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# 1987 AGRICULTURAL WEED CONTROL GUIDE

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## INTRODUCTION

THE WEED CONTROL SUGGESTIONS are based on Federal label clearances and on information obtained from the North Dakota Agricultural Experiment Station and the Research Report of the North Central Weed Control Conference.

**CAUTION:**
The weed control suggestions in this circular are based on the assumption that all herbicides mentioned in this guide will continue to have a registered label with the Environmental Protection Agency.

**USE PESTICIDES ONLY AS LABELED.** Certification is required for purchase and use of restricted use herbicides, picloram (Tordon), diallate (Avadex), diclofop (Hoelon), paraquat (Gramoxone), sulfuric acid, amitrole (Amitrol-T, Cytrol), and cyanazine (Bladex).

RATES ARE BASED on broadcast application and are expressed as active ingredient or acid equivalent, and as the amount of commercial product. Commercial formulations of the same herbicide may vary in their amount of active ingredient. For example, a pint of 4-pound acid equivalent per gallon 2,4-D contains 0.5 pound, while a pint of 6-pound acid equivalent per gallon contains 0.75 pound. Three pounds of atrazine (AAtrex 80W) powder contains 2.4 pounds active ingredient ($3 \times 0.80 = 2.4$), or 3 pounds active ingredient is 3.75 pounds of product ($3 \div 0.80 = 3.75$).

WEED COMPETITION reduces crop yields severely, unless weeds are removed when small. Good cultural practices are one of the many methods of controlling weeds. However, selective herbicides at the recommended rate will control many annual weeds satisfactorily without damaging the crop in which the weeds are growing.

## HERBICIDE USE INFORMATION

**POSTEMERGENCE HERBICIDES:**

1. Effectiveness of postemergence herbicides is influenced by crop tolerance, weed species and climatic conditions and should be considered in determining the rate of herbicide to apply. A range of rates is given for most of the herbicides in this circular. Use the lowest recommended rate of postemergence herbicides under favorable growing conditions when weeds are small and actively growing. Under adverse conditions of drought or prolonged cool weather, or for well established weeds, use the highest suggested rate, except for barban (Carbyne 2EC). (See paragraph 124.)

2. Ideal temperatures for applying most postemergence herbicides are between 65 and 85 F. Below 60 F weeds are killed very slowly or not at all; above 85 F there is danger of herbicide injury to the crop. Avoid applying volatile herbicides such as 2,4-D ester, MCPA ester and dicamba (Banvel) during hot weather, especially near sensitive broadleaf crops, shelterbelts or farmsteads.

3. Rainfall shortly after application often reduces weed control from postemergence applications because the herbicide is washed off the leaves before absorption is complete. Herbicides vary in rate of absorption and in ease of being washed from leaves; therefore, herbicides vary in response to rainfall. The amount and intensity of rainfall influence the washing of herbicide from leaves. The approximate time between application and rainfall needed for maximum weed control from several herbicides follows:

| Herbicide | Time Interval | Herbicide | Time Interval |
|---|---|---|---|
| acifluorfen (Blazer) | 6 hours | diclofop (Hoelon) | 1 hour |
| atrazine + oil | 4 hours | difenzoquat (Avenge) | 6 hours |
| barban (Carbyne) | 5 minutes | fluazifop-P (Fusilade 2000) | 1 hour |
| bentazon + oil (Basagran) | 8 hours | glyphosate (Roundup) | 6 hours |
| bromoxynil (ME4 Brominal, Buctril) | 1 hour | 2,4-D or MCPA amine | 4 hours |
| | | 2,4-D or MCPA ester | 1 hour |
| dalapon (Dowpon) | 8 hours | propanil + MCPA (Stampede CM) | 4 hours |
| desmedipham (Betanex) | 6 hours | | |
| desmedipham + phenmedipham (Betamix) | 6 hours | sethoxydim (Poast) | 1 hour |

**SPRAY DRIFT:**

4. Offtarget movement of herbicides is a problem in North Dakota each year as herbicides move from target fields into nontarget fields containing crops susceptible to the herbicide. Spray drift and crop injury are affected by several factors.

   a) Spray particle size: Large droplets will drift less than small particles. Low spray pressures (20 to 30 psi) and nozzles which deliver high gallons per acre will increase spray droplet size.

   b) Wind velocity and direction: To minimize spray drift injury, wind direction should be away from susceptible crops during herbicide application. The wind velocity should be less than 10 miles per hour; however, drift can occur even with lower wind velocities.

   c) Distance between nozzle and target (boom height): Droplets should be released as close to the target as possible since less distance means less time to fall and therefore less drift.

   d) Herbicide formulation: All herbicides can drift as spray droplets but some herbicides are sufficiently volatile to cause plant injury from vapor or fume drift. 2,4-D and MCPA are formulated as amines or esters. The ester formulations may form damaging vapors while the amines are essentially non-volatile. Dicamba (Banvel) is also volatile and can drift as droplets or vapor. Herbicide vapor drifts further and over a longer time than spray droplets. A wind blowing away from susceptible plants during application will prevent

damage from droplet drift but a later wind shift towards the susceptible plants could move damaging vapors to the plants. Thus, to minimize the risk of drift injury, herbicides with high potential to form damaging vapors such as 2,4-D esters, MCPA esters, and dicamba should not be used near susceptible plants.

e) Drift control: Certain spray nozzles or spray systems such as the Delavan Raindrop nozzle, the Spraying Systems LP nozzle or controlled droplet applicators produce droplets less subject to drift. Nalco-Trol and other additives to spray mixtures cause larger droplets which reduce drift.

f) Drift injury from herbicides: Damaging drift to non-target plants is primarily a problem with 2,4-D, MCPA, dicamba, paraquat (Gramoxone), glyphosate (Roundup), and picloram (Tordon) in North Dakota. Other herbicides may drift but generally do not cause significant damage. Drift control techniques should not be used with postemergence herbicides that require small droplets for optimum performance such as barban (Carbyne 2EC), desmedipham (Betanex), and bentazon (Basagran).

5. Herbicide volatility and thus risk of damage to susceptible plants increases with increasing temperature. The so-called high volatile esters of 2,4-D or MCPA may produce damaging vapors at temperatures as low as 40 F while low volatile esters may produce damaging vapors between 70 and 90 F. Amine formulations are essentially non-volatile. The temperature on the soil surface often is several degrees warmer than air temperature, thus an applied low volatile ester could be exposed to temperatures high enough to cause damaging vapor formation even when the air temperature was below 70 F.

**PREEMERGENCE HERBICIDES:**

6. Good weed control with preemergence herbicides depends on many factors, including rainfall after application, soil moisture, soil temperature, soil type and weed species. For these reasons, preemergence chemicals applied to the soil surface sometimes fail to give satisfactory weed control. Herbicides which are incorporated into the soil surface usually require less rainfall after application for effective weed control than unincorporated herbicides. Weeds emerging through a preemergence herbicide treatment may be controlled by rotary hoeing or harrowing without reducing the effect of the herbicide.

**INCORPORATION OF HERBICIDES:**

7. Many herbicides which are applied before crop and weed emergence need to be incorporated to give optimum weed control. Included in this group are butylate (Sutan+, Genate+), cycloate (Ro-Neet), diallate (Avadex), EPTC (Eptam, Genep, Eradicane, Eradicane Extra), ethalfluralin (Sonalan), triallate (Fargo) and trifluralin (Treflan). Incorporation of alachlor (Lasso), ethofumesate (Nortron), metolachlor (Dual) and pendimethalin (Prowl) generally improves weed control.

8. Butylate, cycloate, diallate, EPTC and triallate should be incorporated immediately (within minutes) after application. Trifluralin incorporation may be delayed up to 24 hours if applied to a cool, dry soil and if wind velocity is less than 10 mph. Ethalfluralin incorporation may be delayed up to 48 hours. Pendimethalin must be used preemergence on corn but may be incorporated for soybeans. Incorporation often improves the performance of pendimethalin and may be delayed up to seven days after application. Alachlor, ethofumesate and metolachlor may be used preemergence but incorporation often improves performance especially on fine textured soils. Incorporation of alachlor, ethofumesate and metolachlor may be delayed several days.

9. An estimate of the efficiency of an incorporating tool can be obtained by operating the tool through flour or lime which has been spread thickly over the soil. A thorough incorporation should cover most of the flour or lime and mix it uniformly through the soil. Several tillage tools have been used successfully for the incorporation of herbicides. Some herbicides require more thorough incorporation than others and the incorporation method should be appropriate for the herbicide.

10. Butylate, cycloate, EPTC, ethalfluralin, pendamethalin and trifluralin require a thorough incorporation and should be incorporated by one of the following methods or a method which will incorporate similarly.

    a) A tandem disk should be set at a depth of 3 to 4 inches for pendimethalin and a depth of 4 to 6 inches for other herbicides. Operating speed should be 4 to 6 mph. Tandem disks with disk blades spaced 8 inches or less and a disk blade diameter of 20 inches or less have given good herbicide incorporation. Larger disks have often given streaked incorporation and poor weed control.

    b) Field cultivators of various types may be used. These should have overlapping sweep shovels with at least three rows of gangs and the operating depth should be 3 to 4 inches for pendimethalin and 4 to 6 inches for the other herbicides. A harrow should follow the field cultivator. The operating speed necessary to achieve a satisfactory incorporation will vary somewhat depending on the type of field cultivator but the speed usually will be 6 to 8 mph.

    c) Field cultivators with Danish tines and rolling crumblers behind have given good herbicide incorporation. These tools should be operated 4 inches deep and 7 to 8 mph or faster. Adequate incorporation with one pass may be possible with these tools if soil conditions are ideal for herbicide incorporation. However, a second incorporation may be good insurance against poor weed control.

    d) Power driven rototiller type equipment will give adequate incorporation when set to operate at a depth of 2 to 3 inches at the manufacturer's recommended ground speed.

11. A single incorporation with a power driven tiller is sufficient for butylate, cycloate, EPTC, and trifluralin. However, a second tillage at right angles to the initial incorporation should be done if the disk or field cultivator is used. The second incorporation has two purposes: a) Most of the herbicide left on the surface after the first incorporation will be mixed into the soil with the second tillage, and b) the second tillage will

give more uniform distribution of the herbicide in the soil which will improve weed control and may reduce crop injury.

12. Trifluralin (Treflan) may be applied to wheat and barley after planting and then incorporated above the seed. Shallow incorporation of trifluralin does not give as effective weed control as deep incorporation, but fair to good control of shallow germinating weeds such as green and yellow foxtail (pigeongrass) can be obtained.

13. Diallate (Avadex) and triallate (Far-go) will adequately control wild oats with a shallow incorporation. Two spike tooth harrowings at right angles will give sufficient incorporation if the soil is loose and free of trash. Experiments at North Dakota State University have shown that deeper incorporation generally enhances wild oats control from diallate or triallate. Triallate applied after seeding should be incorporated **less deeply** than the placement of the crop seed. Triallate applied before seeding should be incorporated with a field cultivator plus harrow operated 3 to 4 inches deep. Delay seeding for 3 days. Triallate applied before seeding may injure certain varieties. Spring preplant incorporated triallate has greater potential for injury to wheat than other application times. Refer to label for information on varieties which may be susceptible to preplant incorporated triallate.

**THE SOIL ORGANIC MATTER TEST:**

14. Certain herbicides are partially absorbed and inactivated by soil organic matter, so knowledge of the organic matter level will serve as a guide in selecting an effective herbicide and an effective herbicide rate. Herbicides such as atrazine, cycloate (Ro-Neet), EPTC (Eptam, Genep), linuron (Lorox) and pyrazon (Pyramin) require higher rates to be effective in high organic matter soils. However, crop safety may be marginal on low organic matter soils. Herbicides also are adsorbed to the clay fraction in a soil, thereby reducing weed control. However, organic matter level generally affects herbicide performance more than clay content.

15. EPTC is used on safflower, sugarbeets, sunflower, dry beans and potatoes. Sugarbeets have marginal tolerance to EPTC, so the rate must be adjusted on various soils to give good weed control without crop injury. The following discussion on selecting an EPTC rate only gives guidelines. Other factors such as method of incorporation affect EPTC performance (immediate and thorough incorporation gives best performance). Rates must be adapted for individual conditions. The suggested spring-applied EPTC rate is 2 to 3 lb/A. The 3 lb/A rate should give good weed control without crop injury on a soil with a silty clay texture and more than 7 percent organic matter. The minimum rate of 2 lb/A may injure sugarbeets on a sandy loam or coarse-textured soil with less than 4 percent organic matter. The EPTC rate should be adjusted within the 2 to 3 lb/A range when the soil is intermediate between the two extremes. EPTC at 2.5 lb/A should give good weed control and little crop injury on clay loams or fine-textured soils with more than 5 percent organic matter.

16. Some herbicides give good weed control only when organic matter levels are low. Linuron (Lorox) and pyrazon (Pyramin) have not been effective in the Red River Valley, except on the coarse-textured soils with less than 5 percent organic matter. The lower the organic matter, the more effective they become. The atrazine rate must be adjusted according to organic matter levels. Apply the high labeled rates on higher organic matter soils. Many herbicides such as diallate (Avadex), propachlor (Ramrod), triallate (Far-go) and trifluralin (Treflan) and most postemergence herbicides are affected only slightly by organic matter levels. Organic matter levels should be determined on each field where organic matter sensitive herbicides are to be used. Organic matter levels change very slowly and testing once every five years would be adequate.

**FALL APPLICATION OF HERBICIDES:**

17. Several herbicides may be applied in the fall for weed control the following spring. Included in this group are chlorsulfuron (Glean), diallate (Avadex), EPTC (Eptam, Genep), triallate (Far-go) and trifluralin (Treflan). Chlorsulfuron and trifluralin may be applied after September 1 and until soil freeze-up. Fall treatments of diallate (Avadex), EPTC (Eptam, Genep) and triallate (Far-go) should be applied after October 15 and until soil freeze-up. Application of herbicides after October 15 when soil temperature has cooled minimizes herbicide loss by volatilization, and microbial and chemical degradation. Both granular and liquid formulations of the herbicides except chlorsulfuron are registered for use in the fall. Fall applications of granular formulations generally have given more effective weed control than the liquid formulations, especially under heavy crop residue situations.

18. Chlorsulfuron (Glean) applied at 1/64 lb/A in the fall will control a number of annual weed species in spring wheat. Chlorsulfuron should be applied to undisturbed stubble where straw is spread evenly, or after cultivation to a uniform soil surface. Shallow tillage, not more than 4 inches deep, may be done after application. Spring tillage should be shallow. Do not moldboard plow.

19. Diallate (Avadex) applied at 1.25 to 2 lb/A in the fall controls wild oats. Diallate is volatile and must be incorporated into the upper 2 inches of soil immediately after application to prevent loss by evaporation. The liquid formulation of diallate may be applied in the fall for wild oats control in flax, barley and sugarbeets. The granular formulation of diallate is registered for use on sugarbeets only.

20. EPTC (Eptam, Genep) fall applied at 4 to 4.5 lb/A gives good control of annual grasses and certain broadleaf weeds. EPTC must be incorporated into the soil immediately after application to prevent loss of herbicide. The liquid and granular formulations of EPTC may be applied in the fall for weed control in dry beans, flax, potatoes, sugarbeets and sunflower.

21. Triallate (Far-go) is applied at 1 to 1.25 lb/A in the fall. The liquid formulation may be applied at 1 lb/A and the granules at 1.25 lb/A for wild oats control in barley, wheat, and durum. Triallate performs best when incorporated immediately after application; however, triallate granules may be surface applied in

the fall and incorporated with normal tillage operations the following spring. Fall surface applied triallate may perform less consistently than fall incorporated triallate. Research at North Dakota State University with fall applications indicates that, at similar rates, the granular formulation performs more effectively than the liquid formulation.

22. Trifluralin (Treflan) fall applied at 0.5 to 1 lb/A (depending on crop) gives good control of annual grasses and broadleaf weeds except wild mustard. Incorporation may be delayed 24 hours if applied to a cool, dry soil and if wind velocity is less than 10 mph. The liquid or granular formulations may be applied in the fall for weed control in soybeans, safflower, dry beans, sunflower, flax, and wheat.

**HERBICIDE COMBINATIONS:**

23. The recommended sequence of addition of formulations for tank mixes is a) water, b) wettable powders or dry flowables plus agitation, c) liquid flowables, d) emulsifiable concentrates, and e) solutions. Compatability testing as described in paragraph 25 can be used to determine if tank mixes of pesticides will form a uniform mixture in the spray tank. The effect of postemergence herbicides often is increased when applied to areas already treated with a preemergence or preplant herbicide. Combinations of certain postemergence herbicides or preemergence herbicides may give better weed control than use of the individual herbicide alone. However, loss of weed control or increased crop damage may result from the use of certain other herbicides in combination. Herbicide combinations should be used with caution until experience or research has shown that the combination is effective and safe. See the discussion on individual crops for more specific information.

24. All agricultural pesticides which are tank mixed should be registered for use as a mixture by the Environmental Protection Agency. Agricultural pesticides may be tank mixed if all pesticides in the mixture are registered by the Environmental Protection Agency on the crop being treated. However, users must assume liability for crop injury, inadequate weed control and illegal residues.

**HERBICIDE-LIQUID FERTILIZER COMBINATIONS:**

25. Thorough mixing and continuous, vigorous agitation are required to obtain an even application of herbicide-fertilizer combinations. Some herbicide-fertilizer combinations will not form a uniform mixture even with thorough agitation. Compatibility of the herbicide in the liquid fertilizer should be tested before the herbicide is added to the tank. The compatibility test may be conducted by combining small quantities of the components being mixed in the same proportions used in the spray tank. One teaspoon of liquid herbicide in 1.5 pints of fertilizer is equivalent to one quart of herbicide in 35 gallons of fertilizer. One teaspoon of dispersible granules in 1.5 pints of fertilizer is equivalent to one pound of granules in 16 gallons of fertilizer. One teaspoon of wettable powder in 1.5 pints of fertilizer is equivalent to one pound of wettable powder in 32 gallons of fertilizer. Wettable powders and dispersible granules should be mixed with a small amount of water to form a slurry before adding to the fertilizer. For other fertilizer volumes per acre or herbicide rates, adjust proportions accordingly. Close the jar and shake well. Watch the mixture for several seconds and check again 30 minutes later. If the mixture does not separate, the combination is compatible. If the mixture separates or gets very thick or syrupy, do not combine for field application. Mixing ability may be improved by adding a compatibility agent such as Compex or Unite. Different batches of fertilizer may differ in their mixing properties so should be tested separately.

**HERBICIDE-DRY FERTILIZER COMBINATIONS:**

26. Many preplant incorporated herbicides are registered for impregnation on dry bulk fertilizer. Ammonium sulfate, ammonium phosphate-sulfate, diammonium phosphate, potassium chloride, superphosphate, treble superphosphate, and urea are some of the approved fertilizer materials for impregnation. Impregnated fertilizer should be applied immediately and incorporated according to label instructions. Accurate spreader calibration and uniform fertilizer distribution are essential. Consult the herbicide label for minimum amounts of fertilizer per acre and for maximum amounts of herbicide per given weight of fertilizer. Ranges of 200 to 400 lbs/A of dry bulk fertilizer are recommended to maintain uniformity of herbicide application.

**HERBICIDE RESIDUE:**

27. The persistence of phytotoxic levels of a herbicide for more than one year can be a problem with some of the herbicides used in North Dakota. Herbicide residues are most likely to occur following years with unusually low rainfall because chemical and microbial activity needed to degrade herbicides are limited in dry soil. Crop damage from herbicide residues can be minimized by application of the lowest herbicide rate which will give good weed control, by using band rather than broadcast applications, and by moldboard plowing before planting the next crop. Moldboard plowing reduces phytotoxicity by diluting the herbicide residue in a large volume of soil. Moldboard plowing is ineffective for picloram (Tordon), chlorsulfuron (Glean), and metsulfuron (Ally).

28. Herbicide residues can often be detected by bioassay. A soil sample representative of the whole field must be obtained by sampling at many places to the depth of the tillage layer. Also, a sample of soil known to be free of herbicide residues must be obtained from near the treated field to serve as the untreated check. The samples should be dried and the clods broken so that the largest particles are no larger than a wheat kernel. Prepare at least two samples each of the untreated check soil and the test soil in pots or other containers with holes in the bottom for water drainage. The crop to be grown in the field should be used as one bioassay species. Preparing extra pots and testing a more susceptible

species may be helpful in detecting residues. Plant in each pot 12 seeds of large-seeded crops like corn or soybeans, or 20 seeds of small-seeded crops like cereals or flax. Water the soil for germination and plant growth as needed, but do not over-water. When the plants are about 2 inches tall, thin to about 6 large-seeded or 12 small-seeded uniform seedlings in each container. The containers should be placed in a warm place at about 70 to 75 F, and in direct sunlight. Observe the plants in the untreated check and test samples for two to three weeks after emergence. Some tangible measurements such as plant height and leaf length can be taken for evaluation, along with visual observation of abnormalities. Symptoms of some herbicides, like atrazine and metribuzin (Lexone/Sencor) develop slowly after food reserves in the seed have been depleted so symptoms may not be apparent soon after emergence. The soil should be washed from the roots to observe root growth, especially for dinitroaniline herbicides such as pendimethalin (Prowl) and trifluralin (Treflan).

29. Atrazine generally has a residue the year following application to corn at 2 to 4 lb/A in North Dakota. If soil moisture is deficient, 1 lb/A of atrazine may cause injury to susceptible crops the following year. Corn and millet are tolerant to atrazine while other crops vary in susceptibility. The approximate ranking of other crops from most to least tolerant is flax, soybeans, barley, wheat, oats, sunflower and sugarbeets.

30. Ethalfluralin (Sonalan), pendimethalin (Prowl), and trifluralin (Treflan) are similar herbicides called dinitroanilines. Under dry soil conditions these herbicides can persist in the soil for more than one year. Ethalfluralin has less soil residue than treflan and pendimethalin. Land treated with ethalfluralin in the spring may be planted to any crop the next year. However, ethalfluralin treated land should be moldboard plowed at least 6 inches deep before planting sugarbeets. Sunflower, soybeans, potatoes and dry edible beans are quite tolerant to dinitroaniline herbicides. The approximate ranking of other crops from most to least tolerant is flax, barley, wheat, corn, oats and sugarbeets.

31. Dicamba (Banvel) at 1 to 2 lb/A applied for perennial weed control may carryover in the soil. Corn, sorghum and soybeans may be planted in the spring following applications made during the previous year. Wheat may be planted in the fall or spring following applications.For all these crops injury may occur if the interval between application and planting is less than 45 days per 0.5 lb/A of dicamba used, excluding days when ground is frozen. Research at North Dakota State University indicated that dicamba at 1 qt/A applied in late September caused some visible injury to wheat and barley planted the following spring, but the effect on yield was minimal. Dicamba at 0.5 lb/A applied the previous fall prevented seed production by sunflower.

32. Picloram (Tordon) at 1/64 lb/A active ingredient (1 oz/A of formulated product) may carryover in the soil for more than one crop year. Only grass or grain crops such as small grains, corn, sorghum, or flax should be planted on fields treated with picloram the previous year. Sunflower, soybeans, dry edible beans and potatoes are especially susceptible to picloram.

33. Metribuzin (Lexone, Sencor) generally is used on soybeans in combination with other herbicides or is used on potatoes alone. No harmful metribuzin residues would be expected when used at 0.25 lb/A active ingredient. Rates over 0.5 lb/A may damage susceptible crops the next year. The approximate ranking of crops from most to least tolerant is potatoes, soybeans, dry edible beans, corn, barley, wheat, oats, sunflower, flax and sugarbeets.

34. Ethofumesate (Nortron) often has a residue the year following use on sugarbeets. The approximate ranking of crops from most to least tolerant is sunflower, soybean, corn, barley and wheat. Moldboard plowing usually will eliminate crop injury. Ethofumesate should be applied in a band to reduce cost and reduce potential crop injury from residues the following year.

35. Chlorsulfuron (Glean) at 1/128 lb/A active ingredient (1/6 oz/A of formulated product) or higher may carryover in the soil for more than 3 crop years. The most important factor influencing chlorsulfuron carryover in soil is pH. As soil pH increases, the rate of chlorsulfuron breakdown decreases. Chlorsulfuron should not be applied on soils with a pH above 7.5. Land previously treated with chlorsulfuron cannot be rotated to crops other than wheat, barley or oats until a field bioassay confirms that residues of chlorsulfuron are not present. The minimum recropping intervals are 0 months for wheat, 10 months for spring oats and 16 months for barley. The approximate ranking of crops from most to least tolerant is wheat, barley, oats, safflower, dry beans, sunflower, flax, corn, soybeans and sugarbeets.

36. Metsulfuron (Ally) at 1/267 lb/A (0.1 oz/A of formulated product) may carryover in soil for more than 3 crop years. The most important factor affecting metsulfuron carryover in soil is pH. As soil pH increases, the rate of metsulfuron breakdown decreases. Metsulfuron should not be applied to soils with a pH above 8.0. The minimum recropping intervals are 1 month for spring and winter wheat, 10 months for durum wheat, barley and oats, 22 months for proso millet, dryland sorghum, dryland corn, flax, safflower, and sunflower, and 34 months or more for all other crops. Land previously treated with metsulfuron should not be rotated to crops other than those listed above until a field bioassay confirms that residues of metsulfuron are not present.

## SMALL GRAINS-SPRING WHEAT (INCLUDING DURUM) BARLEY AND OATS

37. Weed control in small grains is important to maximize yields. Broadleaf weeds, foxtails (pigeongrass), and wild oats infest small grains statewide. Several applications of different herbicides or mixtures may be required to control all weeds. Normal height wheat varieties, rye, and winter wheat are more competitive than semidwarf wheat and thus will increase the effectiveness of herbicides. All small grains are sensitive to 2,4-D during the seedling stage but can be treated safely with MCPA from emergence until just

prior to the boot stage. Do not treat small grains in the boot stage. Wheat and barley, when treated from the fifth leaf until just prior to the boot stage, are more tolerant than oats to 2,4-D applications. Oats are more tolerant to MCPA than to 2,4-D, but injury to oats is possible with either chemical at any growth stage. Use 2,4-D on oats only for such hard-to-kill weeds as Russian thistle, kochia, common ragweed, and redroot pigweed and when the crop is in the third to fourth leaf stage. While some injury to the oats can be expected, the better control of these weeds with 2,4-D usually will compensate for any yield loss caused by the chemical. Oat varieties vary in their tolerance to 2,4-D MCPA, bromoxynil or chlorsulfuron, but wheat and barley varieties differ little in tolerance.

38. Dicamba (Banvel) at 0.06 to 0.12 lb/A controls wild buckwheat, smartweed and certain other broadleaf weeds in wheat, barley and oats. Dicamba can be applied alone but usually is applied with MCPA to increase control of wild mustard and other broadleaf weeds. Oats are more tolerant to dicamba than wheat. Both crops must be treated during the second through fourth leaf stage. Barley can be treated during the 2nd through 3rd leaf stage but barley tolerance is marginal. Dicamba also can be applied in combination with 2,4-D, bromoxynil or chlorsulfuron to wheat.

39. Picloram (Tordon) at 1/64 to 1/43 lb/A with 0.25 to 0.37 lb/A of 2,4-D or MCPA is labeled for broadleaf weed control in hard red spring wheat, barley and oats. Picloram may be applied during the 3rd through 5th leaf stage of crop growth. NOTE: Picloram should be used only on land that will be planted the following year to grass or grain crops including small grains, corn, sorghum, and flax. See herbicide residue section, paragraph 32.

40. Bromoxynil (Buctril, ME4 Brominal) controls wild buckwheat, fumitory and most annual broadleaf weeds in wheat, barley and oats from emergence of the crop to early boot. Mixtures of bromoxynil plus MCPA ester (Bronate, 3 + 3 Brominal) are applied from the 3rd leaf to early boot stage to improve wild mustard control.

41. Chlorsulfuron (Glean) controls false chamomile, wild mustard, and many annual broadleaf weeds in wheat preemergence or in wheat, barley and oats postemergence. Chlorsulfuron also suppresses growth of green and yellow foxtail when applied preemergence or early postemergence (less than 2 inches tall). See herbicide effectiveness table or herbicide label for more information on species controlled. Postemergence applications of chlorsulfuron should be applied with surfactant WK or X-77 at 0.25 to 0.50% v/v (1 to 2 qt/100 gal of spray). Fall applications of chlorsulfuron may be made to undisturbed stubble where straw is evenly spread, or after cultivation to a uniform soil surface. Do not moldboard plow. Tillage after application must be shallow. NOTE: See herbicide residue section, paragraph 35.

42. Metsulfuron (Ally) controls false chamomile, wild mustard and many annual broadleaf weeds in wheat and barley postemergence. Postemergence metsulfuron should be applied with surfactant of at least 80 percent active ingredient at 0.25 to 0.5 percent v/v (1 to 2 qt/100 gal of spray). See herbicide effectiveness table or herbicide label for more information on species controlled. Note: See herbicide residue section, paragraph 36.

43. Small grains underseeded to sweetclover, alfalfa or other legumes cannot be treated with 2,4-D, MCPA, bromoxynil, dicamba or picloram at rates required to control most broadleaf weeds without seriously injuring or killing the legumes.

**GREEN AND YELLOW FOXTAIL (PIGEONGRASS) CONTROL:**

44. Foxtails commonly infests small grains in North Dakota. Foxtails usually are most competitive when small grains are seeded late and soil temperatures are warm for foxtail germination and rapid growth. Fields which have been chisel plowed generally have more foxtails than moldboard plowed fields. Moldboard plowing buries the foxtail seed which prevents emergence and reduces viable seed for subsequent years.

45. Diclofop (Hoelon) at 0.75 to 1.25 lb/A in wheat or soybeans or 0.75 to 1 lb/A in barley applied postemergence controls foxtails in addition to wild oats. The lower rate is for green and yellow foxtail with one to three leaves. The higher rates are for foxtail growing in dry conditions or for foxtail with three to four leaves. Research at NDSU has indicated green foxtail is more susceptible than yellow foxtail to diclofop. (See wild oats section for information on diclofop mixtures with other herbicides, paragraph 128.)

46. Propanil + MCPA ester (Stampede CM) at 0.94 + 0.25 lb/A (2.5 pts product) controls wild buckwheat, redroot pigweed and many other annual broadleaf weeds in hard red spring wheat, durum wheat and barley. The propanil component of this mixture also controls foxtails. See tables for crop and weed stages. Propanil is not translocated, so good weed coverage by the spray is essential. Propanil should only be applied when temperatures at or after application are between 65 and 85 F and plants are actively growing with adequate soil moisture within 2 inches of the surface. Propanil should not be applied to wheat treated with carbamate or organophosphate insecticides or wheat grown on soil treated the previous year with organophosphate insecticides.

47. Trifluralin (Treflan) at 0.5 to 0.75 lb/A and harrow incorporated shallowly after seeding is labeled for control of foxtails in wheat and barley. The lower rate is for use on coarse textured soils and the higher rate on fine textured soils. Incorporation should be by harrowing twice at right angles and the depth of incorporation of the herbicide must be above the wheat seed. The wheat should be seeded 2 to 2.5 inches deep to permit incorporation above the seed. Some wheat varieties, especially semi-dwarfs, emerge poorly from deep seeding so seed should be placed no deeper than 2 to 2.5 inches. A heavy rain or irrigation immediately after trifluralin application has caused wheat injury on light and medium textured soils. Trifluralin applied in this manner does not control wild oats. (See wild oats section for discussion on trifluralin-triallate combination, paragraph 123.)

48. Trifluralin (Treflan) at 0.5 to 0.75 lb/A may be fall applied for control of foxtails on ground to be planted to wheat or barley the following spring. Some stand reduction may occur from fall applied trifluralin but wheat will usually tiller and compensate so no yield loss occurs. Trifluralin is available in both liquid and granular formulations. Granular formulations may be applied to standing stubble; liquid or granular formulations may be used when residue is at a manageable level that will not interfere with incorporation. Seed wheat or barley no more than 2 inches deep into a moist seedbed.

**VOLUNTEER SUNFLOWER:**

49. Volunteer sunflower is often a problem in small grains seeded in the rotation the year after sunflower and occasionally the second year. Tillage practices distribute the sunflower seeds to various depths in the soil causing emergence over several days or weeks depending on climatic conditions. Judgment may be needed in determining the time of herbicide application. Early herbicide application would not control late emerging sunflower and late application would allow competition from the early emerged sunflower. Generally application should be before the first sunflower is 4 inches tall and a second application may be needed for late emerging sunflower.

50. Bromoxynil at 0.25 lb/A plus MCPA ester at 0.25 lb/A (3 + 3 Brominal, Bronate) give excellent control of volunteer sunflower. Treated sunflower appear severely burned within several days and die within about one week after treatment. Dicamba (Banvel) at 0.12 lb/A plus MCPA amine at 0.25 lb/A, 2,4-D or MCPA at 0.5 lb/A, and picloram (Tordon) at 1/64 to 1/43 lb/A plus 2,4-D or MCPA at 0.37 lb/A all give good control of volunteer sunflower. These treatments will cause the sunflower to stop growing shortly after treatment, but they may remain green and alive for several weeks or more, depending on climatic conditions and crop competition. The approximate order of effectiveness on volunteer sunflower from most to least effective is bromoxynil + MCPA, dicamba + MCPA, 2,4-D + picloram, 2,4-D and MCPA.

**KOCHIA:**

51. Kochia is an exceptionally competitive weed and a few uncontrolled plants can cause severe yield losses. The proper rates of herbicides and spray volumes for thorough coverage should be used to maximize control. Dicamba (Banvel) at 0.125 lb/A plus MCPA amine at 0.25 lb/A gives good kochia control. 2,4-D at 0.5 lb/A gives good kochia control, but good spray coverage is essential because 2,4-D does not translocate readily in kochia. Treatment should be to small plants (less than 3 inches tall) or large spray volumes should be used to penetrate the kochia foliage. MCPA is less effective for kochia control than 2,4-D. However, MCPA at 0.5 lb/A will control small kochia. Bromoxynil at 0.25 lb/A plus MCPA at 0.25 lb/A also gives good control of kochia, but plants should be small and spray coverage good. Picloram (Tordon) is not effective on kochia, but when combined with 2,4-D at 0.37 lb/A, especially the ester, control is good.

**REDROOT PIGWEED:**

52. Redroot pigweed is another important weed in small grains. Rates of most herbicides need to be higher for redroot pigweed control than for control of wild mustard. Dicamba (Banvel) at 0.12 lb/A plus MCPA at 0.25 lb/A, 2,4-D at 0.5 lb/A, bromoxynil at 0.25 lb/A plus MCPA at 0.25 lb/A, and picloram (Tordon) at 1/64 to 1/43 lb/A plus 2,4-D at 0.37 lb/A all give good redroot pigweed control. MCPA is less effective than 2,4-D for redroot pigweed control. The esters of 2,4-D or MCPA are generally more effective than the amines for redroot pigweed control.

**FALSE CHAMOMILE:**

53. False chamomile is an important weed in small grains in north central and northeastern North Dakota. False chamomile is resistant to most of the herbicides used in small grains except chlorsulfuron (Glean) and metsulfuron (Ally). Fall or spring applications of chlorsulfuron at 1/64 to 1/43 lb/A or metsulfuron 1/267 lb/A control false chamomile. Refer to paragraph 35 and 36 for information on chlorsulfuron and metsulfuron use and residues. Bromoxynil at 0.37 lb/A plus MCPA at 0.37 lb/A gives fair to good control of small spring emerging false chamomile. The fall emerging plants which survive spring seedbed preparation are usually too large at treatment for adequate control. Thorough fall and spring tillage is essential to control fall emerged chamomile. False chamomile less than 6 inches tall in tree rows and around potholes can be controlled with paraquat (Gramoxone) at 0.5 lb/A with X-77 or other nonionic surfactant at 1 quart per 100 gallons of water. Glyphosate (Roundup) at 0.75 lb/A and amitrole (Amitrole T, Cytrol) at 1.5 lb/A control false chamomile less than 6 inches tall and can be used in tree rows and around potholes. Avoid drift to tree foliage when applying glyphosate or amitrole.

**HARROWING FOR WEED CONTROL:**

54. Harrowing a few days after a spring sown crop has sprouted but before it has emerged is effective in reducing stands of foxtails, wild oats and other weeds. The weeds must be emerging. Since foxtails are shallow rooted and easily controlled, set the teeth back on the harrow to minimize crop injury. Small grains can be harrowed after they have emerged and have two to four leaves but before tillering. Soil moisture should be good but with a dry solid surface. Wheat can be harrowed one to three times, but barley only once. Oats normally are not harrowed because it is injured more easily than wheat and barley.

## FLAX

55. Flax is less competitive with weeds than are small grains, and should be grown on relatively weed-free fields. Early after-harvest tillage of small grain stubble will prevent weed seed production, control perennial weeds and encourage annual weed seed germination prior to freeze-up. Weed problems will be

reduced when weeds are controlled in the preceding crop. Flax may be seeded directly or with shallow spring tillage in fields which did not have weed seed produced the previous year. Deep tillage on such fields could bring dormant seeds to the surface, increasing weed problems. If fields are weedy, moldboard plowing after a year of weed seed production will bury the weed seeds, reducing the weed infestation in the following crop season. Moldboard plowing is especially effective in reducing infestation of small seeded weeds like foxtails which have short seed survival. Delayed seeding of flax with tillage prior to seeding will control wild oats and reduce infestations of other early germinating weeds. However, delayed seeding generally reduces flax yields. Early maturing flax varieties should be used with late seeding. Flax is a poor competitor with weeds so control is needed before or soon after emergence to reduce flax yield losses. Preemergence herbicides control weeds before emergence which eliminates early weed competition and maximizes flax yields. Postemergence herbicides applied soon after weed emergence to small weeds and flax usually give better control and allow more time for flax recovery from possible herbicide injury than applications to larger weeds and flax.

56. EPTC (Eptam, Genep) fall applied at 4 lb/A controls annual grass weeds, including wild oats, and some broadleaf weeds in flax. Fall applied EPTC at 3 lb/A in coarse-textured soils generally has given good control with less flax injury than 4 lb/A. Incorporate EPTC immediately (within minutes) and thoroughly after application. (See paragraph 10 for incorporation discussion.) Flax stunting and stand loss may occur from EPTC application. Usually flax yields will not be reduced because the remaining plants will recover, branch out and compensate for a thin stand. Spring applied EPTC for flax was removed from registration.

57. Trifluralin (Treflan) at 0.5 to 1.0 lb/A may be fall applied for control of foxtails and some broadleaf weeds on ground to be planted to flax. Trifluralin is available in both liquid and granular formulations. Granular formulations may be applied to standing stubble; liquid or granular formulations may be used when residue is at a manageable level that will not interfere with incorporation. Seed flax less than 1.5 inches deep into a moist seedbed.

58. The flowable formulation of propachlor (Ramrod 4L) controls certain annual grasses and broadleaf weeds but is ineffective against wild oats, wild mustard and perennial weeds. Flax tolerance to propachlor is excellent. Propachlor incorporation will injure flax and reduce weed control.

59. MCPA at 0.25 lb/A on 2 to 6-inch flax controls most broadleaf weeds. MCPA amine rates higher than 0.25 lb/A and MCPA ester should be used in flax for improved kochia and Russian thistle control. Picloram (Tordon) + MCPA amine enhances redroot pigweed and wild buckwheat control.

60. Bromoxynil (ME4 Brominal, Buctril) at 0.25 to 0.5 lb/A on 2 to 6-inch flax controls wild buckwheat, volunteer sunflower and most broadleaf weeds. Some leaf burn may be observed at the higher rates or if high temperatures follow application. Mixtures of bromoxynil + MCPA may cause flax injury if applied under hot, humid conditions.

61. Dalapon (Dowpon) will control green and yellow foxtail in young flax. Apply dalapon as soon as possible after flax is 1 inch tall and the weeds are less than 2 inches tall for best results. CAUTION: Spraying must be completed prior to 6 inches tall or the early bud stage, whichever is earlier, to minimize flax injury. Generally, dalapon is applied in a mixture with MCPA amine to control both the susceptible grass and broadleaf weeds with one application.

62. Diclofop (Hoelon) at 0.75 to 1.0 lb/A will control foxtail and wild oats in flax. Apply diclofop at the 1 to 4 leaf stage of foxtail and wild oats. Diclofop can be tank mixed with bromoxynil for broadleaf weed control. Do not use oil additive with diclofop in flax. Broadleaf herbicides other than bromoxynil should not be applied within 4 days of diclofop application.

## CORN

63. A combination of cultural, mechanical and chemical methods is necessary for consistently effective weed control in corn. Control early germinating weeds by cultivation before planting if conventional tillage is used. A rotary hoe can be used to control emerging weeds when the corn is beyond the spike stage. Cultivation between the rows should be done soon after weeds emerge.

64. Most herbicides used in corn are labeled for tank mixing with other herbicides for broad spectrum weed control. Some of the combinations best adapted to North Dakota are given in the chemical weed control tables. Consult the label and discussion of individual herbicides for a complete list of all possible registered combinations.

65. Wild proso millet is an aggressive, competitive annual weed that is becoming a serious problem in some areas of eastern North Dakota. EPTC + Safener (Eradicane), EPTC + Safener + Extender (Eradicane Extra), alachlor (Lasso) or metolachlor (Dual) applied preplant incorporated at the full label rate for the soil type will give control of early germinating wild proso millet. However, these herbicides usually do not give season long millet control. EPTC + Safener + Extender may give slightly better control than EPTC + Safener since it is formulated with an extender which increases the soil life of the herbicide. For full season control of wild proso millet, a preplant incorporated treatment of EPTC + Safener or EPTC + Safener + Extender can be followed with a delayed preemergence application of cyanazine (Bladex), cyanazine plus alachlor (Lasso) or metolachlor (Dual), or an early post application of cyanazine (Bladex 80W) or pendimethalin (Prowl) plus cyanazine (Bladex 80W) (corn at 2-leaf stage or smaller).

**PREEMERGENCE:**

66. Atrazine (AAtrex, Atrazine) at 2 to 4 lb/A gives good control of annual weeds without crop injury. Fine textured soils with high organic matter require a 4 lb/A application. Atrazine residues injurious to susceptible crops may remain in soils longer than one growing season. (See paragraph 29 in herbicide residue

registered as a tank mixture with chloramben, linuron (Lorox), and metribuzin.

88. Trifluralin (Treflan) at 0.5 to 1 lb/A applied preplant incorporated controls annual grasses and certain broadleaf weeds. Set the implement at a 4 to 6-inch depth to uniformly mix trifluralin in the soil. Trifluralin incorporation may be delayed up to 24 hours if applied to a cool, dry soil and if wind velocity is less than 10 mph. Do not plant soybeans deeper than 2 inches. Trifluralin is registered as a tank mixture with metribuzin.

89. Alachlor (Lasso) and metolachlor (Dual) at 2 to 3 lb/A give good preemergence control of annual grasses and some broadleaf weeds, including redroot pigweed and common lambsquarters but are ineffective against wild mustard. Apply the higher rate on clay soils high in organic matter. Soybeans have good tolerance to metolachlor and alachlor and incorporation improves the consistency of weed control. Alachlor and metolachlor are registered as a tank mixture with chloramben, linuron plus paraquat (Gramoxone), linuron plus glyphosate (Roundup), and metribuzin plus glyphosate.

90. Chloramben (Amiben) at 2 to 3 lb/A is applied preemergence to control most grass and broadleaf weeds, including wild mustard. At least 0.5 inch of rain is necessary within 10 days after application for effective weed control. Excessive rainfall on light soils may leach chloramben below the level of germinating weed seeds, resulting in poor weed control and/or crop injury. Research at North Dakota State University indicates that incorporation of chloramben improves the consistency of wild mustard control. Chloramben is registered as a tank mixture with alachlor, linuron, metolachlor, metribuzin, pendimethalin and trifluralin.

91. Metribuzin (Sencor, Lexone) at 0.19 to 0.37 lb/A controls annual broadleaf weeds, especially wild mustard.The **rate is critical.** Consult the label for the proper rate based on soil type, pH, and percent organic matter. Maple Amber soybeans are susceptible to metribuzin. Seed soybeans 2 inches below the soil surface to reduce possible injury. Soybean injury also can be reduced by using herbicide combinations with lower rates of metribuzin. Metribuzin is registered as a tank mixture with alachlor, metolachlor, alachlor plus paraquat, paraquat, pendimethalin and trifluralin.

92. Acifluorfen (Blazer, Tackle) at 0.37 to 0.5 lb/A postemergence controls many broadleaf weeds. The low rate will control wild mustard and redroot pigweed but the high rate is needed for nightshade, smartweed and common cocklebur. Acifluorfen will not adequately control volunteer sunflower. Acifluorfen kills primarily by contact action, thus for effective control, application should be to actively growing 1 to 4-inch weeds and 1st to 2nd trifoliolate soybeans. Soybeans beyond the 3rd trifoliolate leaf stage may intercept the spray pattern and prevent spray coverage of the weeds. Application should be made by ground sprayer delivering a minimum of 20 gallons per acre at 40 psi. Do not make application during periods of moisture stress, frost, flooding, wind damage or unseasonably cool or hot temperatures as weed control may be reduced or crop injury increased. Best results are obtained with applications at maximum daytime temperatures of 70 to 85 F. Do not apply if rain is expected within six hours after application as weed control is reduced. Drift control agents, liquid fertilizers, and other pesticides should not be mixed with acifluorfen. Surfactants should be used with acifluorfen except under conditions outlined on the label. A nonionic surfactant (80% active ingredient) should be added to the tank at the rate of 1/8 percent. Do not apply within 50 days of harvest or use treated plants for feed or forage.

93. Bentazon (Basagran) at 0.75 to 1.5 lb/A postemergence controls many broadleaf weeds. In North Dakota good wild mustard control has been obtained with a 0.5 lb/A when wild mustard is small (less than 4 inches tall) and when used with an oil additive. For volunteer sunflower control, apply 0.75 lb/A to plants less than 5 inches and 1 lb/A to plants 5 to 8 inches tall. An oil additive with bentazon improves weed control. Bentazon at 1 lb/A with oil additive gives good control of common lambsquarters less than 1.5 inches tall and fair to good control of redroot pigweed less than 1.5 inches tall. Soybean leaf burn occurs occasionally from bentazon application, but recovery is good. For Canada thistle control apply 1 lb/A when the plants are 8 inches tall to bud stage and make a second application at 1 lb/A 7 to 10 days later.

94. Fluazifop-P (Fusilade 2000) at 0.09 to 0.19 lb/A + oil concentrate at 1 percent v/v can be applied in soybeans for annual and perennial grass control. Fluazifop-P at 0.09 lb/A will control volunteer corn and wild proso millet. Fluazifop-P at 0.19 lb/A will control wild oats, foxtail and volunteer small grains. Quackgrass with at least 4 leaves but less than 10 inches tall can be suppressed with fluazifop-P at 0.19 lb/A. If regrowth occurs, a second application of 0.19 lb/A can be applied when quackgrass regrowth has 3 to 5 leaves. Fusilade 4-E may still be available, suggested rates are 0.125 to 0.25 lb/A. Mixing fluazifop-P with other herbicides may reduce weed control and increase crop injury. Bentazon is registered for combination with fluazifop-P + oil but the fluazifop-P rate must be increased by 50 percent.

95. Sethoxydim (Poast) at 0.1 to 0.5 lb/A plus oil concentrate will control annual and perennial grasses. Application rates for several grass species are 0.1 lb/A for wild proso millet, 0.2 lb/A for volunteer corn, green foxtail, yellow foxtail, and barnyardgrass, and 0.3 lb/A for wild oats and volunteer cereals. Quackgrass 6 to 8 inches tall can be suppressed with sethoxydim at 0.5 lb/A. Quackgrass regrowth should be treated with 0.3 lb/A. Cultivation between 14 and 21 days after application will improve quackgrass control. Mixing desmedipham (Betanex), desmedipham + phenmedipham (Betamix), endothall (H-273), acifluorfen or bentazon with sethoxydim has generally reduced wild oats control and occasionally reduced foxtail control compared to sethoxydim plus oil concentrate alone. Also, oil concentrate has frequently increased crop injury when combined with desmedipham, desmedipham + phenmedipham, endothall, or acifluorfen. Bentazon is registered for combination with sethoxydim + oil but the sethoxydim rate must be increased by 50 percent.

96. Naptalam + 2,4-DB at 1 to 1.5 + 0.03 to 0.045 lb/A may be applied for salvage control of common cocklebur, giant ragweed, and volunteer sunflower 10 inches or taller in soybeans. Apply after first bloom of soy-