Crop Profile for Hard Red Spring and Durum Wheats in North Dakota

Prepared June, 2000

General Production Information

The primary production region for durum is the Northwest and North Central part of the state. Of 3,000,000 acres of durum planted in 1998, 1,520,000 were planted in the Northwest district, 410,000 in the West Central, and 370,000 in the North Central.

Spring wheat was grown statewide. Of the 6,700,000 acres of spring wheat planted in 1998, 1,250,000 were planted in the Northeast district, 990,000 in the East Central, and 830,000 in the Southeast.

Table 1. Wheat Production and its Economic impact on North Dakota s Economy

Year	Crop	National Rank	Total Acres Planted	Total Production (bushels)	Cash Value ($)
1996	Durum	1st	3,000,000	79,380,000	447,120,000
	Spring Wheat	1st	9,600,000	313,500,000	1,269,675,000
1997	Durum	1st	2,700,000	56,540,000	284,093,000
	Spring wheat	1st	8,800,000	210,000,000	730,800,000
1998	Durum	1st	3,000,000	97,350,000	311,520,000
	Spring wheat	1st	6,700,000	211,200,000	665,280,000
1999	Durum	1st	3,450,000	72,000,000	---
	Spring Wheat	1st	5,900,000	168,000,000	---

Cultural Practices

North Dakota has a temperate climate that is conducive to growing wheat. Average annual days above freezing range from 110 days in the North to 130 days in the South. Average growing season precipitation ranges from 16.0 inches in the Southeast to less than 12.0 inches in the Northwest. North Dakota soil types range from rich organic

soils in the east to lighter soils in the west. This combination of climate and soils is ideal for statewide wheat production.

Spring and durum wheats are planted in the spring, from late April to the end of May. Seedbed preparation can vary based on the type of seeding equipment used. No-till, and reduced tillage drills are designed for use in high residue conditions. Conventional drills require greater seedbed preparation. This is achieved through the use of tillage equipment in the fall following harvest and in the spring prior to seeding. Row spacing ranges from 6 to 9 inches with seed planted at 2 inch depth or less. A plant population of 28 to 30 plants per square foot is desired.

Spring and durum wheats are harvested in the fall from early August to late September. During the 1990's, durum yields averaged from 22 to 38 bushels per acre, while spring wheat yields range from 25 to 42 bushels per acre.

Hard Red Spring and Durum Wheat Processing

Hard red spring has the highest protein content of all U.S. wheats, usually 13 to 16 percent. High protein content corresponds with greater gluten content. For this reason, flour mills in the United States and in many export markets blend hard red spring wheat with lower protein wheats to increase the gluten content in flour. The addition of hard red spring improves dough handling and mixing characteristics, and water absorption.

Durum is the hardest of all wheats. Its density, combined with its high protein content and gluten strength, make durum the wheat of choice for producing premium pasta products. Pasta made from durum is firm with consistent cooking quality. Durum kernels are amber-colored and larger than those of other wheat classes. Also unique to durum is its yellow endosperm, which gives pasta its golden hue.

When durum is milled, the endosperm is ground into a granular product called semolina. A mixture of water and semolina forms a stiff dough. Pasta dough is then forced through dies, or metal discs with holes, to create hundreds of different shapes.

Durum production is geographically concentrated to North Dakota and the surrounding area because it demands a special agronomic environment. North Dakota produces 73 percent of the U.S. durum crop. Many international and domestic millers prefer North Dakota durum for its color and strong gluten characteristics.

Insect Management

Insecticides were applied on 4% of the wheat acreage in 1996. Starting in 1996 the wheat midge had a significant influence on insecticide usage. Approximately 500,000 acres were treated with chlorpyrifos, the only registered insecticide for wheat midge. Other products used were lambda cyhalothrin, carbofuran, carbaryl, and ethyl parathion. The most frequent target pests for these products included grasshoppers and cereal aphids. A total of 541,500 acres were treated with insecticides. The producer applied 22% with ground equipment and the remaining 78% of treatments were aerial applied.

Aphids: Greenbug (*Schizaphis graminum*), English grain aphid (*Sitobion avenae*), Bird cherry oat aphid (*Rhopalosiphum padi*), and Russian wheat aphid (*Diuraphis noxia*).

The English grain aphid, bird cherry oat aphid, and the greenbug are the most common aphid pests of small grains in North Dakota. The Russian wheat aphid has only been a minor pest in the state. The greenbug and the Russian wheat aphid are considered to be the most injurious of the aphids. During feeding these aphids inject saliva which is toxic to the plant causing yellowing and death of leaf tissue. Large populations of bird cherry oat aphid are associated with high infection levels of Barley yellow dwarf virus.

Problems with cereal aphids are dependent on when they migrate into the region, weather conditions when they arrive, and growth stage of wheat when populations increase. Aphids are present in wheat fields each season. Aphids are usually the most troublesome during periods of cool, wet weather. Late seeded crops are likely to be most severely infested. Growers are discouraged from appling excess nitrogen, since excessive plant growth will promote aphid infestations. Most infestations are minor and are kept in check by natural enemies such as syrphid fly larvae, aphid lions, ladybird beetles, several parasitic wasps, and parasitic fungi. When natural enemies are present in large numbers, farmers are discouraged from spraying insecticides.

Orange Wheat blossom Midge: *Sitodiplosis mosellana*

In recent years the orange wheat blossom midge has been a cause of economic concern. In North Dakota the wheat midge has been detected in all counties north and east of the Missouri River. Significant damage has also been reported in Minnesota and the prairie provinces of Canada. Damage caused by the wheat midge is difficult to detect. The wheat plant is only attractive to the wheat midge from the time the head emerges from the boot to flowering. At this time female adults lay their eggs within the wheat head. After hatching the midge larvae feed on the developing wheat kernels causing them to shrivel and become deformed. Only by examining the kernels can damage be found. The wheat growing areas of Northeast and North Central North Dakota have been the areas most heavily damaged. However, other regions of the state have had populations of wheat midge which warranted control.

Wheat midge populations have been partially held in check by a parasitic wasp called *Macroglenes penetrans* (Kirby). This wasp can control up to 50% of the overwintering midge population each year. Rotating wheat with other non susceptible crops aids in reducing wheat midge numbers. Crops such as oilseeds, barley, and oats can be grown with little or no risk of damage. By selecting early maturing varieties and planting early, the wheat crop will head and flower before the peak of the wheat midge emergence.

Current treatment recommendations are when one or more midge are observed for every four to five wheat heads. Treat only when 75% of wheat heads have emerged from the boot. Treatment after 50% of the wheat heads have flowered is not recommended because of reduced efficacy and for the protection of the parasitic wasps.

Grasshoppers: Clearwinged grasshopper (*Camnula pellucida*), Two-striped grasshopper (*Melanoplus bivittatus*), Migratory grasshopper (*Melanoplus sanguinipes*), differential grasshopper (*Melanoplus differentialis*), and Redlegged grasshopper (*Melanoplus femurrubrum*).

Grasshoppers are sporadic pests in North Dakota, especially in regions that receive little rainfall. Weather is one of the main factors affecting grasshopper populations. Outbreaks are usually preceded by several years of hot, dry summers and warm falls, allowing populations to increase. Damage to wheat is usually concentrated near field margins. Individual plants can be damaged by leaf stripping, awn loss, head clipping, and damaged kernels.

Natural enemies include parasites, predators, and diseases. Some type of natural enemy attacks all grasshopper stages. Early seeding establishes vigorously growing plants that are more tolerant to grasshopper injury. Early seeded crops will mature earlier and reduce the risk of late season migrations of adult grasshoppers. Crop rotation, tillage, trap strips, and harvesting crops early are other cultural control practices used to reduce grasshopper damage. Grasshoppers are more easily controlled in the nymphal stage. Treatment is advised when 50 or more nymphs per square yard are found in field margins or 30 or more nymphs per square yard are found within the field.

Armyworms: *Pseudaletia unipuncta*

Outbreaks in North Dakota occur when large migrations of moths from the south occur in late spring and early summer. Armyworms feed at night on above ground vegetation, and hide under the foliage and in the soil during the day. In most years, populations are kept low by unfavorable weather conditions such as cool wet weather.

A number of diseases and parasites attack armyworms. Tachinid flies, parasitic wasps, and viruses are all natural controls of the armyworm. These natural enemies often do not destroy armyworm larvae until after severe crop damage has occurred. Their greatest impact is preventing excessive increases in the next generation.

Current treatment recommendations are when four to five or more worms per square foot are present.

Cutworms: several species (Lepidoptera: Noctuidae)

In western North Dakota, the pale western and the army cutworms are important pests of small grains. Pale western cutworm eggs hatch in the spring, and the larvae feed below ground cutting plants over at ground level. Army cutworm eggs hatch in the fall and the spring, larval feeding is above ground. The dingy cutworm, red-backed, and dark-sided cutworms are common but wheat is not as frequently affected as the regions field crops.

Wireworms: (Coleoptera: Elateridae)

Wireworms are a minor pest of spring and durum wheats in North Dakota. The wireworms or click beetle larvae live for two-nine years in the soil. They are attracted to carbon dioxide, which is released by germinating seeds and growing plant tissue. Wireworms feed on the seeds and roots. Damaged plants are then more susceptible to plant pathogens.

The only insecticide registered for wireworm control is lindane. Lindane is applied to the seed just before planting. Lindane can be purchased as a dry drill box treatment or as a liquid formulation.

There are multiple minor insect pests present in the region. These include: wheat stem sawfly, *Cephus cinctus*, wheat stem maggot, *Meromyza americana*, and Hessian fly, *Mayetiola destructor*. These insects are managed most effectively through cultural practices. Insecticidal control has not proven adequate for these pests.

Table 2. Registered insecticides and their usage in North Dakota to manage wheat insect pests.

Active Ingredient	Trade name	Acres Treated [1]	Application rate (product/acre)	Target Insects	Pre-harvest Interval

		x 1000	%			(days)
carbaryl	Sevin	13.4	0.1	Rate varies by formulation	Armyworms and grasshoppers	21
carbofuran	Furadan	26.8	0.2	0.25 0.5 pt	Grasshoppers	Apply before heading
chlorpyifos	Lorsban	450.6	3.6	1 pt	wheat midge, aphids	28
diazinon	Diazinon	0.1	0.0	Rate varies by formulation	grasshopper border treatments (non-crop)	NA
esfenvalerate	Asana XL	2.3	0.0	3.9 - 5.8 fl oz	grasshopper border treatment (non-crop)	NA
ethyl parathion	Parathion	12.7	0.1	8 fl oz	aphids, armyworms, and grasshoppers	15
lambda cyhalothrin	Warrior	34.0	0.3	1.92 3.2 fl oz for cutworms and 2.56 3.84 fl oz for armyworms	cutworms and armyworms	30
malathion	Malathion	4.7	0.0	1.5 2 pts for aphids 2 pts for armyworms and 1.5 2 pts for hoppers	Aphids, armyworms, and grasshoppers	7
methyl parathion	Methyl Parathion	0.6	0.0	8 fl oz	Aphids, armyworms, and grasshoppers	15
	Penncap M	7.4	0.1	2 3 pts	Aphids, armyworms, and grasshoppers	15
dimethoate	Digon 400 Dimethoate 4000	NR	NR	0.5 0.75 pt for aphids, 0.75 pt for grasshoppers	Aphids and grasshoppers	35 60
disulfoton	Di-Syston	NR	NR	0.5 1 pt	aphids	30
methomyl	Lannate LV	NR	NR	12 24 fl oz	aphids and armyworms	7
lindane	lindane	2152.1	17.0	2 oz per bushel (seed trtmt + fungicide)	wireworms	applied at planting

[1] Zollinger et al, 1998.
NR - Use not reported by survey

Disease Management

Several diseases are potential problems on wheat every year in North Dakota. Cool moist soil in the spring slows the growth of wheat and promotes the growth of diseases. Prolonged exposure to dry soils can also hinder germination and promote diseases. Foliar diseases can also be a serious problem in North Dakota. Disease causing fungi can survive in crop debris, field trash, and sometimes seeds. Usually a prolonged period of high moisture and humidity is required for disease organisms to infect growing wheat fields.

Wheat diseases are best managed with a combination of cultural and chemical controls. Rotating other crops with wheat and burying crop residue are examples of cultural controls. Treating wheat seed in the spring with fungicides and during the growing season with foliar fungicides are popular chemical methods for managing wheat diseases. The most commonly used fungicides on wheat in North Dakota in 1996 were: Benlate, Mancozeb, and Propiconazole. In 1996, 279,200 acres were treated with these fungicides, or just over 2% of total wheat acres in the state.

Fusarium head blight (Scab): *Fusarium graminearum* and *Fusarium culmorum*

Repeated scab epidemics and large economic losses have resulted from Fusarium head blight infections during the 1990's. Scab is a problem when long periods of high humidity and wet weather occur at heading and grain-fill. Parts of the wheat head become infected; often kernels infected are pink in color at their base. Scab can severely reduce yields and test weight. Additionally, infected seed may contain fungal toxins to which afect feed and food quality. At this time scab is the most serious fungal disease in small grains in the Upper Midwest.

Growers are encouraged to reduce the risk of scab infection through crop rotation, avoid planting on last year s corn ground, and use tillage to bury crop residue and trash. Scabby grain should not be used for seed. If scabby grain is used for seed, it is recommended to treat the seed with fungicides, such as carboxin + thiram, Maneb + imazalil, or difenconazole. If favorable weather occurs at flowering, some foliar fungicides have been demonstrated to reduce scab severity.

Table 3. North Dakota Section 18 and 24C emergency fungicide exemptions for wheat protection from Fusarium head blight, 1998 - 2000.

Active Ingredient	Trade Name	Acres Treated in 1998	Application rate (product/ acre)	Application Method	Diseases Controlled	Pre-harvest Interval (days)

Tebuconazole	Folicur	800,000	4 fl oz	Foliar Spray	Fusarium head blight	30
Propiconazole	Tilt	200,000	4 fl oz	Foliar Spray	Fusarium head blight	40

Observations from research results and commercial wheat fields indicated the following:

- The two fungicides, applied at heading with angled sprays, resulted in +11.9 bushels yield and +1.3 lb. test weight for tebuconazole, and +8.9 bushels yield and +1.0 lb. test weight with propiconazole on treated wheat acres.
- On treated acres, increased yield from fungicide use was +11.3 million bushels of wheat. Total economic gain was $33.9 million dollars, based on $3.00/bu wheat and yield response alone.

The total cost of fungicide application for both fungicides was $14.00/acre, or $14 million for the 1 million acres treated. Total economic return for wheat producers in North Dakota and northwest Minnesota in 1998 from use of the Section 18 and Section 24C fungicides and their improved application showed a $33.9 million return - $14.0 million cost = $19.9 million dollars

Wheat Leaf Rust: *Puccinia recondita* f. sp. *tritici*

Spores of the rust fungi overwinter in southern states and are carried to North Dakota by the wind. Leaf rust is recognized by reddish-orange pustules found on the leaves and stems of infected plants. Each of these pustules is capable of producing approximately 1,000 spores. Each rust spore is able to infect a new wheat plant. The growing spores deprive the host plant of nutrients.

The use of wheat varieties resistant to rust limit the infection, retard fungus growth, and limit spore formation. However, recent shifts in leaf rust races have resulted in many varieties losing their resistance, and now most varieties grown are susceptible to one or more of the prevalent races of leaf rust. Fungicide sprays containing mancozeb, propiconazole, or triadimenfon can control leaf rust. Applications should be made at the early boot stage for mancozeb products, at flag leaf emergence for propiconazole products, and the early boot stage for triadimenfon products.

Leaf diseases:

Tan spot, *Pyrenophora tritici-repentis*, Leaf blotch, *Septoria* species, Spot blotch, *Helminthosporium sativum*, and powdery mildew, *Erysiphe graminis* f. sp. *tritici*, are common leaf diseases in wheat in North Dakota. If enough leaf surface area is killed, grain yields and test weights are reduced. Fungi overwintering in crop debris and trash promote the development of leaf diseases. Most of these diseases require long periods of high moisture and high humidity for infection to occur.

Crop rotation, and spring tillage with the purpose of burying crop residue can reduce leaf diseases. Foliar fungicides containing Mancozeb or Propiconazole are effective against foliar leaf diseases.

Loose smut: *Ustilago tritici*

All wheat and durum varieties grown in the state are susceptible to loose smut. Generally, smut is not a severe problem, but the reduction in use of seed treatment in recent years has resulted in increased numbers of fields with economic losses due to loose smut..

Crop rotation is recommended for reducing the risk of infection. Applying the appropriate seed treatment containing carboxin, difenoconozole, or triadmenol will protect the wheat crop from loose smut.

Common root rot: *Fusarium* and *Helminosporium* spp.

This is a potential problem every year in North Dakota. Damage is often most severe when the crop is stressed. Root rot can be identified by brown discoloration of the roots and crown, and wheat heads having fewer seeds that may be shriveled.

Crop rotation is recommended for reducing the risk of infection. Seed treatments containing difenoconazole, imazalil, and triadmenol are registered for suppressing root rot.

Take-all: *Gaeumannomyces graminis* var. *tritici*

Take-all is a serious root rot which can completely destroy a crop. It is most common in fields of continuously cropped wheat and high soil moisture. Damage is characterized by a black shiny discoloration at the base of the plant.

Wheat should not be planted on a field having take-all for three seasons. Seed treatments containing difenoconazole and triadimenol are registered for control of take-all.

Glume blotch: *Septoria* spp.

The glume blotch fungus has been endemic in wheat in North Dakota, causing slight to moderate damage. This fungus has contributed to low yields and test weights in recent years especially in durum. This fungus survives on wheat residue, and infection is favored by warm, wet weather following heading.

Crop rotation and tillage practices aid in the management of this disease. Foliar fungicides can help protect against leaf infection. Benlate, when used in a tank mix with Bayleton or Manzate 200, and mancozebs are registered for glume blotch control.

Wheat streak mosaic:

Wheat streak mosaic virus (WSM) causes severe yield losses on wheat some years. The wheat streak mosaic virus is carried by the wheat curl mite. The mite lives and reproduces on wheat and other grass hosts. It survives the winter on seeded or volunteer winter wheat. Symptoms of wheat streak mosaic often appear at the edges of the field first. Infected plants are yellow and stunted, and almost no growth occurs. Diseased plants often don t produce heads; if heads are produced they are often sterile and do not produce seed.

To reduce the risk of WSM, destruction of all volunteer wheat in fields before planting winter wheat is

recommended; volunteers act as a reservoir for the wheat curl mite. Winter wheat should not be planted too early; planting early increases the chance of infection by the mite. In the spring, any infected winter wheat plants should be destroyed or they may become a source of infection for spring planted wheat.

Table 4. Registered seed treatment fungicides and their usage in North Dakota wheat production.

Active Ingredient	Trade Name	Acres Treated [1]		Application	Application Rate	Diseases Controlled
		x 1000	%			
Benomyl	Benolate	NR	NR	Dust of slurry	1 2 oz/Bu	Covered smut, Loose smut
Captan + PCNB + Thibendazole	Rival Flowable	NR	NR	Slurry	4.0 fl oz/cwt.	Seedling blight
Captan + Thiabenazole	Agrosol Flowable	22.0	0.2	Slurry	1.5 fl oz/Bu	Seedling blight
Carboxin	Vitavax 34	1200.0	9.5	Slurry	2 3 fl oz/cwt.	Covered smut, Loose smut, and Seedling blight
Carboxin + Captan	Nu-Gro Captan 20 Carboxin 20 Seed Mate Captan - Vitavax 20-20 Enhance	NR	NR	Drill box	4 oz/cwt.	Covered smut, Loose smut, Seedling blight
Carboxin + Maneb	DB-Green + Vitavax, Enhance Plus	197.2	1.6	Dust or Drill Box Drill Box	2 oz./Bu	Covered smut, Loose smut, Seedling blight
Carboxin + PCNB	Vitavax + PCNB	NR	NR	Slurry or mist	3 4 oz/cwt.	Covered smut, Loose smut, Seedlingblight
Carboxin + Thiram	Vitaflo 280 Vitavax 200 Flowable RTU-Vitavax-Thiram Vitavx T-L Vitavax-Thiram-Lindane	1159.0	9.1	Slurry Slurry or mist Liquid or Slurry Drill box Slurry	5 oz/cwt. 3-4 fl oz/cwt. 5 6.8 fl oz/cwt. 5 6.8 fl oz/cwt. 5 fl oz/cwt.	Covered smut, Loose smut, Seedling blight
Carboxin + Imazalil + Thiabendazole	RTU Vitavax Extra	272.7	2.2	Slurry	5 fl oz/cwt.	Bunt, Loose smut, Seedling blight, Common root rot

Difenoconazole + Mefenoxam	Divedend XL Divedent XL RTA	143.1	1.1	Slurry Ready to apply	1 - 2 fl oz/cwt. 2.5 10 fl oz/ cwt.	Bunt, Loose smut, Seedling blight, common root rot, take-all
Imazalil	Agsco Double R Seed Trt. Flo-Pro IMZ Flowable Nu-Zone 10 ME	136.5	1.1	Slurry	0.8 1.5 fl oz/Bu 0.25 0.5 fl oz/ cwt. 0.8 1.5 fl oz/ cwt.	Seedling blight, Common root rot
Mancozeb	Dithane WSP Dithane ST Grain Guard Grain Guard Plus Manzate 75 DF	45.3	0.4	Drill box Slurry or mist Drill box Slurry	1.3 2 oz/Bu 2 3.2 oz/Bu 2 oz/Bu 2 oz/Bu 1.3 2 oz/Bu	Covered smut, Seedling blight
Maneb	Agsco DB Green, Agsco DB Green L	1687.6	13.3	Dust or Drill box Slurry	2 oz/Bu 3 fl oz/Bu	Covered smut, Seedling blight
Maneb + Thiabendazole	Granox Plus	3.0	0.0	Drill box	1 oz/Bu	Seedling blight
metalaxyl	Allegiance FL	46.5	0.4	Mist or Slurry	0.375 0.75 oz/ cwt.	Seedling blight
Metalaxyl + PCNB + Carboxin	Prevail	NR	NR	Drill box	3 oz/Bu	Covered smut, Loose smut, Seedling blight
PCNB (Terraclor)	Terra coat LT 2N RTU PCNB PCNB Seed Coat	8.2	0.1	Liquid or Slurry Slurry Slurry	2 fl oz/Bu 3 fl oz/Bu 2 oz/Bu	Seedling blight, covered smut
Thiram	42-S Thiram Thiram 50WP Dyed	47.0	0.4	Liquid or Slurry Drill box or Slurry	2 fl oz/Bu 3.3 oz/cwt.	Seedling blight
Tebuconazole	Raxil 2.6F	NR	NR	Slurry or Mist	0.1 fl oz/cwt.	Covered smut, Loose smut Seedling blight, Common root rot
Triadmenol	Baytan 30 F	NR	NR	Slurry	0.75 1.5 fl oz/ cwt.	Covered smut, Loose smut, Seedling blight, Common root rot, take-all

Triadimenol + Thiram	RTU-Baytan-Thiram	NR	NR	Slurry or mist	4.5 9 fl oz/cwt.	Covered smut, Loose smut, Seedling blight, Common root rot

[1] Zollinger et al, 1998. Acres reported seeded with treated seed include multiple applications to the same seed and seed treatment products applied as a tank mixture were totaled separately unless applied as a commercial premix.
NR - Use not reported by survey

Table 5. Registered fungicides and their usage in North Dakota to manage wheat diseases.

Active Ingredient	Tradename	Acres Treated [1]		Application Rate	Diseases Controlled	Remarks
		x 1000	%			
Benomyl	Benlate	76.5	0.6	0.25 0.5 lb/A 0.5 lb/A for scab	Powdery mildew, Scab (Fusarium head blight)	Apply during flowering for scab. Do not apply within 21 days of harvest.
Copper	Champion WP Champ Formula 2 Kocide 2000 Kocide 4.5 LF	NR	NR	1.5 2 lb/A 1 1.33 pt/A 1.25 1.5 lb/A 1 1.33 pt/A	Leaf spot, Leaf rust	
Mancozeb	Dithane DF Dithane F-45 Dithane M-45 Dithane WSP Manex II Manzate 75 DF Penncozeb Penncozeb DF	114.5	0.9	2.1 lb/A 1.6 qt/A 2 lb/A 2 lb/A 1.6 qt/A 2 lb/A 1 2 lb/A 1 2 lb/A	Leaf spot, Leaf rust, Stem rust	Do not apply mancozeb within 26 days of harvest. Do not graze livestock in treated areas prior to harvest.
Mancozeb + Copper	ManKocide	114.5	0.9	2 2.5 lbs./A	Leaf spot	Apply at early heading, do not apply within 26 days of harvest.

Propiconazole	Tilt 3.6 EC Tilt Gel	88.2	0.7	2 4 fl oz/A	Leaf spot, Leaf rust, Stem rust, Powdery mildew	Do not graze of feed livestock treated crops.
Triadmefon	Bayleton 50 DF	NR	NR	2 6 oz/A for Powdery mildew, 4 6 oz/A for rusts.	Leaf rust, Stem rust, Powdery mildew	Do not apply within 35 days of harvest.
Sulfur	Sulfur DF	NR	NR	6 15 lb/A	Powdery mildew	Do not apply when temperatures are high (above 90° F).

[1] Zollinger et al, 1998.
NR - Use not reported by survey

Weed Management

Weed control in small grains is generally required to achieve a profitable yield. Broadleaf weeds, foxtails, and wild oat infest small grains statewide. The use of the proper cultural control techniques plus the use of chemical controls may be required to control troublesome weeds.

Herbicides most commonly used in 1996 were; 2,4-D, Dicamba, and MCPA, they were applied to 50%, 29%, and 16% of the wheat acreage respectively. A total of 11,809,800 acres of wheat were treated in 1996. The producer applied 88% of the herbicides to wheat and 93% was applied by ground equipment.

Foxtails: Green foxtail (*Setaria viridis*), Yellow foxtails (*Setaria glauca*).

Commonly found in field crops across North Dakota, often called pigeongrass. One of the states most serious and widespread annual weeds. Foxtails are most competitive when wheat is seeded late and soil temperatures are warm which promotes foxtail germination and growth. Heavy infestations will cause increased elevator dockage, harvest complications and moisture stress during droughty conditions.

Tillage is one of the best strategies for reducing foxtail infestations. Fall moldboard plowing can bury foxtail seed preventing emergence the following spring. Infestations with less than 30 plants per square foot, and foxtails emerging into a crop at the three to four-leaf stage, generally do not require control. At these levels of infestation the crop can usually out-compete foxtail. Heavy infestations with more than 100 plants per square foot require chemical control. Moisture stress and foxtails emerging before or at the same time as the crop can complicate the decision

process. Under these conditions yield losses can be more severe.

Kochia: (*Kochia scoparia*)

Is an erect bushy annual, two to seven feet in height. It is an exceptionally competitive weed that can cause severe yield losses. This weed is commonly found in most crops in the state of North Dakota. Kochia is one of the first weeds to germinate in the spring but is late in maturing. Kochia has become difficult to control. In many fields 2,4-D and MCPA herbicides no longer control kochia due to the presence of resistant kochia populations. Some kochia populations have become resistant to ALS, triazine, and dicamba herbicides.

Tillage can be an effective practice for controlling kochia. Tillage in the spring before planting and in the fall following harvest can reduce infestations of this highly competitive weed. Tillage is also a strategy for minimizing herbicide resistant plants. Mechanical removal of any resistant plants will prevent seed production and slow the spread of resistant plants.

Herbicide treatments are applied to small plants (less than 3 inches tall). Spray coverage should thoroughly wet the weed foliage. Starane provides good control of ALS, trazine, and dicamba resistant kochia. Banvel/SGF/Clarity plus MCPA amine and Bromoxynil plus MCPA also provides good control.

Wild Oat: (*Avena fatua*)

Wild oat is a cool season annual, one to four feet tall. It is native to Europe but is common throughout much of western North America, including all of North Dakota. Wild oat is one of the most serious weed problems in small grains. It germinates quickly in the spring and can out-compete small grains resulting in severe yield losses. It is difficult to eradicate because the plants drop their seed prior to the crop being harvested. Seed dormancy results in delayed germination.

Delaying seeding is one of the most practical methods of culturally controlling wild oats. By delaying seeding, one or more cultivations can be made to destroy emerged wild oats prior to seeding the crop. Harrowing emerging wild oats following crop seeding may also be effective in reducing wild oat populations before the crop emerges.

Pre-emerge herbicides applied in the fall or spring prior to seeding can provide effective wild oat control. Products such as Far-go (triallate) and Buckle (triallate + trifluralin) can be applied to the soil and incorporated with tillage equipment in advance of seeding. This practice can save the producer time during the growing season and simplifies the timing of herbicide applications. Herbicides applied to the crop after emergence require careful timing of the treatment. Timing treatment at the proper growth stage of the wild oat and the crop is essential for optimum wild oat control. Careful reading of the herbicide label provides the necessary information as to when and how much product to apply.

Redroot pigweed: (*Amaranthus retroflexus*)

Redroot pigweed is a coarse erect annual, usually two to three feet tall. The lower stems are usually red, with color continuing down to the taproot. Redroot is widely distributed throughout the western states and commonly found in crops across North Dakota. Large populations of this weed can compete with small grains resulting in moisture stress and yield loss during droughty conditions.

Tillage prior to planting and on fallow ground is an effective way to reduce pigweed populations. Ally, Amber,

Harmony Extra, and Express give good control. The ALS herbicides, Banvel/SGF/Clarity, 2,4-D, and Tordon plus 2,4-D also give good control. The label provides necessary information on when to apply and how much product to use.

Russian Thistle: (*Salsola iberica*)

A rounded, bushy, much branched annual, usually one half to three feet tall. Seeds are spread as mature plants break off at ground level and are scattered by the wind as tumbleweeds. Russian thistle was introduced from Russia in the late 1800's and has become a common and troublesome weed in the drier regions of North Dakota. Under good crop conditions, small grains can out-compete Russian thistles.

Tillage prior to planting and on fallow ground is an effective way to reduce Russian thistle populations. Seedling plants have fleshy leaves so herbicide applications should be made by this growth stage or earlier. ALS herbicides, Banvel SGF/Clarity, 2,4-D, bromoxynil, and Tordon plus 2,4-D provide good control.

Field Bindweed: (*Convolvulus arvensis*)

Field bindweed (creeping jenny) is a perennial weed introduced from Europe that is well adapted to North Dakota's climate. It can be found across the state and has been declared a noxious weed by the state of North Dakota. Bindweed has a deep root system that competes with crops for water and nutrients. It is easily spread by seed and root fragments. Field bindweed can reduce yields by 50 percent, cause lodging, and can make harvest difficult.

Intensive cultivation can control newly emerging seedlings, and aid in controlling established bindweed stands by reducing nutrient reserves in the roots. When used in combination with herbicides, cultivation becomes a key part of an effective management program.

Control of bindweed requires a long-term management program. Multiple herbicide applications are required to control bindweed. Herbicides should be applied when the bindweed is actively growing and at least 12 inches long. Field bindweed is more difficult to control in semiarid regions of Central and Western North Dakota due to slower herbicide uptake and reduced translocation when plants are moisture and heat stressed. Systemic herbicides work best to kill the extensive root system of bindweed. 2,4-D, dicamba (banvel, Banvel SGF), picloram (Tordon) and glyphosate (Roundup) are all effective systemic herbicides capable of controlling bindweed.

Canada Thistle: (*Cirsium arvense*)

Canada thistle is a colony-forming perennial weed with an extensive root system. Plants are one to four feet tall with spiny-leaves. Canada thistle is a native of Southeastern Eurasia. It was introduced into Canada in the late 18th century. It has become a major problem throughout North Dakota as a result of reduced tillage practices, wet weather cycle, and lack of effective controls. Canada thistle is an aggressive noxious weed that competes well with small grain for water and nutrients.

Periodic tillage on fallow ground is used to control Canada thistle throughout the summer. Tillage keeps the thistle plants in the rosette stage and prevents them from bolting. Following tillage, a herbicide such as glyphosate, Curtail/ M, or stinger can be applied to the rosettes in late September or early October.

Post-harvest treatments give better thistle control than pre-harvest treatments. The highest rate allowed can be used without interfering with next year s crop. Tillage can be a critical factor. Tillage in late fall, after spraying, increases

control, adding an additional 30 to 40% control to treatment. Canada thistle can be controlled in wheat with Curtail, Express, Harmony Extra, MCPA, or 2,4-D. The maximum rate should be used.

Common Milkweed: (*Asclepias syriaca*)

A stout perennial weed that spreads by seeds and long deep roots. The plant is two to four feet in height and has a milky latex sap. It has become a severe weed pest in North Dakota due to it s extensive root system, the wet weather cycle, tolerance to many herbicides, reduced tillage, and the lack of persistence by chemical and cultural controls. Milkweed can be a severe pest in wet regions of the state, competing with the crop for nutrients.

Preventing establishment and spread of milkweed patches requires continuous scouting and implementation of control efforts. Tillage in the spring, prior to planting, or in the fall after harvest aids in the reduction of milkweed populations. Tillage is also a way to address problems with milkweed tolerance to herbicides. The plants can be removed by cultivation, reducing the need for repeated herbicide applications.

Milkweed control is expensive. Patch spraying allows the use of higher herbicide rates with less expense than if an entire field was sprayed. Apply herbicides when milkweeds are in the late-bud to flowering stage and actively growing. Control patches when plants are small. Use glyphosate prior to heading of small grains. After heading, patch-spray with Tordon.

Table 6. Registered herbicides and their usage in North Dakota to manage weeds in wheat.

Active Ingredient	**Tradename**	**Acres Treated 1**		**Application Rate (product / acre)**	**Weeds controlled**	**Application Timing** (Based on Wheat growth stage)
		1000	**%**			
2,4-D	2,4-D	6310.2	49.8	0.5 1 pt of 4lb/gal conc.	Broadleaf weeds	5-leaf until prior to boot.
Tralkoxydim	Achieve	19.8	0.2	40 acres/box or 7 oz	Foxtails, wild oat, and ryegrass	2-leaf to boot
Carfentrazone + 2,4-D amine	Aim	NR	NR	1/3 0.67 oz + 0.5 0.75 pt of a 4 lb./ gal conc.	Most broadleaves and wild buckwheat	Up to jointing stage
Metsulfuron	Ally	264.6	2.1	1/10 oz DF	Broadleafs	2-leaf until prior to boot

Triasulfuron	Amber	247.4	2.0	0.28 0.56 oz DF	Broadleaves, Canada thistle, cheat and downy brome	2-leaf until prior to boot
Imazamethabenz	Assert	248.6	2.0	1 1.5 pt	Wild oat and wild mustard	2-leaf to jointing
Difenzoquat	Avenge	29.1	0.2	2.5 4 pt	Wild oat	2- to 4-leaf stage
Dicamba	Banvel SGF Clarity	3659.3	28.9	0.25 0.5 pt SGF 0.125 0.25 pt Banvel/Clarity	Kochia, buckwheat, smartweed, and other broadleaf weeds	2- to 4-leaf stage
Bromoxynil	Buctril Broclean Moxy	256.4	2.0	1 2 pt EC	Most broadleaves, kochia, and buckwheat	Emergence to prior to boot
Bromoxynil + MCPA	Bronate Bromac Bison	895.2	7.1	0.75 2 pt	Broadleaf weeds	3-leaf until prior to boot
Triallate + Trifluralin	Buckle	171.9	1.4	Fall: durum 10 12.5 lb. G, Spring: HRSW and durum, 10 lb. G	Wild oat and foxtails	Fall or spring applied treatment for Durum or as a spring treatment for HRSW and Durum
Metasulfuron + Thifensulfuron + Tribenuron	Canvas	NR	NR	2/10 to 4/10 oz DF 5 to 10 A/ pack	Broadleaf weeds	2-leaf to prior to flag leaf
Fenoxaprop + MCPA + Thifensulfuron + Tribenuron	Cheyenne X-tra	840.4	6.6	40 acres/box 1.4 pt + 3/10 oz of X-tra	Foxtails, wild oat, and most broadleaves	3-leaf stage until tillering. **Do not apply to Durum**
Clopyralid + 2,4-D	Curtail	162.8	1.3	2 2.33 pt	Broadleaf weeds and Canada thistle	4-leaf to jointing

Fenoxaprop + MCPA	Dakota	619.2	4.9	16 to 21 fl oz 1 to 1.33 pt	Foxtails, and some broadleaf weeds	3-leaf to end of tillering do not apply to Durum
Tribenuron	Express	1663.6	13.1	1/6 to 1/3 oz DF	Most broadleaf weeds	2-leaf until prior to flag leaf
Triallate	Far-go	384.9	3.0	1 qt or 12.5 lb. 10G	Wild oat and foxtails	Immediately after seeding
Chlorsulfuron + metsulfuron	Finesse	103.1	0.8	2/10 to 4/10 oz DF	Broadleaf weeds, foxtails, and canada thistle	2-leaf until prior to flag leaf
Glyphosate	Roundup	321.7	2.5	0.5 to 2 pt of a 3 lb. ai/gal conc.	Grass and broadleaf weeds and volunteer crops	Preplant prior to crop emergence
Thifensulfuron + tribenuron	Harmony Extra	571.6	4.5	3/10 to 6/10 oz DF	Most broadleaf weeds	2-leaf until prior to flag leaf
Diclofop	Hoelon	171.8	1.4	2 2.66 pt	Foxtails and wild oat	Up to 4-leaf
Prosulfuron	Peak	NR	NR	0.5 oz DF	Broadleaf weeds	3-leaf until second node is detected
Quinclorac	Paramount	NR	NR	0.33 lb. DF	Field bindweed and foxtails	Postharvest or in the spring prior to seeding
Fenoxaprop-P + safener	Puma	241.6	1.9	0.33 0.66 pt/A	Foxtails, wild oat, barnyardgrass	2-leaf to 6-leaf
Propanil + MCPA ester	Stampede 80 EDF	2.4	0.0	1.25 1.4 lb. EDF + 0.5 pt	Foxtails and annual broadleaf weeds	HRSW: 2-5 leaf Durum: 2-4 leaf

Fluroxypyr	Starane	NR	NR	0.67 pt	ALS resistant kochia and other broadleaf weeds	2-leaf through flag leaf emergence
Fenoxaprop-P + 2,4-D + MCPA	Tiller	189.9	9.4	1 1.7 pt	Foxtails, wild oat, and several broadleaf weeds	3- leaf up to 6-leaf
Picloram + 2,4D or MCPA	Tordon 22K	130.6	1.0	1 1.5 fl oz + 0.5 to 0.75 pt of a 4 lb/gal canc.	Broadleaf weeds	3- leaf to jointing HRSW only
Trifluralin	Treflan	958.3	7.6	1 pt 4E 3.5 - 5 lb. 10G	Foxtails	Prior to freeze-up in fall or in the spring

[1] Zollinger et al, 1998.
NR - Use not reported by survey

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