AG-MI-5868-F

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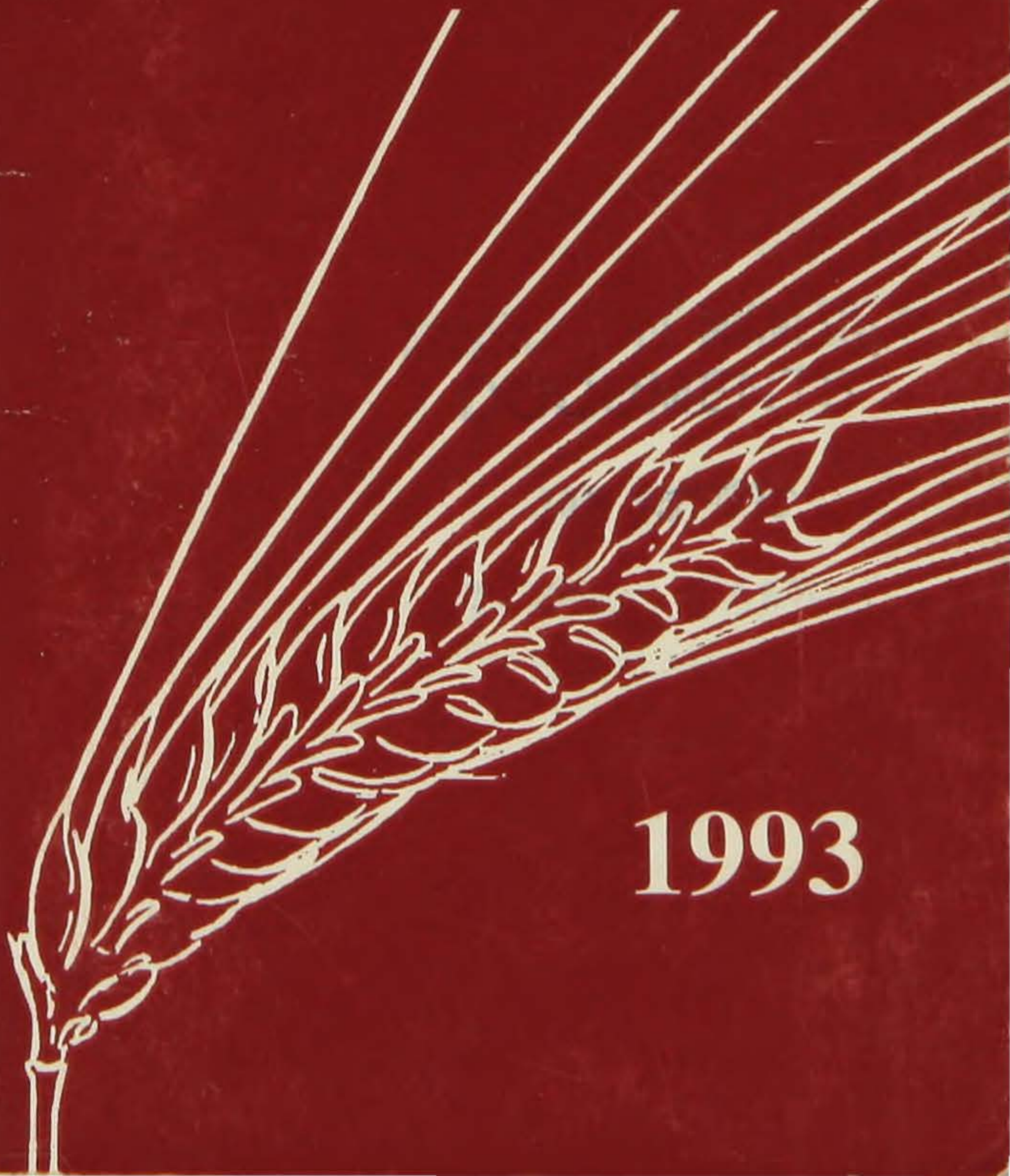
Hard Red Spring Wheat & Spring Barley Production Guide



1993

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1993 Hard Red Spring Wheat & Spring Barley Production Guide

by

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Introduction: Profitable and Environmentally Sound Wheat and Barley Production

Modern technology, fluctuating prices, uncertain farm policies, and environmental concerns all contribute to a producer's need for careful planning and management to assure profitable and environmentally sound production. Fluctuating weather conditions and stored soil moisture levels also require the producer to make careful decisions as to type of tillage, seedbed preparation, rotations, and pest control practices.

This guide will help you make timely management decisions. However, it does not give extensive details on any one production area because of space constraints. More complete discussions of soil fertility, weed, disease and insect control and control of stored grain insects are available in University of Minnesota Extension and Agricultural Experiment Station fact sheets, folders and bulletins such as the *Varietal Trials of Farm Crops* and *Cultural and Chemical Weed Control in Field Crops.*

Suggestions for pesticide use in this guide are based on federal label clearances and on research information from the Minnesota Agricultural Experiment Station. At the time of publication of this guide, all pesticides listed had a federal or state label.

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Fertilizing Spring Wheat and Barley

Fertilizer is a major input for profitable small grain production in Minnesota.

Nitrogen Recommendations: Two procedures can be used to determine the amount of fertilizer N (nitrogen) needed for spring wheat and barley production. Whenever appropriate, the use of the soil nitrate test is highly encouraged. In Minnesota, the soil nitrate test is appropriate for the western part of the state (see map in Figure 1 below).

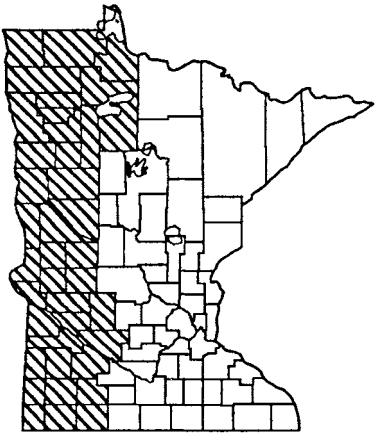


Figure 1. *The soil nitrate test should be used for nitrogen recommendations in the counties that are shaded.*

If the soil nitrate test is used, fertilizer N recommendations are derived from the following:

Wheat: $N_{rec} = 2.5\ (YG) - STN - PCC$

Malting Barley: $N_{rec} = 1.5\ (YG) - STN - PCC$

Feed Grade Barley: $N_{rec} = 1.7\ (YG) - STN - PCC$

In these equations, N_{rec} = recommended rate of fertilizer N to use in lb/acre, YG = yield goal in bu/acre, STN = amount of nitrate-nitrogen measured to 2 feet in lb/acre and PCC = the credit for the

previous crop. Nitrogen credits for various crops that might precede wheat in a crop rotation are:

Previous Crop	1st Year Nitrogen Credit
Soybeans	20 lb N/acre
Edible beans, field peas	10 lb N/acre
Sweet clover that was harvested	10 lb. N/acre
Alfalfa* that was harvested or sweet clover not harvested	
4-5 plants/ft^2	75 lb N/acre
2-3 plants/ft^2	50 lb N/acre
1 or less plants/ft^2	None
Red clover that was harvested	35 lb N/acre

* If 3rd or 4th cutting was not harvested, add 20 lb N/acre to the N credits that are listed.

If there is no information from the soil nitrate test or if spring wheat and barley are grown where the use of the soil nitrate test is not appropriate, N fertilizer recommendations are based on yield goal, soil organic matter content, and previous crop. Nitrogen recommendations in Tables 1 and 2 refer to crop groups:

Crops in Group 1	Crops in Group 2	
alfalfa (2-3 plants/ft^2)	alfalfa (0-1 plants/ft^2)	oats
alsike clover	barley	potatoes
birdsfoot trefoil	buckwheat	rye
fallow	canola	sorghum – sudan
grass – legume hay	corn	sugarbeets
grass – legume pasture	flax	sunflowers
red clover	grass – hay	sweet corn
	grass – pasture	triticale
	millet	vegetable
	mustard	wheat

Phosphate and Potash Recommendations:

Recommendations for phosphate (P_2O_5) and potash (K_2O) use are based on yield goal as well as the results of a soil test. These recommendations for spring wheat and barley are summarized in Tables 3, 3a, 4 and 5 respectively. The rates listed are intended for broadcast application. In general, the broadcast rate can be reduced by one-half if the applied phosphate

Table 1. *Nitrogen recommendations for wheat in situations where the soil nitrate test is not used.*

Crop Grown Last Year	Organic* Matter Level	Yield Goal (bu./acre) Less than 40	40-49	50-59	60-69	70-79	80+
		N to apply (lb./acre)					
alfalfa (4+ plants/ft^2), non-harvested sweetclover	low	0	0	30	55	80	95
	medium and high	0	0	0	35	60	75
soybeans	low	35	60	85	110	135	150
	medium and high	0	40	65	90	115	130
edible beans, field peas, harvested sweetclover	low	45	70	95	120	145	160
	medium and high	25	50	75	100	125	140
any crop in Group 1	low	0	30	55	80	105	120
	medium and high	0	0	35	60	85	100
any crop in Group 2	low	55	80	105	130	155	170
	medium and high	35	60	85	110	135	150
organic soil	-	0	0	0	30	35	50

* Low = less than 3.0%; medium and high = 3.0% or more

Table 2. *Nitrogen recommendations for barley in situations where the soil nitrate test is not used.*

Crop Grown Last Year	Organic* Matter Level	Yield Goal (bu./acre) Less than 50	50-59	60-69	70-79	80-89	90-99	100+
		N to apply (lb./acre)						
alfalfa (4+ plants/ft^2), non-harvested sweetclover	low	0	0	10	25	40	55	70
	medium and high	0	0	0	0	20	35	50
soybeans	low	30	50	65	80	95	110	125
	medium and high	0	30	45	60	75	90	105
edible beans, field peas, harvested sweetclover	low	40	60	75	90	105	120	135
	medium and high	0	40	55	70	85	100	115
any crop in Group 1	low	0	20	35	50	65	80	95
	medium and high	0	0	15	30	45	60	75
any crop in Group 2	low	50	70	85	100	115	130	145
	medium and high	30	50	65	80	95	110	125
organic soil	-	0	0	0	0	30	40	50

* Low = less than 3.0%; medium and high = 3.0% or more

and/or potash is applied in a band such as with the seed at planting.

Since most of the small grain acreage in Minnesota is usually planted in early spring when soil conditions are cold and wet, the application of fertilizer with the drill should be a standard management practice. **CAUTION! Do not** apply more than 5 lb. N/acre as urea in contact with the seed (in the row). If the soil is dry at planting, **do not** apply more than 40 lb. N + K_2O per acre with the drill. Higher amounts can be applied if the soil is wet at planting time. **Do not** place fertilizer containing ammonium thiosulfate (12-0-0-26) in direct contact with the seed. **Do not** place fertilizers containing boron in direct contact with the seed.

Variety Selection

Use of adapted varieties is a positive management decision. Varieties serve as the foundation for all other inputs and if the genetic potential is limited so will final quality and yield. Varieties are described in Tables 6 and 7 for Hard Red Spring Wheat and Barley.

Characteristics to evaluate in selecting a variety are: yield potential in your area; protein content when grown with proper fertility; straw strength and height; reaction to important diseases; days to maturity; milling and baking quality for wheat; and malting quality for barley.

Table 3. *Phosphate fertilizer suggestions for wheat production in Minnesota.**

		Phosphorus (P) Soil Test (ppm)									
		Very Low		Low		Medium		High		Very High	
Yield	Bray:	0 - 5		6 - 10		11 - 15		16 - 20		21+	
Goal	Olsen:	0 - 3		4 - 7		8 - 11		12 - 15		16+	
		broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill
bu./acre		*lb. P_2O_5/acre to apply*									
less than 40		40	20	3	15	15	10	0	10 - 15	0	0
40 - 49		40	20	30	15	15	10	0	10 - 15	0	0
50 - 59		50	25	35	20	20	15	0	10 - 15	0	0
60 - 69		60	30	45	25	20	15	0	10 - 15	0	0
70 - 79		70	35	50	25	25	20	0	10 - 15	0	0
80 or more		80	40	55	30	25	20	0	10 - 15	0	0

* Use one of the following equations if a phosphate recommendation for a specific soil test and a specific yield goal is desired:

P_2O_5 Rec = [.071 - (.054) (Bray P soil test, ppm)] (yield goal)

= [1.071 - (.067) (Olsen P soil test, ppm)] (yield goal)

No phosphate fertilizer is suggested when the Bray P test is 21 ppm or higher or the Olsen P test is 16 ppm or higher.

Table 3a. *Potash fertilizer suggestions for wheat production in Minnesota.**

Yield Goal	Potassium (K) Soil Test (ppm)									
	Very Low 0 - 40		Low 41 - 80		Medium 81 - 120		High 121 - 160		Very High 161+	
	broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill
bu./acre	*lb. K_2O/acre to apply*									
less than 40	95	50	70	35	40	20	0	15 - 20	0	0
40 - 49	105	55	75	40	45	25	0	15 - 20	0	0
50 - 59	130	65	95	50	55	30	0	15 - 20	0	0
60 - 69	155	80	110	55	65	35	0	15 - 20	0	0
70 - 79	180	90	125	65	75	40	0	15 - 20	0	0
80 or more	190	95	135	70	80	40	0	15 - 20	0	0

* Use the following equation if a potash recommendation for a specific soil test and a specific yield goal is desired:
K_2O_{Rec} = [2.710 - .017 (K soil test, ppm)] (yield goal)

No potash fertilizer is suggested when the K test is 161 ppm or higher.

Table 4. *Phosphate fertilizer suggestions for barley production in Minnesota.*

		Phosphorus (P) Soil Test (ppm)									
		Very Low		Low		Medium		High		Very High	
Yield	Bray:	0 - 5		6 - 10		11 - 15		16 - 20		21+	
Goal	Olsen:	0 - 3		4 - 7		8 - 11		12 - 15		16+	
		broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill
bu./acre		*lb. P_2O_5/acre to apply*									
less than 50		35	20	25	15	15	10	0	10 - 15	0	0
50 - 59		40	20	25	15	15	10	0	10 - 15	0	0
60 - 69		45	25	30	15	20	15	0	10 - 15	0	0
70 - 79		50	25	35	20	20	15	0	10 - 15	0	0
80 - 89		60	30	40	20	25	15	0	10 - 15	0	0
90 - 99		65	35	45	25	25	15	0	10 - 15	0	0
100+		70	35	50	25	30	20	0	10 - 15	0	0

* Use one of the following equations if a phosphate recommendation for a specific soil test and a specific yield goal is desired:

P_2O_{5Rec} = [0.785 - (.039) (Bray P soil test), ppm] (yield goal)
= [0.785 - (.050) (Olsen P soil test), ppm] (yield goal)

Table 5 *Potash fertilizer suggestions for barley production in Minnesota.**

Yield Goal	Potassium (K) Soil Test (ppm)									
	Very Low 0 - 40		Low 41 - 80		Medium 81 - 120		High 121 - 160		Very High 161+	
	broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill	broadcast	drill
bu./acre	*lb. K_2O/acre to apply*									
less than 50	50	25	40	20	20	15	0	10 - 15	0	0
50 - 59	60	30	45	25	25	15	0	10 - 15	0	0
60 - 69	70	35	50	25	30	20	0	10 - 15	0	0
70 - 79	85	40	60	30	35	25	0	10 - 15	0	0
80 - 89	95	50	65	35	40	25	0	10 - 15	0	0
90 - 99	105	55	75	40	45	30	0	10 - 15	0	0
100+	110	55	80	40	50	35	0	10 - 15	0	0

* Use the following equation if a potash recommendation for a specific soil test and a specific yield goal is desired:
K_2O_{Rec} = [1.286 - (.0085) (K soil test), ppm] (yield goal)

Estimating Yield Potential of Hard Red Spring Wheat

At late tillering to early joint (Feekes 3–6):

1. Dissect the spike (head) from the stem. It will be found just above the first joint.
2. Use a hand lens to determine the number of ridges on the spike. (Will vary from 6 to 11).
3. Determine the spikelet number. Each ridge gives 2 spikelets (except the last ridge or tip gives 1 spikelet).
4. Multiply the total spikelets times 3 to get a rough estimate of yield potential at this growth stage.

Example: 9 ridges plus 1 ridge at tip = 9 x 2 + 1 = 19 spikelets. 19 spikelets x 3 = 57 bu yield potential.

This estimate assumes a population of about 1.0 million/acre, 2 tillers/plant and 3 kernels/spikelet. These values were based on research done at Mandan, ND.

Individual conditions may vary; more tillers and more kernels/spikelet are possible under a moist environment, resulting in a potentially higher yield. The value is only an estimate of yield potential remaining after the 4–5 leaf stage. This estimate may be used to determine whether additional inputs suchas nitrogen, growth regulators, and fungicides should still be applied to this crop. Compensation should be made for stress conditions that could potentially reduce yield.

At heading (Feekes 10):

A yield estimate at heading can be calculated by using the following formula:

$$\frac{\text{\# spikes (heads)}}{\text{square foot}} \times \frac{\text{\# kernels}}{\text{spike}} \times 0.04 = \text{bu/acre}$$

Table 6. *Hard red spring wheat variety descriptions.*

Variety	Agent or origin[1]	Year released	Heading	Height	Lodging	Rust reaction – rating –		Test weight	Wheat protein	Milling, baking quality
			date	inches	score[2]	stem[3]	leaf[3]	lbs/bu	%[4]	rating[5]
Butte 86	ND	1986	6–20	31	3.2	R	MR	59.3	15.2	M–H
Prospect	SD	1988	6–22	30	2.0	MS	MR	58.7	14.7	M-L
Grandin	ND	1989	6–22	31	2.0	R	R	59.2	15.5	H
Minnpro	MN	1989	6–23	30	3.0	R	R	56.6	16.2	H–M
Stoa	ND	1984	6–24	34	3.6	R	R	58.3	14.9	M–H
Wheaton	MN	1983	6–24	28	2.2	R	R	56.7	14.4	L–M
Vance	MN	1989	6–25	29	2.4	R	R	57.1	15.1	M–H
Marshall	MN	1982	6–26	29	1.7	R	MS	57.5	14.4	M–L
Roblin	Can	1986	6–19	33	4.1	R	MS	57.5	15.8	M–H
Shield	SD	1987	6–20	33	3.6	MS	MR	58.6	14.7	M
Sharp	SD	1990	6–20	32	3.7	R	MR	60.1	15.0	M
Norm	MN	1992	6–24	30	1.7	R	R	58.0	14.7	M–H
Gus	ND	1990	6–24	31	3.2	R	R	58.4	15.7	H
2370	NDF	1990	6–21	30	1.8	MR	MR	58.2	14.7	M
2375	NDF	1988	6–22	30	3.7	R	MR	60.1	15.1	M
2371	NDF	1991	6–24	30	1.5	R	R	58.1	15.1	H
Fjeld	AgriPro	1989	6–22	29	2.2	R	MR	57.3	13.8	L–M
Bergen	AgriPro	1990	6–23	28	1.7	R	R	57.7	14.5	M
Dahlen	AgriPro	1991	6–21	28	1.5	R	R	58.5	14.9	L-M
Krona	AgriPro	1992	6–23	29	1.6	R	R	55.8	14.5	L
Nordic	AgriPro	1986	6–25	31	3.4	R	MS	58.2	13.6	L

[1]Refers to agent or developer: ND=North Dakota, SD=South Dakota, MN=Minnesota, Can= Canada, NDF=North Dakota Foundation, AgriPro=NAPB AgriPro, NuGld=NutriGold (Busch Agricultural Resources); [2]1=erect, 9=flat; [3]Reaction to prevalent races: R=resistant, MR=moderately resistant, MS=moderately susceptible, S=susceptible; [4]12 percent moisture; [5]L=low, M=medium, H–high.

Table 7. *Spring barley variety descriptions.*

Variety	Agent or origin	Year released	Quality	Awns	Maturity	Height	Straw strength	Kernel plumpness	Disease resistance: Spot blotch	Disease resistance: Loose smut
Morex	MN	1978	malting	S[1]	ME[2]	M[3]	W[4]	M[5]	MR[6]	S[6]
Robust	MN	1983	malting	S	M	M	M	H	R	S
Excel	MN	1990	malting	S	M	M	M	L	R	S
Hazen	ND	1984	feed	S	M	M	S	H	R	S
Bowman	ND	1984	feed	S	ME	M	M	H	R	S
Azure	ND	1982	malting	S	ME	M	M	M	R	S
Chilton	WS	1990	feed	S	E	M	S	—	R	—
Chopper	WS	1988	forage	R	L	M	M	—	R	S
B1602	BAR	1989	malting	R	M	S	S	M	R	S
B1603	BAR	1989	malting	R	M	M	W	M	R	S
Bounty	CAN	1988	feed	S	M	M	M	M	S	S

[1]S=smooth, R=rough; [2]E=early, M=medium, L=late;[3]M=medium, S=short; [4]W=weak, M=medium, S=strong; [5]L=low, M=medium, H=high; [6]R=resistant, MR=moderately resistant, S=susceptible.

Tillage

Wheat can be produced with any one of many tillage systems. The seed should be placed in moist soil and the soil firmed around the seed. Factors other than seed placement, however, may dictate your choice of tillage system. Minimum-till or no-till systems are recommended to leave crop residues on the soil for erosion control. On the other hand, tillage is recommended where insects or diseases survive in the residues or volunteer growth. If you do till in the fall for spring wheat, use a light disking or field cultivator to kill weeds and volunteer plants, and then make the last operation a deeper tillage with a chisel plow to leave the soil rough and cloddy to catch moisture and reduce erosion. A pass with a field cultivator in the spring will smooth it for planting.

Planting Date

Plant as early as possible—as soon as a satisfactory seedbed can be prepared. In general you can expect a 1% per day reduction in yield for each day delay after the optimum date. In northern Minnesota this decline in yield usually occurs after the first week in May and in the southern part after mid-April. At a 50 bu/acre yield goal this is one half bushel per day. For those with a 100 bu/acre yield goal it amounts to one bushel per day. The main factor contributing to yield reduction due to delayed seeding is the possibility and probability of higher temperatures during the 4.0 to 5.5 leaf stage. This growth stage is when the number of spikelets on the head is determined. The number of spikelets per spike decreases whenever the maximum day temperatures are above 63° F during this specific growth stage. High temperatures (90° F) during grain fill will reduce kernel fill, thus also yield.

Planting Rate

To assure planting enough seed, planting rate should be obtained on a seed count basis.

To calculate rate, you need to determine:

1. Desired population of main stems at harvest.
2. Average predicted stand loss for your farm.*
3. Germination value for your seed lot.
4. Number of seeds per pound of your seed lot.

*It is not uncommon for stand losses of 40% to occur on some fields if soil conditions are poor.

An example for calculating planting rate for wheat:

1. Desired population is 1,125,000 stems per acre at harvest.
2. Historic field stand loss is 10%.
3. Seed lot germination is 95%.
4. Seed lot has a seed count of 15,000 seeds/lb.

Then: 15,000 x 0.95 = 14,250 viable seeds per pound.

1,125,000 seeds x 110% = 1,237,500 viable seeds needed per acre.

1,237,500 seeds / 14,250 seeds/lb = 87 pounds per acre seeding rate or 28 total seeds per square foot.

The table below gives a rough estimate of plant count (main stems) needed at harvest for various yield goal levels.

Table 8. *Rough estimate of plant count needed at harvest for HRSW or barley.*

Growing Conditions/ Yield Goal Level	**Plants/Acre at Harvest**
Favorable Environments 60 bu/acre and up yields	1.3 million (30 plants/ft^2)
Unfavorable Environments 15–30 bu/acre yields	0.7–1.0 million (16–23 plants/ft^2)

Replanting Decisions

1. Assume you wanted a stand of 1,300,000 plants per acre. That requires at least 30 plants per square foot.
2. Replanting costs must be recovered from a later maturing crop that has a lower yield potential than original crop. Plus, replanting uses extra moisture as a function of soil disturbance.
3. A) If reduced stand is uniform (no big skips or holes), then keep stands of 15 plants per square foot.

   B) If skips are large (3 to 6 ft) or holes are 4 to 6 feet in diameter and stand is 18 plants per square foot or less, then replant if moisture is adequate.

   C) After June 1 in northern Minnesota and May 15 in southern Minnesota, a replant decision should be to a crop other than wheat or barley since yields are reduced by about 50% when planting after these dates compared to normal planting dates.

Seeding Equipment

Several kinds of drills are available for seeding small grains. The double disc, press wheel drill is widely used in tilled soils where seed is placed less than 2 inches deep in a clean, firm, moist seedbed. Hoe drills, and air seeders with sweeps, are used when seeding in untilled soils and crop residues. Hoe drills will move soil to reach through dry soil to plant in moisture under dry conditions.

Press or packer wheels will help cover the seed and enhance germination, especially when drilling into untilled or cloddy soils. They are also frequently used for depth control for proper seed placement.

Several methods of applying fertilizer with the drill are available. While a small amount of "starter" fertilizer with the seed can be helpful for spring planting, 85–95% of the fertilizer should not be placed directly with the seed. Double disc and hoe openers are designed to place fertilizer 2 inches below the seed. Air seeders with sweeps spread the seed and fertilizer over a wide band to prevent seed damage by the fertilizer.

Drills designed to plant through residue are set up with three or four ranks of openers to allow wide spacing for residue flow through the drill. This makes a long rig and care must be taken to make sure that it is level from side to side as well as from front to rear. Be sure tires are inflated equally and depth control devices are properly set.

Grain Drill Calibration and Maintenance

The seeding tables found in your operator's manual or on the hopper lid are based on a standard weight per bushel for various crops. Wheat has a standard weight of 60 pounds per bushel. Due to differences in varieties, the seed size and weight may vary from the standard.

Seed metering systems are based on volume delivered. Therefore, if one lot of seed varies in size and weight from another, different amounts of seed will be metered if the setting is not changed. Drills must be calibrated to be sure the seeding rate is the one you want.

To calibrate for pounds per acre:

1. Measure a distance for your drill width (from the table below) to equal 1/10 acre.
2. Place bags to catch the seed from all drop tubes.
3. Operate the drill at your normal speed through the measured distance.
4. Weigh the seed collected and multiply by 10. (The amount collected was for 1/10 acre)
5. Compare this amount with the seeding rate desired. Adjust if necessary and recheck the calibration.

Table 9. *Drilling distance for 1/10 acre.*

Drill Width (feet)	Distance for 1/10 Acre (feet)
6	726
7	622
8	544
9	484
10	435
11	396
12	363
13	335
14	311
15	290

To calibrate for plant population:

1. Operate the drill on a firm surface at your normal speed. Set it so the seeds are not covered.
2. Count the seeds in one foot of row. Check several places and use an average.
3. Multiply the seed count by the factor in the following table for your row spacing. This gives you the seeds per square foot. Plant population will be somewhat less than this due to germination losses, etc.
4. Adjust and recalibrate if necessary.

Table 10. *Calibration adjustment factor.*

Row Spacing (inches)	Adjustment Factor
6	2.0
7	1.7
8	1.5
10	1.2
12	1.0
14	0.86

Table 11. *Populations per square foot.*

Seeding Rate pounds/acre	Barley 14,300/pound	Spring Wheat 15,000/pound
	--- seeds/square foot ---	
60	20	20
70	23	24
80	26	27
90	30	31
100	33	34
110	36	38
120	39	41

Drill Maintenance Checklist

1. Check the condition of all drives and chains.
2. Be sure disc openers are clean and turn freely.
3. Adjust depth controls and down-pressure springs for proper seed placement.
4. Check drop tubes for kinks or blockage.
5. Lubricate drill as recommended in the operator's manual.
6. Calibrate seed and fertilizer delivery systems.
7. Adjust delivery for seed size and germination.
8. After planting, clean the hoppers, wash the fertilizer hopper and apply a protective coating such as diesel fuel to prevent corrosion.
9. Clean furrow openers, coat with oil, and lubricate bearings and moving parts.
10. Store drills inside or under cover.

Sprayer Calibration

Calibrating a sprayer is not hard. Measure the output of the sprayer over a smaller course and calculate the application rate for the whole acre. In this method, the test course is chosen so that the output from each nozzle (or group of nozzles for each row), measured in ounces, is equal to the gallons per acre applied.

First, check all the nozzles to make sure they are all putting out the same amount. Measure the spray from each nozzle for 30 seconds or use one of the calibrators to determine nozzle flow. Any nozzle showing abnormal flow or spray pattern should be cleaned or replaced.

Check the boom height and spray pattern by spraying at your normal pressure and a very slow speed over a clear hard surface to wet the ground. As the wetted area dries you will be able to see any wet or dry streaks due to improper boom height or faulty nozzles.

Calibration method:

1. Select the length of your test run from the table below. This distance will cause each nozzle, or group of nozzles, to cover 1/128 acre and one ounce of spray delivered in the test will represent one gallon per acre of spray applied.
2. Spray over the test course at the normal speed and pressure. Time the test run in seconds.
3. With the sprayer standing still, and at the operating pressure, catch the liquid from each nozzle for the number of seconds that it took to run the test course.
4. The ounces collected from each nozzle, or group of nozzles directed at one row, is equal to the gallons per acre the sprayer is applying.

To calculate your speed:

$$\text{Miles per hour} = \frac{\text{Course length (feet)}}{\text{Time of run (seconds)}} \times 0.68$$

Nozzle or Row Spacing (inches)	Test Course Length for 1/128 Acre (feet)
40	102
30	136
22	185
20	204
10	408

Nozzles

Choose your nozzle type and pressure for droplet size. Use small droplets for complete coverage of foliage, select large droplets for drift control. Most applications will be a compromise between complete coverage and drift control. Lower pressures will produce larger drops for better drift control.

For herbicide application:

Flat fan	20–40 psi
Flooding	10–20 psi
XR Flat fan	15–30 psi
Low pressure full cone	15–40 psi
Even flat fan (banding)	20–40 psi

For insecticides and fungicides:

Hollow cone	40–120 psi
XR Flat Fan	40–60 psi

Conversion Factors:

You have:	**Multiply by:**	**To get:**
cubic feet	7.4805	gallons
cups	0.0625	gallons
liters	0.2642	gallons
ounces (liquid)	0.0078	gallons
pints	0.125	gallons
# of water	0.1198	gallons
quarts	0.25	gallons
feet/minute	0.0114	miles/hour
feet/second	0.682	miles/hour
square feet	0.000023	acres
acres	43560	square feet
mile	5280	feet
#/Acre	0.367	Oz/1000 Ft^2
#/Acre	0.023	#/1000 Ft^2
#/Acre	0.0023	#/100 Ft^2
#/Acre	0.0306 x row width	Oz/1000 FT
#/1000 Ft^2	43.56	#/Acre
Oz/1000 Ft^2	2.72	#/Acre
Oz/1000 Ft	32.67/row width	#/Acre

Formulas:

$$\text{Acres/Hour} = \frac{\text{Speed (MPH)} \times \text{Width (feet)} \times \text{Field Efficiency}^{*}}{8.25}$$

*Field efficiency normally will range from 0.6 to 0.9

$$\text{Horsepower} = \frac{\text{Speed (MPH)} \times \text{Force (pounds)}}{375}$$

$$\text{Gal/Acre} = \frac{\text{Gal/Min} \times 5940}{\text{Speed (MPH)} \times \text{Width (inches)}}$$

$$\text{Gal/Min} = \frac{\text{Gal/Acre} \times \text{Speed (MPH)} \times \text{Width (inches)}}{5940}$$

$$\text{Miles/Hour} = \frac{\text{Distance (feet)}}{\text{Time (seconds)}} \times 0.682$$

Weed Control

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.

Sowing **clean seed** at an adequate seeding rate will help to reduce weed populations in small grains. Also, small grains 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 (pigeongrass). However, early spring seeding does not help to reduce wild oat populations.

Perennial weeds, such as quackgrass, should be controlled prior to seeding small grains (preferably the year before). Most herbicides available for use in small grains will control many annual weeds at safe usage rates, but will not adequately control established perennial weeds.

The number of **weed species** controlled is often increased when postemergence herbicides are applied to fields already treated with a preemergence or preplant herbicide. Also, **combinations** of certain postemergence or preemergence herbicides may give better weed control than an individual herbicide used alone. Herbicide effectiveness is influenced by application method, rate, weed species, and environment. Herbicides are most effective when climatic conditions promote vigorous plant growth. Weeds growing under environmental stress, such as drought, generally absorb less herbicide and are more difficult to control than actively growing plants. However, crops growing under environmental stress may be more susceptible to herbicide injury.

The **ideal temperature** for applying most postemergence herbicides is between 65° and 85° F. Herbicides are generally less active at low temperatures than high temperatures (except Carbyne and Hoelon). Thus, weeds usually die slowly or not at all if cool temperatures occur during and after herbicide application. Herbicides usually become more active at high temperatures, and therefore, crop injury is more likely to occur if herbicides are sprayed on extremely hot days.

Rainfall shortly after application often reduces weed control from postemergence herbicides because the herbicide can be washed from the leaf surface. Herbicides vary in absorption rate and ease of being washed from the leaves. The rainfall effect can also vary depending on rainfall amount and intensity. The approximate time between application and rainfall needed for maximum weed control is given in the following table:

Table 12. *Rainfree period needed after application.*

Herbicide	Time between application and rainfall
Ally	4 hours
Assert	3 hours
Avenge	6 hours
Banvel	6–8 hours
Buctril	1 hour
Bronate	1 hour
Carbyne	5 minutes
Cheyenne	4 hours
Curtail	6–8 hours
Curtail M	6–8 hours
Express	4 hours
Harmony Extra	4 hours
Hoelon	1 hour
Roundup	6 hours
Stampede	4 hours
Stampede CM	4 hours
2,4–D or MCPA amine	4 hours
2,4–D or MCPA ester	1 hour
Tiller	1 hour

Off target movement (**drift**) of herbicides is a problem in Minnesota every year as herbicides move from target fields into nontarget fields containing crops susceptible to the herbicide. Herbicide drift can be a result of particle movement with the wind or vapor drift. **Particle drift** occurs at the time of herbicide application and vapor drift can occur at the time of or after application. Particle drift is most likely to occur with small droplets and high wind speeds. All herbicides are subject to particle drift. Particle drift can be minimized by spraying large droplets at low wind speeds and when the wind direction is away from the susceptible crops.

Vapor drift occurs when volatile herbicides vaporize following application. Vapor drift is most likely to occur with volatile herbicides such as Banvel and the ester formulations of 2,4–D and MCPA. Volatility increases as temperature increases, therefore the risk of vapor drift is greatest when volatile herbicides are applied during hot temperatures. Susceptible crops can be injured by vapor drift even if the herbicide was sprayed when the wind was blowing in the opposite direction. Therefore, to minimize the risk of vapor drift injury, herbicides with high potential to form damaging vapors should not be used near susceptible plants.

Damaging drift to non-target plant is primarily a problem with 2,4–D ester, MCPA ester, Banvel, Roundup, Harmony Extra, Express, and Tordon. However, all herbicides may drift and cause significant damage to susceptible non-target plants, so caution must be observed with all herbicide applications.

Herbicide combinations may provide more complete control and control of more weed species than individual treatments. However, the herbicide mixture must be compatible to avoid poor weed control or crop injury. Generally, the recommended sequence of addition of the various formulations in tank mixes is:

1. water
2. wettable powders or dry flowables with agitation
3. liquid flowable
4. emulsifiable concentrates
5. water soluble materials.

It is often beneficial to mix each pesticide with water before adding to the spray mixture. This is especially important with many dry flowable formulations. A compatibility test should be conducted on a small scale prior to adding the chemicals to the spray tank.

Herbicides can be legally **tank mixed** with other pesticides or fertilizers if all chemicals in the mixture are labeled for use in a crop and if applied according to the label. Use of some herbicide mixtures may result in poor weed control or crop injury. Growers or applicators may be responsible for chemical residues in crops, crop injury or lack of weed control resulting from the use of unlabeled mixtures. The manufacturers of the products are no longer responsible for performance of the pesticides when a nonlabeled combination is used. Be sure to read the label for tank mixing instructions and precautions.

Several **herbicide-insecticide combinations** have been shown to increase crop injury compared to either pesticide applied alone. For example, crop injury has occurred when sulfonylurea herbicides (Harmony Extra, Express) have been applied with an organophosphate insecticide. Similarly, small grain injury has occurred when Stampede CM is applied with an organophosphate or carbamate insecticide. Efficacy data on herbicide-insecticide combinations is limited

because of the number of potential combinations. Nonlabeled tank-mixtures should be used with caution until experience or research has shown that the combination is effective and safe.

The weed control recommendations in this production guide are based on the assumption that all herbicides mentioned have a **registered label** with the Environmental Protection Agency. The information in this publication and on product labels will help you select and use herbicides properly. **Nonlabeled herbicide** use is illegal, and a user could be subject to a large fine. Further, wheat and barley treated with a nonlabeled herbicide may have an illegal residue which, if detected, could cause condemnation of the crop.

Table 13. *Glossary of herbicide names, formulations, 1993 prices, and restricted use herbicides.*

Trade Name[1]	Common Name	Formulation[2] Concentration (lb a.i. or a.e./gal)	Cost[3] ($/lb a.i. or a.e.)	Rate Range (lb a.i. or a.e./A)	Price Range ($/A Broadcast)
Ally	Metsulfuron	60% DF	755.47	0.004	3.00
Amber	Triasulfuron	75% DF	NA[4]	0.013 – 0.026	NA[4]
Assert	Imazamethabenz	2.5 E	43.01	0.31 – 0.38	13.33 – 16.34
Avenge	Difenzoquat	2 S	20.73	0.62 – 1.00	12.86 – 20.73
Banvel	Dicamba	4 S	17.35	0.06 – 0.125	1.04 – 2.17
Bronate	Bromoxynil + MCPA	2.0 + 2.0 E	12.05	0.50 – 1.00	6.03 – 12.05
Buckle	Triallate + Trifluralin	10% + 3% G	8.46	1.30 – 1.63	11.00 – 13.79
Buctril	Bromoxynil	2 E	23.56	0.25 – 0.38	5.89 – 8.96
Carbyne 2EC	Barban	2 E	17.42	0.25 – 1.00	4.35 – 17.42
Cheyenne[5]	Fenoxaprop + MCPA Ester +Thifensulfuron + Tribenuron	0.67 + 4.00 + 75% DF	35.11	0.47	16.50
Curtail	Clopyralid + 2,4–D Amine	0.38 + 2.0 S (ae)	11.51	0.59	6.85
Curtail M	Clopyralid + MCPA Ester	0.42 + 2.35 (ae)	12.15	0.60 – 0.87	7.29 – 10.57
2,4–D Amine, others	2,4–D Amine	4 S (ae)	2.48	0.12 – 0.66	0.30 – 1.65
2,4–D Ester, others	2,4–D Ester	4 E (ae)	3.11	0.16 – 0.66	0.50 – 2.05
Express	Tribenuron	75% DF	416.55	0.008 – 0.016	3.33 – 6.66
Far-Go	Triallate	4 E	9.59	1.00 – 1.50	9.59 – 14.38
Far-Go	Triallate	10% G	8.30	1.00 – 1.50	8.30 – 12.45
Gramoxone Extra[5]	Paraquat	2.5 S	13.53	0.25 – 1.00	3.38 – 13.53

Harmony Extra	Tribenuron + Thifensulfuron	50% + 25% DF	240.73	0.008 – 0.032	1.93 – 7.70
Hoelon[5]	Diclofop	3 E	17.69	0.50 – 1.00	8.85 – 17.69
MCPA Amine, others	MCPA Amine	4 S	3.38	0.12 – 0.66	0.41 – 2.23
MCPA Ester, others	MCPA Ester	4 E	3.90	0.16 – 0.66	0.63 – 2.57
Ranger	Glyphosate	2.0 S (ae)	16.75	0.19 – 1.5	3.18 – 25.12
Roundup	Glyphosate	3 S (ae)	18.24	0.25 – 3.00	4.56 – 54.71
Stampede EDF	Propanil	80% DF	NA[4]	1 – 1.13	NA[4]
Stampede CM	Propanil + MCPA	3.0 + 0.85 E	7.17	1.19	8.53
Stinger	Clopyralid	3.0 S (ae)	152.64	0.09 – 0.12	6.87 – 18.30
Tiller	Fenoxaprop + 2,4–D + MCPA	0.38 + 0.58 + 1.75 (ae)	26.67	0.36 – 0.457	9.63 – 12.19
Tordon 22K[5]	Picloram	2 S	45.53	0.015 – 0.023	0.68 – 1.05
Treflan DC	Trifluralin	80% DC	NA[4]	0.50 – 0.75	NA[4]
Treflan MTF, EC	Trifluralin	4 E	7.70	0.50 – 0.75	3.85 – 5.80
Treflan[5]	Trifluralin	5 E	7.07	0.50 – 0.75	3.53 – 5.30
Treflan TR–10	Trifluralin	10% G	9.47	0.50 – 0.75	4.73 – 7.10

[1] Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Minnesota Extension Service is implied.

[2] DC=Dry Concentrate, DF=Dry Flowable, E=Emulsifiable concentrate, F=Flowable, G=Granular, MT=Micro Tech (encapsulated), S=Soluble, SP=Soluble Powder, WF=Wettable Powder. All formulations listed are lb a.i., except for acid equivalent formulations designated by ae. Dry formulations are listed % a.i. by weight.

[3] Herbicide prices generally represent average retail prices from dealers throughout the state during fall 1992. Prices are for small containers and do not include cost of additives such as oils and surfactants or machinery costs. These prices are subject to change over time. Consult your local dealer for actual prices.

[4] NA = Cost information not available at this time.

[5] Restricted Use Herbicide.

Do Not Use This Table After December 31, 1993.

Table 14. *Effectiveness of herbicides on major weeds in small grains.*[1,2]

Herbicide	Type of application	Grasses				Broadleaves														
		Barnyardgrass	Green foxtail	Wild oats	Yellow foxtail	Canada thistle	Cocklebur	Common ragweed	Eastern black nightshade	Field bindweed*	Giant ragweed	Kochia	Lambsquarters	Marshelder	Perennial sowthistle*	Pigweed	Russian thistle	Smartweeds (annuals)	Sunflower	Wild buckwheat	Wild mustard
barban (Carbyne 2E)	Post	N	N	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bromoxynil (Buctril)	Post	N	N	N	N	N	G	G	G	P	G	G	G	G	N	F/G	G	G	G	G	F
bromoxynil + MCPA ester (Bronate)	Post	N	N	N	N	P	G	G	G	P	G	G	G	G	P	G	G	G	G	G	G
clopyralid (Stinger)	Post	N	N	N	N	G	G	G	F	P	G	P	N	G	F	N	P	F	G	G	N
clopyralid + 2,4-D amine (Curtail)	Post	N	N	N	N	G	G	G	G	G	G	F	G	G	F	G	F	F	G	G	G
clopyralid + MCPA ester (Curtail M)	Post	N	N	N	N	G	G	G	F	F	G	P	G	G	F	F	F	F	G	G	G
dicamba (Banvel)	Post	N	N	N	N	G	G	G	G	G	G	G	G	G	G	G	F	G	G	G	P
diclofop (Hoelon)	Post	G	G	G	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
difenzoquat (Avenge)	Post	N	N	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

fenoxaprop + 2,4-D ester + MCPA ester (Tiller)	Post	G	G	G	G	N	P	F	F	N	F	F	G	F	N	P	F	P	P	P	G
fenoxaprop + MCPA ester + thifensulfuron + tribenuron (Cheyenne)	Post	G	G	G	G	F	G	G	P	P	G	G	G	G	F	G	G	G	G	F	G
imazamethabenz (Assert)	Post	N	N	G	N	N	N	N	N	N	N	F	N	N	N	N	N	P	N	F	G
MCPA (amines or ester)	Post	N	N	N	N	F	G	G	G	G	G	G	G	G	F	G	N	P	F	P	G
metsulfuron (Ally) + (2,4-D or MCPA)	Post	N	N	N	N	F	G	G	F	F	G	G	G	G	F	G	G	F	G	F	G
picloram (Tordon)	Post	N	N	N	N	P	F	F	F	P	F	F	F	F	P	F	F	F	G	G	P
propanil (Stampede)	Post	G	G	P	G	P	P	P	P	N	P	P	G	P	N	G	P	F	P	G	G
propanil + MCPA ester (Stampede CM)	Post	G	G	P	G	F	F	F	F	P	F	F	G	F	F	G	P	F	F	G	G
triallate (Far-Go)	PEI/ PPI	N	N	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
tribenuron (Express) + (2,4-D or MCPA)	Post	N	N	N	N	G	F	G	F	P	G	G	G	G	F	F	G	F	G	F	G
tribenuron + thifensulfuron (Harmony Extra)	Post	N	N	N	N	G	G	G	N	N	G	G	G	G	-	G	G	G	G	G	G
trifluralin (Treflan)	PEI PPI	G	G	P	G	N	N	N	N	N	N	F	F	N	N	F	N	N	N	N	N
2,4-D (amine or ester)	Post	N	N	N	N	F	G	G	G	G	G	G	G	G	F	G	F	P	G	P	G

*Only control of top, no control of roots.

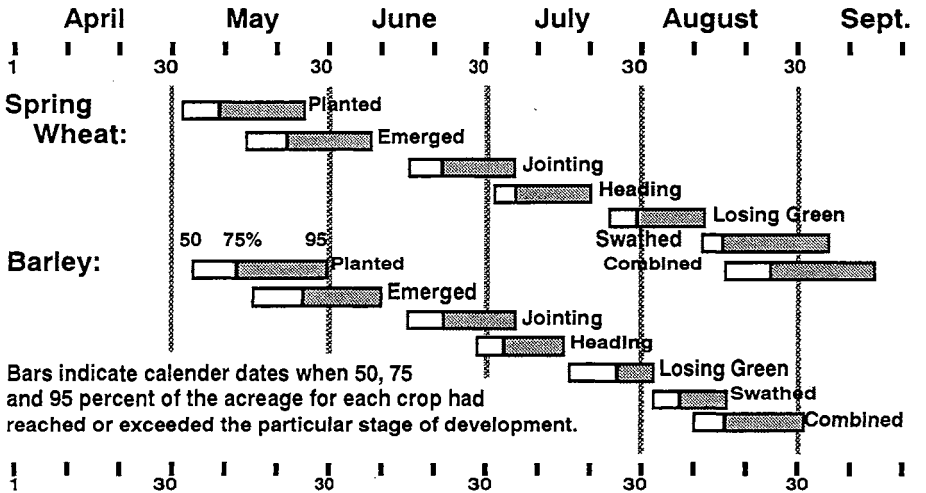
[1]G = Good; F = Fair; P = Poor; N = No control; - = inadequate information; Post = Postemergence; PEI = Preemergence incorporation; PPI = Preplant incorporation.

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

Notes

Small Grain Development Calender for Minnesota

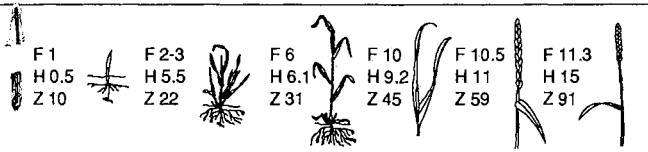
1981-85



SPRING WHEAT and BARLEY CALENDAR

GROWTH STAGE

Growth Stage Scales
Feekes = F
Haun = H
Zadok = Z



MONTH	SEPT-OCT	NOV-FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
Production Practices	soil test fertilize, 82-0-0 only fall tillage		soil test starter fertilizer soil probe for water variety selection seed bed preparation and planting			topdress N if needed, 46-0-0 or 28-0-0		harvest
Insect and Disease Management		clean/treat seed with insecticide/fungicide combination			scout: cutworms aphids grasshoppers armyworms scout: diseases - plan control seedling blights | leaf diseases | head diseases			
Weed Management	fall preplant final weed survey perennial weed control			scout: weeds postemergence preplant and preemergence			preharvest treatments	postharvest control to prevent seed production volunteers
Stored Grain Management	aerate to cool aerate to cool			aerate to warm, if necessary			clean/spray bins	dry grain if necessary
	inspect grain bins at least monthly for molds, moisture, and insects							

Table 15. *Chemical weed control guide for hard red spring wheat and barley.*

Herbicide	Active ingredient, lb/A or (formulation/A)	Weeds Controlled, Application Time, and Remarks
NO-TILL OR MINIMUM TILL		
glyphosate (Roundup/RoundupRT/ Ranger)	.19 to .75 (.5 to 2 pts)	Apply prior to wheat and barley emergence. Controls emerged annual grass and broadleaf weeds with no soil residual. Apply with nonionic surfactant.
Labeled mixtures		
dicamba (Banvel)	.12 to .25	Improves broadleaf weed control when low glyphosate rate used.
2,4–D	.25 to .5	Improves broadleaf weed control when low glyphosate rate used.
paraquat (Gramoxone Extra)	.47 to .94 (1.5 to 3 pts)	Apply prior to grain emergence but after weeds have emerged. No soil residual. Apply with an nonionic surfactant. Apply the low rate to weeds 1 to 3 inches tall and increase the rate as weed size increases. Good coverage is essential. **Restricted use herbicide**
PREPLANT INCORPORATED OR PREEMERGENCE		
triallate	1.0 to 1.25	Apply fall or spring for wild oats control. Must be incorporated, except when applying Far-Go granules at 15 lb/A in fall.
(Far-Go 4EC)	(1.0 to 1.25 qt)	
(Far-Go 10G)	(10.0 to 12.5 lb)	
Package mixtures		
triallate + trifluralin (Buckle)	(10 to 12.5 lb/A)	Buckle is formulated as a 13% active ingredient granule. Buckle contains 10% triallate and 3% trifluralin. Apply in the fall or spring only to land that will be planted to barley. **Do not use on spring wheat.** See label for additional information.

trifluralin	.5 to .75	Apply fall, granules preferred, or postplant spring, liquid formulation
(Treflan)	(1 to 1.5 pts)	preferred. Must be incorporated. Apply after Sept. 1 for fall applications.
(Treflan TR–10)	(5 to 7.5 lbs)	
Labeled mixtures		
triallate	1	Apply preemergence incorporated in spring only. Incorporate with a harrow.
(Far-Go)	(2 pts)	Adds wild oats control.
POSTEMERGENCE		
barban	.25 to .38	Postemergence control of wild oats. Apply 1 to 1.5 pt/A to 2-leaf wild oats
(Carbyne 2EC)	(1 to 1.5 pts)	and 2 pt/A to 2.5 to 3.5-leaf wild oats. Control decreases as wild oat stage increases.
Labeled mixtures		
bromoxynil (Buctril)	.25	Adds broadleaf weed control.
diclofop (Hoelon)	.25 to .5	Apply to 1.5 to 4-leaf wild oats. Improves wild oats control and adds annual grass control. **Restricted use herbicide.**
difenzoquat (Avenge)	.25 to .5	Improves wild oats control. Apply to 1.5 to 5-leaf wild oats. See label for spring wheat variety restrictions.
bromoxynil	.25 to .5	Apply from crop emergence until boot stage. Postemergence control of
(Buctril)	(1 to 2 pts)	most small broadleaf annual weeds. Weak on wild mustard and pigweed.
Labeled mixtures		
clopyralid + MCPA ester (Curtail M)	.69	Adds additional broadleaf control. Apply from 3-leaf stage to jointing.
clopyralid + 2,4–D amine (Curtail)	.59	Adds additional broadleaf control. Apply after tillering and before boot stage.

Herbicide	Active ingredient, lb/A or (formulation/A)	Weeds Controlled, Application Time, and Remarks
diclofop (Hoelon)	.75 to 1	Adds wild oats and other annual grassy weed control. Apply when grassy weeds are in the 1 to 4-leaf stage. **Restricted use herbicide.**
dicamba (Banvel)	.125 to .25	Apply before the wheat and barley is in the 5-leaf stage. **Barley injury possible.**
difenzoquat (Avenge)	.62 to 1	Adds wild oats control. Apply to 3 to 5-leaf wild oats. See narrative for wheat variety restrictions.
MCPA	.25 to .5	Improves broadleaf weed control. Apply to wheat and barley after tillering but before boot stage. Available as a package mixture – Bronate.
metsulfuron (Ally)	.004	Adds additional broadleaf control. **Do not** apply to soils over ph 7.9.
tribenuron (Express)	.008 to .016	Adds additional broadleaf control. Apply from 2-leaf stage until flag leaf is visible.
tribenuron + thifensulfuron (Harmony Extra)	.016 to .032	Adds additional broadleaf control. Apply from 2-leaf stage but before flag leaf is visible.
2,4–D	.25 to .5	Improves broadleaf weed control. Apply to wheat and barley after tillering but before boot stage.
clopyralid (Stinger)	.09 to .12 (.25 to .33 pt)	Controls Canada thistle top growth and suppresses regrowth. Apply from the 3-leaf stage of the crop to early boot. **Do not** rotate to any crop other than small grains, grass, or sugarbeet within 12 months of application. See label for additional recropping restrictions. Weak on several annual broadleaf weeds.
Labeled mixtures		
bromoxynil (Buctril)	.188 to .25	Adds additional annual broadleaf control.

dicamba (Banvel)	.06 to 0.125	Apply at the 2 to 4-leaf stage of wheat and barley. This tank mix will be weak on wild mustard. **Crop injury possible.**
MCPA (amine/ester)	.25 to .5	Adds additional annual broadleaf control.
2,4–D (amine/ester)	.25 to .5	Adds additional annual broadleaf control. Apply when wheat and barley are at the 5-leaf stage until just prior to boot.
clopyralid + MCPA ester premix (Curtail M)	.60 to .81 (1.75 to 2.33 pts)	For control of most annual broadleaf weeds and Canada thistle suppression. Apply from 3-leaf stage to jointing. **Do not** rotate to any crop other than small grains, corn, grass, or sugarbeet within 12 months of application.
Labeled mixtures		
bromoxynil (Buctril)	.188 to .25	Adds additional broadleaf control.
dicamba (Banvel)	.06 to .125	Adds smartweed control. **Do not** apply after the 5-leaf stage. **Crop injury possible.**
difenzoquat (Avenge)	.63 to 1	Adds wild oat control. See label for spring wheat variety restrictions.
2,4–D	.25	Adds additional broadleaf control. **Crop injury possible.**
clopyralid + 2,4–D amine pre-mix (Curtail)	.09 + 0.5 (2 pts)	For control of most annual broadleaf weeds and Canada thistle suppression. Apply after tillering and before the boot stage. **Do not** rotate to any crop other than small grains, corn, grass, or sugarbeet within 12 months of application.
Labeled mixtures		
bromoxynil (Buctril)	.19 to .25	Adds additional broadleaf weed control, especially smartweeds.
dicamba (Banvel)	.06 to .125	Adds smartweed control. **Do not** apply after the 5-leaf stage. **Crop injury possible.**
difenzoquat (Avenge)	.62 to 1	Adds wild oats control. See label for spring wheat variety restrictions.
MCPA	.25	Adds additional broadleaf control.
2,4–D	.25	Adds additional broadleaf control.

Herbicide	Active ingredient, lb/A or (formulation/A)	Weeds Controlled, Application Time, and Remarks
dicamba	.06 to .125	Apply before wheat is in the 5-leaf stage and barley is in the 3-leaf stage.
(Banvel)	(.12 to .25 pt)	Applying at the 2 to 4-leaf stage of wheat will increase safety. Controls many broadleaf weeds including wild buckwheat and smartweeds. Weak on wild mustard. Most commonly used in tank mixes.
Labeled mixtures		
bromoxynil (Buctril)	.25 to .38	Improves broadleaf weed control.
MCPA	.25 to .38	Improves broadleaf weed control, especially wild mustard. Apply when wheat is in the 4-leaf stage and barley is in the 3-leaf stage. Proper timing of application is important to avoid crop injury.
diclofop	.75 to 1	Apply when wild oats and other annual grasses are in the 1 to 4-leaf
(Hoelon)	(2 to 2.67 pts)	stage. Apply before wheat and barley is in the jointing stage. **Restricted use herbicide.**
Labeled mixtures		
bromoxynil (Buctril)	.25 to 0.38	Adds broadleaf weed control.
MCPA ester	.05	Can be added to a tank mix of diclofop plus bromoxynil to improve wild mustard control.
difenzoquat	.62 to 1	For wild oats control. Some spring wheat varieties will be injured. See label
(Avenge)	(2.5 to 4 pts)	for variety restrictions. Barley has good tolerance. Apply to 3 to 5-leaf stage wild oats.
Labeled mixtures		
bromoxynil (Buctril)	.25 to .38	Adds broadleaf weed control.

bromoxynil + MCPA ester (Bronate)	.5	Adds broadleaf control.
clopyralid + MCPA ester (Curtail M)	.60	Adds broadleaf control. Apply up to jointing stage of wheat and barley. Recropping restrictions, see label.
clopyralid + 2,4–D amine (Curtail)	.59	Adds broadleaf control. Apply after tillering and before boot stage. Recropping restrictions, see label.
MCPA	.25 to 1	Adds broadleaf weed control. Apply to wheat and barley in the 2-leaf to early boot stage.
tribenuron (Express)	.008 to .016	Adds broadleaf control. Apply from 2-leaf stage until flag leaf visible.
tribenuron + thifensulfuron (Harmony Extra)	.016 to .023	Adds broadleaf control. Apply from 2-leaf stage but before flag leaf is visible.
2,4-D	.25 to .75	Adds broadleaf weed control. Apply to wheat and barley in the 5-leaf stage until just prior to boot stage.
fenoxaprop + MCPA ester + thifensulfuron + tribenuron (Cheyenne)	.08 + .38 + .009 + .005	**Apply to Spring Wheat only. Do not** apply to barley. Controls wild oats and foxtails. Apply from 3-leaf to 6-leaf stage. Apply to 1–4 leaf grass weeds. **Restricted use herbicide.**
fenoxaprop + 2,4–D ester + MCPA ester (Tiller)	.05 + .07 + .22 to .08 + .12 + .37 (1 to 1.7 pts)	**Apply to Spring Wheat Only. Do not** apply to barley. Controls wild oats and foxtails. Apply after tillering until the 6-leaf stage. See label for tank mixing restrictions.
imazamethabenz (Assert)	.31 to .38 (1.0 to 1.2 pts)	Apply when wild oats are in the 1 to 4-leaf stage and wheat and barley is from the 2-leaf stage until the development of the first internode. Use 1.0 pt when wild oats are in the 1 to 2-leaf stage. See label for crop rotation restrictions. **Always apply with a nonionic surfactant.**

Herbicide	Active ingredient, lb/A or (formulation/A)	Weeds Controlled, Application Time, and Remarks
Labeled mixtures		
bromoxynil + MCPA ester (Bronate)	.25 + .25	Adds annual broadleaf control. Apply to small weeds.
clopyralid + MCPA ester (Curtail M)	.60 to .81	Adds broadleaf control. Apply up to jointing stage.
MCPA ester	.16 to .5	Adds annual broadleaf control. **Do not** use amine formulations as reduced wild oats control will result.
2,4–D ester	.16 to .5	Adds annual broadleaf control. Apply after the 5-leaf stage of the crop. **Do not** use amine formulations as reduced wild oats control will result.
tribenuron (Express)	.008 to .016	Adds broadleaf control. Apply from 2-leaf stage until flag leaf is visible.
tribenuron + thifensulfuron (Harmony Extra)	.016 to .032	Adds broadleaf control. Apply from the 2-leaf stage but before flag leaf is visible.
MCPA		
(Amines)	.25 to .66 (several formulations)	Controls many broadleaf weeds, but weak on wild buckwheat and smartweeds. Apply from 2-leaf to early boot stage of wheat.
(Esters)	.16 to .5 (several formulations)	
Labeled mixtures		
bromoxynil (Buctril)	.25 to .38	Improves wild buckwheat and smartweed control.
dicamba (Banvel)	.06 to .12	Improves wild buckwheat and smartweed control. Apply when wheat and barley are in the 2 to 4-leaf stage.

difenzoquat (Avenge)	.62 to 1	Adds wild oats control. See label for spring wheat variety restrictions.
picloram (Tordon)	.015 to .023	Improves wild buckwheat and smartweed control. Apply to 3 to 5-leaf wheat and barley. See label for recropping restrictions. **Restricted use herbicide.**
metsulfuron	.004	Apply postemergence to small weeds. **Do not** apply to soils over pH 7.9.
(Ally)	(.1 oz/A)	See label for additional information.
Labeled mixtures		
MCPA (ester/amine)	.25 to .5	Adds additional broadleaf control.
2,4–D (ester/amine)	.25 to .5	Adds additional broadleaf control, especially kochia and pigweed.
difenzoquat (Avenge)	.62 to 1	Adds wild oats control. See label for spring wheat variety restrictions.
propanil	1 to 1.13	For control of foxtail and some broadleaf weeds. Apply at the 2- to 5-leaf
(Stampede EDF)	(1.25 to 1.4)	stage of spring wheat, 2- to 4-leaf stage of barley and 1-3 leaf stage of foxtail. Temporary crop yellowing may occur.
Labeled mixtures		
MCPA ester	.25	Adds additional broadleaf control.
propanil + MCPA ester premix (Stampede CM)	1.19 to 1.44	For control of foxtails and some broadleaf weeds. Apply at 2 to 5-leaf stage of spring wheat, 2 to 4-leaf stage of barley, and 1 to 3 leaf stage of foxtails. Temporary yellowing of wheat and barley may occur. Use high rate only when weed pressure is heavy.
2,4–D		
(Amines)	(.25 to .66) (several formulations)	Controls many broadleaf weeds. Weak on wild buckwheat and smartweeds. Apply when wheat and barley are in the 5-leaf stage until just prior to boot
(Esters)	(.16 to .5) (several formulations)	
Labeled mixtures		
bromoxynil (Buctril)	.25 to .38	Improves wild buckwheat and smartweed control.
dicamba (Banvel)	.06	Improves wild buckwheat and smartweed control. Apply when wheat is in the 4-leaf stage. Proper timing of application is important to avoid crop injury. **Not recommended for use on barley as crop injury is likely.**

Herbicide	Active ingredient, lb/A or (formulation/A)	Weeds Controlled, Application Time, and Remarks
difenzoquat (Avenge)	.62 to 1	Adds wild oats control. See label for spring wheat variety restrictions.
picloram (Tordon)	.015 to .023	Improves wild buckwheat and smartweed control. Apply to 3 to 5-leaf wheat and barley. See label for recropping restrictions. **Restricted use herbicide.**
triasulfuron (Amber)	.013 to .026 (.28 to .56 oz/A)	For control of many annual broadleaf weeds. Long soil residue. See label for cropping restrictions.
tribenuron (Express)	.008 to .016 (.167 to .33 oz/A)	For control of many annual broadleaf weeds and Canada thistle suppression. Apply from 2-leaf stage until flag leaf visible. Use low rate for small weeds.
Labeled mixtures		
difenzoquat (Avenge)	.62 to 1	Adds wild oat control. See label for spring wheat variety restrictions.
imazamethabenz (Assert)	.31 to .38	Adds wild oat control.
MCPA (amine/ester)	.125 to .375	Adds additional broadleaf control, especially pigweed.
2,4–D (amine/ester)	.125 to .375	Adds additional broadleaf control, especially pigweed and kochia. Apply after tillering.
tribenuron + thifensulfuron premix (Harmony Extra)	.016 to .032 (.33 to .67 oz/A)	For control of most annual broadleaf weeds and Canada thistle suppression. Apply from the 2-leaf stage, but before flag leaf is visible. Use low rate for small weeds. 0.5 oz/A is the maximum rate needed for control of most weeds.
Labeled mixtures		
difenzoquat (Avenge)	.62 to 1	Adds wild oat control. See label for spring wheat variety restrictions.
imazamethabenz (Assert)	.31 to .38	Adds wild oat control. Apply to 1 to 4-leaf wild oats.
MCPA (amine/ester)	.125 to .375	Adds additional broadleaf control.
2,4–D (amine/ester)	.125 to .375	Adds additional broadleaf control. Apply after tillering.

Do Not Use This Table After December 31, 1993.

Disease Control

Seedling Diseases, Seed Treatment – Shriveled, low test weight, diseased, or weathered seed benefits from seed treatment through protection against soil-borne or seed-borne fungi. Cold, moist soils slow the growth of seedlings, and favor growth of certain disease organisms. Seed treatment stops these organisms from causing decay, rot, and blight. Different fungicides may be used for different purposes. Select the correct fungicide for the job to be done (see Fungicide Tables). Always avoid over-application with seed treatment products.

Loose Smut – Loose smut of wheat or barley can be controlled with seed treatment fungicides containing carboxin (see Fungicide Tables). All currently grown varieties are susceptible to loose smut, but it is not a severe problem in most seed lots. The embryo test to detect loose smut in barley seed can't be used to accurately determine loose smut in wheat seed. Foundation seed and registered seed of both wheat and barley should always be treated for loose smut. Suspect seed lots should also be treated.

Root Rots – Common root rot is a potential problem on wheat and barley almost every year in Minnesota. Damage often is more severe under heat and moisture stress. Root rot shows as a seedling blight or as mature plant root and crown rot, with brown discoloration of the roots and crown. Heads on diseased plants have fewer and shriveled seeds. Some plants die prematurely and affected heads turn white. The fungus that causes common root rot of wheat and barley survives in the soil and crop debris. Crop rotation away from wheat and barley, to crops such as flax, sugarbeets, corn, beans, or sunflowers, as well as fallow, helps reduce the disease. Imazalil and triadimenol fungicides are registered for use as seed treatments to suppress common root rot.

Take-all – Another serious root rot which can completely destroy affected plants. It is recognized by a black, shiny discoloration at the base of the stem.

Take-all is found primarily in fields of continuous wheat cropping under high soil moisture. When take-all occurs in a field, no wheat or barley should be grown in that field for at least 3 seasons. Oat is a good rotation crop, being much less susceptible to take-all. Triadimenol (Baytan) seed treatment is registered for suppression of take-all of wheat (see Fungicide Tables).

Rusts – Stem and leaf rust fungi attack hard red spring wheat and barley. However, many varieties of wheat are resistant to both stem and leaf rust (see variety lists). Spores of the rust fungi overwinter in southern states and then are carried north by winds. New races of rust appear periodically, making rust research and the release of new varieties necessary. Leaf rust control with fungicide sprays is not usually economical unless susceptible varieties are grown.

Leaf Diseases – Several other fungi plus some bacteria cause leaf disease. If enough leaf area is killed, especially the flag leaf, grain fill and seed set are reduced. The results are lower test weights and poorer yield (yield losses from 10%–40% are possible). Leaf disease-causing fungi and bacteria survive in infected cereal debris and trash, in grassy weeds, and sometimes in seed. Most of these disease organisms require long periods of dew or high humidities for infection to occur. Tan spot, the major leaf spotting fungus on wheat, produces tiny black fruiting bodies on wheat residue from which spores are blown by wind onto leaves during early May. Other leaf diseases that may affect wheat and barley include *Septoria* leaf blotch, spot blotch, powdery mildew and net blotch (barley).

Chemical control (see Fungicide Tables) of fungal leaf spots is possible and practical under certain conditions: high yield potential, disease organisms present, and persistent humid weather. Rotating the crop with a non-cereal crop or fallowing a field reduces the risk of leaf spot diseases. Burying crop residue also helps reduce disease; this can be done in the fall or the spring.

Glume Blotch – The glume blotch fungus, *Septoria nodorum,* has been endemic in wheat, causing slight to moderate damage. In 1992, glume blotch was present in the central parts of the Red River Valley. The glume blotch fungus survives on wheat residue. Infection of glumes is promoted by wet, warm weather following heading. The disease can be managed by crop rotation and tillage practices. Foliar fungicides (see Fungicide Tables) help protect against leaf infection and have been shown to reduce glume infection, but the profitability of these treatments is highly variable.

Scab – A *Fusarium* fungus causes scab when warm, humid, rainy weather occurs at flowering. Parts or all of infected heads have a bleached or white appearance. Scabby kernels may show a pink color at their base. Scab severely reduces yields and test weights. Scabby seed may contain fungal toxins. Among livestock, swine are the most susceptible to the scab toxins. For a fee, the University of Minnesota Veterinary diagnostic laboratory will test scabby grain for toxins.

Reduce scab with crop rotation: allow at least a one year break between plantings of small grains or corn. The severest scab often occurs in wheat that has been planted on last year's corn ground. Tillage to bury crop residues also helps to reduce scab potential. Scabby grain should not be used for seed. If seeding scabby grain is unavoidable, clean grain thoroughly and treat with a fungicide seed treatment to minimize seedling blight.

Note: The fungicide tables for disease control of wheat are based on the latest information available from the Minnesota Agricultural Experiment Station, United States Department of Agriculture, Environmental Protection Agency (EPA) and the agricultural chemical industry. The information conformed to federal and state regulations at the time of printing. Always follow label directions, making certain to check instructions on how to apply, when to apply, how long to wait prior to harvest, whether treated crops can be fed to livestock, and what safety precautions should be followed.

Table 16. *Seed treatment.*

Chemical	Dosage (Formulations/ bu or cwt)	Disease Control[1]			Remarks
		Loose Smut	Seedling Blights	Common Root Rot	
Carboxin					
Vitavax 34	2–3 fl oz/cwt	E	(G)	No	
Carboxin + Captan					
Nu-Gro Captan 20–Carboxin 20	4 oz/cwt	E	E	No	
Seed Mate Captan–Vitavax 20–20	4 oz/cwt	E	E	No	
Carboxin + Maneb					
DB–Green + Vitavax	2 oz/bu	E	E	No	DB Green + Vitavax and Enhance Plus contain 18.75% lindane insecticide.
Enhance Plus	2 oz/bu	E	E	No	
Carboxin + Thiram					
Vitavax 200 Flowable	3–4 fl oz/cwt	E	(E)	No	
RTU–Vitavax–Thiram	5–6.8 fl oz/cwt	E	(E)	No	
Vitavax–Thiram–Lindane	5 fl oz/cwt	E	(E)	No	Vitavax–Maneb–Lindane contains 8% lindane insecticide.

Chemical	Dosage (Formulations/ bu or cwt)	Disease Control[1]			Remarks
		Loose Smut	Seedling Blights	Common Root Rot	
Imazalil					
Agsco Double R	0.5–0.8 fl oz/bu	No	(G)	G–E	Registered, for supression of common root rot of wheat and barley. May be used with other fungicides. If used in combination with seed treatment products that contain lindane, treated seed should be planted as soon as possible. **Do not graze or feed foliage from treated area to livestock.**
Flo–Pro IMZ Flowable	0.25–0.5 fl oz/cwt	No	(G)	G–E	
Nuzone 10 EC	0.8–1.5 fl oz/cwt	No	(G)	G–E	
Mancozeb					
Clean Crop Mancozeb 80WP	1.3–2 oz/bu	No	G–E	No	
Clean Crop Mancozeb 4L	2.2 fl oz/bu	No	G–E	No	
Dithane M–45	1.3–2 oz/bu	No	G–E	No	
Grain Guard	2 oz/bu	No	G–E	No	
Manzate 200 DF	1.3–2 oz/bu	No	G–E	No	
Manex II	2.2 fl oz/bu	No	G–E	No	
Maneb					
Agsco DB Green or		No	G–E	No	All combined with 18.75% lindane for wireworm control.
Granox NM, or	2 oz/bu	No	G–E	No	
Trinox, or Seed Mate	(1.5 oz/bu Trinox)	No	G–E	No	

Maneb–Lindane		No	G–E	No	
Agsco DB–Green L	3 fl oz/bu	No	G–E	No	Contains 8.6% lindane insecticide.
Trinox LX	3 fl oz/bu	No	G–E	No	Contains 10.5% lindane insecticide.
Maneb + Thiabendazole					
Granox Plus	1 oz/bu	–	G–E	No	
PCNB (Terraclor)					
Terra–Coat LT–2N	2 fl oz/bu	No	G–E	No	
Triadimenol					
Baytan 30F	0.75 fl oz/cwt for control of smuts 1.5 fl oz/cwt1for control of seed born glume blotch and for suppression of take-all, root rot 1.5 fl oz/cwt for control of carly season foliar diseases	E	(G–E)	(G–E)	For use only by commercial seed treaters. Green forages may be grazed 40 days after seeding. Baytan 30 treated seed should not be planted at depths greater than 1 1/2". **Baytan 30 cannot be used in combination with any seed treatment insecticide containing lindane.**

[1]P = Poor; F = Fair; G = Good; E = Excellent; N = No control; ( ) = Not registered for disease; – = No data.

Table 17. *Foliar sprays.*

Chemical	Dosage (Formulations/A)	Disease Control[1] Leaf Spots[2]	Leaf Rust	Stem Rust	Powdery Mildew	Remarks
Benomyl						
Benlate	0.5–1 lb/A	–	–	–	G	Also registered for Septoria leaf and glume blotch of wheat. Apply at boot stage and 14 days later. **Do not** apply within 21 days of harvest. **Do not** enter treated fields within 24 hours of treatment without protective clothing (see label). Also labeled for fungigation.
Copper						
Champion WP	1.5–2 lb/A	F–G	(G)	–	(No)	Spray in early boot, when flag leaf emerged. (Feeke's growth stage 10). Second application 7–10 days later. 5 gal. water/A, aerial application.
Champ Flowable	2–2.66 pt/A	F–G	(G)	–	(No)	
Kocide 101	1.5–2 lb/A	F–G	(G)	–	(No)	
Kocide DF	1.5–2 lb/A	F–G	(G)	–	(No)	
Kocide 606	2–2.66 pt/A	F–G	(G)	–	(No)	
Top Cop Tri-Basic	3–4 pt/A	F–G	(G)	–	(No)	

Mancozeb						
Clean Crop Mancozeb 80WP	2 lb/A	G–E	E	(G–E)	(No)	**Do not** make more than 3 applications of mancozeb; **do not** apply mancozeb within 26 days of harvest.
Clean Crop Mancozeb 4L	1.6 qt/A	G–E	E	(G–E)	(No)	**Do not** graze mancozeb treated area within 26 days of application. Also labeled for fungigation.
Dithane DF	2 lb/A	G–E	E	(G–E)	(No)	
Dithane F–45	1.6 qt/A	G–E	E	(G–E)	(No)	
Dithane M–45	2 lb/A	G–E	E	(G–E)	(No)	
Manex II	1.6 qt/A	G–E	E	(G–E)	(No)	
Manzate 200 DF	2 lb/A	G–E	E	(G–E)	(No)	
Penncozeb	2 lb/A	G–E	E	(G–E)	(No)	
Penncozeb DF	2 lb/A	G–E	E	(G–E)	(No)	
Propiconazole						
Tilt 3.6E	4 fl oz/A	G–E	E	G–E	E	Apply at start of flag leaf emergence (Feeke's growth stage 8). Make only one application. **Do not** apply after heads have emerged. For aerial application use minimum of 5 gal. water/A. Use minimum 15 gal. water/A for ground application. **Do not** graze or feed livestock treated forage or harvest treated crop for hay or silage. Straw may be used for bedding or feed.

Chemical	Dosage (Formulations/A)	Disease Control[1] Leaf Spots[2]	Leaf Rust	Stem Rust	Powdery Mildew	Remarks
Triadimefon						
Bayleton	2–6 oz/A, powdery mildew 4–8 oz/A, rusts	P	E	E	E	1–2 applications; **Do not** apply over 16 oz/A; **Do not** apply within 21 days of harvest. **Do not** enter treated areas without protective clothing until sprays have dried. Registered for Septoria leaf blotch. If Septoria leaf blotch is severe, it is recommended that Bayleton be tank mixed with another registered fungicide with good activity against this disease.
Sulfur						
That Flowable	3–5 pt/A	–	–	–	G	**Do not** apply when temperatures are high (above 90°F). For powdery mildew only.
Sulfur DF	6–15 lbs/A	–	–	–	G	
Thiolux	6 lb/A	–	–	–	G	

[1]P = Poor; F = Fair; G = Good; E = Excellent; – = No Data; ( ) = Not registered specifically for this disease; N = No control.
[2]Leaf spots include tan spot, Septoria leaf blotches and spot blotch.

Do Not Use This Table After December 31, 1993.

Insect Control

NOTICE: This section contains information on the control of common wheat insects occurring in Minnesota. Due to space limitations the reader will not find information on the prevention and control of stored grain insects. This information is available in extension publication AG–FS–0997 *Preventing stored-grain insect infestation* and AG–FS–1034A *Fumigating stored grain.*

Table 18. *Hard red spring wheat and barley insect control.*

Pest	Insecticide	Dosage (Active Ingredient)	Remark
APHIDS Greenbug Corn Leaf Bird Cherry-Oat Aphid, and others	Cygon	1/4–3/8 lb per acre	**Do not** apply within 14 days of grazing immature plants. **Do not** harvest grain within 35 days of last application. **Do not** make more than two applications per season.
	*Di-Syston	1/2–1 lb per acre	Aerial application only. **Do not** apply within 30 days of grain harvest. Use lower rate on plants up to tillering and higher rate after tillering.
	*Ethyl parathion	1/4 lb per acre	Aerial application only. **Do not** apply within 12 days of harvest. Read label for additional restrictions.
	Malathion EC	1 lb per acre	**Do not** apply within 7 days of harvest on wheat, oats, rye and barley. **Do not** apply below 60 ° F.
	*Methyl parathion EC	1/2 lb per acre	Aerial application only. **Do not** use within 15 days of harvest.
	*Penncap-M	1/4–1/2 lb per acre	**Do not** apply within 15 days of harvest or grazing. To avoid injury to bees, **do not** apply during pollen shed if bees are visiting the areas to be be treated during the foraging hours.

Aphid action levels for small grains: Recent research suggests that aphid control at flag leaf (Feekes 8) provides maximum prevention of yield reduction in spring wheat. Work in Sweden and more recently in Minnesota indicates that an action level of 12 aphids (greenbug, bird cherry-oat and corn leaf aphid(s)) per stem or 89% of stems infested (100 stem sample) will usually provide an economic return. If one misses this action level, we then recommend treating headed grain (milk to early dough) with 20 aphids per stem.

Pest	Insecticide	Dosage (Active Ingredient)	Remark
ARMYWORMS	Carbaryl (Sevin)	1–1.5 lb per acre	**Do not** apply within 21 days of harvest. **Do not** make more than two applications after the boot stage.
	Dylox SP, EC	1 lb per acre	**Do not** apply within 21 days of harvest.
	*Methomyl (Lannate, Nudrin)	1/4–1/2 lb per acre	**Do not** harvest within 7 days or feed treated forage within 10 days of application.
	Malathion	1 1/4 lb per acre	**Do not** harvest for 7 days.
	*Methyl parathion EC	1 lb per acre	Aerial application only. **Do not** apply within 15 days of harvest. Read label for additional restrictions.
	*Penncap-M	1/2–3/4 lb per acre	**Do not** apply within 15 days of harvest.

NOTE: Treat when 4–5 worms per square foot are present in small grains. Most infestations are likely to appear in lodged grain, especially barley. Infestations may also appear in rye, oat, wheat and grassy roadsides or field margins. When daytime counts exceed 3 worms per square foot the field will probably need treatment. **Do not** delay treating a field with 5 worms per square foot.

CUTWORMS	Dylox SP, EC	1 lb per acre	Three applications may be made per season but not within 21 days of harvest.
	*Ethyl parathion	1/2 lb per acre	Aerial application only. **Do not** apply within 15 days of harvest. Read label for additional restrictions.
	*Methyl parathion	1/2 lb per acre	Aerial application only. **Do not** apply within 15 days of harvest.

NOTE: For small grains, the economic threshold for cutworms is 4–5 per square foot. In contrast to armyworm, be very slow to treat a field with these numbers.

GRASSHOPPERS	Cygon 400	3/8 lb per acre	**Do not** apply within 14 days of grazing immature plants. **Do not** harvest grain within 35 days of last application. **Do not** make more than two applications per season.
	*Ethyl parathion	1/2 lb per acre	Aerial application only. **Do not** apply within 15 days of harvest. Read label for additional restrictions.
	*Furadan 4F	1/8–1/4 lb per acre	**Do not** make more than two applications at 1/8 lb or one application at 1/4 lb per season. **Do not** apply to heading grain. **Do not** feed treated forage to livestock. **Do not** apply in proximity to waterfowl nesting or feeding areas.
	Malathion EC	1 1/2 lbs per acre	Wait 7 days before harvest of grain. No time limitation on grazing or straw or dairy or slaughter animals.
	Malathion (ULV)	8 fl ozs per acre	Commercial aerial applicators only. **Do not** harvest for 7 days.
	*Methyl parathion	1/2 lb per acre	Aerial application only. **Do not** apply within 15 days of harvest.
	*Penncap-M	1/4–3/4 lb per acre	**Do not** apply within 15 days of harvest. Aerial application only.
	Carbaryl (Sevin)	1/2–1 1/2 lbs per acre	**Do not** apply within 21 days of grain harvest. No limitations on forage. The lower rate (1/2 lb) is suggested for nymphs on small plants or sparse vegetation. The higher rate is suggested for mature grasshoppers or when material is applied to crops requiring greater coverage.

NOTE: Control advised when grasshoppers exceed 8 per square yard in the field or 20 per square yard in the margin.

Pest	Remark
HESSIAN FLY	This insect probably overwinters in the pupal stage in Minnesota and it is normal to experience two generations damage per season. Early season damage is on the culm, reducing tiller numbers and size. Late season damage causes stem breakage. The annual population swings, and the unpredictability of the (damage) peaks, suggest that control through cultivation, crop rotation, and/or the use of an insecticide as planting time treatment are of relatively little economic value over time.

South Dakota State (USDA) has produced two semi-dwarf wheat varieties (Guard and Shield) which have resistance to Hessian fly. However, because there is absolutely no predictability to Hessian fly outbreaks, we would not suggest switching from presently superior, but susceptible, wheat varieties to them.

WHEAT MIDGE	No effective control measures known.
WHEAT STEM MAGGOT	No chemical control is recommended. In most years, a very small percentage of the stems will be infested. Heads of infested plants usually turn white and they can be easily pulled out. Crop rotation, destruction of volunteer grain and infested straw, and/or cultivation have little effect on annual population fluctuations.
WIREWORMS	Currently the only insecticide registered for wireworm control that will provide effective suppression is lindane. This insecticide can be purchased as a drill box treatment in combination with fungicide (Maneb or Captan) and is also available in liquid (flowable) formulation to be applied alone or with fungicides such as Vitavax, Captan or Thiram.

Caution: Do not use treated seed for feed or food purposes. Prevent the contamination of commercial grain by thoroughly cleaning bins, grain augers and trucks that have been used to store, handle and/or home treat seed.

*EPA has classified this insecticide as a restricted use pesticide. Restricted use pesticides are to be applied by or under the direct supervision of certified pesticide applicators only.

Do Not Use This Table After December 31, 1993.

Grain Harvesting

Wheat reaches physiological maturity at about 35 percent moisture and should be swathed at 20–30% moisture. If grain is still standing at less than 20% moisture, swathing will cause excessive shatter loss and straight combining should be considered. Combine at 15–18% moisture and dry the grain to safe storage levels.

Set the combine to the manufacturer's recommendations and then adjust according to grain conditions. Wet grain may require more aggressive threshing. If so, narrow the concave setting first and then increase cylinder speed if needed. Check the condition of the grain in the tank and grain on the ground to indicate combine adjustments.

Harvest losses of about 3% are considered normal. More than this left on the ground calls for some corrective action. To determine your harvest losses, use a one foot square frame, and count the number of kernels per square foot.

1. Count the kernels directly behind the combine. Count several areas to get a representative number.
2. Count the kernels in the area between the swaths, away from the combine discharge.
3. Subtract the count in step 2 from the count in step 1.
4. Calculate the ratio:

$$\frac{\text{Width of combine sieve discharge}}{\text{Width of swather cut or combine header}}$$

   Multiply the amount calculated in step 3 by this ratio.
5. Divide the result in step 4 by the number of kernels it takes to represent one bushel per acre loss from the table below. This result is the approximate bushel per acre combine loss.

Make adjustments to the cylinder, fan, or sieves to reduce this loss.

6. Divide the count in step 2 by the factor in the table to determine the bushel per acre loss from preharvest shatter and cutting operations. Make adjustments to the header or reel, or cut earlier to reduce this loss.

Number of kernels per square foot to equal one bushel per acre.

Hard Red Spring Wheat	20	Oats	10
Durum	16	Sunflowers	3
Flax	100	Corn	2
Barley	14	Soybeans	4

Managing Stored Grain

After investing time, money, and other resources to produce grain, make sure to protect that investment by managing grain properly in storage to prevent losses. Here are some tips:

Clean bins before harvest. Grain and fines (small particles) remaining from previous years almost always contain stored grain insects. To reduce insect problems in the new crop, avoid mixing old and new grain. Also, clean bin walls and floors, the space under perforated floors, and the area outside bins to remove all old grain dust, fines, and kernels.

Consider using insecticides. Consider spraying grain bins with an approved residual-type insecticide before harvest. Then, consider treating grain with an approved protectant as it is loaded into storage. Check with potential buyers before using insecticides, however, because some buyers will not accept treated grain.

Control fines. Select and use grain harvesting and handling equipment to minimize fines and foreign material in grain. Consider using a grain cleaner to remove fines and foreign material before grain is stored. Fill bins in a way that prevents a concentra-

tion of fines at the center. Either use a grain spreader to distribute fines uniformly throughout the bin, or don't use a spreader and periodically withdraw fines from the center as the bin is filled.

Control moisture. Maximum recommended moisture content for wheat is 14% (wet basis) for up to 9 months storage, and 13% for more than 9 months storage. Barley moisture should be 13.5% and 12.5%, respectively, for the same storage periods.

If grain is too wet when it is harvested, it can be dried with unheated (natural) air if the bin is equipped with a full perforated floor and a large enough drying fan. Recommended airflow values for natural-air wheat and barley drying are 0.5 cfm/bu (cubic feet of air per minute per bushel of grain) for 14 to 16% moisture grain, 0.75 cfm/bu for 16 to 18% moisture, and 1.0 cfm/bu for 18 to 19% moisture. (Get a copy of *Selecting fans and determining airflow for crop drying, cooling, and storage,* AG–FO–5716, or use the FANS computer program to estimate airflow in bins.) In general, operate drying fans continuously (24 hours/day) until all grain in the bin is dry or until average daily temperatures drop below freezing. If drying is not completed in fall, run fans as needed to keep grain at 20 to 30° F during winter, and resume drying in early spring.

Wheat and barley can also be dried in dryers that use heated air, but the drying air temperature might have to be reduced to prevent grain damage. Keep grain temperature below 140° F for grain used in milling, and keep it below 110° F for grain used for seed or malting.

Aerate to control grain temperature. Dry grain should be cooled to less than 60° F as soon as possible after harvest by operating aeration fans during cool weather. In late summer, this might mean running fans only at night. Don't worry about high nighttime relative humidity during aeration—grain rewets much slower than it cools.

In late fall, use aeration fans again to cool grain to 20 to 30° F for winter storage. If grain is not cooled

to less than 20° F in winter, you shouldn't need to run fans to warm it in spring. If you do run fans in spring, start early in the season and make sure you don't warm grain beyond 50° F.

Estimate the number of hours a fan must be operated to cool a bin of grain by dividing the number 15 by the airflow in cfm/bu. For example, in a storage bin that has an airflow of 0.1 cfm/bu (a typical value for farm bins) it takes about 15 ÷ 0.1 = 150 hours or about 6 days of fan operation to cool the grain. See *Management of stored grain with aeration,* AG–FO-1327 for more information.

Check stored grain regularly. Every 2 to 4 weeks in cold weather and every 1 to 2 weeks in warm weather, measure grain temperature and moisture, and look for moldy or discolored kernels and signs of insects. Also, start the fan briefly and check the first air to leave the bin for musty or sour odors. If problems are detected, run aeration fans to cool the grain. If aeration doesn't control the problem, unload the bin and clean, dry, feed, or sell the grain. Wear a dust mask designed to filter mold spores when handling moldy grain to avoid health problems.

More information on wheat and barley managment is provided in *Wheat and barley drying,* AG-FS-5949, and *Wheat and barley storage,* AG-FS-5947.

Table 19. *Conversion factors.*

From		To
Acres	x 0.405	Hectares
Acres	x 43,560	Square feet
Acres	x 4047	Square meters
Acres	x 160	Square rods
Acres	x 4,840	Square yards
Bushels	x 2,150.42	Cubic inches
Bushels	x 4	Pecks
Bushels	x 64	Pints
Bushels	x 32	Quarts
Centimeters	x 0.3937	Inches
Centimeters	x 0.01	Meters
Centimeters	x 10	Millimeters
Cords (4' x 4' x 8')	x 8	Cord feet
Cord feet (4' x 4' x 8')	x 16	Cubic feet
Cubic centimeters	x .061	Cubic inches
Cubic feet	x 1,728	Cubic inches
Cubic feet	x 0.03704	Cubic yards
Cubic feet	x 7.4805	Gallons
Cubic feet	x 59.84	Pints (liquid)
Cubic feet	x 29.92	Quarts (liquid)
Cubic inches	x 16.39	Cubic centimeters
Cubic meters	x 1,000,000	Cubic centimeters
Cubic meters	x 35.31	Cubic feet
Cubic meters	x 61,023	Cubic inches
Cubic meters	x 1.308	Cubic yards
Cubic meters	x 264.2	Gallons
Cubic meters	x 2,113	Pints (liquid)
Cubic meters	x 1,057	Quarts (liquid)
Cubic yards	x 27	Cubic feet
Cubic yards	x 46,656	Cubic inches
Cubic yards	x 0.7646	Cubic meters
Cubic yards	x 202	Gallons
Cubic yards	x 1,616	Pints (liquid)
Cubic yards	x 807.9	Quarts (liquid)
Cups	x 8	Fl. ounces
Cups	x 236.5	Milliliters

Cups	x 0.5	Pints
Cups	x 0.25	Quarts
Cups	x 16	Tablespoons
Cups	x 48	Teaspoons
Degrees Celsius (+17.98)	x 1.8	° Fahrenheit
Degrees Fahrenheit (–32)	x 0.5555	° Celsuis
Fathoms	x 6	Feet
Feet	x 30.48	Centimeters
Feet	x 12	Inches
Feet	x 0.3048	Meters
Feet	x 0.33333	Yards
Feet per minute	x 0.01667	Feet per second
Feet per minute	x 0.01136	Miles per hour
Fluid ounces	x 2	Tablespoons
Fluid ounces	x 6	Teaspoons
Fluid ounces	x 29.57	Milliliters
Furlongs	x 40	Rods
Gallons	x 269	Cubic inches (dry)
Gallons	x 3,785	Cubic centimeters
Gallons	x 0.1337	Cubic feet
Gallons	x 231	Cubic inches
Gallons	x 3.785	Liters
Gallons	x 128	Ounces (liquid)
Gallons	x 8	Pints (liquid)
Gallons	x 4	Quarts (liquid)
Gallons of water	x 8.3453	Pounds of water
Grains	x 0.0648	Grams
Grams	x 15.43	Grains
Grams	x 0.001	Kilograms
Grams	x 1,000	Milligrams
Grams	x 0.0353	Ounces
Grams per liter	x 1,000	Parts per million
Hectares	x 2.471	Acres
Hundred wt (cwt.)	x 100	Pounds
Inches	x 2.54	Centimeters
Inches	x 0.08333	Feet
Inches	x 0.02778	Yards

Kilogram (kg)	x 1000	Grams (g)
Kilograms	x 2.205	Pounds
Kilograms/hectare	x 0.8929	Pounds per acre
Kilometers	x 3,281	Feet
Kilometers	x 1,000	Meters
Kilometers	x 0.6214	Miles
Kilometers	x 1,094	Yards
Knots	x 1.15	Miles per hour
Knots	x 101.27	Feet per minute
Liters	x 1,000	Milliliters
Liters	x 1,000	Cubic centimeters
Liters	x 0.0353	Cubic feet
Liters	x 61.02	Cubic inches
Liters	x 0.001	Cubic meters
Liters	x 0.2642	Gallons
Liters	x 2.113	Pints (liquid)
Liters	x 1.057	Quarts (liquid)
Liters	x 0.908	U.S. dry quarts
Meters	x 100	Centimeters
Meters	x 3.281	Feet
Meters	x 39.37	Inches
Meters	x 0.001	Kilometers
Meters	x 1,000	Millimeters
Meters	x 1.094	Yards
Miles	x 5,280	Feet
Miles	x 1.69093	Kilometers
Miles	x 320	Rods
Miles	x 1,760	Yards
Miles per hour	x 88	Feet per minute
Miles per hour	x 1.467	Feet per second
Miles per minute	x 88	Feet per second
Miles per minute	x 60	Miles per hour
Milliliters	x 0.034	Fluid ounces
Ounces (dry)	x 437.5	Grains
Ounces (dry)	x 28.3495	Grams
Ounces (dry)	x 0.0625	Pounds
Ounces (liquid)	x 1.805	Cubic inches
Ounces (liquid)	x 0.0078125	Gallons
Ounces (liquid)	x 29.573	Cubic centimeters
Ounces (liquid)	x 0.0625	Pints (liquid)

Ounces (liquid)	x 0.03125	Quarts (liquid)
Ounces (oz.)	x 16	Drams
P_2O_5	x 0.44	Phosphorus (P)
Parts per million	x 0.0584	Grains per gallon
Parts per million	x 0.001	Grams per liter
Pecks	x 0.25	Bushels
Pecks	x 537.605	Cubic inches
Pecks	x 16	Pints (dry)
Pecks	x 8	Quarts (dry)
Phosphorus (P)	x 2.29	P_2O_5
Pints	x 28.875	Cubic inches
Pints	x 2	Cups
Pints	x 0.125	Gallon
Pints	x 473	Millileters
Pints	x 32	Tablespoons
Pints (dry)	x 0.015625	Bushels
Pints (dry)	x 33.6003	Cubic inches
Pints (dry)	x 0.0625	Pecks
Pints (dry)	x 0.5	Quarts (dry)
Pints (liquid)	x 28.875	Cubic inches
Pints (liquid)	x 0.125	Gallons
Pints (liquid)	x 0.4732	Liters
Pints (liquid)	x 16	Ounces (liquid)
Pints (liquid)	x 0.5	Quarts (liquid)
Potash (K_2O)	x 0.83	Potassium (K)
Potassium (K)	x 1.20	Potash (K_2O)
Pounds	x 7,000	Grains
Pounds	x 453.5924	Grams
Pounds	x 16	Ounces
Pounds	x 0.0005	Tons
Pounds	x 0.45359	Kilograms (kg)
Pounds of water	x 0.01602	Cubic feet
Pounds of water	x 27.68	Cubic inches
Pounds of water	x 0.1198	Gallons
Pounds per acre	x 1.12	Kilograms/ hectare
Quarts	x 946	Milliliters
Quarts (dry)	x 0.03125	Bushels
Quarts (dry)	x 67.20	Cubic inches
Quarts (dry)	x 0.125	Pecks

Quarts (dry)	x 2	Pints (dry)
Quarts (liquid)	x 57.75	Cubic inches
Quarts (liquid)	x 0.25	Gallons
Quarts (liquid)	x 0.9463	Liters
Quarts (liquid)	x 32	Ounces (liquid)
Quarts (liquid)	x 2	Pints (liquid)
Rods	x 16.5	Feet
Square feet	x 0.000023	Acres
Square feet	x 144	Square inches
Square feet	x 0.11111	Square yards
Square inches	x 0.00694	Square feet
Square meters	x 0.0001	Hectares (ha)
Square miles	x 640	Acres
Square miles	x 27,878,400	Square feet
Square miles	x 3,097,600	Square yards
Square yards	x 0.0002066	Acres
Square yards	x 9	Square feet
Square yards	x 1,296	Square inches
Tablespoons	x 15	Milliliters
Tablespoons	x 3	Teaspoons
Tablespoons	x 0.5	Fl. ounces
Teaspoons	x 0.17	Fl. ounces
Teaspoons	x 5	Milliliters
Tons	x 907.1849	Kilograms
Tons	x 32,000	Ounces
Tons (long)	x 2,240	Pounds
Tons (short)	x 2,000	Pounds
U.S. bushels	x 0.3524	Hectoliters
U.S. dry quarts	x 1.101	Liters
U.S. gallons	x 3.785	Liters
Yards	x 3	Feet
Yards	x 36	Inches
Yards	x 0.9144	Meters
Yards	x 0.000568	Miles

Notes

Notes

Notes

Pesticide Safety Rules

Transporting Pesticides

1. Farmers are exempt from required shipping papers when transporting ag chemicals for their own farm within a 50 mile radius of the business location.
2. Interstate farming operations are not exempt for shipping papers.
3. If transporting ag chemicals behind a farm tractor, MN DOT regulations do not apply.
4. Tie down pesticide containers securely. Load security is top priority.
5. Pesticide materials must be properly packaged, labeled, and marked. Markings include material name, EPA registration number, DOT hazard label, placard.
6. Placarding is necessary when carrying 1000 lbs. or more if transporting in a cargo tank (i.e. mini-bulk).
7. Report accident or spill to Minnesota Department of Public Safety, Division of Energy Services. Phone (612) 778–0800 (calls accepted 24 hours a day year round).

Mixing, Loading, and Applying

1. Read label carefully before using chemical products.
2. Wear protective clothing when handling agricultural pesticides. If a chemical comes in contact with skin, wash immediately.
3. Do not eat, drink, or smoke while handling pesticides.
4. Measure chemicals accurately and apply at the rate recommended on label to specified crops and target pests.
5. Have a plentiful supply of soap and water available when mixing and loading chemicals.
6. Apply pesticides so as not to contaminate humans, livestock, fish and endangered species, other wildlife or water sources.
7. Clean equipment immediately and thoroughly after each use to avoid subsequent crop injury from chemical residues.
8. Triple rinse pesticide containers. Properly dispose of containers by recycling or burial at approved landfills.
9. Shower after handling pesticides. Wash protective clothing used in handling pesticides daily. Keep separate from other wash, and line dry.
10. **Keep pesticide records:** chemical, application rate, date of application, wind direction and speed, and temperature.

Printed on recycled paper with agribase ink.

Storing

1. Store all chemicals in original containers with labels intact.
2. Store chemicals alone in locked storage room. **NEVER** use pesticide storage room for anything else.
3. Storage room should have a concrete floor (constructed with fire resistant materials), be well lit, well ventilated, and insulated against temperature extremes.
4. Store chemicals packaged in water-permeable packages off the floor on pallets.
5. Have available supplies for small spills:

detergent	broom
hand cleaner	shovel
absorbent clay	cat litter
sawdust	fire extinguisher

For additional copies of this guide contact:

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Extension Service
3 Coffey Hall
St. Paul, MN 55108-6064

(612) 625-8173

OR: your nearest county office of the Minnesota Extension Service.

1993

JANUARY

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This publication was produced by the Educational Development System, Minnesota Extension Service.