Bent

Extension Folder 212—Revised

Cultural and Chemical

WEED CONTROL

in Field Crops 1966

Agricultural Extension Service
UNIVERSITY OF MINNESOTA

Cultural and Chemical Weed Control in Field Crops — 1966

Information in this publication summarizes research at the Minnesota Agricultural Experiment Station and elsewhere on the effectiveness and practicability of using herbicide chemicals in 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.

It is dangerous to ignore approved label directions; they should be read and followed carefully. For information on specific problems contact your county agent. The University will provide new information on residues and tolerances as it becomes available.

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 unsafe 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.

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; ½ 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 ½ mile long.

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

1 **rod** = 5½ yards; 16½ feet.

Follow label instructions carefully when using agricultural chemicals.

Revised for 1966 by R. Behrens, professor, Department of Agronomy and Plant Genetics, and G. R. Miller, assistant professor and extension agronomist. Other staff members concerned with field crop weed control include J. R. Justin, assistant professor and extension agronomist; H. J. Otto, professor and extension agronomist; R. G. Robinson, associate professor, Department of Agronomy and Plant Genetics; and R. N. Andersen, plant physiologist, Agricultural Research Service, USDA.

Trade names are sometimes used in this publication to clearly identify 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. Luther J. Pickrel, Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55101. 35M—12-65

Contents

Chemical Weed Control Practices

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

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

Preplanting application—Herbicide applied before the crop is planted.

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

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

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

Broadcast application—Herbicide applied over entire area.

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.

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.

Soil incorporation—Mechanical mixing of the herbicide with the soil. This usually involves disking or harrowing after the chemical is applied, or using special equipment on the planter.

Preemergence Applications

Several excellent herbicides for use as preemergence applications are now available to farmers. 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 preemergence herbicides. Control of some deep-germinating and tolerant annual species may not be adequate with preemergence treatments. The surviving species varies 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 preemergence applications of herbicides. Table 1 shows the performance of a number of preemergence herbicides in corn for several years in county demonstrations. Table 2, page 9, gives similar information for herbicides in soybeans. Figures in Table 1 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. Some herbicides are not included in this table because they have been tested only 1 year or because special incorporation techniques not adapted to small-plot comparisons are required.

Granular Versus Spray Forms of Herbicides

Granular forms of herbicides are a recent development. Tests indicate that weed control varies in some granular and spray forms of an herbicide. Granular forms require no mixing and they can be used directly from the package. This is an advantage over spray forms. 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 usually 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, may be used with greater safety in the granular form than in the spray form.

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
Atrazine	2	1960-64	294	274	53	27	19	68	20	12
Atrazine	3	1959-65	393	370	77	15	8	85	10	5
Atrazine (early postemergence)	3	1961-65	279	258	70	15	15	84	9	7
Atrazine + prometryne	1½ + 1½	1964-65	130	125	72	19	8	81	10	9
CDAA (Randox) granular	4	1959-64	333	313	40	35	25	11	26	63
CDAA (Randox) granular	5	1963-65	190	178	49	32	19	19	23	58
CDAA-T (Randox-T) granular	3½ + 7	1960-65	355	335	47	35	17	46	31	23
EPTC + 2,4-D (Knoxweed)	2 + 1	1964-65	131	127	21	31	48	34	31	35
Linuron (Lorox)	2	1963-65	189	179	52	26	22	61	21	18

Control of Weeds in Field Crops

Corn

Weed control in corn is based on a combination of cultural practices and herbicide 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 preemergence applications have been used.

Herbicides—*Preemergence* 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 rainfall is low.

Atrazine sometimes affects small grains, flax, sugar beets, soybeans, and other legumes planted the following spring. Damage 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 susceptible crops. Certain combinations of atrazine and other chemicals offer possibilities for reducing residue problems. A 1-to-1 ratio of active ingredients of an atrazine-linuron combination has given weed control comparable to an equivalent rate of atrazine alone in Minnesota research trials. Rates vary from ½ to 1½ pounds per acre of each chemical according to soil type. Another promising combination is atrazine with prometryne for preemergence applictaion. In preemergence applications, corn tolerance to these combinations is not as great as to atrazine alone. Do not use any of these combinations for postemergence application. Also, these combinations are less effective than atrazine alone on quackgrass. **Caution**—As of December 1965 prometryne has not received clearance for use on corn.

Used in preemergence 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.

CDAA-T (Randox-T) contains an additive that kills some broad-leaved species not controlled by CDAA. Soybeans have been affected in some instances by soil residues when they were 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.

CP31393 (Ramrod) is a recently developed herbicide chemically related to CDAA that 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 CP31393 with effective broadleaf herbicides looked promising in research trials. Suggested rates are the same as for CDAA. Corn is very tolerant to CP31393. The chemical is less irritable than CDAA, but should be handled cautiously. **Caution**—Do not graze or feed treated forage to livestock.

Preemergence applications of linuron (Lorox) at ½ 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. Using linuron in combination with atrazine reduces the likelihood of corn injury and usually improves weed control compared with linuron alone.

Preemergence 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.

In limited trials, dicamba (Banvel-D) as a preemergence treatment at ½ to 1 pound per acre has given good broad-leaved weed control, but poor grass control with some corn injury.

A mixture of EPTC and 2,4-D (Knoxweed 42) has given erratic performance as a preemergence herbicide, depending on rainfall, soil moisture, and soil type.

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

Postemergence—Annual broad-leaved weeds have been controlled with broadcast postemergence applications of ¼ to ½ pound per acre of 2,4-D amine when the corn is less than 8 inches tall. The ¼-pound rate has been adequate for susceptible weeds and is less dangerous to corn. The ½-pound rate has been satisfactory for moderately resistant weeds. One pound per acre of 2,4-D has been necessary for control of 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 va-

por 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 if the corn is sprayed with 2,4-D during the period from emergence to tasseling. 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 treatments. Hybrids vary in tolerance to 2,4-D treatments. 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 ½ pound per acre or 2,4-D amine at ¾ 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. Aerial sprays should not be used during the pollination period.

MCPA has not proved less injurious to corn than 2,4-D.

Dicamba shows promise for control of broad-leaved weeds in corn. Dicamba can be used in corn at ⅛ to ¼ pound per acre until corn is 36 inches tall.

Caution—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 at 1 to 4 pounds per acre effectively control annual weeds with no injury to corn. Broad-leaved weed control is especially good. Grass control is less consistent. Apply atrazine while weeds are less than 1½ inches tall and within 3 weeks after the corn is planted. Early postemergence applications of atrazine tend to be somewhat more effective on heavier soils and under conditions of lower rainfall than equivalent preemergence applications.

The addition of special nontoxic oils to postemergence sprays of atrazine has improved weed control. Further research is needed on use of these oils, but present results indicate possibilities for using lower rates of atrazine.

Directed sprays—Especially 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. Attachments to lift the corn leaves as the spray is directed at the base of the corn plants and the weeds in the row should also be used to minimize spray contact with corn leaves.

Directed sprays of dalapon-2,4-D mixtures at rates of 1½ pounds of dalapon and ½ pound of 2,4-D per acre can be used on corn from 8 to 16 inches tall to the whorl. This mixture will stunt or kill most weeds within the row which 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

Weed control with chemicals is sometimes quite striking. Corn at left received chemical application and cultivation while corn at right was cultivated but received no chemical.

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.

Flame Cultivation—Flame weeding in corn has not been promising enough for widespread usage to develop. Corn injury and the necessity of repeated applications are important disadvantages. Corn cannot be flamed until it is 8 to 12 inches tall; by this time weeds may have already caused substantial corn yield losses. An advantage of flame cultivation over herbicides is the elimination of residue problems.

Directed sprays of either linuron or dalapon-2,4-D mixtures or flame cultivation cannot be used on small corn. Therefore, early season weed growth must be controlled by some other means (use of rotary hoe, harrowing, preemergence herbicides or cultivation) to prevent yield losses from early weed competition. Directed sprays and flame cultivation are considered emergency measures to control heavy weed stands 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 wire-tooth 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 6-E), trifluralin (Treflan), amiben, DCPA (Dacthal), and DNBP amine (Premerge).

EPTC at 3 pounds per acre or trifluralin at 1 pound per acre are applied preplanting and incorporated into the soil. Incorporation must be accomplished within minutes after application to avoid loss of the herbicide.

Amiben, DCPA, or DNBP amine are applied preemergence 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.

Use drop nozzles for 2,4-D after corn is 8 inches tall.

Weed control from herbicide in band 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. Practice early afterharvest tillage of small grain stubble to control perennial weeds, prevent weed seed production, and stimulate annual weed seed germination in late summer and fall to prepare land for flax, except where afterharvest tillage results in serious wind erosion.

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 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 yields 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, stinkweed, 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 ¾ pound per acre will kill green, yellow, and giant

foxtail in young flax. Best results have followed when the flax was at least 2 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 13.

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 ½ 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. 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 ¼ 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 have been treated with 2,4-D, when broad-leaved weeds were a problem, using up to ¾ pound per acre 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 salt of 2,4-DB can be applied at ½ to 2 pounds per acre or the ester of 2,4-DB can be applied at ½ to 1 pound per acre in 15 to 30 gallons of water per acre. Do not use more than ¾ 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. 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 (1½ quarts) 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 ¼ to ½ pound per acre look promising for controlling young nightflowering catchfly and white cockle plants. 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. 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 good 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 more kinds of weeds by a single application than is obtained by 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.

Caution—Do not graze dairy cattle for 7 days after treatment with 2,4-D.

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 ¼ to ½ pound of 2,4-D ester or ½ to ⅔ pound of 2,4-D amine has usually been used to control broad-leaved weeds without injury to crops.

Avoid spraying wheat and barley in the boot stage of development. Varietal differences in wheat and barley have been unimportant.

Some injury to oats should be expected, but weed control generally will more than offset losses resulting from 2,4-D injury. Oats are more tolerant of MCPA than of 2,4-D, permitting the use of ½ pound per acre. At rates adequate for susceptible weeds like mustard, the stage at application is not so important as it is when ½ pound and more of 2,4-D amine is used. Varieties differ in their response to 2,4-D.

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

Bromoxynil is a recently developed herbicide that controls most annual broad-leaved weeds in wheat and barley when applied at ⅜ to ½ pound per acre as an early postemergence treatment. Bromoxynil does not control annual grasses or perennials.

Dicamba at ⅛ pound per acre controls hard-to-kill broad-leaved weeds such as wild buckwheat and smartweeds in small grains when used alone or in mixtures with ¼ pound per acre MCPA or 2,4-D. The combination of dicamba and 2,4-D or MCPA gives better control of mustard than dicamba alone. Commercial combinations of dicamba and MCPA are available. 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 1965 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 ½ 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. 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 have been controlled in winter wheat and rye by spraying with 2,4-D—using the ester at ¼ to ½ pound per acre or the amine at ½ to ¾ 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 length of the Minnesota growing season will not allow later planting if maximum grain production is desired.

Treatment with CDAA (Randox), norea (Herban), propazine, or atrazine is usually necessary to prevent drastic reduction in sorghum yield due to weed

Table 2. 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	1963-65	118	107	56	28	16	61	21	18
Amiben	3	1959-65	253	247	74	19	7	74	17	8
CDAA (Randox) granular	4	1959-64	219	199	54	29	16	15	27	58
CDAA (Randox) granular	5	1963-65	119	105	58	31	11	21	29	50
Linuron (Lorox)	2	1962-65	167	163	52	28	20	66	20	15

competition. These herbicides control annual grasses (not wild oats) in sorghum. Propazine, atrazine, and norea also kill broad-leaved annual weeds. CDAA at 4 pounds per acre, norea at 3 pounds per acre, or propazine at 2 pounds per acre are applied preemergence. 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 providing grasses are less than 1½ inches tall when treated.

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.

CP31393 (Ramrod) is chemically related to CDAA and was better than CDAA in 1965 tests. **Caution**—As of December 1965, CP31393 has not received clearance for use on sorghum.

2,4-D may be used at ¼ to ½ pound per acre for the control of broad-leaved weeds. 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 delayed sowing of the crop can kill many weeds. Postemergence cultivation with the rotary hoe is effective if done when the weeds are small and soil conditions are favorable.

Table 2 shows the performance of some preemergence herbicides in 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.

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

Preemergence 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.

Preemergence applications of herbicides work well for controlling weeds in soybeans if conditions are right. The research plot on the left received no chemical. The plot on the right was treated with a chemical that can be used on soybeans.

CP31393 (Ramrod) is a recently developed herbicide chemically related to CDAA that 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 CP31393 with effective broadleaf herbicides looked promising in research trials. Suggested rates are the same as for CDAA. Although the chemical is less irritable than CDAA, it should be handled cautiously. **Caution**—As of December 1965 CP31393 has received clearance for use on soybeans grown for seed only.

Preemergence 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.

Preemergence applications of linuron at ½ 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 preemergence 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 before planting or just after planting with a rotary hoe or spike-tooth harrow.

In soybeans, trifluralin (Treflan) applied at ½ to 1 pound per acre preplanting and incorporated has given good control of annual weeds—except ragweed, cocklebur, velvetleaf, mustard, sunflower, and other large-seeded, deep-germinating weeds. Proper incorporation can be accomplished by double disking twice at right angles 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 may be done at application time, followed by an additional disking at planting.

Control of cocklebur can be obtained by applying 2,4-DB to soybeans from 10 days before bloom up to midbloom growth stages at a 0.2-pound-per-acre rate. Cocklebur 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.

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 preemergence.

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.

A combination of EPTC (EPTAM) at 2 pounds per acre incorporated into the soil before planting plus TCA at 6 pounds per acre preemergence has given excellent control of annual grasses (particularly pigeongrass) 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.

A mixture of endothall, pyrazon (Pyramin), and a numbered experimental herbicide has given excellent control of the major species of broad-leaved weeds that infest sugar beets. The mixture was applied as an early postemergence treatment. Further research will be conducted on this promising treatment. **Caution**—This combination is not cleared for use on sugar beets as of December 1965.

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 ⅝ to ¾ 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 smartweeds, wild buckwheat, and marshelder—may be controlled by a postemergence application of endothall at ¾ 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 harrowing about 1 week after planting but before sunflowers germinate.

Sunflower seedlings are strongly rooted so they can be rotary hoed or spike-tooth harrowed after emergence. Only the 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 must be accomplished on a "try-and-adjust" basis.

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 6-E) 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 fall-plowed ground followed immediately by seedbed preparation of cross-disking (twice at right angles), spike-tooth harrowing once, and planting has given good weed control and no sunflower injury. EPTC has not been effective 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 underground parts do not extend below the plow layer and can be pulled to the surface by spring-tooth tillage implements. Cultivations 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 freeze up. A field cultivator equipped with overlapping sweeps operated at a 4-inch depth works well for this job.

In the spring, begin cultivations 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 be formed, 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 controlled 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 kill top growth and prevent seed production.

Perennial broad-leaved weeds 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. 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.

Amitrole or amitrole-T will control Canada thistles 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 is emerged 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 sumer 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. 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. 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 or 4 pounds per acre are used, plant corn 2 years to avoid possible carryover injury.

Split applications, one-half of the atrazine on quackgrass sod in the fall or early spring and one-half on the corn as a preemergence treatment have the advantage of controlling annual weeds in the corn as well as eliminating the quackgrass.

The use of combination treatments—amitrole-T or dalapon plus atrazine— are a possibility for reducing the carryover of atrazine while eradicating quackgrass. Amitrole-T or dalapon must be applied to the quackgrass foliage about 2 weeks prior to spring plowing. A preemergence or early postemergence application of atrazine at 1 to 3 pounds per acre is then used on the corn. Quackgrass control is not as good as from higher rates of atrazine alone.

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. If the land is cropped the next year, make a second application of 18 pounds per acre after plowing or cultivate after harvest to eradicate the quackgrass.

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 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, a period in which the seed coat becomes more permeable to oxygen, which is necessary for germination. Seeds which require this afterripening germinate the next spring after they have been produced, or the following fall.

Seeds kept under conditions favorable for germination have grown in 2 or 3 years. However, when seeds are plowed under—or otherwise kept under conditions unfavorable for germination at the time the rest period has been completed—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 rate of sowing.

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 preemergence 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 (Far-go) 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, after-seeding 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. Shallow disking plus harrowing or harrowing twice at right angles has given satisfactory incorporation.

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.

For information on the control of wild oats in sugar beets, see page 10.

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.

Relatively low rates of picloram (Tordon) give 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 (Banvel-D) 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.

Benzabor effectively controls perennial broad-leaved weeds and annual weeds when applied at ¾ to 1½ pounds per square rod. It is not recommended for controlling perennial grasses.

Trichlorobenzoic acids (Benzac or Trysben) 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.

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.

Polybor-chlorate or Atlacide at 8 to 10 pounds per square rod causes no fire hazard and may be used as sodium chlorate is used.

Substituted urea compounds effectively control vegetation for an extended time. Monuron (Telvar), diuron (Karmex), and fenuron (Dybar) are related compounds that control vegetation; apply 20 to 40 pounds per acre (⅛ to ¼ 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.

Urox is a chemical combination of monuron and TCA that maintains areas free of vegetation when applied at 1½ pounds per square rod. It is applied dry or as a spray.

Borax 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.

BMM (Ureabor) is a mixture of monuron and borates containing 4 percent monuron. It is designed for use as a nonselective residual herbicide on industrial sites. Apply dry at 3 pounds per square rod.

Bromacil (Hy-var X or Hy-var XWS) controls annual and perennial weeds in noncrop land 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 (Novon or Baron) is a nonselective herbicide effective on most broad-leaved and grass weeds. Docks, nutgrass, milkweed, and Canada thistle are resistant to erbon. Apply as a spray at 1 pound per square rod.

The first vegetation reinfesting sterilized acres is usually a 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.

Suggestions for chemical control of specific weeds on cropland. Application rates are on a broadcast basis and refer to acid equivalent or active ingredient rather than amount of commercial product. Follow label precautions carefully.

Weeds	*Chemicals*	*Pounds per acre*	*Time*	*Remarks*
Quackgrass	TCA	22	Sept. or early Oct.	Best on plowed ground.
		18	Next fall after harvest	To kill escaped plants.
	dalapon (Dowpon)	12 to 15	Fall	Foliage application, plowed 1 or 2 weeks later.
	dalapon (Dowpon)	5	Spring	Foliage application, plowed 1 or 2 weeks later.
	atrazine	2 to 4	Spring or fall	Use low rate on sandy soils. Only corn can be grown the year after treatment.
Field bindweed:	2,4-D ester	1	Late fall	Re-treat second year.
	2,4-D amine	½	Bud to bloom	
Leafy spurge:	2,4-D ester	2 to 3	Bud	After grain harvest or on grass pastures. Re-treat growth when 4 to 6 inches.
	2,4-D ester	½	Bud	Safest in wheat or barley. Cultivate after harvest until freezup.
Canada and sow thistle	2,4-D amine	½	Just before bud	Can spray in tolerant crop.
	2,4-D ester	1	Fall rosette	Plow or clip in fall and spray when 6 inches.
	amitrole	4	Just before bud or regrowth when 6 to 8 inches after clipping or plowing	A full stand before spraying is important.
	amitrole-T	4		See crop recommendations.
	dicamba (Banvel-D)	⅛ to ¼		
Wild Oats	barban (Carbyne)	¼ to ⅜	When wild oats is in two-leaf stage	Rate for wheat, barley, flax.
	barban (Carbyne)	⅝ to ¾		Rate for sugar beets.
	diallate (Avadex)	1 to 2	Preplanting or preemergence	Rate for flax, barley, sugar beets; must be incorporated into soil.
	triallate (Far-go)	1 to 1¼	Preplanting or preemergence	Rate for wheat, barley; must be incorporated into soil.

For spot spraying of perennial weeds or complete vegetation control see section on complete vegetation control beginning on page 13. Follow label directions carefully.

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
Wheat or barley	2,4-D amine or	½ to ⅔	Fifth leaf to early boot	Amine less injurious to crop.
	2,4-D ester	¼ to ½	Fifth leaf to early boot	See section on wild oats.
Wheat	dicamba and MCPA	⅛ + ¼	Two- to five-leaf stage	Kills legumes.
Oats	2,4-D amine	½	Sixth leaf to early boot	MCPA less injurious to crop.
	MCPA amine	½	To early boot	
	dicamba and MCPA	⅛ + ¼	Two- to five-leaf stage	Kills legumes.
Flax	MCPA amine	¼	Before bud	Mixture of MCPA with TCA or dalapon for broad-leaved and grassy weeds.
	TCA	5	Weeds 1 to 2 inches	Grassy weeds except wild oats.
	dalapon (Dowpon)	¾	Weeds 1 to 2 inches	See section on wild oats.
Corn	atrazine	1 to 4	Preemergence or early postemergence	Carryover may injure crops the following year.
	CDAA-T (Randox-T)	3½*	Preemergence	Carryover may injure crops the following year.
	CDAA (Randox)	4 to 5	Preemergence	Grass weeds only.
	CP 31393 (Ramrod)	4 to 5	Preemergence	Grass weeds only.
	atrazine and linuron	½ to 1½ of each	Preemergence	
	linuron (Lorox)	1½	Directed postemergence	Wetting agent increases effectiveness.
	dalapon (Dowpon)	1½	Directed postemergence	Add 2,4-D if broad-leaved weeds are present.
	2-4-D amine	¼ to ½	After two-leaf stage to layby	Corn most susceptible during rapid growth.
	2,4-D ester	1/6 to ⅓	After two-leaf stage to layby	Use drop nozzles after corn is 8 inches tall.
	2,4-D amine	½ to 1	After layby	Spray base of stalks only.
	2,4-D ester	⅓ to ⅔	After layby	Spray base of stalks only.
	dicamba (Banvel-D)	⅛ to ¼	Postemergence	For Canada thistle and annual broad-leaved weeds except mustards.
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.
	2,4-DB	½ to 1½	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.
Alfalfa, sweetclover, and birdsfoot trefoil in flax	TCA	5	Weeds 1 to 2 inches	For grass weeds.
	dalapon (Dowpon)	¾	Weeds 1 to 2 inches	Will injure red and alsike clover.
	MCPA amine	¼	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.
Legume establishment without a companion crop	EPTC (Eptam)	3	Preplanting incorporation	
	2,4-DB	½ to 1	Legumes 2 to 3 inches	Sweetclover injured. Do not harvest or graze for 30 days.
	dalapon (Dowpon)	1	Legumes 2 to 3 inches	Will injure red and alsike clover. Do not feed first-year crop to dairy cows or animals being finished for slaughter.
Established legumes	2,4-DB amine	½ to 2	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 or harvest for feeding wtihin 30 days after treatment.
	2,4-DB ester	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 or harvest for feeding wtihin 30 days after treatment.
Grain sorghum	CDAA (Randox)	4	Preemergence	Grass weeds only.
	norea (Herban)	3	Preemergence	
	propazine	2	Preemergence	
	atrazine	2	Early postemergence	
	2,4-D amine	½	4 to 12 inches	For broad-leaved weeds.
Soybeans	CDAA (Randox)	4 to 5	Preemergence	Grass weeds only.
	CP 31393 (Ramrod)	4 to 5	Preemergence	Grass weeds only, and used only on soybeans grown for seed.
	amiben	3	Preemergence	
	linuron (Lorox)	½ to 2½	Preemergence	
	trifluralin (Treflan)	½ to 1	Preplanting incorporation	Must be well incorporated.
	2,4-DB	1/5	Postemergence	For cocklebur control.
Sugar beets	TCA	6	Preemergence	For grass weeds except wild oats.
	dalapon (Dowpon)	3	Weeds 1 to 3 inches	For grass weeds except wild oats.
	diallate (Avadex)	1½ to 2	Preplanting incorporation	For wild oats.
	barban (Carbyne)	⅝ to ¾	Wild oats in two-leaf stage	For wild oats.
	endothall	¾ to 1½	Early postemergence	For wild buckwheat and annual smartweeds.
	EPTC (Eptam)	2	Preplanting incorporation	For grass and some broad-leaved weeds.
Dry edible beans	EPTC Eptam)	3	Preplanting incorporation	Do not graze treated areas or use treated plants for feed or forage.
	trifluralin (Treflan)	1	Preplanting incorporation	Do not graze treated areas or use treated plants for feed or forage.
Sunflowers	EPTC (Eptam)	3	Preplanting incorporation	

* Plus TCBC at 7 pounds per acre.

FARM SPRAYER CALIBRATION AND ADJUSTMENT

UNIFORM APPLICATION of spray chemicals is essential to control weeds. 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.

A simple method for determining the amount of liquid a sprayer applies per acre is as follows:

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 30 to 40 pounds).

3. Drive exactly ⅛ 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, a calibrated stick can be used to measure amount of liquid used.)

For broadcast applications calculate the application rate as follows:

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

Example: if 2½ gallons were used in ⅛ 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.

$$\frac{2.5 \times 66}{24} = \frac{165}{24} = 6.9 \text{ gallons per acre.}$$

For band applications calculate the application rate as follows:

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

Example: If 1 gallon was used in ⅛ mile and sprayer applies 4 bands 1 foot in width, multiply 1×66 and divide by 1×4. The result is 16.5 gallons per acre. **This is the volume per acre applied to the area within the band that is actually sprayed.**

Here is the way 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.

Example: If the tank holds 55 gallons and the sprayer applies 6.9 gallons per acre, one tank will spray 8.0 acres (55 divided by 6.9 equals 8.0). If 1 pint of spray material is required per acre, 8.0 pints would be required for each tankful. That is, 1 pint per acre $\times$ 8.0 acres = 8.0 pints per tankful.

DESCRIPTION OF HERBICIDES

THIS LISTING OF HERBICIDES gives the common name, chemical name, and trade names other than the common name:

Amiben—3-amino-2,5-dichlorobenzoic acid, amine salt

Amitrole—3-amino-1,2,4-triazole, Amino-Triazole, Weedazol

Amitrole-T—amitrole plus ammonium thiocyanate, Amitrol-T, Cytrol

Atrazine—2-chloro-4-isopropylamino-6-ethylamino-s-triazine, Atra-bor

Barban—-2-chloro-2-butynyl-N-(3-chorophenyl) carbamate, Carbyne

BDM—borate and 2,4-D mixture, DB Granular

Benzabor—disodium tetraborate pentahydrate; disodium tetraborate decahydrate; 2,3,6-trichlorobenzoic acid

BMM—borate and monuron mixture, Ureabor

Borascu, concentrated—contains 61.5 percent B_2O_3;

—Borate and sodium chlorate mixtures, Polybor-chlorate, Atlacide

Bromacil—5-bromo-3-sec-butyl-6-methyluracil, Hy-var X, Hy-var XWS

Bromoxynil—3,5-dibromo-4-hydroxybenzonitrile, Buctril, Brominil

CDAA—2-chloro-N, N-diallylacetamide, Randox

CDAA-T—CDAA and trichlorobenzyl chloride mixture, Randox-T

CIPC—isopropyl-n-(3-chlorophenyl) carbamate

CP31393—N-isopropyl-a-chloroacetanilide, Ramrod

Cypromid—3'4'-dichlorophenylcyclopropanecarboxanalide, Clobber

Dalapon—2,2-dichloropropionic acid, Dowpon

DCPA—dimethyl-2,3,5,6-tetrachloroterephthalate, Dacthal

Diallate (DATC)—2,3-dichlorallyl diisopropylthiolcarbamate, Avadex

Dicamba—2-methoxy-3, 6-dichlorobenzoic acid, Banvel-D

Diuron—3-(3,4-dichlorophenyl)-1,1-dimethylurea, Karmex

DNBP amine salt—4,6-dinitro-o-sec-butylphenol, Premerge, Sinox PE

Endothall—disodium 3,6-endoxohexahydrophthalate, Endothal

Erbon—2-(2,4,5-trichlorophenoxy)-ethyl-2-2-dichloropropionate, Baron, Novon

EPTC—ethyl N,N-di-n-propylthiolcarbamate, Eptam

Fenac—2,3,6-trichlorophenylacetic acid, Fenatrol

Fenuron—3-(phenyl)-1,1-dimethylurea, Dybar

Linuron—N-(3,4-dichlorophenyl)-N-methoxy-N'-methylurea, Lorox

MCPA—2-methyl-4-chlorophenoxyacetic acid

Monuron—3-(chlorophenyl)-1,1-dimethylurea, Telvar

Norea—3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea, Herban

NPA—N-1-napthyl phthalamic acid; Alanap

PBA—polychlorobenzoic acid

PCP—sodium salt of pentachlorophenol

Pebulate—propyl butyethylthiolcarbamate, Tillam

Picloram—4-amino-3,5,6-trichloropicolinic acid, Tordon, Boralin

Prometone—2-methoxy-4,6-bis (isopropylamino)-s-triazine, Pramitol

Prometryne—2,4-bis (isopropylamino)-6-methylmercapto-s-triazine, Caparol

Propazine—2-chloro-4,6-bis(isopropylamino)-s-triazine

Pyrazon—1-phenyl-4-amino-5-chloropyridazone-6, PCA, Pyramin

Silvex—2-(2,4,5-trichlorophenoxy) propionic acid

Simazine—2-chloro-4,6-bis(ethylamino)-s-triazine

Sodium chlorate—highly flammable when mixed with organic materials

TBA—trichlorobenzoic acid, Benzac, Trysben

TCA—trichloracetic acid

Triallate (DATC-BW)—2,3,3-trichlorallyl diisopropylthiolcarbamate, Far-go

Trifluralin—2,6-dinitro-N,N-dipropyl-4-trifluoromethylanaline, Treflan

2,4-D—2,4-dichlorophenoxyacetic acid

2,4-DB—amine salt of 4-(2,4-dichlorophenoxy) butyric acid

2,4,5-T—2,4,5-trichlorophenoxyacetic acid

Urab—3-phenyl-1,1-dimethylurea trichloroacetate

Urox—3-(chlorophenyl)-1,1-dimethylurea trichloroacetate

Vernolate—s-propyl dipropylthiocarbamate, Vernam