro, trichloro, and tetrachloro benzoic acids (PBA) at rates of 30 to 50 pounds per acre have been as effective as TBA.

Mixtures of TBA and borates effectively control perennial broad-leaved weeds and annual weeds. These are not recommended for controlling perennial grasses.

Sodium chlorate at 4 to 6 pounds per square rod will control annuals, biennials, and most perennials. This compound has been used extensively in spot treatments to control bindweed, leafy spurge, Russian knapweed, Canada thistle, and other deep-rooted perennials. Sodium chlorate is highly flammable when mixed with organic matter, so use it with care.

Borate and sodium chlorate mixtures cause no fire hazard and may be used as sodium chlorate is used.

Substituted urea compounds effectively control vegetation for an extended time. Monuron, diuron, and fenuron are related compounds that control vegetation; apply 20 to 40 pounds per acre (one-eighth to one-fourth pound per square rod). Diuron is the slowest acting, but has the longest residual. Fenuron acts more rapidly, but has a shorter residual. Monuron is intermediate in both respects. Monuron and diuron are wettable powders applied as sprays; fenuron is applied in dry form.

Borate compounds at 10 pounds of B_2O_3 per square rod or borate-chlorate mixtures at 8 pounds of active ingredient per square rod have given satisfactory vegetation control. Another treatment may be required for surviving plants, beginning the second spring after the original treatment.

Mixtures of monuron and borates are designed for use as nonselective residual herbicides on industrial sites.

Bromacil controls annual and perennial weeds in noncropland where bare ground is desired. Bromacil should be applied just before or during active growth of weeds. Rates vary from 3 to 15 pounds per acre according to the weed species; refer to the label for specific rates.

Atrazine and simazine are effective for complete vegetation control when applied at 10 to 20 pounds per acre, either as granules or sprays. They are not very effective on some woody plants.

Prometone (Pramitol) is a related triazine material that gives a more rapid kill of existing top growth.

A mixture of amitrole and simazine (Amizine) at 20 pounds per acre is equal to 10 pounds per acre of simazine in length of complete vegetation control; the amitrole portion of the mixture quickly kills young vegetation that persists for long periods when simazine is used alone.

Erbon is a nonselective herbicide effective on most broad-leaved and grass weeds. Docks, nutsedge, milkweed, and Canada thistle are resistant to erbon. Apply as a spray at 1 pound per square rod.

The weeds reinfesting sterilized areas are usually broad-leaved species. Relatively inexpensive treatments with 2,4-D ester at 1 pound per acre may maintain areas free of vegetation for several additional years.

Table 5. Chemicals for Noncropland Weed Control (fencerows, building sites, rights-of-way, parking lots, etc.)

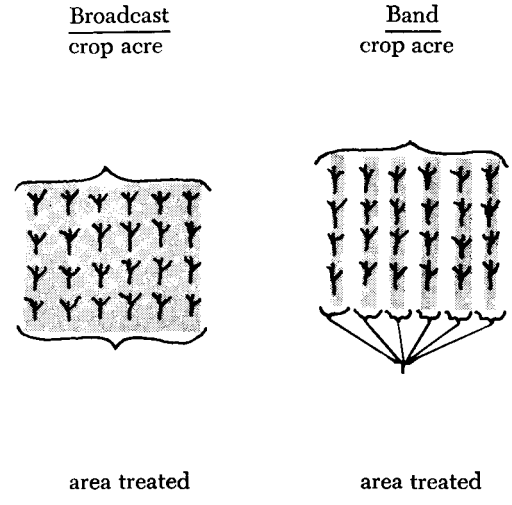
Weeds Controlled		
Grasses	Broadleafs	Broadleafs and Grasses
dalapon	dicamba	amitrole, amitrole-T
TCA	2,4-D	AMS
mixtures	fenac	atrazine
	PBA	borates
	picloram	bromacil
	silvex	diuron
	2,3,6-TBA	erbon
	TBP	fenuron
	2,4,5-T	monuron
	mixtures	prometone
		simazine
		sodium chlorate
		mixtures

Follow manufacturer's recommendations on rates and times of application. Consider possible damage to nearby trees, shrubs, grass, crops, and possible movement of chemicals with water or wind. See section on complete vegetation control, page 16.

FARM SPRAYER CALIBRATION AND ADJUSTMENT

Uniform application of spray chemicals is essential for effective weed control. A small variation in the rate of application may result in poor kill of the weeds or injury to the crop, thereby causing a loss of time, effort, and money.

Rates in this bulletin are in terms of active ingredient or acid equivalent per acre treated. Rate per acre in the treated area should be the same for broadcast as for band applications. But proportionately less material is used per crop acre with band than broadcast applications. For example, a 3 pound per acre rate requires 3 pounds of material per crop acre with broadcasting but only half as much per crop acre (1½ pounds) if a 15-inch band is treated on rows spaced 30 inches apart.



To determine how much liquid a sprayer applies per acre:

1. Check the output of all nozzles for a set time to make sure that all nozzles discharge at the same rate.

2. Start with a full tank of clean water and have the pressure adjusted as you will use it in the field (usually 20 to 40 pounds).

3. Drive exactly one-eighth mile (40 rods) (660 feet) in a field at the speed you will use when spraying—usually 4 to 5 miles per hour. Mark throttle setting or speed indicator reading and maintain same speed when spraying.

4. Refill the tank, carefully measuring the amount of liquid required. (If water spillage from a full tank is a problem, you can use a calibrated stick to measure amount of liquid used.)

To calculate broadcast application rate:

$$\frac{\text{Number of gallons used} \times 66}{\text{Boom width in feet}} = \text{gallons per acre.}$$

Example: If 2½ gallons were used in one-eighth mile and the width covered by the boom is 24 feet, multiply 2½ by 66 and divide by 24. The result is 6.9 gallons per acre.

To calculate band application rate (volume per acre applied to the area within the band that is sprayed);

$$\frac{\text{Number of gallons used} \times 66}{\text{Band width in feet} \times \text{Number of bands}} = \text{gallons per acre}$$

Example: If 1½ gallons were used in one-eighth mile and the sprayer applied 4 bands 15 inches (1¼ feet) in width, multiply 1½ × 66 and divide by 1¼ × 4. The result is 19.8 gallons per acre.

This is the volume per acre applied to the area within the band that is sprayed.

To determine the amount of herbicide formulation to use per acre sprayed:

1. Determine the number of pounds of acid equivalent or active ingredient suggested per acre for your situation. Use acid equivalent if it appears on the label. Otherwise, use active ingredient.

2. For dry materials, divide the number of pounds of active ingredient or acid equivalent desired by the percent of active ingredient or acid equivalent in the commercial product to determine the number of pounds of the material to apply per acre. Example: If 3 pounds of active ingredient are required and the commercial product is an 80 percent active ingredient powder, divide 3 by .8 = 3.75 pounds of commercial powder per acre.

For liquids, determine the volume of commerial product to apply per acre to get the proper amount of acid equivalent or active ingredient per acre. Example: If one-half pound of acid equivalent is required per acre and the commercial product contains 4 pounds acid equivalent per gallon, then 1 quart contains 1 pound acid equivalent; 1 pint contains one-half pound acid equivalent.

Similar calculations were used to make table 6.

To determine the amount of herbicide to put in the tank:

1. Divide the number of gallons the tank will hold by the number of gallons your sprayer applies per acre. This will give you the number of acres one filling will spray.

2. Multiply the number of acres the tank will spray by the amount of herbicide to be used per acre. This will give the amount of herbicide to be used per tank.

CALIBRATION OF A GRANULAR APPLICATOR

1. Determine the number of pounds of active ingredient or acid equivalent suggested per acre for your situation from this bulletin.

2. Divide the number of pounds of active ingredient or acid equivalent desired by the percentage of active ingredient or acid equivalent in the commercial material to determine the number of pounds of the material to apply per acre or determine from table 6.

3. Consult the manufacturer's recommendation to make approximate setting. Adjust setting on each hopper.

4. Select an area for a test run, preferably in the field to be treated, so that speed and traction conditions are constant. Measure off a distance of 660 feet (40 rods).

5. Fill hoppers and attach a suitable container (sack, pail, etc.), to each hopper spout to catch granules from each hopper.

6. Put machine in gear and drive the measured distance at the same speed that will be used when applying the chemical.

7. Weigh the material collected from each hopper. Multiply this weight in pounds by 66 and divide by the band width (in feet). This will give the pounds of granular material applied per acre on the area treated. In equation form:

$$\frac{\text{Weight of granules in pounds} \times 66}{\text{Band width in feet}} = \text{Pounds of granules applied per acre}$$

8. Readjust machine output and repeat the calibration process until the desired amount is obtained from each hopper.

Weights and Measures

1 pound = 16 ounces; 454 grams.

1 gallon = 4 quarts; 8 pints; 128 fluid ounces; 256 level tablespoonfuls; 3,785 cubic centimeters; (milliliters).

1 tablespoonful = 3 teaspoonfuls; one-half fluid ounce; 14.8 milliliters.

1 acre = 43,560 square feet; 160 square rods; an area 208.7 feet square; an area 16½ feet wide and one-half mile long.

1 mile = 5,280 feet; 1,760 yards; 320 rods.

1 rod = 5½ yards; 16½ feet.

Table 6. Amounts of herbicide products of different concentrations to use per acre for various application rates

Concentration of herbicide formulation	Amount of formulation to use per acre broadcast to obtain an active ingredient or acid equivalent rate of				
	⅛ lb.	¼ lb.	½ lb.	¾ lb.	1 lb.**
Pounds of active ingredient or acid equivalent per gallon	pints	pints	pints	pints	pints
1	1.0	2.0	4.0	6.0	8.0
1½	.67	1.33	2.67	4.0	5.33
2	.50	1.0	2.0	3.0	4.0
3	.33	.67	1.33	2.0	2.67
4	.25	.50	1.0	1.50	2.0
5	.20	.40	.80	1.20	1.60
6	.16	.33	.67	1.0	1.33
7	.14	.29	.57	.86	1.14
8	.125	.25	.50	.75	1.0
9	.11	.22	.44	.67	.89
10	.10	.20	.40	.60	.80
Percentage of active ingredient or acid equivalent in dry formulation	lb.*	lb.	lb.	lb.	lb.
2	6.25	12.5	25.0	37.50	50.0
5	2.50	5.0	10.0	15.0	20.0
8	1.56	3.12	6.25	9.38	12.50
10	1.25	2.50	5.0	7.50	10.0
20	.62	1.25	2.5	3.75	5.0
25	.50	1.0	2.0	3.0	4.0
30	.42	.83	1.67	2.50	3.33
40	.31	.62	1.25	1.88	2.50
50	.25	.50	1.0	1.50	2.0
60	.208	.42	.83	1.25	1.67
65	.192	.38	.77	1.15	1.54
70	.178	.36	.72	1.07	1.43
75	.167	.33	.67	1.0	1.33
80	.156	.31	.62	.94	1.25
85	.147	.29	.59	.88	1.18
90	.139	.28	.56	.83	1.11

* To convert to ounces multiply by 16.
** For rates over 1 lb/A, multiply amount for 1 lb/A by the desired rate.

Table 7. Herbicide names and formulations

Common name	Trade name	Chemical name	Concentration and commercial formulation[1]
Amiben	Amiben, Vegiben	3-amino-2, 5-dichlorobenzoic acid	10% G, 2 lb/gal L
Amitrole	Amino-triazole, Amizol, Weedazol Mixtures	3-amino-1,2,4-triazole	50, 90% WSP
Amitrole and Simazine	Amizine		15% amitrole WSP 45% simazine WP
Amitrole-T	Amitrol-T, Cytrol	3-amino-1,2,4-triazole plus ammonium thiocyanate	2 lb/gal L
AMS	Ammate	ammonium sulfamate	95% WSP
Atrazine	Atrazine, Atratol Mixtures	2-chloro-4-ethylamino-6-isopropylamino-s-triazine	80% WP 8% P
Atrazine and prometryne	Primaze		40% atrazine, 40% prometryne WP

Herbicide Names and Formulations

Common name	Trade name	Chemical name	Concentration and commercial formulation[1]
Atrazine and linuron	Several		30.8% linuron, 30.8% atrazine WP
Barban	Carbyne	4-chloro-2-butynyl m-chlorocarbanilate	1 lb/gal L
Boron compounds (borax, sodium pentaborate, boron trioxide, anhydrous sodium, biborate, and mixtures.)	Several, Mixtures		Various
Bromacil	Hyvar-X, Hyvar-XWS, Mixtures	5-bromo-3-sec-butyl-6-methyluracil	80% WP 50% WSP Various
Bromoxynil	Buctril, Brominil	3,5-dibromo-4-hydroxybenzonitrile	2 lb/gal L
CDAA	Randox	2-chloro-N,N-diallylacetamide	4 lb/gal L 20% G
CDAA and TCBC	Randox-T	CDAA plus trichlorobenzylchloride	3.1 lb/gal CDAA, 6.3 lb/gal TCBC L 11.7% CDAA, 23.3% TCBC G
Chloroxuron	Tenoran	N-(4-chlorophenoxy)= phenyl-N,N-di= methylurea	50% WP
CIPC	Chloro IPC Mixtures	isopropyl N-(3-chlorophenyl)= carbamate	5, 20% G 4 lb/gal L
Cypromid	Clobber	3′,4′-dichlorocyclopropane= carboxanilide	2 lb/gal L
Dalapon	Dowpon, Radapon Mixtures	2,2-dichloropropionic acid	74% WSP
Dalapon and TCA	Dowpon C		46.5% dalapon, 26.2% TCA WSP
DCPA	Dacthal	dimethyl 2,3,5,6-tetrachloroterephthalate	50, 75% WP
Diallate	Avadex	S-2,3-dichloroallyl N,N-diisopropyl= thiolcarbamate	4 lb/gal L
Dicamba	Banvel-D Mixtures	2-methoxy-3,6-dichlorobenzoic acid	4 lb/gal L
Dicamba and MCPA	Banvel-M		1.25 lb/gal dicamba, 2.50 lb/gal MCPA L
Diuron	Karmex Mixtures	3-(3,4-dichloro= phenyl)-1,1-dimethylurea	L, WP, G Varies
DNBP	Several, Mixtures	4,6-dinitro-o-sec-butylphenol	1, 3, 5 lb/gal L 10% G
Endothall	Endothal, Herbicide 273	7-oxabicyclo-(2.2.1) heptane-2,3-dicarboxylic acid	1.46 lb/gal L 3 lb/gal L 5% G
EPTC	Eptam	ethyl N,N-dipropyl= thiocarbamate	6 lb/gal L, 10% G
EPTC and 2,4-D	Knoxweed		4 lb/gal EPTC, 1.6 lb/gal 2,4-D L 10% EPTC, 4% 2-4-D G

Herbicide Names and Formulations

Common name	Trade name	Chemical name	Concentration and commercial formulation[1]
Erbon	Baron, Novege	2-(2,4,5-trichloro= phenoxy) ethyl-2,2-dichloro= propionate	1, 4 lb/gal L
Fenac	Fenac Mixtures	2,3,6-trichloro= phenylacetic acid	1½ lb/gal L 10% G
Fenac and amitrole and atrazine	Fenatrol		.55 lb/gal fenac, .33 lb/gal amitrole, 1.0 lb/gal atrazine L
Fenac and amiben	Fenaben		½ lb/gal fenac 1 lb/gal amiben L
Fenuron	Dybar Mixtures	3-phenyl-1,1-dimethylurea	Varies WP,G
Linuron	Lorox, Mixtures	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	50% WP
Linuron and propachlor	Londax		5% linuron, 10% propachlor G
MCPA	Several, Mixtures	2-methyl-4-chlorophenoxy= acetic acid	Various L
Monuron	Telvar Mixtures	3-(p-chloro= phenyl)-1,1-di= methylurea	G, L, WP Various
Neburon	Several, Mixtures	1-butyl-3-(3,4-dichlorophenyl) -1-methylurea	Various WP
Nitralin	Planavin	4-(methylsulfonyl) 2,6-dinitro-N,N-dipropylanaline	75% WP
Norea	Herban Mixture with atrazine	3-(hexahydro-4, 7-methanoindan-5-yl)-1,1-dimethylurea	80% WP
Norea and atrazine	Herban 21A		53.33% norea and related, 26.67% atrazine WP
NPA	Alanap	N-1-naphthyl= phthalamic acid	2 lb/gal L, 10% G
NPA and CIPC	Alanap Plus		2 lb/gal NPA 1⅓ lb/gal CIPC L 7.5% NPA 5% CIPC G
PBA	Several, Mixtures	polychlorobenzoic acid	Various L
PCP	Several, Mixtures	pentachloro= phenol	L, WP, WSP, G Various
Picloram	Borolin, Tordon Beads Mixtures	4-amino-3,5,6-trichloropicolinic acid	2% G
Picloram and 2,4-D	Tordon 212		1 lb/gal picloram, 2 lb/gal 2,4-D L
Prometone	Pramitol	2-methoxy-4,6-bis(isopropylamino) -s-triazine	2 lb per gallon L 5% P
Prometryne	Caparol	2,4-bis (isopropylamino)-6-methylmercapto-s-triazine	80% WP

Herbicide Names and Formulations

Common name	Trade name	Chemical name	Concentration and commercial formulation[1]
Propachlor	Ramrod	2-chloro-N-iso= propylacetanilide	65% WP 20% G
Propazine	Propazine, Milogard	2-chloro-4,6-bis(isopropylamino) -s-triazine	80% WP
Pyrazon	Pyramin	5-amino-4-chloro-2- phenyl-3(2H)-pyridazinone	80% WP
R1910	Sutan	ethyl di-isobutylthiolcarbamate	6 lb/gal L
Silvex	Several, Mixtures	2-(2,4,5-trichloro= phenoxy)propionic acid	L, G Various
Simazine	Simazine Mixtures	2-chloro-4,6-bis(ethylamino) -s-triazine	80% WP, 4% G
Sodium arsenite	Several, Mixtures		L, WP Various
Sodium chlorate	Several, Mixtures		WSP Various
TBA	Several, Mixtures	2,3,6-trichloro= benzoic acid	Various
TBP	Several, Mixtures	2,3,6-trichloro= benzyloxypropanol	Various
TCA	TCA Mixtures	trichloroacetic acid	4.76 lb/gal L 84%, 80.2% WSP
Triallate	Far-go	S-2,3,3-trichloro= allyl N,N-diiso= proplythiocar= bamate	4 lb/gal L
Trifluralin	Treflan	a, a, a, -tri= fluoro-2,6- dinitro-N,N-di= propyl-p-toluidine	4 lb/gal L, 5% G
2,3,6-TBA	Several, Mixtures	2,3,6-trichloro= benzoic acid	Various L, G
2,4-D	Several, Mixtures	2,4-dichlorophenoxy= acetic acid	L, G Various
2,4-DB	Butyrac, Butoxone	4-(2,4-dichlorophenoxy)= butyric acid	L Various
2,4,5-T	Several, Mixtures	2,4,5-trichloro= phenoxyacetic acid	L Various
Vernolate	Vernam	S-propyl dipropyl= thiocarbamate	6 lb/gal L 10% G

[1]
G—granular
L—liquid
WP—wettable powder
WSP—water-soluble powder
P—Pellets

* Trade names are listed only to aid the reader in identifying herbicides. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

A chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

Table 8. Suggestions for chemical control of weeds in field crops. Application rates are on a broadcast basis and refer to acid equivalent or active ingredient rather than amount of commercial product. Avoid repeated and prolonged contact with all herbicides, especially direct contact with the skin and eyes. Check label restrictions for use of crops for food or forage.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	USDA registration limitations on crop use
Wheat or barley	2,4-D	¼ to ⅔	Fifth leaf to early boot	Amine less injurious to crop.	None
	MCPA	¼ to ⅔	Two leaf to early boot	Reduce rates one-third for ester.	None
Wheat	dicamba and MCPA	⅛ + ¼	Two- to five-leaf stage	Kills legumes.	Do not graze or feed forage or threshings to livestock.
Oats	2,4-D amine	¼ to ½	Sixth leaf to early boot	MCPA less injurious to crop.	None
	MCPA amine	¼ to ½	Two leaf to early boot		None
	dicamba and MCPA	⅛ + ¼	Two- to five-leaf stage	Kills legumes.	Do not graze or feed forage or threshings to livestock.
Flax	MCPA amine	¼	Before bud	Mixture of MCPA with TCA or dalapon for broad-leaved and grass weeds.	None
	TCA	5		Grass weeds except wild oats.	None
	dalapon (Dowpon)	¾	Weeds 1 to 2 inches	See section on wild oats.	None
Corn	atrazine	1 to 4	Preplanting, Pre-emergance or early post-emergence	Atrazine may injure crops the following year.	None
	atrazine and linuron	½ to 1½ of each	Pre-emergence	Do not use linuron on sandy soil.	None
	atrazine and propachlor	1 to 1½ + 3	Pre-emergence		None
	linuron and propachlor	1 to 1½ + 3	Pre-emergence	Do not use on sandy soils.	None
	propachlor (Ramrod)	4 to 5	Pre-emergence	Grass weeds only.	None
	dalapon (Dowpon)	1½	Directed postemergence	Add 2,4-D if broad-leaved weeds are present.	Do not use on corn grown for seed.
	linuron (Lorox)	1½	Directed postemergence	Wetting agent increases effectiveness.	None
	2,4-D amine	¼ to ½	After two-leaf stage to layby	Corn most susceptible during rapid growth.	None
	2,4-D ester	1/6 to ⅓		Use drop nozzles after corn is 8 inches tall.	None
	2,4-D amine	½ to 1	After layby	Spray base of stalks only.	None
	2,4-D ester	⅓ to ⅔	After layby		None

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	USDA registration limitations on crop use
Alfalfa and clover in small grains	2,4-D or MCPA amine	¼	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.	Do not graze dairy animals on treated areas within 7 days after application of 2,4-D.
	2,4-DB	½ to 1½			Do not graze or cut hay from treated fields within 30 days after treatment.
Alfalfa, sweetclover, and birdsfoot trefoil in flax	TCA	5	Weeds 1 to 2 inches	For grass weeds.	Do not graze animals on treated areas.
	dalapon (Dowpon)	¾		Will injure red and alsike clover.	None
	MCPA amine	¼	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.	None
Legume establishment without a companion crop	EPTC (Eptam)	3	Preplanting incorporation		None
	2,4-DB	½ to 1	Legumes 2 to 3 inches	Sweetclover injured.	Do not graze livestock or cut hay from treated fields within 30 days after treatment.
	dalapon (Dowpon)	1	Legumes 2 to 3 inches	Will injure red and alsike clover.	Do not feed first year's growth to dairy animals or animals being finished for slaughter.
Established legumes	2,4-DB amine 2,4-DB ester	½ to 2 ½ to 1	When annual weeds are 2 to 3 inches tall or perennials 6 to 8 inches tall	Do not use more than ¾ pound per acre of ester form on red clover.	Do not graze treated areas nor feed straw or hay from treated crops to livestock within 30 days after application.
Grain sorghum	Propachlor (Ramrod)	4	Pre-emergence	Grass weeds only.	Do not graze or feed forage to dairy cattle.
	norea (Herban)	2.4	Pre-emergence		None
	propazine	2	Pre-emergence		None
	atrazine	2	Early postemergence		Do not graze or feed forage from treated area within 60 days after application.
	2,4-D amine	½	4 to 12 inches	For broad-leaved weeds.	None

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	USDA registration limitations on crop use
Soybeans	CDAA (Randox)	4 to 5	Pre-emergence	Grass weeds only.	None
	propachlor (Ramrod)	4 to 5	Pre-emergence	Grass weeds only.	Only for soybeans grown for seed. Do not graze treated area or feed forage to livestock. Do not use seed for food, feed or oil purposes.
	amiben	3	Pre-emergence		Do not graze or feed forage from treated fields to livestock.
	linuron (Lorox)	½ to 2½	Pre-emergence		None
	trifluralin (Treflan)	½ to 1	Preplanting incorporation	Must be well incorporated.	Do not graze or feed forage from treated fields to livestock.
	2,4-DB	1/5	Postemergence	For cocklebur control.	None
Sugar beets	TCA	6	Pre-emergence	For grass weeds except wild oats.	Do not use treated tops for food or feed.
	dalapon (Dowpon)	2 to 3	Beets up to 6-leaf stage	For grass weeds except wild oats.	None
		2½ to 3½	Directed, beets 7-leaf stage to 14 inches		
	diallate (Avadex)	1½ to 2	Preplanting incorporation	For wild oats.	Do not graze unharvested crop.
	barban (Carbyne)	⅝ to ¾	Wild oats in two-leaf stage	For wild oats.	Do not allow livestock to graze treated fields until after crop is harvested.
	endothall	¾ to 1½	Early postemergence	For wild buckwheat and annual smartweed.	None
	EPTC (Eptam)	2	Preplanting incorporation	For grass and some broad-leaved weeds.	None
Dry edible beans	EPTC (Eptam)	3	Preplanting incorporation		Do not graze or feed treated vines to livestock.
	trifluralin (Treflan)	¾ to 1	Preplanting incorporation		Do not graze or feed forage from treated fields.
Sunflowers	EPTC (Eptam)	3	Preplanting incorporation		None
Established grass pastures	2,4-D	½ to 2	Before bud stage, preferably when weeds are 2 to 6 inches tall and growing vigorously	Rate depends on kinds of weeds. Use low rates of MCPA if legumes are present.	Do not graze dairy animals on treated areas within 7 days after application.
	2,4,5-T	1 to 2			None
	MCPA	¼ to 2			None

Suggestions for chemical control of specific weeds on cropland. Follow label precautions carefully.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	USDA registration limitations on crop use
Canada and sow thistle	2,4-D amine	½	Just before bud	Can spray in tolerant crop.	See crop
	2,4-D ester	1	Fall rosette	Plow or clip in fall and spray when 6 inches.	See crop
	amitrole	4			
	amitrole-T	4	Just before bud or regrowth when 6 to 8 inches after clipping or plowing	A full stand before spraying is important.	Do not plant to crops other than corn or graze for 8 months after treatment.
	dicamba (Banvel-D)	⅛ to ¼		See crop recommendations.	Do not graze or feed forage or threshings of wheat or oats to livestock.
				Drift may affect sensitive crops.	Corn—Do not graze treated areas. Do not harvest for dairy animal feed prior to milk stage.
Field bindweed	2,4-D ester	1	Late fall	Re-treat second year.	See crop
	2,4-D amine	½	Bud to bloom		See crop
Leafy spurge	2,4-D ester	2 to 3	Bud	After grain harvest or on grass pastures. Retreat growth when 4 to 6 inches.	See crop
	2,4-D ester	½	Bud	Safest in wheat or barley. Cultivate after harvest until freezeup.	See crop
Quackgrass	TCA	22	Sept. or early Oct.	Best on plowed ground.	See crop
		18	Next fall after harvest	To kill escaped plants.	See crop
	dalapon (Dowpon)	12 to 15	Fall	Foliage application, plowed 1 or 2 weeks later.	See crop
	dalapon (Dowpon)	5	Spring	Foliage application, plowed 1 or 2 weeks later.	See crop
	atrazine	2 to 4	Spring or fall	Use low rate on sandy soils. Only corn can be grown the year after treatment.	See crop
Wild oats	barban (Carbyne)	¼ to ⅜	When wild oats is in two-leaf stage	Rate for wheat, barley, flax, soybeans.	Do not allow livestock to graze treated wheat, barley, sugar beet or soybean fields until after crop is harvested.
	barban (Carbyne)	⅝ to ¾		Rate for sugar beets.	Do not feed soybean forage or flax straw from treated fields.
	diallate (Avadex)	1½ to 2	Preplanting or pre-emergence	Rate for flax and sugar beets; must be incorporated into soil.	Do not graze unharvested crop.
	diallate (Avadex)	1¼	Pre-emergence	Rate for barley.	Do not graze livestock on treated areas.
	triallate (Far-go)	1 to 1¼	Preplanting or pre-emergence	Rate for wheat, barley; must be incorporated into soil.	Do not graze livestock on treated areas.