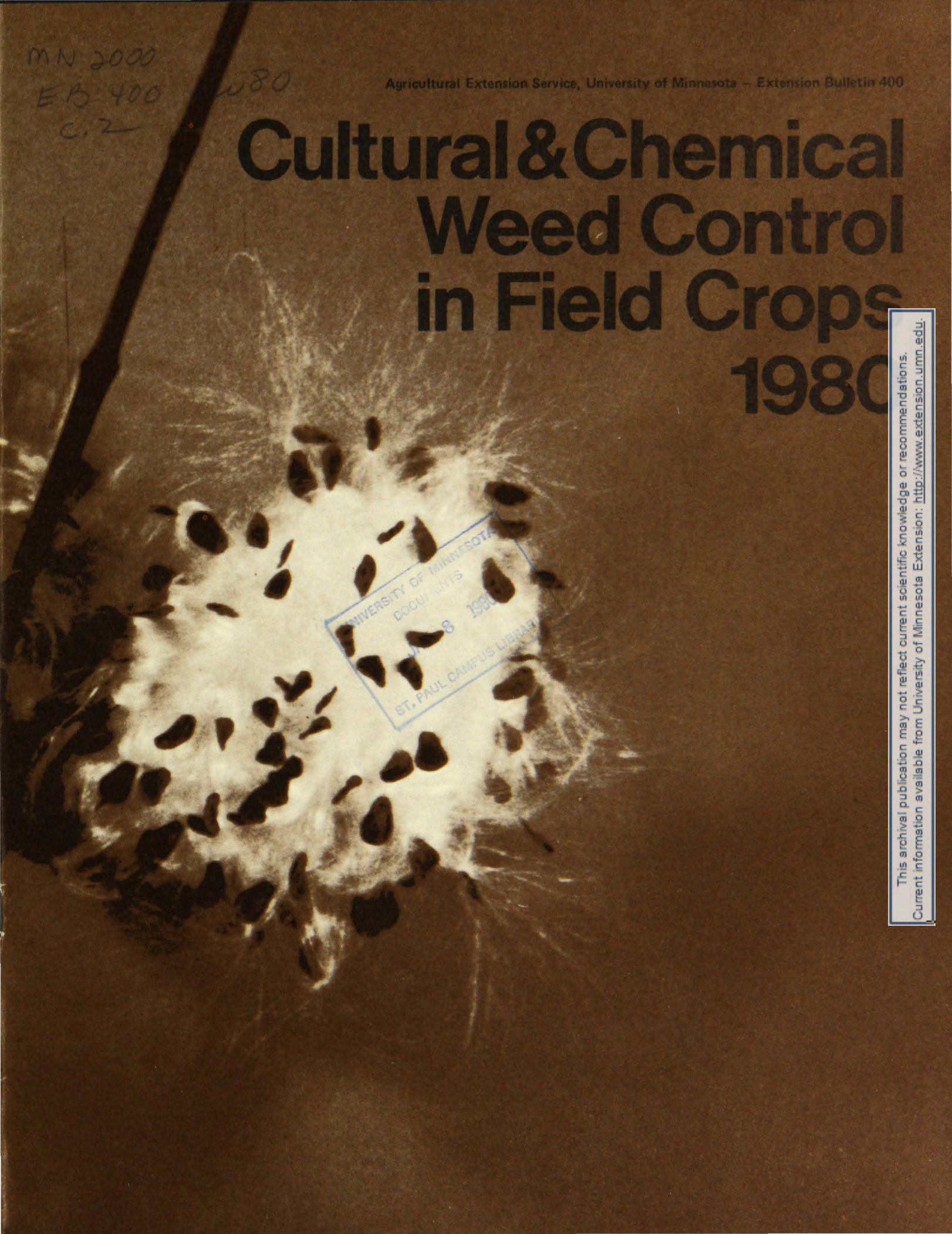


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Cultural & Chemical Weed Control in Field Crops 1980



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Cultural and Chemical Weed Control in Field Crops — 1980

Information in this publication is based on research by the Minnesota Agricultural Experiment Station, other experiment stations and U.S. Department of Agriculture on the effectiveness of cultural practices and chemicals for controlling weeds. The suggested chemical uses in this publication are within clearances established by the U.S. Environmental Protection Agency (EPA).

Herbicides are registered by the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act as amended for uses involving food or feed on the basis of finite chemical tolerances or exemptions from the requirement of tolerances established by the Food and Drug Administration. The Federal Food, Drug, and Cosmetic Act, as amended by Public Law 518 (Miller Amendment), makes liable for seizure any raw agricultural commodity 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.

Instructions for registered uses of herbicides are given on container labels. Read and follow these label instructions carefully. Use products that are labelled specifically for the intended use. Some formulations of a chemical may not be labelled for certain uses. Persons using herbicides in a manner contrary to the label instructions are subject to penalty under federal laws.

This publication is for your information. The University of Minnesota or its officers or employees make no claims or representations that the chemicals discussed will or will not result in residues on agricultural commodities and assume no responsibility for results from using herbicides.

Some registrations are under review; therefore, some uses suggested in this bulletin could change during the year. New information will be available from County Extension Agents as changes occur.

Follow label restrictions on crop use. Some uses of herbicides are classified as restricted by the EPA. Before using an herbicide for a restricted use, the applicator must be certified by the Minnesota Department of Agriculture.

Rates: Application rates listed in this publication are broadcast rates and refer to acid equivalent or active ingredient rather than commercial product. In practice, rates will need to be adjusted for varying row widths if applied in bands and for the concentration of the particular product used. See Fact Sheet AgChem No. 5 "How to—Calculate Herbicide Rates and Calibrate Herbicide Applicators."

Safety precautions — Always follow carefully the precautions and use restrictions on the label to help protect the operator, avoid crop injury, and prevent harmful residues in food and feed crops. Use herbicides only on crops specified on the label. Use only recommended amount; 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. Prevent drift onto nearby susceptible plants. Return larger quantities of unused herbicides to the manufacturer or

store them properly until used. Dispose of empty containers in a safe manner:

1. Rinse container thoroughly with water and use the rinse water in the sprayer.
2. Bury small and decomposable containers in approved and supervised sanitary landfills.
3. Send empty metal pesticide containers of 15 gallon capacity or more back to the manufacturer or to professional drum reconditioners.
4. Observe special label instructions relating to disposal.

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Follow label instructions carefully when using agricultural chemicals

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.

Preemergence 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, that is, on a broadcast basis.

Soil incorporation — Mechanical mixing of the herbicide with the soil. Chemicals may be incorporated 2 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.

Weed Control Programs

Effective weed control usually results from a combination of cultural, mechanical, and chemical practices. The ideal combination for each field will depend on a number of considerations including: 1) the crop being grown, 2) the kinds of weeds, 3) the seriousness of the weed infestation, 4) the soil type, 5) the cropping system, and 6) the availability of time and labor.

Cultural practices that are optimum for crop growth should be followed. These practices include good seedbed preparation, adequate fertility, optimum stands and row width, and proper seeding date. Tillage operations should be timed to destroy weeds. Tilling the soil immediately before planting will kill weeds that have germinated, thus giving the crop a competitive advantage and often improving weed control from chemicals that do not control weeds that have germinated.

Early cultivations when weeds are small are most effective. Use a rotary hoe, harrow, or cultivator as soon as weeds begin emerging and are in the "white stage," even if herbicides have been applied. Set cultivators for shallow operation to avoid crop root pruning and to reduce the number of weed seeds brought to the surface. Throw enough soil into the row to cover small weeds, but avoid excessive ridging that may encourage erosion or interfere with harvesting. Shallow cultivation should be repeated as necessary to control newly germinated weeds.

Mowing is an effective weed control practice in perennial forage crops and noncropland areas. To be effective, mowing must be done before seeds are formed which means you must mow by the time weeds are in the bud stage or just beginning to bloom. Earlier mowing will reduce weed competition and improve crop yield more than later cutting.

Selecting Chemicals

Selection of an appropriate chemical or combination of chemicals should be based on consideration of the following factors:

- Label approval for use
- Use of the crop
- Crop and variety tolerance
- Potential for soil residues that may affect following crops
- Kinds of weeds
- Soil texture
- pH of soil
- Amount of organic matter in the soil
- Formulation of the chemical
- Application equipment available
- Potential for drift problems

The information in this publication and on product labels will help you select and use chemicals properly according to the above factors. Proper application of chemicals is essential for obtaining satisfactory results. Follow carefully the suggested rates on labels for specific soil and weed situations. Apply herbicides at the times specified. Delayed applications usually result in poorer weed control and may injure the crop.

Weather conditions will affect herbicide performance. Weed control from soil-applied herbicides may be poor if there is insufficient rain soon after treatment, which will make timely cultivation necessary to control emerging weeds. If rainfall is very heavy, some herbicides may move downward in the soil, resulting in poor weed control and/or crop injury. Temperature and moisture conditions affect the weed control and crop injury resulting from herbicides applied postemergence. Observe label precautions regarding weather conditions and crop size when applying herbicides on growing crops.

Granular Versus Spray Forms of Herbicides

Several herbicides are available in formulations to be applied as dry granules or as sprays. With a few exceptions, approximately the same weed control can be expected from either form. 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 poor distribution has resulted in variable weed control. A wide, flat press wheel or similar attachment on the planter that leaves a level fine surface is desirable for uniform granule application. Dry granular formulations of triazine herbicides require more rain and may result in more soil residues than the spray formulations. Chemicals that cause irritation are less irritating in the granular form than in the spray form.

Herbicide Mixtures

Herbicide mixtures are used to overcome 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, or (5) reduce crop injury.

Only those mixtures that have been field tested under local conditions should be used. Use of some mixtures may result in poor weed control or crop injury. Growers or applicators may be responsible for chemical residues in crops, crop injury or lack of weed control resulting from use of unlabeled mixtures.

Weed Control in Field Crops

Corn

Cultural practices — Cultural practices for weed control in corn include seedbed preparation, establishment of an optimum stand, adequate fertility, 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 rough space between rows 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 also should be used while the weeds are very small. Set the implements for shallow cultivation to prevent root pruning and to bring fewer weed seeds to the surface. A rotary hoe, harrow, or cultivator should be used as soon as weeds appear even if preemergence applications have been used.

Herbicides

Numerous tests have been conducted in Minnesota to determine the overall effectiveness of herbicides. Table 1 shows the performance of herbicides on uncultivated corn plots in several years of county demonstrations. Figures in Table 1 are the percentages 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 2 indicates corn tolerance to herbicides suggested for use in corn and relative effectiveness and reliability of these herbicides in controlling common 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.

Preplanting applications. Some herbicides may be applied to the soil before planting and incorporated 2 to 3 inches into the soil by disking or field cultivating. The disk or field cultivator should be set to operate twice as deeply as the desired depth of incorporation. Use sweep shovels on the field cultivator to get more uniform mixing of the chemical and soil. The field should be disked or cultivated twice, once in each direction, after applying the chemical. To avoid excessive loss of volatile chemicals like EPTC or butylate, the first tillage operation should follow immediately behind the sprayer.

Butylate (Sutan +) or EPTC (Eradicane) applied preplanting and incorporated at 3 to 6 pounds per acre has given good control of annual grasses and fair control of a few annual broadleaves, but these chemicals do not control several annual broadleaves or most perennial weeds. Both chemicals are effective against nutsedge. EPTC may be used to control quackgrass, but results in experiments have been somewhat inconsistent. (See page 17.) Butylate and EPTC are formulated with an antidote chemical to prevent corn injury. Butylate alone or with atrazine may be applied and incorporated in the late fall before the ground freezes. The high rate of 6 pounds per acre is suggested for fall applications.

Preplanting and disked-in applications of atrazine have resulted in weed control equal to or, under dry conditions, slightly better than preemergence applications without incorporation. Broadcast applications, necessary when preplanting treatments are used, may increase the potential of atrazine carryover compared to banded preemergence applications.

Mixtures of butylate or EPTC (Eradicane) and atrazine or cyanazine (Bladex) applied preplanting and incorporated have controlled both annual grasses and broadleaves. These mixtures improve broadleaf control compared to butylate or EPTC alone. Cyanazine does not carry over to the following year and the low

rate of atrazine used in the mixture reduces carryover problems from atrazine compared to those caused by the higher rates used when atrazine is applied alone. Cyanazine with butylate is not recommended for use on coarse to medium textured soils with less than 2 percent organic matter because of potential corn injury.

Preplanting, incorporated applications of alachlor (Lasso) at 3 to 4 pounds per acre or metolachlor (Dual) at 2 to 3 pounds per acre have effectively controlled nutsedge. Under dry conditions, control of annual weeds has usually been improved over pre-emergence applications by shallow preplanting incorporation of alachlor or metolachlor. Atrazine or cyanazine may be tank mixed with alachlor or metolachlor to improve broadleaf control.

Preemergence applications of atrazine at 1 to 3 pounds per acre have given good control of annual weeds with no injury to corn. A 3-pound per acre rate of atrazine should be used on fine textured soils or those high in organic matter. One to 2 pounds per acre of atrazine is adequate on sandy soils that are low in organic matter.

Atrazine sometimes affects small grains, flax, sugarbeets, sunflowers, soybeans, other legumes, vegetables, and other sensitive crops planted the following spring. The label requires that small grains, flax, sugarbeets, vegetables, and small-seeded legumes or grasses 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 or if application is made after June 10. However, in some years, soybean injury has occurred following use within these restrictions, especially on highly alkaline soils of western 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. Toxic residues are more likely to persist if soil moisture or temperatures are low.

Cyanazine (Bladex) chemically similar to atrazine, has given good control of annual grasses and most broadleaves when applied preemergence. There has been no soil residue the following season except from granules following dry years. Weed control is not as good under dry conditions as under moderate to heavy rainfall. Within the suggested rates of 1.2 to 4 pounds per acre, the higher rates are required on soils higher in organic matter and finer textured. Corn injury may occur on sandy soils. Granular formulations of cyanazine have been less effective than sprays under limited rain conditions.

Propachlor (Ramrod, Bexton) has given good annual grass control when applied preemergence at 4 to 6 pounds per acre. Propachlor does not consistently control most broad-leaved or perennial weeds, but it may be used in mixtures with atrazine or linuron for annual grass and broadleaf control. Corn is very tolerant to propachlor.

Alachlor (Lasso), chemically related to propachlor, controls annual grasses in corn. In addition, alachlor has given fair to good control of redroot pigweed and common lambsquarters, but control of other broadleaves has been erratic. Corn has good tolerance to alachlor. Suggested rates are 2 to 3½ pounds per acre in the liquid formulation and 2.4 to 3.9 pounds per acre in the granular formulation (Lasso II).

Metolachlor (Dual), chemically related to alachlor and propachlor, controls annual grasses and redroot pigweed. Corn has good tolerance to the chemical. Preemergence applications have controlled nutsedge on coarser soils that are low in organic matter, but on finer textured, dark soils, preplanting applications have controlled nutsedge better than preemergence treatments. Metolachlor is labelled for preemergence application at 1.5 to 3 pounds per acre. The corn grain may be fed, but corn treated with

Table 1. 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
Alachlor (Lasso)	2½, 3	1969-79	226	219	85	11	4	51	20	29
Atrazine	3	1959-79	780	749	76	16	8	88	8	4
Cyanazine (Bladex)	3	1969-79	227	220	81	13	6	77	13	10
Cyanazine (early postemergence)	2	1973-79	118	113	75	11	15	90	4	6
Metolachlor (Dual)	3	1977-79	51	49	78	4	18	43	30	27
Pendimethalin (Prowl)	2	1976-79	70	67	61	32	7	55	26	19
Propachlor (Ramrod, Bexton)	5	1965-73, 1975-79	425	413	81	12	7	44	25	31
Alachlor, pre + bentazon (Basagran), post	3 + 1	1978-79	27	26	81	11	8	93	7	0
Alachlor, pre + 2,4-D amine, post	3 + ¾	1978-79	25	23	68	4	28	83	4	13
Atrazine + alachlor	1½ + 2	1970-79	195	188	89	9	2	91	6	3
Atrazine + Metolachlor	1½ + 2	1977-79	52	50	81	9	10	64	12	24
Atrazine + pendimethalin	1½ + 1½	1976-79	70	68	75	17	8	84	11	5
Atrazine + propachlor	1½ + 3	1967-78	296	301	83	14	3	86	8	6
Atrazine + oil (1½ gal/A) (early postemergence)	2	1966-79	382	373	85	9	6	95	4	1
Atrazine + oil concentrate (½ gal/A) (early postemergence)	2	1975-76	35	35	66	20	14	100	0	0
Atrazine + surfactant (1 pt/A) (early postemergence)	2	1968-69, 1971-77	178	175	60	30	10	95	4	1
Cyanazine + alachlor	2 + 2	1974-79	113	110	86	10	4	83	9	8
Cyanazine + pendimethalin	2 + 1½	1976-79	70	67	77	16	7	79	12	9
Dicamba (Banvel) + alachlor	½ + 2	1972-79	146	140	87	8	5	88	6	6
Linuron + alachlor	1½ + 2	1970-75	120	114	94	5	1	88	6	6
Linuron + propachlor	1½ + 3	1968-73	152	148	88	9	3	78	14	8
Alachlor + atrazine, ppi	2 + 1½	1978-79	21	19	76	19	5	95	5	0
Metolachlor + atrazine, ppi	2 + 1½	1978-79	21	19	72	24	4	84	16	0
Alachlor + cyanazine, ppi	2 + 2	1978-79	20	18	75	15	10	89	11	0

*Applied preemergence unless specified early postemergence (post) preplanting incorporated (ppi).

metolachlor cannot be grazed or used for silage. Corn, soybeans, root crops or small grains may be grown the year after use of metolachlor, other crops should not be planted for 18 months after application of metolachlor.

Pendimethalin (Prowl) may be used alone at 1 to 2 or in mixtures at 1 to 1½ pounds per acre for preemergence control of most annual grassy weeds and some broadleaves such as common lambsquarters, pigweed, smartweed, and velvetleaf in corn. In Minnesota trials, this compound has been somewhat less effective on grasses but more effective on broadleaves than alachlor. Tank mixes with atrazine, cyanazine, or dicamba provide a broader spectrum of weed control. Do not use pendimethalin on soils that contain less than 1½ percent organic matter, nor on sands, loamy sands, peat, muck, or clay soils. Corn injury may occur on sandy soils. With dicamba, do not use on soils with less than 2½ percent organic matter.

Preemergence herbicide mixtures. Mixtures of atrazine with alachlor, linuron, metolachlor, pendimethalin, or propachlor are registered for preemergence application on corn to control annual grasses and broadleaves. Soil residues of atrazine are reduced by using these mixtures since application rates are lower than if atrazine is used alone. These mixtures are less effective than atrazine alone on quackgrass. Do not apply the mixture with linuron after corn is up or severe corn injury may occur. These mixtures should not be incorporated into the soil.

A 1:1 ratio of active ingredients of an atrazine-linuron mixture has given weed control comparable to an equivalent rate of atrazine alone on soils low in organic matter. Using linuron in combination with atrazine reduces the likelihood of corn injury and usually improves weed control compared with linuron alone. Rates vary from ½ to 1½ pounds per acre of each chemical according to soil type. Corn tolerance to this mixture is not as great as to atrazine alone. Corn injury may occur on coarse textured soils that have low organic matter content.

The mixtures of atrazine or cyanazine with alachlor, meto-

lachlor or propachlor control broad-leaved weeds better than alachlor, metolachlor or propachlor alone and give more consistent control on high organic matter soils or with limited rain than atrazine or cyanazine alone. Corn has good tolerance to these mixtures.

Using mixtures of linuron and propachlor or alachlor reduces the potential for corn injury compared to linuron alone since lower rates of linuron are used. These mixtures control broadleaves better than propachlor or alachlor alone. Suggested rates are 1 to 1½ pounds per acre of linuron with 3 pounds per acre of propachlor or 1 to 3 pounds per acre of alachlor. Do not use these mixtures on sandy soils because of possible crop injury from linuron.

A preemergence mixture of alachlor or metolachlor with dicamba (Banvel) improves broadleaf control compared to alachlor or metolachlor alone and improves grass control and reduces corn injury compared to dicamba alone. Dicamba should be applied preemergence only on fine-textured soils with over 2.5% organic matter. Do not incorporate this mixture prior to corn emergence. Harrowing or dragging before corn emerges may increase corn injury.

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 while the weeds are less than 1½ inches tall. Application may be made until corn is 30 inches tall. Drop nozzles should be used to keep the spray out of the tops of the corn and to give better spray coverage on the weeds.

The addition of 1 gallon per acre of special oils with an emulsifier or ¼ to ½ gallon per acre of special adjuvant-oil emulsions to the spray increases the effectiveness of early postemergence applications of atrazine. Labeled emulsions of either vegetable or petroleum oils are satisfactory. Various formulations of surfactants and detergents used with atrazine have not improved weed

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

	Preplanting						Preemergence							Postemergence					
	Alachlor (Lasso)	Metolachlor (Dual)	Butylate (Sutan +)	EPTC (Eradicane)	Cyanazine (Bladex)	Atrazine	Alachlor (Lasso)	Atrazine	Dicamba (Banvel)	Pendimethalin (Prowl)	Propachlor (Ramrod, Bexton)	Metolachlor (Dual)	Linuron (Lorox)	Cyanazine (Bladex)	2,4-D	Dicamba (Banvel)	Atrazine and oil	Cyanazine (Bladex)	Bentazon (Basagran)
Corn tolerance	G	G	G	G	F	G	G	G	F	F	G	G	F	F	F	G	G	F	G
Grasses																			
Giant and robust foxtail	G	G	G	G	F	F	G	F	P	F	G	G	F	F	N	N	F	F	N
Green foxtail	G	G	G	G	G	G	G	G	P	F	G	G	F	G	N	N	G	G	N
Yellow foxtail	G	G	G	G	G	G	G	G	P	F	G	G	F	G	N	N	G	G	N
Barnyardgrass	G	G	G	G	F	F	G	F	P	F	G	G	F	F	N	N	F	F	N
Crabgrass	G	G	G	G	F	P	G	P	P	F	G	G	F	F	N	N	P	F	N
Panicum	G	G	G	G	F	P	G	P	P	F	G	G	F	F	N	N	P	F	N
Woolly cupgrass	G	G	F	G	P	P	G	P	P	F	G	P	P	N	N	F	F	N	
Wild proso millet	F	F	F	G	P	P	F	P	P	F	F	P	P	N	N	P	P	N	
Nutsedge	G	G	G	G	P	P	F	P	N	F	F	P	P	N	N	F	P	G	
Quackgrass	N	N	N	F	P	G	N	G	N	N	N	N	N	P	N	N	G	P	N
Wild Oat	P	P	F	F	F	G	P	G	N	P	P	G	F	N	N	G	F	N	
Broadleaves																			
Buffalobur	P	P	F	G	P	P	P	P	P	P	P	P	P	P	P	P	G	F	P
Cocklebur	N	N	P	P	F	F	N	F	P	P	N	P	F	G	G	G	G	F	G
Kochia	P	P	P	F	G	G	P	G	F	P	P	P	F	G	F	G	G	G	-
Lambsquarters	F	P	P	F	G	G	F	G	F	P	P	G	G	G	G	G	G	G	P
Mustard	P	P	P	P	G	G	P	G	G	P	P	P	G	G	G	F	G	G	G
Pigweed	G	G	F	F	F	G	G	G	F	F	G	G	F	G	G	G	G	F	P
Ragweed	P	P	P	F	G	G	P	G	G	P	P	P	G	G	G	G	G	G	G
Smartweed	P	P	P	P	G	G	P	G	G	P	P	P	F	F	P	G	G	G	G
Velvetleaf	P	P	F	F	F	F	P	F	F	P	P	P	F	F	G	G	F	F	G
Wild sunflower	P	P	P	P	F	F	P	F	P	P	P	P	F	F	F	G	G	F	G
Canada thistle	N	N	N	N	P	P	N	P	N	N	N	N	P	P	F	G	F	P	F
Jerusalem artichoke	N	N	N	N	P	P	N	P	P	N	N	P	P	P	G	G	P	P	P

G — Good
 F — Fair
 P — Poor
 N — None
 — Insufficient information

control as much as the use of oils. Suggested atrazine rates for postemergence application with oil are 1.2 pounds per acre for broadleaves and 2 pounds per acre for annual grasses.

When atrazine is used, early postemergence treatments are preferred to preemergence if the soil is high in clay or organic matter and in western Minnesota where rainfall is less certain. These are the areas where preemergence applications of atrazine have given less satisfactory weed control. Severe corn injury has resulted from the addition of 2,4-D to this mixture. Corn injury has occurred also when atrazine and oil were applied to corn growing under cold, wet conditions, or if frost occurred shortly before or after application.

Cyanazine (Bladex 80W) is effective on annual grasses and broadleaves as an early postemergence herbicide. It is cleared for use through the 4-leaf stage of corn and before weeds are over 1½ inches tall. Pigweed and lambsquarters have shown some tolerance. Oils or surfactants added to the spray increase the potential for corn injury, but under dry conditions vegetable oils or certain surfactants may be used to improve weed control. Use only the wettable powder formulation for postemergence application. Do not use on sands with less than 1% organic matter.

Bentazon (Basagran) may be applied postemergence in corn to control certain annual broad-leaved weeds, Canada thistle, and nutsedge. Corn has good tolerance to bentazon, but applications should not be made when corn is stressed from adverse growing conditions. Applications should be made when annual weeds are less than 2 inches tall, but some species may be

controlled up to 10 inches tall. See page 17 for information on controlling Canada thistle and yellow nutsedge. Rain within 24 hours after application will reduce the effectiveness of bentazon. Do not mix bentazon with fertilizers. A non-phytotoxic oil concentrate or crop oil may be mixed with bentazon or with a combination of bentazon and atrazine for applications in corn.

Alachlor (Lasso) may be applied postemergence in a mixture with dicamba (Banvel) to corn less than 3 inches tall. Alachlor or metolachlor (Dual) may be applied with atrazine on corn that is no more than 5 inches tall to control weeds in the two-leaf stage or smaller. Weed control may be less consistent than that from preemergence applications. Propachlor (Bexton, Ramrod) alone or mixed with atrazine may be applied after corn has emerged to control grasses up to the 2-leaf stage. Pendimethalin (Prowl) in mixtures with atrazine or cyanazine wettable powder may be applied after corn emergence but no later than when corn is in the 2-leaf stage and when weeds are no more than 1 inch tall.

Postemergence — Annual broad-leaved weeds can be controlled with broadcast postemergence applications of ¼ to ½ pound per acre of 2,4-D amine when the corn is 4 to 8 inches tall. Onion leafing may occur from 2,4-D applications made in the 2- to 3-leaf stage of the corn. 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, but corn has usually been injured by this rate. If 2,4-D esters are used, about ⅓ less acid equivalent rate is needed than in the amine form.

Spray drift from either amines or esters of 2,4-D will injure susceptible plants. Since the ester forms are volatile, vapor injury to nearby susceptible crops is a possibility. Low volatile esters should be used rather than high volatile esters. The use of amines eliminates the danger of vapor injury because amines are not very volatile.

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. 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. Do not use spray additives with 2,4-D as corn injury may be increased.

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 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 or poor kernel set may occur. 2,4-D can be applied at ½ to 1 pound per acre after the dough stage if necessary, but it is more beneficial to control weeds earlier.

Dicamba (Banvel) 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. Dicamba also controls other broad-leaved weeds except mustard, but does not control grasses. But when used, dicamba drift has often affected soybeans in the vicinity of treated cornfields.

Dicamba can be used in corn at ⅓ to ¼ pound per acre either alone or in mixtures with 2,4-D amine at ¼ to ½ pound per acre. Applications can be made until corn is 2 feet tall or until 15 days before tassel emergence, whichever occurs first. Do not use on corn grown for seed. Later applications, especially when corn is tasseling, may result in poor kernel set. Use drops after corn is 8 inches tall. Do not use additives with dicamba.

A mixture of dicamba and atrazine is cleared for use on corn as an early postemergence treatment. The mixture has given good broadleaf control, but grass control has been erratic. Oils and other additives should not be used with the mixture.

Caution: Soybeans and other broad-leaved plants are very sensitive to dicamba. In recent years, there were many instances in which dicamba drift affected soybeans. Users of dicamba must 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. Applications are not recommended at temperatures above 85° F. Effects on soybeans can be reduced by spraying corn early before soybeans have emerged or when they are small, less than 10 inches tall. Do not graze or harvest for dairy feed prior to the milk stage of the grain if corn is treated with dicamba.

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, herbicides, or cultivation) to prevent yield losses from early weed competition. Directed sprays are considered emergency measures to control heavy weed stands that have become established within corn rows.

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 and direct the spray to the base of corn plants and onto weeds in the row.

Directed sprays of linuron at 1½ pounds per acre can be applied when the corn is not less than 15 inches tall. Ametryne (Evik) is cleared for use as a directed spray at 1.6 to 2 pounds per acre after corn is 12 inches tall. Do not apply ametryne later than 3 weeks prior to tasseling. Ametryne should not be used on sandy soils. The addition of a wetting agent is necessary for effective weed control with linuron or ametryne. Care must be taken in application to minimize spray on the corn leaves while covering most of the weed foliage with the spray. Either chemical will kill corn leaf tissue it contacts and, if leaf kill is extensive, corn yields may be reduced.

Dry Edible Beans

Cultural practices — Before emergence, bean fields can be spike-tooth harrowed to kill emerging weeds. After beans emerge, implements such as the weeder, rotary hoe or coil spring harrow are preferred over the spiketooth harrow to kill weeds. Only small emerging weeds in the "white" stage can be uprooted and killed without injury to the beans. It may be necessary to harrow the field several times before the first cultivation if weeds continue to emerge. Beans are generally cultivated twice before the vines cover the middles. Hand hoeing for control of weeds that escape tillage is desirable when economically feasible.

Herbicides — Preplanting applications — EPTC (Eptam) at 3 pounds per acre will control most annual grass weeds and some annual broadleaves when applied preplanting and incorporated into the soil. Incorporation to a depth of 2 to 3 inches to avoid loss of the herbicide should be accomplished immediately after application. EPTC may be applied at 4 pounds per acre on sandy soils to 4½ pounds per acre on other soils in the fall before planting beans the next spring, but performance has been less consistent than with spring application. Under abnormal weather conditions, stunting may occur on several bean varieties including Sanilac, Seafarer, Seaway, Michelite and Gratiot. Do not use EPTC on Adzuki beans.

Trifluralin (Treflan) can be applied preplanting in the fall or spring at ½ pound per acre on sandy soils and up to 1 pound per acre on silt and clay soils to control most annual grass and some annual broad-leaved weeds. For best results incorporation should take place immediately or at least within 8 hours of application. A mixture of EPTC at 1½ to 3 pounds per acre and trifluralin at ½ to 1 pound per acre may be used. **Caution:** Do not graze or feed to livestock bean foliage that has been treated with a mixture of EPTC and trifluralin.

Dinitramine (Cobex) may be used preplanting and incorporated to control most annual grasses and some annual broad-leaved weeds. Use ⅓ pound per acre on sandy soils, ½ pound per acre on loam and silt loam soils, and ⅔ pound per acre on clay soils. Soil incorporation of dinitramine may be delayed up to 24 hours with satisfactory results. A mixture of dinitramine and EPTC may be used on coarse and medium textured soils, but not on fine-textured soils.

Profluralin (Tolban) may be applied preplanting with soil incorporation within 4 hours to control most annual grasses and some annual broad-leaved weeds. Use ½ pound per acre on sandy soils and up to 1 pound per acre on loam and clay soils. Do not use on peat or muck soils. A mixture of profluralin at ½ to 1 pound per acre and EPTC at 2 to 4 pounds per acre may be applied preplanting and incorporated.

Alachlor (Lasso) may be applied either alone or in a tank mixture with trifluralin (Treflan) as a preplanting, incorporated treatment to control annual grasses, yellow nutsedge, pigweed, and black nightshade. Apply within 7 days of planting at 2½ to 3 pounds of alachlor per acre alone or with ½ pound of trifluralin per acre. Incorporate uniformly into the top 2 inches of soil within 8

hours of application. Alachlor is very injurious to Adzuki beans.

Preemergence applications — Chloramben (Amiben) will control many annual grass and broad-leaved weeds when applied preemergence at 2 to 3 pounds per acre. The higher rate should be used on clay loam or clay soils or soils with 3 to 8 percent organic matter. Weed control has been good where sufficient rainfall occurred before weeds emerged. A preplanting application of EPTC, trifluralin, dinitramine, or profluralin followed by a preemergence application of chloramben has given good control of both grasses and broadleaves.

Dinoseb amine (Premerge, Dinitro Weed Killer) may be applied preemergence at a rate of 9 pounds per acre, except on sandy soils, or can be used at 3 to 4½ pounds per acre when beans are emerging (not later than crook stage). Weed control has often been erratic and some injury to beans has occurred. Adverse weather or rapid growth of the beans often makes treatment at the time of emergence impractical.

For smartweed, chlorpropham (Furloe Chloro IPC) may be applied preemergence at 3 pounds per acre alone or in combination with certain herbicides. See product label for specific use instructions.

Postemergence applications — Bentazon (Basagran) controls many annual broadleaves when applied at ¾ to 1 pound per acre. Apply after the first trifoliolate leaf is fully expanded and when broad-leaved weeds have 2 to 6 leaves. Split applications of bentazon may be used to control Canada Thistle and yellow nutsedge. Do not mix bentazon with other herbicides. Do not apply when beans are under stress conditions. Rain or irrigation within 8 to 24 hours of application may reduce or prevent effective weed control.

Flax

Cultural practices — Flax does not compete well with weeds so growers should control weeds in the preceding crop by cultivation or by after harvest tillage or mowing. Late summer or early fall tillage, except where wind or water erosion is a problem, will help control perennial weeds, prevent weed seed production and stimulate fall germination of annual weed seeds. Shallow early spring tillage to stimulate germination of annual weeds such as wild oat, followed by tillage operations and delayed seeding of flax has been successful in some areas. However, the delay in seeding flax usually results in decreased yields. An early maturing flax variety, such as Culbert or Linnott, should be used if this practice is followed.

Herbicides — EPTC (Eptam) applied preplanting and incorporated at 2 to 3 pounds per acre controls most annual grasses and some annual broad-leaved weeds in flax. Stand reduction or injury to flax may occur if unfavorable temperature, soil moisture or other adverse conditions are present during early flax growth. EPTC may be fall applied and incorporated at 4 to 4½ pounds per acre prior to planting flax the next spring. Use the lower rates on coarse-textured soils and the higher rates on medium and fine textured soils.

MCPA amine or ester at ¼ pound per acre will control many broad-leaved weeds in flax. Weeds susceptible to MCPA such as wild mustard, common lambsquarters, common ragweed, marshelder, and field pennycress are usually controlled at this rate of application. More resistant weeds such as redroot pigweed, Canada thistle and perennial sowthistle are usually not controlled, but growth is checked and seed production reduced. For best weed control, MCPA should be applied when flax is 2 to 6 inches tall. Spray as soon as possible after most of the weeds have emerged. Some injury to flax may occur, but reducing the weed competition will usually more than offset any injury from the chemical. Flax injury is less likely with MCPA amine than with MCPA ester. Do not spray flax with MCPA during the period between bud stage and when 90 percent of the bolls have formed. Germination of the flax seed may be reduced by spraying between full bloom and the stage when seeds are colored.

Bromoxynil can be used on flax for annual broadleaved weed control at ¼ to ½ pound per acre. It is especially useful for

controlling annual smartweeds and wild buckwheat, which are not controlled by MCPA. For best results, apply when weeds are small. To reduce flax injury, use the lower rate and spray when flax is 2 to 8 inches tall. Do not treat during or after bud stage. Also do not treat during excessively humid weather, when the temperature is over 85° F., or when plants are stressed from lack of moisture.

Dalapon at ¾ pound per acre will kill green, yellow, and giant foxtail in young flax. Best results have occurred when the flax was 2 to 6 inches tall and the weeds were less than 2 inches. Dalapon can be applied in a tank mixture with MCPA to kill susceptible grass and broadleaved weeds with one application, but spraying must be done before flax is 6 inches tall. Dalapon may cause some injury to flax and should not be used unless a serious annual grass population is present. Also, dalapon applied to flax during drought conditions may cause excessive injury. Use 10 to 20 gallons per acre of spray when applying dalapon.

Barban (Carbyne) at ¼ to ⅝ pound per acre may be used for wild oat control in flax. Application should be made when wild oats are in the 2-leaf stage from 4 to 10 days after emergence. Do not spray after flax is in the 12-leaf stage or excessive flax injury will likely result. **Caution:** Do not feed barban-treated flax straw to livestock. Barban may not be used where flax is underseeded with legumes or grasses.

Diallate (Avadex) may be used preplant or preemergence incorporated at 1½ to 2 pounds per acre to control wild oat in flax with no injury to the crop. Diallate at these rates may persist in the soil enough to affect tame oats the next year. Diallate may be used where alfalfa or clover is underseeded in flax.

When flax is used as a companion crop to establish alfalfa or other forage legumes or grasses, MCPA may be used for control of susceptible broad-leaved weeds at ⅙ to ¼ pound per acre. Legume seedlings should be at least 2 inches tall and be protected by a canopy of flax or weeds. Sweetclover seedlings are likely to be killed and other legumes injured by MCPA. Dalapon may not be used in flax that is underseeded with legumes or grasses.

Asulam (Asulox) was granted an emergency use label for 1979 in five Minnesota counties to control wild oat and to suppress foxtail and wild buckwheat in flax. Rates were 1 to 1¼ pounds per acre when flax was 2 to 6 inches tall and when wild oat was in the 3- to 4-leaf stage. Some injury or temporary stunting of flax occurred. Restrictions specified that after treatment with asulam root crops may not be planted for 18 months, small grains may not be planted for 10 months and other crops may not be planted for 12 months. **CAUTION:** As of December 1979, asulam is not cleared and should not be used on flax.

Forages — Alfalfa, Clover, and Grasses

LEGUME ESTABLISHMENT

Cultural practices — Seedling legumes generally are poor competitors with weeds. Management practices such as use of intertilled crops and after harvest tillage to control weeds and prevent weed seed production are desirable. Clipping of weeds in seedling legumes (except sweetclover) when sown alone, mowing the weeds and stubble of companion crops after harvest, and mowing of perennial weed patches aid in weed control. To allow adequate legume regrowth before frost, do not mow after September 1.

Herbicides — Preplanting incorporated treatments of 2 to 4 pounds of EPTC (Eptam) per acre have given effective control of some annual broad-leaved and most annual grass weeds in alfalfa, red clover, alsike clover, sweetclover, and birdsfoot trefoil when these legumes are sown without a grass or a combination crop. Do not use EPTC if grass or a grain companion crop is to be planted with the legume. The herbicide should be incorporated into the soil to a depth of 2 to 3 inches immediately after application.

Benefin (Balan) has given effective control of annual grasses, common lambsquarters and pigweed when applied preplanting

and incorporated into the soil just before seeding legumes. Incorporate benefin 2 to 3 inches into the soil as soon as possible within 8 hours after application. Benefin may be used at rates of 1½ to 1¼ pounds per acre on alfalfa, birdsfoot trefoil, red, alsike, and ladino clovers. Use the lower rate on coarse and medium textured soils and the higher rate on fine textured soils.

Profluralin (Tolban) has effectively controlled annual grasses, pigweed, and common lambsquarters when applied preplanting and incorporated at ½ to 1 pound per acre just before seeding alfalfa. For best results apply profluralin to a loose, dry soil and incorporate as soon as possible within 4 hours after application. Profluralin is cleared for use in Minnesota on a special local need basis.

Postemergence treatments of 2,4-DB amine at ½ to 1½ pounds per acre or 2,4-DB ester at ½ to 1 pound per acre can be used to control broad-leaved weeds in seedling alfalfa, birdsfoot trefoil, red, alsike, and ladino clovers when sown alone. Spray when weeds are less than 3 inches tall and when legumes have 1 to 4 trifoliolate leaves. Wild mustard is not effectively controlled by 2,4-DB. **Caution:** Do not graze or feed hay from treated fields within 60 days after application.

Seedling stands of alfalfa, birdsfoot trefoil, red, alsike, or ladino clovers established with a small grain companion crop may be sprayed with some formulations of MCPA and 2,4-D amine at rates up to ¼ pound per acre after the companion crop or weeds are large enough to form a protective canopy over the legumes if this use is listed on the label. Seedling legumes established with a flax companion crop may be sprayed with MCPA amine. **Caution:** Because seedling legumes can be seriously injured from these herbicides, do not spray unless it is necessary to control broad-leaved weeds and do not spray unless a canopy of companion crop or weeds is present. Reduced sprayer pressure and lower volume of spray may help to minimize injury. Do not use 2,4-D or MCPA ester on seedling legumes and do not spray sweetclover with either MCPA or 2,4-D.

ESTABLISHED LEGUMES

Cultural practices — Properly established stands of small-seeded legumes can effectively compete with many annual and perennial weeds. Weeds may become a problem if inadequate soil fertility, low soil pH, poor soil drainage, or poor management of the stand occurs.

Maintaining proper soil fertility and pH levels will increase forage yields and increase legume growth and vigor for better competition with weeds.

Many biennial and perennial weeds common in established legumes may be controlled effectively by harvesting the crop at the best time to prevent weed seed formation and dispersal. If weed seeds do mature before the legume is ready for harvest, the forage should be ensiled, if possible. Fermentation in the silo kills many weed seeds.

Herbicides — The wettable powder formulation of simazine (Princep) may be used on pure alfalfa stands established for a year or more to control seedling plants of wild mustard, yellow rocket, hoary alyssum, white cockle, shepherdspurse, and pennycress. Established plants except hoary alyssum are not consistently controlled. Application should be made after the last cutting in the fall and before the ground is frozen. Grasses in the alfalfa will be injured or killed. Some injury to alfalfa may occur. Recommended rates are 0.8 to 1.6 pounds per acre depending on soil type. Simazine should not be used on sands, loamy sands, gravelly soil, or on soils where soil pH is above 7.5. **Caution:** Do not graze areas treated with simazine for 30 days or cut hay for 60 days after treatment.

The wettable powder formulation of metribuzin (Lexone, Sensor) may be applied on alfalfa or alfalfa-grass mixtures at rates of ¾ to 1 pound per acre to control certain grass and broadleaf weeds when the alfalfa is dormant in fall or spring. The higher rates will severely reduce forage grass stands. **Caution:** Do not graze or harvest within 28 days after application.

Pronamide (Kerb) can be used on pure legume stands of alfalfa, clover, birdsfoot trefoil, or crown vetch to suppress quack-

grass and other perennial grasses. Pronamide will also control many annual grasses and some annual broad-leaved weeds but will not control perennial broad-leaved weeds. Suggested rates are 1 to 2 pounds of pronamide per acre applied in the fall when soil temperatures are below 60°F. but before freezeup. The lower rate should be used on coarse textured soils and the higher rate on medium to fine textured soils. Applications may be made in the fall of the seeding year. **Caution:** Do not graze or harvest alfalfa within 25 to 45 days depending on rate of application. Do not graze or harvest clover, birdsfoot trefoil or crownvetch within 120 days of application.

Terbacil (Sinbar) may be applied to pure alfalfa stands established for one or more years at ¼ to ¾ pound per acre to control several annual grasses and broadleaves. Application may be made in the fall or spring while the alfalfa is dormant. There is potential for alfalfa injury, especially on sandy soils or soils with low organic matter. Other crops cannot be planted within 2 years after application.

MCPA is hazardous to use on established legumes and should be used only when a serious weed problem exists. It should be applied only when legumes are dormant in late fall to control susceptible broad-leaved weeds that are present at this time and only if this use is specified on the label. MCPA amine at ¼ to ½ pound per acre may be used only on alfalfa and red clover to control certain winter annuals such as shepherdspurse and pennycress. Some control of yellow rocket should result, but white cockle is not controlled at these rates.

In established alfalfa, the amine salt of 2,4-DB can be applied at ½ to 1½ pounds per acre or the ester of 2,4-DB can be applied at ½ to 1 pound per acre in 10 or more gallons of water per acre. Apply when the annual broad-leaved weed seedlings are 1 to 3 inches tall (2- to 5-leaf stage). Do not apply when extremes of temperature or moisture are expected within the next few days. **Caution:** Do not graze for 60 days or feed hay for 30 days after application.

PERENNIAL GRASSES

Cultural methods — Broad-leaved weeds may be controlled in perennial forage grasses grown for forage or seed by periodic clipping as needed to prevent weed seed formation. Repeated clipping of perennial weed patches together with fertilizer treatments as needed will favor the grasses and control the weeds.

Herbicides — 2,4-D, MCPA, or dicamba will control broad-leaved weeds in established perennial grasses such as timothy, bluegrass, orchardgrass, reed canarygrass, and brome grass. Combinations of dicamba with 2,4-D or MCPA give better control of mustards and other weeds resistant to dicamba. Dicamba controls perennial thistles more effectively than MCPA or 2,4-D. However, repeated applications of dicamba, 2,4-D or MCPA may be required for complete thistle or other perennial weed control.

In timothy or bluegrass grown for seed, dicamba is effective in controlling small seedlings of white cockle and night-flowering catchfly. If timothy is sown with wheat or oats, spray for seedling weeds with ¼ pound per acre of dicamba when the small grain is in the 2- to 5-leaf stage. In established stands of timothy or bluegrass, spring applications of dicamba at ¼ to ½ pound per acre when timothy or bluegrass is 2 to 4 inches tall will control white cockle, night-flowering catchfly, and most other broad-leaved weeds. If spring application is delayed, weed control will be erratic and some injury to timothy may occur.

ESTABLISHED GRASS PASTURES

Cultural practices — In established pastures, good management and controlled grazing are necessary to maintain a productive, weed-free stand. Protect new seedlings from grazing until they are well established and graze moderately thereafter. Allowing established pastures a recovery period after grazing by excluding cattle for 3 to 4 weeks on a rotational basis will reduce weeds and increase forage yields. Mowing after each grazing period will control many pasture weeds and encourage new forage growth. Do not clip closer than 3 to 4 inches above the soil.

In very weedy pastures where perennial grasses are thin, reseeding may be the best practice. To be successful, add lime and fertilizer according to soil test, destroy old sod and weeds by plowing or extensive surface tillage and seed an adapted mixture of legumes and grasses in a firm seedbed.

Herbicides — Spraying with 1 or 2 pounds per acre of 2,4-D or MCPA gives better control of broad-leaved weeds and some brush species with a single application than is obtained with a single mowing treatment. The weeds should be sprayed when perennials are 6 to 8 inches tall and annuals or biennials are 3 to 4 inches tall (usually late May or early June). Brush should be sprayed when it is fully leaved. Repeated treatment for 2 or more years is usually necessary. Grasses will not be injured at these rates of herbicide, but legumes will likely be killed. MCPA can be used at low rates of about $\frac{1}{4}$ to $\frac{1}{2}$ pound per acre to control susceptible broad-leaved weeds where legumes such as white clover are present. At higher rates of 1 to 2 pounds per acre, MCPA will control some 2,4-D resistant weeds such as buttercup and spotted knapweed. **Caution:** See label. Do not graze dairy cattle on pastures treated with 2,4-D for 7 to 14 days after treatment. Do not cut 2,4-D treated grass for hay within 30 days after application.

Dicamba is cleared for broad-leaved weed control in grass pastures. The suggested rate of application ranges from $\frac{1}{4}$ pound per acre for susceptible annuals to 4 to 8 pounds per acre for resistant perennials. Mixtures of $\frac{1}{2}$ to 1 pound per acre with 2,4-D will give better control of 2,4-D-resistant species. The higher rates of dicamba may be practical for spot treatment of perennial broadleaved weeds. Do not apply on or near desirable trees or plants or in locations where the chemical may be washed or moved into contact with the roots of desirable plants. Prevent drift of dicamba to desirable plants, particularly soybeans. **Caution:** After treatment of pastures with dicamba, do not graze dairy animals for 7 to 60 days nor harvest for hay for 37 to 90 days depending on the rate of application. See label for details. There is no waiting period between treatment and grazing for animals other than dairy animals; except, do not graze meat animals in treated fields within 30 days of slaughter.

Small Grains — Spring Wheat, Oats, and Barley

Cultural practices — Early germinating weeds may be destroyed by tillage during seedbed preparation. Sowing clean seed at an adequate seeding rate will also reduce weed populations. Small grain must be seeded early for best yields, so repeated spring tillage to control weeds with delayed seeding of small grain is not feasible. Early spring seeding also reduces annual grass weed problems such as foxtail that are increased by late seeding. If adverse weather prevents early seeding and annual grass weeds develop, harrowing in the very early growth stages will reduce weed populations.

Herbicides — Broad-leaved weeds have been the major weed problem in small grains. Wider use of the less competitive, shorter-strawed, semidwarf wheats has increased the need for both broadleaf and grass control. Several effective broad-leaved weed control herbicides are available. Close attention to suggested rates and times of application as given on the label is necessary to reduce small grain injury potential.

In late seedings of semidwarf spring wheat, heavy stands of foxtail may be a problem. Control is possible with postplant preemergence incorporated applications of trifluralin at $\frac{1}{2}$ to $\frac{3}{4}$ pound per acre. Wheat should be planted at least 2 inches deep with a press-wheel drill. Trifluralin should be applied after planting and incorporated shallowly with a spike-tooth or flexible-tined harrow. Shallow planting or deeper incorporation of trifluralin may result in wheat injury especially on coarser textured soils that are low in organic matter. Under extremely dry conditions trifluralin may persist in the soil enough to affect sensitive crops such as corn, oats, grain sorghum, and sugarbeets planted the next year. Plowing with a moldboard plow reduces the potential for residue injury.

Postemergence applications of propanil (Stampede 3) at $1\frac{1}{2}$ pounds per acre when weeds were in the two- to four-leaf stage have controlled foxtails and some annual broadleaf weeds which resulted in increased spring wheat yields. Temporary injury to wheat, evident as leaf burn or yellowing, slowed early growth, and a several-day delay in maturity has occurred in some trials. **Caution:** As of December, 1979, propanil has not been cleared for use in spring wheat in Minnesota. A label has been submitted to EPA for use of this product in hard red spring wheat in 1980.

Delayed preemergence application of propachlor at 3 pounds per acre has given good annual grass control in spring wheat, oats, and barley in trials at several locations in Minnesota over a period of several years. Efforts are now being made to clear propachlor for this use. **Caution:** As of December 1979 propachlor has not been cleared for use on small grains in Minnesota.

Wheat and barley are relatively tolerant to 2,4-D from tillering until the early-boot stage. During this period $\frac{1}{4}$ to $\frac{1}{2}$ pound of 2,4-D ester or $\frac{1}{4}$ to $\frac{3}{8}$ pound of 2,4-D amine will control most broad-leaved weeds without serious injury to these crops. Oats are less tolerant to 2,4-D and some injury should be expected, but weed control generally will more than offset losses resulting from 2,4-D injury. Oat injury can be reduced by using the amine form and no more than $\frac{1}{2}$ pound per acre. **Caution:** Do not cut for forage or graze treated grain fields for 2 weeks after treatment with 2,4-D. Label restrictions on some 2,4-D formulations do not permit the use of straw from treated fields for livestock feed. To avoid crop injury don't spray small grain seedlings before tillering or small grains in the boot stage of development. Varietal differences in wheat and barley have been unimportant but oat varieties differ in their response to 2,4-D.

Small grains may be sprayed with 2,4-D amine or ester at $\frac{1}{2}$ to 1 pound per acre when grains are in the dough stage to control large weeds that may interfere with harvest. **Caution:** If ester formulations are used for this treatment, do not feed treated straw to livestock.

Small grains, especially oats, 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 $\frac{1}{4}$ pound per acre of amine or $\frac{1}{6}$ pound per acre of ester will control small mustard plants. For other broad-leaved weeds or larger mustard, up to $\frac{3}{8}$ pound per acre of amine and $\frac{1}{2}$ pound per acre of ester may be required. MCPA may be applied up to the boot stage of the small grain.

Bromoxynil controls many annual broad-leaved weeds, including some 2,4-D and MCPA resistant weeds such as wild buckwheat and smartweed in wheat, barley, and oats when applied at $\frac{1}{4}$ to $\frac{1}{2}$ pound per acre. The lower rate is effective on small weed seedlings up to the 4 leaf stage. Some injury to small grains has occurred at the higher rate. If weeds are beyond the 4 leaf stage, or are less susceptible to bromoxynil, use $\frac{3}{8}$ pound per acre or refer to product label for higher rate suggestions. Spray when small grains are in the 2-leaf to early boot stage. Good coverage of weeds is essential for good control.

Bromoxynil can also be used in combination with MCPA ester at $\frac{1}{4}$ pound of each material per acre on wheat or barley. Apply before the 3- to 4-leaf stage of the weeds and before the 3- to 4-leaf stage of wheat or barley for best results. Bromoxynil does not control perennials. **Caution:** Do not forage or graze for 30 days after application of bromoxynil or bromoxynil-MCPA mixtures.

Dicamba at $\frac{1}{8}$ pound per acre controls broad-leaved weeds such as wild buckwheat and smartweed that are tolerant to 2,4-D and MCPA in oats and wheat when used alone or in mixtures with $\frac{1}{4}$ pound per acre MCPA. The combination of dicamba and MCPA gives better control of mustard than dicamba alone. Oats are more tolerant than wheat to dicamba. Use of dicamba on barley is not advised because of poor crop tolerance. Applications made at the 2- to 5-leaf stage of small grain growth are the least injurious to the grains. **Caution:** Do not graze treated areas or harvest for dairy feed prior to crop maturity.

Picloram (Tordon 22K) may be used at rates of $\frac{1}{4}$ to $\frac{3}{8}$ ounce

per acre in a tank mixture with 2,4-D amine at ¼ to ¾ pound per acre for control of wild buckwheat, Russian thistle, and other broad-leaved weeds in spring barley and spring and winter wheat not underseeded with a legume. Use the low rates when weeds are small and the higher rates when weeds are more advanced or under dry conditions. One application of the tank-mix combination may be applied per year from the four-leaf stage up to the late tiller or early boot stage of spring wheat or barley. **Caution:** Picloram may persist in the soil for more than 12 months. Therefore, use only on land which will be fallowed or replanted to a grass or grain crop the following year.

Take proper precautions to prevent wind drift of herbicides used on small grains to sensitive crops such as sunflowers, soybeans, field beans, peas, potatoes, sugarbeets, and alfalfa. Dicamba and the esters of 2,4-D and MCPA can be hazardous to these crops by drift of vapors from treated fields a day or more after application as well as from droplet drift by wind at the time of application.

For wild oat control, triallate (Far-go) may be used in hard red spring or durum wheat at 1 to 1¼ pounds per acre, applied after seeding and incorporated into the soil. Barley is more tolerant to triallate and rates of 1¼ to 1½ pounds per acre may be used, applied either before or after seeding and soil incorporated. In each case, use the lower rate of triallate liquid and the higher rate for triallate granules. Diallate (Avadex) may be used for wild oat control in barley seeded alone or underseeded with alfalfa, or sweet, red, and alsike clover. Apply after planting at 1¼ pounds per acre and incorporate into the soil. Fall applications of liquid or granular formulations of triallate before spring planting of barley and wheat and of diallate before barley have been effective in northern areas that are not subject to wind or water erosion. A good seedbed free of trash should be prepared before incorporating the chemicals to a depth of 2 inches. A shallow seedbed, no more than 2 inches deep, should be prepared in the spring. To minimize possible crop thinning, seed wheat or barley just below the treated soil layer.

Barban (Carbyne) can be used for wild oat control in spring wheat or barley. It should be applied at ¼ to ¾ pound per acre when wild oats are in the 2-leaf stage. If a second flush of wild oat occurs, a second application of barban may be made at ¼ to ¾ pound per acre depending on wild oat density when most of the wild oat stand is in the 2-leaf stage. If the first application is missed, a single application of ½ pound per acre may be made when most of the wild oats have 2½ to 3½ leaves. Thick stands of small grain aid in suppression of wild oat. Control may not be satisfactory in thin crop stands. To reduce crop injury, do not spray barban after wheat or barley is in the 4-leaf stage. **Caution:**

Do not allow livestock to graze treated barley or wheat until after the crop is harvested.

Difenzoquat (Avenge) at ¾ to 1 pound per acre has controlled wild oat when applied on wild oat with 3 to 5 leaves. Barley has good tolerance, but some wheat varieties are susceptible to injury. Era, Olaf, Kitt and Butte are the only varieties of spring wheat that have label approval for applying difenzoquat. Difenzoquat may be used on spring seeded durum wheat varieties except Lakota and Wascana. The suggested rate depends on the density of wild oat plants with higher rates required for denser wild oat stands. Difenzoquat may be used in a mixture with 2, 4-D, MCPA or bromoxynil. Follow time of application recommendations of the 2, 4-D, MCPA or bromoxynil labels to obtain optimum crop safety and broadleaf weed control. Do not apply difenzoquat when plants are wet or if rain is expected within 6 hours. **Caution:** Do not graze treated fields or cut treated forage for silage.

A promising new herbicide, diclofop (Hoelon), for the control of wild oat and foxtail in wheat and barley has been evaluated for several years in Minnesota experiments. Satisfactory control of these weeds with little effect on these crops has been obtained using ¾ to 1 pound per acre applied to weeds in the 1- to 4-leaf stage. **Caution:** A request for registration has been submitted to EPA but as of December, 1979 diclofop has not been cleared for use in small grains.

Small Grains — Winter Wheat and Rye

Cultural practices — Winter annuals and/or perennials are usually the major weed problem in fall sown cereal grains. Perennials should be controlled by tillage or herbicides before or during seedbed preparation. Seeding of winter wheat should be completed by September 20 and rye should be seeded by October 1 so the crops are well established before winter and able to compete well with weeds.

Herbicides — 2,4-D and MCPA can be used to control most broad-leaved weeds in winter wheat and rye if applied in the spring after the grain is fully tillered but before the boot stage. Use 2,4-D amine at ¼ to ¾ pound per acre and 2,4-D ester at ¼ to ½ pound per acre. Higher rates of 2,4-D, up to 1½ pounds per acre may be used from dough stage to harvest if necessary to control broadleaf weeds. Rates over 1 pound per acre are more likely to cause crop injury. **Caution:** Do not feed treated straw to livestock. MCPA amine or ester can be used at ¼ to ¾ pound per acre. See the product label for specific use instructions. Do not spray winter wheat or rye in the fall. **Caution:** Do not graze or feed forage from 2,4-D treated fields within 2 weeks after treatment.

Table 3. Effectiveness of herbicides for weed control in small grains and flax.

Herbicide	Performance rating of herbicide on weeds*						Crop tolerance and herbicide clearance†			
	Wild mustard	Wild buck-wheat, annual	Canada & perennial sowthistle	Pigweed, lambs-quarters, common ragweed	Wild oat	Foxtail	Oats	Wheat	Barley	Flax
2,4-D amine	G	F	F	G	N	N	F	G	G	—
2,4-D ester	G	F	F	G	N	N	P	F	G	—
MCPA amine	G	F	F	G	N	N	G	G	G	G
MCPA ester	G	F	F	G	N	N	G	G	G	F
Bromoxynil (Buctril, Brominal)	F	G	N	G	N	N	G	G	G	F
Dicamba (Banvel)	P	G	G	G	N	N	G	F	P	—
Triallate (Far-go, Avadex-BW)	N	N	N	N	G	N	—	G	G	—
Diallate (Avadex)	N	N	N	N	G	N	—	F	F	F
Barban (Carbyne)	N	N	N	N	G	N	—	F	F	F
Difenzoquat (Avenge)	N	N	N	N	G	N	—	**	G	—
EPTC (Eptam)	P	P	N	F	F	G	—	—	—	F
Trifluralin (Treflan)	N	P	N	xxx	P	G	—	F	—	—

*P = poor, F = fair, G = good, N = no control.

†P = poor, F = fair, G = good, — = not cleared for use.

**Wheat varieties differ in tolerance. Use only on spring wheat variety Era, or on winter wheat.

xxx = Good on pigweed and lambsquarters, no control of ragweed.

Bromoxynil controls many annual broad-leaved weeds, and especially controls wild buckwheat and smartweed in winter wheat and rye when applied in the spring at ¼ to ½ pound per acre. For best results spray when weeds are in the seedling stage and after wheat or rye has fully tillered. Bromoxynil may be used with MCPA for better control of wild mustard. **Caution:** Do not forage or graze for 30 days after treatment.

Dicamba at ⅓ pound per acre plus either MCPA or 2,4-D at ¼ to ⅝ pound per acre may be used in winter wheat for broadleaved weed control. Apply after winter dormancy and before grain begins to joint. **Caution:** Do not graze treated areas or harvest for dairy feed prior to crop maturity.

Picloram (Tordon 22K) may be used at rates of ¼ to ⅝ ounce per acre in a tank mixture with 2,4-D amine at ¼ to ⅝ pound per acre to control wild buckwheat, Russian thistle, and most other broad-leaved weeds in winter wheat after growth begins in the spring. See precautions for this treatment under spring grains.

Barban (Carbyne) or difenzoquat (Avenge) may be used for wild oat control in winter wheat. Sequential treatments of barban can be used if necessary. (See discussion under spring small grains.)

Forage Sorghum, Sorghum-Sudan Crosses, and Sudangrass

Cultural practices — Sorghum, sudangrass, and crosses of these two are warm season crops and should not be planted until about May 20 to June 5 in Minnesota. Delayed planting until soil temperatures are warm enough for rapid crop seed germination provides an excellent opportunity for early weed control by tillage. The use of a rotary hoe or harrow will kill small weeds as they are emerging. A row cultivator with shovels set for shallow cultivation should be used after the crop and weeds emerge.

Herbicides — Atrazine may be used to control many annual grass and broad-leaved weeds in forage sorghum and sorghum-sudan hybrids. Atrazine is not registered for use on sudangrass. Application may be made preplanting (within 2 weeks of planting), preemergence, or postemergence. Do not use atrazine on sandy soils. On medium and fine textured soils with organic matter levels of more than 1½ percent, atrazine can be used at 2 to 3 pounds per acre. However, some crop injury may occur at the higher rate, especially if heavy rains follow application or if sorghum or sorghum crosses are under certain stress conditions. Postemergence treatments with atrazine alone should be made before weeds are more than 1½ inches tall. If an emulsifiable oil is used with atrazine for postemergence control of broad-leaved weeds, use no more than 1.2 pounds of atrazine per acre and apply before broadleaves are 4 to 6 inches tall. **Caution:** Do not graze or feed forage from treated areas for 21 days following application.

Propazine (Milogard) may be applied preemergence for annual grass and broad-leaved weed control in forage sorghum (but not in sorghum-sudan crosses or sudangrass) at 2 pounds per acre. Do not use propazine on sandy soils.

For the control of broad-leaved weeds in forage sorghum, sorghum-sudan crosses or sudangrass, 2,4-D amine or ester may be used when these crops are 4 to 12 inches tall. Application at earlier or later stages of the crop may result in serious crop injury. Use 2,4-D amine at ¼ to ½ pound per acre or 2,4-D ester at ⅓ to ½ pound per acre. **Caution:** Do not graze or harvest for 14 days after 2,4-D treatment.

Grain Sorghum

Cultural practices — Sorghum will not germinate or grow in cold soil. Therefore, late planting in warmer soil, May 20 to June 5, 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.

Herbicides — Treatment with propachlor (Bexton, Ramrod), propazine (Milogard), atrazine, cyanazine (Bladex), or terbutryn

(Igran) is usually necessary to prevent drastic reduction in sorghum yield due to weed competition. These herbicides control annual grasses in sorghum. Propazine, cyanazine, atrazine, and terbutryn also kill broad-leaved annual weeds. Propachlor at 4 to 5 pounds per acre, terbutryn at 1.6 to 2.4 pounds per acre, propazine at 2 pounds per acre, or cyanazine at 1 to 1.6 pounds per acre are applied preemergence.

Atrazine may be applied preplanting, preemergence or post-emergence for annual grass or broadleaf control at 1.6 to 2.4 pounds per acre depending on soil type and organic matter content. If soil is worked after application, avoid deep incorporation. Postemergence applications should be made before weeds exceed 1½ inches in height. A mixture of atrazine at 1.2 pounds per acre plus special emulsifiable oils at 1 gallon per acre in water may be used for broad-leaved weed control. Approved emulsions of either vegetable or petroleum oils are satisfactory. Apply before broad-leaved weeds exceed 4 to 6 inches in height.

Mixtures approved for preemergence application are propachlor at 2½ to 4 pounds per acre plus atrazine at 1 to 1.6 pounds per acre and propachlor at 2¼ to 3 pounds per acre plus propazine at 0.8 to 1 pound per acre. **Caution:** Do not graze or feed forage within 21 days after application of atrazine or propachlor-atrazine. Do not graze or feed sorghum forage from propachlor-treated fields to dairy cattle.

Atrazine, terbutryn, or propazine should not be used on sandy soils, as injury to sorghum may occur, but some mixtures of propachlor with atrazine or propazine are approved. Rainfall or overhead irrigation at the time of sorghum emergence may result in injury from terbutryn. Terbutryn should not be used on sand and may be used at 1.6 to 2 pounds per acre on loamy sand. Terbutryn should not be used until the soil temperature has reached 60° F for at least 3 consecutive days. Winter wheat may be planted 4 months or more after terbutryn application.

Cyanazine (Bladex) at 0.8 to 1.6 pounds per acre may be used with propachlor or propazine except on peat or muck soils.

For the control of broad-leaved weeds, 2,4-D may be used at ¼ to ½ 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.

Dicamba (Banvel) at ¼ pound per acre is also approved for control of broad-leaved weeds in sorghum if applied within 10 to 25 days after sorghum emergence. **Caution:** Do not graze or feed forage from dicamba-treated sorghum prior to the mature grain stage.

Soybeans

Cultural practices — 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. Preparing the seedbed immediately prior to planting of the crop kills many weeds. Postemergence cultivation with the rotary hoe, harrow, or cultivator is effective if done when the weeds are small and soil conditions are favorable. Even when preemergence herbicides are used, and especially if dry conditions prevail for several days, the rotary hoe, harrow or cultivator should be used as soon as weeds appear at the soil surface.

Herbicides — Table 4 shows the performance of some herbicides in uncultivated soybeans during several years of county demonstrations. Figures show 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.

Table 5 indicates soybean tolerance to herbicides suggested for use in soybeans and efficiency of these herbicides in control-

ling common 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.

Preplanting applications — In soybeans, alachlor (Lasso), dinitramine (Cobex), fluchloralin (Basalin), metolachlor (Dual), pendimethalin (Prowl), profluralin (Tolban), trifluralin (Treflan), and vernolate (Vernam) have given good control of annual grasses, pigweed, and common lambsquarters when applied as preplanting soil-incorporated treatments. Other broad-leaved weeds are usually not adequately controlled. Preplanting incorporated applications of vernolate, alachlor (Lasso) or metolachlor (Dual) have also controlled nutsedge.

Selection of the proper rate of these chemicals is especially important to obtain satisfactory weed control and avoid excessive soybean injury. The proper rate depends on soil texture and the amount or organic matter in the soil. Be sure to read label rate charts carefully for specific rate information. The suggested rate ranges are: dinitramine, $\frac{1}{3}$ to $\frac{2}{3}$ pound per acre; fluchloralin, $\frac{1}{2}$ to $1\frac{1}{2}$ pounds per acre; pendimethalin, $\frac{1}{2}$ to $1\frac{1}{2}$ pounds per acre; alachlor, $2\frac{1}{2}$ to 4 pounds per acre; profluralin, $\frac{1}{2}$ to $1\frac{1}{2}$ pounds per acre; trifluralin, $\frac{1}{2}$ to 1 pound per acre; vernolate, 2 to 3 pounds per acre; metolachlor, $1\frac{1}{2}$ to 3 pounds per acre.

Under extremely dry conditions, fluchloralin, pendimethalin, profluralin, and trifluralin may persist in the soil enough to affect sensitive crops such as corn, small grains, grain sorghum, and sugarbeets planted the next year. Plowing with a moldboard plow reduces the potential for crop injury from residues of these herbicides compared to reduced tillage such as with a chisel-plow, field cultivator, or disk.

Proper incorporation of the above chemicals can be accomplished with a tandem disk, field cultivator with sweep shovels, rotary cultivator, or power driven rotary tiller. Pulling a spike-tooth harrow behind the disk or field cultivator is also advisable. Operating the disk or field cultivator 3 to 4 inches deep and the rotary cultivator or tiller at 2 to 3 inches usually gives the desired depth of incorporation. Observe label instructions for proper equipment depth and speed of operation. The chemicals should be incorporated while applying or within a few minutes after application. To get uniform incorporation, the disk or field cultivator should be operated twice over the field in different directions. With early applications, one operation can be done at application time and the second just prior to planting. Incorporation is usually better when the soil surface is dry enough to permit good soil mixing. Vernolate should not be applied to wet soils because a considerable amount of the chemical may be lost as vapor resulting in poor weed control.

Fall applications of trifluralin are feasible if the full rate for the soil type is applied after October 15 on a relatively level surface and disked in. Weed control has not been quite as good from fall applications as from spring applications, but with cultivation, weed control should be satisfactory. Fall applications should not be attempted on rough cloddy fields or on fields subject to serious wind erosion, water erosion, or flooding.

Several preemergence chemicals are labeled for use after some of the preplanting treatments to improve broad-leaved weed control. Over preplanting dinitramine, metolachlor, profluralin, pendimethalin, or trifluralin applications, preemergence applications of chloramben, linuron, or metribuzin have given improved grass and broad-leaved weed control. Metribuzin is also labeled for tank mixing with dinitramine, metolachlor, pendimethalin, profluralin, and trifluralin and applying as a preplanting incorporated treatment. Metribuzin should not be used with vernolate because of potential soybean injury problems. Vernolate and trifluralin may be applied as a preplanting and incorporated mixture to give control of many kinds of weeds, but neither chemical controls several broadleaves. Chloramben may be tank mixed with metolachlor or trifluralin and applied preplanting. Chlorpropham may be tank mixed for preplanting application with profluralin, trifluralin or vernolate.

Preemergence applications — Preemergence applications of chloramben (Amiben) at 3 pounds per acre control most annual broad-leaved and grass weeds. Performance has been consistent on all soil types where sufficient rain occurred before weeds emerged. In a few instances stand reductions and slight stunting of soybeans treated with chloramben have been noted. However, yields did not appear to be reduced. Chloramben at 2 to 3 pounds per acre has worked well as a preemergence treatment over dinitramine, pendimethalin, profluralin, trifluralin and vernolate applied preplanting. Chloramben is also labeled for use preemergence with alachlor, dinoseb, linuron, or metribuzin.

Alachlor (Lasso) and metolachlor (Dual) have given good control of annual grasses, redroot pigweed and nightshade in soybeans. Alachlor and metolachlor have given fair to poor control of common lambsquarters and control of other broadleaves has been erratic. Soybeans have good tolerance to alachlor and metolachlor. Alachlor and metolachlor have usually controlled annual weeds better when applied preemergence than preplanting, but preplanting incorporated treatments controlled nutsedge better than preemergence applications.

Alachlor and metolachlor are labeled for use preemergence on soybeans in mixtures with chloramben, dinoseb, naptalam plus dinoseb, linuron, and metribuzin. These mixtures will improve annual broad-leaved weed control, but soybean injury may occur under certain conditions.

Preemergence applications of linuron (Lorox) at $\frac{1}{2}$ to $2\frac{1}{2}$ pounds per acre control annual broad-leaved weeds and grasses in soybeans. Linuron is best suited for medium textured soils with less than 4 percent organic matter. Weed control has been inconsistent on soils higher in organic matter and clay. Soybean injury has sometimes occurred on sandy soils. It is extremely important to use the rates recommended on the label for your soil type. Linuron may be used as a preemergence treatment for broadleaf control after trifluralin has been applied preplanting. Linuron may be used in mixtures with alachlor.

Chlorpropham (Furloe Chloro IPC) applied preemergence at 2 to 3 pounds per acre has given good control of smartweed. Other weeds are usually not controlled. Soybeans have good tolerance to chlorpropham. Chlorpropham may be applied preemergence to fields treated preplanting with trifluralin, profluralin, or vernolate or in a preemergence mixture with alachlor.

Metribuzin (Sencor, Lexone) is a preemergence herbicide that has given good annual broadleaf control and fair annual grass control at rates of $\frac{1}{4}$ to $\frac{3}{4}$ pound per acre depending on the kinds of weeds to be controlled, soil texture, organic matter and pH. Early soybean injury has frequently occurred at the higher rates. Metribuzin should not be used on Altona or Steele varieties which are more susceptible to injury. Metribuzin may be used at $\frac{1}{4}$ to $\frac{1}{2}$ pound per acre in a mixture with 2 to $2\frac{1}{2}$ pounds per acre of alachlor, with $1\frac{1}{4}$ to $2\frac{1}{2}$ pounds per acre of metolachlor or as a preemergence treatment over preplanting dinitramine, metolachlor, pendimethalin, profluralin, or trifluralin. Metribuzin is also labelled to use as a preemergence mixture with chloramben, but this mixture may be less effective on grassy weeds than the above mixtures. Do not use on soils with less than 2 percent organic matter, or on sandy soils. Injury may be more severe on alkaline soils or on soils with atrazine residues.

Dinoseb (DNBP) applied preemergence or up to the cotyledon stage of the soybeans, usually controls mustard satisfactorily, but has not consistently controlled most other weeds. Good results on emerged weeds are dependent on relatively warm temperatures and some crop injury may occur.

Naptalam plus dinoseb (Dyanap) as a preemergence treatment up to the crook-stage of soybeans has given fair broadleaf control but poor grass control and serious soybean injury has sometimes occurred. This mixture may be used preemergence with alachlor or metolachlor.

Bifenox (Modown) is a preemergence herbicide that has given fair to good control of pigweed, common lambsquarters, annual smartweeds, and velvetleaf and inconsistent annual grass control. Soybean tolerance is limited and malformation and stunting

of young soybeans often occurred. Bifenox may be used as a preemergence treatment over trifluralin or as a preemergence mixture with alachlor.

Oxyfluorfen (Goal) applied preemergence has controlled some annual broad-leaved weeds, but grass control has been less consistent in research trials. Soybean tolerance is limited and early injury to young soybeans has often occurred. Incorporation has reduced the effectiveness of oxyfluorfen. **Caution:** As of December 1979, oxyfluorfen is not labelled for use on soybeans, but clearance is expected for the 1980 season.

Postemergence applications: Cocklebur can be controlled by applying 2,4-DB amine at 0.2 pound per acre as a directed spray when soybeans are 8 to 12 inches tall. 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. Because of potential soybean injury, 2,4-DB should be used only in cases of severe cocklebur infestation. **Caution:** Do not harvest within 60 days after application.

Dinoseb (Premerge) or a mixture of dinoseb and naptalam (Dyanap) may be used as postemergence treatments for broad-leaved weed control in soybeans. Results from using these treatments have been inconsistent and are influenced by temperatures. Follow label instructions accurately if you use these materials.

Diclofop (Hoelon) has controlled small annual grasses when applied postemergence to grasses less than 3 inches tall with 1 to 3 leaves and to soybeans near the first trifoliolate stage of growth. Giant foxtail, green foxtail, and barnyardgrass have been well controlled, but yellow foxtail has considerable tolerance. Volunteer corn can be controlled with diclofop. (See discussion on volunteer corn control on page 18.) **Caution:** As of December 1979, diclofop is not labelled for use on soybeans, but clearance is expected for the 1980 season. Diclofop should not be mixed with other herbicides since diclofop is less effective in mixtures. If bentazon is to be applied also, wait 3 days or more after the diclofop application before spraying with bentazon.

Bentazon (Basagran) gives excellent control of several annual broad-leaved weeds, volunteer sunflower, Canada thistle, and yellow nutsedge when applied postemergence in soybeans. See page 17 for information on controlling Canada thistle and yellow nutsedge. Pigweed and common lambsquarters are somewhat tolerant. Bentazon does not control grasses. It is most effective if applied when weeds have the first two to four leaves and soybeans are in the first trifoliolate leaf stage. It can be applied up to soybean harvest but weed control is not as good and the treatment is less economical than early application. Suggested rates are $\frac{3}{4}$ to $1\frac{1}{2}$ pounds per acre depending on the kinds of weeds and weed size. Bentazon has been more effective if applied when foliage is dry and during the day. Early morning, late evening, and night applications were less effective than daytime applications. Rain before 8 to 24 hours after application reduces weed control from bentazon. Soybeans damaged by conditions such as hail, flooding, drought, other herbicides or extreme temperatures may be injured by bentazon. A non-phytotoxic oil concentrate may be mixed with bentazon to increase the activity of the chemical.

Acifluorfen (Blazer) applied as an early postemergence spray on soybeans has given good control of some annual broad-leaved weeds including pigweed, wild mustard, common ragweed, giant ragweed, black nightshade and buffalobur. Control of annual grasses has been erratic. Soybean leaves are often burned by the spray, but the plants have soon recovered normal growth. **Caution:** As of December 1979, acifluorfen is not labelled for use on soybeans, but clearance is expected for the 1980 season.

Barban (Carbyne) can be used as a postemergence treatment for wild oat control in soybeans. Six ounces per acre are applied when most of the wild oats are in the two-leaf stage. Do not apply later than 30 days after soybean emergence.

Sugarbeets

Herbicides may be used in sugarbeets to supplement conventional cultivation practices. Hand labor, mostly hoeing, may still be needed but can be reduced or eliminated by timely cultivations and herbicide applications. More than one herbicide application may be practical in some fields. Chemicals such as dalapon, endothall, phenmedipham, or desmedipham may be applied postemergence following preemergence or preplanting herbicide applications. However, the sugarbeet injury potential is greater where these combination treatments are used than if only one application is involved. To minimize injury from combination treatments, the lower suggested rates should be used and postemergence treatments should not be applied at high temperatures.

Table 6 indicates sugarbeet tolerance to herbicides suggested for use in sugarbeets and relative effectiveness of these herbicides in controlling common weeds. This is a general 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.

Annual grasses, except wild oat, may be controlled by TCA at 5 to 7 pounds per acre applied preemergence. **Caution:** TCA is not cleared for use on sugarbeets if the tops are to be fed.

EPTC (Eptam) at 2 to 3 pounds per acre incorporated into the soil before planting usually gives excellent annual grass control and often good annual broad-leaved weed control. Fall applications of EPTC at 4 to $4\frac{1}{2}$ pounds per acre have performed well. Applications should be made after October 15 until freeze-up and incorporated immediately and thoroughly. The higher rates should be used only on fine-textured, high organic matter soils. Some stand reduction and temporary stunting may occur, especially from the highest rates. If postemergence treatments of other herbicides are planned, the lower rate of EPTC should be used to reduce sugarbeet injury.

Cycloate (Ro-neet), chemically related to EPTC, controls annual grasses and some broadleaves when applied at 4 pounds per acre preplanting and incorporated. Cycloate has resulted in less sugarbeet injury than EPTC, but cycloate has given slightly more variable weed control. Less sugarbeet injury has resulted from postemergence treatments following cycloate than following EPTC. Cycloate should be considered as an alternative for EPTC on soils where EPTC causes excessive sugarbeet injury. Both EPTC and cycloate give better results if applied when the soil surface is dry and the chemicals are thoroughly mixed into the soil immediately.

Ethofumesate (Nortron) at 2 to $3\frac{3}{4}$ pounds per acre controls several broad-leaved and grassy weeds. It is particularly effective against redroot pigweed and wild buckwheat but, it is weak against yellow foxtail and wild mustard. For improved grass control, ethofumesate should be used at planting time with another herbicide like TCA or cycloate or following fall-applied EPTC. In research trials incorporating ethofumesate with a tillage tool operating 1 to 4 inches deep improved weed control compared to surface application without incorporation. Ethofumesate often leaves a residue in the soil the year following use on sugarbeets that may affect wheat, barley, and oats. Mold board plowing prior to planting the crop after sugarbeets has eliminated crop injury. Band application has reduced the potential soil residue problem and reduces costs, but special equipment may be needed to band apply and incorporate the chemical just ahead of the planter. The mixture of ethofumesate and TCA has been relatively safe on sugarbeets, but use of ethofumesate with cycloate or following fall-applied EPTC can cause sugarbeet injury, especially on sandy soils or soils low in organic matter. Applications of ethofumesate with spring-applied EPTC have been especially damaging and should be used only on silty clay loam soils with over 6 percent organic matter.

Dalapon applied to sugarbeets from emergence through the 6-leaf stage at 2 to 3 pounds per acre will control most emerged annual grasses. Higher rates or repeated treatments are usually required to control wild oat and some sugarbeet injury may occur.

Table 4. 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
Alachlor (Lasso), pre	2½, 3	1969-79	181	176	89	7	4	63	22	15
Bentazon (Basagran), pst	¾	1973-75	45	45	13	18	69	78	13	9
Bifenox (Modown), pre	2	1975-76	27	26	33	33	33	65	19	16
Chloramben (Amiben), pre	3	1959-79	525	506	75	16	9	76	16	8
Dinitramine (Cobex), ppi	⅝, ¾	1972-78	89	87	80	13	7	64	26	9
Fluchloralin (Basalin), ppi	1½	1976-77	26	24	88	8	4	79	9	12
Fluchloralin (Basalin), ppi	1¼	1978-1979	24	23	88	0	12	69	13	18
Linuron (Lorox), pre	2	1962-75	381	368	53	25	22	68	18	14
Metribuzin (Sencor, Lexone), pre	½, ⅝	1972-78	100	98	70	16	14	80	10	10
Pendimethalin (Prowl), ppi	1½	1977-79	37	36	89	11	0	75	20	5
Profluralin (Tolban), ppi	1, 1½	1973-77	69	65	82	13	5	54	35	11
Profluralin (Tolban), ppi	1¼	1978-79	24	23	96	0	4	66	22	13
Trifluralin (Treflan), ppi	1	1965-79	252	241	87	10	3	61	24	15
Alachlor, pre + bentazon (Basagran), post	3 + ¾	1978-79	23	21	87	4	9	91	5	4
Alachlor, pre + bentazon, post	3 + 1	1973-77	70	65	87	7	6	88	7	5
Alachlor, pre + chloramben, pre	2 + 2	1976-79	52	49	89	6	5	84	12	4
Alachlor, pre + bifenox, pre	2½ + 2	1976-79	53	49	91	5	4	94	4	2
Alachlor, pre + dinoseb, pre	2½ + 4½	1973-77	76	73	88	10	2	76	13	11
Alachlor, pre + linuron, pre	2 + 1½	1971-76, 1978-79	120	116	87	10	3	86	6	8
Alachlor, pre + metribuzin, pre	2 + ½	1974-79	86	82	93	5	2	91	5	4
Alachlor, pre + naptalam + dinoseb (Dyanap), pre	2 + 3 + 1½	1975-76	27	26	78	4	18	50	35	15
Trifluralin, ppi + bentazon, pst	1 + ¾	1973-74	31	28	81	16	3	86	14	0
Trifluralin, ppi + bifenox (Modown), pre	¾ + 2	1975-79	62	59	95	3	2	91	7	2
Trifluralin, ppi + chloramben, pre	¾ + 2	1971-79	124	119	94	5	1	91	6	3
Trifluralin, ppi + linuron, pre	¾ + 1½	1970-79	142	136	90	7	3	90	6	4
Trifluralin, ppi + metribuzin, pre	¾ + ½	1974-79	81	77	94	4	2	95	3	2

*ppi — preplanting incorporated
pre — preemergence
pst — postemergence

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 sugarbeets are 14 inches tall. If repeated applications are used, no more than 6 pounds per acre can be applied in any single growing season. Use of a surfactant in the spray mixture with dalapon may improve grass control, but sugarbeet injury may be increased.

Pyrazon (Pyramin) applied preemergence controls many annual broadleaved weeds. Pyrazon should be used in combination with TCA to give control of most annual broad-leaved weeds and grasses. Pyrazon plus TCA should be used only on medium- to coarse-textured soils with less than 5 percent organic matter, and a rain shortly after application is necessary for best results. Postemergence treatments of pyrazon have given erratic results.

Diallate (Avadex) at 1½ to 2 pounds per acre may be applied after October 15 in the fall or in the spring as a preplanting soil-incorporated treatment to control wild oat in sugarbeets. At these rates, diallate may persist in the soil enough to affect tame oats the next year. Barban (Carbyne) at ¾ to 1 pound per acre may be used to control emerged wild oat when wild oat is in the two-leaf stage and within 30 days of sugarbeet emergence.

Certain broad-leaved weeds — annual smartweed, volunteer sunflower, wild buckwheat, and marshelder — may be controlled by a post-emergence application of endothall at ¾ to 1½ pounds per acre. Sugarbeets should have 4 to 6 true leaves when endothall is applied. Do not apply endothall later than 40 days after sugarbeet emergence.

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 to very small sugarbeets. Endothall may cause leaf burn on the sugarbeets but recovery is usually rapid. Endothall will generally give disappointing results on most broad-leaved weeds not mentioned above.

Desmedipham (Betanex) at 1 to 1¼ pounds per acre and phenmedipham (Betanal) at 1 to 1½ pounds per acre are post-emergence herbicides for controlling annual broad-leaved weeds. To reduce the possibility of sugarbeet injury from desmedipham and phenmedipham, observe the following precautions. The sugarbeets should have four true leaves before treatment. Use no more than 1 pound per acre following EPTC or TCA applications. Start application late in the afternoon or early in the evening so cool temperatures follow application. Do not apply if the highest temperature on the day of application exceeds 85° F. Set the desired band width near the top of the weeds and sugarbeets so that the plants rather than the ground receive the proper rate. Calibrate the sprayer accurately. Desmedipham and phenmedipham give good control of wild mustard and common lambsquarters. Desmedipham is slightly better on wild mustard. Phenmedipham is slightly better on common lambsquarters. Desmedipham controls redroot and prostrate pigweed significantly better than phenmedipham, but phenmedipham is better for controlling kochia and wild buckwheat. The two compounds may be used individually or mixed depending on the weed species present.

When sugarbeets are planted early in the spring or when good moisture conditions prevail well into the season, late germinating weeds can become a problem and the use of an herbicide after thinning may be advisable. Trifluralin (Treflan) is cleared at ¾ lb/A and EPTC (Eptam) is cleared at 3 lb/A for use on sugarbeets after thinning for annual grass and broadleaf control. The chemicals should be broadcast applied and incorporated immediately with cultivators or tillers adjusted to mix them thoroughly with soil in the row without damaging the sugarbeets. The crop should be clean cultivated before application since established weeds are not controlled. Exposed sugarbeet roots should be covered with soil prior to trifluralin application to reduce the possibility of injury.

Table 5. Effectiveness of herbicides on major weeds in soybeans

	Preplanting								Preemergence						Postemergence	
	Alachlor (Lasso)	Dinitramine (Cobex)	Fluchloralin (Basalin)	Metolachlor (Dual)	Pendimethalin (Prowl)	Profluralin (Tolban)	Trifluralin (Treflan)	Vernolate (Vernam)	Alachlor (Lasso)	Chloramben (Amiben)	Chlorpropham (Furloc Chloro (PC)	Linuron (Lorox)	Metolachlor (Dual)	Metribuzin (Sencor, Lexone)	2,4-DB	Bentazon (Basagran)
Soybean Tolerance	G	F	F	G	F	F	F	F	G	G	G	F	G	F	P	G
Grasses																
Giant foxtail	G	G	G	G	G	G	G	G	G	G	P	F	G	F	N	N
Green foxtail	G	G	G	G	G	G	G	G	G	G	P	F	G	F	N	N
Yellow foxtail	G	G	G	G	G	G	G	G	G	G	P	F	G	F	N	N
Barnyardgrass	G	F	F	G	G	G	G	G	G	G	P	F	G	F	N	N
Wild proso millet	F	F	F	F	F	F	F	F	F	F	P	F	F	F	N	N
Nutsedge	G	N	N	G	N	N	N	G	F	P	P	F	P	N	F	N
Broadleaves																
Black nightshade	G	F	P	G	P	P	P	G	F	P	P	G	P	|	F	F
Cocklebur	P	N	N	N	N	N	N	P	F	F	F	Z	F	|	F	F
Kochia	P	G	G	P	G	G	G	P	G	G	F	P	G	|	F	F
Lambsquarters	F	G	G	F	G	G	G	F	G	F	F	P	G	P	F	F
Mustard	P	N	N	P	N	N	N	|	G	F	F	P	G	P	F	F
Pigweed	G	G	G	G	G	G	G	G	G	F	F	G	G	P	F	F
Common ragweed	P	P	N	P	N	N	N	P	G	F	F	P	G	P	F	F
Giant ragweed	P	P	N	P	N	N	N	P	G	F	F	P	G	P	F	F
Smartweed	P	F	P	P	F	P	P	P	G	F	F	P	G	P	F	F
Velvetleaf	P	P	N	P	F	N	N	P	G	F	F	P	G	P	F	F
Venice mallow	P	P	P	P	P	P	P	P	G	F	F	P	G	P	F	F
Wild sunflower	P	N	N	P	N	N	N	P	G	F	F	P	G	P	F	F

G — Good
 F — Fair
 P — Poor
 N — No control
 — Insufficient information

Table 6. Effectiveness of herbicides on major weeds in sugarbeets

	Preplanting		Preemergence			Postemergence				
	Diallate (Avadex)	EPTC (Eptam)	Ethofumesate (Nortron)	Pyrazon (Pyramin)	TCA	Barban (Carbyne)	Dalapon (Downon, Bastapon)	Endothall (Herbicide 273)	Desmedipham (Betanex)	Phenmedipham (Betanal)
Sugarbeet tolerance	G	F	G	G	G	G	F	F	F	F
Grasses										
Giant foxtail	P	G	G	P	G	P	G	P	P	F
Green foxtail	P	G	G	P	G	P	G	P	P	F
Yellow foxtail	P	G	G	P	G	P	G	P	P	F
Barnyardgrass	P	G	G	P	G	P	G	P	P	F
Wild oat	G	F	F	P	P	G	F	P	P	F
Broadleaves										
Common ragweed	P	F	P	G	P	P	P	F	G	G
Lambsquarters	P	P	P	P	P	P	P	P	G	G
Marshelder	P	|	|	|	P	P	P	P	|	G
Pigweed	P	P	|	|	P	P	P	P	|	G
Smartweed	P	P	P	P	P	P	P	P	P	G
Wild buckwheat	P	P	P	P	P	P	P	P	P	G
Wild mustard	P	P	P	P	P	P	P	P	P	G

G — Good
 F — Fair
 P — Poor
 — Inadequate information

Sunflowers

Cultural practices — Sunflowers normally do not emerge for 10 days to 2 weeks after planting. Therefore, weeds frequently emerge before sunflowers. Many weeds can be killed by spike-tooth or coil spring harrowing about 1 week after planting. After sunflowers emerge, such implements as the weeder, rotary hoe, and spike-tooth or coil spring harrow may be used to kill weeds because the sunflower seedlings are more strongly rooted and are usually not injured if the implement is properly adjusted. More than one such tillage operation may be needed if seedling weeds continue to emerge. Weeds that are missed in these early tillage operations may be controlled by cultivation between the rows. However, sunflowers are more easily damaged or broken by the cultivator than is corn.

Herbicides — EPTC (Eptam) can be used at 3 pounds per acre preplanting and incorporated immediately, to control most annual grasses and many annual broadleaved weeds. EPTC gives some control of wild oat, but does not control wild mustard or smartweed. Trifluralin (Treflan) can be used preplanting and incorporated at ½ pound per acre on sandy soils low in organic matter, ¾ pound per acre on medium textured soils or sandy soils with 2 to 5 percent organic matter, and 1 pound per acre on silt loam or clay soils or on sandy soils with over 5 percent organic matter. Trifluralin controls most annual grasses and some annual broad-leaved weeds, but is not effective on wild mustard, common ragweed, or smartweed. Trifluralin should be incorporated from immediately to within 8 hours after application. Either EPTC at 4 to 4½ pounds per acre or Trifluralin at ½ to 1 pound per acre may be applied and incorporated in late fall before the ground freezes prior to planting sunflowers in the spring.

Dinitramine (Cobex) may be used preplanting and incorporated to control most annual grasses and some annual broad-leaved weeds. Use ⅓ pound per acre on sandy soils, ½ pound per acre on loam and silt loam soils, and ¾ pound per acre on clay soils. Refer to product label for more specific rate suggestions on different soils. Soil incorporation may be delayed up to 24 hours with satisfactory results.

Profluralin (Tolban) may be used preplanting and incorporated at rates from ½ pound per acre on sandy soils to 1 pound per acre on loam and clay soils to control most annual grass and some annual broad-leaved weeds. Incorporate immediately or within 4 hours after application.

Chloramben (Amiben) can be used to control many annual grasses and broad-leaved weeds when applied preemergence at 2 to 3 pounds per acre. Use the low rate on sandy soils of less than 3 percent organic matter. Chloramben does not control wild oat. If sufficient rainfall does not fall within 3 to 4 days after application, use a rotary hoe or similar implement for shallow tillage to assist in weed control. Excellent weed control has been obtained when dinitramine, EPTC, trifluralin or profluralin was applied preplanting followed by chloramben applied preemergence. Chloramben may be tank mixed with trifluralin and applied as a preplanting, soil incorporated treatment. **Caution:** Do not graze or feed sunflower forage from chloramben-treated areas.

Barban (Carbyne) may be used for wild oat control in sunflowers at ⅙ pound per acre applied when most of the wild oats are in the 2-leaf stage. Do not apply later than 30 days after sunflowers emerge.

Special Weed Problems

Perennial Weeds

Perennial weeds such as Canada thistle, perennial sowthistle, field bindweed, Jerusalem artichoke, leafy spurge, nutsedge, 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 rhizomes 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 or rhizomes to clean parts of the field.

Tillage practices may be effectively combined with growing winter small grains or short-season, late-planted summer annu-

als 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.

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.

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 broad-leaved 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 space between rows should be wide enough to cultivate so problem weeds can be controlled by cultivation.

Perennial Broad-leaved Weeds in Crops

Perennial broad-leaved weeds such as Canada thistle, perennial sowthistle, field bindweed, Jerusalem artichoke, and leafy spurge can be suppressed with 2,4-D or MCPA in tolerant crops. Use 2,4-D or MCPA on oats, wheat or barley; MCPA is less injurious to oats. 2,4-D can be used in corn. 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 with 2,4-D 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, grass pastures, and corn. Use the maximum rate of dicamba listed for the specific crop. Drift may damage soybeans or other broad-leaved plants.

Canada thistle can be controlled in the fall or spring before planting soybeans. Spray with 1 pound per acre of 2,4-D ester in the fall 10 days before plowing or in the spring when thistles are a few inches tall and at least 2 weeks before planting soybeans. Delay seedbed preparation and planting of soybeans at least 2 weeks after spraying to allow time for 2,4-D to act and to avoid 2,4-D residue effects on the soybeans. Do not use dicamba before planting soybeans as serious crop injury can occur.

Bentazon (Basagran) may be used as a postemergence treatment to control Canada thistle or perennial sowthistle in corn or soybeans. Two applications of $\frac{3}{4}$ to 1 pound per acre each have been more effective than a single application of 1 to 1½ pounds per acre. The first application should be when thistles are 8 to 12 inches tall. Repeat the treatment 7 to 10 days later. If a single application is used, apply when tallest thistles are 8 to 12 inches.

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.

Glyphosate (Roundup) has given excellent quackgrass control in experiments when applied at 1 to 1½ pounds per acre. The chemical is applied as a spray on the foliage of actively growing quackgrass in the fall or spring before plowing. The field may be plowed and planted three or more days later. Underground rhizomes as well as topgrowth are killed. Other vegetation is also

killed. Glyphosate is not active through the soil and leaves no residue in the soil that affects subsequently planted crops. Normal control practices are needed to control annual weeds in crops grown after glyphosate applications. Glyphosate is cleared for use in fields before planting barley, corn, oats, sorghum, soybeans, wheat, alfalfa, edible beans, peas, forage grasses for seed production and turf or for spot treatment in these crops. The crop in the treated area will be killed. Special precautions should be followed to avoid drift.

Atrazine is an effective herbicide for quackgrass control. Pre-plow 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 before plowing on the foliage of quackgrass sod in the fall or early spring and 1 to 2 pounds per acre on the corn as a preemergence or early postemergence treatment, have the advantage of controlling annual weeds in the corn as well as eliminating the quackgrass. Adding crop oil to atrazine improves control from foliar applications.

Preplanting incorporated applications of EPTC (Eptam, Eradicane) may be used to control quackgrass, but results have been somewhat inconsistent. Use of EPTC in the spring following fall application of glyphosate or atrazine has looked promising in research trials with corn. The higher rates of EPTC labelled for the crop to be planted should be used to control quackgrass. Before applying EPTC, the field should be plowed, then disked, to thoroughly cut up the rhizomes. Control has been better where plowing was at an 8-inch depth than at a 4-inch depth.

Dalapon (Dowpon, Radapon) applied postemergence in the fall to the foliage of actively growing quackgrass has given fair to good quackgrass control the following year. Dalapon should be applied at 11 pounds per acre in the fall and followed by plowing or other similar tillage 1 to 2 weeks after application. Repeated treatments in successive years may be needed to eradicate quackgrass. Control is better if rain occurs between treatment and plowing. Corn, dry beans, some varieties of potatoes, and sugarbeets may be planted in the spring following fall treatment. However, some crop injury may occur if it has been dry following application of dalapon. Use of a surfactant in the spray mixture with dalapon will improve wetting of the foliage and grass control.

Dalapon may also be applied to quackgrass in the spring, but spring applications are not as practical as fall applications in Minnesota because planting is delayed and there is more risk of crop injury from dalapon residues in the soil. The lower rate, 6 pounds per acre, that can be used in the spring is less effective on the quackgrass than the higher rates that can be used in the fall. Corn, dry beans, some varieties of potatoes, and sugarbeets may be planted but not until at least 4 weeks after the dalapon application.

Yellow Nutsedge

Yellow nutsedge is a perennial weed that propagates from seeds and from underground rhizomes and tubers (nuts) that are formed on the rhizomes. The grass-like leaves of nutsedge are light green and the seedheads are yellow to brown. The nuts are $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter and tan to brown in color. The stems are triangular in cross section. Nutsedge usually becomes established in wet areas of fields. The weed is spread by tillage operations which scatter the seeds, rhizomes, and nuts.

Nutsedge can be controlled, but usually not eliminated, by using a combination of cultural practices and chemicals. Infested spots of fields should be tilled separately from the remainder of the field to avoid dragging plant parts to clean areas of the field. Nutsedge is not tolerant of intense shade. So growing crops with a dense canopy such as narrow-rowed soybeans helps suppress

nutsedge. Repeated cultivations are usually needed to destroy regrowth and new seedlings, even where chemicals are used.

Following has given effective control in dry years, but, in wet years, the tubers are just transplanted and continue to grow. Disking or dragging about every 3 weeks or when sprouts appear should considerably reduce the nutsedge population in a dry year.

Preplanting incorporated application of high rates of alachlor (Lasso), metolachlor (Dual), butylate with protectant (Sutan +), or EPTC with protectant (Eradicane) in corn and alachlor or vernolate (Vernam) in soybeans usually gives good nutsedge control. If other crops that are tolerant to EPTC such as potatoes, sunflowers, or dry edible beans can be grown in the infested areas, EPTC without the protectant may be used to control nutsedge. Alachlor, metolachlor, and propachlor (Ramrod, Bexton) applied pre-emergence have sometimes controlled nutsedge, but have not been as effective as the preplanting treatments discussed above.

Some regrowth and new plants can be expected to occur following herbicide applications. These can be controlled by cultivation. In corn, early postemergence applications of atrazine and oil have been effective in controlling regrowth following preplanting treatments with the chemicals discussed above. Directed applications of linuron (Lorox) or ametryne (Evik) have also been partially effective for controlling nutsedge in larger corn.

Bentazon (Basagran) may be used as a postemergence treatment to control nutsedge in corn, dry beans and soybeans. Two applications of $\frac{3}{4}$ to 1 pound per acre each have been more effective than a single application of 1 to 1½ pounds per acre. The first application should be when the nutsedge is 6 to 8 inches tall. Repeat the treatment 7 to 10 days later. If a single application is used, apply when the tallest nutsedge is 6 to 8 inches. Addition of a non-phytotoxic oil concentrate increases the activity of bentazon.

Volunteer Corn in Soybeans

Volunteer corn may be reduced in soybean fields by proper harvest techniques to avoid losses, fall plowing to bury dropped

ears and kernels, delayed planting and tillage to kill germinated corn prior to planting soybeans. After soybeans have emerged, volunteer corn may be removed by cultivation, hoeing and hand pulling. Two herbicides, diclofop (Hoelon) and selective applications of glyphosate (Roundup) have satisfactorily controlled corn in recent research.

Diclofop (Hoelon) has controlled corn in soybeans when applied as a postemergence treatment at $\frac{3}{4}$ to 1 pound per acre when the corn was 10 to 12 inches tall. Soybeans have good tolerance to diclofop, although some leaf spotting may occur. Volunteer corn from some hybrids shows some tolerance to low rates of diclofop. The higher rates of application suggested on the label have usually controlled even the more tolerant corn. Good spray coverage is necessary for diclofop to kill the corn. Corn plants that are protected from the spray by the canopy of other corn in clumps or by taller growing soybeans or weeds may not be controlled by the spray. Banded and directed sprays of diclofop may improve control as well as reduce costs compared to overall sprays. **Caution:** As of December 1979, diclofop is not labelled for use on soybeans, but clearance is expected for the 1980 season.

Volunteer corn in soybeans can also be killed with spot applications of glyphosate (Roundup). However, glyphosate is nonselective and will kill soybeans as well as corn contacted by the spray. Recently, many devices have been developed to selectively apply glyphosate to corn and other weeds that are growing taller than the soybeans. These devices include the recirculating sprayer, roller applicator, rope wick applicator, and various modifications of these. With all of these devices, there must be sufficient height differential between the soybeans and the corn or other weeds to allow chemical application to the corn and weeds without contacting the soybeans. Careless use or malfunctioning equipment can result in crop damage with any of these applicators. Satisfactory control may require more than one application, since all of the corn plants or weeds may not be taller than the soybeans at the time of treatment. Delaying treatment until more corn is taller than the soybeans could result in increased soybean yield reduction and more application problems due to the taller corn and weeds.

Table 7. Herbicide names and formulations

Common name	Trade name ¹	Concentration and commercial formulation ²
Alachlor	Lasso	4 lb/gal L
	Lasso II	15% G
Alachlor and atrazine	Lasso + atrazine	9 + 6% G
Ametryn	Evik	80% WP
Amitrole	Amino-triazole, Amizol, Weedazol, Mixtures	50, 90% WSP
Amitrole and simazine	Amizine	15% amitrole WSP 45% simazine WP
Amitrole-T	Amitrol-T, Cytrol	2 lb/gal L
AMS	Ammate	95% WSP
Asulam	Asulox	3.34 lb/gal L
Atrazine	AAtrex, Atrazine, Several, Mixtures	80% WP, 4 lb/gal L 8% P, 90% WDG
Atrazine and metolachlor	Bicep	2 lb/gal atrazine, 2½ lb/gal metolachlor
Barban	Carbyne	1 lb/gal L
Benefin	Balan	1½ lb/gal L
Bentazon	Basagran	4 lb/gal L
Bifenox	Modown	80% WP, 4 lb/gal L
Boron compounds (Borax, sodium pentaborate, boron trioxide, anhydrous sodium, bitorate, and mixtures.)	Several, Mixtures	Various
Bromacil	Hyvar-X, Hyvar-XL Mixtures	80% WP, 2 lb/gal L, Various
Bromoxynil	Buctril, Brominal	2 lb/gal L
Bromoxynil and MCPA	Bronate, Brominal Plus	2 lb/gal MCPA L 2 lb/gal bromoxynil L
Butylate and protectant	Sutan +	6, 6.7 lb/gal L, 10% G
Chloramben	Amiben	10% G, 2 lb/gal L
Chlorpropham (CIPC)	Furloe Chloro IPC Mixtures	10% G 4 lb/gal L
Cyanazine	Bladex	80% WP, 15% G, 4 lb/gal L
Cycloate	Ro-neet	6 lb/gal L
Dalapon	Basfapon, Dalapon 85, Dowpon M, Mixtures	74% WSP 5 lb/gal L

Table 7. Herbicide names and formulations (con't)

Common name	Trade name ¹	Concentration and commercial formulation ²
Dalapon and TCA	Dowpon C.	46.5% dalapon, 26.2% TCA WSP
DCPA	Dacthal	50, 75% WP
Desmedipham	Betanex	1.3 lb/gal L
Diallate	Avadex	4 lb/gal L, 10% G
Dicamba	Banvel, Mixtures	4 lb/gal L
Dicamba and 2,4-D	Banvel-K	1.25 lb/gal dicamba 2.50 lb/gal 2,4-D
Dicamba and 2,4,5-T	Banvel 2 + 2	2 lb/gal dicamba 2 lb/gal 2,4,5-T
Dicamba and MCPA	Banvel-M, MonDak	1.25 lb/gal dicamba, 2.50 lb/gal MCPA L
Diclofop	Hoelon	3 lb/gal L
Difenzoquat	Avenge	2 lb/gal L
Dinitramine	Cobex	2 lb/gal L
Dinoseb (DNBP)	Several, Mixtures	1, 3, 5 lb/gal L 10% G
Diuron	Karmex, Mixtures	L, WP, G Varies
Endothal	Endothal, Herbicide 273	1.46 lb/gal L 3 lb/gal L 5% G
EPTC	Eptam	6, 7 lb/gal L, 10% G
EPTC and protectant	Eradicane	6.7 lb/gal L
Ethofumesate	Nortron	1½ lb/gal L
Fenac	Fenac, Mixtures	1½ lb/gal L 10% G
Fenac and amitrole and atrazine	Fenamine	.55 lb/gal fenac, .33 lb/gal amitrole, 1.0 lb/gal atrazine L
Fluchloralin	Basalin	4 lb/gal L
Glyphosate	Roundup	3 lb/gal L
Linuron	Lorox, Mixtures	50% WP
MCPA	Several, Mixtures	Various L
Metolachlor	Dual	6 and 8 lb/gal L
Metribuzin	Sencor, Lexone	50% WP, 4 lb/gal L, 75% DF
Naptalam (NPA)	Alanap	2 lb/gal L, 10% G

¹"Several" means there are numerous trade names for this chemical. "Mixtures" means the chemical is mixed with other chemicals in commercial formulations.
²G — Granular, L — Liquid, WDG — water dispersible granule, WP — wettable powder, WSP — water-soluble powder, P — pellets, DF — dry flowable.

Table 7. Herbicide names and formulations (con't)

Common name	Trade name ¹	Concentration and commercial formulation ²
Naptalam and dinoseb (DNBP)	Dyanap, Kleen Krop	2 lb/gal naptalam 1 lb/gal dinoseb L
Paraquat	Paraquat	2 lb/gal L
Pebulate	Tillam	6 lb/gal L
Pendimethalin	Prowl	4 lb/gal L
Phenmedipham	Betanal	1.3 lb/gal L
Picloram	Tordon 22K, Tordon 10K Tordon Beads, Tordon K, Amdon 10K	10%, 2% G 2 lb/gal L
Picloram and 2,4-D	Tordon 212, Tordon 101 Amdon 101	1 lb/gal picloram + 2 lb/gal 2,4-D L ½ lb/gal picloram + 2 lb/gal 2, 4-D L
Profluralin	Tolban	4 lb/gal L
Prometone	Pramitol	2 lb/gal L 5% P
Pronamide	Kerb	50% WP
Propachlor	Ramrod, Bexton	65% WP, 4 lb/gal L 20% G
Propanil	Stampede 3	3 lb/gal L
Propazine	Propazine, Milogard	80% WP
Pyrazon	Pyramin	76% WP
Simazine	Princep, Mixtures	80% WP, 4% G, 4 lb/gal L
Sodium chlorate	Several, Mixtures	WSP Various
TCA	TCA, Mixtures	4.76 lb/gal L 79.3% WSP
Terbacil	Sinbar	80% WP
Terbutryn	Igran	80% WP
Triallate	Far-go, Avadex-BW	4 lb/gal L 10% G
Trifluralin	Treflan	4 lb/gal L. 5% G
2,4-D	Several, Mixtures	L, G Various
2,4-DB	Butryac 200 Butoxone	2 lb/gal L
Vernolate	Vernam	6, 7 lb/gal L 10% G

¹"Several" means there are numerous trade names for this chemical. "Mixtures" means the chemical is mixed with other chemicals in commercial formulations.

²G— Granular, L— Liquid, WDG— water dispersible granule, WP— wettable powder, WSP— water-soluble powder, P— pellets, DF— dry flowable.

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 feed.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Corn	alachlor (Lasso) (Lasso II)	2 to 4 2.4 to 3.9	Preemergence or preplanting		None
	metolachlor (Dual)	1.5 to 3	Preplanting or preemergence		Do not graze, feed forage or use for silage.
	atrazine	1 to 3	Preplanting, preemergence or early post-emergence	Atrazine may injure crops the following year	Do not graze or feed forage for 21 days after treatment
	EPTC with protectant (Eradicane)	3 to 6	Preplanting incorporation	Do not use on corn seed stock.	None
	butylate (Sutan +)	4 to 6	Preplanting incorporation	Do not use on corn seed stock (Breeders, Foundation, Increase)	None
	propachlor (Ramrod, Bexton)	4 to 6	Preemergence		None
	cyanazine (Bladex)	2 to 4 2	Preemergence Early Postemergence	Do not use on sandy soils.	None
	atrazine and alachlor	1 to 2+ 1½ to 2½	Preplanting or preemergence		Do not graze or feed forage for 21 days after treatment.
	atrazine and metolachlor	1 to 2+ 1¼ to 2½	Preplanting or preemergence		Do not graze, feed forage or use for silage
	cyanazine and alachlor	1 to 2.2+ 2 to 2½	Preplanting or preemergence	Do not use on sandy soils.	None
	cyanazine and propachlor	1 to 1.8 + 2.5 to 6	Preemergence	Do not use on sands with less than 2% organic matter.	None
	dicamba (Banvel) + alachlor	½ + 2 to 2½	Preemergence	Do not use on sandy soils or soils with less than 2.5% organic matter	Do not graze or feed silage prior to milkstage.
	atrazine and butylate	1 to 1½ + 3 to 4	Preplanting incorporation	Do not use on corn seedstock (Breeders, Foundation, Increase)	Do not graze or feed forage for 21 days after treatment. None
	cyanazine and butylate	1 to 2 + 3 to 4	Preplanting incorporation		
	atrazine and EPTC (Eradicane)	1 to 1½ + 3 to 4	Preplanting incorporation	Do not use on corn seedstock.	None
	cyanazine and EPTC (Eradicane)	1½ to 2 + 3 to 4	Preplanting incorporation	Do not use on corn seedstock.	None
	atrazine and propachlor	1 to 1½ + 2 to 3¾	Preemergence		None
	linuron (Lorox) and alachlor	½ to 1½ + 1 to 3	Preemergence	Do not use on sandy soils.	Do not graze or harvest immature corn for feed within 12 weeks after treatment.
	linuron and propachlor	1 to 1½ + 2 to 3	Preemergence	Do not use on sandy soils.	None
	2,4-D amine	¼ to ½ } ⅙ to ⅓ }	Corn 4 inches to tasseling	Broadleaves only. Corn most susceptible during rapid growth. Use drop nozzles after corn is 8 inches tall.	Do not forage or feed fodder for 7 days following 2,4-D application.
	2,4-D ester				
	2,4-D amine 2,4-D ester	½ to 1 ⅓ to ⅔	Corn over 3 feet	Spray base of stalks only.	
dicamba (Banvel)	⅙ to ¼	Postemergence before corn is 2 feet tall and not within 15 days of tasseling.	See Precautions on page 6 to reduce risk of serious drift problems.	Do not graze or harvest for feed before milk stage.	
dicamba + 2,4-D amine	⅙ + ¼				
Bentazon (Basagran)	¾ to 1	Weeds 2 to 6 inches	Early applications most effective	None	

Table 8. Suggestions for chemical control of weeds in field crops (con't)

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Winter wheat	2,4-D amine 2,4-D ester MCPA	$\frac{1}{4}$ to $\frac{3}{4}$ $\frac{1}{4}$ to $\frac{1}{2}$ $\frac{1}{4}$ to $\frac{3}{4}$	Wheat fully tillered to boot stage.		Do not graze or feed forage from 2,4-D treated fields within 2 weeks after treatment. None for MCPA
	dicamba + MCPA amine	$\frac{1}{8}$ + $\frac{1}{4}$ to $\frac{3}{8}$				After winter dormancy until wheat begins to joint.
	dicamba + 2,4-D amine	$\frac{1}{8}$ + $\frac{1}{4}$ to $\frac{3}{8}$	Wheat fully tillered to boot stage	Do not forage or graze for 30 days after treatment with bromoxynil.	
	bromoxynil bromoxynil + MCPA ester	$\frac{1}{4}$ to $\frac{1}{2}$ $\frac{1}{4}$ + $\frac{1}{4}$			
Rye	2,4-D amine 2,4-D ester	$\frac{1}{4}$ to $\frac{3}{4}$ $\frac{1}{4}$ to $\frac{1}{2}$	Rye fully tillered to boot stage		Do not graze or feed forage from 2,4-D treated fields for 2 weeks after treatment.
Spring wheat	trifluralin (Treflan)	$\frac{1}{2}$ to $\frac{3}{4}$	Postplanting incorporation	Improper application may result in wheat injury.	None
Spring wheat or barley	2,4-D amine 2,4-D ester	$\frac{1}{4}$ to $\frac{2}{3}$ $\frac{1}{6}$ to $\frac{1}{2}$	Fifth leaf to early boot	Amine less injurious to crop. May injure legumes.	Do not forage or graze for 2 weeks after treatment.
	MCPA amine MCPA ester	$\frac{1}{4}$ to $\frac{2}{3}$ $\frac{1}{6}$ to $\frac{1}{2}$				Two leaf to early boot	May injure legumes.	None
	bromoxynil and MCPA esters bromoxynil (Brominal, Buctril)	$\frac{1}{4}$ + $\frac{1}{4}$ $\frac{1}{4}$ to $\frac{1}{2}$	Two leaf to early boot Two leaf to early boot	Use for smartweeds or wild buckwheat. Do not use on underseeded legumes.	Do not forage or graze for 30 days after treatment.
Spring wheat or oats	dicamba and MCPA amine	$\frac{1}{8}$ + $\frac{1}{4}$	Two- to five-leaf stage			Kills legumes. Use if weeds include smartweeds or wild buckwheat.	Do not graze treated areas or harvest for dairy feed prior to crop maturity.
Oats	2,4-D amine	$\frac{1}{4}$ to $\frac{1}{2}$	Sixth leaf to early boot	MCPA less injurious to crop.	Do not forage or graze for 2 weeks after treatment.
	MCPA amine MCPA ester bromoxynil	$\frac{1}{4}$ to $\frac{2}{3}$ $\frac{1}{6}$ to $\frac{1}{2}$ $\frac{1}{4}$ to $\frac{3}{8}$	Two leaf to early boot		None None Do not forage or graze for 30 days after treatment.
Flax	MCPA	$\frac{1}{4}$		Flax 2 to 6 inches	Mixture of MCPA amine with dalapon for broadleaved and grass weeds.	None
	dalapon	$\frac{3}{4}$	Flax 2 to 6 inches		
	EPTC (Eptam)	2 to 3	Preplanting incorporation		None
	bromoxynil	$\frac{1}{4}$ to $\frac{1}{2}$	Flax 2 to 8 inches	For smartweed, wild buckwheat in 2 to 4 leaf stage.	Do not graze for 30 days after treatment.
Alfalfa and clover in small grains	Some formulations of 2,4-D amine or MCPA amine (See label)	$\frac{1}{8}$ to $\frac{1}{4}$	Not before clover is 2 inches tall	Injures legumes. Canopy of crop or weeds reduces injury. Do not use on sweetclover.	Do not graze dairy animals on treated areas within 7 days after application of 2,4-D.

Table 8. Suggestlons for chemical control of weeds in field crops (con't)

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Alfalfa, sweet-clover, and birdsfoot trefoil in flax	MCPA amine	1/8 to 1/4	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.	None
Legume establishment without a companion crop	benefin (Balan)	1 1/8 to 1 1/2	Preplanting incorporation	Alfalfa only	None
	EPTC (Eptam)	2 to 3			None
	profluralin (Tolban)	1/2 to 1			None
	2,4-DB amine	1/2 to 1 1/2	1 to 4 trifoliolates on legumes	Sweetclover injured.	Do not graze within 60 days or cut hay within 30 days after application.
	2,4-DB ester	1/2 to 1			
Established alfalfa	2,4-DB amine	1/2 to 1 1/2	When annual weeds are 1 to 3 inches tall (2 to 5 leaves)	May injure alfalfa	Do not graze within 60 days or cut hay within 30 days after application.
	2,4-DB ester	1/2 to 1			
	simazine (Princep)	0.8 to 1.6	Fall	May injure alfalfa.	Do not graze for 30 days or cut hay for 60 days after treatment.
	metribuzin (Lexone, Sencor)	3/8 to 1	Fall or spring when alfalfa is dormant.	May injure alfalfa.	Do not graze or harvest within 28 days of application.
	terbacil (Sinbar)	1/4 to 3/4		May injure alfalfa.	Do not plant other crops within 2 years after application.
		pronamide (Kerb)	1 to 2	Fall	May injure alfalfa	Do not graze or harvest alfalfa within 25 to 45 days after application.
Established grass pastures	2,4-D	1/2 to 2	Before bud stage, preferably when weeds are 2 to 6 inches tall and growing vigorously. When woody plants are fully leaved.	Rate depends on kinds of weeds. Use low rates of MCPA if legumes are present. Use 2,4-D, dicamba or mixture of these for woody plant control. Avoid drift, especially of dicamba to susceptible crops, particularly soybeans and sunflowers.	Do not graze dairy animals on treated areas within 7 to 14 days after application of 2,4-D. See label. Do not cut 2,4-D treated grass for hay for 30 days. Do not graze dairy animals for 7 to 21 days after application of these rates of dicamba. See label.
	MCPA dicamba	1/4 to 2 1/2 to-1			
Dry edible beans	chloramben (Amiben)	3	Preemergence		None
	EPTC (Eptam)	3	Preplanting incorporation		None
	trifluralin (Treflan)	1/2 to 1	Preplanting incorporation		None
	profluralin (Tolban)	1/2 to 1	Preplanting incorporation		None
	dinitramine (Cobex)	1/3 to 2/3	Preplanting incorporation		None
	alachlor (Lasso)	2 1/2 to 3	Preplanting incorporation		None
	bentazon (Basagran)	3/4 to 1	Postemergence	Beans in first trifoliolate, weeds small	None

Table 8. Suggestions for chemical control of weeds in field crops (con't)

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Grain sorghum	propachlor (Bexton, Ramrod)	4 to 5	Preemergence	Grass weeds only.	Do not graze or feed forage to dairy animals.
	propazine (Milogard)	2	Preemergence		None
	atrazine and propachlor	1 to 1.6 + 2½ to 4	Preemergence		Do not graze or feed forage to dairy animals.
	propazine and propachlor	0.8 to 1 + 2¼ to 3	Preemergence		Do not graze or feed forage to dairy cattle.
	atrazine	1.6 to 2.4	Preemergence or early postemergence		Do not graze or feed forage from treated area within 21 days after application.
	2,4-D amine	½	4 to 12 inches	For broad-leaved weeds.	None
Tame mustard	trifluralin (Treflan)	½ to ¾	Preplanting incorporated		None
Soybeans	alachlor (Lasso) (Lasso II)	2 to 4 2.4 to 3.9	Preemergence or preplanting	Incorporate preplanting for nutsedge control.	None
	chloramben (Amiben)	3	Preemergence		None
	chlorpropham (Furloe Chloro IPC)	2 to 3	Preemergence or preplanting	For smartweed control.	None
	chloramben and alachlor	2 + 2	Preemergence		None
	linuron (Lorox) and alachlor	½ to 1½ + 1 to 3	Preemergence	For medium textured soils with less than 4% organic matter	Do not graze or feed soybean hay or forage.
	metolachlor (Dual)	1½ to 3	Preemergence or preplanting	Incorporate for nutsedge control	
	chloramben and metolachlor	2 + 1½ to 2	Preemergence or preplanting		
	linuron and metolachlor	½ to 1½ + ¼ to 2½	Preemergence	Do not use on sands, gravelly soils or exposed subsoils.	
	metribuzin and metolachlor	¼ to ½ + 1¼ to 2½	Preemergence or preplanting	Do not use on sandy soils, soils with less than 0.5% organic matter or soils with pH over 7.4	
	metribuzin (Sencor, Lexone) and alachlor	¼ to ½ + 2 to 2½	Preemergence	See page 12.	None
	dinitramine (Cobex)	⅓ to ⅔	Preplanting	Must be incorporated.	None
	fluchloralin (Basalin)	½ to 1½	Preplanting	Must be incorporated	Do not graze or feed forage.
	pendimethalin (Prowl)	½ to 1½	Preplanting	Incorporate	None
	profluralin (Tolban)	½ to 1	Preplanting	Must be incorporated.	None
	trifluralin (Treflan)	½ to 1	Preplanting	Must be incorporated.	None
	vernolate (Vernam)	3	Preplanting	Incorporate immediately	None
bentazon (Basagran)	¾ to 1½	Soybeans in first trifoliolate, weeds less than 2 inches	Controls most annual broadleaves, Canada thistle, nutsedge	Do not feed treated forage or hay to livestock.	
2,4-DB amine	⅓	Postemergence directed	For cocklebur control.	Do not harvest within 60 days after application.	

(See pages 12-13 for information on mixtures.)

Table 8. Suggestions for chemical control of weeds in field crops (con't)

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Sugarbeets	TCA	5 to 7	Preemergence	For grass weeds except wild oat.	Do not use treated tops for food or feed.
	pyrazon (Pyramin) + TCA	3.8 to 7.6 + 5 to 7	Preemergence	Use only on medium to coarse textured soil with less than 5% organic matter	None
	dalapon	2 to 3	Beets up to 6-leaf stage	For grass weeds except wild oat.	None
			Directed, beets 7-leaf stage to 14 inches		
	diallate (Avadex)	1½ to 2	Preplanting incorporation	For wild oat.	Do not graze unharvested crop
	barban (Carbyne)	¾ to 1	Wild oat in two-leaf stage	For wild oat.	Do not allow livestock to graze treated fields until after crop is harvested.
	phenmedipham (Betanal)	1 to 1½	Early postemergence	See page 14.	Do not apply within 90 days of harvest.
	desmedipham (Betanex)	1 to 1¼	Early postemergence	See page 14.	
	endothall	¾ to 1½	Early postemergence	For wild buckwheat and annual smartweed.	None
	EPTC (Eptam)	2 to 3	Preplanting incorporation	For grass and some broad-leaved weeds.	None
Ethofumesate (Nortron)	2 to ¾	Preplanting incorporation	See page 13.	None	
Sunflowers	chloramben (Amiben)	2 to 3	Preemergence		Do not graze or feed forage.
	dinitramine(Cobex)	⅓ to ⅔	Preplanting incorporation		None
	EPTC (Eptam)	3	Preplanting incorporation		None
	trifluralin (Treflan)	½ to 1	Preplanting incorporation		None
	profluralin (Tolban)	¾ to 1	Preplanting incorporation		Do not feed treated forage to livestock.

Table 9. Suggestions for chemical control of specific weeds on cropland. Follow label precautions carefully.

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	EPA registration Remarks	EPA registration limitations on crop use	
Canada and sowthistle	2,4-D amine	½	Just before bud	Can spray in tolerant crops.	See crop	
	2,4-D ester	1	Fall rosette	Plow or clip in fall and spray when 6 inches.	See crop	
	dicamba (Banvel)	⅙ to ¼		See crop discussion. Drift may affect sensitive crops. Use for patch treatment of 2,4-D-resistant thistles.	See discussion sections on oats, wheat, corn, and pastures.	
	glyphosate (Roundup)	1½	Bud stage or in fall before frost	May be used before planting or for spot treatment in barley, corn, oats, sorghum, soybeans, wheat (kills crop)	Do not feed or forage subsequently grown crop for 8 weeks after application.	
	bentazon (Basagran)	¾ to 1 each time-two applications or 1 to 1½ one application	8- to 12-inch thistles Repeat 7 to 10 days later. 8- to 12-inch thistles	For soybeans or corn Split applications usually better than one.	See crop	
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	
	glyphosate (Roundup)	2¼ to 3¾	Full bloom to frost	May be used before planting or for spot treatment in barley, corn, oats, sorghum, soybeans, wheat (kills crops)	Do not feed or forage subsequently grown crop for 8 weeks after application.	
Germander, field mint	atrazine + oil	2	Early postemergence	For corn	See crop	
	EPTC (Eradicane)	4 to 6	Preplanting, incorporated	For corn	See crop	
Jerusalem artichoke	2,4-D	⅔ to ½	6-inch artichoke. Repeat when regrowth reaches 6 to 8 inches.	Use during crop tolerant periods in corn, small grains, pastures.	See crop	
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.	See crop	
	2,4-D ester	½	Bud	In corn, wheat, or barley. Cultivate after harvest until freezeup.	See crop	
Yellow nutsedge	metolachlor (Dual)	3	Preplanting, incorporated	For corn, soybeans	See crop	
	alachlor (Lasso)	4		For corn, soybeans	See crop	
		3		For dry beans	See crop	
	butylate (Sutan +)	4 to 6		For corn	See crop	
	EPTC (Eptam)	3		For dry beans, sugarbeets, sunflowers	See crop	
	EPTC + protectant (Eradicane)	4 to 6		For corn	See crop	
	vernolate (Vernam)	3		For soybeans	See crop	
	atrazine + oil	2		Postemergence after a preplanting treatment when nutsedge is less than 3 inches tall.	For corn	See crop
	bentazon (Basagran)	¾ to 1 each time-two applications or 1 one application		6- to 8-inch nutsedge Repeat 7 to 10 days later. 6- to 8-inch nutsedge	For soybeans or corn Split applications usually better than one.	See crop

Table 9. Suggestions for chemical control of specific weeds on cropland. Follow label precautions carefully (con't)

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	EPA registration Remarks	EPA registration limitations on crop use
Quackgrass	dalapon (Dowpon)	11	Fall	Foliage application, plow 1 or 2 weeks later. May plant corn, dry beans, some varieties of potatoes, sugar-beets next spring.	Do not graze treated areas in year treated.
	EPTC (Eradicane)	6	Preplanting incorporated	For more consistent control, apply glyphosate or atrazine in the fall followed by EPTC in the Spring.	
Quackgrass Wirestem muhly (muhlenbergia)	atrazine	2 to 4	Spring or fall Split application in fall and spring preferred.	Use low rate on sandy soils. Only corn can be grown the year after treatment.	See corn.
	glyphosate (Roundup)	1½	Fall or Spring before plowing or for spot treatment in crop (kills crop)	Quackgrass should be at least 8 inches tall (3 to 4 leaf stage) and actively growing. For use before planting barley, corn, oats, sorghum, soybeans, wheat	Do not feed or graze treated crops within 8 weeks after application.
Wild oat	barban (Carbyne)	¼ to ⅝	When wild oat is in two-leaf stage. Before 4-leaf stage of spring small grains, before 12-leaf stage of flax, within 30 days after emergence of sugarbeet, sunflower, mustard, soybean	Rate for wheat, barley, flax. Two applications may be made.	Do not allow livestock to graze treated fields until after crop is harvested. Do not feed soybean forage or flax straw from treated fields.
	barban (Carbyne)	⅝		Rate for semidwarf wheat varieties, sunflower, mustard, soybeans	
	barban (Carbyne)	¾ to 1	Rate for sugarbeets.		
	diallate (Avadex)	1½ to 2 (liquid)	Preplanting or preemergence, fall or spring	Rate for flax and sugarbeets; must be incorporated into soil.	None
	diallate (Avadex)	1½		Rate for corn	
	diallate (Avadex)	1½ to 2 (granules)	Fall or spring, preplanting incorporated.	For sugarbeets.	None.
	triallate (Far-go)	1 to 1¼ (wheat) 1¼ to 1½ (barley)	Preplanting or preemergence fall or spring.	Must be incorporated into soil. Use the higher rate for granules, lower rate for liquids.	Do not graze livestock on treated areas.
difenzoquat (Avenge)	⅝ to 1	When wild oat has 3 to 5 leaves.	For barley, winter wheat, Era, Olaf, Kitt and Butte spring wheat varieties, all durum varieties except Lakota and Wascana	Do not graze treated fields or cut for silage. Grain and straw can be fed.	

Weights and Measures

1 pound = 16 ounces; 454 grams.
1 ounce = 28.35 grams.
1 gallon = 4 quarts; 8 pints; 128 fluid ounces; 256 level tablespoons; 3,785 cubic centimeters; (milliliters); 3.785 liters
1 tablespoon = 3 teaspoons; ½ fluid ounce; 14.8 milliliters.
1 pound per acre = 1.12 kilogram per hectare.
1 kilogram per hectare = 0.892 pounds per hectare.

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.
1 hectare = 2.47 acres.
1 liter = 1.057 quarts
1 kilogram 2.205 pounds.

Table 10. 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				
	1/8 lb.	1/4 lb.	1/2 lb.	3/4 lb.	1 lb.**
Pounds of active ingredient or acid equivalent per gallon	<u>pints</u>	<u>pints</u>	<u>pints</u>	<u>pints</u>	<u>pints</u>
1	1.0	2.0	4.0	6.0	8.0
1 1/2 .....	.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	<u>lb.*</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>
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.

**DO NOT USE THIS PUBLICATION AFTER
DECEMBER 31, 1980**

For information on weed control in other crops see

1980 Weed Insect and Disease Control Guide for Commercial Vegetable Growers Special Report 5 Agricultural Extension Service University of Minnesota

1980 Commercial Fruit Spray Guide—Weed Insect and Disease Control Special Report 6 Agricultural Extension Service, University of Minnesota

