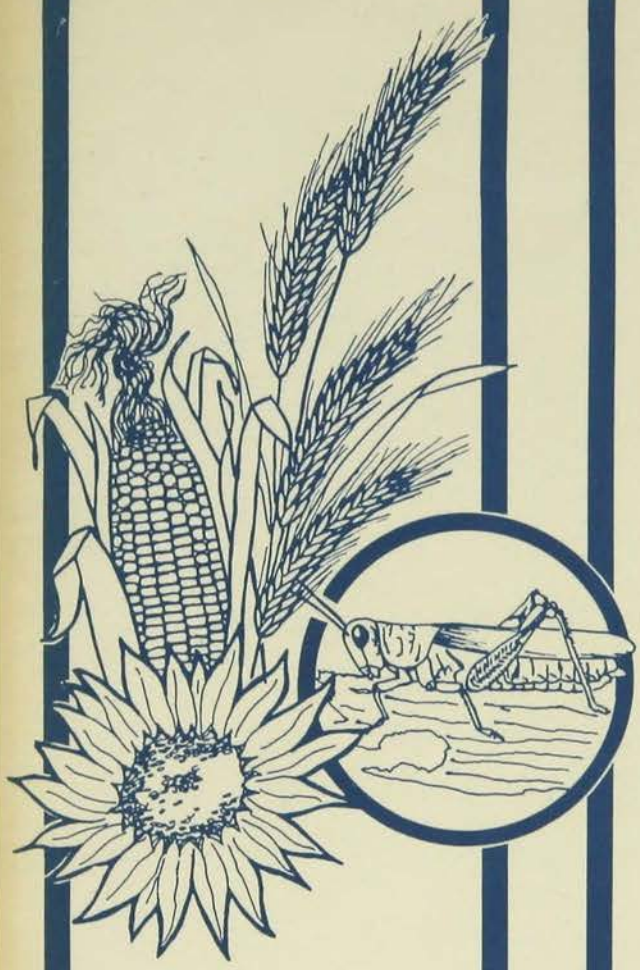

OSP 8-1
Agricultural Extension Service
University of Minnesota

1986
Minnesota Pesticide Recommendations and Applied Research Reports

Prepared by
Agricultural Extension Specialists
in Agronomy, Entomology, and
Plant Pathology

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

1986
MINNESOTA PESTICIDE RECOMMENDATIONS AND APPLIED RESEARCH REPORTS

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Office of Special Programs Educational Series 8-1

Published by
Office of Special Programs
University of Minnesota
405 Coffey Hall
1420 Eckles Avenue
St. Paul, Minnesota 55108

December 12, 1985

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RECOMMENDATIONS FOR 1986

D. M. Noetzel, K. R. Ostlie, P. M. Ives
Extension Entomology
University of Minnesota

The major change in insecticide labels for 1986 is the placing of several granular materials in the Restricted Use Category (RUC). Carbofuran (Furadan), ethoprop (Mocap), fonofos (Dyfonate), phorate (Thimet, Phorate), and terbufos (Counter) will all have RUC labels when packaged after Sept. 1, 1985. The EPA, however, has wisely permitted the continued sale of supplies of these compounds whose packaging retains the pre Sept. 1, 1985 general use label until Sept. 1, 1986.

It will be legal to use such general use labeled materials in 1986 without applicator certification. However the grower (ie private applicator), from a purely practical standpoint, would be well advised to obtain private applicator certification for use of RUC insecticides rather than gamble on being able to obtain some general use label material. It is clearly evident that more pesticides will be placed in the RUC as time goes on. It is also reasonable to assume that certification and probably licensing will be improved (ie toughened) in the years ahead.

SALE AND APPLICATION OF RESTRICTED USE CATEGORY (RUC) PESTICIDES

The volume of sales of the granular materials and the addition of RUC labels to several, but not all, of the commonly used granular materials may tempt some to use this reclassification as a sales argument. We would strongly discourage such an approach for a number of reasons.

First it is probably not legal to say, in writing or verbally, that product A (a general use product) is safer than product B (a restricted use category material). Yet that is the implication when a dealer is encouraged to stock and the applicator use the general use material. Furthermore we have to keep in mind that classification in the RUC may have come about for reasons other than hazards to man. The pyrethroids, such as Pydrin and Ambush, are enormously toxic to aquatic organisms for example, and as a result will probably remain in the RUC.

Secondly some general use products have environmental effects which are to be avoided. A classic example of this is honey bee poisoning by such products as Sevin, Malathion ULV, Dursban, and Cygon. Each of these insecticides is quite safe for man. With minor exceptions most insecticides have a negative impact on non-target insects many of which are beneficial.

We, in extension, feel that the choice of an insecticide should first be based on the fact it is labeled on the crop. We further believe that insecticide choice should be determined by consistent effectiveness, by cost, and by the least potential environmental damage possible. This last factor is determined as much by the manner in which the product is used as by (mammalian) toxicity of that chemical.

Safety to man, the crop and the environment is always a concern when applying pesticides. All pesticides are to some degree hazardous when handled improperly. Without question our entire industry will benefit from improved understanding and improved application of the products with which we work.

The key to reduced numbers of pesticide incidents is improved knowledge of the product being considered for use. Improved knowledge comes through applicator training, through obtaining as much information about the chemical from as many sources as possible, and from reading the label.

Applicator training and certification is a major method for improvement of both private and commercial applicator knowledge. We believe that the chemical industry, applicators of all types, consultants agronomists and public sources such as extension should encourage all pesticide users to obtain additional training. All of us working with chemicals should re familiarize ourselves with the products we use each new season. We believe the record of safe pesticide use is exceptional. But we also believe we can further improve this record.

HONEY BEE PROTECTION

Carbaryl (Sevin), ULV malathion, methidathion (Supracide), methyl parathion (Penncap M), and parathion, for example, are very toxic to bees. Crops in bloom should not be treated and applications should not be made near bee yards or when bees are present in fields to be treated. Do not move bees into alfalfa fields treated with Furadan 4F within 7 days of treatment. A listing of insecticides and their toxicity to honey bees is contained in Entomology AG-FS-1028, Protecting Honey Bees from Insecticides and in AG-BU-0499, Insecticides.

INSECTICIDE MOVEMENT IN SOIL

Insecticides applied to steep slopes often move with soil and water in the erosion process. Greatest movement occurs where slope is greatest and erosion control (eg. tillage, contouring, and terracing) is least. The magnitude of movement will be related to amount of run-off and the concentration of the insecticide in the soil. Early season run-off shortly after application, for example, will move the greatest amounts of pesticides.

In the Karst area in southeastern Minnesota the same factors that contribute to soil-pesticide run-off may also potentially contribute to movement of pesticide into aquifers.

A third situation exists where pesticides have potential to move into shallow aquifers. In this case pesticide solubility and the volume of water moving past the root zone are major variables in moving pesticides to the water table. Areas of Minnesota where greatest potential for this to take place are the glacial outwash sand plains in the central part of the state. Care should be taken to use as little pesticide as is practical and perhaps to be concerned about both pesticide solubility and amounts of water added to these soils.

HANDLING OF HIGHLY TOXIC INSECTICIDES

Aldicarb (Temik), demeton (Syston), disulfoton (DiSyston), mevinphos (Phosdrin), methomyl (Lannate, Nudrin), methyl parathion, parathion, phorate (Thimet), and phosphamidon (Dimecron) are highly toxic chemicals. They should be handled only by persons knowledgeable in their safe use. Posting of fields in which these chemicals are foliarly applied is advisable. Protective measures outlined on the label, including clothing and method of application, should be followed carefully. Granular formulations are less hazardous during application than are liquids. However, in all cases avoid inhaling dusts or vapors, avoid skin contact with the chemical, and change clothing and shower thoroughly after applying insecticides.

INSECT AND INSECTICIDE MANAGEMENT TO REDUCE RESISTANCE POTENTIAL

Insect resistance develops in insect populations as a result of intense selection (near 100% kill) by the insecticide. Selective pressure is increased when dosage is increased, spray frequency is increased and more life stages of the insect are exposed to the insecticide. Immigration of insecticide susceptible insects into treated populations is the major factor preventing the build-up of resistance.

The question of how to manage pest insect populations in such a manner that initially effective insecticides remain effective for a longer period suggests the possibility of two patterns of insecticide use. Both patterns have been subjected to tests through modeling a theoretical insect population with various assumed constraints.

The first strategy can be called the "high dose" strategy. This is, in simple terms, the use of an insecticide at a level that "eliminates" a resident pest population (i.e. 100% control). In addition, the insecticide is assumed to have no persistence so that immigrants are not subjected to any selective pressure, and there is no outward migration of treated (i.e. resistant) individuals. Finally, it is assumed the insecticide dosage does not lead to collateral resistance in other pest species in the target area.

Authors who have spent considerable thought on these problems have the general consensus that it is not likely all, or very many, of the assumptions upon which the "high dose" strategy is based are valid in nature. And, if they are, they are not likely to continue once chemical selective pressure is placed on a population. Thus, at best, a high dose strategy could only be used very early in an insecticide history.

The second of these strategies has been termed the "low dose" strategy. It is assumed low dosage treatments remove susceptible insects only. High immigration of susceptible insects into the area treated is again assumed. Insecticide is used at the least dosage which provides maximum economic benefit.

Because most workers feel the assumptions upon which the "low dose" strategy are based are most likely to be operative in nature we feel it prudent to encourage its use. It is basically the use of an insecticide only when net profit can be realized by the grower from the use of the

insecticide. Furthermore, the insecticide dosage should not be higher than is necessary for the greatest net return to chemical dollar. Professionally speaking, this means insecticide use should be based on field monitoring and the obtaining of precise pest counts.

INSECTICIDE SUGGESTIONS TO CONTROL INSECT PESTS OF FIELD CROPS IN 1986

Abbreviations used in tables: phi - pre harvest interval, EC or E - emulsifiable concentrate, D - dust, G - granules, S - solution, WP - wettable powder, and SP - soluble powder. Dosages of insecticides are actual chemical per acre, with some exceptions.

ALFALFA

Insect	Insecticide	Formulation Recomm.	Formulation Product/acre	Dosage	Limitations
Alfalfa weevil	azinphosmethyl (Guthion)	50% WP only	1 - 1 1/2 lb	1/2-3/4 lb	21 day phi, not more than one application per cutting.
	*carbofuran (Furadan)	4F	1/2 - 1 pt	1/4-1/2 lb	7 day phi 1/4 lb, 14 days 1/2 lb. Not more than 2 application per season, nor 1 per cutting. Note crop rotation restrictions in label.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	14 day phi. Not more than 1 application per cutting.
	*methyl parathion (Penncap M)	2F	1 pt	1/4 lb	15 day phi
	phosmet (Imidan)	50 WP	2 lb	1 lb	7 day phi. Not more than one application per cutting.
	carbaryl	XLR plus	2 - 3 pt	1-1 1/2 lb	3 day phi. Note plant damage precautions on label.
	malathion plus methoxychlor	2E + 2E	3 pt	3/4 lb+3/4 lb	7 day phi-available as a ready-to-use mixture.
	*methidathion (Supracide)	2E	2 pt	1/2 lb	10 day phi.
	malathion (Cythion)	5E	2 pt	1 1/4 lbs	No time limitations.

* Restricted-use material

Cut first crop early to avoid most losses. Treat when more than 30 percent of plant tips show feeding. Treat stubble if there are more than 8 larvae per square foot or when regrowth has 50 percent of the terminals with feeding or if larvae are delaying regrowth. Do not treat alfalfa in bloom.

Aphids	*carbofuran (Furadan)	4F	1/2 - 1 pt	1/4-1/2 lb	7 day phi 1/4 lb, 14 days 1/2 lb. Not more than 2 applications per season nor 1 per cutting. Note crop rotation restrictions in label.
	chlorpyrifos (Lorsban)	4F	1 pt	1/2 lb	14 day phi. Not more than 1 application per cutting.
	diazinon	4E	1 pt	1/2 lb	7 day phi.
	dimethoate (Cygon, Defend, Rebelate, Dimex 267)	4E 2.67E	1/2 pt 3/4 pt	1/2 lb	10 day phi, one application per cutting.
	malathion (Cythion)	5E	1 3/5 pt	1 lb	No time limitations.
	*parathion	4E	1/2 pt	1/4 lb	15 day phi.
	*methyl parathion (Penncap M)	2F	1 pt	1/2 lb	15 day phi.

Control pea aphids if populations 2 weeks prior to harvest exceed an average of 1.2 per stem and plants are under drought stress. Spotted alfalfa aphids may severely damage new seedings.

Armyworms, cutworms	carbaryl (Sevin)	XLR plus	3 pts	1 1/2 lb	3 day phi, spray or bait. Note plant damage precautions of label.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	14 day phi. Not more than 1 application per cutting.
	malathion (Cythion)	5E	2 pts	1 1/4 lb	No time limitations.
	trichlorfon (Dylox,	4E	2 pts	1 lb	No time limitations. Not more than

* Restricted-use material

	Proxol)				3 applications per cutting.
	*methomyl (Lannate, Nudrin)	90% SP 1.8E	3/8 lbs 1 - 2 pts	1/4-1/2 lb	7 day phi. Note plant damage precautions on label.
	*methyl parathion (Penncap M)	2F	2 pts	1/2 lb	15 day phi.
	Treat when more than 5 per square foot.				
Leafhoppers	azinphosmethyl (Guthion)	50% WP only	1/2 - 1 lb	1/4-1/2 lb	16 day phi. Not more than one application per cutting.
	carbaryl (Sevin)	XLR plus	2 pts	1 lb	3 day phi. Note plant damage precautions on label.
	*carbofuran (Furadan)	4F	1/2 - 1 pt	1/4-1/2 lb	7 day phi 1/4 lb; 14 days 1/2 lb. Not more than 2 applications per season, nor one per cutting. Not crop rotation restrictions in label.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	14 day phi. Not more than 1 application per cutting.
	diazinon	4E	1 pt	1/2 lb	7 day phi.
	methoxychlor (Methoxchlor, Marlate Prentox)	2E	4 pts	1 lb	7 day phi.
	*methidathion (Supracide)	2E	2 pts	1/2 lb	10 day phi.
	phosmet (Imidan)	50WP	2 lbs	1 lb	7 day phi, one application per cutting.
	dimethoate (Cygon, etc)	4E	1/2 - 1 pt	1/4-1/2 lb	10 day phi, the application per cutting.
	Apply when potato leafhoppers average or exceed 0.3 per pendulum sweep on alfalfa less than 3" tall, 0.4 per sweep on alfalfa 3-5" tall, 0.5 per sweep for 6-7" alfalfa, 1.0 per sweep for 8-11"				

* Restricted-use material

alfalfa, and 2 per sweep on alfalfa 12" or taller. New seedings are most susceptible to injury.

Grasshoppers	azinphosmethyl (Guthion)	50% WP only	1 - 1 1/2 lb	1/2-3/4 lb	21 day phi. Not more than 1 application per cutting.
	carbaryl (Sevin)	XLR plus	2 - 3 pts	1-1 1/2 lb	3 day phi.
	*carbofuran (Furadan)	4F	1/4 - 1/2 pt	1/8 - 1/4 lb	7 day phi, one application per season.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	14 day phi. Not more than 1 application per cutting.
	diazinon	4E	1 pt	1/2 lb	7 day phi
	dimethoate (Cygon, Rebelate)	4E 2.67E	1/2 - 1 pt 3/4 - 1 1/2 pt	1/4-1/2 lb	10 day phi, one application per cutting.
	malathion (Cythion)	5E	2 pts	1 1/4 lbs	No time limitations.
	Control when there are more than 8 grasshoppers per square yard in the field, or treat margins after cutting at more than 20 per square yard.				
Spittlebug	malathion (Cythion)	5E	1 3/5 - 2 pts	1-1 1/4 lbs	No time limitations.
	methoxychlor (Methoxychlor, Marlate, Prentox)	2E	4 pts	1 lb	7 day phi.
	chlorpyrifos (Lorsban)	4E	1 - 2 pts	1/2-1 lb	14 day phi 1/2 lb; 21 day phi 1 lb. Not more than 1 application per cutting.
	methyl parathion (Penncap M)	2F	1 - 3 pts	1/4-3/4 lb	15 day phi.
	Apply on first crop when spittle masses average more than one per stem.				

* Restricted-use material

Plant bugs	malathion + methoxychlor	2E + 2E	3 pts	3/4 lb + 3/4 lb	7 day phi
	trichlorfon (Dylox)	4E	2 pts	1 lb	

Control seldom needed except on seed crop. Cut early to avoid injury.

ALFALFA, CLOVER
(FOR SEED ONLY)

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
Plant bugs	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	14 day phi. Not more than 1 application per cutting.
	endosulfan (Thiodan)	3E	3 pts	1 lb	Do not harvest for forage or graze.
	trichlorfon (Dylox)	4E	2 - 3 pts	1-1 1/2 lbs	7 day phi. Chaff may be used for feed or forage, but do not cut green crop for these purposes.

Do not treat crop in bloom

CORN, FIELD

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
			(per 1000 row ft.)		
Corn rootworm larvae	*carbofuran (Furadan)	15G	8 oz	1.2 oz = 1 lb/acre in 40" rows	May be applied in furrow or banded.

* Restricted-use material

chlorpyrifos (Lorsban)	15G	8 oz		Apply as band in front of press wheel.
*ethoprop (Mocap)	15G	8 oz		Phytotoxic - Do not apply in-furrow or band over open seed furrow.
*fonofos (Dyfonate)	20G	6 oz	All same as above	Phytotoxic - Do not apply in-furrow or band over open seed furrow.
*phorate (Thimet)	20G	6 oz		Phytotoxic - Do not apply in-furrow or band over open seed furrow.
*terbufos (Counter)	15G	8 oz		May be applied in-furrow or in band.
trimethacarb (Broot)	15G	8 oz		Phytotoxic - Do not apply in-furrow or band over open seed furrow.

The potential for rootworm infestation can be predicted by scouting corn fields weekly for adult beetles during August. If adult counts average less than one beetle per plant during August, a soil insecticide used the next spring will rarely increase yield. If adult counts average more than 5 beetles per plant, rotate to a crop other than corn. Rootworm control may be unsatisfactory during heavy rootworm infestation. If a field was not scouted last year, use a soil insecticide where corn follows corn.

Soil insecticides may be applied during cultivation. Cultivator application of Broot, Counter, Dyfonate, Furadan (15G, 4F), Lorsban (15G, 4E), Mocap, or Thimet/Phorate may provide effective control if applied before larvae hatch in mid-June. Apply at base of stalks and cover with soil. This method may provide poor control if dry soil conditions prevent effective insecticide movement into the root zone.

Avoid continuous use of the same soil insecticide. Continuous use may condition the soil to rapidly degrade the insecticide and result in unsatisfactory control. Rotate insecticides, especially if poor performance occurs.

			(per 1000 row ft.)		
Wireworms	*carbofuran (Furadan)	15G	16-24 oz	2.4-3.6 oz	Apply in-furrow
	*chlorpyrifos (Lorsban)	15G	16 oz	2.4 oz	Band or in-furrow at planting.
			13.4 lbs/acre	2 lbs/acre	Broadcast ppi
	*ethoprop (Mocap)	15G	8 oz	1.2 oz	As for rootworm - 7" band only

* Restricted-use material

	*terbufos (Counter)	15G	8-16 oz	1.2-2.4 oz	As for rootworm - 2.4 oz in 7" band, 1.2 oz in furrow
	*phorate (Thimet)	20G	6 oz	1.2 oz	As for rootworm - Apply in 7" band only
			(per 1000 row ft.)		
White grubs	chlorpyrifos (Lorsban)	15G	8-16 oz	1.2-2.4 oz	Apply in-furrow
		4E	4 pts/acre	2 lbs/acre	Liquid, broadcdast and incorporate before planting.
	*phorate (Thimet)	20G	6-12 oz	1.2-2.4 oz	Apply in 7" band. Do not place in contact w/seed.
	*terbufos (Counter)	15G	16 oz	2.4 oz	Apply 1-2 lbs in 7"band or 1 lb in-furrow.
Seed-corn maggot, seed-corn beetle	chlorpyrifos (Lorsban)	50 SL	1/2 lb/bu	1 oz per bu.	Seed treatment only. Will not control wireworms.
	diazinon		See Label	1-1 1/2 oz per bu.	Use slurry treatment with cyclo-planters. Will not control wireworms.
	lindane		See Label	1 oz per bu.	Has some wireworm activity.
	Seed treatments are strongly recommended for fields where manure was applied or where cover crops were recently plowed. Planting time applications of some corn rootworm insecticides (Counter, Dyfonate, Furadan and Lorsban) will also control these insects.				
Stalk Borer	*fenvalerate (Pydrin)	2.4E	5.3-10.6 fl oz	.1 - .2	21 day phi. Treat at spike stage. If paraquat used, apply before corn emerges.
	Insecticide treatment only reduces, not eliminates, stand loss. Long term elimination of in-field trouble spots requires control of perennial grassy weeds (e.g. quack grass). Corn rootworm insecticides, applied at planting, will not prevent stand loss.				

* Restricted-use material

Hop Vine Borer	None Labelled				
	Where repeated infestations occur, perimeter or spot treatments of grassy areas when corn is spiking and again two weeks later, using fenvalerate (Pydrin), permethrin (Ambush, Pounce) and flucythrinate (Payoff) can reduce stand loss. Long term elimination of infield trouble spots depends on control of perennial grassy weeds (e.g. quack grass, woolly cupgrass) and crop rotation.				
Cutworms	carbaryl (Sevin)	5% Bait	20-40 lbs	1 - 2 lb	No time limitations. Carbaryl bait is more effective than sprays for cutworms except under dry conditions.
	chlorpyrifos (Lorsban)	4E	2 - 3 pt	1 - 1 1/2 lb	35 days forage or silage
	*fenvalerate (Pydrin)	2.4E	1/3 pt	0.1 lb	21 day phi
	*flucythrinate (Payoff)	2.5E	2 - 4 oz	0.04-0.08 lb	60 day phi
	*permethrin (Pounce, Ambush)	3.2E 2E	1/4 pt 6.4 fl oz	0.1 lb	Apply before brown silk. Effective as rescue or planting time sprays.
	Apply when 3% to 6% of the plants are cut. NOTE: Lorsban 15G, Dyfonate 20G, Counter 15G, Furadan 15G and Mocap 15G are also registered for cutworm control or suppression. With these "at-planting" treatments, additional treatment may be required under moderate to heavy infestations. "Rescue" sprays provide more consistent and cost-effective control than do granules applied at planting. Surface treatments are usually ineffective against subterranean species (e.g. glassy cutworm).				
Armyworm	carbaryl (Sevin)	All e.g. XLR	3-4 pts	1 1/2 - 2 lb	No time limitations.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	35 day phi
	*fenvalerate (Pydrin)	2.4E	1/3 pt	1/10 lb	21 day phi
	*methomyl (Lannate, Nudrin)	All e.g. 90% SP	4.5-9oz	1/4 - 1/2 lb	3 day phi, forage
	*methyl parathion (Penncap-M)	2F	2 pts	1/2 lb	12 day phi
	*parathion	8E	1/4 - 3/8 pt	1/4 - 3/8 lb	12 day phi

* Restricted-use material

*permethrin (Pounce, Ambush)	3.2E 2E	1/4 pt 4/10 pt	1/10 lb	12 day phi
trichlorfon (Dylox)	80% SP	1 1/4 lb	1 lb	No time limitations.

Treat when more than 25% of the plants are infested with 2 or more larvae per plant. Higher rates are for large worms.

European corn borer (First & second brood)	Bacillus thuringiensis (Dipel)	10G	10 lb	1 lb	No time limitations
	carbaryl (Sevin)	All	e.g. XLR - 3 pts	1 1/2 lb	No time limitations.
	*carbofuran (Furadan)	15G 4F	6.7 lb 2 pts	1 lb	30 day phi forage or grain. No more than 2 foliar applications.
	chlorpyrifos (Lorsban)	15G 4E	6.7 lb 2 pts	1 lb	35 day grain, 14 days forage. Does not perform well with low gallonage.
	diazinon	14G	7.1 lb	1 lb	No time limitations grain, 10 day phi forage.
	*fonofos (Dyfonate)	20G	5 lb	1 lb	30 day phi.
	*methyl parathion (Penncap-M)	2E	1 - 2 pt	1/4-1/2 lb	12 day phi. Do not apply when foraging honeybees or granules are present.
	*permethrin (Pounce, Ambush)	3.2E 2E 1.5G	1/4 - 1/2 pt 6.4-12.8 fl oz 6.7 - 13.4 lbs	.1 - .2 lb	Spray or granules. Do not apply after brown silk stage.
	*phorate (Thimet)	20G	5 lb	1 lb	First generation only, 1 application, 30 day phi.

FIRST GENERATION: Treat when 50% of the plants are infested with fresh egg masses or show shotholing of whorl leaves. Thresholds may be lower for high-value seed fields (25%) or fields of exceptional yield potential (35%). Dissect several whorls to insure larvae are present and accessible to insecticides. Direct first-generation corn borer treatment into the whorl. Granules

* Restricted-use material

usually perform better than sprays.
SECOND GENERATION: Treat when 50% of the plants are infested with fresh egg masses or newly hatched larvae. Sprays should be applied with sufficient water to insure thorough coverage in the ear zone. Repeat applications usually are required. If fields are heavily infested, harvest early.
CENTER PIVOT APPLICATION: Sevin 80S, Lorsban 4E, Penncap-M, and Pounce 3.2E are labelled for center pivot application. Make sure your system is properly equipped. Follow label directions.
NOTE: Carbofuran (Furadan), fonofos (Dyfonate), or phorate (Thimet) should not be used in seed production fields to be detasseled by hand.

Aphids	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	35 days to feeding
	diazinon	50% WP	2 lb	1 lb	No time limitations.
		4E	2 pts		
	*disulfoton (DiSyston)	5E	1/2 pt	1/2 lb	28 day phi
	malathion (Cythion)	5E	1 1/2 pt	1 lb	5 day phi
	*methomyl (Lannate)	All e.g.	90% SP 4 oz	1/4 lb	3 day phi
	*methyl parathion (Penncap-M)	2F	1 pt	1/4 lb	12 day phi. Aerial application only.
	*parathion	8E	1/4 pt	1/4 lb	12 day phi

Chemical control of corn leaf aphids is seldom economically justified. If 10% of the plants have more than 500 aphids per plant prior to tasseling during drought stress, treatment may pay.

Corn rootworm adults	carbaryl (Sevin)	All e.g.	80S - 1 1/4 lb	1 lb	No time limitations
	chlorpyrifos (Lorsban)	4E	1 pt	0.5 lb	35 day phi
	diazinon	50% WP	2 lbs	1 lb	No time limitations
		4E	2 pts		
	*fenvalerate (Pydrin)	2.4E	1/3 - 2/3 pt	0.1 - .2	21 day phi
	malathion (Cythion)	5E	1 1/2 pt	1 lb	5 day phi
	*methyl parathion (Penncap-M)	2F	1 - 2 pt	1/4 - 1/2 lb	12 day phi. Do not apply when foraging honeybees are present.
	*permethrin (Pounce	3.2E	1/4 - 1/2 pt	0.1 - .2 lb	Apply before brown silk

* Restricted-use material

	Ambush)	2E	6.4 - 12.8 oz}		
	phosmet (Imidan)	50% WP	1/2 - 1 lb	1/4 - 1/2 lb	14 day phi

Treat when beetles clip silks so as to prevent proper pollination. This usually occurs with populations of 10 or more beetles per plant on corn which has less than 50% silk emergence. Seed fields may benefit from treatment at lower levels of beetle infestation.

Grasshoppers	carbaryl (Sevin)	All e.g. XLR - 3 pts		1 1/2 lb	No time limitations.
	chlorpyrifos (Lorsban)	4E	12-16 oz	1/3 - 1/2 lb	No more than 3 parts per season
	*carbofuran (Furadan)	4F	4 - 8 oz	1/8 - 1/4 lb	30 day phi.
	diazinon	4E	2 pt	1/2 lb	No time limitations.
	dimethoate (Cygon)	4E	1 pt	1/2 lb	14 day phi.
	*fenvalerate (Pydrin)	2.4E	5.3 oz	1/10 lb	No time limitations.
	malathion (Cythion)	5E	1 1/2 pt	1 lb	5 day phi.
	*methyl parathion (Penncap-M)	2E	2 pt	1/2 lb	12 day phi.

Treat field margins early when grasshoppers are small.

CORN, SWEET (for processing) NOTE: See precaution on bees, p. __.

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
Corn rootworm	chlorpyrifos (Lorsban)				
	*ethoprop (Mocap)				
	*fonofos (Dyfonate)			See field corn.	
	*phorate (Thimet)				
	*terbufos (Counter)				
	trimethacarb (Broot)				

* Restricted-use material

Seed corn maggot	diazinon		See label	1/4 oz/bu	Seed treatment.
	chlorpyrifos (Lorsban)	50 SL	1 oz/bu	1/2 oz/bu	Slurry seed treatment.
Cutworms	carbaryl (Sevin)	5 or 20%	20 or 5 lb	2 lb. bait	No time limitations.
	chlorpyrifos (Lorsban)	4E	2 - 3 pts	1 - 1 1/2 lb	35 day phi.
	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	1 day phi.
	trichlorfon (Dylox)	4E	2 pts	1 lb	No time limitations. Not more than 3 applications/season.
	*permethrin (Pounce, Ambush)	3.2E 2E	4.0 fl oz 6.4 fl oz	0.1 lb	1 day phi.
Armyworm	carbaryl (Sevin) All	eg. XLR plus	3-4 pts	1 1/2 - 2 lbs	No time limitations. Not Sevin 4-oil.
	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	1 day phi. Do not exceed 2 lbs ai/A per season.
	malathion (Cythion, malathion)	5E	1 1/2 pts	1 lb	5 day phi.
	methomyl (Lannate, Nudrin)	90% SP	1/4-1/2 lb	4-7 oz	No time limitations. 3 days, forage. Note plant damage precaution in label.
	*permethrin (Ambush, Pounce)	2E 3.2E	6.4 fl oz 4 fl oz	0.1 lb	1 day phi. Not more than 6 applications.
	trichlorfon (Dylox)	4E	2 pts	1 lb	No time limitation. Not more than 3 applications/season.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	35 day phi.
Aphids	diazinon	4E	1 pt	1/2 lb	No time limitations. Not Sevin 4-oil.
	malathion (Cythion)	5E	1 1/2 pt	1 lb	5 day phi
	*parathion (Penncap-M)	4E 2F	1/2 pt 1 pt	1/4 lb	12 day phi

* Restricted-use material

European corn borer	*Bacillus thuringiensis* (Dipel)	10G	10 lbs	1 lb	No time limitations.
	carbaryl (Sevin) All eg. XLR plus		2-4 pts	1 - 2 lbs	No time limitations. Not Sevin 4-oil. Sevin XLR is safe for honey bees.
	*carbofuran (Furadan)	4F	1 pt	1/2 lb	7 day phi. Apply weekly; no more than four applications. Do not enter field within 14 days without protective clothing. Machine harvest only. Do not graze or harvest stalk within 21 days.
	diazinon	14 G	10 1/2 lbs	1 1/2 lb	No time limitations. Do not feed treated folder for 10 days.
	*methomyl (Lannate Nudrin)	90% SP	1/2 lb	7 oz	No time limitations. 3 days, forage. Note plant damage precaution in label. Other formulations restricted.
	*methyl parathion (Penncap M)	2F	2 pts	1/2 lb	3 day phi (12 days, forage or grazing).
	*permethrin (Pounce Ambush)	3.2E 2E	4 - 8 fl oz 6.4-12.8 fl oz	0.1 - 0.2 lb.	1 day phi. Not more than 6 applications.
Corn earworm	carbaryl (Sevin) All eg. XLR plus		3-4 pts	1 1/2 - 2 lbs	No time limitations. Not Sevin 4-oil.
	diazinon	4E	2-2 1/2 pts	1 - 1 1/4 lbs	No time limitations.
	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	1 day phi.
	*methomyl (Lannate, Nudrin)	90% SP	1/4-1/2 lb	5-7 oz	No time limitations. 3 days, forage. Note plant damage precaution in label. Other

* Restricted-use material

					formulations are restricted use.
	*methyl parathion (Penncap M)	2F	2 pts	1/2 lb	3 day phi. 12 days, forage or grazing. Highly toxic to honey bees.
	*permethrin (Pounce, Ambush)	3.2 2E	4 - 8 fl oz 6.4-12.8 fl oz	0.1 - 0.2 lb	1 day phi. Not more than 6 applidcations.

SOYBEANS

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
Seed corn maggot	diazinon		See Label	0.7-1 oz per bu.	Seed treatment only.
Bean leaf beetle, flea beetles blister beetle	carbaryl (Sevin)	All	e.g. XLR - 2 pts	1 lb	No time limitations.
	chlorpyrifos (Lorsban)	4E	1 - 2 pts	1/2 - 1 lb	28 day phi
	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	21 day phi
	Treat when defoliation exceeds 50% during seedling stages, 25% during pod fill, or when pod feeding is extensive.				
Cutworms, armyworms	carbaryl (Sevin)	All	e.g. XLR - 3 pts	1 1/2 lb	No time limitations.
	chlorpyrifos (Lorsban)	4E	1 - 2 pts	1/2 - 1 lb	28 day phi
	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	21 day phi
	*permethrin (Ambush, Pounce)	2E	6 1/2 or	0.1 lb	60 day phi
		3.2E	4 fl oz }		
	thiodicarb (Larvin)	3.2E	1 1/4-1 7/8 pt	1/2 - 3/4 lb	28 day phi. Do not feed forage to livestock.
Potato leafhoppers	carbaryl (Sevin)	All	e.g. XLR-2pts	1 lb	No limitations.
	*fenvalerate (Pydrin)	2.4E	2 2/3 fl oz	0.05 lb	21 day phi

* Restricted-use material

	malathion (Cythion)	5E	1 1/2 pt	1 lb	7 day phi
	*methyl parathion (Penncap-M)	2F	1/2 - 1 1/2 pt	1/4-3/4 lb	20 day phi
Green cloverworm	acephate (Orthene)	75W	2/3 lb	1/2 lb	14 day phi
	Bacillus thuringiensis (Dipel, Thuricide, Sok Bt, Clean Crop BT)				As labeled.
	carbaryl (Sevin)	All	e.g. XLR - 1 pt	1/2 lb	No limitations.
	chlorpyrifos (Lorsban)	4E	1/2 - 1 pt	1/4 - 1/2 lb	28 day phi
	dimethoate (Cygon)	4E	1/2 - 1 pt	1/4 - 1/2 lb	7 day phi
	*fenvalerate (Pydrin)	2.4E	2 2/3 fl oz	0.05 lb	21 day phi
	malathion (Cythion)	5E	1 1/2 pt	1 lb	No time limitation
	*permethrin	2E	3.2 fl oz	0.05 lb	60 day phi
	(Ambush, Pounce)	3.2E	1/8 pt		
	*methomyl (Lannate, Nudrin)	All	e.g. 1.8L-1pt	1/4 lb	14 day phi
	*methyl parathion (Penncap M)	2F	1 pt	1/2 lb	20 day phi
	thiodicarb (Larvin)	3.2E	5/8 - 1 pt	1/4 - 4/10 lb	28 day phi. Do not feed forage to livestock.
	Treat when defoliation exceeds 25% or when worms number more than 15 per foot of row during pod fill.				
Spider mites	carbophenothion (Trithion)	8E	1/2 pt	1/2 lb	7 day phi. Do not feed treated foliage.
	dimethoate (Cygon)	4E	1 pt	1/2 lb	21 day phi (5 days to feed livestock).
Grasshoppers	acephate (Orthene)	75W	3/8 - 3/4 lb	1/4 - 1/2 lb	14 day phi. Do not feed foliage.
	carbaryl (Sevin)	All	e.g. XLR - 3 pts.	1 1/2 lb	No limitations.
	chlorpyrifos (Lorsban)	4E	1/2 - 1 pt	1/4 - 1/2 lb	28 day phi
	dimethoate (Cygon, Defend)	4E	1/2 - 1 pt	1/4 - 1/2 lb	7 day phi

* Restricted-use material

*carbofuran (Furadan)	4F	1/4 - 1/2 pt	1/8 - 1/4	
*methyl parathion (Penncap M)	2F	1 - 3 pt	1/4 - 3/4	

SMALL GRAIN

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
Aphids	malathion	5E	1 1/2 pt	1 lb	7 day phi
	*methyl parathion	4E	1/2 pt	1/4 lb	12 day phi
	*methyl parathion	4E	3/4 - 1 pt	3/8 - 1/2 lb	15 day phi
	(Penncap M)	2F	1 1/2 - 2 pt		
	*parathion	8E	1/4 pt	1/4 lb	15 day phi
	*disulfoton (DiSyston)	8E	1/4 - 3/4 pt	1/4 - 3/4 lb	30 day phi, for wheat only, do not graze
	Treatment most economical before heading with more than 25 aphids per 6" stem (15 greenbugs) or with 35 aphids/stem from 6" to boot. Do not treat after heading as there is no yield change.				
Armyworm, cutworms	*methomyl (Lannate, Nudrin)	All e.g. 90% SP	3/8 - 3/4 lb	1/4 - 1/2 lb	7 day phi
	*parathion	8E	1/4 - 3/8 pt	1/4 - 3/8 lb	48 hour re-entry; 12 day phi
	*methyl parathion	4E	1 pt	1/2 lb	24 hour re-entry; 12 day phi
	(Penncap M)	2F	2 pt	1/2 lb	15 day phi
	trichlorfon (Dylox)	4E	2 pt	1 lb	21 day phi, maximum of 3 applications.
	Treat when number of worms exceeds 5 per sq. ft. For armyworm control in non-crop land see p. 19.				
Grasshoppers	*acephate (Orthene)	75W	1/4 lb	1/6 lb	Wheat only.
	*carbofuran (Furadan)	4F	1/4 - 1/2	1/8 - 1/4 lb	Wheat, oats, barley. Do not apply after heading.

* Restricted-use material

	dimethoate (Cygon)	4E	1/2 - 1	1/4 - 1/2 lb	Wheat only, 60 day phi.
	malathion	5E	1 1/2 pt	1 lb	7 day phi.
	*methyl parathion	4E	1 pt	1/2 lb	15 day phi.
	(Penncap M)	2F	2 pts		
	Treat when more than 8 per sq. yd. in field or more than 20 in margins.				
Wireworms	lindane			1 oz per bu.	Seed treatments only.

SUGARBEET

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
Webworm	carbaryl (Sevin) All	e.g. XLR plus	3 pts	1 1/2 lb	14 day phi, tops.
	endosulfan (Thiodan)	3E	2 2/3 pts	1 lb	Do not feed tops.
	*parathion	8E	1/4 - 1/2 pt	1/4 - 1/2 lb	20 day phi
	trichlorfon (Dylox)	4E	2 pts	1 lb	14 day phi
	Treat when worms exceed 5 per sq. ft.				
Spider mites	carbophenothion (Trithion)	8E	1 1/2 pt	1 1/2 lb	7 day phi
	dimethoate (Cygon)	4E	1 pt	1/2 lb	7 day phi
	disulfoton (DiSyston)	8E	1 pt	1 lb	30 day phi
Cutworms	carbaryl (Sevin) All	e.g. XLR plus	4 pts	2 lb spray	14 day phi, tops, bait formulation preferred.
		e.g. 20% bait	50-100 lb	1 - 2 lb bait	
	chlorpyrifos	15G	8-16 oz/1000 row ft.	1.2-2.4 oz/ 1000 row ft.	Row treatment at planting time.
	(Lorsban)	4E	2 pts	1 lb	Broadcast foliar spray.
	trichlorfon (Dylox)	4E	2 pts	1 lb	14 day phi

* Restricted-use material

			(per 1000 row ft.)		
Root maggots	*aldicarb (Temik)	15G	6.5-9.5 oz 4.3 oz	1.2 oz = 1 lb in 40" rows	Apply in 2-4" band at planting and incorporate. Modified in-furrow.
	*carbofuran (Furadan)	15G	4.3-5.3 oz		Modified in-furrow
	chlorpyrifos (Lorsban)	15G	4.5-9 oz	All	In furrow treatment has activity against cutworms.
	diazinon	14G	4.7-9.4 oz	same as above	Apply in 7" band or as a furrow treatment after seed is covered.
	*fonofos (Dyfonate)	20G	3.5-5.0 oz		Apply in 7" band and lightly incorporate. Do not place in contact with seed.
	*terbufos (Counter)	15G	4.5-9 oz		Apply in 7" band and lightly incorporate. Do not place in contact with seed.
Wireworms	*terbufos (Counter)	15G	4.5-9 oz/1000 row ft.		Banded in 7" band & incorporate.
	diazinon	14G	14.3-28.6 lb	2 - 4 lbs	Broadcast incorporated.
	*fonofos (Dyfonate)	20G	20 lb	4 lbs	Soil treatment preplant.
	lindane			1 oz per bu.	Seed treatment only.

SUNFLOWER

Insect	Insecticide	Formulation Recomm.	Product/acre	Dosage	Limitations
Wireworm	lindane			1-1 1/2 oz.	(2 3/4 oz DB green per bu.) seed treatment.
Cutworm	carbaryl (Sevin)	5 or 20%	20 or 5 lb	1 lb	Use 5% or 20% bait
	chlorpyrifos (Lorsban)	4E	2 pts	1 lb	Rescue treatment with as much water

* Restricted-use material

					as practical.
	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	

Treat when there is more than 1 cutworm per 2 sq. ft. and before plant population goes below 75% of that recommended for area. Granular preventive treatments are not normally economical.

Grasshoppers	carbaryl (Sevin)	All eg. XLR plus	2-3 pts	1 - 1 1/2 lb	60 day phi.
	*carbofuran (Furadan)	4F	1/4 - 1/2 pt	1/8 - 1/4 lb	28 day phi.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	42 day phi.
	*fenvalerate (Pydrin)	2.4E	5 1/3-10 2/3 fl oz	0.1 - 0.2 lb	28 day phi.

Treat before 25% defoliation at all plant stages, irrespective of insect stage.

Sunflower beetle	*carbofuran (Furadan)	4F	1/4 - 1/2 pt	1/8 - 1/4 lb	Lower rates will provide 90% control.
	*fenvalerate	2.4E	1/2-1 1/2 fl oz.	.01-0.03 lb.	240-80 acres per gallon E

Two adult sunflower beetles per 4 leaf plant or 15 SB larvae per plant will cause 25% or more defoliation. Do not exceed 25% defoliation. Ground application banded on row at last cultivation is most economical treatment.

Thistle caterpillar	*fenvalerate (Pydrin)	2.4E	5 1/3 fl oz	0.1 lb	28 day phi
	carbaryl (Sevin)	XLR plus	2 - 4 pts	1 - 2 lbs	60 day phi prior to harvest

Do not exceed 25% defoliation.

Spotted and black sunflower stem weevil — Extensive trials in 1982-1985 suggest we do not improve yields enough to recommend treatment with soil systemic. However if action level of 1 adult spotted stem weevil per plant is exceeded, an aerial application of .1-.2 lb fenvalerate (Pydrin) may be worthwhile.

Action level = 1 adults per plant at 10 to 20 leaf stage. Droughty fields are most subject to stem weevil injury. Normal fields show no yield effects.

Sunflower midge — Control with insecticides has been unsuccessful and attempts are not recommended. Use tolerant

* Restricted-use material

sunflower hybrids (AD-MR-1953- Varietal Trials of Farm Crops) and delay planting until late May or early June.

Sunflower moth and banded sunflower moth larvae	*carbofuran (Furadan)	4F	1 pt	1/2 lb	28 day phi, 14 days before reentry.
	chlorpyrifos (Lorsban)	4E	1 pt	1/2 lb	42 day to harvest.
	*methyl parathion	4E	1 - 2 pt	1/2 - 1 lb	30 day phi.

DO NOT TREAT WHEN FORAGING BEES ARE IN FIELD.

Treat with 2 adult/sunflower moths per 5 plants or when banded moth is noticeable in field margins. Application when between 3 and 5 plants have first made florets extended (30-50% bloom) provides best control.

Sunflower seed weevil	*carbofuran (Furadan)	4F	1 pt	1/2 lb	28 day phi, 14 days before reentry.
	*fenvalerate (Pydrin)	2.4E	5 1/3-10 2/3	0.1-0.2 lb	30 day phi.
	*methyl parathion	4E	1 - 2 pt	1/2 - 1 lb	30 day phi.

DO NOT TREAT WHEN FORAGING BEES ARE IN FIELD.

Treat when between 3 and 5 of ten plants have a ring of female flowers in bloom. Action level for oil hybrids is 10 to 20 weevils per plant, and confection with 2 to 4 weevils per plant. Respray if action level is exceeded.

* Restricted-use material

SUNFLOWER BEETLE (SB) CONTROL

Sunflower beetle numbers were low in 1985 and as a result Minnesota growers probably received no economic benefit from any controls for this insect. Because we have found control of SB to be so easy and inexpensive our 1985 SB control trials were designed to use the least dosage of each insecticide that we believed would provide 90% or better control at 96 hours posttreatment. Hence you may be a little surprised at the dosages reported in Table 1 and there may be little relationship to labeled rates.

The age distribution of the larval population treated was as follows:

Instar	% of population
1	9.5
2	15.4
3	29.6
4	45.6
	100.1

Numbers were not high (see pretreatment counts) but the age distribution was such that mature lavae constituted nearly 1/2 the population at treatment time. Pretreatment counts were not significantly different between treatments.

Table 1. Sunflower beetle control - Minnesota 1985 (Preliminary data)

Insecticide & formulation	Dosage in lb ai/A	Number live larvae per 10 plants		
		Pretreat	24h post	120h post
Ambush 2E	.01	113	.6	0
Cymbush 3E	.005	99	.6	0
Scout .3E	.01	110	1.0	3.0
Ammo 2.5E	.005	117	1.6	0
Pydrin 2.4E	.005	84	3.6	0
Capture 2E	.01	87	3.6	0
Larvin 3.2F	.4	94	4.0	0
Thiodan 3E	.4	105	4.0	0
Penncap M 2F	.4	89	4.6	0
Capture 2E	.005	127	5.2	0
Furadan 4F	.125	115	5.2	0
Zectran 2E	.4	70	5.2	0
Spur 2E	.0025	86	5.2	.5
Baythroid 2E	.0025	95	5.2	1.5
Supracide 2E	.25	112	5.6	0
Karate 1E	.001	121	6.6	1.0
Pounce 3.2E	.01	111	7.0	0
Capture 2E	.001	103	7.6	0
Sevin XLR 4F	.75	96	7.6	0

Pay-Off 2.5E	.001	84	9.0	0
Lorsban 4E	.4	107	10.0	0
Scout .3E	.005	104	11.0	10.0
Untreated -	-	81	27.6	7.5
Untreated -	-	83	48.0	10.3

In our final analysis we will convert individual plots to % reduction, transform the data and compare % control. The individual insecticides will rearrange themselves somewhat in this process. However it is fairly clear that excellent control of SB larvae was obtained by most insecticides at the dosages we selected. It is possible to design control methods that will reduce cost in view of these low dosages.

THE VALUE OF STICKER FOR LARVAL SUNFLOWER BEETLE (SB) CONTROL

Questions had been directed toward us regarding the value of sticker-extender in enhancing Pydrin persistance for the control of sunflower beetle. Two separate trials were run one of whose preliminary data is reported in Table 2.

The sticker-extender used was Bond, a synthetic laytex type, at the rate of 4 oz per acre. Two insecticides, Pydrin and Karate were used at labeled dosage and at 1/10, 1/100, and 1/1000 labeled dosages. Counts of live larvae were collected pretreatment and 24 and 120 hours posttreatment.

Table 2. A comparison of sunflower beetle larval control using Pydrin and Karate with and without sticker. Minnesota 1985.

Insecticide & formulation	Dosage in lb ai/A	Number live larvae/10 plants: Pretreat w/Bond	Pretreat w/o Bond	24h post w/Bond	24h post w/o Bond	120h post w/Bond	120h post w/o Bond
Pydrin 2.4E	.1	79	57	3.0	1.0	0	0
	.01	95	63	3.6	5.0	0	.3
	.001	71	66	17.0	9.6	1.8	1.3
	.0001	72	79	21.0	6.6	32.3	20.8
Karate 1E	.02	81	88	1.0	4.0	0	0
	.002	77	74	2.0	1.5	.5	0
	.0002	91	60	31.6	3.6	0	.5
	.00002	74	72	24.0	29.6	8.3	12.8
Untreated	-	77	81	24.0	32.1	29.3	24.3

Even without statistical analysis one would have to conclude that Bond adds nothing in addition to the usual excellent performance of either Pydrin or Karate against SB larvae.

FURADAN SOIL TREATMENT VS FOLIARS FOR SUNFLOWER INSECT CONTROL

D. Noetzel, H. Ford, D. Warnes and J. Wiersma.

Soil systemic plots were established at 10 locations in 1985. These sites

extended from Lamberton in the south to Lancaster and Greenbush in the north. Excess rainfall destroyed plots at two locations. Of the remaining eight sites yield data from 5 locations are summarized in Table 3.

I compared the high and low labeled rates of Furadan 15G & 4F. We included a 1/2 rate soil applied of the lowest labeled dosage (ie .65 lb ai/A) as I was interested in seeing how that method of application performed vis a vis a foliar against adult beetle feeding. Treatment 7 is our recommended dosage of Pydrin for larval beetle control usually applied at the 16-20 leaf stage. Treatment 8 was a split treatment (both 0.1 lb ai/A Pydrin) one early to act against stem weevil, and the second to provide larval beetle control. Treatment 9 used Furadan .65 lb per acre as a foliar for adult beetle control on 2 leaf plants followed by our recommended rate of Pydrin (0.01 lb ai/A) against larval beetle at the 16 leaf stage.

Table 3. Furadan soil treatment vs foliars for sunflower insect (sunflower beetle, stem weevil, etc.).

Treatment & formulation	Dosage in oz/1000 row ft. or lb ai/A	Yield in lb/A by treatment at 5 different locations					Average yield in lb/acre
		A	B	C	D	E	
1) Furadan 15G	16	2617	2644	1753	1388	1043	1889
2) " "	8	2803	2832	1947	1331	1201	2023
3) " "	4	2655	2668	2028	1192	1023	1913
4) Furadan 4F	5 fl oz	2806	2982	1884	1621	1060	2071
5) " "	2.5 fl oz	2505	2839	1825	1197	865	1846
6) " "	1.25 fl oz	2866	2718	1872	1562	1030	2010
7) Pydrin 2.4E	.01	2870	2612	1638	1406	1113	1928
8) " "	0.1	2644	2850	1922	1406	856	1936
9) Furadan 4F Pydrin 2.4E	.65 .01	2624	2800	1765	1283	1151	1925
10) Untreated		2596	2689	1554	1305	1041	1837
Average		2698	2764	1819	1369	1038	

Both formulations of Furadan are labeled as soil applied systemics for sunflower beetle, stem weevil and grasshopper control. We observed 30 - 40% defoliation in the untreated plots at locations D and E. Stem cross sections showed stem weevil injury to be much below levels where we observed breakage to be present in 1984. Thus I have not included injury readings in this preliminary summary.

The data suggest that under a wide range of environmental conditions including insects and weather, we did not derive any yield benefit for Furadan use against the sunflower insect complex in Minnesota in 1985. We probably received no benefits from foliars in 1985 either.

In summary in Minnesota in 1984 and 1985 and based on replicated comparisons at seventeen locations statewide we did not obtain a single significant yield benefit through the use of Furadan as a soil systemic in sunflower. It is quite likely that this was also the case for growers

those years as well.

The major reason for the lack of yield benefit was the lack of damage by insects which Furadan has the potential to control. Where one makes an insecticide application commitment at planting time there must be a predictable average annual yield benefit that exceeds the cost of chemical and application, in this case $10 - $15/acre. If sunflower seed is $.08 per pound then yield differences must be 125 to 185 pounds per acre annually or 250 to 370 lbs every other year in order for the grower to break even. In Minnesota it is extremely unlikely this is occurring.

BANDED SUNFLOWER MOTH (BSM) CONTROL

Banded sunflower moth (BSM) numbers declined dramatically at Lamberton as well as throughout our major sunflower producing areas. Indeed numbers of most sunflower insects declined probably in response to the unusually moist and cool conditions. Even so our highest banded moth infestations may have been in southern Minnesota this year.

The late season and number of trials have not permitted analysis of these data in time for this publication. However preliminary Lamberton data produced in cooperation with Harlan Ford Southwest Experiment Station Agronomist is reported (see Table 4).

Table 4. Banded sunflower moth (BSM) control Lamberton 1985
D. Noetzel and H. Ford.

Treatment & formulation	Dosage in lb ai/A	Average number damaged seeds per 100
Capture 2E	.04	1.8
Karate 1E	.025	2.8
Ammo 2.5E	.05	2.8
Baythroid 2E	.05	3.0
Penncap M 2F	.5	3.0
Furadan 15G	1.3 (soil)	
+ Baythroid 2E	.05	3.5
Furadan 15G	2.6 (soil)	
+ Baythroid 2E	.05	3.8
Karate 1E	.01	4.3
Cymbush 3E	.05	4.3
Pounce 3.2E	.1	4.5
Pydrin 2.4E	.1	5.0
Ambush 2E	.1	5.0
Lorsban (HF) 4E	.5	5.3
Furadan 4F	.5	5.3
Baythroid 2E	.025	5.3
Capture 2E	.01	5.5
Pay-Off 2.5E	.05	5.5
Scout .3E	.019	5.8
Scout .3E	.015	7.8
Thiodan 3E	1.0	8.0

Dipel -	2 pts	10.5
Furadan 15G	1.3 (soil)	12.3
Furadan 15G	2.6 (soil)	13.0
Untreated -	-	13.0

We would not expect soil treatments to affect BSM and they did not. We included these in order to provide an additional site for statewide soil systemic comparisons reported elsewhere.

There are no surprises in these BSM control data. The synthetic pyrethroids are clearly outperforming our older insecticides against BSM. Capture (biphenthrin) a new pyrethroid from FMC appears to be as effective as Karate, Ammo (cypermethrin) and Baythroid (cyfluthrin). Of our presently labeled materials methyl parathion is at the top of the list in effectiveness and cost.

BANDED SUNFLOWER MOTH (BSM) CONTROL - FIELD MARGIN AS ENTIRE FIELD TREATMENT

We sampled a paired set of sunflower fields in 1985 to determine how field border treatment perform. Pretreatment counts of adult moths suggested similar pretreatment populations with field 1 (field completely treated) having slightly more females than field 2 (border and edge treatments). There were two border applications based on visual counts of adults of 0.1 Pydrin each. A single application consisted of two plane passes on the field edge and one pass on adjoining roadside, etc. The whole field application was made at 20% bloom using .75 lb methyl parathion per acre.

Table 5. Control of banded sunflower moth-whole field (field 1) vs border applications (field 2). Minnesota 1985.

Feet from field edge	Number infested seeds per 200 seeds	
	Field 1	Field 2
25	12.0	28.0
100	1.5	.75
200	.75	9.0
Center	0	11.5

Replicated 1/1000 acre samples were taken from four locations in each field. Heads were dried, a pre-threshing sample removed and BSM damaged seeds counted. Yields were also taken but are not reported here.

We would suggest a conservative use of these data as a single comparison of paired fields has some shortcomings. However the data are consistent with what we have reported in the past. Both fields 1 & 2 had economic levels of BSM if sunflower seed yields exceeded 1500 lbs per acre. There is a "border effect" as indicated by greater damage in field edges at both locations. The border effect remained following both treatments but did not appear to extend beyond 100 feet (40 rows) into the field. Whole field

treatment (field 1), assuming 1500 lb yields, gave an economic return to the grower while border treatment did not. It is not clear whether these differences are due to possible poor performance of Pydrin against this insect. However other methods of evaluating border applications suggest them to be inadequate.

EUROPEAN CORN BORER:
STATUS AND INSECTICIDE PERFORMANCE IN 1985

Kenneth R. Ostlie
Extension Entomologist
Department of Entomology
University of Minnesota

INTRODUCTION

Just two summers ago European corn borer populations reached record infestation levels. During 1984, infestation levels declined across most of the state. Based on historical patterns in the fall ECB survey, I projected this spring that infestation levels should decline further in 1985. What was the ECB situation in Minnesota during 1985? How has research on economic thresholds and insecticide performance progressed during 1985?

THE EUROPEAN CORN BORER IN 1985

Although ECB populations declined from 1983 to 1984, sufficient numbers of overwintering larvae were present this spring to cause real problems. Adult abundance this spring reached normal levels according to lighttrap captures. Yet, severe infestations never materialized. Why?

Failure of any problem to develop in southern and central Minnesota reflects the interaction between spring weather, planting dates, and weather during the adult flight. A warm, early spring beginning with >90°F days in April hastened ECB emergence. Although corn planting dates were normal to early throughout southern Minnesota, the early developmental advantage to the ECB provided by warm April temperatures was not erased. Thus ECB emergence relative to corn development was early compared to the normal synchrony between ECB and corn. Because "young" corn possesses higher levels of a resistance factor called DIMBOA, low larval survival was expected. More importantly, extremely cool nights and frequent rainfall during the adult flight in June provided inhospitable conditions for mating and egg laying. For these reasons, first generation infestation levels were extremely low and economic infestations were essentially nonexistent.

After a dismal first generation, adult captures in lighttraps during the second flight were extremely low. Second generation larvae never posed a significant economic threat. As indicated in Table 1, we enter the 1985-1986 winter with low numbers of overwintering borers.

First generation ECB populations in northern Minnesota also declined. Expectations of early ECB emergence were tempered by cool, rainy weather and peak emergence date was near last year's date. As in the south, cool nighttime temperatures (< 50 degrees Farenheit) disrupted mating and oviposition. Economic infestations, although more prevalent than in southern Minnesota, were less common than in 1984. The difficulties of making sound treatment decisions were compounded by uneven infestations within fields, subtle buildups in infestation, and speculation on

whether corn would reach maturity after the cool spring. Taller corn in sheltered areas attracted the heaviest infestations. Cool weather and retarded ECB development eliminated the potential for a second flight, as seen in 1983 and 1984.

Table 1. Results of Minnesota's fall survey for European corn borer, Oct. 14-25, 1985. Data supplied by the Minnesota Department of Agriculture - Plant Industry Division.

District	% plants infested	# ECB larvae 100 plants	% shanks infested	# ears on ground
WC	22	22	3.5	0.0
C	17	16	2.2	0.0
EC	6	3	0.6	0.0
SW	6	3	0.8	0.0
SC	10	6	1.7	0.1
SE	18	12	3.8	0.1
State Average	13	11	2.1	0.03

PROGRESS IN DEVELOPING ECONOMIC THRESHOLDS

Economic thresholds provide a valuable tool in deciding whether treatment of an ECB infestation will provide yield benefits exceeding control costs. Currently, most growers are familiar with older, nominal thresholds for the ECB. These thresholds advise treatment when 50% of the plants exhibit shotholing. Although a practical guide, this threshold is static and does not reflect changing yield potentials, crop prices, or control costs. Consequently, there's a potential for costly mistakes in making treatment decisions. More precise economic thresholds can be calculated from the following formula:

$$ET = \frac{\text{Control Costs}}{(\text{Expected yield X crop price X \% loss/borer X insecticide efficacy})}.$$

Using this threshold formula improves the chances of making a profitable decision about ECB control because control costs, yield potential, and expected crop price can be tailored to the individual farming operation.

Using calculated thresholds to Minnesota's ECB situation requires research on insecticide performance and yield loss per borer. Although values gleaned from other states provide a satisfactory first approximation, the Minnesota situation is sufficiently unique that additional research is required. For example, the yield loss values appearing Table 2 were derived from Iowa and Kansas studies using longer maturing varieties. Although the relative trends between growth stages may be correct, the magnitude of yield loss per tunnel may differ between 130 day varieties in Kansas and 75 day varieties in northern Minnesota. Similarly, differences in crop stage and larval location when insecticide application is made could alter insecticide performance. For these reasons, my research in 1985 focused on insecticide performance and yield loss.

Table 2. Corn yield loss, expressed as % loss per borer, caused by European corn borer larvae infesting various corn growth stages. Reproduced from Iowa and Kansas data summarized in NCR Publication no. 22.

Plant Stage	% loss per borer per plant
Early whorl	5.5
Late whorl	4.4
Pre-tassel	6.6
Pollen shedding	4.4
Kernels initiated	3.0

INSECTICIDE PERFORMANCE

Four insecticide trials were conducted in northern Minnesota against first generation larvae. Three of the trials, located near Twin Valley, Crookston, and Euclid, evaluated the performance of aerially applied insecticides. Heavy rainfall within 48 hours postapplication reduced performance of all insecticides at Euclid. For example, Penncap-M and Furadan 15G reduced larval abundance at Euclid 34% and 10%, respectively, compared to 81% and 84%, respectively, at Crookston. Therefore, data from Euclid will not be presented. Insecticide performance at Crookston and Twin Valley sites is summarized in Tables 3 and 4, respectively.

Table 3. Effectiveness of aerially-applied granular and liquid insecticides against first-generation European corn borer in northern Minnesota. Northwest Experiment Station, Crookston, Polk Co. - 1985.

Treatment	Rate (lbs ai/A)	Larvae per 50 plants	% Control
Furadan 15G	1.000	22.33 c	83.5
Pounce 3.2EC	0.150	23.67 c	82.5
Penncap-M 2EC	0.500	25.67 c	81.0
Lorsban 4E	1.000	49.33 b	63.5
Pydrin 2.4EC	0.150	55.00 b	59.3
Untreated Check	----	135.00a	----

Control ranged from 38 to 84%. Individual insecticides were farily consistent in their performance between the two trials. Furadan 15G, Penncap-M, and Pounce 3.2 EC provided better control than either Lorsban 4E or Pydrin 2.4EC. Over both sites, Furadan 15G, Penncap-M, and Pounce 3.2EC provided a minimum of 70% control. This was better than expected from last year's small plot trials where Furadan 15G, Penncap-M, and Pounce 3.2EC provided 68%, 50% and 50% respectively. Performance may have improved becuase the corn was in late whorl stage in 1985 rather than a pretassel or early tassel stage as in 1984.

Table 4. Effectiveness of aerially-applied liquid insecticides on first-generation European corn borer in northern Minnesota. Christenson farm, Twin Valley, Norman Co. - 1985.

Treatment	Rate (lbs ai/A)	Larvae per 10 plants	% Control
Pounce 3.2EC	0.15	5.00 d	74.1
Penncap-M 2EC	0.50	5.67 d	70.7
Penncap-M 2EC	0.25	6.33 cd	67.3
Lorsban 4E	1.00	10.33 bc	46.6
Pydrin 2.4EC	0.15	11.33 b	41.4
Pydrin 2.4EC	0.10	12.00 b	37.9
Untreated Check	----	19.33a	----

One small-plot insecticide trial was conducted near Gonvick, Beltrami Co., to evaluate the preformance of both labelled and unlabelled compounds against first-generation ECB in northern Minnesota. The performance of these insecticides is presented in Table 5.

Table 5. Effectiveness of granular and liquid insecticides on first generation European Corn Borer in small plot trials in northern Minnesota. John Brook farm, Gonvick, Beltrami Co. - 1985.

Treatment	Rate (lb ai/A)	Tunnels per 10 plants	% Control	Larvae per 10 plants	% Control
Baythroid 2EC	0.025	0.00 f	100.0	0.50 ef	95.9
Ammo 0.75G	0.075	0.25 ef	98.7	1.00 def	91.8
Furadan 15G	1.000	0.50 def	97.4	1.25 cdef	89.7
Ammo 2.5EC	0.075	0.75 def	96.1	0.00 f	100.0
Lorsban 4E	1.000	0.75 cdef	96.1	0.50 ef	95.9
Pounce 1.5G	0.150	0.75 cdef	96.1	0.50 ef	95.9
Lorsban 15G	1.000	1.00 bcdef	94.8	0.75 ef	93.8
Karate 1EC	0.015	1.00 bcdef	94.8	1.00 def	91.8
Capture 2EC	0.010	1.25 bcdef	93.5	1.25 cdef	89.7
Diazinon 14G	1.000	1.25 bcdef	93.5	1.75 cde	85.6
Larvin 3.2EC	0.500	1.25 bcdef	93.5	1.25 def	89.7
Furadan 4F	1.000	1.50 bcdef	92.2	1.50 cdef	87.7
Pounce 3.2EC	0.150	1.50 bcdef	92.2	0.75 def	93.8
Dipel 10G	1.000	2.50 bcd	87.0	2.50 bcd	79.4
Aastar 15G	1.000	3.00 bc	84.4	3.25 bc	73.2
Counter 15G	1.000	3.00 b	84.4	3.00 bcd	75.3
Thimet 20G	1.000	3.00 b	84.4	2.33 bcd	80.8
Pydrin 2.4EC	0.150	9.75a	49.2	5.25 b	56.7
Dyfonate 20G	1.000	10.00a	47.9	5.63 b	53.6
Untreated check	----	19.19a	----	12.13a	----

Two compounds, Pydrin 2.4EC and Dyfonate 20G, provided only a 45-50% reduction in tunnels and did not differ significantly from the check in the number of tunnels per 10 plants. All remaining compounds provided

at least an 84% reduction in tunnels and a 73% reduction in larval abundance. Although statistical analysis indicates some difference in performance between these remaining compounds, all except Pydrin and Dyfonate performed satisfactorily. Of the compounds evaluated, Baythroid, Ammo, Karate, Capture, Larvin, Aastar, and Counter are currently unlabelled for first generation ECB control.

Low larval abundance in southern and central Minnesota during 1985 eliminated the opportunity to evaluate insecticide performance against both first and second generation. Plans for 1985 include continued evaluation of insecticides against ECB throughout Minnesota. Specific attention will focus on general performance in aerial trials against first and second generation ECB, comparison of granule and liquid formulations, and comparison of application methods against first generation in southern Minnesota.

YIELD LOSS EXPERIMENTS IN 1985

Experiments quantifying the yield loss per tunnel continued in northern Minnesota. After two years of research, preliminary analysis of the data suggests an average loss of 7-8% per tunnel. This exceeds the value of 6.6% reported for pretassel corn in Table 2. Research in 1986 will continue to explore the yield-loss relationship with ECB tunneling in northern Minnesota and, if resources are available, expand these studies to southern Minnesota.

CORN ROOTWORM INSECTICIDE PERFORMANCE IN 1985

Kenneth R. Ostlie
Extension Entomologist
Department of Entomology
University of Minnesota

INTRODUCTION

The combined strategies of crop rotation and soil insecticide use usually limit corn rootworm (CRW) damage effectively. This report presents the results of soil insecticide trials against northern and western corn rootworms in Minnesota.

PERFORMANCE IN 1985 TRIALS

The performance of corn rootworm insecticides was evaluated at three locations in Minnesota: Waseca, Lamberton, and Morris. Table 1 presents the results of these trials for labelled insecticides and insecticides with an experimental use permit (Lance 15G). Only Lamberton experienced excellent pressure from CRW populations , receiving a root rating of 3.97 on the Iowa 1-6 rating scale. CRW pressure was greatly reduced at both Morris and Waseca compared to previous years with root ratings of only 2.14 and 2.38 respectively.

Table 1. Summary of corn rootworm insecticide performance in 1985 trials at University of Minnesota Experiment Stations in Lamberton, Waseca, and Morris*.

Treatment	Rate (oz/1000 row-ft)	Root Ratings		
		Lamberton	Morris	Waseca
Aastar 15G	8.0	2.69 cde	1.95 de	1.85 cde
Broot 15G	8.0	2.69 cde	1.98 cde	1.83 cde
Counter 15G	8.0	2.39 de	1.88 e	2.05 bcd
Dyfonate 15G	8.0	2.56 de	1.93 de	2.28ab
Dyfonate 20G	6.0	2.58 de	2.00 bcde	2.03 bcde
Dyfonate 4.6MS	***	3.39ab	2.13abcd	----
Furadan 15G	8.0	2.78 cde	2.23a	1.98 bcde
Furadan 4F	***	2.81 bcde	----	----
Lance 15G	8.0	2.29 e	1.98 cde	1.80 cde
Lance 15G	6.0	2.48 de	2.03abcde	1.73 de
Lorsban 15G	8.0	3.01 bcd	2.05abcde	2.00 bcde
Lorsban 4E	***	3.23 bc	----	----
Mocap 15G	8.0	2.95 bcd	2.18abc	2.13 bc
Thimet 20G	6.0	2.65 cde	2.08abcde	2.03 bcde
Untreated Check	----	3.97a	2.14abcd	2.38a

* Planting dates: Morris - May 24, Lamberton - May 13, Waseca - May 10. Cultivation treatments applied June 7.
Roots rated: Morris - Aug. 8, Lamberton - July 30, Waseca - Aug. 5.
*** Liquids applied at cultivation time at a rate of 1.0 lb ai/A in ca. a 10 inch band centered over the row, using a CO_2 powered backpack sprayer set at 30 psi and delivering 17 gallons of water per acre.

Yield loss and lodging associated with corn rootworm injury are generally associated with root ratings exceeding 3.0. Insecticide performance at Waseca and Morris will not be discussed because corn rootworm pressure was not sufficient to produce root damage exceeding 3.0. At these sites, although significant differences occur in root damage ratings, these differences are not economically meaningful. Low damage ratings at Morris probably resulted from late planting combined with earlier than normal corn rootworm hatch. The most critical time in the life of a corn rootworm larvae is its movement from the egg to a suitable host root. Failure to find a suitable root means death. When corn development is retarded compared to corn rootworm hatch, the root systems are much smaller, more difficult to find, and damage is reduced because mortality is increased. Generally, earlier planting is associated with greater injury. Low injury ratings at Waseca, however, do not seem related to planting date but to low population levels.

At Lamberton, all planting-time applications significantly reduced root damage but Lorsban 15G and Mocap 15G failed to acceptably protect the root systems (root rating > 3.0). All other granular materials applied at planting provided acceptable control. This year, three cultivation time treatments (Lorsban 4E, Furadan 4F, and Dyfonate 4.6MS) were evaluated at Lamberton. Of these treatments, only Furadan 4F provided acceptable root protection. Both Lorsban 4E and Dyfonate 4.6MS at cultivation provided unacceptable root protection.

CONSISTENCY OF CORN ROOTWORM INSECTICIDE PERFORMANCE

Corn rootworm insecticides vary in their performance from year to year. The consistency of an insecticide in keeping root ratings below a 3.0 is very important. Both consistency and price should be considered when choosing a corn rootworm insecticide. Consistency of insecticide performance during recent years in summarized in Table 2.

Table 2. Consistency of corn rootworm insecticide performance in Minnesota, 1977-1985, as measured by the proportion of trials where the insecticide maintained a root rating < 3.0 (Iowa 1-6 rating scale).

Insecticide	# Ratings < 3.0 / # Trials	%
Counter 15G	22/23	96
Thimet 20G	21/22	95
Broot 15G	19/20	95
Dyfonate 20G	18/22	82
Furadan 15G	18/23	78
Mocap 15G	16/22	73
Lorsban 15G	13/22	59
Untreated Check	6/23	26

SITUATION FOR 1986

Results of the adult corn rootworm survey conducted by the Minnesota Department of Agriculture - Plant Industry Division are presented in Table 3. Adult populations increased substantially in SE Minnesota, remained comparable in WC,C, and SC Minnesota, and decreased substantially in SW and EC Minnesota. The statewide ratio of northern to western corn rootworms stayed constant at 90:10 respectively. However, in SE Minnesota, western corn rootworm beetles increased in relative abundance to 28%.

Table 3. Corn rootworm adult survey (Aug. 1-20) in Minnesota.

District	Fields	Corn plants per acre	Adult beetles/acre 1984	Adult beetles/acre 1985	Percent lodging
WC	43	21,516	43,437	45,616	0.2
C	43	22,407	46,432	43,345	0.4
EC	34	22,398	43,535	23,011	0.5
SW	29	21,209	55,278	28,145	Trace
SC	62	22,411	44,883	42,505	Trace
SE	53	22,676	50,298	72,197	Trace
State Average		22,103	42,636	47,310	<1%

NORTHERN CORN ROOTWORM INJURY IN FIRST-YEAR CORN: CURIOUSITY OR THREAT ?

Kenneth R. Ostlie
Extension Entomologist
Department of Entomology
University of Minnesota

INTRODUCTION

The risk of corn rootworm injury in first-year corn is generally considered minimal and, consequently, the use of soil insecticides is generally considered unwarranted. Yet, during 1985, northern corn rootworm damage produced significant lodging in over 150 fields within a three state area (Iowa, Minnesota, and South Dakota). How severe was the problem? What are its causes? Is this problem likely to persist or does it represent a unique curiousity?

BRIEF HISTORY OF THE PROBLEM

Northern corn rootworm injury in corn following soybean or small grains is not new. As early as 1883, Forbes reported injury in corn following oats. Bigger reported a similar occurrence in a corn-corn-oat rotation in Iowa in 1932. Injury in corn following soybean, however, was not reported until 1971. For the most part, northern corn rootworm problems were usually isolated incidents. These problems were usually attributed to egg laying in soybean fields with grassy weeds or volunteer corn or in small grain regrowth after harvest.

During the late 1970's, lodging problems in first-year corn were reported with increasing frequency in SC Minnesota. This area of Minnesota has a strong corn/soybean rotation. Corn rootworm egglaying in weedy soybean fields was suggested as the cause of the problem. Consultants in the area, who had monitored weed populations in the soybeans disagreed, however, because the fields were essentially clean. During 1984, 6 problem fields, with root damage rating between 3.5 and 5.5, were reported by consultants in SC Minnesota. These fields accounted for ca. 1% of the first-year corn that these consultants scouted. For many of these growers, rootworm damage to corn following soybeans was not new. The frequency of this problem in SC Minnesota for a 5 year period indicated that we were facing something different, different enough to warrant investigation.

The occurrence of rootworm damage in first-year corn during 1985, therefore, was not surprising. However, both the magnitude and the distribution of the problem were totally unexpected. Not only did the problem reoccur with greater magnitude in SC Minnesota but it was distributed throughout southern Minnesota, northwestern Iowa, and eastern South Dakota. Over 150 fields with lodging attributed to northern corn rootworm injury have been reported to date. The distribution of fields with confirmed northern corn rootworm injury in Minnesota is presented in Fig. 1. In all three states, damage was not

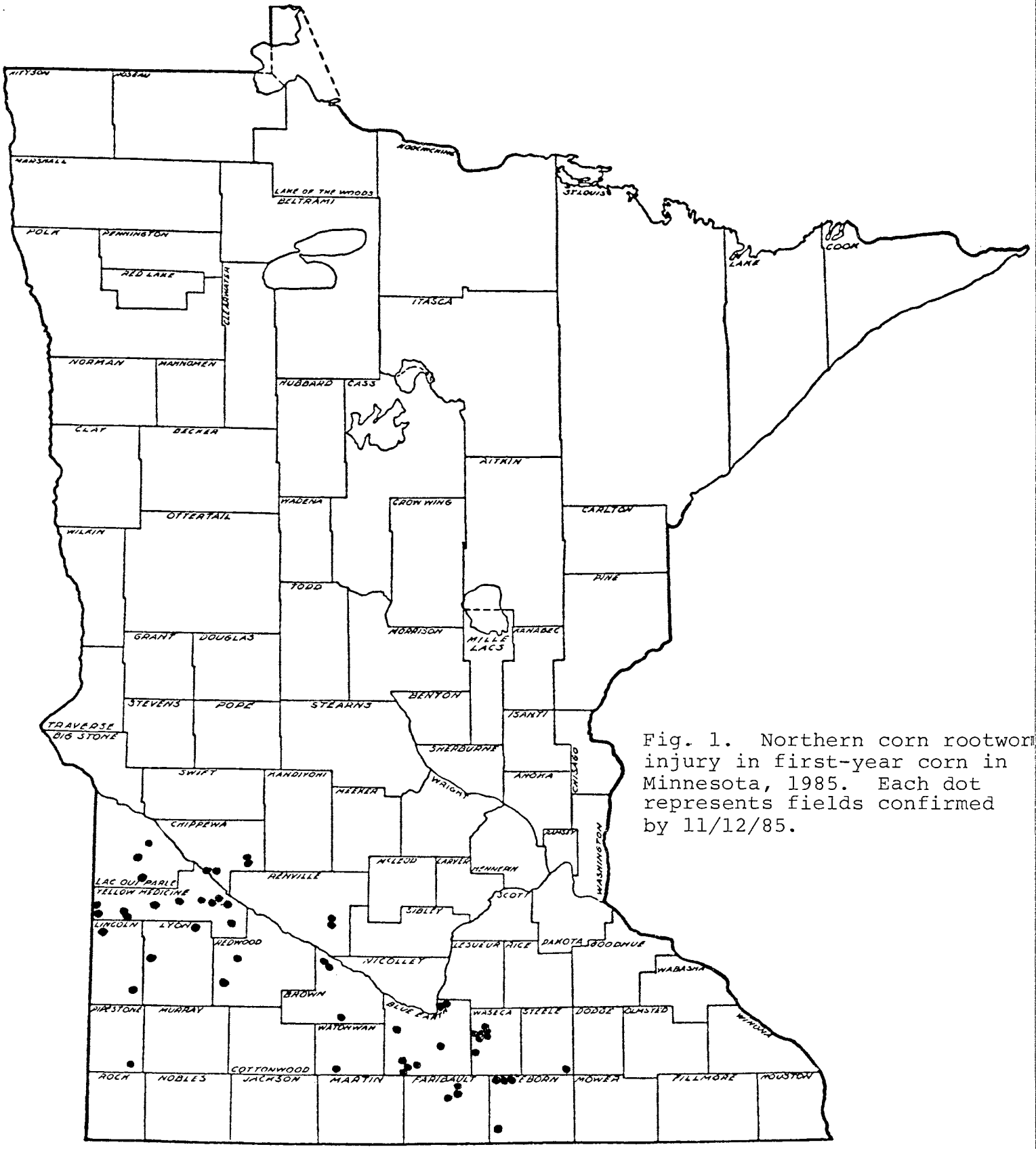

Fig. 1. Northern corn rootwor injury in first-year corn in Minnesota, 1985. Each dot represents fields confirmed by 11/12/85.

distributed uniformly. Instead, the problem tended to occur in pockets with several fields affected in each area. The pockets were widely scattered, surrounded by apparently undamaged fields. The majority of corn rootworms observed in these fields were northern corn rootworms. Abundance of adult northern corn rootworms in these first-year corn fields reached up to 6 beetles per plant. Recent research in South Dakota, indicating that over 98% of emerged beetles from first-year corn were northern corn rootworms, agrees with these observations.

The dramatic increase in northern corn rootworm problems in first-year corn raises some serious questions. Does this increase represent a unique situation that is unlikely to repeat itself? or Does this increase represent the tip of a long-term problem that threatens to negate the advantages of a corn/soybean rotation?

CAUSES OF THE PROBLEM

How can rootworm larvae end up in corn following soybean or small grains? Because northern corn rootworms have an annual life cycle, it was thought that adults laid their eggs in soybean and small grain fields the previous summer and fall. Many early investigators of this problem observed that northern corn rootworms, particularly females, left corn fields and foraged for pollen on broadleaf and grassy weeds, volunteer corn, and soybean. The investigators assumed that egg laying occurred where the rootworms were foraging. Later studies showed that northern corn rootworms predominately laid their eggs near the bases of corn plants, including volunteer corn. Although frequently seen on a variety of plants, few eggs were found in association with these plants. Thus, evidence suggests that egg laying is closely tied to corn and, to a much lesser extent, some grasses. So, why do problems occur following grass-free soybeans? Perhaps the best explanation of this problem involves "extended diapause".

Northern corn rootworms normally have an annual life cycle. The eggs laid in late summer and early fall go into a resting stage, called diapause, that allows them to successfully survive Iowa and Minnesota winters. These eggs either die during the winter or hatch the next spring. Over 10 years ago, Dr. Chiang, of the University of Minnesota, found that a small proportion of northern corn rootworm eggs (<0.3%) could successfully overwinter two winters. Thus, these rootworms have an extended diapause and a two-year life cycle.

Why would extended diapause benefit northern corn rootworms? In continuous corn, extended diapause has no real benefit. However, in a corn/soybean or corn/small grain rotation, all larvae that hatch after the first winter face starvation because they can survive only on corn and a few grassy weeds. Larvae that hatch after the second winter survive on the corn. Thus, extended diapause has a real advantage in a corn/noncorn rotation. Over time, the proportion of rootworms would be expected to increase. Evidence from recent rearing studies indicate a shift is taking place. Examination of northern corn rootworms from 3 areas of Minnesota and South Dakota where farmers routinely rotate corn and soybean indicate 40-50% of the rootworms have the 2-year life cycle. In contrast, less than 10% of the northern corn rootworms from 1

continuous corn area exhibited a 2-year life cycle. These data suggest northern corn rootworms are adapting to the common corn/soybean rotation.

A SURVEY OF FIELDS INJURED BY NORTHERN CORN ROOTWORMS

As the problem developed this past summer, entomologists in Minnesota, Iowa, and South Dakota concentrated on gathering as much information as possible about the extent of the problem and its possible causes. Area and county-based extension personnel, consultants, agronomists, and ag chemical dealers helped pinpoint, diagnose, and gather field histories on problem fields. These field histories provided our first clues on causal factors and cultural practices associated with the problem. At this time, results are still arriving but the preliminary findings are highly interesting.

Based on 28 initial histories from Minnesota and extrapolating to the number of reported fields, I estimate that less than 0.1% of the state's corn acreage is affected. For 89% of these farmers, it was the first time they had experienced the problem. Strict corn/soybean or corn/small grain rotations were practiced on 86% of the fields over the last 5 years. 96% of the farmers used some form of conservation tillage following soybean including 29% who used no fall tillage. Fall tillage following corn was more diverse, with 46% using a moldboard plow, 50% using a chisel plow or soil saver, and 4% using a disk. Spring tillage was fairly uniform, usually including ca. 1.6 passes with a field cultivator or disk.

Preliminary results also indicate that extended diapause offers the most consistent explanation of the problem. For example, 85% of the soybean fields did not have problems with grass control. More importantly, 100% of the problem fields were in corn during 1983. The necessity of corn two years previously strongly supports the extended diapause hypothesis. If the problem were caused solely by oviposition in soybean, I would have expected a greater proportion of fields, ca. 35% in Minnesota, enrolled in PIK or diversion programs in 1983.

PRELIMINARY FIELD RESEARCH

During 1985, a pilot study was initiated to determine if the problem would reoccur, its severity, and the economics of soil insecticide as a preventive measure. Conversations with these farmers indicated sporadic reoccurrence of the problem on the farm. Three corn fields were selected on farms with a prior history of thhe problem. Each field received 4 treatments, including 3 soil insecticides (Counter, Lorsban, Thimet) and an untreated check, replicated across the field.

Root ratings in early August confirmed corn rootworm injury, averaging ca. 3.0, in 2 of the 3 fields. Lodging was also evident in these two fields. Preliminary yield data indicates a significant yield benefit was not realized at any locations during 1985. However, the level of damage was not considered high enough to produce yield effects.

These findings confirm the tendency for problems to reoccur for a given farmer. In fact, the one farmer whose field escaped corn rootworm injury in our study had a nearby first-year corn field damaged by northern corn rootworms.

RECOMMENDATIONS FOR 1986

My concern about this problem is that we don't know what to expect in 1986. Is the magnitude of the problem in 1985 unique and unlikely to reoccur? Does it represent a unique combination of early planting, high egg numbers surviving from 1983, and ideal conditions for lodging? Or are we facing a problem that will persist?

Most likely, we'll see similar problems in 1986. Throughout the affected area, northern corn rootworm populations increased in 1984. However, mortality through two winters, crop rotation, planting dates, and weather will all influence the magnitude of the problem.

Prediction of individual fields that will experience damage in 1986 is impossible at this point. We do know that the problem tends to remain in pockets, because of the limited dispersal of northern corn rootworms, and the problem tends to reoccur on farms. Therefore, farmers, who had corn following soybean or small grain damaged in 1985 or who lived near a farmer with problems, should carefully consider the following options for first-year corn. Basically, a farmer has three options for first-year corn fields (that were in corn during 1984):

1. Lengthen the rotation sequence by planting another noncorn crop. This will break the cycle but, unfortunately, the noncorn crop options are limited.
2. Use a soil insecticide. This will protect the 1986 crop but the relative economic benefit is unknown.
3. Do not change your plans for 1986. Reoccurence in SC Minnesota is sporadic and hot spots seem to shift over the years. Although the overall risk is small, e.g., <0.1% in Minnesota during 1985, infestation rates as high as 50% occurred in one pocket in SC Minnesota.

Choose the option best suited to your farming operation, its financial situation, and your perception of the risk in your area. I wish I had a more definitive recommendation to offer but our knowledge of the problem, its pattern of occurrence, and ability to predict it are limited. As research progresses and our experience increases, I envision the ability to predict first-year corn problems and take cost-effective measures. The solution may be as simple as scouting first-year corn fields for adults and making decisions about cropping practices two years away.

Farmers who did not have a problem in their fields or did not live near a farmer with problems should not change their plans for 1986. Generally, I still advise against the use of soil insecticides on corn following soybeans or small grains.

CEREAL CROPS

WHEAT LEAF SPOT DISEASES AND THEIR CONTROL WITH FUNGICIDES

Maximum yield wheat management programs require a knowledge of all factors that affect crop culture. It is of interest to note, that only in recent years has the grower or the industry recognized the importance of cereal leaf diseases. It is interesting because leaf spot diseases occur after all of the production inputs have been made. Even in the best wheat production management programs; the occurrence of cereal leaf spot diseases can reduce yields by 25% to 50%. The protection of the wheat crop from losses caused by disease protects the potential yield that may be obtained from maximum management programs thus increasing the economic return to the grower. So as growers look to economic high yielding systems for wheat production, disease control programs will have to be developed, understood and used.

A disease control program includes the intelligent use of cultural practices, disease resistant varieties and agricultural chemicals known as fungicides. Such a program begins with clean disease-free seed and seed treatment.

Disease control programs have economic considerations, in that prevention of crop yield and quality losses results in higher returns for the crop production inputs.

However, as seed treatment and clean seed practices are established, I will relate this paper only to the newer practices of controlling the leaf spot diseases. Taking editorial liberty I will group such diseases as Powdery Mildew, Septoria Leaf and Glume Blotch, Helminthosporium Leaf Blights, Cephalosporium Stripe, Eyespot, Tan Spot, Stripe, Leaf and Stem Rust as leaf spot diseases. For the most part, wheat varieties have a high degree of resistance Stem Rust and plant breeders are in the position to manipulate sources of resistance into new varieties, so it is basic that a disease control program should include Stem Rust resistant varieties. With some types of wheat, Durum, Spring and Hard Red Winter, Leaf Rust resistance is also well identified; if such resistance is available the use of resistant varieties reduces the potential for loss and is part of the management decision. The successful use of a disease control program will depend upon a high degree of knowledge of these diseases, disease control concepts and the proper use of this knowledge by farmers and crop consultants. I would also include the Agricultural Businesses industry and Service sectors.

There are some basic considerations that growers will have to examine to put into practice a successful disease control program. The selection of the wheat variety to grow has become very challenging with the introduction of private Breeder varieties. In the past with only public varieties, growers have had the advantage of long testing programs as a decision aide, such public testing programs may not be available with the private breeding programs. However, the private breeding program is making available to growers many new, high yielding and high quality varieties; some of which will

be valuable and acceptable to growers.

The disease control program will also require very close attention to the growing conditions, stage of plant growth and disease presence, in order to plan fungicide application and chemical selection.

The economical method of fungicide application will have to be identified to fit particular areas and the individual growers capabilities. Fungicides may be applied by high pressure ground sprayers. Usually weed-sprayers are not adequate. Aerial application has been very successful in large field situations. But like the ground sprayers, techniques for weed spraying may be inadequate for fungicide treatment. In order to obtain adequate application with agricultural aircraft, the aircraft must develop a uniform spray swath and the spray must be delivered to the crop at close range to ensure deposition on the target leaves. Whether a grower elects to apply fungicides by ground equipment or by aircraft, this new technology will require some experience. Even though the "best" material may not be available at this time, it is to a growers advantage to get started with the available chemical so as to gain experience and learn what to expect.

Everyone is interested in "new things" in the area of fungicides there are some "new things", systemic type chemicals. The older protectant type chemicals being used are active on the surface of the plant. The systemic chemicals are active inside of the plant. These materials may be redistributed within the plant to some degree, in the plant's xylem system. systemic chemicals present advantages and disadvantages. The chemical must gain entrance into the plant in sufficient quantity to kill or inhibit the invading fungus. The chemical being inside the plant is protected from the environment and thus may persist in an active stage longer than protectant chemicals thus requiring fewer applications.

In general the systemic-type fungicides are very effective. The point of activity (interference with the fungus) may be very narrow. When a very effective chemical with a narrow area of activity challenges a population of the fungus pathogen, as might be expected, the fungicide exert pressure on the population that may result in the selection of fungicide resistance within the population. Systemic fungicide resistant populations of fungal pathogens have been identified in the laboratory and have developed in the field. In the field such changes in the pathogen populations reduce the efficiency of the fungicide.

The pathogen resistance phenomena does not have to eliminate the use of systemic fungicides, but rather identifies that very precise use of systemic fungicides will be necessary to prolong their beneficial effects on crop pathogens. Some systemic chemicals may have hormonal or growth stimulating effects which may be positive or negative. The mode of action of some of the systemic fungicides have some similarities even though they make up a hetrogenious group of chemicals.

Experience has or should have taught us that the fungi have the ever-present

potential to survive the best attempts of man to control them. The method or site of action of the systemic fungicides will have to be understood when using these chemicals. In order to keep the fungus population "off balance", it may be advantagious to alternate or use different chemicals when more than a single application is to be used.

Some of the same systemic fungicides that will be recommended for foliar applications will be promoted as seed treatment fungicides. Therefore, it will be important to make sure that the same chemical is not used for both treatments. If the plant contains a low rate of the fungicide from the seed treatment, there will be "presence" on the native population of the pathogen, with the possibility of favoring the development of resistant segments of the population. Then when a foliar application is made a further extension of the selection "pressure" is in effect. Such a situation may bring about the development of a fungicide resistant field population of the pathogen.

Benzimidazole - MCB - Active in the Nucleus		
Ergosteral Inhibitors	--	Disrupt the cell membrane of the fungus.
Piperazines Pyridines Pyrimidines Imidazoles Triazoles		
Morpholines	--	Ergosteral inhibitors but different from (above)
Hydroxopyrimidines	--	Inhibit and disrupt approsoria formation.

Where have we been and where are we going? Not to belabor all of the research and field work that has been done to identify the benefits of fungicide control programs, I will present only a few examples of my own experience over 25 years work.

Early work, 1962 resulted in some very slim beginnings. In the Spring Wheat areas, Selkirk wheat had been grown for 12 years. It was resistant to Stem Rust race 15. By the late 1950's. Leaf Rust and Septoria Leaf Blotch were affecting the leaves. Early fungicide tests did result in yield increases (Table 1). During the 60's and early 70's the only fungicides available were the Ethylene Bisdithiocarbamates materials. These fungicides are protectants and still provide good control for most of the leaf spot pathogens, with the exception of Mildew (Table 2).

Some selected data from Experiment Station research for the detection of disease control activity is presented in Table 3. Obviously this work was not done to identify maximum yields. Note the differences in yields, between treated and untreated. The variety Marquis (1940's), a very old variety rust and Septoria susceptible was used to see if a variety without disease resistance could be improved with fungicide treatment. It appears that there is a limit to what may be expected, thus demonstrating that we should use the most resistant varieties to effect a favorable fungicide response.

Results from on-farm research (1985) with a cooperating grower are in Table 4. This data, like that in Table 2 reflects efforts to obtain maximum yields. In Table 4, Cerone was used to reduce the loss resulting from lodging. The only tall variety, Stoa, responded very favorable to such a treatment, while the semi dwarf varieties (Marshall, Oslo, Pioneer 2369 and Wheaton) did not have similar response. All varieties responded to fungicide treatment. Oslo, Pioneer 2369 and A99 are private varieties, Marshall, Wheaton, and Stoa are public varieties.

Although the growth inhibiting hormone Cerone may not provide a regular positive yield response, the use of such a chemical may reflect it's economic value, by reducing the time required for harvesting a crop. This is a value that the grower will have to identify.

The affect of such chemicals has not been positive on all varieties, therefore a grower should identify whether or not there has been negative effects on the particular variety he will be treating.

For many of these leaf spotting diseases the inoculum, in the form of spores or mycelium, persists from one crop to the next crop on the previously infected plant debris. The current "wave" of reduced tillage or no-till cultural practices can provide a very serious disease potential. The use of these tillage practices should include a system of crop rotation. Where wheat is to follow wheat in the cropping sequence some other system of erosion control should be followed.

The yield of wheat can be favorably influenced by the use of fungicides for the control of leaf spot diseases. For maximum yield programs the growers must pay attention to variety, selection, fertility requirements, weed control, cultural practices, and disease control practices.

Plant diseases are shifty enemies that cause economic crop loss.

TABLE 1. CEREAL LEAF DISEASE CONTROL ON FARMS (2) WITH AERIAL APPLICATION OF ZINEB FUNGICIDES, ARGUSVILLE, NORTH DAKOTA, 1962 - 1963.

VARIETY	YIELD BU/A		
	UNTREATED	TREATED	% INCREASE
1962			
SELKIRK	31.9	35.9	12.5
SELKIRK	34.2	38.2	11.7
1963			
SELKIRK	18.3	25.8	40.9

TABLE 2. DISEASE CONTROL WITH MANCOZEB TYPE FUNGICIDES ON CURRENTLY GROWN SPRING WHEAT VARIETIES IN MINNESOTA.

1984 Variety	Yield (bushels/acre) Treated[1/] bu/a	Protein	Untreated bu/a	Protein	Difference
Marshall	82.5	14.6	75.1	14.3	7.4*
Oslo	93.8	14.8	79.3	14.4	14.5*
Pioneer 2369	91.6	14.7	84.2	14.3	7.4*
Era	84.8	14.7	81.9	14.2	2.9
Marshall	68.5		58.2		10.3*
Wheaton					
Minimum Tillage	93.4		81.4		12.1*
Plowed	95.7		96.2		--
1983					
Len	79.1		63.5		15.6*
Marshall	85.6		75.9		9.7*

1/ 2 pounds Dithane M-45 per acre, 2 applications, early heading and 10 days later.

* Statistically significant 1% level of significance.

TABLE 3 **SOME SELECTED DATA FROM FUNGICIDE TESTS AT THE ROSEMOUNT EXPERIMENT STATION TO IDENTIFY FUNGICIDAL ACTIVITY.**

1979	Era	% Increase	Angus	% Increase	% Necrosis Leaf Era	% Necrosis Angus
BTS 40542	31.9	8%	21.6	10%	12	--
Dithane M-45	31.2	6%	21.4	8%	25	--
Check	29.4		20.0		30	
	Era		Marquis		Era	Marquis
340 F	36.1	22%	16.2	12%	10	100
ME147	33.4	13%	15.3	6%	15	100
	Era		Marquis		Era	Marquis
CGA-64250	36.3	12%	23.2	52%	10%	30%
Check	32.5		15.3		25%	100%
	Era		Marquis		Era	Marquis
Bravo	26.6		11.8		7	100%
Dithane	26.6		12.7		10	95
Check	25.1		11.6		15	100%

TABLE 4. NORMAN COUNTY, (GORDNER FARM) - 1985

DISEASE CONTROL WITH MANCOZEB FUNGICIDES ON CURRENTLY GROWN SPRING WHEAT VARIETIES IN MINNESOTA.

	BU/A					
	Marshall	Oslo	Pioneer	Stoa	Wheaton	A99
80#/a Seed Rate						
Untreated						
Check	73.4	66.4	61.4	54.9	74.5	60.0
Cerone	76.2	68.1	64.3	62.9	71.4	60.5
Treated						
2X	75.9	81.0	70.9	63.1	76.8	67.9
3X	86.9	79.4	73.1	61.3	79.7	69.2
2X + C	85.1	82.1	72.4	69.0	82.3	65.1
3X + C	80.1	86.1	69.3	72.0	85.2	63.8

2X = 2 Applications Dithane M-45, 2#/acre
3X = 3 Applications Dithane M-45, 2#/acre

SUGAR BEETS

Cercospora leaf spot occurred on time again this year. However, due to the warm dry conditions in July, the disease moved very slowly.

Disease control practices can and do work if no short-cuts are taken. Early detection is important, proper application is essential for chemical treatments to be beneficial. We have been extremely concerned about variety selection, fungicide selection and rightly so however, the application technique is just as important. Some aerial application of less than 5 gallons per acre were observed, giving less than adequate disease control. The general aerial and ground applications were successful in keeping the Cercospora leaf spot disease in check this year.

The Cercospora leaf spot decision model, where used in 1985 worked very favorably for growers. In many beet growing areas the model did not identify the need for fungicide treatment, thus saving a considerable cost to growers.

Growers and Ag. Service persons should become aquainted with the model, so that a good disease control program can be maintained.

POTATOES

Verticillium wilt is no longer only a disease problem in our area, now it is recognized as a nation-wide disease problem on potatoes.

In the simplest form, cleaning-up this disease problem is going to be expensive. The wilt fungus seems to do quite well living in the soil. However, the wilt fungus really makes its mark when one examines the infected plant debris. This may well be the important factor in the success of wilts rise to prominence in the potato disease world.

It is quite apparent that wilt got it start with the variety Kennebec. Very susceptible, sort of a "Typhoid-Mary" syndrome. The variety came on when Mercury seed treatment went out. It was widely grown especially as the processing industry developed. Crop rotation practices were changing, from potatoes one out of four years to once out of two years. Some growers even went to mono-culture. Also there were no restrictions for wilt on seed.

Verticillium reflects its presence by lowering yield quality. There may be total yield reduction, there is definitely tuber size (quality) reduction and internal vascular necrosis.

Can wilt be controlled? It would appear that many things can be done to reduce the losses resulting from wilt. Control will require a major effort by all parts of the industry.

In the field, the primary source of the disease, infected potato vines

should be destroyed, after harvest. Crop rotation will have to be stretched out to 3 or 4 years, until such a time that the inoculum potential in the field has been reduced. Disease resistant varieties will have to be worked into the system. Seed stocks will have to be cleaned up. Last but not least, ultra susceptible varieties should not be grown.

Soil fumigation can reduce the crop loss caused by Verticillium wilt. Even though the results of soil fumigation are economical, It does not appear that fumigation alone will solve the problem. The inoculum going back into the soil from infected stems must be eliminated. Then we should find much better results from soil fumigation.

Soil fumigation field tests were carried out near Big Lake, Minnesota, on irrigated sand in 1984, 1985 and at Mentor, Minnesota in 1985. The results from these tests are in Table 1,2, and 3. Soil fumigation increased yield of marketable potatoes and reduced the internal tuber symptoms. Table 4 identifies the amount of fungal inoculum that infected plant debris may carry back into the field by different varieties. It appears that along with soil fumigation a field sanitation program will have to be developed. Sanitation will require the removal or destruction of the infested plant debris.

Wilt resistance has been identified in the Minnesota Potato Breeding materials. As this material becomes a new variety, the grower will have to still exercise disease control practices to reduce the amount of disease inoculum or these varieties will also succumb to the disease.

TABLE 1. THE AMOUNT OF VERTICILLIUM INOCULUM ISOLATED FROM POTATO STEMS GROWN IN THE DISEASE NURSERY AT THE GRAND FORKS POTATO RESEARCH FARM

Season	Identification[1]	Colony County	Rating[2]
1984	9648	3886	
	Agassiz	1877	
	Eric	602	R
	Tolaas	2203	
	Reddale	156	R
	Russet Burbank	6658	
	Kennebec	11022	
	BR7093-23	577	R
	11719	178	R
	12454	900	R
	12482	377	R
	12761	419	R
	82344	644	R
	82370	943	R
	82393	210	R
1983	Norchip	4273	

1/ Only a partial listing of material in the nursery showing that resistance is present.

2/ Counts under 1000 are presently being identified as resistant.

TABLE 2. VERTICILLIUM COLONIES (INOCULUM) COUNTS FROM FUMIGATED SOIL, BIG LAKE, MINNESOTA AFTER ONE CROP OF POTATOES (RUSSET BURBANK).

	Treatment In Gallons/A	Season	Colonies Counts Grade of Potato Debris
Irrigator Applied	50	1983	4,620
Chisel Applied	50	1984	2,500
Chisel Applied	25	1984	10,800
Untreated			36,900

TABLE 3. RANKING OF POTATO VARIETIES AS TO SOURCE OF INOCULUM OF VERTICILLIUM SPECIES ISOLATED FROM STEMS (2 YEARS).

Variety	V. Albo-Atrum Rank	V. Albo-Atrum Cor./Cof.	V. Dahliae Rank	V. Dahliae Cor./Cof.
Red Pontiac	1	11.37	8	5.75
Superior	2	9.87	4	8.25
Irish Cobbler	3	9.05	3	9.00
Kennebec	4	8.25	2	9.75
Norgold Russet	5	8.25	9	4.62
Russet Burbank	6	7.62	1	11.25
Norchip	7	6.62	6	6.88
Norland	8	5.37	7	6.37
Anoka	9	4.75	10	3.12
Red La Soda	10	2.75	11	2.37
La Rouge	11	2.12	12	2.12
Hunter	12	1.62	5	7.75

SUNFLOWERS

Mildew, much more prevalent this year. Some fields were observed with 20% infected plants. The soil can become contaminated from infected debris, so flowers should not be grown on old flower land. Growers should not use seed from infected crop for planting next year's crop. Grow resistant varieties where available.

In 1985 Carlyle Holen, Extension Crop Management Specialist, surveyed 8 counties in Northwest Minnesota for the presence of Downy Mildew. Five fields were selected in each county. Within each selected field 10 areas were sampled. The result of the survey are in the following table.

COUNTY	AVERAGE % MILDEW
Roseau	9.4
Marshall	14.8
Pennington	7.8
Red Lake	6.7
East Polk	15.1
Norman	18.5
Mahnomen	19.2
Becker	9.0

Again we will request a Section 18 exemption from EPA, for the use of the fungicide APRON as a seed treatment. Last year the exemption was granted after planting time.

White mold continues to take its toll. This disease should be of real concern to flower growers. The fungus, in the form of sclerotia, go back into the soil during harvesting. These dark colored, hard fungal bodies are about the size of a pencil eraser, many remain viable in the soil for many years. Not only is the flower crop susceptible, but all broad leaf plants are susceptible: soybeans, edible dry beans, potatoes, etc.

White mold can infect the sunflower plant through the roots, stem injury and the head. At present, the best practice to follow is a long rotation system.

In 1985 White Mold was very severe in the Northwest part of the state. Several fields were observed with 40 to 50% infected plants.

At present there are now fungicides registered for use on sunflowers to control White Mold. However, some sunflower seed companies are developing lines of sunflowers with disease resistance.

FUNGICIDES[1] FOR USE ON FIELD CROPS
CEREALS
SEED TREATMENT - WHEAT, BARLEY, AND OATS

COMMON NAME	TRADE NAMES	BUNT CONTROL	SEEDLING BLIGHT CONTROL	REMARK
Captan	Captan Orthocide Evershield (Several other names)		G**	Combination with maneb or zineb for bunt.
Captan-HCB	Ortho seed protectant	G	G	
Carboxin	Vitavax			For control of loose smut
Carboxin & Thiram	Vitavax 200	F	F	For bunt, seedling Evershield blight and loose smut control.
Imazalil	Fecundal Double R		G	For seedling blights. and Root Rots.
Maneb	ABSCO DB Green L ABSCO DB Yellow cover-up Granol NM	F	G	DB Green & Granol NM are combined with Lindane
Maneb	Granox NM	G	G	
PCNB	Terra-coat Terra-coat	G G	F F	Combined with Terrozol Combined with Terrozol
Polyram		F	G	
TCMTB	Busan (cover-up L)	G	F	
Thiram	Arasan-75 Evershield Thiram	F F	G G	

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* Seed injury may occur if high moisture seed is treated and stored.
** F = Control Fair
G = Control Good

[1] There may be other seed treatment fungicides on the market that I am not aware of that are also satisfactory for treating cereal seed.

FUNGICIDES[1] FOR USE ON FIELD CROPS (CONTINUED)

CEREALS

Cereal Leaf Diseases		Remarks
Dithane M-45 Manzate 200 Maneb Zineb Kocide 101	Rusts and Leaf Spots	Apply by air, using minimum of 5 gallons of water per acre, and spread-sticker per label. See label rate and limitations.
Bayleton	Rusts (leaf, stem, stripe) and mildew.	
Benlate & Manzate 200	Powdery Mildew, leaf rust, Helmintho-sporium leaf blight, Septoria leaf and glume blotch.	A tank mix - see label for rates.

POTATOES

Seed Piece Treatment

Captan
Orthocide Plus
(Captan + Mertect)
Maneb
Polyram
Zineb
Dust Treat T
(Zineb + Streptomycin)
Tops - 2.5 D

Late Blight and Early Blight

Bravo Copper Kocide 101 Difolatan Duter (no spreader sticker) Mancozeb Dithane M-45	See label for rates and limitations

POTATOES (continued)

Late Blight and Early Blight (continued)

Manzate 200	
Maneb	
Dithane M-22	
Manzate	
Zineb	
Polyram	
Blight Out (Polyram + Maneb)	
Ridomil MZ	A systemic fungicide especially good for Late Blight, maneb is added for Early Blight protection. Use as needed, Late Blight has been able to develop resistance when excessive applications have been made.

SUGAR BEETS

Seed Treatment

See Label for Rates & Precautionary Instructions		For Control of Damping-Off				Remarks
		Aphanomyces	Pythium	Phoma	Rhizoctonia	
Captan 35.2%	Slurry	-	-	-	-	General Seed Treatment
Demosan 65W	Slurry	-	G	-	G	May be used as a supplemental treatment
Lesan	Slurry	E	E	P	P	May need 6 oz. on high

NOTE: For maximum protection use with a fungicide that controls Rhizoctonia & Phoma.
CAUTION: See label for care in handling.

Maneb 80% Dithane	drillbox	-	G	-	G	
Maneb + Zinc 80% Dithane M-22 Special	drillbox	-	G	-	G	
PCNB + Etirdiazole Terra-coat 1-205	liquid or slurry	G	G	F	E	
Terra-coat SD-205	slurry	G	G	F	E	
Thiram Arasan 50 Red	drillbox or Dust	-	-	G	G	
Arasan 50 Red ND	Dust	-	-	G	G	

P = Poor, F = Fair, G = Good, E = Excellent, - = No Data.

Cercospora Leaf Spot

Control requires - early irregular applications, at recommended rates.

Copper	Remarks
CITCOP 4E CITCOP 6E Copper County - N Kocide 101 Kocide 404 Oxy-Cop 8L Tribasic Copper Sulfate	For all fungicides used see label for rate and limitations. Do not use less than minimum rate, during favorable conditions of infection the spray schedule may be closed-up. When leaves are wet for 8 1/2 continuous hours, temperatures above 62^{o} (optimum 75^{o}) conditions are favorable for infection.
Mancozeb	
Dithane M-45 Dithane M-45 Flowable Manzate-200	
Maneb	
Dithane M-22 Maneb	
Metiram	
Polyram	
Metiram + Maneb	
Blite-Out	
Triphenyl Tin	
Hydroxide	
Duter Super Tin Triple Tin	20 ounce rate, at 5-7 day intervals, during hot, humid days, may result in some leaf injury. Follow schedule on the label.

Powdery Mildew

Fungicides for Powdery Mildew Control	Remarks
Benomyl Benlate	
Sulfur *BIG 8 that is Flowable 64%	Apply sulfur if mildew appears by mid-August. One Application usually gives adequate protection for 4 weeks.
Magnetic 6 Flowable 51%	
That flowable 52%	
TOP-COP + Sulfur	

Copper

See listing under Cercospora leaf spot	See label for rate and limitations. *Can be used in irrigation system.

Rhizoctonia and Scab

PCNB - Terraclor emulsifiable concentrate
(Broadcast or in-furrow applications)
See label for rates and limitations.

EFFECT OF RONILAN, BENLATE, ROVAL, TOPSIN M AND TWO NUMBERED COMPOUNDS ON THE CONTROL OF WHITE MOLD

Pinto bean growers have recognized for a long time that White Mold, caused by Sclerotinia sclerotiorum can be especially detrimental to pinto bean yields. Chemicals such as Benlate and Topsin M have been important tools in the control of White Mold epidemics. The following study was designed to evaluate the effectiveness of different rates of Ronilan, Benlate, Roval, Topsin M, TD2192 (a Pennwalt Product) and CGA-449 (a Ciba Geigy Product).

The data collected in this experiment indicates that Benlate, and Topsin M still has the ability to control White Mold in Minnesota. Ronilan, when the Federal label is obtained should also be a treatment of choice. TD2192 was also quite effective in controlling White Mold and increasing the yield over the unsprayed check (Table 1). Roval at the higher rates was also effective in controlling White Mold (Table 1). More rates of Roval along with CGA-449 were not nearly as effective in controlling the disease (Table 1). Competitive price and availability along with effectiveness will be the factors which will keep our chemical tools a viable option in the fight against White Mold.

Chemical control, however, is just one method of keeping White Mold under control. Three year rotations with non-host crops such as corn and small grains will do a lot to prevent serious build-up of White Mold in the soil. Crops like sunflowers, which are very susceptible to White Mold, should be avoided in a dry bean rotation. Planting tolerant varieties such as Bonsi (Ex Rico 23) Neptune + C-20 navies is another way to help keep the disease to a minimum. When selecting other classes of Dry beans, select varieties with upright growth habits which will encourage good air circulation in the canopy. The fact that upright varieties are more resistant to infection by White Mold is obvious in many bean growing area of the state in 1985. This was demonstrated in one case when two fields of pinto beans were grown next to each other. One field was of a vine type while the other field was an upright type. At the beginning of August the vine type field had approximately 75% wilting while upright varieties had only an occasional plant affected. Air circulation is very important in helping to control the disease in a dry edible bean canopy.

When considering when to spray, remember that fields which have been wet for a long extended time before blossoming are good candidates for White Mold infection. The odds for White Mold greatly increase when bean foliage covers the row. When these conditions are present, and the farm has a White Mold history and the outlook is for continued damp weather the present recommended sprays are 1 to 2 applications of Benlate or Topsin M at 1.5 - 2 lbs/acre. Michigan data has suggested that 1 spray at about 100% bloom is may be the most economical. Spraying a second time has been shown to reduce the disease but may not be economically feasible.

White Mold spray program will not control 100% of the disease but in most cases should be cost effective. Coverage is very important. Since these chemicals are systemic and only travel upward in the plant it is important to get adequate canopy penetration. Ground sprayers with more than 1 nozzle/row and high pressure (30-40 gal H_2O, 75-125 lbs.) will give the most consistent results.

TABLE 1. Yields and White Mold Levels in 1985 - Staples White Mold Trials.

Fungicide	Rate	First Application	Second Application	Yield lb/A	% Canopy Wilted By White Mold 8/15	8/29
Benlate, 50 WP	2 lb F/A	30% bloom	peak bloom	2,574	2	23
TP2192, 4.5 F	30 oz F/A	10% bloom	14 days later	2,134	3	37
Ronilan, 50 W	.75 lb ai/A	10% bloom	14 days later	1,970	2	33
Topsin M, 70 WP	1.50 lb F/A	10% bloom	14 days later	1,720	5	53
Roval, 50 W	1.00 lb ai/A	10% bloom	14 days later	1,522	12	50
CGA-449, 50 WP	1.00 lb ai/A	5% bloom	21 days later	1,456	13	60
Topsin, 70 WP + Ronilan, 50 WP	.5 lb F ea/A	10% bloom	14 days later	1,444	5	57
CGA-449, 50 WP	.5 lb ai/A	5% bloom	21 days later	1,288	15	65
Roval, 50 WP	.75 lb ai/A	10% bloom	14 days later	1,229	12	67
CGA-449, 50 WP	.25 lb ai/A	5% bloom	21 days later	1,016	30	82
Rovral, 50 WP	.5 lb ai/A	10% bloom	14 days later	951	35	78
None	0	---	---	851	28	97

CHEMICALS FOR DISEASE CONTROL IN DRY EDIBLE BEANS

Chemicals are an important tool in controlling the diseases of dry edible beans. A list of the names of a number of chemicals which are effective in controlling some of the most common diseases are listed below.

The diseases caused by fungi are more easily controlled by chemicals than the bacterial blights. Common bacterial blight, a seedborne bacterial disease, is not efficiently controlled by chemicals. There is evidence, however, that coppers will slow down halo blight (seedborne) and brown spot.

Coverage, timing and application rate is very important when applying chemicals. Ground applications should be made with 30-50 gallons of water with 75-125 lbs. pressure. Air applications should be made with no less than 5 gallons/acre.

Many chemical applications have failed because of inadequate coverage, (due to low rates, low pressure or flying too high, etc.). Coverage is especially important with systemics like Benlate and Topsin-M which are restricted to upward movement in the plant. Good canopy penetration is necessary for optimum control using these chemicals. Though coverage is also important for protectant fungicides.

This list contains information which is current but subject to change. To assure appropriate use, **READ THE LABEL** before use, and follow the recommended rates and safety precautions.

Dry Beans

Chemicals Labeled for Seed Treatment of Fungus and Bacterial Diseases

SEED TREATMENT

Chemical	Labeled Use	Rate	Company
Agri-Strep 500, or AS-50 Slurry (5%)	halo blight	50,000 ppm (5%) -83 lb./100 gal. spray or slurry	Merck & Co. Inc.
Agrox 2-way	damping off, seed decay, seedling blight	2 oz./bu. mixed thoroughly with seed in planter box	Chipman Chemicals, Inc.

Chemical	Labeled Use	Rate	Company
Agrox 3-way	damping off, seed decay, seedling blight	3 oz./bu. mixed thoroughly with seed in planter box	Chipman Chemicals, Inc.
Agrox D-LPlus	seedling blight, damping off, seed decay	2 oz./bu./ mixed thoroughly with seed in planter box	Chipman Chemicals, Inc.
Captan 400-D, 39.1%	seed decay, damping off, seedling blight	2 to 3 fl. oz. /100 lb.	Gustafson
Hopkins-Bean Seed Treatment	damping off, seedling blight; for use in Michigan, Nebraska, New York, North Dakota, and Wisconsin states only	3 oz./bu./ mixed thoroughly with seed in planter box	Hopkins
Lesan-70-WP	damping off, seed rot	1 oz./100 lb. seed	Mobay

Dry Beans

Chemicals Labeled for Foliar Spray of Fungus and Bacterial Diseases

FOLIAR SPRAY

Chemical	Labeled Use	Rate	Company
Benomyl			
Benlate	white mold, grey mold	1.5 to 2 lbs./A at 25%-50% bloom; repeat at peak bloom 14 day PHI.	DuPont

Chemical	Labeled Use	Rate	Company
chlorothalonil			
Bravo 500	rust, anthracnose, downy mildew	2 to 3 pt./A at early bloom; repeat at 7 to 10 day intervals. 6 week PHI.	SDS Biotech
copper			
Citcop 5E	bacterial blights	3 pt. in 3 gal. water/A. beginning when weather conditions favor disease development and continue at 7 to 10 day intervals to harvest.	Tennessee Chemical Company
Tri-Basic Copper Sulfate	angular leaf spot anthracnose bacterial blight, downy mildew	2 to 4 lb./A. beginning when plants are about 5 inches tall and repeat every 5 to 7 days.	Tennessee Chemical Company
Flowable Tri-Basic Copper	bacterial blights	1 to 2 qt./A. beginning when disease is first expected and repeat at 7 to 10 day intervals.	Tennessee Chemical Company
Kocide 101	halo blight and common blight	1 to 3 lb./A. beginning when plants are 6 inches high and repeat at 7 to 14 day intervals.	Kocide Chemical Corporation
Kocide 606	halo blight and common blight	1 1/3 to 4 pt./A. when plants are 6 inches high and and repeat at 7 to 14 day intervals.	Kocide Chemical Corporation

Chemical	Labeled Use	Rate	Company
copper & sulfur			
Kocide 404S	halo blight and common blight rust. NOTE: the first rate is for control of blights the second is for control of rust.	1 to 3 qt./A. when plants are 6 inches High and repeat at 7 to 14 day intervals 1.5 to 3.0 qt./A. make 3-4 applications at 7-10 day intervals.	Kocide Chemical Company
maneb			
Maneb 80	anthracnose, rust	1.9 lb/A. beginning during early bloom or when disease first appears, then at 4 to 7 day intervals as needed.	Pennwalt Corporation
maneb + zinc			
Agsco MN Flowable	anthracnose, downy mildew, rust	0.8 to 2.4 qt./A. when disease first appears then repeat at 5 to 7 day intervals.	Agsco, Inc.
Dithane FZ	anthracnose, downy mildew, rust	0.8 to 2.4 qt./A. when disease first appears and repeat at 10 day intervals as long as necessary.	Rohm & Haas
Dithane M-22 special	downy mildew and rust	1 to 3 lb./A. when disease first appears and repeat at 7 day intervals.	Rohm & Haas

Chemical	Labeled Use	Rate	Company
Manex	anthracnose, downy mildew, rust	1.2 to 1.6 qt./A. 100 gal. spray/A. beginning when plants are small. Repeat at 5 to 7 day intervals.	Griffin Corporation
Manzate D	rust	1.5 to 2.0 lb./A. when disease first appears and repeat at 7 day intervals as needed	DuPont
Manzate 200 flowable	anthracnose, downy mildew, rust	1.2 to 1.6 qt./A. when disease first appears and repeat at 4 to 10 day intervals (7 day intervals for rust)	DuPont
thiophamate methyl			
Topsin M-4.5 F	white and grey mold	30 to 40 fl. oz./A. once at 50% to 70% bloom or 20 to 30 fl. oz./A. twice first application at 10 to 30% bloom and second application 4 to 7 days later or at peak bloom.	Pennwalt
zineb			
Dithane Z-78	anthracnose, downy mildew rust	3 to 4 lbs./A. when first blossoms appear and repeat at 7 to 14 day intervals to within 7 days of harvest.	Rohm & Haas

Chemical	Labeled Use	Rate	Company
Zineb 75-WP	rust anthracnose	1.5 to 2 lb./100 gal. of water use 100 to 125 gal. of spray/A beginning when disease first appears and repeat at 4 to 7 day intervals as long as disease threatens.	FMC

POWDERY MILDEW OF SOYBEANS

Powdery Mildew (PM) was first reported on soybeans in Germany in 1921. The disease is commonly seen on greenhouse-grown soybeans and has been a problem in many fields in the United States. PM was widespread and severe in Georgia in 1972 and 1973; Wisconsin first observed it in August of '74. The first report of PM in Minnesota was in 1973 and again in 1974 from field plots at the St. Paul Agricultural Experiment Station.

PM is caused by the fungus Microsphaera diffusa on soybeans and can also infect other legumes, such as bean (Phaseolus vulgaris), mung bean (Vigna radiata), pea (Pisum sativum), cowpea (V. unguiculata) and other species in the Honeysuckle family and Nightshade family. PM is an obligate parasite that produces mycelium and conidia on plant surfaces, with root like structures in the host epidermal cells. The mycelium and conidia are clear to white and when abundant appear as white powder like patches on the surface of leaves, stems and pods. Some soybean hosts are reported to develop chlorosis, green islands, defoliate or just are covered by visible mycelium and conidia as was seen in Minnesota. The fungus produces an overwintering structure "Cleistothecia", which when mature has branched appendages useful in identification.

PM was not observed on soybeans in Iowa from 1953 to 1973 and other than a report of PM in plots at St. Paul no record of the disease in Minnesota was published prior to 1975. In central Iowa in 1975 PM was found in 23 counties in 311 fields of the 38 counties sampled. The disease was present in 19% of the soybean fields and an average of 79% of the plants were infested. The symptom was first found in Iowa the first week of June and PM increased steadily during July and August until entire fields of susceptible varieties were infested. PM was first reported in early August in SE Minnesota and soon after mid-August reports of PM were received from all Minnesota soybean growing areas. Early in September a general concern was expressed about the widespread "blight" of soybeans.

Early yield loss studies in Iowa reported an average yield loss in 1975 of 10% for susceptible varieties. Data from Ames (central) 1976 and Kanawha (North Central) 1977-78, Iowa show a yield loss of 19.6% when growing the susceptible lines Corsoy or a 17.3% loss when growing Harosoy 63. Resistant lines Beeson and Lindarin 63 did not yield any significant increase when sprayed with Benomyl. The resistant plants did not show any PM symptoms and the seed yield was unaffected by treatment with Benomyl. Seed yield losses in susceptible varieties are believed to be due to PM. Seed losses were variable over the 3 years, ranging from no loss to a high of 26%.

A fungicide study at the Rosemount Agricultural Experiment Station - Plant Pathology Farm shows a yield increase of 8.0% when treating with Benomyl. Hodgson 78 was planted in 30 inch row, June 3 on a 1 acre site. The previous crops were soybeans and the area was designed to evaluate the effect of foliar fungicides. One application was made on 8/14 (late flowering, early pod fill stage) with Benomyl 8 oz., Mertect 8 oz. and Bravo 1 1/2 pts. Six replicates were treated and observed during the growing season. The major foliar disease present in 1985 was PM. Little evidence of Bacterial Blight, Septoria Brown Spot or Downy Mildew was observed, however, half the plants showed symptoms on September 4 of Brown Stem Rot.

Table 1.

	DISEASE SCORES					YIELD
TREATMENT	**BB**	**SBS**	**DM**	**BSR**	**PM**	**BU/A**
Benomyl	1	1	1	3	0.5	29.6
Mertect	1	1	1	3	1.8	27.9
Bravo	1	1	1	3	2.0	28.4
Check	1	1	1	3	3.0	27.4

1 = Trace, 2 = 1-30%, 3 = 31-60%, 4 = 61-90%, 5 = > 91%.

PM infection on a susceptible soybean leaf, i.e. Harosoy 63 does not produce a change in leaf color, shape or life span. The leaf however, when 82% covered by visible mycelia had less than one half the rate of photosynthesis and transpiration of a healthy control. The loss in net photosynthesis and transpiration is believed to be a result of a direct change in soybean metabolic activity induced by the pathogen. Since most PM infection is present on lower, poorly illuminated leaves it is unlikely that 50% losses will be present under field conditions, however, with a favorable environment for early infection and complete leaf cover by PM, losses can be large. Other field studies report loss range from 35% to 10%.

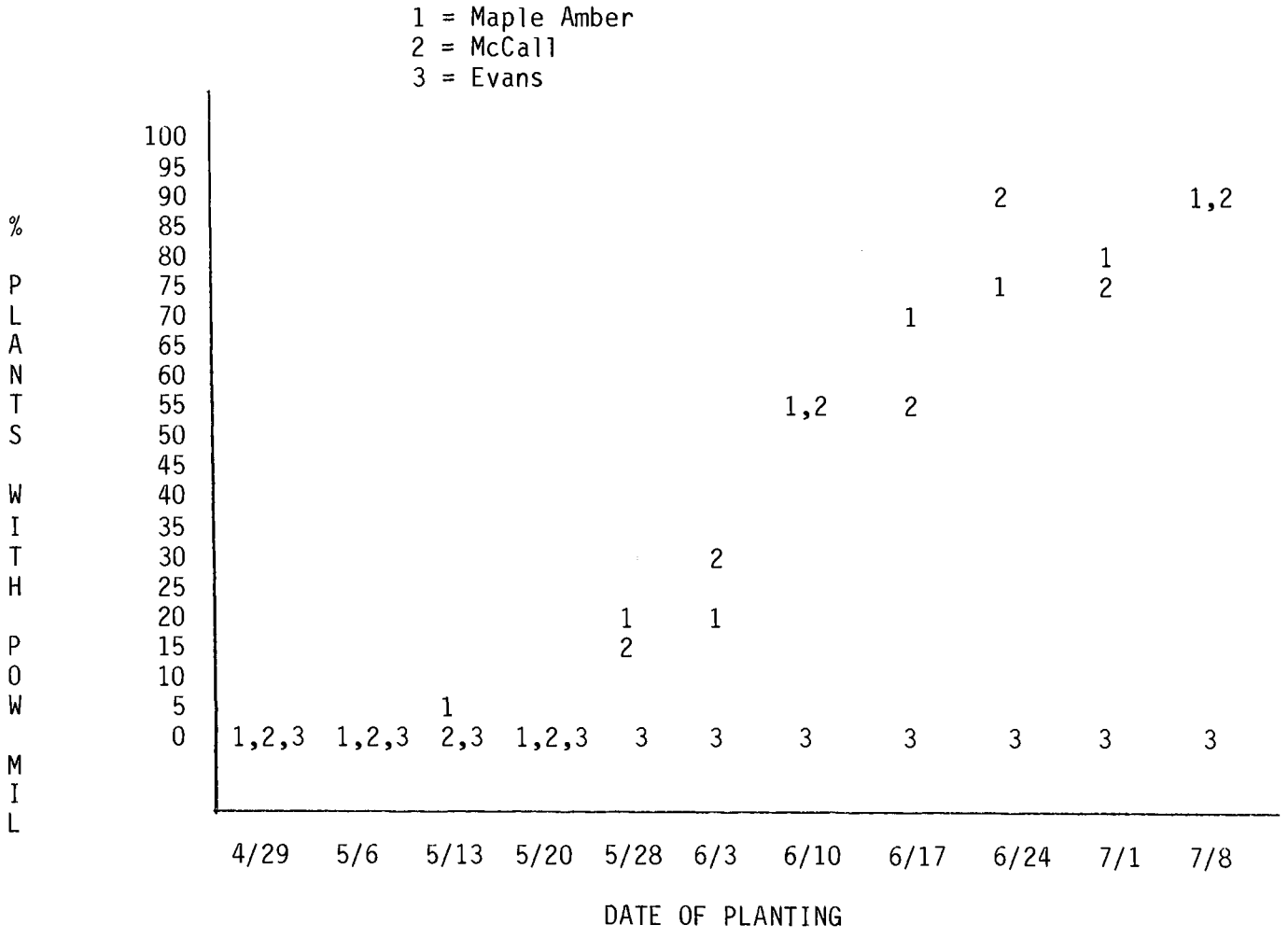
PM has not become a major disease in the past decade but it was very abundant on susceptible cultivars in Minnesota - 1973, Wisconsin - 1974, Georgia - 1972 & 73 and repeatedly in Iowa from 1973-78. Significant PM symptoms were seen in Wisconsin, Iowa, North Dakota and Minnesota again this year (85). The sudden occurrence of this disease in the early 70's and again its widespread development in 1985 should not be ignored. In the early 70's less was known about its potential destructiveness but today good estimates are available on the yield losses associated with PM.

Resistance to PM is available and it appears that there are two primary types of field resistance which are inherited as a single dominant genetic trait. The two forms of resistance may be described as "Resistant" and "Highly Resistant". These two forms of resistance cannot be differentiated in the field but do appear different in the greenhouse. In greenhouse testing "HR" reaction has no mycelium on the leaf while the "R" reaction has sparse mycelium and limited sporulation and the "S" (susceptible) reaction has extensive mycelial development and sporulation.

Symptom development is also affected by temperature. Resistant soybeans remained resistant at the 3 temperatures used while susceptible varieties had disease progress most rapidly at 18°C (64°F) at both 9 and 17 days after inoculation. The susceptible varieties were severely infected in 17 days at 18°C while similar disease ratings were obtained in 24 days at 24°C (75°F) and 30°C (86°F). Disease development is slightly slower at higher temperatures for susceptible varieties. The most favorable temperature for PM development was 18°C (64°F).

Symptom development differences of soybean varieties that are greenhouse susceptible but field resistant may be due to adult plant resistance. Growth of PM mycelia on leaf tissue was followed by remission of fungal growth at later stages of plant development. Plants inoculated at 8 days had remission of fungal growth in 28 days while plants inoculated at 29 days of age showed fungal growth remission in 18 days. Development of visible mycelia was negligible if plants were inoculated at 50 days of age. The adult plant resistance expression becomes apparent near flowering. Soybeans that have adult plant resistance are also valuable in areas where the PM disease arrives late in the growing season.

This adult plant resistance is nicely seen from data collected at Crookston by Drs. Wiersma and Orf. A date of planting study with 3 varieties was observed on September 16 for PM. The soybean Evans is resistant while Maple Amber and McCall are susceptible. Note from the graph that all varieties appear resistant when planted 4/29 through 5/20 and the two susceptible varieties show increasing PM with delayed planting while Evans remains resistant.



The following public and private varieties were observed for PM reaction at Waseca on August 30. The mean of 3 observations is presented.

VARIETY	SOURCE	PM RATING[a]
AH2244	Arrowhead Inc.	3
AH8650	Arrowhead Inc.	1
Agripro AP10	Agripro Seeds	4
Agripro AP200	Agripro Seeds	0
Agripro Ex 034	Agripro Seeds	0
Agripro HP 20-20	Agripro Seeds	4.5
Asgrow A1525	Asgrow Seed Company	4
Asgrow A1937	Asgrow Seed Company	0
Asgrow A2187	Asgrow Seed Company	3
Asgrow A2522	Asgrow Seed Company	2
BSR 101	Iowa A.E.S.	1
BSR 201	Iowa A. E. S.	0
CB EXP-1301	Country Brand Seeds Inc.	1
CB Stetson	Country Brand Seeds Inc.	3
CB Wrangler	Country Brand Seeds Inc.	0
Cenex 8017	Cenex	0
Cenex 8212	Cenex	1
Cenex 8422	Cenex	1
Challenge CSV 15	Challenger Seed LTD	0
Challenge CSV 20	Challenger Seed LTD	3
Corsoy 79	Illinois A.E.S.	4
DK-PF CX155	Dekalb Pfizer Genetics	4
DSR-151	Dairyland Seed Company Inc.	4
DSR-171	Dairyland Seed Company Inc.	0
DSR-205	Dairyland Seed Company Inc.	3
DSR-207	Dairyland Seed Company Inc.	3
Dekalb CB151P	Dekalb Pfizer Genetics	3
Dekalb CX174	Dekalb Pfizer Genetics	3
Desoy 302B	Kruger Seed Company	3
Desoy 414	Kruger Seed Company	3
Diamond D-140B	Diamond Brand Seed	3
Diamond D-201	Diamond Brand Seed	0
Elgin	Iowa A.E.S.	0
Ehrich E-84	Ehrich Seed Farms	1
Ehrich E-85	Ehrich Seed Farms	4
Enterprise II	Farmacy Seed Company	1
FFR 10248	FFR Cooperative	0
FFR 12003	FFR Cooperative	1
FFR 13004	FFR Cooperative	0
FSF Exp1770	Field Seed Farms	2
FSF-150	Field Seed Farms	1
Farmacy Eve	Farmacy Seed Company	3
Funk 12231	Funk Seeds International	0
Funk 63145	Funk Seeds International	3
Funk G3213	Funk Seeds International	4
Hack	Illinois A.E.S	1
Hardin	Iowa A.E.S.	4
Hodgson 78	Minnesota A.E.S.	3.5

VARIETY	SOURCE	PM RATING[a]
Hoffman 8300	Hoffman Seed Farms Inc.	3
Hoffman 8501	Hoffman Seed Farms Inc.	4
Hoffman Dawn	Hoffman Seed Farms Inc.	0
Hoffman EX61161	Hoffman Seed Farms Inc.	0
Hy-Vig Derby 9	Hy-Vigor Seeds Inc.	4
Hy-Vig Row T-9	Hy-vigor Seeds Inc.	3
Hy-vig 901	Hy-Vigor Seeds Inc.	4
Jacques E8590	Jacques Seed Company	4
Jacques E8590	Jacques Seed Company	4
Jacques E8597	Jacques Seed Company	4
Jacques J-2386	Jacques Seed Company	0
KB125	Kaltenberg Seed Farms Inc.	0
KB231	Kaltenberg Seed Farms Inc.	3
Kruger KB220	Kruger Seed Company	3
LOL 60-44	Land O'Lakes	0
LOL L180B	Land O'Lakes	0
LOL LL0023	Land O'Lakes	0
Lakeside 104	Rossbach Lakeside Seeds	3
Lakeside 105	Rossbach Lakeside Seeds	4
Lakeside 107	Rossbach Lakeside Seeds	3
Latham 301	Latham Brothers Farms	0
Latham 500	Latham Seed Company	3
Latham 551	Latham Seed Company	3
Latham 650	Latham Brothers Farm	3
Latham 851	Latham Seed Company	2
Latham Ex-330	Latham Brothers Farm	0
Lynks 8190	Lynks Seeds	2
Lynks 8202	Lynks Seeds	1
Midwest 2620	Midwest Oilseed Inc.	0
Midwest Oil 1480	Midwest Oilseeds Inc.	4
Mustang 1220A	Domestic Seed and Supply Inc.	0
Mustang 1225	Domestic Seed and Supply Inc.	3
Mustang Exp-9	Domestic Seed and Supply Inc.	4
NK S14-60	Northrup King Company	3
NK S15-50	Northrup King Company	3
NK S23-03	Northrup King Company	2
PS 0019	Payco Seeds Inc.	1
PS 0021	Payco Seeds Inc.	1
Pride 225 Brand	Pride Company Inc.	2
Pride B203	Pride Company Inc.	1
Pride B216	Pride Company Inc.	2
Pride PEX110	Pride Company Inc.	0
Profi Trisoy 84	Profiseed Inc.	4
Profiseed 1138	Profiseed Inc.	4
Profiseed 1152	Profiseed Inc.	3
Riverside 1405	Lynnville Seed Company	0
Riverside 303C	Lynnville Seed Company	3
Riverside 4042	Lynnville Seed Country	4
Riverside 404P	Lynnville Seed Company	3
Robinson H-1233	J. C. Robinson Seed Company	3
Robinson X190	J. C. Robinson Seed Company	0
Robinson X198	J. C. Robinson Seed Company	3.5
Roebke R-180	Roebke Seed Company	4

VARIETY	SOURCE	PM RATING[a]
Sand Soi 226	Sand Seed Services Inc.	3.5
Sand Soi 254	Sand Seed Services Inc.	0
Sand Soi Exp. 255	Sand Seed Services Inc.	1
Schech EX40A	Schechinger Seed Company	0
Schech EX41B	Schechinger Seed Company	0
Schechinger S-41	Schechinger Seed Company	0
Select Seeds 189	Bruellman Select Seeds	0
Select Seeds 213	Bruellman Select Seeds	0
Select Seeds 286	Bruellman Select Seeds	3
Select Seeds 288	Bruellman Select Seeds	3
Sexauer BR SX29		3
Stine 2220	Stine Seed Farm Inc.	2
Stine 2720	Stine Seed Farm Inc.	0
Thompson T-12	Thompson Farms Seeds	4
Thompson T-15	Thompson Farms Seeds	1
Thompson T-25	Thompson Farms Seeds	0
Thompson T-30P	Thompson Farms Seeds	3
Vickery	Iowa A. E. S.	4
Weber 84	Iowa A. E. S.	0
Wil'N Blend 1650	Wilson Hybrid Inc.	3
Wil'n Blend 2010	Wilson Hybrids Inc.	1
Wil'n Blend 2101	Wilson Hybrid Inc.	2
Wilsoy 84	Willette Seed Farm Inc.	3
Ziller BT2300	Ziller Seed Company	1
Ziller Exp. 20	Ziller Seed Company	1
Ziller Exp. 21	Ziller Seed Company	3

[a] Mean of 3 replications. Rating based on scale ranging from 0 = no symptoms, 1 = two plants with a few isolated lesions, 2 = 1 -- 30%, 3 = 31 -- 60%, 4 = 61 -- 90% and 5 = > 91% of leaf areas covered by the fungus.

SOYBEAN SEED TREATMENT - 1985

Soybean seed treatments: Vitavax 200, Vitavax 34, Apron, Thiram 42S and Captan were applied to three soybean varieties: Hardin, Hodgson 78 and McCall of two grades: Certified and Bin Run. Seed were planted at: Buffalo Lake, Crookston, Morris, Lamberton, Rosemount and Waseca Minnesota. Plots at St. Paul and West Concord were not harvested due to severe lodging from wind and rain damage. Germination tests were done, regular and cold/stress at the St. Paul Campus.

The seed quality used in 1985 was excellent. Two bin run seed sources required cleaning to remove the high number of splits. Cold test germination level was the same as regular germination values. Seed treatments were applied at label rates in St. Paul and select seed lots were germinated after treatment. No germination was lost due to seed treatment. The Minnesota soybean seed quality and ability to germinate under local conditions was good to excellent. Difference in yield due to seed treatment or source was not significant.

GERMINATION TEST RESULTS

	% Germination			
	No Seed Treatment		Treated Seed	
	Standard	Stress	Standard	Stress
McCall				
Certified	98	100	--	--
Bin Run	100	99	98	99
Hardin				
Certified	100	100	--	--
Bin Run	100	100	99	98
Hodgson 78				
Certified	100	100		
Bin Run	100	99	99	100

YIELD

SEED TREATMENT	DATE PLANTED/LOCATION						
	5/19 Waseca	5/20 Lamberton	5/11 Morris	5/21 Buffalo Lake	5/20 Rosemount	5/18 Staples	4/30 Crookston
Certified	Hardin	Hardin	Hodgson 78	Hodgson 78	Hodgson 78	McCall	McCall
Apron	46.6	35.8	59.7	29.2	32.4	37.1	40.1
Captan	47.1	36.8	57.2	31.0	31.7	33.5	41.6
Thiram	46.5	38.2	54.9	30.1	32.1	40.0	40.2
Vitavax	46.5	38.3	55.3	27.6	32.0	41.3	38.3
Vitavax Two	46.6	36.8	55.4	30.1	30.8	36.8	40.6
Vitavax Two + Apron	46.2	40.4	59.2	31.1	33.6	35.6	37.7
None	45.3	40.2	56.3	30.6	31.3	33.0	40.4
Bin Run							
Apron	46.6	36.1	54.8	25.8	31.7	33.3	36.3
Captan	48.9	38.8	57.8	30.3	35.3	40.0	35.8
Thiram	47.9	39.2	51.6	29.8	33.4	39.9	37.0
Vitavax	46.4	36.0	59.0	29.9	34.2	37.0	36.5
Vitavax Two	47.5	39.4	57.9	28.8	35.9	34.1	35.3
Vitavax Two + Apron	45.7	40.0	51.1	27.8	34.6	34.1	36.2
None	46.4	37.6	57.0	30.4	33.4	33.2	33.8

Seed treatment for soybeans is generally not recommended, however, increasing problems with Phytophthora Root Rot (PRR) the previous 3 years (82-84) indicated Apron seed treatment did increase yield for select varieties in locations known to have severe PRR. Studies in 1985 at 3 locations with little direct history of PRR show little benefit except when raising fully susceptible - no resistance and no tolerance - soybean varieties.

SEED TREATMENT - PHYTOPHTHORA ROOT ROT LOSS

Soybean Race	Rating Tolerance	Apron Treatment	Waseca 5/9	Lamberton 5/20	Buffalo Lake 5/21
S	5*	-	45.3	26.0	13.8
		+	45.3	27.9	18.7
R1 & 2	5	-	40.9	33.6	29.7
		+	41.6	33.5	31.6
S	3.5	-	44.9	34.7	25.0
		+	43.8	32.4	27.3
R1 & 2	3.8	-	42.5	34.8	27.9
		+	48.0	33.0	26.5
R1,2,3, 7,8,9	3.5	-	48.7	27.4	22.8
		+	45.9	30.3	23.3

S = Susceptible, R = Resistant Tolerance 1 no dead or stunted plants 5 most are dead and stunted * estimated.

SOYBEAN BROWN STEM ROT

This disease, discovered in the mid 40's is known to be present in most of the United States. It is believed that a high % of Minnesota soybean fields are infested. Brown Stem Rot (BSR) is reported to be the next major yield limiting disease in soybean production fields. The fungus Phialophora gregatum survives in infected residue in the soil, especially on woody stem sections. The movement of infected residue and spores produced in that residue is the major means of disease spread.

Soybean plants are infected through the roots and lower stem. After plants are infected, mostly by root penetration the fungus mycelium grows slowly in and up the water conducting tubes. Fungal conidia and mycelium in the xylem vary from a few cells to a solid mass which fills the entire water vessel and may reduce water flow. Sudden development of leaf symptoms - wilting and browning occurs in periods of water deficit. The lack of water (drought) is accentuated by the reduction in internal water flow due to vascular plugging.

This year the field symptoms resembling frost damage was observed. This leaf color change, usually sudden, was quite different from the normally maturing soybean yellow green color. The leaf symptom is not in itself a reliable diagnostic method. It may not occur every year and can be confused with other leaf disease problems. It is most common when plants are grown in cool, moist conditions followed by a warm, drought stress period. The leaf may wilt and the tissue between the veins turns brown and dries quickly. The leaf tissue nearest the vein remains green longest and the leaf curls up. Often plants show no external symptom.

Splitting the soybean stem after the R-4 stage reveals a dark reddish brown discoloration of the water conducting tissue - xylem and pith in infected plants. Healthy tissue is usually white. Browning is first seen just above the soil line and may be more intense at the nodes. As the plant matures browning is more continuous and moves up the stem.

Observation of the soybean stubble after harvest may indicate disease incidence but not severity and counts at the stage do not correlate well with disease loss. It appears that the BSR fungus colonizes faster under periods of moisture stress and also grows faster in older plants. Temperatures above 27°C (81°F) slow disease progress. Fungal growth is greatest at temperatures from 15°C (59°F) to 26°C (78°F). Cool weather favors stem browning.

Phialophora gregata survives in soil on soybean debris and will grow and reproduce even when buried to a depth of 30 cm (11.8 inch). The fungus will grow on all soybean plant parts but pods and can produce several crops of spores from the same piece of straw. Repeated crops of soybeans have raised the inoculum level in the soil and have contributed to greater severity of BSR. It has also been suggested that newer soybean varieties may be more

susceptible. Yield studies at Iowa report a 1.6 bushel loss per 10 percent of infected plants. The best correlation of loss with plant symptoms occurs when scoring infection at the R5 or R6 stage. R4 is too early and after R6 the correlation becomes more variable.

Crop rotation out of soybeans, alfalfa or red clover for 3 years is required for infested residue to decompose. Corn three years followed by soybeans at Waseca produce 5.5 bushels more soybeans than the average of 2, 3 & 4 years of soybeans. The advantage of soybeans following 3 years of corn verses 4th years soybeans was 12.5 bushels at Waseca and 6.1 bushels at Lamberton. The other control measure is resistant varieties. These resistant varieties have a yield advantage over susceptible varieties when grown on infested soil but do not have the yield potential in non-infected soil. Resistant varieties are recommended if more than 75% of the plants in a field are diseased.

SOYBEAN CYST NEMATODE AREA EXPANDS

Soybeans infected with the soybean cyst nematode (SCN), Heterodera glycines become stunted, yellow or chlorotic and are also killed. Symptoms are more severe on lighter soil but are not limited to lighter soils. Yield losses range from very little to very high as nematode population increases. Drought and root rots can greatly increase the damage caused by SCN.

The SCN had been identified in 8 counties in Southern Minnesota: 1) Faribault, 2) Brown, 3) Cottonwood, 4) Freeborn, 5) Kandiyohi, 6) Martin, 7) Waseca, 8) Blue Earth. SCN was found in Mower and Dodge counties in 1985. Low levels of infestation will remain undetected, however, awareness of SCN symptoms will help locate additional problem areas.

The above ground symptoms is not diagnostic for positive identification, however, the pattern is quite suggestive. The yellow-chlorotic portion is oval and greater damage is present near the center. This yellowing is seen best when fields are under water stress or are low fertility sites. Slight stunting is difficult to detect and often the first symptoms are missed and later larger areas are found in years of stress conditions. Field diagnosis of SCN, can be made if plants are dug up, the roots washed free of soil and white to brown, lemon shaped cysts are observed on the soybean roots.

SCN control is a difficult task. It begins with detection. Crop rotation and resistant varieties are the next methods and then soil fertility nematicides and nematode analysis could be used. Since SCN cysts are present in soil, the entire root zone, any thing that gets in the field can pick up cysts and move them to a new location. Often new areas are near the field entrance. Soybean producers in areas of Minnesota that have SCN present should thoroughly clean equipment by washing soil from machinery used in infested soil and seed from infested fields should be thoroughly cleaned by a spiral cleaner before planting.

CORN NEMATODES - 1985

Plant parasitic nematodes attack all crops, while symptoms are most obvious in fields with light-colored, sandy soils. Damage can also occur in all soil types but above ground symptoms are often lacking. As reported in 1984 the lesion nematode is present in Minnesota and also the lance nematode. However, little direct evidence was found to support any widespread nematode damage in 1985. A few fields - usually in sandy soils spots were found to have significant nematode numbers. Nematode distribution in a field is usually not uniform but patchy.

The use of nematicides should progress slowly as nematode damage needs to be found, measured and presently is not cost effective. Nematicide use can only be recommended when known populations exist at levels greater than economic thresholds. Proper collection and soil testing is required for adequate nematode analysis.

1/86 AGRICULTURAL EXTENSION SERVICE PW-18
UNIVERSITY OF MINNESOTA - U.S. DEPARTMENT OF AGRICULTURE (revised)
INSTITUTE OF AGRICULTURE, FORESTRY AND HOME ECONOMICS
ST. PAUL, MINNESOTA 55108

Weed and Brush Control Along Roadside, Drainage Ditches, and Other Rights-of-Way

Richard Behrens, Extension Agronomist

Weeds and brush along roadsides and rights-of-way must be controlled to protect the large investment in these public utilities and to protect the public who use them. If not controlled, weeds and brush create hazards by restricting visibility at road intersections and on highway warning and marker signs. Brush interferes with telephone and electric power lines. Weeds fill in drainageways and are fire hazards around buildings. Roadsides and rights-of-way are "weed nurseries" which propagate troublesome weeds that then spread to adjoining cropland. In addition, poisonous plants, such as poison ivy, and pollen-bearing plants, such as ragweed, are public health hazards. Noxious weeds and brush in rights-of-way areas must be controlled, but complete vegetation control is usually not desired because of erosion and aesthetic considerations. Periodic applications of 2,4-D or one of the related phenoxy herbicides, or combinations of these, will control most of the troublesome broadleaf weeds and brush without killing the grasses and most of the desireable native broadleafs (forbs). "Spot treatment", or spraying only where patches of noxious weeds and brush occur, is recommended. Grasses and forbs will be favored by the lack of broadleaf competition. Encouragement of the grasses and forbs in these areas provides erosion control and wildlife cover and also improves the appearance of the roadway. Grasses are fibrous rooted and hold the soil better on steep slopes than the tap-rooted broadleaf weeds. Also, most grasses do not grow as tall as broadleaf weeds or brush and require less mowing along roadside shoulders to maintain proper visibility and to minimize excessive drifting of snow onto roadways.

Methods of Weed and Brush Control

Weeds and small brush can be controlled by periodic mowing. However, two or more mowings are often required to keep weeds down and to prevent weed seed formation. When brush is mowed or cut it quickly resprouts from the base, and becomes thicker. Frequent cutting is necessary for control. With high costs of labor, fuel and machine repairs, mowing of highways and other rights-of-way is extremely expensive. Also, early mowing, before weed seeds mature, is a hazard to nesting birds, their eggs and young birds.

A phenoxy herbicide such as 2,4-D, on the other hand, can be applied from the roadway to adjoining roadsides and ditch banks with little chance of damaging eggs or injuring or killing birds and other wildlife. The herbicide can be applied early in the season (usually sometime in June) in time to prevent the production of weed seeds. A mowing along the edge of

the roadside after the nesting season and after grasses are mature is all that is needed to reduce snow pileup in the roadway during the winter months. The use of herbicides on a "spot treatment" basis to control patches of noxious weeds and troublesome brush is less expensive and less time consuming than mowing. Phenoxy herbicides should also be applied in early fall to suppress perennial weed regrowth and weaken the plants for the following year.

Minnesota Noxious Weed Law

Nine weeds are designated as noxious weeds in the state of Minnesota. These weeds are deemed by the Commissioner of Agriculture to be injurious to public health, public roads, crops, livestock or other property. In addition, there are 47 weeds on a secondary weed list in the state. The Minnesota Commissioner of Agriculture may, without further hearing, take a weed or weeds from this secondary list and add it to the noxious weed list on a county basis if: (1) a majority of township boards and city mayors in a county file a petition requesting this addition, (2) the petition is approved by the County Board of Commissioners, and, (3) the Commissioner of Agriculture deems the weed or weeds to be a problem.

The land owner, his agent, or the public official in charge of the land, if it is public land, is responsible to see that noxious weeds growing theron are controlled. Weed control is generally understood to mean preventing weeds from going to seed. Weeds not adequately controlled can be ordered destroyed or eradicated. Destroying or eradicating weeds refers to "complete killing of weeds, both the top growth and underground propagating parts of such weeds". If weeds are not controlled, an official notice may be served by the local weed inspector (township officers or municipal mayor or president), by the County Agricultural Inspector, the district inspector, the state supervisor, or by the State Commissioner of Agriculture. The official notice (Form #1) must contain the following information:

1) Kinds of weeds
2) How to destroy or eradicate these weeds
3) The number of days allowed to comply with the notice
4) Signature of local or County Agricultural Inspector

The nine weeds on the noxious weed list in Minnesota are (1) four herbaceous perennials: Canada thistle, perennial sowthistle, field bindweed, and leafy spurge; (2) three biennials: bull thistle, musk thistle and plumeless thistle; (3) one annual: wild hemp and (4) one woody perennial: poison ivy. In addition to these noxious weeds, the Minnesota Department of Transportation lists ragweed species and common dandelion as additional weeds to be controlled along public highways to improve the roadside environment for human health considerations.

Selection of Herbicides for Use Along Roadsides, Ditch Banks or other Rights-of-Way (Non-cropland)

1. 2,4-D

2,4-D is a phenoxy or chloro-phenoxy herbicide that is formulated as an amine, oil-soluble amine or low-volatile ester. It is usually the first choice of an herbicide for weed control along rights-of-way because it has little effect on grasses, is effective on a large number of broadleaf weed species and woody plants, is relatively low in cost and is usually readily available. These 2,4-D formulations are low in volatility and are less hazardous to use than the more volatile formulations. Highly volatile formulations, such as butyl ester of 2,4-D, should not be used for right-of-way spraying because vapors may drift and cause injury to nearby desirable plants.

2,4-D will control some woody species such as aspen (poplar), willow and boxelder. However, ash, maple, oak and several other common woody species are resistant to 2,4-D. If these brush species are present, 2,4-D can be mixed with another herbicide, such as 2,4-DP, to control a wide variety of broadleaf weeds and brush. 2,4-D may be used along drainage ditch banks or adjacant to home yards. However, when using 2,4-D or any herbicide used for vegetation control along rights-of-way, precautions must be taken to avoid wind drift to susceptible broadleaf crops, trees, ornamentals or other desireable plants. Drift hazard can be reduced by using low sprayer pressure, preferably no more than 30 to 40 psi (pounds per square inch), using a higher gallonage of water per acre and larger nozzles, by not spraying on windy days, or by using invert emulsions or spray-thickening agents. 2,4-D is rapidly broken down on plant foliage and in the soil, and is not considered a persistant herbicide. For example, 2,4-D may be used on grass pasture if a 7 to 14 day waiting period is observed before grazing dairy cattle on treated areas. Beef cattle should be removed from freshly treated areas for 7 days before slaughter. Check the product label for specific limitations.

2. 2,4-DP

2,4-DP is a phenoxy compound closely related to 2,4-D. 2,4-DP may be used alone, or in combination with 2,4-D to control many 2,4-D resistant broadleaf weed or brush species. 2,4-DP is not cleared for use on pastures, but may be used along drainage ditch banks and on non-cropland areas. The herbicide is not considered persistent and will break down within a few weeks of application.

3. Picloram (Tordon, Amdon)

Picloram is formulated as a 2 lb/gal liquid or as 10 percent pellets. Picloram is a very persistent broadleaf weed and woody plant killer that can be used along roadsides and other rights-of-way to kill phenoxy-resistant weeds or brush. It should not be used along drainage ditches or along streams, lakes, ponds or water runoff areas. Picloram is cleared for spot treatment and broadcast use in grass pastures in Minnesota for the control of 2,4-D resistant broadleaf weeds

and brush. Picloram is useful for spot treatment of deep rooted perennials such as leafy spurge, or hard-to-kill woody and fern species such as ash and bracken fern. Because of its longer persistence in soil as compared to 2,4-D and other phenoxy herbicides, and because many broadleaf crops and ornamental plants, including trees and shrubs, are very susceptible to injury from picloram, great care should be taken to avoid drift or misapplication to non-target areas. Picloram has been designated as a restricted use pesticide by the Environmental Protection Agency, and some formulations can only be applied by a certified applicator. Refer to the product label for additional information.

4. MCPA

MCPA is a phenoxy herbicide that is formulated as an amine, an ester or a sodium salt. It is normally not used for roadside or other rights-of-way spraying, but could be used to control certain broadleaf weed or brush species such as spotted knapweed, buttercup, burcucumber, or honeysuckle on which it is more effective than 2,4-D. MCPA is cleared for use on grass pastures with no limitation on use and is non-persistant.

5. MCPP (mecoprop)

MCPP is another phenoxy herbicide closely related to MCPA. MCPP may be used alone or in combination with 2,4-D and/or dicamba (Banvel) for the control of 2,4-D or MCPA resistant broadleaf weeds or brush. MCPP alone, and in various combinations, is cleared for use on lawns and other turf areas, and on non-cropland, but is not yet cleared for use on grass pastures in Minnesota. However, additional clearances are being sought and are expected shortly.

6. Dicamba (Banvel)

Dicamba is labeled for use along roadsides, but because of the great sensitivity of soybeans and most other legume and broadleaf crops and woody plants to dicamba, this herbicide should not be used to spray roadsides and other rights-of-way that are in the vicinity of susceptible field crops, ornamentals, trees and vegetable or fruit crops. Dicamba may be used in combination with 2,4-D to control a broad spectrum of broadleaf weeds and brush where the drift hazard is not a problem. Dicamba is also formulated as a granule, which greatly reduces the drift hazard. However, dicamba is very water soluble, and high rates should not be used along ditches carrying water. Dicamba may be used in grass pastures for broadleaf weed control. Exclude dairy cattle from grazing treated areas for 7 days after application of 1/2 lb or 21 days after application of 1 lb of dicamba. For use of higher rates, see product label.

Note: Before any weeds can be sprayed or otherwise controlled in public waters (rivers, lakes, streams) in the state of Minnesota, a permit must be secured from the Department of Natural Resources, Centennial Office Building, St. Paul, MN.

Mowing roadsides for forage use

In some areas, farmers wish to mow the roadside once or twice each season and harvest the forage as feed for livestock. This practice is particularly desirable to the landowner on wide roadways and medians where past use of herbicides has eliminated most of the broadleaf weeds and brush. Where this practice is common, highway crews should not spray these areas prior to mowing, or if spraying is necessary, they can spot spray with a herbicide such as 2,4-D so the forage can be harvested for hay after a two week waiting period. If certain poisonous broadleaf weeds such as waterhemlock or bracken fern are present, the farmer should be alerted to the possibility of livestock poisoning from these weeds, and if present, poisonous plants should be controlled with herbicides prior to harvest, or harvesting these areas should be delayed until after chemical treatment and required waiting period. Farmer mowing of the roadway and utilization of this unused resource as livestock feed is looked upon as a benefit to both the farmer and the municipality and is encouraged in some areas. However, regular mowing may destroy the area for wildlife food and cover. Therefore, a system of partial or rotational mowing of an area is desirable, with some sections of roadside being left unmowed each year for wildlife utilization.

Types of herbicides

Herbicides such as 2,4-D and 2,4-DP are called "selective herbicides" because they will selectively control broadleaf weeds with little or no injury to the grasses. Also, they will selectively control deciduous (broadleaf) woody plants with little or no injury to evergreen (coniferous or needle-bearing) trees. Many selective herbicides, however, may become non-selective if the application rate is increased over the recommended amount.

Another group of herbicides is called "non-selective herbicides". Non-selective herbicides are chemicals that "burn off" or kill all vegetation and may leave the soil non-productive (barren) for a year or more. Some of these complete vegetation control chemicals may be needed around highway guardrails, signs, and around buildings or industrial sites to eliminate fire hazards or to reduce hand labor weed control efforts.

Herbicides may be classed as to their types of applications. Foliarly applied herbicides such as 2,4-D, or paraquat must be applied to the foliage and are not effective if applied to the soil at the rates commonly used. Other herbicides, such as bromacil or simazine, are taken up mainly by plant roots from the soil and do not need to have plant foliage present when the application is made. Herbicides may also be classified as to their mode of action. A contact herbicide, such as paraquat, kills above ground plant tissue only and does not translocate into the root system. 2,4-D is a good example of another type of herbicide - a "translocated herbicide". It moves into the root system from the foliage. These translocated herbicides can kill many perennial weed and brush species. A contact herbicide will not. Herbicides may also be classed as residual and non-residual chemicals. Most herbicides used along roadsides, such as 2,4-D and 2,4-DP are considered to be non-residual chemicals because they break

down rapidly and are gone in a few weeks or months. Some herbicides, such as the soil-sterilants already mentioned, are considered residual chemicals and may persist in the area of application for several years.

Selection of the best herbicides or herbicide combination

There are two primary considerations in selecting a herbicide for weed and brush control along highways or other rights-of-way. The first consideration may be safety to non-target plants and other organisms, including the applicator. The second and equally important consideration is performance or effectiveness of the herbicide.

Crops, trees and other broad-leaved plants adjacent to rights-of-way may be injured by herbicides in two main ways, (1) wind drift of the herbicides as it is being applied or (2) vapor drift, by volatility of certain formulations of a herbicide after application, which is evaporation of the herbicide into the air (especially troublesome on hot days) and subsequent drift of these vapors to sensitive plants, which can happen two or three days or more after application. Wind drift can be minimized by using low sprayer pressure, using higher gallonage nozzles, and by not spraying when the wind exceeds 5 to 10 mile per hour. In addition, invert emulsions (water-in-oil droplets rather than oil-in-water), which have the consistency of mayonnaise, can be used to reduce or prevent wind drift. Spray thickening agents of various kinds can also be used to reduce drift potential. Volatility can be minimized by choosing low-volatile herbicides or herbicide formulations. Among the herbicides, dicamba (Banvel) is the cause for most concern. It should be used only when sensitive plants are not in the vicinity. Among formulations, high volatile esters of 2,4-D should not be used because of the possiblity of vapor drift. Safety to the applicator may be accomplished by strict adherence to label precautions and safe equipment operating procedures.

Effective herbicide performance is dependent on proper identification of the weed or brush species to be controlled and the careful selection of herbicides or herbicide combinations that are most effective in controlling those species. Refer to "Systemic Herbicides for Weed Control", No. AD-BU-2281, to herbicide labels or to this publication (Table 1) to determine the best herbicide for a particular weed problem.

Time of application of herbicides

For best results, foliarly applied herbicides such as 2,4-D should be applied when perennial weeds are 6 to 8 inches tall and up to bud stage. Brush should be fully leaved out and growing rapidly. Perennial weeds should normally not be sprayed early in the spring when they are 2 to 3 inches tall or less because not enough spray will usually be retained on the foliage to kill the root. Also, the early spring flow of nutrients from root to shoot to support early spring top growth limits herbicide movement from shoot to root and results in poor control. Herbicides may also be applied in the fall until frost kills the leaves, but if perennial weeds are mature or nearing maturity and seed production has occurred, it is more effective to mow perennial weeds and then spray the regrowth when it is 6 to 8 inches tall. Application of herbicides in the fall, when

crops and gardens are nearing maturity, will often result in much less injury to non-target plants.

Summary of principal considerations for spraying rights-of-way with herbicides

1. Identify weeds and brush to be controlled.
2. Select best herbicide or combination of herbicides for control. (Tables 1,2,3 or 4)
3. Select a low-volatile ester, amine or formulation of 2,4-D to reduce or eliminate the danger of vapor drift.
4. Calibrate the sprayer to determine output per acre or per unit area (using linear feet of miles of roadway sprayed x width of area sprayed and measurement of water used to spray an area).
5. Put the right amount of herbicide concentrate in the tank for each tankful.
6. Use low pressure (no more than 30 to 50 psi) to minimize spray drift.
7. Don't spray when the wind speed is excessive (preferably not over 5 miles per hour). Use an invert emulsion or spray thickening agent to reduce drift, if necessary. Avoid direct spraying of herbicides onto non-target plants.
8. Spray early in the season (usually in June) to perennial weeds in the bud stage, to brush that is fully leaved out, or spray in the fall when perennial weeds have new short growth of 8 inches or more.
9. Prevent herbicide spills on clothing or skin, follow safety precautions listed on label.
10. Do not use picloram (Tordan) or high rates of dicamba (Banvel) along drainage or irrigation ditches or along streams, lakes, or other open water.
11. Keep a complete record of spraying operations, recording chemical used, weather and wind conditions at time of spraying, date sprayed, etc.

Application of herbicides along rights-of-way

There are two principal methods of herbicide application used along rights-of-way. First, and perhaps the most common, is the use of a broad jet or gun type nozzle that makes use of considerable pressure, usually more than 50 pounds per square inch, to direct the spray at the weeds and brush to be controlled. This method utilizes relatively large gallonages of 50 to 200 gallons of water per acre and wets the foliage to the point of run-off. The spray is prepared by mixing the desired quantity of herbicide concentrate in the estimated gallonage of spray to be applied. A more accurate estimation can be made of sprayer output by measuring a roadside or right-of-way area, then computing the acreage involved (43,560 sq ft = 1 acre), spraying it with water only, and determining the gallonage applied per acre. Then the proper amount of herbicide concentrate can be put in the tank for the size of batch being mixed.

The second method of spraying rights-of-way is using a boom on either ground or aerial equipment. The boom type sprayer delivers a much more accurate and uniform spray pattern, gives better coverage of plant foliage, and can utilize smaller gallonages of water (as little as 15 to 20 gallons per acre will give adequate coverage in many cases). When using ground equipment, the height of the boom must be adjusted to give a uniform spray

pattern, and all nozzles should be calibrated to make sure they are delivering the same volume of spray. The sprayer should be calibrated by determining sprayer output per acre or by linear feet of right-of-way sprayed and then putting the proper amount of herbicide spray concentrate in the tank for the gallonage of spray being delivered per unit area.

Right-of-way spraying examples

1. Suppose you are to operate a broadjet sprayer to apply herbicides along a road right-of-way. There is mixed hardwood brush, Canada thistle and other broad-leaved weeds to be controlled. You have been asked to apply a mixture of 2,4-D and 2,4-DP at 1 lb of each component per acre. The label on the product stated that there are 2 lbs of 2,4-D and 2 lbs of 2,4-DP acid equivalent per gallon. The label also states that the material is a low-volatile ester formulation and an emulsifiable concentrate in liquid form.

Question 1 - How much product, as it comes from the container, should you apply per acre?_____

2. You wish to calibrate your sprayer to determine approximate sprayer output per acre. There is a 320 gallon tank on the sprayer graduated in 10 gallon increments. You wish to mix a full batch of spray each time you fill. You fill the spray tank with water in preparation for a test run. You measure off a distance of 330 feet on the roadway and determine that the width of the area to be sprayed on each side of the roadway is approximately one rod (16.5 feet). From a "running start" at a sprayer pressure of 40 pounds per square inch (psi) and at uniform speed, spray the foliage on one side of the roadway for the 330 feet distance just as you would if you were using the herbicide. Spray to the point of runoff, moving the nozzle gun smoothly and uniformly to achieve good coverage of the weeds and brush to be controlled. Then you refill the tank, and by measuring the amount needed you determine that you used 10 gallons of water to cover the test area. There are 43,560 square feet/acre.

Question 2 - What fraction of an acre did you spray?_____

Question 3 - What gallonage are you applying per acre?_____

Question 4 - How many acres can you spray per tankful?_____
There are 5,280 feet per mile.

Question 5 - How many miles of roadway (spraying both sides) can you spray per tankful?_____

Answers: 1) 1/2 gallon; 2) 1/8 acre; 3) 80 gpa; 4) 4 acres; 5) 1 mile.

Table 1. Susceptibility of noxious and other undesirable weeds and brush to phenoxy herbicides 1/

Plant	Life cycle	2,4-D	2,4-DP	Dicamba	Picloram
Field bindweed	Perennial	Fair	Fair	Good	Good
Leafy spurge	Perennial	Poor	Fair	Fair	Good
Canada thistle	Perennial	Fair	Fair	Excellent	Excellent
Perennial sowthistle	Perennial	Fair	Fair	Good	Good
Bull thistle	Biennial	Excellent	Excellent	Excellent	Excellent
Musk thistle	Biennial	Good	Good	Good	Excellent
Plumeless thistle	Biennial	Good	Good	Good	Excellent
Hemp	Annual	Good	Good	Good	Excellent
Poison ivy	Woody perennial	Fair	Good	Good	Good
Common ragweed	Annual	Excellent	Excellent	Excellent	Excellent
Giant ragweed	Annual	Excellent	Excellent	Excellent	Excellent
Common dandelion	Perennial	Excellent	Excellent	Excellent	Excellent
Ground Ivy (Creeping Charlie)	Perennial	Fair	Good	Good	Excellent
Common chickweed	Annual	Fair	Good	Excellent	Excellent
Waterhemlock	Perennial	Good	Good	Excellent	Excellent
Ash	Woody perennial	None	Poor	Poor	Fair
Boxelder	Woody perennial	Good	Good	Good	Fair
Buckbrush	Woody perennial	Good	Good	Poor	Good
Elm	Woody perennial	Poor	Fair	Fair	Good
Aspen (poplar)	Woody perennial	Fair	Fair-Good	Fair	Good
Oak	Woody perennial	Poor	Fair-Good	Poor	Fair
Willow	Woody perennial	Good	Good	Fair	Good
Maple	Woody perennial	Poor	Fair	Poor	Good

1/Adapted from Farmer's Bulletin No. 2183 USDA, Using Phenoxy Herbicides Effectively, and from research trials.

Table 2. Summary of herbicides for broadleaf weed and brush control on roadsides and drainage ditch banks.

Chemical	lb/A	Time of application	Precautions
For thistles and other broadleaf weeds			
2,4-D amine or L.V. ester	2	When perennial broadleaf weeds are 6 to 10 inches tall and before bud stage or in the fall on active new weed growth.	Use low pressure (30-40 psi). Avoid drift. 2,4-D may be used along drainage ditches. Glean should not be used near water or drainage ditches.
Chlorsulfuron (Glean)	1/4 oz-2 oz/acre		
For broadleaf weeds and 2,4-D resistant brush			
2,4-DP	2	When brush is fully leaved out and before bud stage of broadleaf weeds or in the fall on active new weed growth.	Avoid drift. May be used along drainage ditch banks.
2,4-D + 2,4-DP	1 + 1		
MCPP (mecoprop)	2		
2,4-D + MCPP + dicamba (Trimec-352)	2 + 1 + 0.2		
2,4-D + MCPP + dicamba (Trimac 4-41)	1.88 + 2 + 0.5		
For spot treatment of 2,4-D resistant broadleaf weeds or brush			
Picloram (Tordon, Amdon)	1/2 to 1	When brush is fully leaved out and before bud stage of broadleaf weeds or in the fall on active new weed growth.	Picloram is a persistent and water soluble herbicide. (Restricted use material.) Do not use these herbicides along drainage ditch banks or along streams, lakes or water supplies. Avoid drift to non-target broadleaf plants.
Picloram + 2,4-D (Amdon 101 Tordon 101)	1/2 + 1		
Dicamba + 2,4-D (Banvel 720)	1 + 2		
Brush control			
Fosamine (Krenite)	6 to 12	Apply during the 2 month period prior to fall leaf coloration.	May be used on drainage ditch banks.

Table 3. Chemicals for temporary or short-term vegetation control (non-cropland, fence rows, highway guardrails, parking lots, building sites, etc.

Grasses and cattails	Broadleafs	Grasses and broadleafs
dalapon (Dowpon M)	2,4-D	paraquat
TCA	2,4-DP	amitrole
dalapon and TCA (Dowpon C)	MCPP	amitrole - T
	picloram (Tordon, Amdon)	glyphosate (Roundup)
	MCPA	ammonium-sulfamate (Ammate)
	dicamba (Banvel)	
	2,4,5,-T or Silvex	

1 Restricted use herbicide. May be applied only by a certified applicator.

2 Water soluble compounds. Use with caution around desirable broadleaf plants, trees and shrubs.

3 May still be used on certain non-cropland sites such as airports, fencelines not adjacent to pasture, lumber yards, refineries, storage areas, tank farms or industrial sites (not otherwise included in suspended uses).

Table 4. Chemicals for long-term vegetation control (non-selective) (non-cropland, fence rows, highway guardrails, parking lots, building sites, etc.)

Broadleaf and Grass Control
sulfomethureon methyl (Oust)
*bromacil (Hyvar-X, Hyvar-XL)
diuron (Karmex)
diuron/bromacil (Krovar, liquid; Bromex granules)
simazine (Princep)
atrazine (AAtrex, atrazine)
prometone (Pramitol)
simazine and amitrol (Amizine)
*AMS (Ammonium sulfamate) Ammate
borates
sodium chlorate
borax and 2,4-D (D.B. Granular)
*hexazinone (Velpar)
*tebuthiuron (Spike - available as wettable powder or pellets)
chlorosulfuron (Telar)

* May also be used for spot treatment of brush species. However, these materials must be used with caution because the roots of desirable trees or shrubs may pick up and translocate these materials.

Table 5. Cut stump treatment of brush and trees.

2,4-D + 2,4-DP + penetrating agent (Weedone CB - apply undiluted
Dicamba (Banvel CST) - apply undiluted
Dicamba + 2,4-D + oil or diesel fuel as carrier
Picloram (Tordon 101R, Tordon RTU) - apply undiluted
Ammonium sulfamate (Ammate) - apply as crystals or water base spray
Triclopyr (Garlon) - apply undiluted or mix with diesel fuel

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

AG-FS-0921 — 1985
AGRICULTURAL CHEMICALS
R. Behrens and L. L. Hardman

Weed Control in Dry Beans

Dry beans are sensitive to weed competition. Early weed growth reduces bean yields by competing for light, moisture, and nutrients. Weeds also are likely to cause a buildup of disease and/or insect problems that may affect bean growth and development adversely. Weeds increase harvest losses and reduce bean quality. Cultivation or other tillage sometimes controls weeds adequately without the use of herbicides. However, weeds usually are not controlled adequately in the row and use of herbicides with tillage is necessary.

Early Growth and Development of Beans

Dry beans grown in Minnesota include five common bean (*Phaseolus* sp.) classes: navy, pinto, kidney, pink, and small red, as well as the adzuki bean (*Vigna* sp.). All common beans emerge by elongation of the hypocotyl (portion of the stem below the cotyledons or seed leaves), which "crooks" or arches through the soil and then straightens out with unfolding cotyledons. These common beans emerge quite rapidly (usually within 7-10 days) if planted in warm soil (50° F or higher) in late May or early June in Minnesota. However, earlier planting may delay emergence.

Adzuki beans, on the other hand, emerge by elongation of the epicotyl (portion of the stem above the cotyledons), and the cotyledons (seeds) remain below the soil surface. Adzuki beans emerge more slowly than common beans, usually 10-14 days in warm soils and 15-20 days in cold soils. Because of the type and time required for emergence, adzuki beans are more susceptible to injury from preplanting or preemergence herbicides. For example, EPTC (Eptam or Genep), alachlor (Lasso)[1], metolachlor (Dual), or dinoseb (Premerge) can be used on common beans but should not be used on adzuki beans (table 2). Because of slower bean emergence and less early season crop competition, weed control is more critical with adzuki beans than with common beans.

Cultivation

Before emergence, dry beans can be spike-toothed harrowed to kill emerging weeds. The weeder, rotary hoe, or flexible-tined harrow are safer to use after bean emergence than the spike-toothed harrow. More than one harrowing may be necessary.

After the beans emerge, they develop quite rapidly and progress through the cotyledon stage (or plumule stage in the adzuki bean) to the fully expanded unifoliolate leaf stage and

[1]Alachlor (Lasso) is now undergoing a special review by the U.S. Environmental Protection Agency (EPA) because tests show that tumors are caused when high levels of alachlor are fed daily to laboratory animals over long periods of time. In this special review, EPA is reexamining all health and safety tests and product benefits from alachlor usage. Recommendations from EPA on future uses of alachlor will be developed based on the agency's estimates of these risks and benefits. As of November 1984, it seems probable that alachlor will continue to be available during 1985 for use by Minnesota farmers.

Table 1. Effectiveness of herbicides on major weeds in dry beans[1]

	Preplant Incorporated						Preemergence			Post-emergence
Weed	alachlor (Lasso)	EPTC (Eptam)	trifluralin (Treflan)	ethalfluralin (Sonalan)	pendimethalin (Prowl)	metolachlor (Dual)	metolachlor (Dual)	chloramben (Amiben)	dinoseb (several names)	bentazon (Basagran)
Grasses										
green foxtail	G	G	G	G	G	G	G	G	F	N
yellow foxtail	G	G	G	G	G	G	G	G	F	N
giant foxtail	G	G	G	G	G	G	G	F	F	N
barnyardgrass	G	G	G	G	G	G	G	G	F	N
wild oat	P	F	P	F	P	P	P	P	P	N
quackgrass*	N	F	N	N	N	N	N	N	N	N
Broadleafs										
common lambs-quarters	F	F	F	F	F	F	F	G	G	P
pigweed	G	F	G	G	G	G	G	G	G	P
wild mustard	P	P	N	N	N	P	P	F	G	G
smartweed	P	P	P	P	F	P	P	G	F	G
common ragweed	P	F	N	N	N	P	P	G	G	G
kochia	P	F	G	G	G	P	P	F	G	P
velvetleaf	P	F	N	N	F	P	P	F	F	G
cocklebur	P	P	N	N	N	P	P	P	F	G
eastern black nightshade	G	P	P	F	P	F	G	G	F	F
hairy nightshade	G	P	P	F	P	F	F	G	F	F
Canada thistle*	N	N	N	N	N	N	N	N	N	G

1 G = good control, F = fair control, P = poor control, N = no control.
* Glyphosate (Roundup) can be used in fields before planting dry beans and for spot treatment where these perennial weeds are a problem. See label.

Table 2. Summary of herbicides for use on dry beans (incudes navy, pinto, pink, small red, adzuki)[1]

Herbicide	Lb/A of active ingredient or acid equivalent broadcast	Time of application[2]	Remarks
chloramben (Amiben)	2 to 3	Pre/PPI	Use lower rate on adzuki beans
EPTC (Eptam or Genep)	3 to 4	PPI	Do not use on adzuki beans. Do not exceed 3 lb/A on coarse-textured soils.
pendimethalin (Prowl)	.5 to 1.5	PPI	Adzuki bean tolerance unknown.
trifluralin (Treflan)	.5 to 1	PPI	Use lower rates on coarse-textured soils, higher rates on medium and fine-textured soils.
ethalfluralin (Sonalan)	.56 to 1.12	PPI	Use higher rates up to 1.69 lb/A for nightshades. Adzuki bean tolerance unknown.
metolachlor (Dual)	1.5 to 3	PPI/Pre	Do not use on adzuki beans.
alachlor (Lasso)	2.5 to 3	PPI	Do not use on adzuki beans.
bentazon (Basagran)	.75 to 1	Post	Beans in first trifoliolate, weeds small. Use lower rate on adzuki beans.
dinoseb or DNBP	9	Pre	Do not use on sandy soils. May be applied at crook stage at 3 to 4½ lb/A (see label). Do not use on adzuki beans.

1. For more information on herbicides for use in dry edible beans, see product labels.
2. Pre = preemergence, PPI = preplant incorporation, Post = postemergence.

then to the first and subsequent trifoliolate (three-part) leaves. Beans differ in canopy growth. Most navy and adzuki bean varieties are erect or "bush" type. Most pinto, pink, and small red bean varieties are prostrate vines, although bush or semi-vine types of small red and pinto are available.

Dry edible beans may be cultivated once or twice to control weeds; however, cultivation should be shallow to avoid damaging the rather shallow root systems. Cultivation or harrowing should not be done when the bean foliage is wet because bacterial diseases may be spread. Beans are hilled at the last cultivation to allow use of bean pullers. However, if beans are to be direct-combined or swathed, the last cultivation should leave the field as level as possible.

Herbicides

For effective weed control in dry edible beans, any weeds present should be identified, and the best herbicide or herbicide combination should be selected (tables 1 and 2). For preplanting incorporation, several herbicides are available that give good annual grass control and fair-to-good control of some annual broadleafs. These herbicides are EPTC (Eptam or Genep), trifluralin (Treflan), ethalfluralin (Sonalan), pendimethalin (Prowl), metolachlor (Dual), and alachlor (Lasso). Thorough incorporation requires two tillage operations at right angles, with most tillage implements. Metolachlor and alachlor should be incorporated shallowly to no more than 2 inches deep.

Three herbicides, metolachlor, chloramben (Amiben), and dinoseb or DNBP (several trade names), are available for preemergence use to control a wide range of annual broadleaf weeds and annual grasses. If sufficient rainfall does not occur within seven days after applying chloramben, alachlor, or metolachlor, use a shallow cultivation to kill germinating weeds and incorporate the herbicide. If rain is not expected, chloramben or metolachlor may be incorporated shallowly (1-2 inches deep) right after application. Dinoseb may be applied at a lower rate as the beans are emerging and up to the crook stage (table 2). Bentazon (Basagran) for broadleaf weed control is applied when weeds are small and after beans reach the first trifoliolate leaf stage. The effectiveness of bentazon is much reduced after broadleaf weeds become larger than the six to eight leaf stage (or more than 6 inches tall). Use the higher rate of bentazon and/or add a crop oil concentrate for larger weeds up to the size limit specified for the species. See label.

Herbicide Combinations

Several herbicides are cleared for use in combination with another herbicide for broader spectrum weed control. Combinations of alachlor or metolachlor with trifluralin, EPTC, or chloramben, and of ethalfluralin or pendimethalin with EPTC may be used preplanting incorporated. Mixtures of alachlor or metolachlor may also be used preplanting with chloramben or ethalfluralin. See herbicide labels for rates and precautions.

Summary

A weed control program should be based on the kind of beans, the weed species in the field, the soil type, the type of tillage, and any irrigation. Herbicide costs and expected bean yields also should be considered. if perennial or other weeds that cannot be controlled by tillage or a labelled herbicide are present, a more competitive crop than beans should be planted. Total weed control is neither probable nor necessary. However, adequate weed control, especially for the first three to four weeks, is required for profitable dry bean production.

Table 3. Herbicide names and formulations

Common Name	Trade Name	Concentration[1]
alachlor	Lasso	4 lb/gal L
bentazon	Basagran	4 lb/gal L
chloramben	Amiben	2 lb/gal L, 10% G
dinoseb (DNBP)	Premerge, others	1, 3, 5 lb/gal L, 10% G
ethalfluralin	Sonalan	3 lb/gal L
EPTC	Eptam or Genep	7 lb/gal, 10% G
metolachlor	Dual	8 lb/gal L
pendimethalin	Prowl	4 lb/gal L
trifluralin	Treflan	4 lb/gal L, 5% G

1. L = liquid, G = granular

Read the pesticide label and follow the instructions as a final authority on pesticide use.

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AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

AG-FS-0924
Agricultural Chemicals
Oliver Strand* and Neal P. Martin
Revised 1984

Establishing Forage Legumes with Herbicides

Each year Minnesota farmers establish nearly one million acres of alfalfa and legume-grass mixtures for livestock feed. Most of this acreage is seeded with a companion crop such as oats, wheat, or flax. A companion crop is used to help crowd out weeds that otherwise would compete excessively with the forage legumes. However, this companion or "nurse" crop also competes with the forage legumes and often reduces the forage stand.

Most of the companion crop acres are harvested as grain for a cash crop, or the straw is used for bedding and the grain for livestock feed. When the companion crop is allowed to grow to maturity, competition for light, water, and nutrients becomes severe and often kills or reduces the vigor of many forage legume seedlings and reduces forage yields. In Minnesota, most small grain companion crop acres are cut and swathed before combining to allow further drying. If rain delays combining, windrows often mat down over the forage legume seedlings and smother them. Also, the companion crop tends to shatter before or during combining, and thick stands of volunteer grain provide further competition for young forage seedlings.

Seedling legumes generally are poor competitors with weeds. If the seeding is done in the spring, annual grasses such as the foxtails and annual broadleaf weeds such as pigweed and common lambsquarters usually compete aggressively with the legumes. Unless the field is comparatively weed free or unless repeated tillage is used to kill seedling weeds prior to seeding, a herbicide usually is needed.

Direct Seeding

Seeding alfalfa or other forage legumes alone in early spring with herbicides to control annual weeds is a relatively new method of legume establishment called "direct seeding." With this method there is little or no competition to the forage legumes, and better stands and higher yields are possible in the seeding year and subsequent years.

If alfalfa or other forage legumes are direct-seeded with a herbicide, no forage grasses can be included in the mixture or they will be injured or killed. Direct seeding of alfalfa should not be attempted on steep slopes or other soils where wind or water erosion is a problem. On these sites, a companion crop will give more soil protection and can be used, but it should be harvested as forage before the grain matures.

There are three herbicides cleared for use to control annual grass and broadleaf weeds in direct-seeded forage legumes. These are: EPTC (Eptam), and benefin (Balan), both preplant incorporated herbicides that will control most annual grass weeds and a few annual broadleafs, and 2,4-DB (Butyrac, Butoxone), which will control many annual broadleaf weeds when applied early postemergence (see table).

Annual grass weeds such as green, yellow, or giant foxtail usually compete more severely with forage legume seedlings than do broadleaf weeds. Therefore, one of the preplant incorporated herbicides should be used to control grass weeds and increase seeding year forage legume yields.

Selecting a Herbicide

Both of the preplant incorporated herbicides can injure the forage legume seedlings if used at excessive rates for the soil type. Use the lower labeled rate on coarse- and medium-textured soils and the higher rate on fine-textured soils. These herbicides should be thoroughly incorporated into the top two to three inches of soil (see table).

EPTC is the most water soluble of the two, more subject to loss by leaching, and more likely to cause legume seeding injury under irrigation or high rainfall conditions, especially on coarse-textured soils. However, EPTC requires less soil moisture to activate the herbicide and has performed somewhat better under low rainfall conditions. EPTC also has given fair control of a few more broadleaf weeds such as common ragweed and mustard, which benefin does not control.

Controlling Perennial Weeds

If perennial weeds are a problem in a field to be seeded to forage legumes, these weeds should be controlled prior to seeding. Herbicides, tillage, or a combination of both can be used. Once forage legumes are seeded, perennial weeds are difficult to control without injury to the crop.

Perennial broadleaf weeds such as Canada thistle, perennial sowthistle, or field bindweed can be treated the fall prior to seeding with 2,4-D, low rates of dicamba (Banvel), or a combination of the two. For best results, spraying should be done before a killing frost when the weeds still are growing and temperatures are higher than 50° F. Before seeding pure alfalfa stands, glyphosate (Roundup) can be used to control perennial weeds such as quackgrass or Canada thistle either fall or spring prior to seeding. Spray when there is at least four to six inches of leaf canopy, and allow one week after treatment before tillage and seeding.

Comparing Advantages and Disadvantages

Direct seeding has several advantages over establishing forage legumes with a companion crop. They include: less competition for legumes, thus better forage stands (especially true for birdsfoot trefoil); more high protein can be harvested per acre in the seeding year; less risk of weeds taking over the stand; and no establishment costs for companion crop.

Disadvantages include: less erosion control with legumes than with grass and legume mixture; no straw for bedding and no grain for potential cash crop; can only seed pure stands of legumes, not legume and grass mixtures; and seeding costs may be higher (herbicide cost).

*Deceased

Keys to Successful Direct Seeding

Seed in the spring as soon as a good seedbed can be prepared. Alfalfa and red clover can be seeded earlier than birdsfoot trefoil. Birdsfoot trefoil is slower to germinate and has less seedling vigor. For alfalfa or red clover, usual seeding dates are April 15 to May 1 in southern Minnesota and May 1 to May 15 in northern Minnesota. Seeding of birdsfoot trefoil is often delayed two to three weeks after alfalfa or red clover.

Select an adapted, disease resistant species or cultivar. Seed 15 pounds of alfalfa, 14 pounds of red clover, or 10 pounds of birdsfoot trefoil per acre. Red clover and birdsfoot trefoil will tolerate poorly drained soil conditions better than alfalfa. If alfalfa is to be planted on poorly drained soils it is important to select a phytophthora resistant variety.

Apply corrective phosphate and potash, according to soil test needs, before secondary tillage. Apply lime to correct acid soil to a pH 6.8 for alfalfa and 6.0 for red clover and birdsfoot trefoil. Red clover and birdsfoot trefoil require less phosphate and potash than alfalfa. Yearly maintenance applications of phosphate and potash are needed on most soils to keep the stand productive.

Select one of the two preplant, incorporated herbicides – EPTC (Eptam) or benefin (Balan), –for annual grass weed control. Use the rate recommended for the soil type and apply and incorporate according to the herbicide label. It is best to apply and incorporate the herbicide three to five days before seeding.

Seed at the proper depth, ¼ to ½ inches, into a firm, level seedbed to help ensure seed germination and good seedling emergence.

Scattered annual broadleaf weeds will not compete seriously with forage legumes and likely will be killed by the first cutting. However, if annual broadleaf weeds become a serious problem, apply 2,4-DB (Butyrac, Butoxone) according to label directions when the forage legumes have two to four trifoliolate leaves and when weeds are small.

Harvest the first cutting of alfalfa in the bud to first bloom stage (usually 60 to 70 days after seeding). Birdsfoot trefoil can be cut 80 to 90 days after seeding. Two or three cuts of alfalfa are possible during the seeding year when seeded early and if rainfall is normal.

If the forage legume is seeded in mid to late summer, annual weeds are much less of a problem and seeding without a herbicide is usually possible. If the field is known to be weedy, however, one of the preplant, incorporated herbicides should be used to help reduce weed competition. The seeding should be done by early to mid-August to ensure good root establishment before a killing frost occurs.

Control perennial weeds with herbicides, tillage, or a combination of these prior to establishment.

Insect and disease problems need to be identified and controlled using recommended practices.

Herbicides for direct seeding of forage legumes.

Crop(s)	Herbicide	Rate lbs/A	Time of Application	Remarks	EPA Limitations on use
Alfalfa; red or alsike clover; sweetclover; birdsfoot trefoil	EPTC	2 to 4	Preplanting incorporation	Incorporate immediately after application.	None
Alfalfa; red, alsike, or ladino clover; birdsfoot trefoil	benefin (Balan)	1 1/8 to 1 1/2	Preplanting incorporation	Incorporate as soon as possible within 8 hours after application.	None
Alfalfa; red, alsike, or ladino clover; birdsfoot trefoil (amine) Alfalfa; birdsfoot trefoil (ester)	2,4-DB (Butyrac, Butoxone)	1/2 to 1 1/2 (amine) 1/2 to 1 (ester)	When legumes have 2 to 4 trifoliolates and weeds are small	Use lower rates for weeds less than 1 inch tall; higher rates for weeds 2 to 3 inches tall.	Do not graze or feed treated crop within 60 days after application.
Alfalfa; red, alsike, or ladino clover; birdsfoot trefoil; sweet clover	dinoseb (Premerge)	1 1/8 to 1 1/2	When legumes have 2 or more leaves and weeds are small	Dinoseb is highly toxic to humans, see label for proper use precautions.	Do not graze or feed treated crop within 60 days after application.

Clearance expected for 1984: The postemergence soybean herbicide, sethoxydim (Poast), is expected to receive clearance by spring, 1984, for early postemergence use in newly seeded alfalfa for the control of most annual grasses. It must be applied with an oil concentrate. Normal usage rate is 0.2 pounds per acre (one pint per acre) when grasses are three to eight inches tall. Caution: As of November 1, 1983, this clearance has not been received.

Read the pesticide label and follow the instructions as a final authority on pesticide use.

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

AG-FS-0923
Reviewed 1985

Agricultural Chemicals
Richard Behrens

Broadleaf Weed Control in Grass Pastures

Broadleaf weeds, many of them on the noxious weed list and several of them poisonous to livestock, infest considerable grass pasture acreage in Minnesota. These broadleaf weeds are generally less palatable, less nutritious, lower yielding, and are less dependable as a forage supply for livestock than the desirable grass or legume pasture species that they replace.

Kinds of Pasture Weeds

Most pasture weed species are perennial in growth habit or life span (will live for several years) and spread by underground rhizomes (stems) or rootstocks in addition to spreading by seed. These perennial weeds are not easily controlled by mowing because regrowth occurs from the underground perennial plant parts.

Some troublesome pasture weeds are biennial in growth habit. These spread entirely by seed but require two years to complete their life cycle. The first year they produce a rosette of basal leaves and a vigorous tap root system. The second year they produce flowers and seeds and then die. Many of these weeds are also diffcult to control by mowing because during the first year they do not have an erect stem. By the second year they have developed an extensive root system with large food reserves that enables the plant to regrow several times if mowed off.

There are also a few annual weeds that infest grass pastures. These weeds grow from seed each year and die after producing flowers and seeds. They may be summer annuals that germinate in the spring and die in the fall; or they may be winter annuals that germinate in the fall, live over winter, and produce flowers and seed in the spring or early summer before they die. Some of these weeds can be readily controlled by mowing, but unless they are clipped very close to the ground, they also may recover and regrow to produce seed.

Herbicides for Use in Grass Pastures

There are four herbicides presently available for broadleaf weed and brush control in grass pastures (table 1). These herbicides are:

1. 2,4-D (available under several trade names)
2. MCPA (available under several trade names)
3. dicamba (Banvel)
4. combinations of the above
5. picloram (Tordon 22K or 2K)

These herbicides control some weeds but not others. Therefore, the first step in effective pasture weed control is to identify the weeds and be aware of their growth habit or life span (table 2). Then selection and timely use of the best herbicide or herbicide combination (tables 1 & 2)--together with other good pasture management practices such as fertilizer use, rotational grazing, clipping herbicide

Table 1. Herbicides for weed control in grass pastures

Chemicals	Pounds per acre of acid equivalent or active ingredient/A	Time of application	Remarks	Environmental Protection Agency registration limitations on use
2,4-D	1/2 to 2	Before bud stage of weeds, preferably when perennial weeds are 6 to 10 inches tall and growing rapidly or when biennials are in rosette stage. When woody plants are fully leaved.	Rate depends on kinds of weeds. Use only MCPA at low rates if legumes are present. Use 2,4-D, dicamba, or mixtures of these for woody plant control. Esters or oil soluble amine formulations are more effective than amines on many weed species and are less affected by rainfall or dew. Avoid drift to susceptible broadleaf crops, especially soybeans, dry beans, sunflowers, and sugar beets. Do not use picloram on sandy soils with a high water table or if pasture is to be rotated to cropland. See label.	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.
MCPA	1/4 to 2			
Dicamba (Banvel)	1/2 to 1			Do not graze dairy animals on dicamba treated pastures for 7 to 21 days after these rates of application. See label.
Dicamba + 2,4-D	1/3 to 1/2+ 1 to 2			
Picloram (Tordon 22K and 2K)	1/2 to 2			Do not graze or feed forage from picloram treated areas for 2 weeks after treatment.

Table 2. Susceptibility of common pasture weeds to herbicides (weeds followed by an asterisk may be poisonous to livestock).

Weed name	Life span of weed	Susceptibility to herbicide[1] 2,4-D	MCPA	Dicamba	Picloram
Alyssum, hoary	perennial	F	F	F	G
Aster sp.	perennial	F	F	G	G
Bracken fern*	perennial	P	P	F	G
Burdock, common	biennial	G	E	E	E
Buttercup sp.*	perennial	F	E	G	G
Daisy, oxeye	perennial	F	F	F	G
Dandelion, common	perennial	G	E	E	E
Dock, curly	perennial	G	F	G	G
Goldenrod sp.	perennial	G	F	G	G
Hawksbeard sp.	annual or biennial	P	P	F	G
Hawkweed sp.*	perennial	F	P	F	G
Hemp*	annual	E	E	E	E
Horseweed	annual	G	F	F	G
Knapweed, spotted	biennial	F	E	G	G
Kochia	annual	G	G	G	G
Milkweed, common*	perennial	P	N	F	F
Mullein, common	biennial	P	P	F	G
Nettle, stinging	perennial	G	F	F	G
Pennycress, field	annual	E	E	P	G
Plantain sp.	perennial	E	E	G	G
Ragweed, common	annual	E	E	E	E
Sorrel, red	perennial	N	N	G	G
Snakeroot, white*	perennial	F	F	G	G
Sowthistle, perennial	perennial	F	F	G	G
Spurge, leafy*	perennial	P	N	F	G
Tansy	perennial	G	N	G	G
Thistle, Canada	perennial	F	F	G	G
Thistle, bull	biennial	E	E	E	E
Thistle, musk	biennial	G	F	G	E
Thistle, plumeless	biennial	G	F	G	E
Thistle, Russian	annual	G	G	G	E
Toadflax, yellow	perennial	N	N	P	F
Waterhemlock, spotted*	perennial	G	F	F	G
Wormwood, absinthe	perennial	F	P	G	G
Yarrow, common	perennial	F	P	F	G

[1] E=excellent, G=good, F=fair, P=poor, N=no control. (Ratings apply if recommended rate and time of application of herbicide is used and optimum temperature and growing conditions prevail.) References: USDA Farmer's Bulletin 2183, Revised 1975, "Using Pasture Herbicides Effectively;" Pasture Weed Control Demonstration and Research Results, Agricultural Extension Service, University of Minnesota; and herbicide labels.

resistant weeds, and periodic clipping of ungrazed forage--will gradually reduce weed problems and improve grass pasture stands and yields

Many years of research data and practical farmer use have shown that these herbicides are not harmful to livestock when applied on pasture grass and weeds at recommended usage rates following label restrictions. Because applied herbicides may make toxic weeds more palatable to livestock, however, livestock should be excluded from the sprayed area for 7 to 10 days after treatment if poisonous plants are present. Follow grazing restrictions and safety precautions as prescribed on the label for the specific herbicide used.

Time of Application of Herbicides

Annual and biennial weeds are easiest to control with herbicides early in the first year of growth--after they have germinated and leafed out, but when they are still small. Biennial and winter annual weeds also may be effectively controlled with herbicides in the fall of the seedling year when they are in the rosette stage. Perennial weeds that grow from a parent rootstock or underground rhizome, on the other hand, are best controlled with herbicides when they are at least 6 to 8 inches tall but before the bloom stage. During this growth stage, the perennial weeds are large enough to intercept an adequate amount of foliar herbicide to translocate enough into the root system to kill the weed. Also during this growth stage, translocation (of sugars produced in the leaves) is from leaf shoot to root rather than from root to shoot, which favors movement of the herbicide into the perennial root system and makes root kill more likely.

Grass Pasture Improvement Recommendations

1. Evaluate the pasture area to determine yield improvement potential. Consider soil type, land capability, fertility level, and potential soil moisture supply. Do not attempt to improve "poor risk" pasture areas that are too wet, too droughty, too rocky, or otherwise unsuitable.

2. Identify weeds and select best herbicide or herbicide combination for control.

3. Take a representative soil sample from the pasture area. Have soil tested and apply phosphate and potash fertilizer according to need. If the grass stand is adequate, apply an increment of approximately 50 pounds of actual nitrogen (150 pounds of ammonium nitrate or equivalent) early in the spring. If rainfall is adequate, apply one or more additional increments of nitrogen as needed during the growing season to stimulate growth of additional grass. The use of fertilizer will make the grass more productive and more vigorous so that it will compete better with the weeds.

4. Apply herbicide(s) when predominant perennial pasture weeds are 6 to 8 inches tall but before bloom. Allow woody plants to become fully leaved out before spraying. More than one application of an herbicide may be needed for control. Early fall treatment of some biennials or fall retreatment of the regrowth of some perennials may be more effective than spring treatment.

5. Identify and avoid grazing areas where poisonous pasture weeds predominate until these weeds have been killed by herbicides.

6. Manage the pasture to favor the grass and help control the weeds. Allow grass to attain 5 to 6 inches of top growth before grazing the area. Use sufficient grazing pressure to utilize the grass rapidly before it matures. Rotate cattle to another pasture area to allow the grass 3 to 4 weeks recovery time after grazing. Clip grazed pasture areas to control escaped weeds and promote uniform re-growth of grass. Spread cattle droppings if needed.

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AGRICULTURAL WEED CONTROL GUIDE
for
SUGARBEETS

Alan G. Dexter
Extension Sugarbeet Specialist

General Herbicide Use Information

THE WEED CONTROL SUGGESTIONS are based on Federal label clearances and on information obtained from Agricultural Experiment Stations 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 have and will continue to have a registered label with the Environmental Protection Agency. Herbicide labels should be checked for registered uses on sugarbeets prior to application.

USE CHEMICALS ONLY AS RECOMMENDED ON THE LABEL.

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, Avadex is available in a liquid formulation which has four pounds of active ingredient per gallon or in a granular formulation which has 10% active ingredient. A desired application rate of 1.5 lb/A would require 1.5 quarts/A of the liquid formulation or 15 pounds/A of the granules.

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 and therefore vary in response to rainfall. The amount and intensity of rainfall also influence the washing of herbicides from leaves. The approximate time between application and rainfall needed for maximum weed control from several herbicides follows: Carbyne 2EC--5 minutes; Dowpon--8 hours; Betanex--6 hours; 2,4-D or MCPA amine--4 hours; 2,4-D or MCPA ester--1 hour; Roundup--6 hours; Betamix--6 hours; and Poast--1 hour.

SPRAY DRIFT is a problem in North Dakota and Minnesota 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 nonvolatile. Dicamba (Banvel) is also volatile and can drift as droplets or vapor. A less volatile formulation of dicamba (Banvel II) is available. 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, herbicides with high potential to form damaging vapors such as 2,4-D esters, MCPA esters, and Banvel should not be used near susceptible plants.

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 nonvolatile. 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 formulation even when the air temperature was below 70 F.

e) Drift control: Certain spray nozzles such as the Delavan Raindrop nozzles and the Spraying Systems LP nozzles produce large droplets which reduce drift. The controlled droplet applicator (CDA) at 2000 rpm has also reduced drift compared to the 8001 flat fan nozzles at 40 psi. Nalco-Trol and other similar additives to spray mixtures cause larger droplets which reduce drift.

f) Drift injury from herbicides: Damaging drift to nontarget plants is primarily a problem with 2,4-D, MCPA, Banvel, Banvel II, paraquat, Roundup, and Tordon in North Dakota and Minnesota. Other herbicides may drift but generally do not cause significant damage. Drift control techniques producing large droplets should not be used with postemergence herbicides that require small droplets for optimum performance such as Carbyne 2EC, Betanex, Betamix, and Basagran.

PREEMERGENCE HERBICIDES: 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 unless the harrow or rotary hoe removes the herbicide from a treated band.

INCORPORATION OF HERBICIDES: Many herbicides which are applied before crop and weed emergence need to be incorporated to give optimum weed control. Included in this group are Ro-Neet, Avadex, and Eptam. Herbicides that should be incorporated in some instances are Norton, Pyramin, TCA, and Antor.

Ro-Neet, Avadex, and Eptam should be incorporated immediately after application regardless of whether the liquid or granular formulation is used. Nortron, Antor, Pyramin, and TCA may be used preemergence but incorporation usually improves weed

control especially on fine-textured soils or with limited rainfall after application. Incorporation may reduce weed control if heavy rains follow application and incorporation may increase sugarbeet injury compared to surface application. Experience indicates that lack of rainfall is more common than excess rainfall following planting. TCA should not be incorporated on soils where sugarbeet injury from TCA is a concern.

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 give uniform mixing 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 matched to the herbicide.

Ro-Neet and Eptam 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 4 to 6 inches for Eptam or Ro-Neet. Operating speed should be 4 to 6 mph. Tandem disks with disk blades spaced 8 inches or less and disk blade diameter of 20 inches or less have given good herbicide incorporation. Larger disks often give 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 4 to 6 inches for Eptam and Ro-Neet. 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 plus rolling crumblers behind have given good herbicide incorporation. These tools should be operated 4 inches deep and at 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. A single incorporation with a power driven rototiller is sufficient for Ro-Neet or Eptam. However, a second tillage at right angles to the initial incorporation should be done if the disc 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. Avadex and TCA will give adequate weed control 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 have shown that deeper incorporation generally enhanced wild oats control from Avadex. Nortron, Antor, and Pyramin do not require deep incorporation. A tillage tool operating at a minimum depth of 2 inches will give adequate incorporation if the tool mixes the herbicide uniformly through the soil.

THE SOIL ORGANIC MATTER TEST: Certain herbicides are partially adsorbed 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 Ro-Neet, Eptam, and Pyramin require higher rates to be effective in high organic matter soils. On the other hand, crop safety may be marginal on low organic matter soils. Herbicides also are adsorbed to the clay fraction in a soil, so clay content affects herbicide performance. However, organic matter level generally affects herbicide performance more than clay content.

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

Some herbicides give good weed control only when organic matter levels are low. Pyramin has not been effective in the Red River Valley, except on the coarser-textured soils with less than 5% organic matter. The lower the organic matter, the more effective.

Many herbicides such as Avadex and most postemergence herbicides are affected only slightly by organic matter levels.

Determine organic matter levels on each field where organic matter sensitive herbicides are to be used. Organic matter levels change very slowly and testing once every 5 years would be adequate.

FALL APPLICATION OF HERBICIDES: Certain herbicides may be applied in the fall for weed control the following spring. Included in this group are Avadex, Eptam, and Ro-Neet. Fall treatments should be applied after October 15 and until soil freeze-up. Application of herbicide treatments after October 15 when soil temperature has cooled minimizes herbicide loss by volatilization. Applications made more than 3 weeks before soil freeze-up can result in poor weed control. Both granular or liquid formulations of the herbicides are registered for use in the fall. Fall applications of granular formulations have generally performed more effectively than the liquid formulations, especially under heavy crop residue or cloddy situations.

Avadex applied at rates of 1.5 to 2 lb/A in the fall controls wild oats. Avadex is volatile and should be incorporated into the upper 2 inches of soil immediately after application to prevent losses by evaporation.

Eptam is registered at 4 to 4.5 lb/A fall applied and gives good control of annual grasses and certain broadleaf weeds. Eptam must be incorporated into the soil

immediately after application to prevent herbicide loss. The use of fall Eptam a) eliminates the need for deep spring tillage thus improving the seedbed, b) gives less sugarbeet injury than spring Eptam, and c) allows planting in the spring with no delay for herbicide application. On the negative side, fall Eptam a) may increase soil erosion over winter, b) gives more variable broadleaf weed control, c) requires a higher rate and thus costs more than spring Eptam, and d) limits crop choice of spring.

Ro-Neet is registered at 4 lb/A fall applied and gives good control of annual grasses and certain broadleaf weeds. Ro-Neet must be incorporated into the soil immediately after application to prevent herbicide loss. Ro-Neet is similar to Eptam except Ro-Neet gives less sugarbeet injury than Eptam and can be used on more coarse-textured, lower organic matter soils than Eptam. Research in North Dakota and Minnesota has shown that a mixture of fall applied Ro-Neet and Eptam gave effective weed control with less sugarbeet injury than Eptam alone and at a lower cost than Ro-Neet alone. Rate of application of the mixture must be adjusted for soil texture and organic matter. Effective rates in research have been 2 to 3 lb/A of Eptam plus 2 to 2.5 lb/A of Ro-Neet.

HERBICIDE COMBINATIONS: 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.

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 of nonlabeled mixtures must assume liability for any possible crop injury, inadequate weed control, and illegal residues.

HERBICIDE-LIQUID FERTILIZER COMBINATIONS: Thorough mixing and continuous vigorous agitation are required to obtain an even application of herbicide-liquid fertilizer combinations. Some herbicide-liquid 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. Generally, mix 1 pint of fertilizer and 2 teaspoons of the liquid herbicide. For wettable powders, mix 2 teaspoons of powder with a small quantity of water to form a slurry, and add the slurry to the fertilizer. 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: 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 lb/A of dry bulk fertilizer are recommended to maintain uniformity of herbicide application.

HERBICIDE RESIDUE or 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 and Minnesota. Herbicide residues are most likely to occur following years with unusually low rainfall because chemical and microbial activity needed to degrade herbicides is 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 of some herbicides by diluting the herbicide residue in a large volume of soil.

Herbicide residues can be detected by use of a bioassay for herbicide residue. A soil sample representative of the whole field must be obtained by sampling at many places to the depth of the tillage layer. A field which was only tilled shallowly after herbicide application the previous year should be sampled shallowly while a deep tilled field should be sampled as deep as the tillage tool was operated. Also, a sample of soil known to be free of herbicide residue 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 as needed for optimum germination and plant growth, 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 during the day. Observe the plants in the untreated check and test samples for 2 to 3 weeks after emergence. Some tangible measurements such as plant height and leaf length can be taken for evaluation, along with visual observation of abnormalties. Some herbicides, like atrazine and metribuzin, have slow developing symptoms that appear 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 Basalin, Prowl, and Treflan.

Atrazine (several trade names) generally has a residue the year following application to corn at 2 to 4 lb/A in North Dakota and Minnesota. 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 are susceptible to various degrees. The approximate ranking of other crops from

most to least tolerant is flax, soybeans, barley, wheat, oats, sunflower, and sugarbeets.

Basalin, Prowl, and Treflan are similar herbicides called dinitroanilines. Under dry soil conditions these herbicides can persist in the soil for more than one year. Sunflower, soybeans, potatoes, and dry edible beans are tolerant to dinitroaniline herbicides. The approximate ranking of other crops from most to least tolerant is flax, barley, wheat, oats, corn and sugarbeets. Sugarbeets are very susceptible to these herbicides but moldboard plowing plus adequate rainfall generally will prevent injury to this crop.

Tordon at 1/64 lb/A active ingredient or 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.

Sencor or Lexone (Metribuzin) 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 of 0.5 lb/A or higher could cause damage to susceptible crops the next year. The approximate ranking of crops from most to least tolerant are potatoes, soybeans, dry edible beans, corn, barley, wheat, oats, sunflower, flax, and sugarbeets.

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 three 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 and 16 months for barley and spring oats. The approximate ranking of crops from most to least tolerant is wheat, barley, oats, safflower, dry beans, sunflower, flax, corn, soybeans, and sugarbeets.

PREEMERGENCE CONTACT OR TILLAGE SUBSTITUTION HERBICIDES

Paraquat, a nonselective contact herbicide, can be used at 0.5 lb/A alone or at 0.25 to 0.5 lb/A in combination with a residual herbicide as a substitute for tillage. Paraquat may be applied before or after planting until just before crop emergence. Apply paraquat in 5 to 10 gpa of water by air or in 20 to 60 gpa of water by ground. Add Ortho X-77 to the spray solution at 0.5 to 1 pint/100 gallons. Paraquat can be used on land intended for barley, corn, potatoes, soybeans, sugarbeets, sunflower and wheat. Paraquat is corrosive to exposed aluminum spray equipment and aircraft structures so rinse equipment immediately after use. Paraquat is toxic so avoid contact with the skin; small amounts could be fatal if swallowed.

Roundup is applied postemergence for annual weed control at 0.19 to 0.75 lb/A (0.5 to 2 pt/A). Roundup at 0.19 to 0.37 lb/A must be used in combination with a nonionic surfactant of at least 50% active ingredient at 0.5% v/v. Roundup at 0.19 lb/A controls foxtails, 0.29 lb/A controls volunteer small grains, and 0.38

lb/A controls wild oats and downey brome when applied to plants less than 4 inches tall. The 0.37 lb/A rate will not control wild buckwheat, Russian thistle, or kochia. Use the higher rate on larger weeds, more resistant weeds, or if the plants are under moisture stress. When low rates of Roundup are used, apply in 3 to 10 gallons of water per acre by ground or in 3 to 5 gpa by air. Delay tillage for at least 3 days after treatment. Apply Roundup at 0.75 lb/A when quackgrass is at least 8 inches tall (3 to 4 leaf stage) and active growing. Apply Roundup at 1.5 to 2.25 lb/A when Canada thistle is actively growing and at or before the bud stage. Fall treatment of Canada thistle must be applied before frost for best results. Do not till until 3 or more days after treatment. Roundup can be used in the spring before or after planting but before emergence of barley, corn, oats, soybeans, dry beans, forages, potatoes, sugarbeets, wheat, and sorghum (milo), or in the fall when these crops will be planted the next growing season.

PREEMERGENCE SOIL APPLIED AND PREPLANT INCORPORATED HERBICIDES

The reasons for using a Pre or PPI herbicide in sugarbeets include the following:

1) To reduce early season weed competition.

2) To make postemergence herbicides more effective.

3) To give weed control if unfavorable weather presents timely cultivations or postemergence herbicide applications.

4) A single herbicide treatment usually will not give total weed control. A Pre or PPI herbicide followed by postemergence herbicides generally will improve weed control.

RELATIVE RESPONSE OF WEEDS TO PREEMERGENCE OR PREPLANT INCORPORATED HERBICIDES

	E. black nightshade	Barnyardgrass	Cocklebur	Field bindweed & P. thistles	Foxtails (pigeongrass)	Kochia	Lambsquarters	Pigweed, redroot	Russian thistle	Sunflower, vol.	Wild buckwheat	Wild mustard	Wild oats	Herbicide persistence after 12 months
Antor	F-G	F-G	P	P	F-G	P	P	G	P	P	P	P	F-G	N
Avadex	N	N	N	N	N-F	N	N	N	N	N	N	N	G	N
Eptam	F-G	G	P	N	G	F	F	F-G	P	N	F	P	F-G	N
Nortron	F-G	P	P	N	F-G	F-G	P-F	G	F-G	P	F-G	F	F-G	O
Pyramin	G	P	P-F	P	P	P-F	G	G	P-F	P	P-F	G	P	N
Ro-Neet	F-G	G	P	N	G	P	F-G	F-G	P	N	F-P	P	F-G	N
TCA	N	G	N	N	G	N	N	N	N	P	N	N	N	N

G = Good, F = Fair, P = Poor, N = None, S = Seldom, O = Often, - = No data

This table is a general comparative rating of the relative effectiveness of herbicides to certain weeds. Under very favorable weather conditions, control might be better than indicated. Under unfavorable conditions, some herbicides rates good or fair might give erratic or unfavorable results. Relatively dry and/or cool weather increases herbicide persistence while wet and/or warm weather reduces herbicide persistence.

EPTAM preplant incorporated in the spring at 2 to 3 lb/A or fall applied at 4 to 4.5 lb/A gives good control of annual grasses and certain broadleaf weeds. Eptam sometimes causes sugarbeet stand reduction and temporary stunting. However, no yield reduction will result if enough sugarbeets remain to obtain an adequate plant population after thinning. Eptam should be used with extreme caution on sugarbeets grown in sandy loam or coarser-textured soils with low organic matter levels because a safe Eptam rate is difficult to preduct on such soils. See previous sections on soil organic matter test, fall application of herbicides, and herbicide incorporation for more details.

RO-NEET spring applied at 3 to 4 lb/A gives weed control similar to Eptam on the light to medium soils in North Dakota and Minnesota. Eptam generally gives weed control superior to Ro-Neet on more fine-textured, high organic matter soils. Ro-Neet causes less sugarbeet injury than Eptam and is thus safer for use on light soils. Ro-Neet should be incorporated immediately and thoroughly the same as Eptam. Research in North Dakota and Minnesota has shown that a mixture of Eptam and Ro-Neet in the fall or spring gave effective weed control with less sugarbeet injury than Eptam alone and at a lower cost than Ro-Neet alone. Rates of application for the mixture must be adjusted for soil texture and organic matter. Effective rates in research have been 1.0 to 2 lb/A of Eptam plus 2 to 2.5 lb/A of Ro-Neet in the spring and from 2 to 3 lb/A of Eptam plus 2 to 2.5 lb/A of Ro-Neet in the fall.

AVADEX spring applied or fall applied at 1.5 to 2 lb/A controls wild oats in sugarbeets. Avadex is volatile and should be incorporated to reduce losses by evaporation. See previous sections on herbicide incorporation and fall application of herbicides for more details.

TCA at 4.7 to 7.1 lb/A gives good control of green and yellow foxtail. Research has indicated that shallow incorporation generally will not reduce the weed control from TCA and under low rainfall conditions will improve weed control. Incorporation may reduce grass control from TCA if excessive rain follows applications especially on the more coarse-textured soils. TCA should not be incorporated on low organic matter, coarse-textured soils where TCA injury to sugarbeets is a concern.

PYRAMIN spring applied at 3.8 to 7.6 lb/A controls most broadleaf weeds. Pyramin has been less effective on soils with more than 5% organic matter. Weed control from Pyramin generally increases as soil organic matter content decreases. Shallow incorporation improves weed control from Pyramin.

NORTRON at 2 to 3.75 lb/A gives good control of several broadleaf and grassy weeds. Nortron is especially effective on redroot pigweed but is weak on yellow foxtail. Nortron generally gives less sugarbeet injury than Eptam especially on more coarse-textured, low organic matter soils. Nortron may be applied preemergence but incorporation generally improved weed control in tests in North

Dakota and Minnesota. Operating the tillage tool 1, 2, or 4 inches deep gave similar results with slightly better control at 2 and 4 inches compared to 1 inch. Preemergence applications of Nortron will give good weed control when relatively large amounts of rain follow application. The exact amount of rain needed is not known but field observations indicate that at least 1 inch of rain is needed to give best results from preemergence Nortron. More coarse-textured, low organic matter soils probably would require less rain for activation than fine textured, high organic matter soils. Nortron often has a residue the year following use on sugarbeets. Crops most likely to be damaged by Nortron residue are wheat, barley, and oats. Moldboard plowing usually will eliminate crop injury. Nortron should be applied in a band to reduce cost and reduce potential crop injury from residues the following year.

ANTOR spring applied at 4 to 6 lb/A gives good to excellent control of redroot pigweed and prostrate pigweed. Antor generally gives less sugarbeet injury than Eptam especially on more coarse-textured, low organic matter soils. Antor may be applied preemergence but incorporation generally improved weed control in tests in North Dakota and Minnesota. Operating the tillage tool 2 inches deep often gave better weed control than operating the tillage tool 4 inches deep. Thus, deep incorporation of Antor should be avoided unless Antor is combined with Eptam or Ro-Neet. Operating the tillage tool 4 inches deep did not reduce weed control from Antor + Eptam or Antor + Ro-Neet. Preemergence Antor will give good weed control if adequate rain follows application. Antor appears to need amounts of rain similar to Nortron as discussed in the previous paragraph.

COMBINATIONS OF SOIL APPLIED HERBICIDES nearly always give improved weed control compared to the use of individual herbicides. Unfortunately the risk of sugarbeet injury also increases with herbicide combinations so selecting the proper rate for each herbicide combination and each farming situation is very important and also sometimes difficult.

All agricultural pesticides which are tank mixed should be registered for use as a tank 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 of non-labeled mixtures must assume liability for any possible crop injury, inadequate weed control, and illegal residues.

The nonregistered herbicide combination most commonly used in North Dakota and Minnesota is Eptam + Avadex. Research at North Dakota State University indicated that Avadex at 1 lb/A was nearly as effective as 2 lb/A for wild oats control, so Avadex at 1 lb/A should be sufficient when Avadex is combined with Eptam. The rate of Eptam to combine with Avadex depends on soil organic matter and time of application. Eptam + Avadex at 4 + 1 lb/A is the most common rate for fall application. The Eptam + Avadex rate could be reduced to 3.5 + 1 lb/A on low organic matter soils where injury from fall applied Eptam is a concern. Eptam + Avadex spring applied at 2 + 1 lb/A has been quite safe and effective on most soils. However, severe sugarbeet injury can occur on lighter soils, especially soils with less than 4% organic matter. Avadex has also been tested in combination with Ro-Neet, Nortron, and Antor. Generally Avadex in combination improves wild oats control and adds little to the risk of injury to sugarbeets.

TCA has been tested in combination with all other soil applied sugarbeet herbicides. TCA in combination nearly always improves green and yellow foxtail (pigeongrass) control and also has given improved broadleaf control when combined with Eptam or Ro-Neet. TCA + Eptam should only be used on higher organic matter, finer-textured soils since the combination has greater injury potential than either herbicide alone. The Eptam + TCA or Ro-Neet + TCA combination should be incorporated immediately and thoroughly by operating the tillage tool about 4 inches deep. TCA can also be applied preemergence over the top of previously applied Eptam or Ro-Neet. TCA + Avadex gives excellent wild oats and foxtail control with good safety to sugarbeets. Only a shallow incorporation is required.

Pyramin does not give grass control and Nortron and Antor are sometimes weak on grasses; thus these herbicides should generally be used in combination with a grass herbicide such as TCA, Eptam, Ro-Neet, or Avadex. Pyramin + TCA is the only combination with EPA registration. Applications of Antor, Nortron, or Pyramin in combination with TCA have been relatively safe on sugarbeets but combinations with Eptam or Ro-Neet have sometimes caused serious sugarbeet injury especially on lighter soils. Nortron + spring applied Eptam has been especially damaging and this treatment only should be used on silty clay soils with over 6% organic matter. Applications of Antor, Nortron, or Pyramin with TCA have generally given somewhat less weed control than Antor, Nortron, or Pyramin combined with Eptam or Ro-Neet. Spring applied Antor, Nortron, or Pyramin over fall applied Eptam has given less sugarbeet injury than combinations applied in the spring.

The following tables summarize the incorporation and crop safety characteristics of the various soil applied herbicides and herbicide combinations.

Incorporation	Herbicide Treatment
Deep incorporation required. Tillage tool 4 inches deep.	Eptam, Ro-Neet, Eptam + Avadex, Eptam + TCA, Eptam + Antor, Eptam + Nortron, Ro-Neet + Avadex, Ro-Neet + TCA.
Shallow incorporation required. Tillage tool 2 inches deep.	Avadex, Avadex + TCA, Avadex Nortron, Avadex + Antor, Ro-Neet + Antor, Ro-Neet + Nortron.
Shallow incorporation usually improves weed control.	Antor, Antor + TCA, Nortron TCA, Pyramin + TCA, Nortron.
Shallow incorporation improves weed control under dry conditions but may reduce weed control with high rainfall or increase sugarbeet injury on very low organic matter, coarse-textured soils.	TCA

Relative Safety to Sugarbeets	Herbicide Treatment
Safe	Avadex.
Low risk of injury.	Ro-Neet, TCA, Nortron, Antor, Nortron + TCA, Antor + TCA, Pyramin + TCA, Avadex + TCA, Avadex + Nortron, Avadex + Antor, Ro-Neet + Avadex, Fall Eptam, Fall Eptam + Fall Avadex, Eptam + Ro-Neet.
Low to moderate risk of injury.	Eptam, Eptam + Avadex, Ro-Neet + TCA, Fall Eptam + Spring TCA, Fall Eptam + Spring Antor, Fall Eptam + Spring Nortron.
Moderate risk of injury.	Eptam + TCA, Eptam + Antor, Ro-Neet + Nortron, Ro-Neet + Antor.
High organic matter, high clay content soils only.	Spring Eptam + Nortron.

POSTEMERGENCE HERBICIDES

Postemergence herbicides may need to be used on fields previously treated with a soil applied herbicide for the following reasons:

1) All presently registered soil applied treatments are weak against certain weeds.

2) Weed populations may be so high that excellent control from the soil applied herbicide may still leave enough weeds to cause yield loss.

3) Conditions such as unfavorable weather or mistakes made in application or incorporation may cause the soil applied herbicide to fail.

4) Weeds may emerge after the soil applied herbicide has lost herbicidal activity due to breakdown or other loss from the soil.

RELATIVE RESPONSE OF WEEDS TO POSTEMERGENCE HERBICIDES

	E. black nightshade	Barnyardgrass	Cocklebur	Field bindweed & P. thistles	Foxtails (pigeongrass)	Kochia	Lambsquarters	Pigweed, redroot	Russian thistle	Sunflower, vol.	Wild buckwheat	Wild mustard	Wild oats
Betamix	G	P	F	N	F	F	G	F-G	P	P	F-G	G	N
Betanex	G	P	P-F	N	P	P-F	G	G	P	P	F	G	N
Carbyne 2EC	N	N	N	N	N	N	N	N	N	N	P-F	N	F-G
Dowpon	N	G	N	N	G	N	N	N	N	N	N	N	F
Herbicide 273	-	N	P-F	N	N	P	P	F	P	F-G	G	F	N
Nortron + Betamix	G	F	F-G	N	F-G	F-G	G	G	P-F	P	G	G	P
Nortron + Betanex	G	F	F	N	F	F	G	G	P-F	P	F-G	G	P
Poast	N	G	N	N	G	N	N	N	N	N	N	N	N
Treflan (Layby)	N	G	N	N	G	G	G	G	N	N	F	N	F

G = Good, F = Fair, P = Poor, N = None, - = No data

This table is a general comparative rating of the relative effectiveness of herbicides to certain weeds. Under very favorable weather conditions, control might be better than indicated. Under unfavorable conditions, some herbicides rated good or fair might give erratic or unfavorable results.

BETANEX and BETAMIX (mixture of Betanal and Betanex) are postemergence herbicides for the control of annual broadleaf weeds. To avoid possible sugarbeet injury from Betanex and Betamix, several precautions should be observed: 1) The sugarbeets should have at least four true leaves before treatment with full rates. 2) Use no more than 1 lb/A following Eptam or TCA. 3) Start application late in the afternoon or early in the evening so cool temperatures follow application. 4) Do not apply if the highest temperature on the day of application exceeds 85 F. 5) Set the desired band width near the top of the sugarbeets so that the beets rather than the ground receive the proper rate. Betanex and Betamix give good weed control of wild mustard and common lambsquarters with Betanex slightly better on wild mustard and Betamix slightly better on common lambsquarters. Betanex gives clearly superior control of redroot and prostrate pigweed while Betamix is better on kochia and wild buckwheat. Betanex should be used alone when the target species are primarily those most susceptible to Betanex while Betamix should be used when some of the target species are more susceptible to Betamix and other species are more susceptible to Betanex.

The precautions listed in the previous paragraph for the use of Betanex and Betamix should be followed in most situations. However, weed control from Betanex and Betamix can sometimes be improved and sugarbeet injury can be reduced by following practices which modify the performance of Betanex and Betamix. Several examples of possible modifications of Betanex and Betamix use follow.

1) Split applications. The application of 0.33 to 0.75 lb/A of Betanex or Betamix followed 5 to 7 days later by application of a second 0.33 to 0.75 lb/A has been shown to reduce sugarbeet injury and increase weed control compared to single applications of full rates (0.66 to 1.5 lb/A). Split applications should be considered for use in situations where sugarbeet injury is a particular concern. For example, split applications would be a good choice when the sugarbeets are smaller than the 4-leaf stage and the field has a serious weed problem. Hot weather the day following application will sometimes increase sugarbeet injury so split applications should be used when hot weather is forecast for the following day. Betanex and Betamix should not be applied when the highest temperature during the day is 85 F. However, delaying application until cooler weather often allows the weeds to become too large for good control. Split application could be used to allow safe applications during hot weather. Split application rates should be lowered for small sugarbeets or hot weather with good soil moisture and rates should be increased for large sugarbeets and weeds or cool, dry conditions.

The first application of a half-rate of Betanex or Betamix sometimes will give good weed control and the second application may not be necessary. The decision whether the second application is needed often is not obvious. Generally the second application should be applied if the sugarbeets do not show significant symptoms of damage after 5 days and if all the weeds have not turned brown after 5 days. Weeds still partially green after 5 days may recover and should be treated with the second half-rate assuming the sugarbeets were not significantly injured.

2) Large Sugarbeets. Sugarbeets become rather tolerant of Betamix and Betanex after the plants reach the 6 to 8-leaf stage and weeds also become more resistant with age. In a field with large sugarbeets and large weeds, the user may wish to apply the Betamix or Betanex in the morning of a hot, sunny day to improve the chances of controlling the large weeds. The leaves of sugarbeets may be burned but death of the plants is unlikely and the sugarbeets will recover from early season leaf burn with no yield loss. Certain combinations such as Nortron + Betanex or Betanex + Dowpon will give increased weed control compared to Betanex alone but may injure small sugarbeets. These combinations could be considered for situations with large sugarbeets and weeds.

3) Cool Weather. Starting application of Betamix or Betanex in late afternoon limits the acreage which can be covered in a day and often a large acreage needs to be treated in a short time. Betamix or Betanex can be applied all day long with little risk of sugarbeet injury when application is made on cool, cloudy days when the temperature increases very little through that day or the following day. However, weather forecasts are not always accurate and unexpected sunshine and/or high temperatures could cause sugarbeets to be severely damaged by Betamix or Betanex applied early in the day.

4) Setting Band Width. If a field has large sugarbeets and smaller weeds, then the correct band width can be set towards the top of the weeds rather than at the top of the sugarbeets. The large sugarbeets should tolerate the higher rate of Betamix or Betanex and the weed control should be good because the weeds will receive the proper rate.

TIMELINESS OF APPLICATION is probably the most important factor in getting good weed control with minimal sugarbeet injury from Betanex and Betamix. Sugarbeets

in the mid 4-leaf stage (second pair of true leaves at least half expanded) are significantly more resistant to Betanex and Betamix than smaller sugarbeets. Sugarbeets become even more tolerant as they become larger but the mid 4-leaf stage is the target stage for beginning application because weeds also become more resistant to Betanex and Betamix as they become larger. Field experiments have indicated a 10-day period from the mid 4-leaf stage of sugarbeets until the redroot pigweed become large enough to develop added resistance to Betanex. Thus, herbicide application should be started promptly when the sugarbeets reach the mid 4-leaf stage and application should be completed within 10 days. Obviously, the number of band sprayers available must be adequate to treat the acreage in a 10-day period. Assuming occasional weather interruptions, perhaps the equipment should be able to treat the acreage in less than 10 days. Severe weed problems in sugarbeets smaller than the mid 4-leaf stage may require application to smaller sugarbeets. Research and field experience has indicated that sugarbeets smaller than the 4-leaf stage can be treated with split applications of Betanex or Betamix at 0.33 to 0.5 lb/A in each split. Small sugarbeets should not be treated during or immediately before hot weather or when under stress from recent standing water.

DALAPON (DOWPON) applied postemergence at 2 to 3 lb/A (2.7 to 4 lb/A of product) controls green and yellow foxtail (pigeongrass). Wild oats control from Dowpon is generally poor to fair. The higher rate should be used if the foxtail has over 4 leaves or if the weeds are under drouth stress. Delaying Dowpon application until after a rain should be considered when weeds are drouth stressed because Dowpon usually gives poor control of drouth stressed grass. Dowpon may be applied more than once up to a maximum of 5.9 lb/A (8 lb/A of product). Some sugarbeet yield reductions may result from rates over 3 lb/A. Dowpon should not be applied when the temperature is over 85 F. Use of surfactant with Dowpon may improve grass control but also may increase sugarbeet injury.

CARBYNE should be applied at 0.75 to 1 lb/A when most of the wild oats are in the 2-leaf stage. Sugarbeets are very tolerant to Carbyne. Carbyne is different from most herbicides since wild oats control is better when applications are made at lower temperatures. Wild oats control may be poor when temperatures are over 85 F or when the weeds are under drouth stress.

HERBICIDE 273 at 0.75 to 1.5 lb/A gives good control of wild buckwheat, smartweed, and marshelder. Good control of volunteer sunflower was obtained from H-273 in research when the volunteer sunflower was growing in good soil moisture. Sugarbeets should have 4 to 6 leaves before application and should not be treated later than 40 days after emergence. Temperatures should be 60 to 80 F at application. Weed control will be poor when weeds are under drouth stress.

POAST at 0.1 to 0.5 lb/A plus an oil additve will control annual and perennial grasses. An oil additive must be used for consistently good grass control. 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 Poast 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. The oil additive may be a petroleum oil additive with 15 to 20% emulsifier or a crop origin oil additive such as soybean oil or linseed oil with emulsifier. Research at North Dakota State University has indicated that petroleum oil additives and crop origin oil additives give similar improvements in

grass control from Poast. However, other grass control herbicides responded differently to type of oil For example, Fusilade gave better grass control with petroleum oil additive than with crop origin oil additive.

COMBINATIONS OF POSTEMERGENCE HERBICIDES give more broad spectrum and greater total weed control compared to individual treatments. The risk of sugarbeet injury also increases with combinations so combinations should be used with caution.

All agricultural pesticides which are tank mixed should be registered for use as a mixture by the Environmental Protection Agency. Pesticides may be tank mixed if all pesticides in the mixture are registered by the EPA on the crop being treated. However, users of non-labeled mixtures must assume liability for any possible crop injury, inadequate weed control, and illegal residues.

Nortron in combination with Betanex and Betamix has given improved weed control compared to Betanex or Betamix used alone. Nortron in combination with Betanex and Betamix increases the risk of sugarbeet injury so this combination should be considered when the sugarbeets have 6 leaves or more and when the weeds are large enough so that Betanex or Betamix alone may not give adequate weed control.

Dowpon has been used in combination with Betanex and Betamix to give improved foxtail control compared to Betanex or Betamix alone. Improved broadleaf weed control has also been observed. Dowpon has been tested at rates of 1 to 2 lb/A (1.35 to 2.7 lb/A product) in combination with Betanex. The low rate will control small grass (1 to 1.5 inches tall) with good soil moisture but higher rates are needed for larger grass or dry soil conditions. The combination of Dowpon with Betanex and Betamix has a high risk of sugarbeet injury. Sugarbeet injury will increase as Dowpon rate increases. Sugarbeets should have at least 6 leaves before treatment and applications should be made only during a period of relatively cool weather.

H-273 has been used at 0.5 lb/A in combination with Betanex or Betamix to give improved control of wild buckwheat compared to Betanex or Betamix alone. H-273 is often combined with Dowpon to give foxtail control as well as control of wild buckwheat, smartweed, marshelder, and volunteer sunflower. H-273 plus Dowpon often gives more rapid grass control than Dowpon alone.

Tank mixing Poast plus oil additive with Betanex, Betamix, or H-273 has often given antagonism or less grass control compared to Poast plus oil additive. Betanex plus Poast plus oil additive gave 5 to 35% less wild oats control than Poast plus oil additive in seven of ten experiments. Betanex was much less antagonistic to foxtail spp. (pigeongrass) control. Betanex plus Poast plus oil additive gave 5 to 10% less foxtail spp. control than Poast plus oil additive in only three of fifteen experiments. Thus the risk of significant antagonism is high with wild oats but low with foxtail spp. Antagonism to wild oats control was eliminated when Poast was applied first and Betanex was applied 24 hours later. Two hours between applications did not eliminate antagonism. Leaving 48 hours between treatments eliminated antagonism when Betanex was applied first. An oil additive is necessary for consistently effective grass control from Poast. However, oil additives have frequently increased sugarbeet injury when combined with Betanex, Betamix, or H-273.

Sugarbeets become more tolerant to herbicides as sugarbeet size increases. Herbicides and herbicide combinations vary in potential for herbicide injury. The following groups of herbicide treatments listed by a sugarbeet leaf stage indicate that the treatments can usually be applied safely to sugarbeets in the given leaf stage. Leaf stage refers to the number of true leaves and does not consider cotyledonary leaves. Herbicide rates are broadcast active ingredient.

RELATIVELY SAFE POSTEMERGENCE TREATMENTS
AT THREE GROWTH STAGES OF SUGARBEETS

Sugarbeets in the 2 true leaf stage or larger.

1) Carbyne
2) Dowpon.
3) Poast + oil additive.
4) Betanex or Betamix at 0.33 to 0.5 lb/A. Probably will need second application in 5 to 7 days.
5) Betanex + H-273 or Betamix + H-273 at 0.33 to 0.5 + 0.25 lb/A. Probably will need second application in 5 to 7 days.

Sugarbeets in the mid 4 leaf stage or larger.

1) Betanex or Betamix at 1 to 1.2 lb/A.
2) H-273.
3) H-273 + Dowpon.
4) H-273 + Betanex or H-273 + Betamix at 0.5 + 1 lb/A.
5) Betanex or Betamix at 0.75 lb/A. May need second application in 5 to 7 days.
6) Betanex + H-273 or Betamix + H-273 at 0.75 + 0.25 lb/A. May need second application in 5 to 7 days.
7) Betanex + Dowpon or Betamix + Dowpon at 0.33 to 0.5 + 1 lb/A. May need second application in 5 to 7 days.
8) Nortron + Betanex or Nortron + Betamix at 0.75 + 0.375 lb/A. May need second application in 5 to 7 days.
9) Betanex + Poast + oil additive or Betamix + Poast + oil additive at 0.33 to 0.5 + 0.1 to 0.3 lb/A + 1 qt/A. This treatment should not be applied a second time but should follow 5 to 7 days after Betanex or Betamix at 0.33 to 0.5 lb/A.

Sugarbeets in the 6-leaf stage or larger.

1) Betanex + Dowpon or Betamix + Dowpon at 1 + 2 lb/A.
2) Nortron + Betanex or Nortron + Betamix at 1.12 to 1.5 + 0.74 to 1 lb/A.
3) Betanex + Poast + oil additive or Betanex + Poast + oil additive at 1 to 1.2 + oil to 0.3 lb/A + 1 qt/A.

Application of the listed treatments at the proper leaf stage of the sugarbeets does not guarantee that sugarbeets will not be injured because environmental conditions can affect postemergence herbicide performance.

High temperatures with good soil moisture and especially a sudden change from cool, cloudy, and wet conditions to hot and sunny can increase the phytotoxicity

of postemergence sugarbeet herbicides. When existing or predicted weather conditions would be expected to cause increased sugarbeet injury, then a herbicide treatment with less risk of sugarbeet injury should be used. For example, the split application of Betanex should be substituted for the full rate single application of Betanex to 4-leaf sugarbeets when the environment would be expected to cause increased sugarbeet injury.

LAYBY HERBICIDES

TREFLAN at 0.75 lb/A is cleared for use on sugarbeets when the sugarbeets are 2 to 6 inches tall and well rooted. Exposed beet roots should be covered with soil before application. Emerged weeds are not controlled. Treflan may be applied over the tops of the sugarbeets and incorporated with a harrow, rotary hoe, or cultivator adjusted to mix the herbicide in the soil without excessive sugarbeet stand reduction. Use of Treflan can reduce the emergence of late season weeds which often cause problems in sugarbeets.

EPTAM at 3 lb/A is cleared as a layby herbicide for sugarbeets and should be applied similarly to Treflan. However, the greater volatility of Eptam and the greater need for thorough incorporation make Eptam less likely to be effective as a layby herbicide than Treflan. Eptam can also be applied by metering the herbicide into irrigation water. Eptam should be applied in the first irrigation after the last cultivation of the season.

CHEMICAL WEED CONTROL FOR SUGARBEETS

Herbicide	Act. Ingred. lb/A (Formulation/A)	Weeds	When to Apply	Remarks
Glyphosate (Roundup)	0.19 to 0.75 (0.5 pt to 1 qt)	Emerged annual grass and broadleaf weeds	Preplant or anytime prior to crop emergence	A nonselective, translocated postemergence herbicide. No soil residual activity. See narrative or label for rates for different weed species.
Paraquat (Ortho Paraquat, Gramoxone)	0.5 (1 qt)			A nonselective, postemergence herbicide. No soil activity. Apply with X-77. Good coverage essential. Restricted use.
EPTC (Eptam, Genep)	2 to 3 (2.3 to 3.4 pt)	Annual grass and some broadleaf weeds	Preplant incorporated	Some stand reduction and temporary stunting may occur from the use of EPTC. Weak on wild mustard.
	4 to 4.5 (4.5 to 5.25 pt 7E, 40 to 45 lb 10G)		Fall incorporated after October 15 until freeze-up	
Cycloate (Ro-Neet)	3 to 4 (4 to 5.3 pt 6E, 30 to 40 lb 10G)		Preplant incorporated	Sugarbeets have better tolerance to cycloate than to EPTC. Weak on wild mustard.
	4 (5.3 pt 6E, 40 lb 10G)		Fall incorporated after October 15 until freeze-up	
Diallate (Avadex)	1.5 to 2 lb (1.5 to 2 qt, 15 to 20 lb 10G)	Wild oats	Spring--preplant incorporated	Operating tillage implement 4 inches deep does not reduce wild oats control. Restricted use herbicide.
			Fall--after October 25 and until freeze-up	
Diethatyl (Antor)	4 to 6 (1 to 1.5 gal)	Redroot and prostrate pigweed and some annual grasses	Preemergence or preplant incorporated	Shallow (1 to 2 inch) incorporation gives best results.

Herbicide	Act. Ingred. lb/A (Formulation/A)	Weeds	When to Apply	Remarks
Ethofumesate (Nortron)	2 to 3.75 (1.25 to 2.5 gal E or 2 to 3.75 qts F)	Some annual grass and broadleaf weeds. Especially good on redroot pigweed	Preemergence or preplant incorporated in band	Should be used with grass control herbicide. Incorporation generally gives improved weed control.
TCA	4.7 to 7.1 (8 to 12 pt)	Most annual grass	Preemergence	Weak on wild oats. Do not use sugarbeet tops for livestock feed.
Pyrazon (Pyramin) + TCA	3.8 to 7.6 + 5 to 7 (3.6 to 7.25 qt F + 8 to 12 pt)	Annual grass and most broadleaf weeds	Preemergence	Has been less effective on soils with more than 5% organic matter. Incorporation improves performance of pyrazon.
Barban (Carbyne 2EC)	0.75 to 1 (1.5 to 2 qt of 2 lb/gal conc.)	Wild oats	Wild oats 2 leaf and within 30 days after emergence of crop	Wild oats usually develops to the 2 leaf stage between 4 and 9 days after emergence.
Dalapon (Dowpon)	2 to 3 (2.7 to 4 lb)	Most annual grass	Apply from emergence to 6 leaf stage of sugarbeets. Use directed spray after beets have 6 leaves	Use high rate if grasses have over 4 leaves or if they are growing slowly due to dry conditions. May be applied more than once up to a maximum of 5.9 lb/A per year. Some yield reduction may occur from rates over 3 lb/A. Add a nonionic surfactant at 0.5 to 2 pints per 100 gal. spray solution.
Endothall (Herbicide 273)	0.75 to 1.5 (2 to 4 pt)	Wild buckwheat, smartweed, marshelder, volunteer sunflower	Sugarbeets should have 4 to 6 leaves. Do not apply later than 40 days after emergence	When temperatures are over 80 F, endothall may cause excessive injury, especially to very small sugarbeets. Endothall is ineffective at temperatures below 60 F or when weeds are drouth stressed.
Desmedipham + Phenmedipham (Betamix)	0.16 to 0.6 + 0.16 to 0.6 (2 to 7.5 pt)	Most annual broadleaf weed	Postemergence when broadleaf weeds are between cotyledon and 4 leaf stage. Sugarbeets with less than 4 leaves will tolerate 0.32 to 0.5 lb/A of these herbicides and sugarbeets with 4 leaves or more will tolerate higher rates.	Risk of sugarbeet injury is reduced by starting application in late afternoon and risk is increased by certain environments (see narrative). Split application with reduced rates has reduced sugarbeet injury and increased weed control compared to single full dose applications.
Desmedipham (Betanex)	0.32 to 1.2 (2 to 7.5 pt)			
Ethofumesate (Nortron EC) + Desmedipham (Betanex)	1.12 to 1.5 + 0.73 to 1 (0.75 to 1 gal E + 4.5 to 6.1 pt)		Postemergence when sugarbeets have at least 6 leaves. Half rate may be applied to 4 leaf sugarbeets	Improved weed control and more sugarbeet injury than from Betanex or Betamix. Split application at half rates has reduced sugarbeet injury and increased weed control compared to single full dose application.
Ethofumesate (Nortron EC) + Desmedipham + Phenmedipham (Betamix)	1.12 to 1.5 + 0.365 to 0.5 + 0.365 to 0.5 (0.75 to 1 gal E + 4.5 to 6.1 pt)			
Sethoxydim (Poast)	0.1 to 0.5 (0.5 to 2.5 pt)	Most annual grass and volunteer grains. Quackgrass suppression.	Wild oats up to 4 inches tall, foxtail 3 to 8 inches, volunteer cereals up to 6 inches, volunteer corn 6 to 20 inches, proso millet 4 to 10 inches.	Apply to actively growing grasses. See narrative or label for rates for different weed species. Apply with oil additive at 1 qt/A.
Trifluralin (Treflan)	0.75 (1.5 pt)	Late emerging annual grass and some broadleaf weeds	Sugarbeets 2 to 6 inches tall and well-rooted to withstand incorporation	Must be incorporated. Exposed beet roots should be covered with soil before application. Emerged weeds not controlled. May be applied over the tops of sugarbeets. Soil residue harmful to wheat and barley not likely but barley is more tolerant and should be grown after dry years.

GLOSSARY OF CHEMICAL NAMES

COMMON NAME	TRADE NAME AND MANUFACTURER	CONCENTRATION AND COMMERCIAL FORMULATIONS
Barban	Carbyne (Velsicol)	2 lb/gal E
Cycloate	Ro-Neet (Stauffer)	10% G 6 lb/gal E
Dalapon	Dowpon M (Dow)	74% SP
Desmedipham	Betanex (Nor-Am)	1.3 lb/gal E
Desmedipham + Phenmedipham	Betamix (Nor-Am)	0.65 + 0.65 lb/gal E
Diallate	Avadex (Monsanto)	10% G 4 lb/gal E
Diethatyl	Antor (Nor-Am)	4 lb/gal E
Endothall	Herbicide 273 (Pennwalt)	3 lb/gal S
EPTC	Eptam (Stauffer) Genep (PPG)	10% G 7 lb/gal E
Ethofumesate	Nortron (Nor-Am)	4 lb/gal F 1.5 lb/gal E
Glyphosate	Roundup (Monsanto)	3 lb/gal S
Paraquat	Ortho paraquat (Chevron)	2 lb/gal S
Pyrazon	Pyramin (BASF)	4.2 lb/gal F
Sethoxydim	Poast (BASF)	1.5 lb/gal E
TCA	TCA (Hopkins)	4.76 lb/gal S

[1] The mention of trade name does not imply that they are endorsed or recommended over those of similar nature not listed.

[2] G = granule, E = emulsifiable concentrate, F = liquid flowable, S = solution, SP = soluble powder, WP = wettable powder.

AG-FO-0892--REVISED FOR 1986

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

WEED CONTROL IN CORN

Richard Behrens, Extension Agronomist--Weeds

Weed control in corn should be based on an optimum combination of cultural, mechanical and chemical practices. The ideal combination for each field will depend on several factors including crop being grown, kinds of weeds, severity of the weed infestation, soil characteristics, tillage practices, cropping systems, and availability of time and labor. There are many opportunities for reducing the costs of weed control in corn. Knowing the weed species that are present and selecting herbicide(s) with a high level of effectiveness on those weeds at the lowest cost per acre can result in substantial savings. Using band applications supplemented with cultivation is also a money-saving option to consider. Reducing herbicide rates below those recommended increases the possibility of costly failures in weed control. However, applying herbicides at rates higher than those suggested adds unnecessarily to your weed control costs, and may result in corn injury. Applying herbicides at the prescribed time and rate with a carefully calibrated applicator provides the best return on your herbicide investment.

Cultural Practices

Cultural practices for weed control in corn include seedbed preparation, establishing an optimum stand, adequate fertility, and timely cultivations. Weeds that germinate before planting can be destroyed with tillage operations or herbicides. Killing weeds just before planting gives the young crop seedlings a competitive advantage and often improves performance of preplanting or preemergence herbicides.

Early cultivations are most effective for killing weeds and for preventing crop yield reduction due to weed competition or corn root damage. The rotary hoe or harrow works best if used after weed seeds have germinated and are in the "white stage" or just emerging. A rotary hoe, harrow, or cultivator should be used as soon as weeds appear, even if preplanting or preemergence herbicides have been applied, unless a properly timed postemergence herbicide treatment is planned.

Set cultivators for shallow operation to avoid pruning the corn roots 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.

Herbicides

When selecting an appropriate herbicide or combination of herbicide treatments, consider carefully the following factors:

--Label approval for use
--Use of the crop
--Corn tolerance to the herbicide
--Potential for chemical residues that may affect later crops
--Kinds of weeds
--Soil texture
--Soil pH
--Amount of organic matter in the soil
--Climate
--Weather
--Formulation of the chemical
--Application equipment available
--Potential for drift problems

There are a number of herbicides available for use in corn. In setting up a weed control program for several years, it may be advisable to rotate a selection of herbicides from different chemical families, particularly in continuous corn.

Chemical rotations reduce the likelihood of a buildup of resistant weeds or of herbicide residues in the soil. Even if corn is being rotated to other crops, a chemical rotation can be planned for several years in the cropping system. Commonly used herbicides for corn in different chemical families are:

Acetamides--alachlor, metolachlor, propachlor
Benzoic acids--dicamba
Dinitroaniline--pendimethalin
Others--bentazon, bromoxynil
Phenoxys--2,4-D
Substituted ureas--linuron
Thiocarbamates--butylate, EPTC
Triazines--ametryne, atrazine, cyanazine, simazine

This folder summarizes herbicide suggestions for corn, based on numerous experiment station and U.S. Department of Agriculture tests to determine their overall effectiveness. Herbicide labels should be followed.

Table 1 indicates corn tolerance to herbicides suggested for use in corn and relative effectiveness and reliability of these herbicides in controlling common weeds. This table shows general comparative control ratings based on field observations. Under unfavorable conditions, any of the herbicides may give unsatisfactory results. Under favorable conditions control may be better than indicated.

No-Till or Minimum Till

With no-till or minimum till, weed problems may become worse. Winter annual, biennial, and perennial weeds that are destroyed or greatly weakened by conventional tillage survive and grow vigorously early in the spring, long before the corn is planted. Special herbicide treatments may be necessary to control or suppress these weeds. Glyphosate (Roundup) and paraquat (Paraquat Plus, Gramoxone) are very active, non-selective herbicides that will control all emerged weeds. These herbicides have no residual soil activity but can be tank-mixed with a number of herbicides that will provide residual weed control (see table 2). Atrazine and cyanazine (Bladex) may be used early preplant to control weed seedlings, but are relatively ineffective on larger annual, biennial, and perennial weeds. The use of liquid nitrogen or fertilizer as carrier in preplant or preemergence applications of cyanazine improves its burndown effectiveness on larger emerged weeds. If herbicides are applied several weeks or more before corn planting, a postplanting herbicide treatment may be required to provide adequate residual weed control.

Preplanting Applications

Some herbicides may be applied to the soil before planting and incorporated 2 to 3 inches into the soil with a disk, field cultivator, or similar implement. 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, crosswise and lengthwise, after applying the chemical. If the soil is not too moist or rough and is in a good tilth condition, adequate incorporation may be achieved with one pass over the field with some combination implements. To avoid excessive loss of volatile chemicals like EPTC or butylate, the first tillage operation should follow immediately behind the sprayer.

EPTC (Eradicane, Eradicane Extra) and butylate (Sutan +, Genate Plus) applied preplant incorporated give excellent control of annual grasses and some annual broadleaf weeds, but do not control other broadleafs or most biennials and perennials (see table 1). Both chemicals are effective on nutsedge. EPTC may be used for quackgrass control but trial results have been inconsistent. EPTC is the most effective soil-applied herbicide for wild proso millet and woolly cupgrass control. Following repeated annual use for several years, the weed control effectiveness of EPTC may decline due to an increased rate of EPTC breakdown in the soil.

Preplanting and disked-in applications of atrazine have resulted in weed control equal to or, under dry conditions, 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 broadleafs. These mixtures improve broadleaf control compared to butylate or EPTC alone. Cyanazine does not carry over to the following year, and the lower rate of atrazine used in the mixtures reduces carryover problems from atrazine compared to those caused by the higher rates when atrazine is applied alone.

Preplanting, incorporated applications of alachlor (Lasso) at 3 to 4 pounds per acre or metolachlor (Dual) at 2 to 3 pounds per acre have controlled nutsedge effectively. Under dry conditions, control of annual weeds usually has been improved over preemergence 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

Atrazine at 1 to 3 pounds per acre has given good control of annual weeds with no injury to corn. A 3-pounds-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 recommends that small grains, flax, sugarbeets, vegetables, and small-seeded legumes or grasses not be planted in the year following atrazine application.

Soybeans may be injured 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 was 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, using band rather that broadcast applications, and plowing or thoroughly tilling the soil before planting soybeans. Atrazine 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 broadleafs when applied preemergence. There has been no soil residue the following season. Weed control is not as good under dry conditions as under moderate to heavy rainfall. Within the suggested rates of 1.2 to 4.75 pounds per acre, the high rates are required on soils higher in organic matter and finer-textured soils. Corn injury may occur on sandy soils or when maximum rates are used on heavier soils.

> NOTICE: Cyanazine (Bladex) is now undergoing a special review by the U.S. Environmental Protection Agency (EPA) because of concern over the results of a laboratory study on animal birth defects that was inconclusive plus evidence suggesting cyanazine contamination of ground water. In this special review, the EPA is re-examining the health and safety risks and benefits of cyanazine use and will eventually develop recommendations for its future use. As of November, 1985, it seems probable that cyanazine will continue to be available for use by Minnesota farmers during 1986 without label changes. However, it is probable that cyanazine will be labeled as a "Restricted use Pesticide" before the 1987 season.

Propachlor (Ramrod) has given good annual grass control when applied preemergence at 4 to 6 pounds per acre. Propachlor does not 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) and metolachlor (Dual) control annual grasses in corn. Both chemicals also have given good control of redroot pigweed, but control of other broadleafs has been erratic. Preemergence applications have controlled nutsedge on coarse soils that are low in organic matter, but on finer-textured, dark soils, preplanting incorporated applications have controlled nutsedge better than pre-emergence treatments. Corn has good tolerance to alachlor and metolachlor. Suggested rates for alachlor are 2 to 4 pounds per acre in the liquid formulation and 2.45 to 3.9 pounds per acre in the granular formuation (Lasso II). Metolachlor is labeled for preemergence application at 1.5 to 3 pounds per acre in the liquid and granular formulations. Corn, soybeans, sorghum, root crops, potatoes, pod crops, buckwheat, or small grains may be grown the year after using metolachlor. Any crop may be grown the year following alachlor use.

> NOTICE: Alachlor (Lasso) is now undergoing a special review by the U.S. Environmental Protection Agency (EPA) because tests show that tumors are caused when high levels of alachlor are fed daily to laboratory animals over long periods of time. In this special review, the EPA is re-examining all health and safety tests and product benefits from alachlor usage. Recommendations from the EPA on future uses of alachlor will be developed based on their estimates of these risks and benefits. As of November, 1985, it seems probable that alachlor will continue to be available during 1986 for use by Minnesota farmers.

Pendimethalin (Prowl) may be used alone at 3/4 to 2 pounds per acre or in mixtures at 3/4 to 1 1/2 pounds per acre for preemergence control of most annual grassy weeds and some broadleafs in corn. In Minnesota trials, preemergence applications of this compound have been somewhat less effective on grasses but more effective on broadleafs than alachlor. Tank mixes with atrazine, cyanazine, or dicamba provide a broader spectrum of weed control.

Corn root injury and lodging have sometimes occurred from applications of pendimethalin, especially on sandy soils. In tank mixes with dicamba, do not use on sandy soils or on loams, silts, and silt loams with less than 3 percent organic matter. Incorporating pendimethalin or ridging soil along the row when cultivating may increase corn injury.

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 broadleafs. 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.

> NOTICE: Linuron (Lorox) is now undergoing a special review by the U.S. Environmental Protection Agency (EPA) because tests show that tumors may occur when high levels of linuron are fed daily to laboratory animals over long periods of time. In this special review, the EPA is re-examining all health and safety tests and product benefits from linuron usage. Recommendations from the EPA on future uses of linuron will be developed based on their estimates of these risks and benefits. As of November, 1985, it seems probable that linuron will continue to be available during 1986 for use by Minnesota farmers.

At 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 to using linuron alone. Rates vary from 1/2 to 1 1/2 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, metolachlor, 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 using linuron alone since lower rates of linuron are used. These mixtures control broadleafs better than propachlor or alachlor alone. Suggested rates are 1 to 1 1/2 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 medium- or fine-textured soils with more than 2.5 percent organic matter. Do not incorporate this mixture prior to corn emergence. Harrowing or dragging before corn emerges may increase corn injury.

Early Postemergence Sprays

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 post-emergence treatments at the proper time or results may be poor. Apply atrazine while the weeds are less than 1 1/2 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.

Adding 1 gallon per acre of special oils with an emulsifier or 1/4 to 1/2 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 control as much as using oils. Suggested atrazine rates for postemergence applications with oil are 1.2 pounds per acre for broadleafs and 2 pounds per care 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 adding 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 and 90DF) is effective on annual grasses and broadleafs as an early post-emergence herbicide. The 4L formulation is not cleared postemergence because corn leaf burn is more likely to occur. Cyanazine is cleared for use through the 4-leaf stage of corn and before weeds are more than 1 1/2 inches tall. Pigweed and lambsquarters have shown some tolerance. Vegetable oils or surfactants added to improve weed control effectiveness under dry conditions increase the potential for corn injury and have resulted in severe corn leaf kill and stand reduction if heavy rains or dews and cool temperature occur soon after application. Smaller corn, spike to 2-leaf stage, is less likely to be injured than larger corn, 3- to 4-leaf stage.

Under dry weather conditions add an emulsible vegetable oil or a at their recommended rates. Do not use petroleum-based crop oils because corn leaf kill and stand reductions may occur. Do not add vegetable oils or surfactants under moist, rainy conditions because corn injury may occur. Do not apply this treatment under cold, wet conditions or to weather-stressed corn. Corn yellowing, leaf kill and stunting may result from this treatment, particularly if cold, adverse growing conditions occur after application. Extreme or extended cold and wet conditions following treatment may result in reduced corn stands. Do not use cyanazine on corn grown for seed.

Any rotational crop may be planted in the fall or spring following the cyanazine treatment. Tridiphane (Tandem), when added to postemergence applications of atrazine plus oil or cyanazine (Bladex) has frequently improved the control of small annual grasses in trials at several locations over several years. Caution: EPA clearance is expected before the 1986 growing season but has not been received as of November, 1985.

Bentazon (Basagran) may be applied alone or in a mixture with atrazine as a postemergence treatment in corn to control certain annual broad-leaved weeds, Canada thistle, and nutsedge. Corn has good tolerance to bentazon, but do not apply it when corn is stressed from adverse growing conditions. Apply when annual weeds are less than 2 inches tall, but some species may be controlled up to 10 inches tall. 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 to improve weed control.

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 2-leaf stage or smaller. Propachlor (Ramrod) alone or mixed with atrazine may be applied after corn has emerged to control grasses up to the 2-leaf stage. Annual grass control may be less consistent in these postemergence applications than that from preemergence applications.

Pendimethalin (Prowl) in mixtures with atrazine or cyanazine (wettable powder or dispersible granule) may be applied after corn emergence, but not later than when corn is in the 4-leaf stage and when weeds are no more than 1 inch tall. These mixtures have been effective against annual grasses and broadleafs. The early postemergence application of pendimethalin and cyanazine used following a preplanting application of EPTC greatly improves the control of proso millet and woolly cupgrass. However, corn leaf burn and stand reductions are possible if cool, wet weather occurs soon after treatment. Applications to corn in the spike to 2-leaf stage are safer but weed control effectiveness is best if the weeds have emerged.

Bromoxynil (Brominal, Buctril) applied at 1/4 pound per acre as an early postemergence spray controls some annual broadleaved weeds, including annual smartweeds, wild buckwheat, cocklebur, kochia, common lambsquarters, pigweed, common ragweed, Russian thistle, wild sunflower, and wild mustard. Bromoxynil does not control grasses or perennial weeds. To be most effective, bromoxynil must be applied when weeds have 2 to 4 leaves and corn is less than 6 inches tall. Corn leaf burn may occur, especially under conditions of high temperature or high humidity. Follow specific label information for bromoxynil use in tank mixes with 2,4-D or atrazine.

Postemergence Applications

Annual broad-leaved weeds can be controlled with broadcast postemergence applications of 1/4 to 1/2 pound per acre of 2,4-D amine when the corn is 4 to 8 inches tall. More severe onion leafing may occur from 2,4-D applications made in the 2- to 3-leaf stage of the corn.

The 1/4-pound rate has been adequate for susceptible weeds and is less dangerous to corn. The 1/2-pound rate has been satisfactory for moderately resistant weeds, but corn usually has been injured by this rate. Rainfall within 8 hours after application reduces the effectiveness of 2,4-D amines more than the effectiveness of 2,4-D esters. About 1/3 less acid equivalent of 2,4-D esters is needed than of the 2,4-D amines.

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. Using 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.

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 the last cultivation, 2,4-D ester at 1/2 pound per acre or 2,4-D amine at 3/4 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 1/2 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 it does not control grasses. But when used, dicamba drift has often affected soybeans in the vicinity of treated cornfields.

Dicamba may be used in corn at 1/8 to 1/2 pound per acre, either alone or in mixtures with 2,4-D amine at 1/4 to 1/2 pound per acre. Do not use dicamba at 1/2 pound per acre after the corn is 5 inches tall. The lower rate of dicamba has given satisfactory weed control with less crop effect than the higher rate. 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.

Mixtures of dicamba and atrazine or cyanazine are cleared for use on corn as early postemergence treatments. These mixtures have given good broadleaf control, but grass control has been erratic. Oils and other additives should not be used.

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 spray drift at the time of application or vapor drift for several days after application. Spray 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. Reduce spray and vapor drift effects on soybeans by spraying corn early in the season when temperatures are lower and before soybeans have emerged, or when they are small. Do not graze or harvest for dairy feed prior to the milk stage of the grain if corn is treated with dicamba.

Directed Sprays

These cannot be used on small corn. Therefore, early season weed growth must be controlled by some other means (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 within corn rows.

Specially designed equipment has been developed to made 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 1 1/2 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. Adding 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 the corn leaf tissue it contacts and, if leaf kill is extensive, corn yields may be reduced.

Read the pesticide label and follow the instructions as a final authority on pesticide use.

Table 2. Herbicide choices for use in corn.

Herbicide	Active Ingredient, lb/A or (formulation/A)	Remarks
NO TILL or MINIMUM TILL		
glyphosate (Roundup)	.75 to 3 (1 to 4 qt)	Kills emerged weeds. Has no soil activity so usually combined with residual herbicides. Apply prior to corn emergence to prevent corn kill.
Labeled mixtures*		
alachlor (Lasso, Bronco)	2.5 to 4	Adds preemergence control of most annual grasses and some broadleafs.
alachlor + atrazine	2 to 3 + 1 to 2	Adds preemergence control of most annual grasses and broadleafs.
alachlor + cyanazine (Bladex)	2 to 3 + 1 to 2.2	Adds preemergence control of most annual grasses and broadleafs.
atrazine	2 to 3	Adds preemergence control of most annual broadleafs and some grasses.
atrazine + metolachlor (Dual)	1.2 to 2 + 1.5 to 2.5	Adds preemergence control of most annual broadleafs and grasses.
metolachlor (Dual)	1.5 to 2.5	Adds preemergence control of most annual grasses and some broadleafs.
paraquat (Paraquat Plus or Gramoxone)	.25 to 1 (1 to 4 pt)	Kills emerged weeds. Has no soil activity so usually combined with residual herbicides. Apply prior to corn emergence to avoid corn kill. A restricted use herbicide.
Labeled mixtures*		
atrazine	2 to 3	Adds preemergence control of most annual broadleafs and some grasses.
cyanazine (Bladex)	1.2 to 4	Adds preemergence control of most annual broadleafs and many grasses.
alachlor + atrazine	2 to 2.5 + 1 to 2	Adds preemergence control of most annual broadleafs and grasses.
metolachlor (Dual)	1.5 to 2.5	Adds preemergence control of most annual grasses and some broadleafs.
metolachlor + atrazine	1.2 to 2 + 1.5 to 2.5	Adds preemergence control of most annual grasses and broadleafs.
cyanazine (Bladex 80W) (Bladex 4L) (Bladex DF)	1.25 to 4.75 (1.5 to 6 lb) (1.25 to 4.75 qt) (1.35 to 5.3 lb)	Kills small weeds and gives preemergence control of annual broadleafs and some grasses. Nitrogen or fertilizer solutions as carriers improve burndown. If applied more than 15 days before planting a preemergence herbicide will be needed.
Labeled mixtures*		
alachlor (Lasso)	2 to 2.5	Improves preemergence control of annual grasses and pigweeds.
atrazine	.4 to 1.6	Improves preemergence control of some broadleafs. Use reduced rates of cyanazine.
metolachlor (Dual)	1.25 to 2.5	Improves preemergence control of annual grasses and pigweeds.
pendimethalin (Prowl)	.75 to 1.5	Improves preemergence annual grass control. Apply after planting. Do not incorporate.
atrazine + alachlor	.4 to 1.6 + 2 to 2.5	Improves preemergence control of most annual broadleafs and grasses.
atrazine + metolachlor	.4 to 1.6 + 1.25 to 2.5	Improves preemergence control of most annual broadleafs and grasses.
2,4-D	.38 to .75	Improves control of emerged broadleaf perennials and pigweeds.

atrazine	2 to 3	Kills emerged weed seedlings and provides preemergence control of most annual broadleafs
(Atrazine 80W)	(2.5 to 3.75 lb)	and some grasses. Use of liquid fertilizer or nitrogen solutions as carrier improves
(Atrazine 4L)	(2 to 3 qt)	weed burndown.
(Atrazine DF)	(2.2 to 3.3 lb)	
Labeled mixtures*		
alachlor (Lasso)	2 to 2.5	Improves preemergence annual grass control.
glyphosate (Roundup)	.75 to 3	Improves burndown of emerged weeds.
metolachlor (Dual or Bicep)	1.5 to 2.5	Improves preemergence annual grass control.
paraquat (Gramoxone)	.25 to 1	Improves burndown of emerged weeds.
pendimethalin (Prowl)	.75 to 1.5	Improves preemergence annual grass control. Apply after planting. Do not incorporate.
PREPLANT INCORPORATED		
butylate	4 to 6	Controls most grasses and some broadleafs. Incorporate immediately.
(Sutan +, Genate Plus)	(3.75 to 7.33 pt)	Safeners have been added to protect corn from injury.
Labeled mixtures*		
atrazine	.75 to 1.5	Improves broadleaf weed control.
cyanazine (Bladex)	1.5 to 2	Improves broadleaf weed control.
atrazine + cyanazine	.5 to 1 + 1 to 2	Improves broadleaf weed control.
EPTC	3 to 6	Controls most grasses and some broadleafs. Incorporate immediately.
(Eradicane)	(3.75 to 7.33 pt)	Eradicane contains a safener to protect corn from EPTC.
(Eradicane Extra)	(4 to 8 pt)	Eradicane Extra contains a safener plus an extender which increases EPTC soil life.
Labeled mixtures*		
atrazine	1 to 1.5	Improves broadleaf weed control.
cyanazine	1.5 to 2	Improves broadleaf weed control.
PREPLANT INCORPORATED or PREEMERGENCE		
alachlor	1.5 to 4	Controls many annual grasses and some broadleaf weeds.
(Lasso)	(2 to 4 qt)	Use high rate and incorporate for nutsedge.
(Lasso II)	(15 to 20 lb)	
Labeled mixtures*		
atrazine	1 to 1.85	Improves broadleaf weed control.
cyanazine (Bladex)	1 to 2.4	Improves broadleaf weed control.
dicamba (Banvel)	.5	Preemergence only on medium or fine soils above 2.5% O.M. Improves broadleaf control.
atrazine + cyanazine	.75 to 1.25 + 2	Improves broadleaf weed control.
linuron (Lorox)	.67 to 3	Do not incorporate. Improves broadleaf control.

atrazine	2 to 4	Controls many broadleaf weeds and grasses. Use split application for quackgrass.
(Atrazine 80W)	(2.5 to 5 lb)	May carry over and injure sensitive crops. See label restrictions on rotational crops.
(Atrazine 4L)	(2 to 4 qt)	
(Atrazine DF)	(2.2 to 4.4 lb)	
Labeled mixtures*		
alachlor (Lasso)	2 to 3	Improves annual grass control.
butylate (Sutan +)	4 to 6	Improves annual grass control. Preplant incorporated only.
cyanazine (Bladex)	.75 to 3.75	Reduces atrazine carryover. Improves annual grass control.
EPTC (Eradicane)	3 to 6	Improves annual grass control. Preplant incorporated only.
linuron (Lorox)	.67 to 3	Do not incorporate. Reduces atrazine carryover.
metolachlor (Dual or Bicep)	1.5 to 2.5	Improves annual grass control.
pendimethalin (Prowl)	.75 to 1.5	Improves annual grass control. Do not incorporate.
propachlor (Ramrod)	4 to 6	Improves annual grass control.
simazine (Princep)	1 to 2	Improves crabgrass and fall panicum control. Increased carryover.
metolachlor + simazine	1.5 to 2.5 + 1 to 2	Improves annual grass control. Increased carryover.
butylate + safener	4 to 6	Use preplant and incorporate immediately. Controls many annual grasses, some broadleaf
(Sutan +, Genate Plus)	(3.75 to 7.33 pt)	weeds and nutsedge.
Labeled mixtures*		
atrazine	.75 to 1.5	Improves broadleaf weed control.
cyanazine	1.5 to 2	Improves broadleaf weed control.
atrazine + cyanazine	.5 to 1 + 1 to 2	Improves broadleaf control.
cyanazine	.6 to 4.75	Controls many broadleaf weeds and grasses. Weak on pigweeds.
(Bladex 80W)	(.75 to 5.9 lb)	
(Bladex 4L)	(.6 to 4.75 qt)	
(Bladex DF)	(.67 to 5.3 lb)	
Labeled mixtures*		
alachlor (Lasso)	2 to 2.5	Improves annual grass control.
atrazine	.5 to 1.5	Improves pigweed control.
butylate (Sutan +, Genate Plus)	1.5 to 2	Improves annual grass control. Use prepaint incorporated only.
EPTC (Eradicane)	1.5 to 2	Improves annual grass control. Use preplant incorporated only.
metolachlor (Dual)	1.25 to 2.5	Improves annual grass control.
pendimethalin (Prowl)	.75 to 1.5	Improves annual grass control. Do not incorporate.
EPTC + safener	3 to 6	Use preplant and incorporate immediately. Controls many grasses, some broadleaf weeds
(Eradicane)	(3.75 to 7.33 pt)	and nutsedge. Eradicane Extra has longer soil activity. Repeated annual use reduces
(Eradicane Extra)	(4 to 8 pt)	weed control effectiveness.
Labeled mixtures*		
atrazine	1 to 1.5	Improves broadleaf weed control.
cyanazine	1.5 to 2	Improves broadleaf weed control.

metolachlor	1.5 to 3	Control many annual grasses and some broadleafs. Can be applied early preplant,
(Dual 8E)	(1.5 to 3 pt)	either alone or in tank mixtures for weed control in minimum- or no-till corn.
(Dual 25G)	(6 to 12 lb)	Use high reate and incorporate for nutsedge.
Labeled mixtures*		
atrazine	1 to 2	Improves broadleaf weed control.
cyanazine	.8 to 2.5	Improves broadleaf weed control.
dicamba (Banvel)	.5	Improves broadleaf control. Preemergence only on medium or fine soils above 2.5% O.M.
propachlor	4 to 6	Preemergence only. Controls many grasses and some broadleaf weeds.
Ramrod 4L)	(4 to 6 qt)	
(Ramrod 20G)	(20 to 30 lb)	
Labeled mixtures*		
atrazine	1 to 1.6	Improves broadleaf weed control.
linuron (Lorox)	.67 to 3	Improves broadleaf weed control.
POSTEMERGENCE		
ametryne	1.6 to 2	Directed spray to corn over 12 inches tall for weeds no more than 4 inches tall.
(Evik)	(2 to 2.5 lb)	To avoid serious corn injury do not spray the upper leaves or whorl.
atrazine with oil	1.2 to 2	Controls small grasses up to 1.5 inches tall and broadleafs to 4 inches tall but pigweed
(Atrazine 80W)	(1.25 to 2.5 lb)	and lambsquarters to 6 inches tall. See label for oil rates and specifications.
(Atrazine 4L)	(1 to 2 qt)	If weed control is poor, cultivation will be required.
(Atrazine DF)	(1.1 to 2.2 lb)	
Labeled mixture*		
pendimethalin	.75 to 1.5	Apply to corn in the spike to 4-leaf stage. Do not add oil. Improves grass control.
bentazon	.5 to .75	Controls small annual broadleafs, Canada thistle and yellow nutsedge.
(Basagran)	(1 to 1.5 pt)	Second application may be required for Canada thistle and nutsedge.
Labeled mixture*		
Atrazine (Laddox)	(2.4 to 3.6 pt)	Improves broadleaf weed control. Always add oil concentrate.
bromoxynil	.25 to .5	Controls small broadleaf weeds in corn up to 14 inches tall.
(Brominal ME4)	(.5 to 1 pt)	Corn foliage burn may occur.
(Buctril)	(1 to 1.5 pt)	
Labeled mixtures*		
atrazine	.5 to 1.2	Improves pigweed control. Rate too low for grass control. Do not use oil.
2,4-D	.25	Improves pigweed and perennial broadleaf control.

cyanazine	1.2 to 2	Controls small broadleafs and grasses. Weak on pigweed. Do not spray corn if the 5th
(Bladex 80W)	(1.5 to 2.5 lb)	leaf is visible. Do not use Bladex 4L. Under dry conditions add surfactant or
(Bladex DF)	(1.35 to 2.2 lb)	vegetable oil.
Labeled mixtures*		
atrazine	.4 to .6	Improves pigweed control.
dicamba (Banvel)	.25 to .33	Improves pigweed control. Avoid drift to sensitive crops.
pendimethalin (Prowl)	.75 to 1.5	Safer on smaller corn. Best for small proso millet and woolly cupgrass.
dicamba	.25 to .5	Controls many annual and perennial broadleaf weeds. Corn up to 36 inches tall. Use drop
(Banvel)	(.5 to 1 pt)	nozzles in corn over 10 inches tall. May be used as an overlay following soil-applied
(Banvel II)	(1 to 2 pt)	herbicides. Avoid spray or vapor drift to soybeans or other sensitive crops.
Labeled mixtures*		
alachlor (Lasso)	1.5 to 4	Before corn is 3 inches tall. Provides annual grass control.
atrazine	1.25 to 4	Before grasses are 1.5 inches tall. Provides grass control.
cyanazine (Bladex 80W)	1.5 to 2	Corn not beyond four leaves and grass up to 1.5 inches tall. Provides grass control.
2,4-D	.12 to .25	Use drop nozzle after corn is 8 inches tall. Improves mustard control.
linuron + surfactant	.62 to 1.5	Directed spray to corn over 15 inches tall for weeds up to 5 inches tall. To avoid
(Lorox WP)	(1.25 to 3 lb)	serious corn injury do not spray the upper leaves or whorl. Controls broadleafs
(Lorox L)	(.62 to 1.5 qt)	and grasses.
2,4-D	.25 to .5	Controls emerged annual and perennial broadleaf weeds. Use drop nozzles after corn is
amine (4 lb/gal)	(.5 to 1 pt)	10 inches tall. Do not spray from before tasseling until the silks are brown. Corn
ester (4 lb/gal)	(.5 to .75 pt)	stalk brittleness commonly occurs when the corn stalk is elongating. Higher 2,4-D
		rates, 1 to lb/A, may be used after the hard dough stage to control perennialsss
		and large annuals. Avoid spray drift to soybeans or other sensitive crops.

* Follow label directions and precautions of all products in a mixture.

Table 1. Effectiveness of herbicides on weeds in corn.[1]

	PREPLANTING							PREEMERGENCE								POSTEMERGENCE								
	alachlor (Lasso)	metolachlor (Dual)	atrazine + metolachlor (Bicep)	butylate (Sutan +)	EPTC (Eradicane, Eradicane Extra)	cyanazine (Bladex)	atrazine (AAtrex, others)	alachlor (Lasso)	atrazine (AAtrex, others)	atrazine + metolachlor (Bicep)	dicamba (Banvel)	metolachlor (Dual)	propachlor (Ramrod)	linuron (Lorox)	cyanazine (Bladex)	2-4-D	dicamba (Banvel)	atrazine and oil	cyanazine (Bladex)	bentazon (Basagran)	bromoxynil (Buctril, Brominal)	bentazon + atrazine (Laddok)	pendimethalin + atrazine (Prowl + atrazine)	pendimethalin + cyanazine (Prowl + Bladex 80W)
CORN TOLERANCE	G	G	G	G	G	F	G	G	G	G	F	G	G	F	F	F	G	G	F	G	G	G	F/G	F
GRASSES																								
Giant & robust foxtail	G	G	G	G	G	F/G	F	G	F	G	P	G	G	F	F/G	N	N	F	F	N	N	F	G	G
Green foxtail	G	G	G	G	G	G	G	G	G	G	P	G	G	F	G	N	N	G	G	N	N	F	G	G
Yellow foxtail	G	G	G	G	G	G	G	G	G	G	P	G	G	F	G	N	N	G	G	N	N	F	G	G
Barnyardgrass	G	G	G	G	G	F	F	G	F	G	P	G	F	F	F	N	N	F	F	N	N	F	G	G
Crabgrass	G	G	G	G	G	F/G	P	G	P	G	P	G	G	F	F/G	N	N	P	F	N	N	P	F/G	G
Panicum	G	G	G	G	G	F	P	G	P	G	P	G	F	F	F	N	N	P	F	N	N	P	F/G	G
Nutsedge	G	G	G	G	G	P	P	F	P	F	N	F	F	P	P	N	N	F	P	G	N	G	P	P
Sandbur	F	F	F	G	G	F	F	F	F	G	P	F	P	-	F	P	P	F/G	F	P	N	P	F	F/G
Quackgrass	N	N	P	N	F	P	G	N	G	P	N	N	N	N	P	N	N	G	P	N	N	P	P	P
Woolly cupgrass	G	G	G	F	G	P	P	G	P	G	P	G	F	P	P	N	N	F	F	N	N	P	F	G
Proso millet	F	F	F	F	F/G	P/F	P	F	P	F	P	F	F	P	P/F	N	N	P	P/F	N	N	P	F	G
Wild oats	P	P	G	F	F	F	G	P	G	G	N	P	P	P	F	N	N	G	F	N	N	G	G	G
BROADLEAFS																								
Buffalobur	P	P	P	F	G	P	P	P	P	P	P	P	P	P	P	P	P	G	F	P	G	G	G	F
Cocklebur	N	N	F	P	P	F	F	N	F	F	F	N	P	F	F	G	G	G	F	G	G	G	G	F
Kochia	P	P	G	P	F	G	G	P	G	G	F	P	P	F	G	F	G	G	G	-	G	G	G	G
Lambsquarters	F/P	F/P	G	P	F/G	G	G	F/P	G	G	G	F/P	P	G	G	G	G	G	G	F	G	G	G	G
Mustard	P	P	G	P	P	G	G	P	G	G	G	P	P	G	G	G	F	G	G	G	G	G	G	G
Eastern black nightshade	F	F	G	F	F	G	G	G	G	G	F	G	P	P	G	F	F	G	G	P	G	G	G	G
Pigweed	G	G	G	F	F	F	G	G	G	G	G	G	F	G	F	G	G	G	F	P	G	G	G	F
Ragweed	P	P	G	P	F	G	G	P	G	G	G	P	P	G	G	G	G	G	G	G	G	G	G	G
Smartweed	P	P	G	P	P	G	G	P	G	G	G	P	P	G	G	P	G	G	G	G	G	G	G	G
Velvetleaf	P	P	F	F	F	F	F	P	F	F	F	P	P	F	F	G	G	F	F	G	G	G	G	G
Wild sunflower	P	P	F	P	P	F	F	P	F	F	F	P	P	F	F	F	G	G	F	G	G	G	G	G
Canada thistle	N	N	P	N	N	P	P	N	P	P	N	N	N	N	P	F	G	F	P	F	F	F	P	P
Jerusalem artichoke	N	N	P	N	N	P	P	N	P	P	P	N	N	P	P	G	G	P	P	P	N	P	P	P
American germander	N	N	P	P	F	P	P	N	P	P	P	N	N	P	P	P	P	G	F	P	N	F	F	F

[1] G = good, F = fair, P = poor, N = none, - = insufficient information.

AG-FO-0841--REVISED FOR 1986

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

WEED CONTROL IN SOYBEANS

Richard Behrens, Extension Agronomist

Weeds can be most effectively controlled in soybeans with a well-planned program that involves a thorough analysis of the field situation and use of a combination of cultural practices and appropriate herbicides. The most effective weed control system depends on the kinds of weeds in the field, soil characteristics, tillage practices, crop rotation, and soybean row width.

Weeds are vigorous competitors with soybeans. Weeds usually germinate and emerge with the soybeans, so the soybeans cannot get ahead of the weeds. Soybeans are relatively short and susceptible to shading from taller weeds. Weeds also compete with soybeans for nutrients and water. Since soybeans are especially sensitive to moisture deficiencies in late summer, a few large weeds can severely reduce yields. Nearly complete weed control must be accomplished within three to four weeks after emergence of the soybeans in order to avoid yield losses due to early emerging weeds.

There are opportunities for reducing the costs of weed control in soybeans. Knowing the specific weed species present and selecting the appropriate herbicide or herbicides that have a high level of effectiveness and the lowest per acre cost may allow substantial savings. Using band applications can cut the cash outlay for herbicides by one-half to two-thirds. Lower cost cultivation can provide between-the-row weed control in band application and may in some instances be used in place of high-cost herbicides. Reducing herbicide rates below label recommendations increases the possibility of costly failures in weed control. On the other hand, applying herbicides at rates higher than label recommendations to assure weed control success adds unnecessarily to herbicide costs and may result in crop injury. Applying herbicides at the proper time and rate with a carefully calibrated applicator provides the best return on your herbicide investment.

Cultural Practices

Several cultural practices aid weed control in soybeans. Seedbed preparation immediately prior to planting will kill weeds that have germinated. Killing these weeds is important in obtaining good results from preemergence herbicides. For effective weed control, herbicides applied preemergence need to be moved into the soil by rainfall before weed seeds germinate. If rainfall has not been sufficient for herbicide activation, control the weed seedlings with a rotary hoe, harrow, or cultivator as soon as they emerge.

Herbicides

A herbicide or herbicide combination should be selected on the basis of the weed species in the field (table 1), performance, soil texture, pH of the soil, amount of organic matter in the soil, soybean tolerance, crop rotation, tillage practices, and economics. Field conditions that affect a herbicide's performance or limit its usefulness must be considered. Dry soil, heavy rain after application, surface trash, or a poor seedbed may reduce weed control. Cultivation practices and postemergence herbicide applications should be used when necessary to supplement soil applied herbicides.

Herbicide mixtures are used to overcome the limitations of single chemicals. Certain mixtures may (1) control more kinds of seeds, (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. See table 2 for labeled tank-mixes of herbicides suggested for use in Minnesota. Only those mixtures that have been field tested under local conditions should be used. The use of some mixtures may result in poor weed control or crop injury.

The correct herbicide rate must be used to obtain good weed control and to minimize soybean injury. Herbicide rates must be adjusted for soil texture, percent organic matter, soil pH, kinds of weeds, potential for soil residue, and whether the herbicide is to be used alone or in combination. See table 2 for herbicide rate ranges. Always consult herbicide labels for specific rates. Only chemicals that are cleared by the Environmental Protection Agency for the specific use intended should be used.

No-Till or Minimum Till

In no-till or minimum till soybean production, herbicides may be required to control emerged weeds. Glyphosate (Roundup) or paraquat (Paraquat Plus or Gramoxone) are non-selective herbicides that will kill emerged weeds. These herbicides have no soil activity and are usually tank-mixed with other herbicides that provide residual control of later-germinating weeds (see table 2). Paraquat is a restricted use herbicide.

Preplant Incorporated Applications

Ethalfluralin (Sonalan), pendimethalin (Prowl), trifluralin (Treflan), or vernolate (Vernam or Reward) are suggested for preplant incorporated use in soybeans. Trifluralin also may be applied in the fall after September 1. These herbicides have provided good control of annual grasses and some broadleaf weeds (see table 1).

Proper herbicide application and favorable soil conditions are necessary for optimum herbicide performance. The soil should be moist, but not wet, to ensure maximum mixing of herbicide and soil during preplant herbicide incorporation. To provide good control, adequate moisture is needed at the point where the emerging weed seedling contacts the herbicide.

Good incorporation thoroughly mixes the herbicide with 2-3 inches of soil. Incorporate the herbicide twice with a disk, field cultivator with sweep shovels, or similar implement, or once with a power-driven rotary tiller. The second incorporation should be carried out at a right angle to the direction of the first incorporation. This is needed to ensure thorough mixing of the herbicide with the soil. Observe label instructions for proper equipment depth and operation speed. Under ideal soil conditions, adequate incorporation may be accomplished with one trip using multiple implements.

To prevent herbicide loss by evaporation, vernolate must be incorporated immediately after application and should not be applied to a wet soil surface. Consult specific labels to determine the maximum time period allowed between application and incorporation of other herbicides.

Ethalfluralin, pendimethalin, and trifluralin may persist more that one year in some soils under dry or cold conditions. Sensitive crops such as small grains, grain sorghum, or sugarbeets can be affected the following year. Some instances of corn injury from trifluralin carryover have been observed in Minnesota when recommended rates have been exceeded on lighter soil areas, in overlapping spray swaths or in sprayer turn-around areas. Plowing with a moldboard plow, compared to reduced tillage systems that do not include moldboard plowing, reduces the potential for crop injury from residues of these herbicides.

Preplant Incorporated or Preemergence Applications

Several herbicides including alachlor (Lasso), chloramben (Amiben), metolachlor (Dual), and metribuzin (Sencor or Lexone) are suggested for use either preplant incorporated or preemergence. These herbicides may be left on the soil surface or incorporated with one or two tillage operations. Preplant incorporated applications of these herbicides into moist soil are more effective when there is inadequate rainfall to activate preemergence applications. However, preemergence applications provide more effective weed control when adequate rainfall does occur. If weed seedlings begin to emerge following a preemergence application due to lack of rainfall, an early harrowing, rotary hoeing, or shallow cultivation will improve weed control.

NOTICE: Alachlor (Lasso) is now undergoing a Special Review by the U.S. Environmental Protection Agency (EPA) because tests show that tumors are caused when high levels of alachlor are fed daily to laboratory animals over long periods of time. In this Special Review, EPA is re-examining all health and safety tests and product benefits from alachlor usage. Recommendations from EPA on future uses of alachlor will be developed based on their estimate of these risks and benefits. As of November, 1985, it seems probable that alachlor will continue to be available during 1986 for use by Minnesota farmers.

Alachlor and metolachlor control annual grasses, nutsedge, redroot pigweed, and nightshade. Control of other broadleaf weeds has been erratic. Preplant incorporation of alachlor or metolachlor has resulted in more consistent yellow nutsedge control than preemergence applications.

Chloramben controls many annual broad-leaved and grass weeds on a wide range of soils when sufficient rainfall occurs before weeds emerge. Excessive rainfall after application may move chloramben below the zone of weed germination and may reduce control. Soybean tolerance is good on a wide range of soils, including high pH soils. Infrequently, very heavy rainfall on coarse-textured (sandy) soils may move chloramben into contact with the germinating soybeans, resulting in stunted roots and delayed emergence.

Metribuzin has provided good control of several hard-to-control broadleaf weeds, but it has marginal crop safety. Crop safety can be improved by using lower labeled tank mix rates. See the label for restrictions on various soils and soybean varieties. Soybean injury is more likely on alkaline soils, sandy soils, where atrazine residues are present, or if used with vernolate.

Chlorpropham (Furloe Chloro IPC) applied preplant incorporated or preemergence has given good control of annual smartweed species. Soybeans have good tolerance to chlorpropham.

Pendimethalin (Prowl) applied preemergence to soybeans may cause callusing and brittleness of soybean stems under Minnesota conditions. Such injury is unlikely when pendimethalin is applied preplant incorporated.

Preemergence applications of linuron (Lorox) controls annual broad-leaved weeds and some grasses in soybeans. Linuron is best suited for medium-textured soils with 4 percent organic matter or less. Weed control has been inconsistent on fine-textured soils with high organic matter content. Soybean injury may occur on sandy, low organic matter soils. Potential crop injury can be decreased by using reduced rates of linuron with another herbicide (see table 2).

NOTICE: Linuron (Lorox) in now undergoing a Special Review by the U.S. Environmental Protection Agency (EPA) because tests show that non-cancerous tumors are caused when high levels of linuron are fed daily to laboratory animals over long periods of time. In this Special Review, EPA is re-examining all health and safety tests and product benefits from linuron usage. Recommendations from EPA on future uses of linuron will be developed based on their estimates of these risks and benefits. As of November, 1985, it seems probable that linuron will continue to be available during 1986 for use by Minnesota farmers.

Dimethazone (Command) is a new herbicide which controls many grass and broadleaf weeds in soybeans when applied preplanting incorporated or preemergence. It is generally more toxic to grasses but is also highly toxic to velvetleaf. It gives effective control of common lambsquarters, Pennsylvania smartweed, common ragweed and suppresses common cocklebur. Caution: A request for registration has been submitted to the U.S. Environmental Protection Agency and clearance is expected prior to the 1986 growing season, but as of November, 1985, dimethazone has not been cleared for use on soybeans.

Postemergence

Acifluorfen (Blazer) and bentazon (Basagran) alone or mixed are suggested for postemergence broadleaf weed control in soybeans. The herbicide or mixture used should be determined by the weed species present (see table 1). The leaf stage and size of the weeds at the time of herbicide application are critical for consistent control with either herbicide. Applications made to weeds larger than the maximum labeled leaf stage may result in inconsistent or partial control with regrowth from surviving roots and stems.

Crinkling, bronzing or burning of young soybean leaves is a common response to acifluorfen treatments but soybeans typically recover and develop normally. Hot, humid weather, active growth at application, and the addition of surfactants or oil concentrates increase both herbicidal effectiveness and the possibility of soybean injury. Do not apply acifluorfen to weeds under stress because effectiveness may be reduced.

Bentazon may cause some leaf burn if applied to soybeans under stress; especially when an oil concentrate is added to improve weed control effectiveness. A split application may be necessary to control Canada thistle, yellow nutsedge, and annual broad-leaved weeds that continue to germinate throughout the growing season.

Chloramben applied early postemergence to soybeans will control a few species of broadleaf weeds; but, for the best weed control with this herbicide, germinated weeds should be controlled with an appropriate postemergence herbicide or removed by cultivation.

Diclofop (Hoelon) is suggested for postemergence annual grass and volunteer corn control in soybeans. Wild oat, giant foxtail, green foxtail, and barnyardgrass should be treated before they exceed the four-leaf stage. Yellow foxtail should be treated before it reaches the three-leaf stage for best results. The full label rate of diclofop should be used when the annual grass is at or near the maximum leaf stage for treatment. Volunteer corn should not be sprayed with diclofop until all of the corn plants have emerged. Do not tank mix diclofop with any other product or apply any other product within seven days of a diclofop application because diclofop may be deactivated by other pesticides. Diclofop is a restricted use pesticide.

Fluazifop (Fusilade) and sethoxydim (Poast) are postemergence chemicals for annual and perennial grass control in soybeans. Soybeans have good tolerance. Neither chemical control broad-leaved weeds. An oil concentrate is used with the spray to improve performance. Tank mixtures with bentazon and acifluorfen provide control of many broadleaf weeds also, but effectiveness of sethoxydim and fluazifop on grasses may be reduced. See the appropriate labels for further information on these tank mixes.

Dinoseb (Premerge) or a mixture of naptalam plus dinoseb (Dyanap) applied at the crook-stage of soybeans give fair control of some broadleafs (see table 1) with temporary soybean burn and stunting likely. Applications of dinoseb or dinoseb plus naptalam made after the first trifoliolate leaf stage of the soybeans vary in effectiveness depending on temperature and humidity and may result in inconsistent weed control or soybean leaf kill and stunting.

Barban (Carbyne) can be used as a postemergence treatment for wild oat control in soybeans. Application should be made when most of the wild oat plants are in the two-leaf stage. Do not apply later than 30 days after soybean emergence.

2,4-DB amine (Butoxone, Butyrac 200) is labeled for postemergence control of common cocklebur in soybeans. Weed control is less satisfactory and the potential for crop injury greater when 2,4-DB is used than when other postemergence broadleaf herbicides are used. A combination of 2,4-DB with naptalam (Rescue) can be applied to larger soybeans in bloom when competition from cocklebur, giant ragweed and sunflower is severe to reduce competition. Some soybean leaf injury and stunting should be expected.

Read the pesticide label and follow the instructions as a final authority on pesticide use.

The information given in this publication is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Minnesota Agricultural Extension Service is implied.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Patrick J. Borich, Dean and Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55108.

Notes:

Table 1. Effectiveness of herbicides on major weeds in soybeans.

	Preplant incorporated								Preemergence						Postemergence								
	alachlor (Lasso)	chloramben (Amiben)	metolachlor (Dual)	metribuzin (Sencor or Lexone)	pendimethalin (Prowl)	ethalfluralin (Sonalan)	trifluralin (Treflan)	vernolate (Vernam, Reward)	alachlor (Lasso)	chloramben (Amiben)	naptalam + dinoseb (Dyanap)	linuron (Lorox)	metolachlor (Dual)	metribuzin (Sencor or Lexone)	acifluorfen (Blazer)	bentazon (Basagran)	2,4-DB (Butoxone or Butyrac 200)	diclofop (Hoelon)	dinoseb (Premerge)	naptalam + 2,4-DB (Rescue)	naptalam + dinoseb (Dyanap)	fluazifop (Fusilade)	sethoxydim (Poast)
Soybean tolerance	G	G	G	F	F/G	F/G	F/G	F	G	G	P	F	G	F	F	G	P	G	P	F/P	F/P	G	G
Grasses																							
Barnyardgrass	G	G	G	F	G	G	G	G	G	F/G	P	F	G	F	P	N	N	G	P	P	P	G	G
Woolly cupgrass	G	G	G	P	G	G	G	F/G	G	G	P	P	G	P	P	N	N	P	P	P	P	G	G
Giant foxtail	G	G	G	F	G	G	G	G	G	F/G	P	F	G	F	P	N	N	G	P	P	P	G	G
Green foxtail	G	G	G	F	G	G	G	G	G	F/G	P	F	G	F	P	N	N	G	P	P	P	G	G
Yellow foxtail	G	G	G	F	G	G	G	G	G	F/G	P	F	G	F	P	N	N	F	P	P	P	G	G
Proso millet	F	F	F	P	F	F	F	F	F	F	P	P	F	P	P	N	N	P	P	P	P	G	G
Nutsedge	G	P	G	P	N	N	N	G	F	P	P	P	F	P	P	G	N	P	P	P	P	N	N
Quackgrass	N	N	N	P	P	P	P	F	N	N	P	P	N	P	N	N	N	N	P	N	P	G	F
Sandbur	F	P	F	P	G	G	G	G	F	P	P	P	F	P	P	P	P	P	P	P	P	G	G
Broadleafs																							
Canada thistle	N	N	N	P	N	N	N	N	N	N	P	P	N	P	P	G	P	N	P	P	F/P	N	N
Cocklebur	P	P	N	F	N	N	N	P	N	P	F	P	N	F	F	G	F	N	F	F	F	N	N
Kochia	P	G	P	G	G	G	G	-	P	G	F	F	P	G	-	F	-	N	-	F	F	N	N
Lambsquarters	F/P	G	F/P	G	F/G	F/G	F/G	F	F/P	G	F	G	F/P	G	P	F	P	N	P	-	P	N	N
Venice mallow	P	G	P	G	P	P	P	G	P	G	-	G	P	G	F	G	P	N	-	-	F	N	N
Mustard	P	F	P	G	N	N	N	F	P	F	G	G	P	G	G	G	P	N	G	-	G	N	N
Eastern black nightshade	F	F	F	P	P	F	P	P	G	G	-	P	G	P	G	F	P	N	G	-	F/P	N	N
Hairy nightshade	F	F	F	P	P	P	P	P	G	G	-	-	F	P	F	F	-	N	-	-	-	N	N
Pigweed	G	G	G	G	G	G	G	G	G	G	F	G	G	G	G	P	P	N	P	-	P	N	N
Common ragweed	P	G	P	G	N	N	N	P	P	G	F	G	P	G	G	G	P	N	F	F	F	N	N
Giant ragweed	P	F	P	P	N	N	N	P	P	F	F	F	P	F	G	F	F	N	-	-	F	N	N
Smartweed	P	G	P	G	F	P	P	P	P	G	F	F	P	G	G	G	P	N	G	-	F	N	N
Wild sunflower	P	P	P	F	N	N	N	P	P	P	F	P	P	F	F/G	G	P	N	F	F	F	N	N
Velvetleaf	P	F	P	G	F	N	N	F	P	F	P	F	P	F	P	G	P	N	P	-	P	N	N

G=good; F=fair; P=poor; n=no control; -=insufficient information.

Table 2. Herbicide choices for soybeans.

Herbicide	Active ingredient, lb/A or (formulation/A)	Remarks
NO-TILL or MINIMUM TILL		
glyphosate (Roundup)	.75 to 3 (1 to 4 qts)	Kills emerged weeds. Has no soil activity so commonly combined with residual herbicides. Apply prior to soybean emergence to prevent soybean kill.
Mixtures listed on the label		
alachlor (Lasso or Bronco)	2.5 to 4	Adds preemergence control of annual grasses and a few broadleaf weeds.
alachlor + linuron (Lorox)	2.5 to 4 + .5 to 1.5	Adds preemergence control of annual grasses and broadleaf weeds.
alachlor + metribuzin	2.5 to 4 + .25 to .75	Adds preemergence control of annual grasses and broadleaf weeds.
Mixtures listed on other labels		
chloramben (Amiben)	2 to 3	Adds preemergence weed control. Use any labeled preemergence chloramben tank mix.
metolachlor + linuron	1.5 to 2.5 + .5 to 1.5	Adds preemergence weed control of annual grasses and broadleaf weeds.
metolachlor + metribuzin	1.5 to 2.5 + .25 to .5	Adds preemergence weed control of annual grasses and broadleaf weeds.
chloramben + metolachlor	2 to 3 + 1.5 to 2.5	Adds preemergence weed control of annual grasses and broadleaf weeds.
chloramben + alachlor	2 to 3 + 1.5 to 3	Adds preemergence weed control of annual grasses and broadleaf weeds.
paraquat (Paraquat Plus or Gramoxone)	.25 to 1 (1 to 4 pts)	Kills emerged weeds. Has no soil activity so commonly combined with residual herbicides. Apply prior to soybean emergence to prevent soybean kill. A restricted use herbicide.
Mixtures listed on the label		
linuron (Lorox)	.5 to 1.5	Adds preemergence weed control.
metribuzin (Sencor or Lexone)	.38 to 1	Adds preemergence control of broadleaf weeds.
alachlor (Lasso) + linuron	2 to 3 + .5 to 1.5	Adds preemergence weed control.
alachlor + metribuzin	2 to 3 + .25 to .5	Adds preemergence weed control.
Mixtures listed on other labels		
chloramben	2 to 3	Adds preemergence weed control. Use any labeled preemergence chloramben tank mix.
metolachlor (Dual) + linuron	1.5 to 2.5 + .5 to 1.5	Adds preemergence control of annual grasses and broadleaf weeds.
metolachlor + metribuzin	1.5 to 2.5 + .25 to .5	Adds preemergence control of annual grasses and broadleaf weeds.
chloramben + metolachlor	2 to 3 + 1.5 to 2.5	Adds preemergence control of annual grasses and broadleaf weeds.
chloramben + alachlor	2 to 3 + 1.5 to 3	Adds preemergence control of annual grasses and broadleaf weeds.

PREPLANT INCORPORATED

ethalfluralin (Sonalan)	.56 to 1.12 (1.5 to 3 pts)	Controls annual grasses and some broadleaf weeds. Use preplant incorporated. At maximum rate gives partial control of eastern black nightshade.
Mixtures listed on the label		
alachlor (Lasso)	2 to 4	Adds control of nightshades, witchgrass and yellow nutsedge.
chloramben (Amiben)	2 to 3	Adds control of broadleaf weeds.
metolachlor (Dual)	1.5 to 3	Adds control of black nightshade and yellow nutsedge.
metribuzin (Lexone, Sencor)	.25 to .5	Adds control of broadleaf weeds.
pendimethalin (Prowl)	.5 to 1.5 (1 to 3 pts)	Controls annual grasses and some broadleafs. Preplant incorporated.
Mixtures listed on the label		
alachlor (Lasso)	2.5 to 4	Improves grass control and adds control of nightshades and yellow nutsedge.
chloramben (Amiben)	2	Adds control of smartweeds, velvetleaf and common ragweed.
metolachlor (Dual)	1.5 to 3	Improves control of grasses and adds control of nightshades and yellow nutsedge.
metribuzin (Lexone, Sencor)	.5 to .75	Controls additional broadleaf weeds.
chloramben + metribuzin	1.5 to 2 + .37 to .55	Controls additional broadleaf weeds.
trifluralin (Treflan 4E) (Treflan 10G)	.5 to 1 (1 to 2 pts) (5 to 10 lbs)	Controls annual grasses and some broadleafs. Use preplant incorporated in the fall or spring. Do not exceed recommended rates for the soil type or carryover may injure sensitive crops the following year.
Mixtures listed on the label		
alachlor (Lasso)	2.5 to 4	Adds control of nightshades and yellow nutsedge. Preemergence overlay cleared.
chloramben (Amiben)	2 to 3	Controls additional broadleafs. Preemergence overlay cleared.
metolachlor	1.5 to 3	Adds control of nightshades and yellow nutsedge. Preemergence overlay cleared.
metribuzin	.25 to .5	Adds control of yellow nutsedge, velvetleaf and wild mustard.
chloramben + metribuzin	1.5 to 2.5 + .25 to .38	Controls additional broadleafs. Preemergence overlay cleared.
vernolate (Vernam 7E) (Vernam 10-G) (Reward)	2 to 3 (2.3 to 3.5 pts) (20 to 30 lbs) (2.7 to 4 pts)	Controls annual grasses, some broadleafs plus yellow nutsedge. Use preplant and incorporate immediately. Extender in Reward increases vernolate soil persistence. Reward or Vernam 10-G may be applied and incorporated after planting.
Mixtures listed on the label		
alachlor (Lasso)	1 to 2	Adds control of nightshades.
chloramben (Amiben)	1.5	Adds control of many broadleafs.
pendimethalin (Prowl)	.38 to .75	Adds control of velvetleaf, kochia and smartweeds.
trifluralin (Treflan)	.5 to 1	Adds control of kochia and improves annual grass control.
trifluralin + metribuzin	.5 + .25 to .38	Adds control of many broadleaf weeds and improves annual grass control.

PREPLANT or PREEMERGENCE

alachlor	1.5 to 4	Controls annual grasses and some broadleafs including nightshade.
(Lasso)	(2 to 4 qts)	Cleared postemergence but less effective on emerged weeds.
(Lasso II)	(1.5 to 3.0 lbs)	
Mixtures listed on the label		
chloramben (Amiben)	2	Adds control of many broadleaf weeds.
dinoseb (Premerge)	3 to 4.5	Preemergence or before soybean leaves unfold. Use low rate for emerged broadleafs. If terminal bud is exposed soybean injury can be serious.
linuron (Lorox)	.5 to 1.5	Do not incorporate. Added broadleaf control.
metribuzin (Sencor or Lexone)	.25 to .5	Adds control of many broadleaf weeds.
chloramben + metribuzin	.75 to 3 + .25 to .5	Adds control of many broadleaf weeds.
linuron + metribuzin	.17 to 1 + .13 to .5	Adds control of most broadleaf weeds.
chloramben	1.8 to 3	Controls broadleafs and grasses, but more effective on broadleafs.
(Amiben)	(4 to 6 qts)	Cleared postemergence but less effective on emerged weeds.
(Amiben DS)	(2.4 to 3.6 lbs)	Weak on wild mustard.
(Amiben Granular)	(20 to 30 lbs)	
Mixtures listed on the label		
alachlor (Lasso)	1.5 to 3	Improves grass, nutsedge and nightshade control.
dinoseb (Premerge)	1.5 to 4.5	Preemergence or before first soybean leaves open. Use low rate for emerged broadleafs at cracking stage. If terminal bud is exposed soybean injury can be serious.
linuron (Lorox)	.33 to 1.5	Preemergence only. Improves grass and broadleaf control.
metolachlor (Dual)	1.5 to 2.5	Improves grass, nutsedge and nightshade control.
metribuzin (Sencor, Lexone)	.25 to .5	Improves broadleaf control, especially wild mustard.
pendimethalin (Prowl)	.75 to 1.25	Preplant incorporated. Improves grass control.
trifluralin (Treflan)	.5 to 1	Preplant incorporated only. Improves grass control.
vernolate (Vernam, Reward)	2.7 to 4	Preplant incorporated. Improves grass and velvetleaf control.
alachlor + metribuzin	1.5 to 3 + .25 to .5	Improves grass, nutsedge, nightshade and mustard control.
metolachlor + metribuzin	.75 to 1.5 + .25 to .5	Improves grass, nutsedge, nightshade and mustard control.
pendimethalin + metribuzin	.75 to 1.5 + .25 to .5	Preplant incorporated. Improves grass and mustard control.
trifluralin + metribuzin	.5 to 1 + .25 to .5	Preplant incorporated. Improves grass and mustard control.
diallate	1.5 to 2	Controls wild oats only. Apply preplant or preemergence incorporated.
(Avadex)	(1.5 to 2 qts)	A restricted use herbicide.

linuron	.5 to 2.5	Use in preemergence mixtures to improve broadleaf weed control. Ineffective if
(Lorox WP)	(1 to 5 lbs)	incorporated. If emerged, soybeans will be severely injured. Do not use on
(Lorox 4L)	(.5 to 2.5 qts)	sandy soils with less than 0.5 % organic matter. Directed postemergence for small broadleafs.
Mixtures listed on the label		
alachlor (Lasso)	.5 to 3	Improves grass control and adds nutsedge and nightshade control.
chloramben (Amiben)	1.5 to 2.5	Improves overall grass and broadleaf control.
metolachlor (Dual)	1 to 2.5	Improves grass control and adds nutsedge and nightshade control.
pendimethalin (Prowl)	.5 to 1.3	Improves grass control. Apply pendimethalin preplant and linuron preemergence.
propachlor (Ramrod)	.65 to 3	Improves grass control. Seed crop only.
dinoseb (Premerge)	1.5 to 4.5	Directed spray to soybeans over 8 inches tall to control weeds up to 3 inches tall.
2,4-DB (Butyrac)	.2	Directed spray to soybeans over 8 inches tall to control 1- to 3-inch weeds.
metolachlor	2 to 3	Controls annual grasses and some broadleafs. Apply preplant incorporated or
(Dual)	(2 to 3 pts)	preemergence. Cleared early preplant for no-till and minimum till.
Mixtures listed on the label		
chloramben (Amiben)	1.8 to 2.7	Adds control of many broadleaf weeds.
dinoseb (Premerge)	1.5 to 4.5	Preemergence or before soybean leaves unfold. Use low rate for emerged broadleafs. If terminal bud is exposed soybean injury can be serious.
linuron (Lorox)	.5 to 1.5	Preemergence only. Adds control of broadleaf weeds.
metribuzin (Sencor, Lexone)	.25 to .5	Adds control of many broadleaf weeds.
dinoseb + naptalam (Dyanap)	1.1 to 1.5 + 2.3 to 3	Use preemergence or before soybean leaves unfold. If terminal bud is exposed soybean injury may occur.
metribuzin	.25 to .87	Controls many broadleaf weeds including wild mustard. Apply early preplant,
(Sencor or Lexone 4L)	(.5 to 1.7 pts)	preplant incorporated or preemergence. Use in mixtures with grass herbicides.
(Sencor or Lexone DF)	(.3 to 1.2 lbs)	Soybean tolerance only fair. In early preplant application, a second preemergence application can be used to extend weed control.
Mixtures listed on the label		
alachlor (Lasso)	2 to 3	Adds grass, nutsedge and nightshade control.
chloramben (Amiben)	1.5 to 2.5	Adds some grass and nightshade control.
ethalfluralin (Sonalan)	.56 to 1.12	Preplant incorporated only. Adds grass control.
metolachlor (Dual)	1.25 to 2.5	Adds grass, nutsedge and nightshade control.
pendimethalin (Prowl)	.75 to 1	Preplant incorporate to minimize soybean injury. Adds grass control.
trifluralin (Treflan)	.5 to 1	Preplant incorporated only. Adds grass control.
dinoseb + naptalam (Dyanap or Premerge Plus)	1.1 to 1.5 + 2.3 to 3	Improves control of cocklebur. Preemergence or before soybean leaves unfold. If terminal bud is exposed soybean injury can be serious.
alachlor + dinoseb + naptalam	2 to 3 + 1.12 to 1.5 + 2.3 to 3	Adds control of grasses and cocklebur. Preemergence but before soybean leaves unfold. If terminal bud is exposed soybean injury can be serious.
alachlor + linuron	.75 to 2 + .17 to 1	Adds grass and some broadleaf control.
metolachlor + linuron	1.25 to 2.5 + .17 to 1	Adds grass and some broadleaf control.

POSTEMERGENCE

acifluorfen (Blazer)	.37 to .75 (1.5 to 3 pts)	Controls small broadleaf weeds. Apply postemergence. Apply again if necessary for late emerging weeds. Burn of soybean leaves is common but recovery is usually complete. Surfactant is needed for maximum effectiveness.
Mixtures listed on the label		
bentazon (Basagran)	.5 to .75	Improves broadleaf control. Adding liquid fertilizer (10-34-0) improves velvetleaf control.
chloramben (Amiben)	2.5 to 3	Provides residual activity for later germinating weeds.
fluazifop (Fusilade)	.13 to .25	Adds grass and corn control. Some antagonism in tank mixes.
sethoxydim (Poast)	.23 to .38	Adds annual grass and corn control. Use 50% greater rates of sethoxydim in tank mixes.
bentazon + sethoxydim	.5 to .75 + .23 to .38	Adds annual grass and corn control. Use 50% greater rates of sethoxydim in tank mixes.
2,4-DB (Butyrac 200)	.03	Improves control of larger cocklebur, pigweed and ragweed.
barban (Carbyne 2EC)	.38 (3 pts)	Controls wild oats only. Apply when wild oats is in the 2-leaf stage.
bentazon (Basagran)	.75 to 1 (1.5 to 2 pts)	Controls many annual broadleafs, nutsedge and Canada thistle. Apply when weeds are small. Add oil concentrate under adverse conditions.
Mixtures listed on the label		
acifluorfen (Blazer)	.25 to .5	Improves control of nightshade, pigweeds and common ragweed. Soybean leaf burn occurs.
sethoxydim (Poast)	.3 to .4	Adds annual grass and corn control. Use 50% higher sethoxydim rate in tank mix.
acifluorfen + sethoxydim	.25 + .3	Improves control of broadleafs. Adds control of annual grasses and corn.
chloramben (Amiben)	3 (6 qts)	Must add crop oil. Use after a soil-applied grass herbicide. Post emergence suppression or control of pigweed, common ragweed and Pennsylvania smartweed plus residual preemergence activity.
(Amiben DS)	(3.6 lbs)	
diclofop (Hoelon)	.75 to 1.25 (2 to 3.3 pts)	Controls many annual grasses and volunteer corn. A restricted use herbicide.
dinoseb (Premerge)	.38 to 2.25 (1 to 6 pts)	Apply high rates to soybeans in the cotyledonary stage. For emerged weeds only. Apply lower rates from 1st trifoliate to bloom stage or soybeans for cocklebur. Soybean leaf burn likely.
Mixtures listed on the label		
naptalam (Dyanap or Premerge Plus)	.75 to 2	Soybeans from 1st trifoliate to bloom only. Expect soybean leaf burn and stunting. Only fair control of many broadleaf weeds. Variable weed control and soybean injury due to temperature. Split applications are possible.

fluazifop (Fusilade 2000)	.09 to .19 (.75 to 1.5 pts)	Controls annual grasses, corn and quackgrass. Quackgrass may require a second application. Always add a surfactant or crop oil concentrate.
Mixtures listed on the label		
acifluorfen (Blazer)	.38 to .75	Adds broadleaf weed control. Add a surfactant. Sequential or tank mix.
sethoxydim (Poast)	.1 to .5 (.5 to 2.5 pts)	Controls grasses plus corn and suppresses quackgrass. Quackgrass may require a second application. Add a crop oil concentrate.
Mixtures listed on the label		
bentazon (Basagran)	.75 to 1	Adds broadleaf weed control. Reduced grass control requires a 50% sethoxydim rate increase Avoid antagonism by using sequential applications.
bentazon + acifluorfen (Blazer)	.75 to 1 + .25 to .5	Adds broadleaf weed control. Reduced grass control requires a 50% sethoxydim rate increase Avoid antagonism by using sequential applications.
2,4-DB (Butyrac 200)	.18 to .4 (.7 to 1.6 pts)	Mainly for common cocklebur. Apply as a directed spray to soybeans at least 8 inches tall and cocklebur to 3 inches tall or other weeds 2 inches tall.
Mixtures listed on the label		
naptalam (Alanap or Rescue-pre mix)	1 to 1.5	Tank mix rate .03 to .045 lb/A of 2,4-DB. Apply broadcast to soybeans after first blooms appear to suppress cocklebur, giant ragweed, sunflower and wild mustard. Some soybean injury should be expected. A non-ionic surfactant or crop oil concentrate is required.

AG-FO-0771 Revised 1986 WEED CONTROL IN SMALL GRAINS

Beverly Durgan
Extension Agronomist-Weeds

Effective weed control in field crops can usually be accomplished with a combination of cultural, mechanical, and chemical practices. In row crops, tillage can be an integral part of weed control. However, in close-sown small grain crops, tillage is not feasible, except that early germinating weeds may be destroyed by tillage during seedbed preparation. Therefore, more dependence on cultural and chemical weed control practices is needed.

Cultural Practices

Sowing clean seed at an adequate seeding rate will help to reduce weed populations in small grains. Also, small grain must be seeded early so the cool season small grain crop can compete effectively with weeds. Early spring seeding reduces warm season annual grass weed problems, such as foxtail, that are increased by late seeding. However, early spring seeding does not help to reduce wild oats or most annual or perennial weed problems. These weeds must be controlled with herbicides because delayed seeding with repeated tillage to control these weeds results in reduced small grain yields.

Perennial Weed Control

Most herbicides available for use in small grains will control annual weeds at safe usage rates for small grain, but will not control established perennials. Perennial weeds such as Canada thistle or quackgrass should be controlled prior to (preferably the year before) seeding small grains. Glyphosate (Roundup) may be used to control most perennials prior to seeding small grain. (See herbicide label.) Also,

many perennial broadleaf weeds can be controlled with 2,4-D or dicamba (Banvel) in the fall prior to seeding small grain.

Herbicides for Weed Control in Small Grains

(This folder summarizes herbicide treatments controlling weeds in small grains. For additional information, refer to herbicide labels.)

Herbicide use on small grains in Minnesota is extensive, with more than 75 percent of the acreage treated annually. However, several weeds are not being effectively controlled (Table 1).

Herbicide Combinations

The weed control of many postemergence herbicides often is increased when applied to fields already treated with a preemergence or preplant herbicide. Combinations of certain postemergence or preemergence may give better weed control than the use of the individual herbicide alone. For example, a tank mix of bromoxynil and MCPA gives greater wild mustard control than either of these herbicides alone. However, loss of weed control or increased crop injury may also result from the use of certain herbicides in combination. For example, the mixing of diclofop (Hoelon) and 2,4-D will decrease the grass control of diclofop. Herbicide combinations should be used with caution until experience or research has shown that the herbicide is effective and safe.

All agricultural pesticides which are sold as a pre-mix are registered for use as a mixture by the Environmental Protection Agency. However, you may tank mix any agricultural pesticides if all pesticides in the mixture are registered for use in the crop by the Environmental Protection Agency. However, you must assume liability for crop injury, inadequate weed control, and illegal herbicide residues.

Spring Wheat, Durum Wheat, Oats, and Barley

If small grain is not underseeded with a legume, more herbicides and higher rates may be used (Table 2). Table 3 includes herbicides that can be used when legumes are underseeded.

Winter Wheat and Rye

For winter wheat and rye, apply most weed control chemicals in the spring. Apply triallate, bromoxynil or chlorsulfuron to winter wheat, not rye, in either fall or spring (Table 2).

Consider Effectiveness, Crop Tolerance, and Cost

Accurately identify the weed problem and then select the most effective herbicide (Table 4). Consider crop tolerance as well as effectiveness of the herbicide (Table 5). For example, wheat and oats are more tolerant to dicamba (Banvel) than barley. Herbicide cost should also be a consideration when planning a weed control program. Many herbicides will control the same weeds; however, one herbicide may be more economical than the other. Accurate calibration of your spray equipment will also help reduce weed control costs and increase the effectiveness of the herbicides used. Under application of herbicides often result in poor weed control, and overapplication increases your weed control costs and may result in grain injury. See Table 6 which lists common names and trade names of herbicides and their formulations.

Table 1. The ten most prevalent weeds in small grain in Minnesota with current weed control practices (1979 survey - 1,021 fields sampled).

Weed species	% fields infested	Weed density infested fields (plants/m^2)
Green foxtail	60	35
Common lambsquarters	56	9
Smartweed sp.	55	7
Wild buckwheat	53	7
Yellow foxtail	47	42
Pigweed sp.	44	6
Canada thistle	39	2
Wild oat	30	6
Wild mustard	28	3
Ragweed sp.	27	10

Table 2. Herbicide choices for use in durum, winter or spring wheat, oats, barley, and rye with no underseeded legumes.

Herbicide	Active Ingredient, lb/A or (formulation/A)	Remarks
No-Till or Minimum Till		
chlorsulfuron	.016 to .05	Controls broadleaves and grasses, except wild oats. Apply during fallow in the fall or
(Glean)	(.33 to .5 oz)	spring prior to seeding wheat. **Do not use on soils over pH 7.5. See rotational crop restrictions on the label that are required due to carryover. Do not use on rye.**
glyphosate	.19 to .75	Controls emerged grass and broadleaf weeds with no soil residual. Apply prior to grain
(Roundup)	(.5 to 2 pts)	emergence. Add surfactant to lower herbicide rates. Avoid spray drift.
Labeled) mixtures*		
dicamba (Banvel)	.12 to .25	Improves control of emerged broadleaf weeds when low glyphosate rates used.
2,4-D	.25 to .5	Improves control of emerged broadleaf weeds when low glyphosate rates used.
paraquat	.25 to .5	Controls emerged grasses and broadleaf weeds with no soil residual. Apply prior to grain
(Paraquat Plus, Gramoxone)	(1 to 2 pts)	emergence. Add surfactant. Restricted Use Pesticide.
Preplant Incorporated or Preemergence		
chlorsulfuron	.008 to .02	For broadleaf weeds and grasses except wild oats in winter or spring wheat and barley
(Glean)	(.16 to .5 oz)	only. Apply in fall or sping. Use shallow tillage only after application. **Do not use on soils over pH 7.5. See label for rotational crop restrictions due to carryover.**
diallate	1.25	For wild oat control in barley. Apply preplant incorporated in the fall or in the spring
(Avadex)	(1.25 qts)	after seeding barley. Restricted Use Pesticide.
triallate	1 to 1.5	For wild oat control in durum, winter or spring wheat and barley applied fall or spring
(Far-Go EC)	(1 to 1.5 qts)	before or after seeding. Use higher rate on barley only.
(Far-Go Gran)	(10 to 15 lbs)	
trifluralin	.5 to .75	For annual grasses, except wild oats and some broadleaves in durum or spring wheat and
(Treflan)	(1 to 1.5 pts)	barley. Apply fall, granules perferred, or postplant spring, liquid formulation
(Treflan 10G)	(5 to 7.5 lbs)	preferred. Must be incorporated. Apply beginning Sept. 1 for all labeled fall
Labeled mixture*		applications.
triallate (Far-Go)	1	Adds wild oat control in spring applications to durum or spring wheat and barley.

Table 2. continued

Herbicide	Active Ingredient, lb/A or (formulation/A)	Remarks
Postemergence		
barban	.25 to .75	Postemergence control of wild oats in all wheats and barley. Apply to wild oats in the
(Carbyne 2EC)	(1 to 1.5 pts)	2-leaf stage.
Labeled mixtures*		
bromoxynil (Buctril, Brominal)	.25	Adds control of emerged annual broadleaf weeds.
chlorsulfuron (Glean)	.008 to .024	Adds broadleaf weed control. **See label for rotational crop restrictions. Do not use on soils over pH 7.5.**
diclofop (Hoelon)	.25 to .5	Improves wild oat and adds annual grass control in wheat and barley. Restricted Use Pesticide.
difenzoquat (Avenge)	.25 to .5	Improves wild oat control. See difenzoquat label for use limitations on spring wheat varieties.
bromoxynil	.25 to .5	Postemergence control of most small annual broadleaf weeds in wheat, oats, and barley.
(Brominal ME4)	(.5 to 1 pt)	May also be applied to winter wheat and rye in the fall for control of winter annuals.
(Buctril)	(1 to 2 pts)	
Labeled mixtures*		
barban (Carbyne)	.38	Adds postemergence control of wild oats in the 2-leaf stage in wheat and barley.
chlorsulfuron (Glean)	.01 to .02	Adds residual weed control in wheat and barley. **See rotational crop restriction on label. Do not use on soils over pH 7.5.**
dicamba (Banvel)	.06 to .12	Improves broadleaf weed control in all wheats and oats. May injure barley.
diclofop (Hoelon)	.75 to 1.25	Adds wild oat and foxtail control in wheat and barley. Restricted Use Pesticide.
difenzoquat (Avenge)	.62 to 1	Adds wild oat control in barley and wheat. See label for spring wheat variety restrictions.
MCPA	.25 to .5	Improves broadleaf weed control, especially perennials.
2,4-D	.25 to .5	Improves broadleaf weed control, especially perennials.
chlorsulfuron	.008 to .02	Controls broadleaf weeds and suppresses grasses, except wild oats in durum, winter or
(Glean)	(.16 to .5 oz)	spring wheat, barley and spring oats. See label for restrictions on Vic durum. **Do not use on soils over pH 7.5. See label for rotational crop restrictions due to carryover.**
Labeled mixtures*		
barban (Carbyne)	.25 to .75	Adds wild oat control in all wheats and barley. Apply to wild oats in the 2-leaf stage.
bromoxynil (Brominal, Buctril)	.25	Improves broadleaf weed control. Apply postemergence to small weeds.
dicamba (Banvel)	.06 to .12	Improves broadleaf weed control in durum, spring or winter wheat.
difenzoquat (Avenge)	.62 to 1	Adds wild oat control in durum or spring wheat and barley. See difenzoquat label for spring wheat variety restrictions.
dicamba	.06 to .12	Controls many broadleaf weeds including wild buckwheat and smartweeds in durum, winter
(Banvel)	(.12 to .25 pt)	or spring wheat and oats. See label for crop growth stage restrictions. Used most
(Banvel II)	(.25 to .5 pt)	frequently in tank mixes. Lower dicamba rates used in tank mixes. Avoid spray drift
Labeled mixtures*		onto nearby sensitive plants.
chlorsulfuron (Glean)	.008 to .02	Adds residual weed control and annual grass suppression, except wild oats. See **rotational crop and pH restrictions on the label.**
bromoxynil (Brominal, Buctril)	.25 to .38	Improves broadleaf weed control in all wheats and oats.

Table 2. continued

Herbicide	Active ingredient, lb/A or (formulation/A)	Remarks
MCPA	.25 to .38	Improves broadleaf weed control, especially wild mustard.
2,4-D	.25 to .38	Improves broadleaf weed control, especially mustard. Do not use on oats.
diclofop	.75 to 1.25	Controls wild oat and other annual grasses in durum, winter or spring wheat and barley.
(Hoelon)	(2 to 3.3 pts)	Use lower rate in barley. Restricted Use Pesticide.
Labeled mixtures*		
bromoxynil (Buctril, Brominal)	.37 to .5	Adds broadleaf weed control.
chlorsulfuron (Glean)	.01	For use on winter wheat only. **See rotational crop and pH restrictions on the label.**
MCPA (ester)	.01	Can be added to a tank mix of diclofop plus bromoxynil. Do not exceed 1.5 oz. of MCPA.
difenzoquat	.62 to 1	For wild oat control only in durum, winter or spring wheat and barley. See difenzoquat
(Avenge)	(2.5 to 4 pts)	label for use limitations on spring wheat varieties.
Labeled mixtures*		
bromoxynil	.375 to .5	Adds broadleaf weed control.
chlorsulfuron (Glean)	.008 to .02	Adds broadleaf control and grass suppression. **See label for rotational crop and soil pH restrictions.**
MCPA	.25 to 1	Adds broadleaf weed control.
2,4-D	.25 to .75	Adds broadleaf weed control.
MCPA		Controls many broadleaf weeds in all small grains. Apply from 2-leaf to early boot stage
(Amines)	.25 to .66 (several formulations)	of crop. Safer to grain than 2,4-D or dicamba. Use lower rates of the ester formula-
(Esters)	.16 to .5 (several formulations)	tions. Weak on wild buckwheat and smartweeds. Avoid drift onto nearby sensitive crops.
Labeled mixtures*		
bromoxynil (Buctril, Brominal)	.25 to .38	Improves control of wild buckwheat and smartweeds.
dicamba (Banvel, Banvel II)	.12	Improves control of wild buckwheat and smartweeds.
difenzoquat (Avenge)	.62 to 1	Adds wild oat control.
propanil + MCPA pre-mix	.94 + .25	For early postemergence control of foxtail and some broadleaf weeds. Apply at 2-5 leaf
(Stampede CM)	(2.5 pt)	stage of spring wheat and 2-4 leaf stage of durum and barley. Temporary yellowing of grain may occur. Do not apply to foxtail beyond the 3 leaf stage.
2,4-D		Controls many broadleaf weeds in all small grains but weak on wild buckwheat and smart-
(Amines)	.25 to .66 (several formulations)	weeds. Oats more sensitive to 2,4-D. Use lower rates of ester formulations. Avoid drift onto nearby sensitive crops.
(Ester)	.16 to .5 (several formulations)	

Table 2. continued

Herbicide	Active ingredient, lb/A or (formulation/A)	Remarks
Labeled mixtures*		
bromoxynil (Buctril, Brominal)	.25 to .38	Improves control of wild buckwheat and smartweeds.
dicamba (Banvel, Banvel II)	.12	Improves control of wild buckwheat and smartweeds. Barley may be injured.
picloram (Tordon)	.015 to .023	Improves control of wild buckwheat in wheat and barley. Picloram is persistent and will carry over in the soil. Do not rotate other crops on treated grain fields. Not cleared for use on durum wheat. Restricted Use Pesticide.
difenzoquat (Avenge)	.62 to 1	Adds wild oat control.

* Follow label directions and precautions of all products in a mixture.

Table 3. Herbicide choices for weed control in spring sown small grains underseeded with legumes.

Herbicide	Active Ingredient, lb/A or (formulation/A)	Remarks
diallate (Avadex)	1.25 (1.25 qts)	Use on barley only for wild oat control. Apply preplant incorporated in the fall or in the spring after the barley is seeded. Restricted Use Pesticide.
MCPA (Amine)	.12 to .25 (several formulations)	Postemergence control of broadleaf weeds. Legumes injured but usually recover. Use on heavy stands of broadleaf weeds. Do not use on sweet clover. Canopy of grain or weeds reduces legume injury.
2,4-D (Amine)	.12 to .25 (several formulations)	Postemergence control of broadleaf weeds. Legumes may be severely injured so use only on heavy infestations of broadleaf weeds. Do not use on sweet clover. Canopy of grain or wee reduces legume injury.

Table 4. Effectiveness of herbicides on major weeds in small grains.

	barban (Carbyne)	bromoxynil (Bromina1/Buctril)	chlorsulfuron (Glean)	diallate (Avadex)	dicamba (Banvel)	diclofop (Hoelon)	difenzoquat (Avenge)	MCPA (amine or ester)	picloram (Tordon 22K)	propanil + MCPA ester (Stampede CM)	triallate (Far-Go)	trifluralin (Treflan)	2,4-D (amine or ester)
Grasses													
Barnyard grass	N	N	G	N	N	G	N	N	N	G	N	G	N
Green foxtail	N	N	G	N	N	G	N	N	N	G	N	G	N
Wild oats	G	N	P	G	N	G	G	N	N	P	G	P	N
Yellow foxtail	N	N	G	N	N	F	N	N	N	G	N	G	N
Broadleaves													
Canada thistle	N	N	G	N	G	N	N	F	P	F	N	N	F
Cocklebur	N	G	G	N	G	N	N	G	F	F	N	N	G
Common ragweed	N	G	G	N	G	N	N	G	F	F	N	N	G
Eastern black nightshade	N	G	N	N	G	N	N	G	F	F	N	N	G
Field bindweed	N	P	F	N	G	N	N	G	P	P	N	N	G
Giant ragweed	N	G	G	N	G	N	N	G	F	F	N	N	G
Kochia	N	G	G	N	G	N	N	G	F	F	N	F	G
Lambsquarters	N	G	G	N	G	N	N	G	F	G	N	F	G
Marshelder	N	G	---	N	G	N	N	G	F	F	N	P	G
Perennial sowthistle	N	N	F	N	G	N	N	F	P	F	N	N	F
Pigweed	N	G	G	N	G	N	N	G	F	G	N	G	G
Russian thistle	N	G	G	N	F	N	N	N	F	P	N	F	F
Smartweed (annuals)	N	G	G	N	G	N	N	F	P	F	N	P	F
Sunflower	N	G	G	N	G	N	N	F	G	F	N	N	G
Wild buckwheat	N	G	G	N	G	N	N	F	G	G	N	P	P
Wild mustard	N	F	G	N	P	N	N	G	P	G	N	N	G

G = good; F = fair; P = poor; N = no control; --- = inadequate information.

Effectiveness ratings apply if herbicide is used according to label recommendations as to rate, time of application, etc., and if favorable temperature and moisture conditions prevail.

Table 5. Crop tolerance and herbicide clearance[1].

Herbicides	Barley	Oats	Rye	Wheat
barban	F	—	—	F
bromoxynil	G	G	G	G
chlorsulfuron	G	G	—	G**
diallate	F	—	—	F
dicamba	P	G	—	F
diclofop	G	—	—	G
difenzoquat	G	—	—	*
MCPA amine	G	G	G	G
MCPA ester	G	G	G	G
picloram	G	G	—	G
propanil + MCPA	G	—	—	G
triallate	G	—	—	G
trifluralin	F	—	—	F
2,4-D amine	G	F	G	G
2,4-D ester	G	P	F	F

[1] P = poor; F = fair; G = good; — = not cleared for use.

* Good tolerance on winter wheat, and on spring wheat and durum wheat varieties listed on the label. Not cleared for use on other spring wheat varieties. See label.

** See label for use on Vic durum wheat.

Table 6. Herbicide names and formulations used in small grains.

Common name	Trade name	Concentration and commercial formulation[1]
barban	Carbyne, Carbyne 2EC	1 lb./gal.L, 2 lb./gal.L
bromoxynil	Buctril, Brominal ME4	2 lb./gal.L, 4 lb./gal.L
bromoxynil and MCPA	Bronate,	2 + 2 lb./gal. MCPA + bromoxynil
	Brominal Plus	3 + 3 lb./gal. MCPA + bromoxynil L
chlorsulfuron	Glean	75% DF
diallate	Avadex	4 lb./gal.L, 10% G
dicamba	Banvel, Banvel II	4 lb./gal.L, 2 lb./gal.L
dicamba + 2,4-D(amine)	Weedmaster	1 lb./gal (dicamba) + 2.87 lb./gal (2,4-D) L.
diclofop	Hoelon	3 lb./gal.L
difenzoquat	Avenge	2 lb./gal.L
MCPA	Several, mixtures	See product label.
picloram	Tordon 22K	2 lb./gal.L
propanil + MCPA (pre-mix)	Stampede CM	3 lb./gal.L (propanil) + 0.85 lb./gal.L (MCPA)
triallate	Far-Go	4 lb./gal.L, 10% G
trifluralin	Treflan	4 lb./gal.L, 10% G
2,4-D	Several	See product label.

[1] G = granular; L = liquid; DF = dry flowable.

Read the pesticide label and follow the instructions as a final authority on pesticide use.

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AG-FS-0920 Revised 1986 WEED CONTROL IN SUNFLOWERS

Agricultural Chemicals
Beverly R. Durgan
Extension Agronomist-Weeds

Cultural Methods of Weed Control

Harrowing and cultivation are important methods of weed control in sunflowers. Sunflowers normally do not emerge for ten days to two weeks after planting, so weeds frequently emerge before the sunflowers do. Many weeds can be killed by shallow tillage by a spike tooth or coil spring harrow about one week after planting. Because sunflower seedlings are strongly rooted, these implements and others such as the weeder and rotary hoe can also be used to kill weeds after the sunflowers emerge. However, the tillage implements must be properly adjusted, and tillage after sunflower emergence should be delayed until the sunflower seedlings have two or more leaves. Harrowing may normally be done several times if weeds continue to emerge and if field conditions are suitable. Weeds missed by early tillage may be controlled by cultivation between the rows. However, for adequate weed control, chemical weed control is usually necessary in addition to tillage (Table 1).

Chemical Weed Control in Sunflowers

This fact sheet summarizes chemicals for weed control in sunflowers. For additional information, refer to the product label.

Proper herbicide application and favorable soil and weather conditions are necessary for optimum herbicide performance. The soil should be dry enough to be easily worked, not wet or cloddy, to ensure maximum mixing with soil particles during preplant herbicide incorporation. Adequate soil moisture is needed to ensure good

herbicide activity. Dry conditions at the point where the germinating weed seedlings contacts the herbicide will reduce effectiveness.

There are a number of herbicides that are effective for annual grass control in sunflowers. Five of these, EPTC (Eptam), trifluralin (Treflan), fluchloralin (Basalin), ethalfluralin (Sonalan), and pendimethalin (Prowl) must be applied before planting. These herbicides should be worked into the top two to three inches of soil, twice at right angles with a disk, field cultivator, or similar implement at sufficient speed to ensure mixing the herbicide thoroughly with the soil. Trifluralin [EPTC + pendamethalin] are also labeled for late fall applications. Alachlor (Lasso) can be applied by either preplanting with shallow soil incorporation or preemergence. Preplant incorporation of alachlor has given more constant weed control. All of these grass herbicides control some broadleaf weeds such as pigweed and lambsquarter under favorable conditions.

Chloramben is primarily a broadleaf herbicide, but it also has activity on many annual grasses. Application may be preplant incorporated or preemergence. With preemergence applications, at least 0.5 inches of rainfall at least ten days after application is needed for effective weed control. Excessive rainfall can move the herbicide below the zone of weed seed germination, especially on coarse-textured soils. If a preemergence application of chloramben is followed by dry weather and weed seedlings start to emerge, then an early shallow cultivation will result in more consistent weed control.

Several of these herbicides are cleared for use in tank mixtures for preplanting incorporation use. These include: trifluralin + EPTC, trifluralin + chloramben, EPTC + chloramben, pendimethalin + chloramben,

ethalfluralin + chloramben, pendimethalin + EPTC and ethalfluralin + EPTC.

In addition, chloramben is cleared as a preemergence treatment over trifluralin, pendimethalin and ethalfluralin, and the mixture of pendimethalin and chloramben may be applied preemergence. Also, alachlor and chloramben are cleared for use as a preemergence tank mixture.

Postemergence applications of sethoxydim (Poast) will control most annual grasses including wild oat and will also suppress perennial grasses. Sunflowers have good tolerance for sethoxydim. Caution: Though registration of sethoxydim for use in sunflowers is expected for the 1986 season, it has not been received as of October 1985.

Weed identification should be the first step in effective weed control. After weeds are identified, select the best herbicide for control (Table 2). If sunflower fields have several weed species or hard-to-control weeds, a combination of two herbicides is often more effective than one (Table 1). Be sure to compare herbicide prices. Make sure you are getting the best weed control possible at the best price.

Herbicide costs can be reduced by applying herbicides in a band over the sunflower row. However, timely cultivation is then needed to control weeds between sunflower rows. Accurate calibration of your spray equipment can also help reduce herbicide costs. Under application of a herbicide is costly due to ineffective weed control. Applying more herbicide than necessary not only adds to your herbicide costs, but may also result in sunflower injury.

Wild Oat Control in Sunflowers

Tillage effectively controls many early germinating wild oat seedlings, both before and after sunflower emergence. Wild oat not controlled by tillage may be controlled with barban or sethoxydim.

CAUTION: Avoid repeated and prolonged contact with all herbicides, especially direct contact with skin and eyes. Check label directions and restrictions carefully. Avoid wind drift of herbicides to susceptible crops and ornamentals.

Table 1. Herbicides for weed control in sunflowers.

Herbicide	Active ingredient(lb/A) or (formulation/A)[1]	Time of application	Remarks
Paraquat (Ortho Paraquat + Plus/ Gramoxone)	0.5 (1 qt)	Preplant or anytime prior to crop emergence	Restricted use herbicide.
EPTC (Eptam/Genep)	2 to 3 (2.3 to 3.4 pt)	Preplant incorporated-Spring	Weak on wild mustard.
	4 to 4.5 (4.5 to 5.25 pt 7E, 40 to 45 lb 10G)	Fall incorporated after October 15 until freeze-up	Weak on wild mustard.
Trifluaralin (Treflan)	0.5 to 1 (1 to 2 pt 4E)	Preplant incorporated	No wild mustard control.
	0.5 to 1 (5 to 10 lb 10G)	Preplant incorporated, fall after September 1.	No wild mustard control.
Pendimethalin (Prowl)	1 to 1.5 (2 to 3 pt)	Preplant incorporated	Use the higher rate on fine textured soils. Do not feed treated forage to livestock. Weak on wild mustard.
Pendimethalin (Prowl) + EPTC (Eptam/Genep)	1 to 1.5 (1 to 3 pts) + 2 (2.3 pt)	Fall incorporated when soil temperature is 45° F or less.	Rate dependent on soil type. See label.
Fluchloralin (Basalin)	0.5 to 1.5 (1 to 3 pt)	Preplant incorporated	No wild mustard control. Do not feed treated forage to livestock.
Alachlor	3 (3 qt, 20 lb 15G)	Preplant incorporated or preemergence	Weak on wild mustard. Do not graze or feed forage.
Chloramben (Amiben)	2 to 3 (several formulations)	Preplant incorporated or preemergence	Inconsistent wild mustard control. Do not graze or feed treated forage.
Ethalfluralin (Sonalan)	0.57 - 1.12 (1-1/2 - 3 pts/A)	Preplant incorporated	Do not graze or feed forage. No wild mustard control. May carryover to next year's crop. See label for re-cropping restrictions.

Table 1. (continued)

Herbicide	Active ingredient(lb/A) or (formulation/A)[1]	Time of application	Remarks
Chloramben (Amiben) + other herbicides	2 + appropriate rate of other herbicide	Preplant incorporated or preemergence	Other herbicides include EPTC, pendimethalin, trifluralin, alachlor, and ethalfluralin. Do not feed treated forage to livestock.
Barban (Carbyne)	0.375 (1.5 pt of 2 EC)	When wild oat is in the two-leaf stage but within 30 days after sunflower emergence.	Apply in 5-10 gallons of water/A using sufficient pressure (min. 45 psi) to break spray to small droplets. Do not let livestock graze treated fields until after harvest.
Sethoxydim (Poast)	0.1 - 0.4 (0.5 - 2.0 pt)	Postemergence	Clearance expected but not received as of October 1985. Always apply with oil concentrate at 1 qt/A.
Paraquat (Ortho Paraquat + Plus/ Gramoxone)	0.25 to 0.5 (0.5 to 1 qt)	For use as a desiccant. Apply when back side of sunflower heads are yellow and bracts turning brown.	Use on oilseeds only. Apply with X-77 at 0.25% v/v. Restricted use herbicide.
Sodium Chlorate (Several suppliers)	4.5 to 6 (1.5 to 2 gal)	For use as a desiccant. Apply when back side of sunflower heads are yellow and bracts are turning brown.	For use on confectionary and oilseed varieties. Thorough coverage of plant is essential.

[1] Use the low rate for coarse textured soils, intermediate rate for medium textured soils, and high rate for fine textured soils.

Table 2. Effectiveness of herbicides for weed control in sunflowers.[1]

	Alachlor (Lasso)	Barban (Carbyne)	Chloramben (Amiben)	EPTC (Eptam/Genep)	Ethalflura (Sonalar
Type of Application[2]:	PRE/PPI	POST	PRE/PPI	PPI	PPI
Sunflower tolerance	G	G	G	G	G
Grasses					
Giant foxtail	G	N	G	G	G
Green and yellow foxtail	G	N	G	G	G
Wild oats	P	G	P	F	F
Broadleaves					
Cocklebur	N	N	P	P	N
Common lambsquarters	F	N	G	F	G
Common ragweed	P	N	G	F	N
Kochia	P	N	G	F	G
Pigweed sp.	G	N	G	F	G
Smartweed sp.	P	N	G	P	P
Wild mustard	P	N	F	P	N

[1] G = Good, F = Fair, P = Poor, N = No control.
[2] PRE = Preemergence, PPI = Preplant incorporated, POST = Postemergence.

Table 3. Herbicide names and formulations used in sunflowers.

Common Name	Trade Name	Concentration and Commercial Formulations[1]
Alachlor	Lasso	4 lb/gal L, 15% G
Barban	Carbyne	1 or 2 lb/gal L
Chloramben	Amiben	1.8 lb/gal L, 10% G, 75% DS
EPTC	Eptam/Genep	7 lb/gal L, 10% G
Ethalfluralin	Sonalan	3 lb/gal L
Fluchloralin	Basalin	4 lb/gal L
Paraquat	Ortho Paraquat+Plus/Gramoxone	2 lb/gal L
Pendimethalin	Prowl	4 lb/gal L
Sethoxydim	Poast	1.5 lb/gal L
Sodium Chlorate	Several	3 lb/gal L
Trifluralin	Treflan	4 lb/gal L, 10% G

[1] L = Liquid, G = Granular, DS = Dry Soluble

Read the pesticide label and follow the instructions as a final authority on pesticide use.

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AG-FS-0922 Revised 1985
AGRICULTURAL CHEMICALS

WEED CONTROL IN ESTABLISHED ALFALFA AND OTHER FORAGE LEGUMES

BEVERLY R. DURGAN,
Extension Agronomist-Weeds

Minnesota has approximately three million acres of alfalfa, alfalfa-grass mixtures, or other forage legumes that are used primarily as livestock feed. Approximately one-third of these "hay-crop" acres are reestablished each year, partly because weeds take over and the stands become unproductive or produce low quality feed. Controlling weeds in forage crops does not always increase total dry matter production; however, most weeds are less palatable and provide a less dependable feed supply than adapted forage species. Controlling weeds usually results in improved forage quality and higher protein levels if good forage production practices are used. Weed control also may prolong the productive life of the alfalfa stand by preventing competitive weeds such as quackgrass from crowding out the alfalfa.

Alfalfa often has been suggested as a rotational crop to help control certain problem weeds. Established stands of forage legumes can compete effectively with many weeds. If alfalfa is to compete well with weeds, however, it is important to establish a stand of at least 20 plants per square foot in the seedling year by using effective establishment practices. Then good management practices should be followed to maintain a competitive forage stand.

Many weeds in established legumes can be controlled by harvesting the crop before the weeds flower in order to prevent weed seed formation and dispersal.

Cultural Practices for Weed Control in Forages

1. Before seeding alfalfa or other forage legumes, apply lime and fertilizer according to soil test needs.

2. Seed adapted varieties at the proper depth into a firm, level seed bed to help ensure good germination and seedling survival.

3. Use a timely and proven method of forage legume seeding and establishment. Direct seeding in the spring with an herbicide(s) or in the late summer without an herbicide has produced better legume stands than spring seeding with a companion crop.

4. Maintain a cutting/grazing schedule that allows adequate regrowth and recovery of the stand, consistent with the need for harvesting good quality forage.

Herbicides for Weed Control in Established Forage Legumes

Many of the biennial or perennial broadleaf weeds that are troublesome in alfalfa are deep rooted and similar to alfalfa in growth habit. These weeds are difficult to control with herbicides without injury to the alfalfa. On the other hand, quackgrass and other grass weeds that invade alfalfa are shallow rooted and are morphologically different enough from alfalfa so that control with herbicides is more feasible. However, the herbicides that control quackgrass also injure or kill most perennial forage grasses as well as the weedy grasses.

The herbicides available to control weeds in established alfalfa are simazine (Princep), metribuzin (Sencor/Lexone), terbacil (Sinbar), pronamide (Kerb), hexazinone (Velpar), 2,4-DB (Butyrac, Butoxone), and certain formulations of MCPA (table 1). All of these except 2,4-DB are cleared for use only when the alfalfa is dormant or after the last cutting in the fall (see table 1) and all may cause alfalfa injury. Simazine should not be used on sands, loamy sands, or other coarse textured soils, or on soils where the soil pH is higher than 7.5. Metribuzine (Sencor/Lexone) may be used at varying rates on alfalfa/grass mixtures to control some broadleaf weeds and the amount of grass in the stand. Terbacil (Sinbar) should not be used on sand, loamy sand, gravely soils, or soils with less than 1 percent organic matter,

or crop injury may result. Hexazinone (Velpar) should not be used on sands, poorly drained or exposed subsoil areas.

All of these herbicides (simazine, metribuzin, terbacil, and hexazinone) should be used only on alfalfa stands established for at least one year. Pronamide (Kerb) will control annual grasses and suppress quackgrass the following year, when applied in the fall, if soil moisture conditions are favorable. Some formulations of MCPA are cleared for fall application (when alfalfa is dormant) to control certain winter annual, biennial, or perennial weeds whose "winter rosettes" are still actively growing. There is considerable potential for alfalfa injury. 2,4-DB (Butyrac/Butoxone) is effective for control of only a few broadleaf weeds if applied when the weeds are small (one to three inches tall) and should be applied only when day-time temperatures range between 40° and 90°F.

Some troublesome perennial weeds cannot be adequately controlled with herbicides in established alfalfa or other forage legumes. Many of these weeds, however, can be controlled with glyphosate (Roundup), see table 2, prior to seeding the legumes.

For effective control, glyphosate must be applied as a spray on at least 6 to 8 inches of topgrowth of actively growing perennial weeds. The field may be tilled and seeded three or more days later. Because individual weeds species differ in their response to various herbicides, the first step in effective weed control with herbicides is to identify the weed problem(s). Then select the best herbicide or herbicide combination to use (tables 1 and 2). Refer to and follow herbicide labels for more information.

Table 1. Herbicides for weed control in established alfalfa and other forage legumes.

Crop(s)	Herbicide	Pounds per acre of active ingredient or acid equivalent broadcast	Time of application	Remarks	Environmental Protection Agency limitations on crop use
Alfalfa[1]	Simazine (Princep)	0.8 to 1.6	Fall, after last cutting. Prior to soil freeze-up.	May injure alfalfa. May carry over to injure next year's crop if other than corn.	Do not graze for 30 days or cut hay for 60 days after treatment.
Alfalfa[1]	Metribuzin (Sencor/Lexone)	0.35 to 1.0	Late fall or early spring when alfalfa is dormant.	May injure alfalfa.	Do not graze or harvest within 28 days of treatment.
Alfalfa[1]	Terbacil (Sinbar)	0.50 to 1.5	Late fall or early spring when alfalfa is dormant.	May injure alfalfa. Do not plant other crops within 2 years after treatment.	None
Alfalfa, clover, birdsfoot trefoil, or crownvetch	Pronamide (Kerb)	1.0 to 2.0	Fall, when soil temperatures are less than 60°F, but before freeze-up.	May injure alfalfa.	Do not graze or harvest alfalfa within 25 to 45 days after treatment, depending on rate used. Do not graze or harvest other forage legumes for 120 days after treatment. See label.
Alfalfa[1]	Hexazinone (Velpar)	0.5 to 1.5	Late fall or early spring when alfalfa is dormant, or after cutting during the season but before alfalfa regrowth.	May injure alfalfa. Moisture needed to activate herbicide. Influenced by soil type.	Do not graze or feed treated alfalfa for 30 days after treatment.
Alfalfa	MCPA[2]	1/4 to 1/2	Fall, after last cutting, when alfalfa is dormant.	Treat when temperatures are higher than 40°F. May injure alfalfa.	None
Alfalfa	2,4-DB amine	0.5 to 1.5	When annual broadleaf 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 of treatment.
Alfalfa	2,4-DB ester	0.5 to 1.0		May injure alfalfa.	

[1] Alfalfa should be established for one year or more.
[2] Certain formulations only, see label.

Table 2. Effectiveness of herbicides on major weeds in established alfalfa[1].

	Growth habit	Simazine	Metribuzin	Terbacil	Pronamide	2,4-DB	MCPA	Glyphosate	Hexazinone
Alfalfa tolerance		F	F	F	G	F	P	N	F
Grasses									
Quackgrass		F	P	P	S	N	N	G	S
Wirestem muhly		F	P	P	S	N	N	G	S
Broadleaves									
Bull thistle	biennial	F	F	F	P	F	F	G	N
Canada thistle	perennial	P	P	P	N	P	P	G	N
Common dandelion	perennial	P	F	F	N	P	P	G	S
Curly dock	perennial	P	F	P	N	P	P	G	F
Field pennycress	winter annual	G	G	G	P	G	G	G	G
Hemp dogbane	perennial	P	P	P	N	N	P	F	N
Hempnettle	perennial	N	N	N	N	N	N	F	N
Hoary alyssum	perennial	F	P	P	N	P	P	G	F
Narrowleaf hawksbeard	annual	P	P	P	N	N	P	F	P
Orange hawkweed	perennial	P	P	P	N	N	P	F	N
Oxeye daisy	perennial	P	P	P	N	N	P	F	N
Perennial sowthistle	perennial	P	N	N	N	P	P	G	N
Shepherd's-purse	winter annual	G	G	G	P	G	G	G	G
Spotted knapweed	biennial or perennial	F	F	F	P	F	P	G	N
Tansy	perennial	N	N	N	N	N	N	F	N
Virginia pepperweed	winter annual	G	G	G	P	G	G	G	G
White cockle	perennial	F	F	F	N	P	P	G	S
Yellow rocket	winter annual or biennial	F	F	F	N	P	F	G	G

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

[1] Effectiveness ratings apply if herbicide is used according to label recommendations as to rate, time of application, etc., and if favorable temperature and moisture conditions prevail.

Read the pesticide label and follow the instructions as a final authority on pesticide use.

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HERBICIDES

This is a listing of some herbicides now sold for major crop use in Minnesota. The application rate refers to pounds of active ingredients or acid equivalent per acre on a broadcast basis. The information given is not intended to replace label instructions; follow label instructions closely. Refer to Agricultural Extension Service, University of Minnesota, fact sheets and folders on weed control by crop and to product labels for additional information.

Acifluorfen (Blazer) - Rohm and Haas

Use--Control of many annual broadleaf weeds in soybeans, including eastern black nightshade. Mixtures with bentazon (Basagran), chloramben (Amiden), fluazifop (Fusilade) and sethoxydim (Poast) are labeled. These mixtures will control more species of weeds than each chemical alone.

Rate of application--1/4 to 3/4 pound per acre.

Time of application--Postemergence; acifluorfen effectively controls most annual broadleaf weeds in soybeans when applied before the weeds exceed the four (4) true-leaf stage. Weeds treated after they exceed the maximum size listed on the herbicide label will not be adequately controlled. Top growth will die, but in most cases regrowth will occur from the roots or lower stems of larger established broadleaf weeds.

Remarks--Rain or irrigation within six (6) hours of application may reduce the effectiveness of acifluorfen. Hot and humid weather increases the effectiveness of acifluorfen. The herbicide should not be applied when recent daytime temperatures are below 70 degrees F.

Acifluorfen may cause minor temporary injury to treated soybean leaves. The injury will appear as a speckled yellowing, and/or crinkling of the treated leaves. The herbicide does not affect subsequent growth. Actively growing soybeans usually recover quickly.

Formulation--2 pounds per gallon liquid. The 2S formulation includes a surfactant. The 2L formulation does not contain a surfactant. Follow the label instructions for adding a surfactant or oil concentrate.

Alachlor (Lasso, Lasso II) - Monsanto

Use--Annual grass, pigweed, nightshade and nutsedge control in corn, dry beans, potatoes, sunflowers and soybeans; some broadleaf control. Use in preemergence mixtures with atrazine, cyanazine, dicamba, simazine, or linuron on corn; with linuron, chloropropham, bifenox, dinoseb, dinoseb + naptalam, chloramben or metribuzin on soybeans; and preplanting with trifluralin on dry beans. Used in minimum tillage corn with paraquat or glyphosate and atrazine, cyanazine, or simazine. In minimum tillage soybeans with glyphosate or paraquat and metribuzin or linuron.

Rate of application--2 to 4 pounds per acre on corn and soybeans, 2 to 3 pounds per acre on dry beans, and 3 to 4 pounds per acre on sunflowers in the liquid formulation.

--2.4 to 3.9 pounds per acre in the granular formulation on corn or soybeans.

Time of application--preplanting or preemergence; preplanting preferred for nutsedge control. Can be used with atrazine on corn up to the time corn is 5 inches tall or with dicamba until corn is 3 inches tall and weeds reach the 2-leaf stage. Postemergence treatments should not be applied with fluid fertilizer. Preplanting or preemergence applications may be applied with fertilizer solutions.

Remarks--Research results show good control of annual grasses, nutsedge, nightshade, pigweed, and fair lambsquarters control. Control of other broadleafs is not consistent. Alachlor alone or with atrazine can be applied with center pivot irrigation for corn. Adzuki beans are very susceptible to injury from alachlor.

Formulation--Lasso--4 pounds per gallon liquid.
Lasso II--15 percent granules
Lasso + atrazine--2.5 + 1.5 pounds per gallon dispersible liquid.

Ametryne (Evik) - Ciba-Geigy

Use--Annual weed control in corn.

Rate of application--1 1/2 to 2 pounds per acre.

Time of application--Postemergence directed after corn is at least 12 inches tall. Do not apply later than 3 weeks before tasseling.

Remarks--Care must be taken to avoid contact with corn leaves. A surfactant should be added. This is usually considered an emergency treatment. May be used for wild proso millet control when corn is more than 12 inches tall and millet is less than 4 inches tall.

Formulation--80 percent wettable powder.

Atrazine (AAtrex and several other trade names) - Ciba-Geigy, Shell and others

Use--Weed control in corn, sorghum, and proso millet. Effective in controlling quackgrass with a fall and/or early spring application followed by plowing. Only corn can be planted following treatment. Used in mixtures with alachlor, dicamba, cyanazine, pendimethalin, glyphosate, linuron, metolachlor, paraquat, simazine or propachlor and with butylate or EPTC plus crop protectant on corn.

Rate of application--(1) Weed control in corn: 1.2 to 3.0 pounds per acre. Use higher rate on fine-textured soils or soils with high organic matter. (2) Weed

control in sorghum: 2 to 3 pounds per acre. (3) Quackgrass control: 3 to 4 pounds per acre; a split application of 2 pounds per acre in the fall before plowing and 2 pounds per acre in the spring works best on quackgrass. (4) Weed control in proso millet: 1/2 to 2 pounds per acre.

Time of application for weed control in corn and sorghum--Preemergence or preplant in corn and postemergence in corn and sorghum before grasses are 1-1/2 inches or broadleaf weeds are 4 inches tall. Atrazine is cleared for use on corn up to layby-stage (about 30 inches tall) of the corn. Addition of emulsifiable petroleum or vegetable oils has improved performance of postemergence atrazine sprays on corn. Various formulations of surfactants and detergents used with atrazine have not improved weed control as much as the use of oils. Apply preplanting or preemergence for weed control in proso millet.

Remarks--Susceptible crops have been injured in rotation following treated crop. To minimize injury to susceptible crops following corn, use the lowest rate consistant with good weed control; use band applications rather than broadcast applications and thoroughly till soil before planting susceptible crops. Cool temperatures can increase the possiblility of corn injury. Do not graze or feed treated corn or sorghum for 21 days after postemergence application.

Formulation--80 percent wettable powder, 4 pounds per gallon dispersible liquid, 90 percent water dispersible granule.

Barban (Carbyne) - Velsicol

Use--Control of wild oat in wheat, barley, flax, soybeans, sugarbeets, sunflowers and peas.

Rate of application--1/4 to 3/8 pound per acre on wheat, barley, and flax; 3/4 to 1 pound per acre on sugarbeets; 3/8 pound per acre on sunflowers and soybeans.

Time of application--Postemergence, when most wild oat are in 2-leaf stage (from the time the second leaf first appears until the third leaf first appears). Time of application is critical. Spray peas before the 6-leaf stage, flax before the 12-leaf stage, and within 30 days of emergence of sugarbeets, sunflower, mustard, and soybeans. Sequential applications (2 sprays of barban) each at 1/4 pound per acre may be made to barley and wheat. Make the first application when the majority of the wild oat are in the 2-leaf stage. The second application (if needed) may be made when the second flush of wild oat are in the 2-leaf stage. If the first application is missed, a single application of 1/2 pound per acre may be made in the 2-1/2 to 3-1/2-leaf stage. Barban is labeled for tank mixing with bromoxynil, chlorsulfuron, diclofop and difenzoquat in wheat and barley.

Remarks--Flax and small grain injury sometimes occurs; injury on flax has been more severe. Observe feeding restrictions on label. Do not spray when plants are wet with dew or rain. Spray only when crop is actively growing and not under stress.

Formulation--2 pounds per gallon liquid.

Benefin (Balan) - Elanco

Use--Annual grass control in seedling legumes.

Rate of application--1-1/8 to 1-1/2 pounds per acre.

Time of application--Preplanting. (Do not apply after seeding)

Remarks--Must be incorporated into soil by disking in two different directions before planting. May be mixed with fluid fertilizers.

Formulation--1-1/2 pounds per gallon liquid.

Bentazon (Basagran) - BASF

Use--Control of most annual broadleaf weeds, inluding hairy nightshade, Canada thistle, and nutsedge in soybeans, corn, dry or succulent edible beans and peas; in a mixture with atrazine for postemergence use in corn; mixtures with acifluofen (Blazer) and sethoxydim (Poast) are labeled for soybeans.

Rate of application--3/4 to 1-1/2 pounds per acre in soybeans and corn; 3/4 to 1 pound per acre in dry and succulent edible beans and peas. Lower rates are for small, susceptible weeds; higher rates are for larger or more tolerant weeds. Oil concentrate at 1 quart/A can be used in all labeled crops except peas when ground application equipment is used.

Time of application--Postemergence bentazon is most effective when the weeds are in the 2- to 4-leaf stage. Soybeans, dry beans, snap and green beans usually have the first to second trifoliolate leaf when the weeds are at the correct size for treatment. Corn is tolerant at all stages, but is usually sprayed when corn has 1 to 5 leaves. To improve control of lambsquarters and pigweed in corn, a postemergence mixture of bentazon, atrazine and oil concentrate can be used. Peas may be treated after 3 pairs of leaves (4 nodes) are present. Do not apply to crops growing under stress such as drought, cold weather, or previous herbicide injury. On thistle and nutsedge, treat when the weeds are 8 to 12 inches and apply a second application 10 days after the first if needed. Do not apply more than a total of 2 pounds of bentazon per acre in one crop year.

Remarks--Rain or irrigation within 24 hours after application may reduce the effectiveness of bentazon. Weed control has been more consistent from applications made during the day than from early morning, late evening, or night applications. Applications made when plants are dry are more effective.

Formulation--4 pounds per gallon liquid.

Bifenox (Modown) - Rhone-Poulenc

Use--Control of some annual broad-leaved weeds in soybeans. May be used alone or as a preemergence application after trifluralin, or in a preemergence mixture with alachlor.

Rate of application--1.6 to 2 pounds per acre.

Time of application--Preemergence.

Remarks--Soybean tolerance is limited and malformation and stunting of young soybeans often occur. Grass control has been inconsistent. Do not apply after soybeans start emerging.

Formulation--80 percent wettable powder, 4 pounds per gallon liquid.

Bromoxynil (Brominal, Brominal-4E, Buctril) - Union Carbide, Rhone-Poulenc

Use--Annual broadleaf control in corn, wheat, barley, oats, rye, flax, and newly planted grasses for sod and seed production. Used in mixture with MCPA ester in wheat, barley, and oats. This mixture may be tank-mixed with difenzoquat (Avenge) to control wild oats or diclofop (Hoelon) to control annual grasses and broadleafs in wheat and barley. Mixtures with atrazine or 2,4-D are labeled in corn.

Rate of application--1/4 to 1/2 pound per acre; 1/4 pound per acre in mixture with MCPA at 1/4 pound per acre.

Time of application--From 2-leaf to early boot stage of wheat, oats, or barley. When corn is less than 14 inches tall. When flax is 2 to 8 inches tall. Early applications more effective on weeds. Treat broadleafs before the 5-leaf stage. Do not treat flax in humid weather or when temperature is over 80 degrees F.

Remarks--Controls wild buckwheat and smartweed better than MCPA or 2,4-D. Does not control perennials but may burn Canada thistle shoots. Injures legumes. Some small grain and corn leaf burn has occurred at higher rates.

Formulation--2 or 4 pounds per gallon liquid. Formulations of 2 or 3 pounds per gallon of bromoxymil + 2 or 3 pounds per gallon of MCPA ester are available (Brominal Plus, Brominal 3+3, Bronate).

Butylate (Sutan +) - Stauffer

Use--Control of annual grasses and nutsedge in corn. Used in mixtures with atrazine or cyanazine for annual grass and broadleaf control. A three-way mixture with atrazine and cyanazine is labeled.

Rate of application--3 to 6 pounds per acre.

Time of application--Preplanting, fall preplanting between Oct. 1 and Nov. 15.

Remarks--Must be incorporated into the soil. Proper incorporation can be accomplished by disking field twice, once in each direction, immediately after applying chemical. Sutan + contains a chemical additive to prevent corn injury. can be applied alone or with atrazine or cyanazine with dry bulk or fluid fertilizer. Sutan + is labeled for use in center pivot irrigation systems.

Formulation--6.7 pounds per gallon liquid, 10 percent granular, 4.8 pounds butylate plus 1.2 pounds atrazine per gallon liquid (Sutazine).

Chloramben (Amiben) - Union Carbide

Use--Preplanting and preemergence control of annual broadleaf weeds and annual grasses in soybeans, sunflowers, and dry edible beans, including adzuki beans. Postemergence applications can be made to soybeans up to the second trifoliolate leaf stage. Chloramben is labeled for tank mixing with trifluralin, ethalfluralin, pendimethalin, vernolate, linuron, alachlor, dinoseb, metribuzin, metolachlor, and 2,4-DB.

Rate of application--1.8 to 2.7 pounds per acre preplanting or preemergence; 2-1/4 to 2.7 pounds per acre postemergence. For wild proso millet control, chloramben may be applied preplant incorporated at 1.8 to 2.7 lb/A followed by a postemergence application of 1.8 to 2.7 lb/A, when soybeans are in the cotyledon to second trifoliolate stage, but before emergence of wild proso millet.

Time of application--Preemergence, preplant incorporated, or postemergence on soybeans up to the second trifoliolate leaf stage of soybeans.

Remarks--Chloramben must be moved into the soil by rainfall or incorporated before weeds sprout to be effective. Incorporated treatments result in improved weed control under dry conditions, however, preemergence applications are more effective when rainfall occurs soon after application. Excessive moisture may leach chloramben below the zone of weed seed germination. This is particularly true in coarse textured (sandy) soils. Chloramben may be applied early postemergence from the cracking to second trifoliolate stage of soybeans.

Early stunting of soybeans has been observed under some conditions, but the crop usually outgrows the injury. Chloramben is cleared for use on corn at 0.9 to 1.8 pounds per acre, but experiment station tests showed a definite injury potential to corn and erratic weed control at these rates. Severe stunting of corn occurred in some fields following heavy rains.

Formulation--1.8 pounds per gallon liquid; 10 percent granule; 75 percent DS (dry soluble)

Chlorpropham (Furloe) - PPG

Use--Annual smartweed control in soybeans.

Rate of application--2 to 3 pounds per acre.

Time of application--Preemergence or preplanting.

Remarks--May be used preplanting in mixtures with alachlor, paraquat, trifluralin, or vernolate. Does not control weeds other than annual smartweed.

Formulation--4 pounds per gallon liquid.

Chlorsulfuron (Glean) - DuPont

Use--Control of most broadleaf and several grass weeds in wheat and barley and spring oats.

Time of application--Preemergence or postemergence, but early postemergence use of chlorsulfuron plus a surfactant appears to be the most effective method of application in Minnesota.

Remarks--Chlorsulfuron is a very active herbicide. Rates of 1/8 to 1/2 ounce/A of the 75 percent dry flowable formulation are effective in controlling many common small grain weeds. Chlorsulfuron persists in high pH soils and causes injury to broadleaf crops following in the rotation. Chlorsulfuron is not labeled for use in soils with a pH above 7.5. A test strip of rotational crops must be successfully grown to maturity in the year prior to the production year. See label before using.

Formulation--75 percent dry flowable, water dispersible, granule.

Cyanazine (Bladex) - Shell

Use--Annual grass and broadleaf control in corn. Preemergence with atrazine, pendimethalin (Prowl), paraquat, metolachlor (Dual), or alachlor (Lasso). Preplanting with alachlor (Lasso), metolachlor (Dual), butylate (Sutan +), or EPTC (Eradicane). Used for minimum tillage corn with paraquat. Used preemergence on grain sorghum in mixtures with propachlor.

Rate of application--1.25 to 4.75 pounds per acre depending on soil texture and organic matter, 0.6 to 3.0 pounds per acre with alachlor, butylate, EPTC (Eradicane), or metolachlor.

Time of application--Preplanting, preemergence, or postemergence on corn through the 4-leaf stage and before weeds exceed 1-1/2 inches. For postemergence, use only the 80 percent wettable powder or 90 percent dry flowable, not the 4 pounds per gallon liquid dispersible formulation.

Remarks--Do not add petroleum oils to postemergence applications or severe corn injury may result. When applied postemergence under droughty or arid conditions, certain surfactants or emulsifiable vegetable oils may be used with the wettable powder formulation, but under moist conditions, these additives may cause severe corn injury. Can be applied preemergence with fluid fertilizer or through center pivot irrigation systems. Cool temperatures, rain, or dew can increase potential for injury.

Formulation--80 percent wettable powder, 4 pounds per gallon dispersible liquid, 15 percent granule, 90 percent dry flowable water dispersible granule.

Cycloate (Ro-neet) - Stauffer

Use--Annual grass, nutsedge, and broadleaf control in sugarbeets.

Rate of application--3 to 4 pounds per acre.

Time of application--Preplanting; fall or spring.

Remarks--Must be incorporated immediately and thoroughly, tillage tool should be operated 4 to 6 inches deep to incorporate to a depth of 2 to 3 inches.

Formulation--6 pounds per gallon liquid, 10 percent granules.

2,4-D - (Various trade names and manufacturers)

Use--Broadleaved weed control in corn, small grains, and grass pastures. Mixtures with dicamba are labeled.

Rate of application--Corn and small grains: 1/6 to 1 pound per acre depending on formulation used, method of application, the size and kinds of weeds, weather conditions, and stage of crop growth. See label. Grass pastures: 1 to 2 pounds per acre depending on kind of weeds to be controlled.

Time of application--Postemergence. Corn--4 inches to tasseling or after dough stage. Use drop nozzles after corn is 8 inches tall. Wheat and barley--5th leaf to early boot; oats--6th leaf to early boot; pastures--spring or fall when weeds are actively growing.

Remarks--Do not graze dairy cattle for 7 to 14 days after treatment of pastures with 2,4-D (see label).

Formulation--Liquids of various concentrations.

Dalapon (Dowpon M, Dalapon-85)- Dow

Use--Grass control in flax and sugarbeets. Quackgrass control in the fall before planting corn, potatoes, dry beans, or sugarbeets in the spring.

Rate of application--(1) Flax: 3/4 pound per acre. May be tank-mixed with 1/4 pound per acre of MCPA on flax. (2) Sugarbeets: 2 to 3-1/2 pounds per acre. (3) 6 to 11 pounds per acre for fall quackgrass control.

Time of application--(1) Flax and sugarbeets: when grasses are not more than 2 inches tall. Postemergence until sugarbeets reach 6-leaf stage, directed from 7-leaf stage until beets are 14 inches. (2) For quackgrass control, apply on growing quackgrass; plow 10 days later.

Remarks--Adding a surfactant to the dalapon spray mix improves wetting and improves grass control.

Formulation--74 percent water soluble powder.

2,4-DB (Butoxone, Butyrac 200) - Vertac, Union Carbide

Use--Broadleaved weed control in seedling stands of alfalfa, birdsfoot trefoil, and clovers and established stands of alfalfa. Cocklebur control in soybeans. 2,4-DB is labeled for postemergence use with naptalam and as directed sprays with linuron and metribuzin in soybeans.

Rate of application--1/2 to 1-1/2 pounds amine and 1/2 to 1 pound ester per acre on forage legumes. 1/5 pound amine per acre on soybeans.

Time of application--Postemergence when seedling legumes have 1 to 4 trifoliolate leaves and weeds less than 3 inches tall or on established legumes in the fall when weeds are less than 3 inches tall. For cocklebur control in soybeans, apply as a directed spray when soybeans are 8 to 12 inches high and cocklebur no more than 3 inches tall.

Remarks--Do not spray drought stressed soybeans or soybeans that show symptoms of phytophthora root rot disease. Do not apply when extreme temperatures are expected within 2 to 3 days. Observe grazing and time of harvest precautions on the label.

Formulation--1.75 or 2 pounds per gallon liquid.

Desmedipham (Betanex), Desmedipham + Phenmedipham (Betamix) - Nor-Am

Use--Annual grass and broadleaf control in sugarbeets, less effective on grasses. Desmedipham is more effective on redroot pigweed than the mixture of desmedipham + phenmedipham.

Rate of application--1 to 1-1/4 pounds per acre of total active ingredient.

Time of application--Early postemergence after sugarbeets have four true leaves. Weeds should not have more than four true leaves for best control.

Remarks--Applications of desmedipham and phenmedipham following preplanting EPTC or preemergence TCA have sometimes resulted in sugarbeet injury. To reduce injury do not use more than 1 pound per acre where preplanting or preemergence herbicides have been used and do not apply if highest temperature expected during the day exceeds 85 degrees F. If temperatures are approaching this limit, application in the late afternoon will decrease injury potential. Split applications (use of a half-rate followed in 5 to 7 days by a second half rate) have reduced sugarbeet injury and improved weed control compared to a single

application at the full rate. Rainfall within 6 hours after spraying may reduce weed control.

Formulation--1.3 pounds per gallon liquid.

Diallate (Avadex) - Monsanto

Use--Control of wild oats in alfalfa, barley, flax, sugarbeets, potatoes, soybeans, forage legumes, corn, lentils, and peas.

Rate of application--1-1/4 pounds per acre barley; 1-1/2 to 2 pounds per acre on other crops.

Time of application--Preplanting on flax or sugarbeets; postseeding (pre-emergence) on barley. Fall application is a possibility before sugarbeets. Granules may be used in fall, but are not recommended for spring.

Remarks--Quite volatile and must be incorporated soon after application. Incorporated preplanting applications with disk, cultivator, or harrow to a depth of 2 inches. In postseeding applications, incorporate chemical with two harrowings at right angles. Barley injury has been observed, particularly with preplanting application. Do not apply to field in ridged condition. This chemical irritates skin and eyes; use caution when handling. Diallate may persist in the soil enough to affect tame oats planted the next year.

Formulation--4 pounds per gallon liquid, 10 percent granules.

Diallate is a restricted use herbicide and can be applied only by a certified applicator. Adhere to ALL label directions concerning safe handling and use of this herbicide.

Dicamba (Banvel, Banvel II) - Velsicol

Use--Postemergence control of most broadleaved weeds except wild mustard in wheats, oats, corn, and grass pastures. Especially useful for controlling wild buckwheat and smartweed in wheat and oats. Can be used preemergence with alachlor or metolachlor, or as an overlay treatment until corn is 5 inches tall following butylate, EPTC +, alachlor, metolachlor, propachlor, atrazine, cyanazine or pendimethalin. May be applied postemergence on corn with 2,4-D or atrazine. No oil or surfactants should be added to postemergence applications.

Rate of application--1/8 pound per acre with MCPA at 1/4 pound per acre in wheat and oats; 1/4 to 1/2 pound per acre alone or with 2,4-D in corn; 1/4 to 8 pounds per acre in grass pastures; 1/4 to 1/2 pound per acre with alachlor preemergence on corn.

Time of application--From 2- to 5-leaf stage of wheat and oats. Up to time corn is 3 feet tall and not within 15 days of tasseling. Application made too close to tasseling can cause barren ears. When perennial broadleaf weeds are 8 to 12 inches tall and up to bud stage in grass pastures.

Remarks--Can be combined with MCPA in wheat and oats or with 2,4-D in corn and wheat for control of mustard and other broad-leaved weeds. If used in pastures, observe grazing restrictions on label. Do not mix additives with dicamba or crop injury may result. Do not apply preemergence on sandy soils or soils with less than 2 percent organic matter. Avoid spray or vapor drift to nearby susceptible broadleaf crops. Considerable drift injury has occurred in soybeans. To prevent drift, follow the application instructions on the label. Apply in 20 gallons or more water per acre; set pressure at 20 psi or less; do not apply to corn when soybeans in the area are over 10 inches tall; do not use on a day the temperature is expected to be over 85 degrees F.; apply when wind is less than 5 mph; do not apply after corn is 3 feet tall; use drop nozzles when possible.

Formulation--2 or 4 pounds per gallon liquid; 5 percent granules; commercial combination with 2,4-D is available.

Diclofop (Hoelon) - American Hoechst

Use--Annual grass control in soybeans, wheat, and barley, including wild oat and volunteer corn.

Rate--3/4 to 1-1/4 pounds per acre for wheat and soybeans
--3/4 to 1 pound per acre for barley

Time of application--Diclofop effectively controls many annual grasses including wild oat and volunteer corn in fall and spring seeded wheat, spring seeded barley, and soybeans. Annual grasses including wild oat can be controlled with diclofop up to the 4-leaf stage. Use 1-1/4 pounds of diclofop per acre when the weeds have 3 to 4 leaves, lower rates when the weeds have 3 or fewer leaves. Treat yellow foxtail and crabgrass before they reach the 3-leaf stage. Volunteer corn should be treated after the corn plants have emerged, but before the tallest corn plants exceed 10 inches in height.

The time of diclofop application also depends on the crop. Fall and spring seeded wheat should not be treated after the 4-leaf stage. Spring seeded barley should not be treated after the 3-leaf stage. Injury may result from applications made after the crop exceeds the maximum labeled leaf stage. Soybeans should be treated before the formation of the sixth trifoliolate leaf. Diclofop is most effective when applied to weeds that are growing rapidly. Weed control may be reduced if treatment is made under dry soil conditions, or when weather conditions are otherwise not favorable for rapid growth.

Remarks--Can be combined with bromoxynil in wheat and barley, or chlorsulfuron in winter wheat only. Do NOT tankmix diclofop with any other pesticide and do NOT apply diclofop within 7 days of the application of any other pesticide. The presence of another pesticide in the tank or on the leaves of treated weeds may reduce the effectiveness of diclofop. Do not apply more than one application of diclofop in a growing season.

Diclofop is a restricted-use pesticide and can be applied only by a certified applicator. Adhere to ALL label requirements concerning safe handling and use of this herbicide.

Formulation--3 pounds per gallon liquid.

Diethatyl (Antor)

Use--Control of pigweed and some annual grasses in sugarbeets.

Rate of application--4 to 6 pounds per acre.

Time of application--Preplanting incorporation or preemergence.

Remarks--Shallow incorporation (1 to 2 inch) gives best results.

Formulation--4 lbs. per gallon liquid.

Difenzoquat (Avenge) - American Cyanamid

Use--Controls wild oat in all varieties of barley and all winter wheat varieties except Borah, WS1877, WS 1809, WS 1859, Klasic and Probrand 771, all varieties of durum wheat except Lakota, Wascona, Vic and Edmore, and the spring wheat varieties of Butte, Era, Fortuna, Kitt, Olaf, Solar, Coteau, Walera and Probrand 771. Do not apply to hard red spring wheat varieties not listed.

Rate of application--5/8 to 1 pound per acre depending on density of wild oat population (see label).

Time of application--Postemergence when majority of wild oat plants are in the 3- to 5-leaf stage of growth.

Remarks--Difenzoquat may be tank-mixed with 2,4-D or MCPA amine or ester, bromoxynil or a mixture of MCPA and bromoxynil and chlorsulfuron. Do not apply mixture of difenzoquat and 2,4-D until the crop is 6 inches tall or until after the crop is well tillered. Apply difenzoquat in 5 to 20 gallons of water per acre by ground equipment or 3 to 10 gallons of water per acre by aircraft, but use a surfactant when applying over 10 gallons of water per acre. Do not apply before a rain or when plants are wet from dew or rain and do not make more than one application per season. Do not graze treated fields or cut treated forage for silage.

Formulation--2 pounds per gallon liquid.

Dimethazone (Command) - FMC

Use--Control of annual grasses and many broadleaf weeds in soybeans in preplanting or preemergence applications. Can be tank mixed with metribuzin or linuron.

Rate of application--3/4 to 1.25 pounds per acre. Use higher rates on heavy soils or on soils with more than 3% organic matter. Use lower rates on lighter soils and in tank mixes.

Time of application--Preplant incorporated with shallow incorporation or preemergence. Rainfall is needed for activation of preemergence applications.

Remarks--Dimethazone is a new experimental herbicide with EPA clearance expected prior to the 1986 growing season. Soybean tolerance is excellent. Plants affected by dimethazone turn white. Spray and volatility drift are very obvious because of plant chlorosis but serious drift injury is not likely to occur. In carryover studies some chlorosis has been observed on wheat and alfalfa planted the following season in trials at Rosemount, Minnesota. Further carryover studies were initiated in 1985 but results will not be available until the 1986 growing season. The foxtails and velvetleaf are especially sensitive to this herbicide. Pigweed and wild mustard control is variable.

Formulation--6 pounds per gallon liquid.

CAUTION: Though EPA registration is expected for 1986, as of November, 1985 clearance has not been received.

Dinoseb (Premerge and others) - Vertac

Use--Control of annual weeds in dry beans, corn, forage legumes, small grains, and soybeans. In preemergence mixture with alachlor (Lasso) or chloramben (Amiben) on soybeans.

Rate of application--Varies with crop, soil type, and temperature. See label.

Time of application--Preemergence and/or postemergence depending on crop. Follow label instructions closely.

Remarks--Results vary with soil and temperature conditions. Crop injury may occur.

Formulation--Liquids of various concentrations.

Endothall (Endothal, Herbicide 273) - Pennwalt

Use--Control of annual smartweed, wild buckwheat, and marshelder in sugarbeets.

Rate of application--3/4 to 1-1/2 pounds per acre.

Time of application--Postemergence when sugarbeets have 4 to 6 leaves.

Remarks--Excessive injury, especially to very small sugarbeets, may occur if temperatures are above 80 degrees F. Poor weed control may result at temperatures below 60 degrees F.

Formulation--3 pounds per gallon liquid and 5 percent granular.

EPTC (Eptam); EPTC Plus Crop Protectant (Eradicane) EPTC plus crop protectant plus extender (Eradicane Extra) - Stauffer

Use--EPTC: Control of annual grasses, nutsedge and some broadleafs in sugarbeets, potatoes, seedling alfalfa, birdsfoot trefoil, clovers, sunflowers, flax, and dry edible beans except adzuki beans. "Eradicane" or "Eradicane Extra" can be used in corn, especially for nutsedge and wild proso millet; gives some quackgrass control. Eradicane can be used in mixtures or as a three-way combination with atrazine and cyanazine on corn and Eptam may be mixed with trifluralin and ethalfluralin on dry beans and sunflowers, and with chloramben on sunflowers.

Rate of application--EPTC: 2 to 3 pounds per acre on sugarbeets spring applications or 4 to 4-1/2 pounds per acre for fall applications; 3 pounds per acre on seedling legumes, sunflowers, flax (fall application only) and dry edible beans; Eradicane or Eradicane Extra: 3 to 6 pounds per acre in corn.

Time of application--Preplanting in spring or previous fall.

Remarks--Must be incorporated immediately to avoid loss of chemical by volatility. Eradicane and Eptam can be applied with dry bulk and liquid fertilizers or through center pivot irrigation. Perennial grasses must be turned under and chopped thoroughly prior to treatment. Effectiveness declines with repeated annual use due to more rapid degradation by soil microorganisms.

Formulation--Eptam: 7 pounds per gallon liquid; 10 percent granular; Eradicane: 6.7 pounds per gallon liquid; Eradicane Extra: 6 pounds per gallon liquid.

Ethafluralin (Sonalan) - Elanco

Use--Annual grass, pigweed, common lambsquarters control and partial control of eastern black nightshade in soybeans, sunflower and dry beans. Can be tank mixed with alachlor, chloramben, metolachlor or metribuzin in soybeans and chloramben and EPTC in sunflower, and EPTC in dry beans.

Rate of application--0.56 to 1.12 pounds per acre.

Time of application--Preplanting incorporation.

Remarks--Must be incorporated in the soil. Do not graze or feed forage.

Formulation--3 pounds per gallon liquid.

Ethofumesate (Norton) - Fisons

Use--Control of some annual broadleafs and grassy weeds in sugarbeets. Use in mixtures with TCA or as a preemergence application following fall application of EPTC.

Rate of application--1.12 to 3.75 pounds per acre.

Time of application--Preplanting, preemergence, or postemergence.

Remarks--Incorporation has improved weed control. Soil residues may affect wheat, barley, and oats the following year. Sugarbeet injury may occur, especially on coarse-textured soils if used in combination with cycloate or EPTC, or if used postemergence in combination with desmedipham and phenmedipham.

Formulation--1-1/2 pounds per gallon liquid and 4 pounds per gallon dispersible liquid.

Fluazifop (Fusilade 2000) - ICI

Use--Control of grassy annual and perennial weeds in soybeans. Can be tank mixed with acifluorfen (Blazer).

Rate of application--1/8 to 1/2 pounds per acre.

Time of application--Early postemergence when grass weeds are 2 to 8 inches tall.

Remarks--Fluazifop has given excellent control of most annual grasses including volunteer corn, foxtails, wild proso millet and woolly cupgrass in soybeans. The chemical also controls perennial grasses. Always add a surfactant or a crop oil concentrate. Avoid spray drift onto corn.

Formulation--1 (Fusilade 2000) or 4 (Fusilade) pounds per gallon liquid.

Glyphosate (Roundup) - Monsanto

Use--Non-selective control of many annual and perennial weeds before planting alfalfa, edible beans, peas, barley, corn, forage legumes and grasses, oats, potatoes, sorghum, soybeans, sugarbeets, wheat, and many vegetable crops. Spot treatment of weeds in these same crops after crop emergence, but crop will be killed or severely injured. May also be used in minimum tillage systems as tank mixtures with alachlor, metolachlor, atrazine, linuron, simazine, metribuzin, and cyanazine.

Rate of application--3/4 to 3 pounds per acre depending on time of application and weed species (see label).

Time of application--In the fall or spring before crops are planted. See label for proper timing on each weed species. Apply to actively growing foliage.

Quackgrass and wirestem muhly--when grass is at least 8 inches tall (3 or 4 leaf stage) and actively growing.

Canada thistle--bud stage in spring or before frost in fall.

Field bindweed--at or beyond full bloom.

Common milkweed--late bud to flower stage.

Can be applied with recirculating sprayers, roller or pipe-wick applicators when weeds overtop the soybeans. Volunteer corn control has been acceptable with all of these applicators.

Remarks--Take extreme care when using this product to avoid drift since most plants are susceptible to injury.

Formulation--3 pounds acid equivalent per gallon liquid.

Hexazinone (Velpar) - DuPont

Use--Weed control in established alfalfa.

Rate of application--0.45 to 1.35 pounds per acre. Use the lower rates (0.45 to 0.90 pounds per acre) on coarse textured soils low in organic matter and the higher rates (0.90 to 1.35 pounds per acre) for medium and fine textured soils and soils high in organic matter.

Time of application--In the fall after alfalfa becomes dormant in the spring before new growth begins, or after cutting before regrowth is 2 inches tall.

Remarks--Treat only stands of alfalfa established for one year or more. Do not use on seedling alfalfa or on alfalfa-grass mixtures or other mixed stands. Hexazinone may injure alfalfa if excessive rates or overlaps occur. Also injury may result from the occurrence of excessive rainfall or too much irrigation water within a week or two after application.

Formulation--90 percent water soluble powder.

Linuron (Lorox) - DuPont

Use--Preemergence weed control in corn, sorghum and soybeans and directed post-emergence in corn. Used in mixtures with atrazine, alachlor, glyphosate, paraquat, or propachlor preemergence on corn and with alachlor, chloramben, metolachlor, glyphosate or paraquat preemergence on soybeans.

Rate of application--(1) Corn: 1/2 to 1-1/2 pounds per acre preemergence in combination with equal rates of atrazine active ingredient or with 3 pounds per acre of propachlor or with 1-1/2 to 3 pounds per acre of alachlor; 1-1/2 pounds per acre with wetting agent in postemergence directed spray applications. (2) Soybeans: 1/2 to 2-1/2 pounds per acre; (rate differs with soil types) or 1/2 to 1-1/2 pounds per acre with 1-1/2 to 3 pounds per acre of alachlor or pre-emergence over preplanting trifluralin.

Time of application--(1) Corn: preemergence or directed spray postemergence

when corn is least 12-18 inches tall and weeds are 8 inches or less in height. (2) Soybeans: preemergence.

Remarks--Use in postemergence directed spray applications does not eliminate early season competition between weeds and corn. This early competition can reduce yields. Linuron has caused injury (stand reduction and stunting) to corn and soybeans in some Minnesota trials, particularly on sandy soils. On corn, do not apply linuron within 60 days of harvest. Reduced effectiveness of linuron if incorporated.

Formulation--50 percent wettable powder, 4 pounds per gallon dispersible liquid.

MCPA (Various trade names and manufacturers)

Use--Broadleaved weed control in small grains, flax, and pastures.

Rate of application--Small grains: 1/6 to 2/3 pounds per acre depending on formulation used, size and kinds of weeds, weather conditions, and stage of crop growth. Flax: 1/4 pound per acre. May be tank-mixed with dalapon on flax. Use 1/4 pound per acre of MCPA plus 3/4 pound per acre of dalapon. Grass pastures: 1/2 to 2 pounds per acre depending on weed susceptibility. See label.

Time of application--Postemergence. Small grains--two leaves to early boot; flax--2 to 6 inches. In pastures, when perennial weeds are 6 to 8 inches tall or in the rosette stage and actively growing.

Remarks--Use low rates on small grains underseeded with alfalfa.

Formulation--Liquids of various concentration.

Metolachlor (Dual) - Ciba-Geigy

Use--Control of annual grasses, pigweed, nightshade and nutsedge in corn, soybeans, dry beans and potatoes. Used in mixtures with atrazine, cyanazine, simazine, or dicamba in corn or with metribuzin, linuron, naptalam + dinoseb, chloramben, chlorpropham, trifluralin or dinoseb in soybeans. For minimum tillage corn in preplant mixtures with glyphosate, paraquat, atrazine, or simazine and for soybeans with linuron, metribuzin, glyphosate or paraquat.

Rate of application--1-1/2 to 3 pounds per acre.

Time of application--Preplanting, preplanting incorporated; preemergence; or early post- emergence alone or with atrazine when weeds are in 2-leaf stage and corn is less than 5 inches tall.

Remarks--Metolachlor can be applied with fluid fertilizer or with center pivot irrigation systems.

Formulation--8 pounds per gallon liquid, 25 percent granule and metolachlor plus

atrazine (Bicep) 2-1/2 plus 2 pounds per gallon dispersible liquid.

Metribuzin (Lexone, Sencor) - DuPont, Mobay

Use--Annual weed control in soybeans. Control of certain annuals, winter annuals, and biennials in established alfalfa or alfalfa-grass mixtures. Better on broadleafs than grass. Can be used on soybeans in mixtures with alachlor, metolachlor, chloramben, glyphosate, paraquat, trifluralin, or pendimethalin.

Rate of application--Soybeans: 3/8 to 7/8 pound per acre depending on soil texture and organic matter. 1/8 to 3/4 pound per acre in mixtures. Alfalfa (established one year or more): 3/8 to 1 pound per acre depending on soil texture and kinds of weeds present.

Time of application--Soybeans: Preplanting, preemergence or a combination of preplanting and preemergence. Alfalfa: When alfalfa is dormant, spring or fall.

Remarks--Soybeans: Early soybean stunting and leaf kill have frequently occurred with this chemical. Consult the label for restrictions and use rates on various soil types. Crop injury may occur on calcareous soils or alkaline soils with a pH over 7.5 or in conjunction with soil applied organic phosphate pesticides. Certain soybean varieties, Tracy and Altona, are susceptible to injury. Alfalfa: do not graze or harvest alfalfa within 28 days of treatment. Metribuzin may be applied on dry fertilizers or with liquid fertilizers.

Formulation--50 percent wettable powder, 75 percent water dispersible, 4 pounds per gallon dispersible liquid.

Naptalam + 2,4-DB (Rescue) - Uniroyal

Use--Postemergence control of annual broad-leaved weeds (cocklebur, giant ragweed, volunteer sunflower, wild mustard) in soybeans.

Rate of application--1 to 1-1/2 pounds per acre of naptalam plus 1/32 to 3/64 pound per acre of 2,4-DB. Use a nonionic surfactant with the mixture.

Time of application--When soybeans are about 18 inches tall (7-10 days before bloom through mid-bloom).

Remarks--This treatment is primarily to control large (12 inch) broadleaved weeds that have escaped earlier control. There is risk of soybean injury. Do not apply to drought stressed soybeans. Rain within 6 hours after application will reduce effectivenes.

Formulation--2 pounds Naptalam + .06 pounds 2,4-DB per gallon liquid.

Naptalam + dinoseb (Dyanap) - Uniroyal

Use--Preemergence and postemergence control of some annual broadleafs and

grasses in soybeans. May be used alone, with alachlor (Lasso) or metolachlor preemergence.

Rate of application--Preemergence: 2 to 4 pounds of naptalam plus 1 to 2 pounds of dinoseb per acre alone or with 2 pounds of alachlor. Rates vary with soil type. Postemergence: 1/2 to 1 pound of naptalam plus 1 to 2 pounds of dinoseb per acre.

Time of application--Preemergence up to emergence of soybeans when used alone or preemergence with alachlor or metolachlor. Postemergence after soybeans have the second trifoliolate leaf up to when soybeans are 20 inches tall.

Remarks--Preemergence application may cause crop injury, especially if heavy rains occur or on sandy soils. Postemergence treatment may injure crop when temperatures are high or if improperly applied. Follow application and rate instructions on the labels.

Formulation--2 pounds naptalam and 1 pound dinoseb per gallon liquid.

Paraquat (Paraquat Plus, Gramoxone) - Chevron, ICI

Use--Paraquat is a contact herbicide for killing vegetation before planting or before crops emerge, and as a desiccant in soybeans and sunflowers (oil seed varieties only). A special local needs registration is also available in Minnesota for postharvest desiccation of Kentucky bluegrass fields to facilitate burning.

Rate of application--1/8 to 1 pound per acre depending on use and crop. Use X-77 spreader with paraquat.

Time of application--Apply paraquat before planting or before the crop emerges for seedling weed control in minimum and no-till cropping situations. As a preharvest desiccant, paraquat is applied after the crop is physiologically mature. In soybeans, application should be made when the beans are fully developed, at least 1/2 of the leaves have dropped, and the leaves left on the plant are turning yellow or when the soybean seeds are at 30 percent moisture or less. In sunflowers, application should be made when the seed is at 35 percent moisture or less. Sunflower head color is no longer considered a good indicator of maturity.

Remarks--Paraquat kills growing annual weed seedlings, but only the top growth of perennials. Paraquat is highly toxic and has a "restricted use" classification (can be applied only by a certified applicator). A small amount could be fatal if swallowed. Avoid contact with the eyes or skin and do not breathe the spray mist. Follow precautions on the label.

Formulation--2 pounds per gallon liquid.

Pendimethalin (Prowl) - American Cyanamid

Use--Preemergence control of annual grasses and some annual broadleaved weeds in corn. Can use alone or in a mixture with atrazine, cyanazine (Bladex), or dicamba (Banvel) for broader spectrum weed control in corn. Preplanting incorporated in soybeans alone or in mixtures with metribuzin, alachlor, chloramben, and metolachlor. Preplanting incorporated alone or with chloramben on sunflowers.

Rate of application--1/2 to 2 pounds per acre for corn; 1/2 to 1-1/2 pounds per acre for soybeans; 1/2 to 1-1/2 pounds per acre for sunflowers.

Time of application--Preemergence or early postemergence, up to 2-leaf stage of corn and weeds up to 1 inch tall, with atrazine or cyanazine in corn; preplanting in soybeans; pendimethalin alone or mixed with atrazine may be applied postemergence incorporated on corn from 4 inches tall to last cultivation; preplant incorporated on sunflowers.

Remarks--Do not use on soils containing less than 1-1/2 percent organic matter, nor on peat or muck. There is crop injury potential on soils with lower organic matter and sandy soils. Weed control has not been consistent on clay soils, peat and muck. Do not drag corn fields before crop emerges and do not incorporate on corn fields. On soybeans and sunflowers, incorporate 1 to 2 inches deep. Can be used with liquid fertilizer.

Formulation--4 pounds per gallon liquid.

Picloram (Tordon) - Dow

Use--One formulation (Tordon 22K) is cleared for use in a tank-mix combination with 2,4-D amine or ester or MCPA amine to improve control of wild buckwheat in spring and winter wheat and barley. All formulations may be used on noncropland, except do not use near rivers, lakes or other water supplies. Two formulations (Tordon 22K and Tordon 2K) may be used on grass pastures in Minnesota on a special local need label.

Rate of application--A tank-mix combination of 1/4 ounce picloram (1 fluid ounce of Tordon 22K) and 1/4 pound 2,4-D amine or ester or MCPA amine for wheat and barley, 1/2 to 2 pounds per acre in grass pastures.

Time of application--Postermergence, when wheat or barley is in the 4- to 6-leaf stage and weeds are small; postemergence in grass pastures when perennial broadleaf weeds are 6 to 8 inches tall but before bloom.

Remarks--A higher rate of application, 3/8 ounce per acre of picloram and 3/8 pound per acre of 2,4-D amine or ester or MCPA amine is cleared for use in the same crops when weeds are more advanced or under dry conditions. This higher rate may be applied from the 6-leaf stage to early boot stage. Apply picloram only on small grain fields that will be fallowed or replanted to a grass or grain crop the following year. Do not use on small grain to be underseeded to a legume. Do not use on sandy soils where ground water level is within 10 feet of the soil surface. Picloram is a restricted use pesticide and can be applied

only by a certified applicator. Adhere to all label requirements for safe use of this herbicide.

Formulation--(Tordon 2K) 2 % pellets.

Propachlor (Ramrod) - Monsanto

Use--Annual grass control in soybeans grown for seed, corn, and grain sorghum. Used in mixtures with atrazine or cyanazine or linuron on corn and with atrazine, cyanazine, or propazine on sorghum.

Rate of application--3 to 6 pounds per acre.

Time of application--Preemergence.

Remarks--Propachlor is cleared to use on corn for grain, seed or forage, but on soybeans for seed only. Do not use propachlor-treated soybeans for food, feed, or oil. Can be used with liquid fertilizer.

Formulation--20 percent granular, 4 pounds per gallon dispersible liquid, or Ramrod/atrazine, 3 + 1 pounds per gallon dispersible liquid.

Propanil + MCPA (Stampede CM) - Rohm and Haas

Use--Control of green and yellow foxtail and specific broadleaf weeds in hard red spring wheat, durum wheat, and spring barley.

Rate of application--Stampede CM is a premix at propanil and MCPA. Apply 0.94 pounds per acre of propanil and 0.25 pounds per acre of MCPA (2.5 pt. of premix).

Time of application--Postemergence when a majority of the foxtail is in the 3 leaf stage.

Remarks--Do not apply beyond the 5 leaf stage of HRS wheat or beyond the four leaf stage of durum wheat and barley. Do not apply to wheat that has been treated with soil applied systemic insecticides such as Furadan, Thimet or Disyston within the past year. Do not graze treated crop or cut for green chop feed. Do not apply if frost is expected within 24 hours or when temperatures are above 85 degrees F, especially with drying winds.

Formulation--3 pounds propanil + 0.85 pounds MCPA per gallon liquid.

Pronamide (Kerb) - Rohm and Haas

Use--Annual and perennial grass control in pure stands of alfalfa, clover, birdsfoot trefoil, or crown vetch.

Rate of application--1 to 2 pounds per acre.

Time of application--Fall when soil temperatures are below 60 degrees F. but before freeze-up.

Remarks--Do not graze or harvest alfalfa within 25 to 45 days, depending on the rate of application, or other crops for 120 days after application. Use only on established legume plantings or on new plantings after the legume has reached the trifoliolate leaf stage.

Formulation--50 percent wettable powder.

Propazine (Milogard)- Ciba-Geigy

Use--Control of annual grasses and broadleaved weeds in grain sorghum. Used in mixtures with propachlor on grain sorghum.

Rate of application--0.8 to 2 pounds per acre.

Time of application--Preemergence.

Remarks--Corn may be planted in rotation 12 months after treatment. Other crops should not be planted for 18 months following treatment. Do not use in sand or loamy sand soils.

Formulation--80 percent wettable powder.

Pyrazon (Pyramin) - BASF

Use--Control of most annual broadleafs in sugarbeets. Has been more effective on medium to coarse textured soils with less than 5 percent organic matter. May be applied preemergence with TCA.

Rate of application--3.8 to 7.6 pounds per acre.

Time of application--Preemergence or preplanting incorporated; postemergence when sugarbeets have two expanded true leaves and before weeds have more than 2 to 4 true leaves.

Remarks--A rain shortly after application is necessary for best results. Incorporation usually improves weed control. Do not use on sands or loamy sands as crop injury may occur; do not use preemergence on peat or muck soils.

Formulation--75.5 percent wettable powder or 4.2 pounds per gallon dispersible liquid.

Sethoxydim (Poast) - BASF

Use--Control of grassy weeds in soybeans and sugarbeets. Mixtures with bentazon or bentazon plus acifluorfen are labeled for soybeans. Increase sethoxydim rate 50% in mixtures.

Rate of application--0.1 to 0.5 pounds per acre. High rate for perennial grasses.

Time of application--Postemergence.
Remarks--Sethoxydim gives excellent control of most annual grassy weeds including volunteer corn, foxtails, wild proso millet and woolly cupgrass. In addition, sethoxydim gives good suppression or control of several perennial grass weeds such as quackgrass and wirestem muhly. An oil concentrate is used with the spray mixture. Avoid spray drift onto corn.

Formulation--1.5 pounds per gallon liquid.

Simazine (Princep) - Ciba-Geigy

Use--Control of grasses and broadleaved weeds in alfalfa, birdsfoot trefoil for seed, and corn.

Rate of application--0.8 to 1.6 pounds per acre on alfalfa and birdsfoot trefoil; 2 to 4 pounds per acre on corn.

Time of application--On established alfalfa, after last cutting in the fall and before the ground is frozen. Preplanting or preemergence on corn. Fall or spring on well established, dormant birdsfoot trefoil.

Remarks--Residues in the soil may injure susceptible crops planted the following year.

Formulation--80 percent wettable powder, 4 pounds per gallon liquid and 90 percent water dispersible granules.

TCA - Hopkins

Use--Control of annual grasses except wild oat in sugarbeets.

Rate of application--5 to 7 pounds per acre.

Time of application--Preemergence.

Formulation--4.76 pounds per gallon liquid.

Terbacil (Sinbar) - DuPont

Use--Control of several annual broadleaf and grass weeds in alfalfa that has been established for one or more years. Treatment will not control established perennial weeds.

Rate of application--0.4 to 1.2 pounds per acre depending upon weed species to be controlled and on soil type and organic matter percentage. Use lower rate on course-textured soils with less than 2 percent organic matter.

Time of application--In the fall after alfalfa plants become dormant or in the spring before new growth starts.

Remarks--Do not use on seedling alfalfa or on alfalfa-grass mixtures or other mixed stands. Do not apply on established stands after new growth starts in the spring. Do not replant treated areas to any crop within two years after last application as injury to subsequent crops may result. There is potential for alfalfa injury, especially on sandy soils or soils low in organic matter.

Formulation--80 percent wettable powder.

Triallate (Far-go, Avadex-BW) - Monsanto

Use--Control of wild oat in spring and durum wheat and barley, peas and lentils.

Rate of application--1 to 1-1/4 pounds per acre on wheat; 1-1/4 to 1-1/2 pounds per acre on barley. Lower rates are for liquid formulation and higher rates are for granular formulation.

Time of application--Postseeding (preemergence) for wheat; preplanting or postseeding for barley (postseeding preferred). Fall incorporated or surface applications are possibilities. See label for details.

Remarks--Must be incorporated by two harrowings at right angles for postseeding applications. Incorporate preplanting applications as described previously for diallate. In postseeding applications, seed crop to a depth of 2 to 3 inches. Do not apply to a field in a ridged condition. Do not plant domestic oats where triallate was used the previous year. May be tank-mixed with trifluralin for spring postseeding application for wheat and barley. This chemical irritates skin and eyes; use caution when handling.

Formulation--4 pounds per gallon liquid; 10 percent granules.

Tridiphane (Tandem) - DOW

Use--Improves postemergence grass control in corn when used in tank mixes with atrazine plus oil or with cyanazine.

Rates of application--1/2 to 3/4 pounds per acre. Use higher rate on heavier soils.

Time of application--Early postemergence when weeds are small, less than 3 inches tall, and have no more than 4 leaves. Later applications are inconsistent.

Remarks--Tridiphane is an experimental herbicide with EPA clearance expected prior to the 1986 growing season. Corn tolerance to cyanazine and atrazine plus oil may be reduced under adverse weather conditions due to the addition of tridiphane.

Formulation--4 pounds per gallon liquid.

CAUTION: Though EPA registration is expected for the 1986 season, as of November, 1985 clearance has not been received.

Trifluralin (Treflan) - Elanco

Use--Annual grass and pigweed control in soybeans, dry edible beans including adzuki beans, sunflowers, mustard, sugarbeets, and spring wheat. Used in mixtures with chloramben, metribuzin, chlorpropham, metolachlor, alachlor, or vernolate on soybeans; with chloramben and EPTC on dry beans; and with triallate on spring wheat and barley; and with EPTC and chloramben in sunflower.

Rate of application--1/2 to 1 pound per acre, depending on soil type. Use lower rates on coarse-textured soils and higher rates on finer-textured soils. On spring wheat, the rates are 1/2 to 3/4 pound per acre.

Time of application--Preplanting on soybeans, dry edible beans, mustard and sunflowers; postemergence on 2 to 6 inch sugar beets after blocking or thinning and before new weeds come up. On spring wheat and barley, apply immediately after planting or the previous fall just before freezeup.

Remarks--Must be incorporated into the soil soon after application. Proper incorporation of preplanting applications can be accomplished by disking field twice, once in each direction, immediately after applying chemical. This chemical sometimes causes slight soybean stand reduction and early soybean injury. To reduce spring wheat injury potential, plant wheat 2 to 3 inches deep, apply the chemical and incorporate shallowly with a harrow operated in two different directions. Can be applied with fluid or dry bulk fertilizer.

Formulation--4 pounds per gallon liquid; 10 percent granular.

Vernolate (Vernam, Reward) - Stauffer

Use--Controls annual grasses and some broadleafs in soybeans. Cleared for use in mixtures with trifluralin, alachlor, pendimethalin and chloramben in soybeans. Cleared for sequential (overlay) treatments with chlorpropham, linuron, bentazon, and naptalam + dinoseb.

Rate of application--2 to 3 pounds per acre.

Time of application--Preplant incorporated; incorporate immediately.

Remarks--Vernolate must be incorporated immediately after application to prevent loss by volatilization. Incorporation should be done by disking twice or by using a power rotary tiller. Early soybean injury has sometimes occurred. Can be applied with fluid or dry bulk fertilizer. Reward formulation contains an extender to increase longevity in the soil.

Formulation--7 pounds per gallon; 10 percent granular. Reward--6 pounds per gallon.

HERBICIDE NAMES

This is an alphabetical list of trade names of herbicides commonly used on cropland in Minnesota. The active ingredient(s) in these products is given across from the chemical's common name.

Trade Name	Common Name/Active Ingredient
AAtrex	atrazine
Alanap	naptalam (NPA)
Amdon 10K	picloram
Amdon 101	picloram + 2,4-D
Amiben	chloramben
Avadex	diallate
Avenge	difenzoquat
Balan	benefin
Banvel	dicamba
Banvel II	dicamba
Basagran	bentazon
Betamix	desmedipham + phenmedipham
Betanex	desmedipham
Bicep	metolachlor + atrazine
Bladex	cyanazine
Blazer	acifluorfen
Brominal	bromoxynil
Brominal Plus	bromoxynil + MCPA
Bronate	bromoxynil + MCPA
Buctril	bromoxynil
Butoxone	2,4-DB
Butyrac 200	2,4-DB
Carbyne	barban
Command	dimethazone
Dow General	dinoseb
Dowpon M	dalapon
Dowpon C	dalapon + TCA
Dual	metolachlor
Dyanap	naptalam + dinoseb
Endothal	endothall
Eptam	EPTC
Eradicane	EPTC+safener
Eracicane Extra	EPTC+safener+ext.
Evik	ametryne
Far-go	triallate
Furloe	chlorpropham
Fusilade	fluazifop
Glean	chlorsulfuron
Gramoxone	paraquat

Trade Name (continued)	Common Name/Active Ingredient (cont.)
Herbicide 273	endothall
Hoelon	diclofop
Kerb	pronamide
Kleen-Krop	naptalam and dinoseb
Lasso	alachlor
Lasso II	alachlor 15% gran.
Lexone	metribuzin
Lorox	linuron
Milocep	propazine + metolachlor
Milogard	propazine
Modown	bifenox
Nortron	ethofumesate
Paraquat Plus	paraquat
Poast	sethoxydim
Premerge	dinoseb (DNBP)
Premerge Plus	dinoseb + naptalam
Princep	simazine
Prowl	pendimethalin
Pyramin	pyrazon
Pyramin Plus	pyrazon and dalapon
Ramrod	propachlor
Rescue	naptalam + 2,4-DB
Reward	vernolate + extender
Ro-Neet	cycloate
Roundup	glyphosate
Sencor	metribuzin
Sinbar	terbacil
Sonalan	ethalfluralin
Stampede CM	propanil + MCPA
Sutan +	butylate + safener
Sutazine	butylate + atrazine
Tandem	tridiphane
TCA	TCA
Tordon	picloram
Tordon 212, 101	picloram and 2,4-D
Treflan	trifluralin
Vernam	vernolate
Weedmaster	dicamba and 2,4-D

Omission of other trade names of similar herbicides is unintentional. The inclusion of a trade name does not imply endorsement and exclusion does not imply nonapproval.

Weed Control In Flax

Richard Behrens, Extension Agronomist

FLAX

Flax does not compete well with weeds, so weed control is essential for obtaining high flax yields. Shallow early spring tillage to stimulate germination of annual weeds, followed by tillage operations to kill these weeds, and delayed seeding of flax has been a successful methods of weed control. However, the delay in seeding flax usually decreases yields. Therefore, appropriate preplanting and postharvest tillage, together with suitable weed control chemicals, should be used for best results (tables 1, 2, and 3).

Table 1. Suggestions for chemical weed control in flax not underseeded with a legume

Chemicals[1]	Pounds per acre of acid equivalent or active ingredient broadcast	Time of application	Remarks	Environmental Protection Agency limitations on use
MCPA amine or ester Dalapon	¼ ¾ }	Flax 2 to 6 inches.	MCPA for broadleafs; dalapon for grasses; mixture of MCPA amine and dalapon for broadleaf and grass control. Dalapon may injure flax.	None
EPTC (Eptam, Genep)	3	Fall incorporation after October 15.	Some flax injury has occurred. For annual grasses and some broadleafs.	None
Bromoxynil (Brominal, Buctril)	¼ to ½	Flax 2 to 8 inches.	For annual broadleafs, smartweed and wild buckwheat in two- to four-leaf stage.	Do not graze for 30 days after treatment
Trifluralin	½ to 1	Fall incorporated	For annual grasses except wild oats and a few broadleafs.	None
Propachlor (Ramrod)	4	Preemergence	For annual grasses except wild oats and a few broadleafs.	None

[1]See table 5 for trade names of herbicides.

Table 2. Suggestions for broadleaf weed control in flax underseeded to a legume

Chemicals	Pounds per acre of acid equivalent broadcast	Time of application	Remarks	Environmental Protection Agency limitations on use
MCPA amine	⅛ to ¼	Flax 4 to 6 inches tall. Not before legumes are 2 inches tall.	Legumes injured, canopy of crop or weeds reduces injury. Sweetclover injured.	None

WILD OAT CONTROL IN FLAX

Wild oat is very competitive with flax; if not controlled, it may reduce crop yields by one-third or more. A combination of cultural and chemical practices is needed for effective control.

Table 3. Chemicals for wild oat control in flax

Chemicals	Pounds per acre of active ingredient broadcast	Time of application	Remarks	Environmental Protection Agency limitations on use
Diallate (Avadex)	1½ to 2	Preplanting or preemergence.	Must be incorporated into soil. May be used where flax is underseeded with alfalfa or clover.	None
Barban (Carbyne)	¼ to ⅜	When wild oat is in two-leaf stage.	Do not spray barban after the 12-leaf stage of flax. Use the high rate for wild oat populations over 50 plants/sq. ft.	Do not feed flax straw from treated fields to livestock or graze treated fields until after harvest.

Table 4. Effectiveness of herbicides for weed control in flax[1]

	Performance rating of herbicide on weeds						
Herbicides	Wild mustard	Wild buckwheat, annual smartweeds	Canada thistle perennial sowthistle	Pigweed, common lambsquarters, and ragweed	*Annual grass* Wild oat	other	*Crop tolerance* Flax
MCPA amine	G	F	F	G	N	N	G
MCPA ester	G	F	F	G	N	N	F
bromoxynil	F	G	N	G	N	N	F
dalapon	N	N	N	N	F	G	F
EPTC	P	P	N	F	F	G	F
diallate	N	N	N	N	G	N	F
barban	N	N	N	N	G	N	F
propachlor	N	P	N	G[2]	P	G	F
trifluralin	N	P	N	G[2]	F	G	F

[1]P = poor, F = fair, G = good, N = no control

[2]Poor on ragweed

Table 5. Herbicide names and formulations used in flax

Common name	Trade name	Concentration and commercial formulations[1]
MCPA	Several, mixtures	See product label
dalapon	Dowpon M, Basfapon	5 lb./gal L, 74% WSP
EPTC	Eptam	7 lb/gal L, 10% G
bromoxynil	Brominal, Buctril	2 lb/gal L
diallate	Avadex	4 lb/gal L, 10% G
barban	Carbyne	1 lb/gal L
propachlor	Ramrod	4 lb/gal F, 20% G
trifluralin	Treflan	4 lb/gal L, 10% G

[1]L = liquid, G = granular, WSP = water soluble powder, F = flowable

CAUTION

Avoid repeated and prolonged contact with all herbicides, especially direct contact with skin and eyes. Check label directions and restrictions carefully. Avoid wind drift of herbicides to susceptible crops and ornaments. This fact sheet is intended only as a summary of weed control information on flax. For more information, refer to product labels.

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

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	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)	1/8 to ¼		See crop discussion. Drift Use for patch treatment of 2,4-D resistant thistles.	See 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	Do not feed or forage subsequently grown crop for 8 weeks after application
	Picloram (turdon)	¼ to ½	Just before bud or fall	Grass pastures spot treatment	Restricted use herbicide
	Bentazon (Basagran)	¾ to 1 each time if two applications or 1 to 1½ if 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
	Dicamba (Banvel)	¼	Bud or in the Fall	Corn, wheat or oats	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	Do not feed or forage subsequently grown crop for 8 weeks after application.
	Picloram (Tordon)	1	when growing	grass pasture spot treatment	Restricted use herbicide
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	3/8 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
	Dicamba	¼		For corn	See corn
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
	Picloram (tordon)	1 to 2	Spring or Fall	Spot treatment on grass pastures	Restricted use herbicide
	Dicamba (Banvel)	4 to 8	Spring or Fall	Spot treat grass pastures	See grazing restrictions on the label.
	Glyphosate (Roundup)	¾	After bloom through fall	Shelter belt spot treatment Use selective equipment in crops	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	Postemergence or shoots 6 to 8 inches tall	For corn or soybeans Repeat if necessary	See crop

Table 2. (continued) Suggestions for chemical control of weeds on cropland. Follow label precautions carefully.

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	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, sugarbeets next spring.	Do not graze treated areas in year treated.
	EPTC (Eradicane)	6	Preplanting incorporation	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)	¾ to 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.	Do not feed or graze treated crops within 8 weeks after application.
	Fluazifop (Fusilade 2000)	1/5	When quackgrass 6 to 10 inches and wirestem muhly 4 to 12 inches.	For soybeans Retreat if needed.	Do not graze treated soybeans or feed forage
	Sethoxydim (Poast)		When quackgrass 6 to 8 inches and wirestem muhly up to 6 inches.	For soybeans or sugarbeets	Do not graze treated soybeans or feed forage
Wild oat	Barban (Carbyne)	¼ to 3/8	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)	3/8		Rate for semidwarf wheat varities, 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	
	Triallate (Far-go)	1 to 1¼ (wheat) 1¼ to 1½ (barley)	Preplanting or preemergence fall or spring.	Must be incorporated into soil, except late fall granules.	Do not graze livestock on treated areas. May be tank-mixed with trifluralin or wheat or barley.
	Difenzoquat (Avenge)	5/8 to 1	When wild oat has 3 to 5 leaves.	For barley, winter wheat and the spring and durum wheat varieties listed on the label.	Do not graze treated fields or cut for silage. Grain and straw can be fed.
	Diclofop (Hoelon)	¾ to 1¼	When wild oats have 1 to 4 leaves. Use higher rates for larger weeds.	For barley, wheat and soybeans. Use lower rates on barley	Do not graze treated areas or cut for forage prior to grain harvest. Diclofop is a restricted use pesticide.