Crop Profile for Wheat in Minnesota

Prepared: July 2002

General Production Information

- Minnesota ranked third in the production of spring wheat and 11th nationally in production of all wheat classes (9)
- Nearly 98% of Minnesota wheat acreage produced hard red spring wheat, 2% hard red winter wheat and <1% amber durum wheat (9)
- Exports of wheat and wheat products from Minnesota ranked 7th nationally with an estimated value of $64.5 million (9)
- Minnesota wheat acreage has declined since 1990 due to low commodity prices and recurring outbreaks of fusarium head blight
- Recent production: despite fewer acres planted in 2000, production rose to 96.5 million bu (all wheat); statewide average=49 bu/ac (9)

Table 1. Minnesota wheat production, 1997-2000 (9)

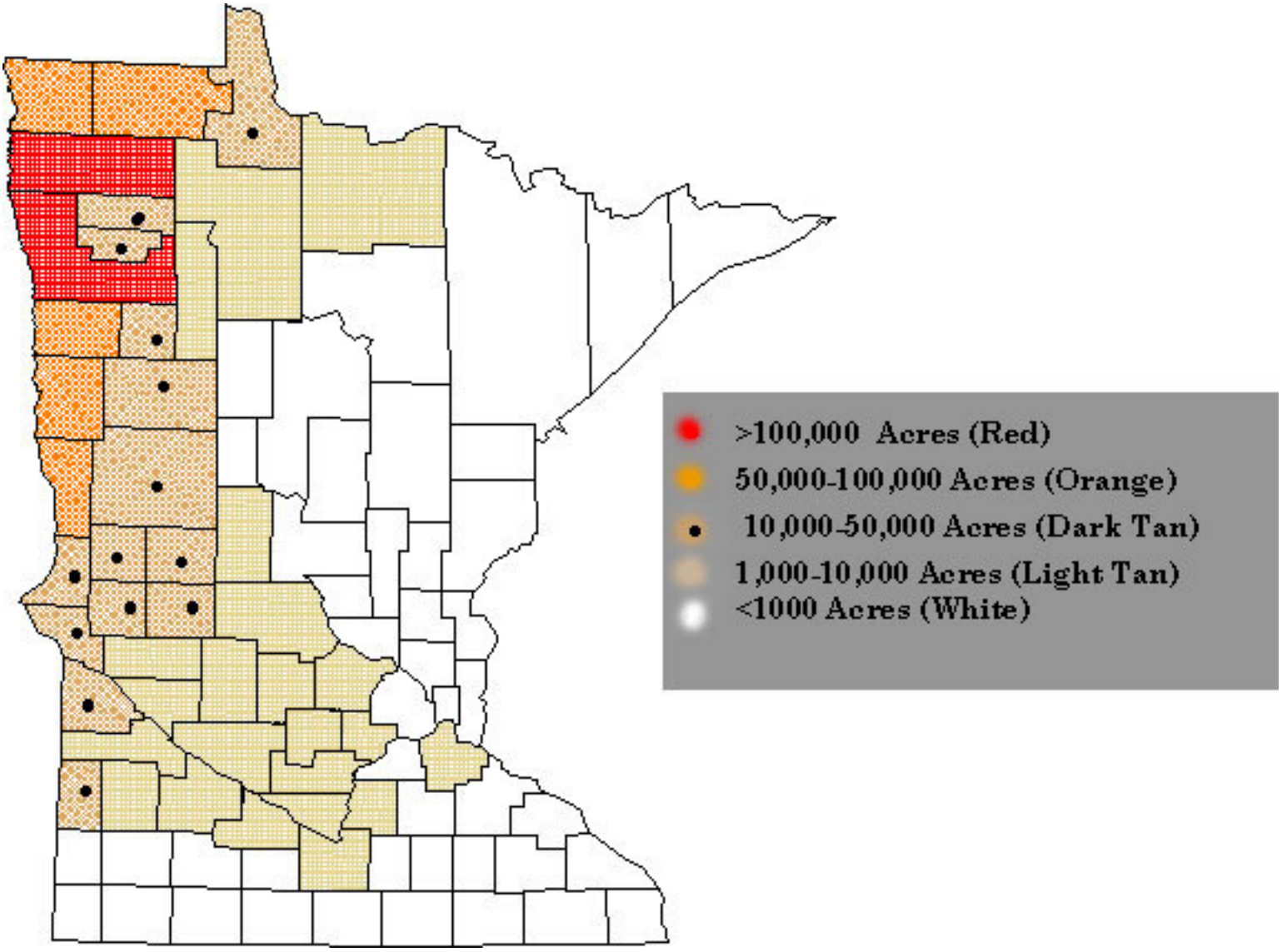
Year	Crop	National Rank	Acres planted (million)	Acres harvested (million)	Production (million bu)
2000	Spring	2	2.00	1.95	95.55

	All Wheat	8	2.02	1.97	96.53
1999	Spring	3	2.00	1.95	78.00
	All Wheat	11	2.05	1.99	79.21
1998	Spring	3	1.95	1.92	78.70
	All Wheat	11	2.02	1.98	80.44
1997	Spring	3	2.45	2.35	75.20
	All Wheat	10	2.52	2.42	77.30

Production Regions

Wheat production in Minnesota is concentrated in the northwest and western border of the state, with minor production in the central and east central regions. (9)

Figure 1. Minnesota wheat producing counties in 1999.



Cultural Practices

Minnesota spring wheat is seeded in late April-early May and harvested in August. Plant populations of 1.2 million plants/acre are recommended. Planting equipment has been rapidly changing from press wheel drills to air-seed systems that perform tillage, seeding and fertilizing operations in a single pass. Improvements in equipment mean the entire wheat crop can be seeded over a three-week period with favorable weather conditions (9).

Wheat is commonly grown in three or four year rotations with other crops. Crop rotation is a important cultural control practice in an IPM program for disease management, insect suppression, and weed management. Rotating crops keeps fusarium head blight, tan spot, and common root rot in check as well as insect pests such as Hessian fly and orange blossom wheat midge. In addition, the practice of rotating crops aids in the management of difficult and expensive to control weeds such as wild oat (3,6). Use of

tillage to manage pest problems has limited the use of no-till systems in Minnesota wheat production. Many wheat producing areas of the state are prone to soil erosion losses from wind and/or water, but tillage aids in the suppression of pests such as fusarium head blight, Hessian fly, and weeds including foxtails. Wheat producers should try to leave crop residue on the soil surface to7 reduce erosion but selectively increase the amount of tillage on fields based on pest pressure.

Diseases

Estimates of disease losses associated with each pathogen are listed in Table 1. Disease loss in this table is categorized as:

- Minor: 0.1-1.9% of production value lost
- Major: >2% of production value lost

Table 1. Diseases of wheat in Minnesota in 1992, 1993, and 1994 and their importance (16)

Bacterial Diseases		1992 Major	'92 Minor	1993 Major	'93 Minor	1994 Major	'94 Minor
Bacterial black chaff	*Xanthomonas campestris pv. translucens*	X			X	X	
Bacterial leaf blight	*Pseudomonas syringae pv. syringae*		X		X		X
Basal glume rot	*Pseudomonas syringae pv. atrofaciens*		X		X		X
Fungal Diseases							X
Common root rot	*Fusarium spp. Bipolaris sorokiniana*	X		X			X
Crown rot	*Gibberella zeae*		X		X	X[2]	
Ergot	*Clavieps purpurea*		X		X		X
Fusarium head blight (FHB)	*Fusarium graminearum*	X[1]		X		X[2]	
Leaf rust	*Puccinia recondita fl sp. tritici*		X		X		X
Loose smut	*Ustilago tritici*		X		X		X

Powdery mildew	*Erysiphe graminis f. sp. tritici*		X		X		X
Septoria leaf blotch	*Septoria tritici*		X	X		X[3]	
Stagnospora blotch	P*haeosphaeria avenaria*	X		X		X[3]	
Stem rust	*Puccinia graminis f. sp. tritici*		X		X		X
Take-all	*Gauemanomyces graminis var. tritici*		X		X		X
Tan spot	*Pyrenophora triticirepentis*	X		X		X	
Virus Diseases							
Barley yellow dwarf	*BYD luteoviurs*		X		X		X
Wheat streak mosaic	*WSM bromovirus*		X		X		X

[1] Losses from Fusarium head blight in 1992 were in excess of 30% and the dollar loss wsa estimated at $400 million

[2] Combined losses from Fusarium head blight, seedling blight and crown rot were in excess of 18% in 1994 and the dollar loss was estimated at $130 million

[3] Losses from Septoria diseases were estimated at 6% and the dollar loss was estimated at $29 million

Fusarium head blight (FHB)

Fusarium head blight, *Fusarium graminearum*, is the most serious disease in wheat in Minnesota and has had an enormous impact on wheat production in the state (see Table 1). FHB infections occur during periods of continuous rain and high humidity at the flowering stage of wheat development. This disease may spread through the head and colonize the spiklets, rachis and developing kernels. Infected kernels are shriveled and may contain mycotoxins that limit the use of the grain for human or livestock consumption. Infected grain should not be used for seed the following year.
Thresholds for control: Disease forecasting systems utilizing weather and spore trapping data are available for FHB and are used by a small but growing number of wheat producers (4).
Alternative controls: Resistant varieties, crop rotation and incorporation of crop residue.

Leaf Disease Complex

Tan spot, *Pyrenophora tritici-repentis*, septoria leaf blotch, *Septori tritici*, Spot blotch, *Helminthosporium sativum*, and powdery mildew, *Erysiphe graminis f. sp. tritici*, are common leaf

spotting diseases and are more serious during years with above average rainfall. These pathogens overwinter on crop residue and are a greater problem on fields without rotation or with reduced tillage.
Thresholds for control: Disease forecasting systems utilizing weather and spore trapping data are available for foliar leaf diseases and are used by a small but growing number of wheat producers (4).
Alternative controls: Resistant varieties, crop rotation and incorporation of crop residue.

Common root rots

Common root rots, *Fusarium* and *Helmenthosporium spp*., are widely distributed diseases and are present on most wheat roots or crowns annually. These diseases can result in seedling blights, reduced plant vigor, and under severe conditions, premature dying of plants that results in small and shriveled kernels.
Thresholds for control: none
Alternative controls: Crop rotation

Chemical Controls Options:

Benomyl
Formulations: Benlate (1)
Diseases controlled: Powdery mildew and fusarium head blight
Typical Use: Often tank mixed with other fungicides to broaden spectrum of control
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 0.25 to 0.5 lbs
Application Timing: postemergence
REI: 24 hours
Pre-Harvest interval: 21 days
Advantages: --
Disadvantages: --

Propiconazole
Formulations: Tilt (1,15)
Diseases controlled: Leaf spot, powdery mildew, leaf rust, stem rust and fusarium head blight
Typical Use: Widely used for fusarium head blight control at early heading
Percent of Crop Treated in 1992: 2%
Percent of Crop Treated in 1997: 12%
Application Rates: 4 ounces
Application Timing: postemergence
REI: 24 hours
Pre-Harvest interval: 40 days
Advantages: broad spectrum
Disadvantages: --

Tebuconazole
Formulations: Folicur (1,15)
Diseases controlled: Leaf spots, powdery mildew, leaf rust, stem rust and fusarium head blight
Typical Use: Widely used for control of fusarium head blight at early heading
Percent of Crop Treated in 1992: not registered for use
Percent of Crop Treated in 1997: 21%
Application Rates: 4 oz.
Application Timing: postemergence
REI: 12 hours
Pre-Harvest interval: 30 days
Advantages: broad spectrum
Disadvantages: --

Mancozeb
Formulations: Dithane M-45, Penncozeb, several others (1,15)
Diseases controlled: Leaf spots, leaf rust and stem rust
Typical Use:
Percent of Crop Treated in 1992: 2%
Percent of Crop Treated in 1997: 12%
Application Rates: 2.1 lbs.
Application Timing: postemergence
REI: 24 hours
Pre-Harvest interval: 26 days
Advantages: broad spectrum, inexpensive
Disadvantages: weak on fusarium head blight; short residual activity

Triadmefon
Formulations: Bayleton 50 DF (1)
Diseases controlled: Powdery mildew, leaf rust and stem rust
Typical Use: Limited use with introduction of broader spectrum fungicides
Percent of Crop Treated in 1992: not available
Percent of Crop Treated in 1997: not available
Application Rates: 2-6 oz.
Application Timing: postemergence
REI: 12 hours
Pre-Harvest interval: 35 days
Advantages: --
Disadvantages: limited spectrum of control

Sulfur
Formulations: Sulfur DF (1)
Diseases controlled: Powdery mildew

Typical Use: Limited use with introduction of broader spectrum fungicides
Percent of Crop Treated in 1992: not available
Percent of Crop Treated in 1997: not available
Application Rates: 6-15 lbs.
Application Timing: postemergence
REI: 24 hours
Pre-Harvest interval: none
Advantages: --
Disadvantages: crop injury risk

Copper
Formulations: Kocide 2000, Champion WP, several others (1)
Diseases controlled: Leaf spots, and suppression of bacterial leaf blights
Typical Use: Limited use
Percent of Crop Treated in 1992: not available
Percent of Crop Treated in 1997: not available
Application Rates: 1.5-2 lbs.
Application Timing: postemergence
REI: 24 hours
Pre-Harvest interval: none
Advantages: Only compound with bacterial disease suppression
Disadvantages: limited fungicidal spectrum

Insect Pests

Aphids Aphids are arguably the most important insect pests of wheat in Minnesota. Several aphid species are present in most fields annually and during outbreak years may reduce yields by >20 bu/acre (11). Three aphid species that commonly damage wheat in the state are English grain aphid, Sitobion avenae, bird cherry oat aphid, Rhopalosiphum padi, and the greenbug, Schizaphis graminum. These aphids do not overwinter in Minnesota; they are deposited in the Upper Midwest by weather fronts originating in the southern U.S. each spring. The insects damage plants by sucking plant sap (all species), injecting toxins (greenbug) or spreading barley yellow dwarf virus (all species). Cool and wet conditions and/or late-planted fields increase the risk of aphid problems.
Thresholds for control: At tillering/flag leaf emergence, >87% of tillers have >1 aphid. Most grower applications are made during anthesis as a tank mix with fungicide to control FHB. Many producers and chemical sales personnel are associating increased yield from these ‘late’ insecticide treatments. These applications are usually made without exceeding threshold levels for any insect, but there is speculation that aphids affect yield at population levels lower than currently developed thresholds (11).

Alternative controls: Natural enemies of aphids hold populations below current treatment thresholds most years. Examples include ladybird beetles, green lacewing larvae, syrphid fly larvae, parasitic wasps, and disease.
Critical pest management issues: Additional research is needed to refine aphid thresholds on wheat.

Armyworm

Armyworm, *Pseudaletia unipuncta*, is an important, but infrequent pest of wheat and other cereal grains in Minnesota. This insect does not overwinter in the state and infestations are from movement of adult moths on weather fronts from southern states. During outbreak years infestations may exceed half a million acres. Larvae are leaf feeders and are easy to overlook during field scouting until substantial defoliation has occurred. This happens because larvae hide under debris and in soil cracks during the day, and because defoliation occurs quickly as nearly 90% of the total amount of leaf area is consumed by the last larval instar (7). A blacklight trap network is used to monitor adult armyworm migration and provides an early warning system for crop monitoring (18).
Thresholds for control: A nominal threshold of 5 larvae/ft^2 is used.
Alternative controls: none

Hessian Fly

Hessian fly, *Mayetiola destructor*, is not a major pest in the state, but can be a problem where reduced tillage is used and wheat is grown without rotation. This insect has two generations per year with most infestations remaining unrecognized. Damage to plants is from a toxic salivary secretion present as the larvae feed on sap under the leaf sheath. Symptoms from the first generation include plant stunting and various growth abnormalities and lodging from the second generation (8).
Thresholds for control: none established
Alternative controls: Resistant varieties; crop rotation; bury crop residue where there are known infestations

Grasshoppers

Grasshoppers are an important pest of wheat in Minnesota, but outbreaks are infrequent. The five most damaging crop species include the two-striped grasshopper, *Melanoplus bivittatus*, the differential grasshopper, *Melanoplus differentialis*, the migratory grasshopper, *Melanoplus sanguinipes*, the clearwinged grasshopper, *Camnula pellucida*, and the red-legged grasshopper, *Melanoplus femurrubrum*. Grasshoppers are leaf feeders and defoliation from grasshopper nymphs is localized in areas bordering roadsides or non-cropland where they hatched. As grasshoppers become adults (develop wings) they move easily from non-cropland or CRP to crop areas, which usually results in whole-field treatment. Outbreaks are associated with successive years of low rainfall or drought conditions (8,10).
Thresholds for control: Treatment for adults is suggested when populations reach eight or more per square yard in the field or 20 or more per square yard in field margins (10).
Alternative controls: Grasshoppers are attacked by a wide range of natural enemies including:

protzoans, Nosema locustae, fungi, Entomophagus grylli, nematodes, mites, birds and mammals. The effectiveness of these organisms depends on grasshopper populations and accompanying environmental conditions (10).

Orange Wheat Blossom Midge

Orange blossom wheat midge, *Sitodiplosis mosellana*, is a serious pest of wheat in many northern wheat producing regions but is but is a localized problem in the northern most counties of Minnesota. This small orange colored fly lays eggs on newly emerged heads of wheat. After hatching, the larvae feed directly on kernels, resulting in shriveled and deformed seed. Late-planted fields are at greatest risk of damage from wheat midge (12).
Thresholds for control: One adult midge for every four to five wheat heads. Timing of the insecticide application is critical to maximize control and to minimize impact on an important parasitic wasp (12).
Alternative controls: Crop rotation; midge populations also suppressed by the small parasitic wasp, *Macroglenes penetrans*.

Wireworm

There are several species of wireworm (Coleoptera: Elateridae) that attack wheat. The beetles feed on the germinating seed as well as the roots of plants. Populations of wireworm favor continuous sod conditions, thus problems are more common on land just out of pasture, alfalfa or CRP (3). Stand reduction from wireworm feeding on roots of developing wheat plants is rarely observed but occasionally fields of corn or soybean are replanted due to damage from this insect.
Thresholds for control: Solar baiting stations (averaging 1 wireworm/station) are suggested, but are rarely used
Alternative controls: None

Chemical Control Options:

Lindane
Formulations: Lindane ST 40, Lindane 75 Seed-Coat, others (1)
Insects controlled: wireworm, seedcorn maggot, seedcorn beetle
Typical Use: Used in combination with fungicides as a seed treatment (DB Green, Enhance Plus, Grain Guard Plus, many others)
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 1 oz.
Application Timing: applied as seed treatment
REI: 12 to 48 hours depending on formulation
Pre-Harvest interval: none
Advantages: only labeled material for wireworm suppression; low cost
Disadvantages: --

Dimethoate
Formulations: Dimethoate 400, Digon 400, many others (1)
Insects controlled: aphids and grasshoppers
Typical Use: Often used in tank mixtures with fungicides at the flowering stage of wheat as part of a prophylactic spray program
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 0.5-0.75 pts.
Application Timing: foliar application
REI: 48 hours
Pre-Harvest interval: 35 days Digon 400; 60m days Dimethoate 400
Advantages: Inexpensive
Disadvantages: --

Methyl Parathion
Formulations: Penncap-M, Methyl Parathion 8EC (1)
Insects controlled: aphids, armyworm, barley thrips and grasshoppers
Typical Use: Often used in tank mixtures with fungicides at the flowering stage of wheat as part of a prophylactic spray program
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 2-3 pts.
Application Timing: foliar application
REI: 5 days
Pre-Harvest interval: 15 days
Advantages: --
Disadvantages: Toxic to honeybees

Lambda-Cyhalothrin
Formulations: Warrior (1)
Insects controlled: armyworm, grasshoppers and suppression of aphids
Typical Use: Used to control infrequent outbreaks of armyworm and grasshopper
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 2.56-3.84 ounces
Application Timing: foliar application
REI: 24 hours
Pre-Harvest interval: 30 days
Advantages: broad spectrum
Disadvantages: --

Carbaryl

Formulations: Sevin XLR Plus, several other formulations
Insects controlled: armyworm
Typical Use: Limited as more effective and less expensive compounds are available
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 2-3 pts.
Application Timing: foliar application
REI: 12 hours
Pre-Harvest interval: 21 days
Advantages: --
Disadvantages: toxic to honeybees and aquatic invertebrates

Malathion
Formulations: Malathion 5, many other formulations (1)
Insects controlled: aphids, grasshoppers and armyworm
Typical Use: Used infrequently as more efficacious products are available
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 1.5 pts.
Application Timing: foliar application
REI: 12 hours
Pre-Harvest interval: 7 days
Advantages: Inexpensive; short preharvest interval
Disadvantages: control is variable

Methomyl
Formulations: Lannate LV and Lannate SP (1)
Insects controlled: armyworm, and aphids
Typical Use: Used infrequently
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 0.75-1.5 pts.
Application Timing: foliar application
REI: 48 hours
Pre-Harvest interval: 7 days
Advantages:
Disadvantages: human toxicity

Lambda-Cyhalothrin
Formulations: Di-Syston (1)
Insects controlled: aphids
Typical Use: Used infrequently
Percent of Crop Treated in 1992: no information available

Percent of Crop Treated in 1997: no information available
Application Rates: 4-12 ounces
Application Timing: foliar application
REI: 72 hours
Pre-Harvest interval: 30 days
Advantages: --
Disadvantages: human toxicity

Carbofuran
Formulations: Furadan 4F (1)
Insects controlled: grasshoppers
Typical Use: Widely used during grasshopper outbreaks
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 0.25-0.50 pts.
Application Timing: foliar application before heads emerge from boot
REI: 48 hours
Pre-Harvest interval: 30 days
Advantages: Inexpensive; excellent grasshopper control
Disadvantages: Toxicity to humans and wildlife

Chloropyrofos
Formulations: Lorsban 4E SG (1)
Insects controlled: Aphids, wheat midge and grasshoppers
Typical Use: Widely used during wheat midge outbreaks
Percent of Crop Treated in 1992: no information available
Percent of Crop Treated in 1997: no information available
Application Rates: 0.5-1 pints
Application Timing: foliar; for wheat midge, application should be made between heading and anthesis
REI: 24 hours
Pre-Harvest interval: 28 days
Advantages: Only insecticide labeled for orange wheat blossom midge
Disadvantages: --

Weeds

Wild Oat Wild oat, *Avena fatua*, is the most serious weed found in cereal grain rotations in Minnesota. It is highly competitive with wheat, is an alternate host for barley yellow dwarf virus and wheat streak

mosaic virus and has resistance to several commonly used post-emergent grass herbicides. This cool season, annual grass has an extensive fibrous root system and often emerges simultaneously with the wheat crop. Wild oat seed commonly remains dormant for 4-10 years, making management on individual fields a long-term process. Surveys list wild oat as the third most abundant weed in wheat fields with 59% of fields infested. The average wild oat density in infested fields was 7.6 plants/m^2. This weed is not uniformly distributed across the state and is primarily a weed problem in the northwest and western regions of Minnesota (2,14).

Thresholds for control: None suggested; Dew calculated a competitive yield loss index of 0.339 for wild oat. A yield loss of 9.3% is calculated from this index when applied to the average wild oat density of 7.6 plants/m^2 in Minnesota (5).

Alternative controls: Delayed planting allows use of tillage to remove early flushes of wild oat.

Green and Yellow Foxtail

Green foxtail, *Setaria viridis*, and yellow foxtail, *Setaria glauca*, are moderately competitive grasses if they emerge within one week of wheat. Green foxtail is an alternate host for wheat streak mosaic while yellow foxtail is an alternate host for ergot. These troublesome weed species interfere with harvest and add to grain dockage. Additionally, there are areas where biotypes are resistant to herbicides with the ACC-ase inhibitor modes of action. Surveys show green foxtail is the most abundant weed in wheat with 63% of fields infested with an average of 39.4 plants/m^2. Yellow foxtail is the fourth most abundant weed with 46% of fields infested with an average of 26.6 plants/m^2. Yellow foxtail is generally more difficult to control than green foxtail when using post-emergent grass herbicides in wheat (2,14).

Thresholds for control: None suggested; Yield losses from foxtail can be highly variable, dependent on environmental conditions and the duration of competition (13).

Alternative controls: Tillage can be used to manage foxtails. Reduced tillage favors increasing foxtail populations while increased tillage tends to bury seed and suppresses populations. Foxtail seed is short-lived so high levels of control for three or more years will strongly reduce the seed bank.

Wild Buckwheat

Wild buckwheat is the most common broadleaf weed in Minnesota wheat. While the plant is only moderately competitive with wheat, its climbing nature causes it to entangle with wheat making harvest difficult. In addition, wild buckwheat serves as an alternate host for aster yellow disease. Surveys indicate 60% of wheat field have wild buckwheat, with an average density of 3.6 plants/m^2 (2,14).

Thresholds for control: None suggested

Alternative controls: None

Redroot Pigweed

Several pigweed species are found across the state but redroot pigweed, *Amaranthus retroflexus*, is one of the most common. This highly competitive plant is capable of producing 150,000 seeds/plant. Seeds

may persist in the soil for up to 40 years causing long-term control issues and plants can be difficult to control if herbicide applications are not made when the plants are small. Surveys indicate 38% of fields contain pigweed with an average density of 3.6 plants/m^2 (2,14).
Thresholds for control: None suggested
Alternative controls: None

Chemical Control Options:

MCPA
Formulations: Several (1,6,15,17)
Plants controlled: annual broadleaf weeds except wild buckwheat and smartweed
Typical Use: tank mixed with other broadleaf herbicides to broaden weed spectrum and increase crop safety of SU herbicides
Percent of Crop Treated in 1992: 54%
Percent of Crop Treated in 1997: 77%
Application Rates: 0.5-1.33 pts.
Application Timing: from two-leaf to early boot stage of development
REI: 12 to 48 hours depending on formulation
Pre-Harvest interval: none
Advantages: Inexpensive low potential for crop injury
Disadvantages: Weak on wild buckwheat and smartweed

2,4-D
Formulations: Several (1,6,15,17)
Plants controlled: annual broadleaf weeds except wild buckwheat and smartweed
Typical Use: tank mixed with other broadleaf herbicides to broaden weed spectrum and increase crop safety of SU herbicides
Percent of Crop Treated in 1992: 36%
Percent of Crop Treated in 1997: 57%
Application Rates: 0.5-1 pt.
Application Timing: from five-leaf to prior to boot stage of development
REI: 12 to 48 hours depending on formulation
Pre-Harvest interval: none
Advantages: Inexpensive
Disadvantages: Weak on wild buckwheat and smartweed

Bromoxynil
Formulations: Buctril, Moxy (1,6,15,17)
Plants controlled: small annual broadleaf weeds
Typical Use: used in a premix with MCPA (Bronate, Bison, Bromac) which broadens weed spectrum
Percent of Crop Treated in 1992: 25%
Percent of Crop Treated in 1997: 37%

Application Rates: 1-2 pts.
Application Timing: from emergence to prior to boot stage of development
REI: 12 hours
Pre-Harvest interval: none
Advantages: Broad spectrum of broadleaf weeds; low potential for crop injury
Disadvantages: Weak on pigweed and wild mustard.

Thifensulfuron
Formulations: Harmony GT (1,6,15,17)
Plants controlled: annual broadleaf weeds
Typical Use: Commonly used in a premix with tribenuron (Harmony Extra) which broadens weed spectrum to include Canada thistle
Percent of Crop Treated in 1992: 11%
Percent of Crop Treated in 1997: 24%
Application Rates: 0.3-0.6 oz.
Application Timing: two-leaf stage until prior to flag leaf emergence
REI: 12 hours
Pre-Harvest interval: 45 days
Advantages: Broad spectrum of annual broadleaf weeds; will control larger weeds at higher use rates
Disadvantages: Will not control ALS resistant kochia or Canada thistle

Tribenuron
Formulations: Express (1,6,15,17)
Plants controlled: annual broadleaf weeds and Canada thistle suppression
Typical Use: Commonly used in a premix with thifensulfuron (Harmony Extra) which increases efficacy on several weed species
Percent of Crop Treated in 1992: 12%
Percent of Crop Treated in 1997: 25%
Application Rates: 0.17-0.33 oz
Application Timing: two-leaf stage until prior to flag leaf emergence
REI: 12 hours
Pre-Harvest interval: 45 days
Advantages: Broad spectrum of annual broadleaf weeds; will suppress Canada thistle
Disadvantages: Will not control ALS resistant kochia; weak on wild buckwheat

Fluroxypyr
Formulations: Starane (1,6,17)
Plants controlled: kochia, including ALS resistant
Typical Use: Use is restricted to areas with ALS resistant kochia; Starane is not a stand alone herbicide and is usually tank mixed with other broadleaf herbicides such as MCPA or 2,4-D for broader spectrum of control
Percent of Crop Treated in 1992: not registered for use
Percent of Crop Treated in 1997: not registered for use

Application Rates: 0.5-0.67 pt.
Application Timing: two-leaf stage through flag leaf emergence
REI: 12 hours
Pre-Harvest interval: 40 days
Advantages: excellent control of kochia
Disadvantages: relatively expensive

Dicamba
Formulations: Banvel, Banvel-SGF, Clarity (1,6,15,17)
Plants controlled: annual broadleaves and suppression of select perennial weeds
Typical Use: Often used in tank mixtures with other broadleaf herbicides to broaden weed spectrum
Percent of Crop Treated in 1992: 11%
Percent of Crop Treated in 1997: not available
Application Rates: 0.13-0.25 pts.
Application Timing: prior to six-leaf stage
REI: 24 hours
Pre-Harvest interval: none
Advantages: Broad spectrum of annual broadleaf weeds including ALS resistant kochia
Disadvantages: crop injury risk; often antagonizes grass herbicides in tank mixes; weak on wild mustard

Clopyralid
Formulations: Stinger (1,6,15,17)
Plants controlled: Canada thistle and select annual broadleaves
Typical Use: Usually used as premix with MCPA or 2,4-D (Curtail, Curtail-M) to broaden weed spectrum and reduce cost
Percent of Crop Treated in 1992: not available
Percent of Crop Treated in 1997: 13%
Application Rates: 0.25-0.33 pts.
Application Timing: three leaf to early boot stage of development
REI: 12 hours (48 hours for Curtail and Curtail-M)
Pre-Harvest interval: none
Advantages: superior control of Canada thistle
Disadvantages: crop rotation restrictions on some crops; expensive

Carfentrazone
Formulations: Aim (1,6,17)
Plants controlled: select annual broadleaf weeds and kochia resistant to the ALS inhibitor MOA
Typical Use: Usually mixed with MCPA or 2,4-D to broaden weed spectrum
Percent of Crop Treated in 1992: not registered for use
Percent of Crop Treated in 1997: not registered for use
Application Rates: 0.33-0.67 oz.
Application Timing: up to jointing stage of development
REI: 12 hours

Pre-Harvest interval: none
Advantages: control of kochia resistant to the ALS inhibitor MOA
Disadvantages: crop injury risk

Imazamethabenz
Formulations: Assert (1,6,15,17)
Plants controlled: wild oat and select Brassica spp
Typical Use: Use of Assert has declined with introduction of herbicides that control both wild oat and foxtails
Percent of Crop Treated in 1992: 11%
Percent of Crop Treated in 1997: 2%
Application Rates: 1.0-1.5 pts.
Application Timing: two leaf until prior to jointing
REI: 48 hours
Pre-Harvest interval: none
Advantages: very good wild oat control; low risk of crop injury
Disadvantages: crop rotation restrictions on some crops; limited grass control spectrum

Difenzoquat
Formulations: Avenge (1,6,15,17)
Plants controlled: wild oat
Typical Use: Use of Avenge has declined with introduction of herbicides that control both wild oat and foxtail
Percent of Crop Treated in 1992: not available
Percent of Crop Treated in 1997: 1%
Application Rates: 2.5-4.0 pts.
Application Timing: prior to flag leaf emergence
REI: 48 hours
Pre-Harvest interval: none
Advantages: good control of large wild oats
Disadvantages: cannot be used on all varieties (crop injury risk); limited grass control spectrum

Fenoxaprop
Formulations: Puma (1,6,15,17)
Plants controlled: wild oat, foxtails, barnyardgrass and millet
Typical Use: Broad use alone and in package mixtures with Harmony Extra (Cheyenne) or MCPA and 2,4-D (Tiller)
Percent of Crop Treated in 1992: 16%
Percent of Crop Treated in 1997: 60%
Application Rates: 0.33-0.66 pts.
Application Timing: one leaf to 60 days prior to harvest
REI: 24 hours
Pre-Harvest interval: 60 days

Advantages: wide spectrum of grass control; wide tank mix options with broadleaf herbicides
Disadvantages: will not control wild oat or foxtail spp resistant to the ACC-ase inhibitor mode of action (MOA)

Clodinafop
Formulations: Discover (1,6,17)
Plants controlled: wild oat, foxtails and barnyardgrass
Typical Use: new registration
Percent of Crop Treated in 1992: registered for use in 2000
Percent of Crop Treated in 1997: registered for use in 2000
Application Rates: 3.2-4 oz
Application Timing: two leaf to emergence of fourth tiller
REI: 24 hours
Pre-Harvest interval: 60 days
Advantages: wide spectrum of grass control; wide tank mix options with broadleaf herbicides
Disadvantages: will not control wild oat or foxtails resistant to the ACC-ase inhibitor MOA

Flucarbazone
Formulations: Everest (1,6,17)
Plants controlled: wild oat, and foxtails
Typical Use: new registration
Percent of Crop Treated in 1992: registered for use in 2000
Percent of Crop Treated in 1997: registered for use in 2000
Application Rates: 0.4-0.6 oz
Application Timing: first to fourth leaf stage of development
REI: 12 hours
Pre-Harvest interval: 60 days
Advantages: ALS mode of action (will control grasses resistant to ACC-ase MOA)
Disadvantages: crop injury risk; only suppression of yellow foxtail

Triallate
Formulations: Fargo, Fargo EC (1,6,15,17)
Plants controlled: wild oat
Typical Use: Use has declined with introduction of herbicides with increased efficacy and broader spectrum of control
Percent of Crop Treated in 1992: 5%
Percent of Crop Treated in 1997: 2%
Application Rates: 12.5 lbs.
Application Timing: pre-plant incorporated
REI: 12 hours
Pre-Harvest interval: none
Advantages: will control wild oat resistant to ACC-ase inhibitor MOA
Disadvantages: limited weed-control spectrum

Trifluralin
Formulations: Treflan 10G, Treflan 4E (1,6,15,17)
Plants controlled: foxtail spp and a few annual broadleaf weeds
Typical Use: Use has declined with introduction of herbicides with increased efficacy
Percent of Crop Treated in 1992: 5%
Percent of Crop Treated in 1997: not available
Application Rates: 1 pt.
Application Timing: pre-plant incorporated in the fall or pre-emergence incorporated in the spring
REI: 12 hours
Pre-Harvest interval: none
Advantages: will control foxtails resistant to ACC-ase inhibitor MOA
Disadvantages: limited weed spectrum; crop injury risk

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