

# **THE MINNESOTA SOYBEAN FIELD BOOK**

**Editor in Chief  
Dr. J. Michael Bennett  
Professor Emeritus, Rhetoric  
University of Minnesota**

**Content Editors  
Dr. Dale R. Hicks  
Professor of Agronomy and Plant Genetics  
University of Minnesota**

**Dr. Seth L. Naeve  
Assistant Professor of Agronomy and Plant Genetics  
University of Minnesota**

**Production Editor  
Nancy Bush Bennett  
Agricultural Education**

Welcome to the first edition of ***The Minnesota Soybean Field Book***. Much of the essential information included in this field guide has been developed from soybean checkoff-funded research projects. Minnesota soybean checkoff funds are governed by the 14 farmer-directors of The Minnesota Soybean Research and Promotion Council. The Soybean Council's sole mission is to improve the profitability of growing soybeans in Minnesota. We're currently number three in the nation for soybean acreage and soybean bushels produced each year. Together we can go all the way to the top.

**Jim Sallstrom — Winthrop  
Tech Transfer Committee Chairman  
Minnesota Soybean Research and Promotion Council**

## **AUTHORS AND CONTRIBUTORS**

**Jerry Wright  
Bill Wilcke  
Edward Usset  
Ward Stienstra  
Michael Schmitt  
Gary Sands  
George Rehm  
Bruce Potter**

**Ken Ostlie  
Kent Olson  
Seth Naeve  
Vance Morey  
Gerald Miller  
Ian MacRae  
John Lamb  
Vern Hofman**

**Dale Hicks  
Dean Herzfeld  
Ken Hellevang  
Jeff Gunsolus  
Bev Durgan  
Kent Crookston  
Don Breneman  
Michael Bennett**

## **FROM THE EDITOR**

Soybeans are an agricultural miracle. They are among the world's oldest cultivated crops, yet they seem to have no perennial diseases, weeds, or insects. Soybeans will grow reasonably well almost anywhere, and they provide us with an amazing, and increasing, array of uses and benefits.

This book is for the soybean growers of our state and region. In a state as large and geographically diverse as is Minnesota, and at our latitude, there are of course a few differences and distinctions between growers' needs and concerns. Most of our soybean acreage is in the southern part of the state, but the central crop and the northern crop, especially in the Red River Valley, are large and growing larger.

This is a small book, and cannot treat in depth all relevant topics and concerns, but the information contained in it is both accurate and cutting-edge. We have tried to anticipate and accommodate most of the immediate needs of all the growers in Minnesota.

The University of Minnesota, and the Minnesota Soybean Growers Association/Minnesota Soybean Research and Promotion Council, exist to serve all the people of our state. We have honored that trust and commitment, as much as space permitted, in this pocket publication.

My personal hope is that the Minnesota Soybean Field Book will prove to be a genuine asset to you in your labors, and in your deliberations.

**J. Michael Bennett**

# CONTENTS

FRONT MATTER .....	1
SOYBEAN HISTORY .....	4
SOYBEAN PLANTING .....	7
SOYBEAN GROWTH AND DEVELOPMENT .....	10
CONTROLLING SOYBEAN PRODUCTION COSTS .....	13
SEEDBED, TILLAGE, AND RESIDUE .....	21
PLANTING RATE .....	23
EVALUATING HAIL-DAMAGED SOYBEANS .....	26
IRRIGATION MANAGEMENT .....	33
FARMLAND DRAINAGE .....	38
FERTILIZING SOYBEANS .....	41
MANURE MANAGEMENT .....	44
SCOUTING .....	49
WEED MANAGEMENT .....	55
INSECT MANAGEMENT .....	67
PICTURE SHEETS	
WEEDS .....	PS 1-9
INSECTS .....	PS 10-13
DISEASES .....	PS 14-17
SOYBEAN INOCULATION .....	78
DISEASE MANAGEMENT .....	81
PESTICIDES .....	88
HARVESTING SOYBEANS .....	111
SOYBEAN DRYING, HANDLING, AND STORAGE .....	117
SOYBEAN MARKETING .....	126
INTERESTING AND USEFUL SOYBEAN WEB SITES .....	130
AREA AND VOLUME CALCULATIONS .....	135
CONVERSION FACTORS .....	136
STORAGE CAPACITIES .....	138
NOTES .....	140



# SOYBEAN HISTORY

## OVERVIEW

Soybean, *Glycine max* (L.) Merr., cultivation has an ancient and fascinating history. Most of it is focused around its center of origin in Eastern Asia. In fact, soybeans are referenced in books written 4500 years ago in China. Although soybean's history in the US is much less lengthy, it is equally interesting and varied. Henry Yonge may have first planted soybean in the US in 1765 on his farm in Thunderbolt, GA. Many references were made to soybean production in experiment station publications and scientific literature between 1804 and 1890. Soybeans were praised for their high productivity, their quality as a forage crop, and their ability to grow in widely diverse climates and on varied soil types.

Soybeans expanded into the Midwest in 1928 when farm groups and an Illinois linseed processor agreed to utilize 50,000 acres of soybean production. U.S. soybeans were first crushed into oil and meal in a cottonseed oil mill in Elizabeth City, NC in 1915. Boll weevil damage to southern cotton may have been an important part of the early rise of soybeans as an oilseed crop. Soybean meal became an accepted ingredient in livestock rations in the mid-1920's. Soybean acreage has been on a general increase since that time.

## MINNESOTA AGRICULTURAL STATISTICS

Minnesota produced a record 257 million bushels of soybeans in 1997 from 6.6 million acres. Thirty thousand Minnesota soybean farmers planted more acres, and harvested more bushels, of this crop than all other states except Iowa and Illinois. Projections indicate that 1998 will be another record breaking year for Minnesota soybean farmers. Minnesota ranked third in production in 1995-1997, contributing 10% of the total U.S. production. Minnesota grown soybeans had average yields of 38 to near 41 bushels per acre in each of these years.

The soybean industry saw much growth in the years between 1989 and 1996. In this period, US soybean oil exports have risen from 610,000 to 910,000 metric tons (49.2 percent increase). In the same period US soybean meal exports have risen 39.6% from 4.8 to 6.3 million metric tons, while the average soybean yield has increased 6.8 %, from 32.2 to 37.6 bushels per acre.

# CONTENTS

FRONT MATTER .....	1
SOYBEAN HISTORY .....	4
SOYBEAN PLANTING .....	7
SOYBEAN GROWTH AND DEVELOPMENT .....	10
CONTROLLING SOYBEAN PRODUCTION COSTS .....	13
SEEDBED, TILLAGE, AND RESIDUE .....	21
PLANTING RATE .....	23
EVALUATING HAIL-DAMAGED SOYBEANS .....	26
IRRIGATION MANAGEMENT .....	33
FARMLAND DRAINAGE .....	38
FERTILIZING SOYBEANS .....	41
MANURE MANAGEMENT .....	44
SCOUTING .....	49
WEED MANAGEMENT .....	55
INSECT MANAGEMENT .....	67
PICTURE SHEETS	
WEEDS .....	PS 1-9
INSECTS .....	PS 10-13
DISEASES .....	PS 14-17
SOYBEAN INOCULATION .....	78
DISEASE MANAGEMENT .....	81
PESTICIDES .....	88
HARVESTING SOYBEANS .....	111
SOYBEAN DRYING, HANDLING, AND STORAGE .....	117
SOYBEAN MARKETING .....	126
INTERESTING AND USEFUL SOYBEAN WEB SITES .....	130
AREA AND VOLUME CALCULATIONS .....	135
CONVERSION FACTORS .....	136
STORAGE CAPACITIES .....	138
NOTES .....	140



In Minnesota, checkoff dollars used in research are funding a wide variety of programs aimed to increase soybean yields, and the quality of the seed produced. Research is being undertaken to develop special-purpose soybean varieties to meet specific market requirements. New products are being developed that not only utilize soybeans in ways not heretofore dreamed of, but that have other very valuable characteristics such as biodegradability. In addition, food scientists and nutritionists are exploring the potential health benefits of soy foods in lowering cholesterol, and as protectors from colon cancer.

The development of products such as Soygold®, a diesel fuel additive, is a direct result of checkoff-funded research and development activities. Soygold® not only adds quality to diesel fuel though increased performance and reduction of engine wear, but it burns cleanly and is completely biodegradable. A market demand of 50 million gallons of soybean oil created by products such as Soygold® would add 7% to the cash price of soybean oil.

Checkoff dollars are also important for consumer and producer education. The Minnesota Soybean Research & Promotion Council provides an invaluable service to the community by educating consumers about the versatility and overall quality of soy-based foods. Partnerships with the American Cancer Society and the American Heart Association aid in the dissemination of valuable information about the soybean's role in cancer and heart disease prevention.

Technology transfer and education programs for producers provide links between researchers and their recently developed technologies, and farmers who can utilize this information to increase production on their own farms. Partnerships between the MSR&PC and the University of Minnesota Extension Service serve to promote the timely and efficient bi-directional transfer of quality information between farmers and agri-businesses in the state of Minnesota, and soybean researchers in Minnesota and across the Midwest.

Questions concerning the soybean checkoff, the Minnesota Soybean Growers Association, or the Minnesota Soybean Research & Promotion Council can be directed to (507) 388-1635, or through their web site at [www.mnsoybean.org](http://www.mnsoybean.org)

Seth Naeve  
Department of Agronomy  
University of Minnesota Extension  
(612)-625-4298  
[snaeve@extension.umn.edu](mailto:snaeve@extension.umn.edu)



# PLANTING

## OVERVIEW

Profitability in soybean production is dependent primarily on the cost of the inputs, the yield of the crop, and the price paid for this commodity. Decisions made by the farmer before, during, and after the growing season can have an impact on all three of these factors. The climatic conditions during the growing season have a large impact on the yield of soybeans produced on any land. It is therefore important for farmers to alter their management strategies to achieve the production of the largest possible yield across the large range of possible climatic conditions for their area. These decisions must be balanced, however, with a consideration of input costs. This section of *the Minnesota Soybean Field Book* deals with management decisions that farmers can make on their farms to produce the largest possible crops, without unnecessary cash inputs.

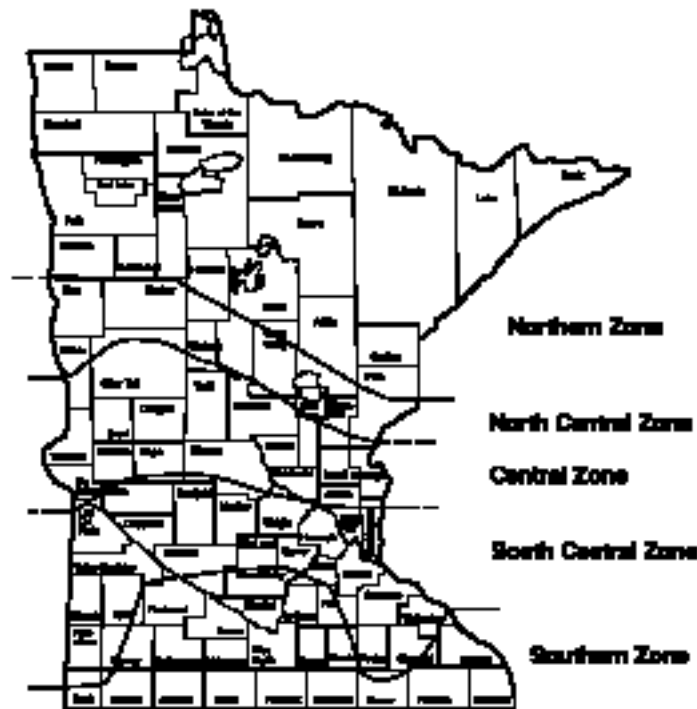
## VARIETY SELECTION

Variety selection is often the first and most crucial management decision made by soybean farmers. Many new, and often improved, varieties are available each year, so that producers can choose from varieties that have higher yield potential, better agronomic characteristics, or improved seed quality characteristics. By re-evaluating varieties yearly, farmers can utilize soybean varieties that best fit yearly changes in agricultural technologies, management practices, and potential pathogen problems. Specific varieties should be chosen for fields, or parts of fields, with a history of special problems such as iron chlorosis, soybean cyst nematode, white mold, or other disease problems. It is important to choose varieties based on their entire suite of agronomic characteristics, and, to not rely entirely on any one of these factors.

Each year the Minnesota Agricultural Experiment Station publishes the results of exhaustive variety trials using seed from public and private sources. These results are published in a special issue of Agri-News, on the Minnesota Soybean Homepage at [www.mnsoybean.org](http://www.mnsoybean.org), as well as county extension offices. The Minnesota Soybean Grower's Association also publishes results of their annual yield contest, and those from county test plots. These, again, are available on their web site and in booklet form. Contact the MSGA with questions.

Optimizing soybean yields through variety selection begins with choosing a variety that has the ideal maturity for a particular location. Soybeans are

very sensitive to day length, so that the date of maturity of a soybean variety is highly dependent on the latitude of production. Each soybean



variety has a relatively narrow range of adaptation, from North to South. Varieties are grouped according to their historical maturity dates across testing locations. Relative maturity group numbers are assigned to each of these (from 0-9). Soybeans with relative maturity ratings of 00 to 1.0 are often grown in the Northern zone, while the Central and Southern zones can raise 0 to 1.5's, and 1 to 2.3's, respectively. Planting a number of soybean varieties that vary slightly in relative maturity will allow the harvest to be spread out in order to reduce harvest losses.

## **BIN-RUN SEED**

Because soybean stand establishment is critical for the production of high-yielding soybeans, it is important to take extra management steps when using saved, or bin-run, seed. Harvest soybeans from fields or parts of fields that are disease- and weed-free. Store seed in a location that will minimize losses to spoilage, and be sure to test the seed for germination and have it professionally cleaned before planting the seed the next spring.

## **PLANTING DATE**

Early planting is a key component in maximizing yields. Early planted soybeans utilize a larger portion of the summer's total sun and heat energy, and planting early gives the grower the opportunity to plant a longer-season variety. Soybeans should be planted as early in May as



possible. Generally, soybean planting should commence as soon after the completion of corn planting as possible.

## **PLANTING RATE**

Soybeans are extremely tolerant to variations in planting rates or plant populations. Optimum plant populations will vary with changes in yearly climate, varietal growth pattern, and latitude. Adjustments should be based on the size of the mature plants because formation of a canopy early in the season is a key factor in producing large yields. To reduce harvest losses, a seeding rate should be chosen that is high enough to keep the plants from podding very low on their stems. Alternatively, planting rates should be low enough to reduce lodging, and keep seed costs low (especially where a large technology fee is included in the cost of seed). A seeding rate of 150,000 seeds per acre is generally sufficient to achieve maximum yields in Minnesota.

## **ROW SPACING**

Yield of soybeans grown in northern latitudes are largely limited by the short growing season. In general, production practices allowing the utilization of the greatest amount of the sun's heat and light energy provides the best opportunity to maximize yields. One such practice is narrow row spacing. In southern Minnesota, reducing row spacing from 30" to 10" may result in a 3-8% increase in yield. This yield benefit will generally be greater in the northern part of the state where the short growing season is an even larger factor in soybean yield capacity. Similarly, late planted or soybeans planted in a no-tillage system, often show larger yield increases in narrow rows due to an earlier canopy establishment.

Better weed control is an additional benefit to narrow-row spacing. Several research groups in many states have found the early canopy closure of narrow-row soybeans to act in shading weed seedlings. In fact, under this system, there is potential to reduce herbicide rates, and even omit one cultivation.

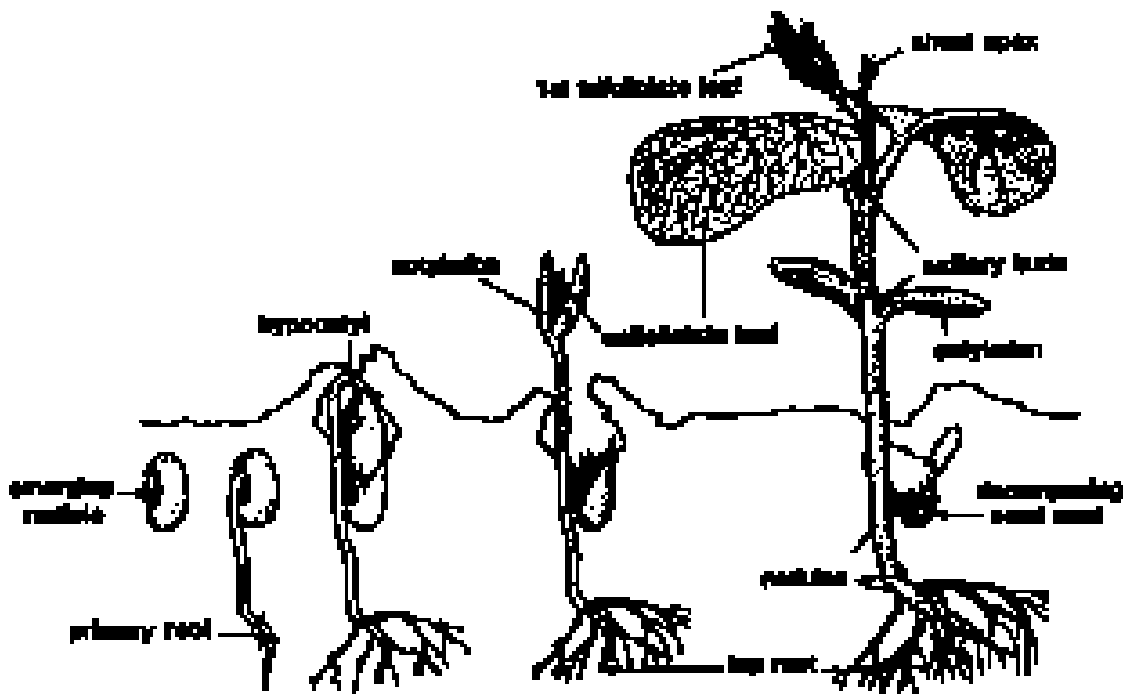
Seth Naeve  
Department of Agronomy  
University of Minnesota Extension  
(612)-625-4298  
[snaeve@extension.umn.edu](mailto:snaeve@extension.umn.edu)



# SOYBEAN GROWTH AND DEVELOPMENT

## OVERVIEW

The soybean is a dicotyledonous plant that exhibits epigeal (above the surface) emergence. During germination, the cotyledons are pushed through the soil to the surface by an elongating hypocotyl. Because of the energy required to push the large cotyledons through heavy soils, soybeans generally emerge best if they are planted no deeper than 2 inches. After emergence, the green cotyledons open and supply the developing leaves with stored energy, while capturing a small amount of light energy.



The first leaves to develop are the unifoliate leaves. Two of these “single” leaves appear directly opposite one another above the cotyledons. All subsequent leaves are trifoliolates comprised of 3 leaflets.

## GROWTH STAGES

Soybean development is characterized by two distinct growth phases. The first is the vegetative stages (V) that cover development from emergence through flowering (Table 1). The second is the reproductive (R) stages from flowering through maturation (Table 2). Plant stages are determined

by classifying leaf, flower, pod, and or seed development. Staging also requires node identification. A node is the part of the stem where a leaf is (or has been) attached. A leaf is considered fully developed when the leaf at the node directly above it (the next younger leaf) has expanded enough so that the two lateral edges on each of the leaflets have partially unrolled and are no longer touching.

Table 1. Vegetative stages

<b>Stage</b>	<b>Description</b>
VE	Emergence – Cotyledons above the soil surface
VC	Cotyledon – Unifoliolate leaves unrolled sufficiently so that the leaf edges are not touching
V1	First-node – Fully developed leaves at unifoliolate node
V(n)	nth-node – Here, the "n" represents the number of nodes on the main stem with fully developed leaves beginning with the unifoliolate leaves.

*From Fehr and Caviness*

Table 2. Reproductive stages

<b>Stage</b>	<b>Description</b>
R1	Beginning bloom – One open flower at any node on the main stem
R2	Full bloom – Open flower at one of the two uppermost nodes on the main stem with a fully developed flower
R3	Beginning pod – Pod 3/16" long at one of the four uppermost nodes on the main stem with a fully developed leaf
R4	Full pod – Pod 3/4" long at one of the four uppermost nodes on the main stem with a fully developed leaf
R5	Beginning seed – Seed 1/8" long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf
R6	Full seed – Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf
R7	Beginning maturity – One normal pod on the main stem that has reached its mature pod color
R8	Full maturity – Ninety-five percent of the pods have reached their mature pod color. Five to ten days of drying weather are required after R8 for the soybean moisture levels to be reduced to less than 15 percent

*From Fehr and Caviness*

Table 3. Number of days between stages

<b>Stages</b>	<b>Average # of days</b>	<b>Range in # of days</b>
Planting to VE	10	5-15
VE to VC	5	3-10
VC to V1	5	3-10
V1 to V2	5	3-10
V2 to V3	5	3-10
V3 to V4	5	3-8
V4 to V5	5	3-8
beyond V5	3	2-5
R1 to R2	3	0-7
R2 to R3	10	5-15
R3 to R4	9	5-15
R4 to R5	9	4-26
R5 to R6	15	11-20
R6 to R7	18	9-30
R7 to R8	9	7-18

*From Fehr and Caviness*

Changes in environment, such as temperature and rainfall, can greatly alter the height of soybeans without a large effect on early reproductive growth stages such as flowering. Post-emergence herbicides are often labeled for application times that are dependent on soybean growth stages. To avoid injury, it is therefore very important to identify soybean development by growth stage rather than by their height, or the date they fill the rows.

Seth Naeve  
 Department of Agronomy  
 University of Minnesota Extension  
 (612)-625-4298  
[snaeve@extension.umn.edu](mailto:snaeve@extension.umn.edu)



# CONTROLLING SOYBEAN PRODUCTION COSTS

## OVERVIEW

Controlling costs has always been a critical component of managing a farm business, but it's even more necessary in today's economy. In this section of the *Minnesota Soybean Field Book*, we will look at how costs have changed over the past few years, how farmers can carefully evaluate production decisions, and ways and methods to estimate soybean costs on your farm.

The current low commodity prices certainly draw attention to the need to look for production alternatives. However, farmers, their families, and their business colleagues continually need to be aggressive in their search for, and implementation of, alternatives; you can't afford to be passive. To be sure of having a good grasp of the production process, current costs, and the potential for alternatives, you should talk with, and possibly physically meet with, a management team for the farm—yourself, your spouse, family, partners, lenders, advisors, and other people critical to the success of your business.

## TRENDS IN COSTS

The need to monitor and control costs can be seen easily in how costs have changed over time. From 1994 to 1997, the average total soybean production costs (on cash rented land) for the members of the Southwestern Minnesota Farm Business Management Association increased from \$197 to \$237 per acre — a \$40 or 20% increase (Table 1). Let's look at these costs in three ways: by sheer magnitude of cost, by monetary change over time, and by percentage change over time.

Land rent was the largest single cost for these farms. Rent was an average of 39% of the total costs of production over these four years. It increased \$11 per acre or 13% from 1994 to 1997. Chemicals (i.e., pesticides and herbicides) were the second biggest cost item. The cost of chemicals was 13% of the total cost over the four years and increased 10% over that same period.

Machinery costs were the third largest cost item for these farms. Estimated total machinery operating costs (fuel and oil, repairs, and custom hire) made up 12% of total costs over the four years. Fuel and oil and repair costs have increased by 18% and 19% respectively. (The decrease in custom-hire costs may be a one-time event in the data since

the number is small and may be from fewer farms.) Machinery and building depreciation made up 11% of the total soybean production cost. This increase in depreciation was the second largest increase in both actual dollars and in percentage.

The other cost items (seed, insurance, interest, etc.) made up 25% of the total costs. While these items seem small individually, they do account for a significant portion of the total cost, and represent almost 40% of the monetary change in total costs over the four years. So, they do need to be carefully considered.

## **CONTROLLING COSTS**

One of the first steps in controlling costs is to describe the process. Write down all the steps and all the inputs that are currently used to produce soybeans. (These steps can be used on any other part of the farming business.) Just describing and writing down the steps may identify ways to improve efficiency. Going over this list of production practices with your management team can help both in being sure all steps and inputs have been identified, and in determining whether a rational process has been followed in deciding whether an expenditure is critical, or can be cut or reduced. While this may seem like a time-consuming, simplistic task, the economy has changed and farmers need to be sure they are ready for the future. Whole systems may need to be changed; it may not be enough to adjust the old system.

One management technique to control costs is to focus on the largest items first. For the average farmer in the Southwest Association, this would be first land rent, and then chemical costs (Table 1). With this management technique, the need for the input is evaluated, cost-cutting alternatives are evaluated, and decisions are made as to decreasing the use or price of the input. For land, the rental contract could be renegotiated, or other land with lower rents could be sought out. If land rents are just too high, the decision becomes very tough as to whether or not to rent additional land. This question also involves ways to replace the income that said land generated. For inputs such as chemicals, which are used up in production, the questions that need to be answered may include considerations such as, "Is there a lower priced source of the input, can the amount of input used be lowered, and is the input needed?"

Another related management technique for controlling costs is "zero-based budgeting." Every expense should be evaluated for its benefit compared to its cost. Don't accept old choices blindly. Some expenses are obviously worthwhile, such as seed, fuel, and labor. However, what is the best seeding rate when crop prices are low? Is tillage needed, or is it

“recreational?” Is it worthwhile to pay technology fees when other pest control methods are available? What is the evidence or data to support the evaluation of costs and benefits of each step? Your decision may be to continue growing as you currently are, or it may be to change some things. Since land rent is the largest single expense, time spent evaluating rental terms and prices may be very worthwhile. A good starting point for rent negotiation is estimating the revenues and costs for both the tenant and the landowner. By splitting the total revenue and costs, both the tenant’s maximum bid and the landowner’s minimum bid can be estimated. This is done, for example, by using information from the Southwestern Minnesota Farm Business Management Association (Table 2).

Note that the categories in Table 2 are slightly different from the usual enterprise budget. Since rent is the cost to be determined, it is left out of the costs. Two items used in rent negotiation, but not usually listed in an enterprise budget, are the returns for the farmer’s labor and management (\$25 per acre in this example), and the value of the landowner’s money tied up in the estimated value of the land (\$88 per acre, which is a 5% return on land worth \$1750 per acre). Based on these estimated yields, prices, and costs, the tenant’s maximum cash rent is the difference between revenue and costs, or \$62 per acre in this example. In order to pay the estimated costs and receive the desired returns to land investment, the landowner’s minimum cash rent is the total of these costs, or \$121 per acre in this example. In most years, the landowner’s minimum and the tenant’s maximum would define a negotiating range between these figures.

In this example, there is not enough income to satisfy both parties, so negotiations involve one or both parties accepting a lower than desired return. For example, the landowner may have to accept less than \$88 per acre for the money invested in land, or the tenant may have to expect less than \$25 per acre for labor and management. If this is not acceptable, other costs must be decreased, or revenues somehow increased, for the two parties to reach agreement.



Table 1. Average Soybean Production Costs on Cash Rented Land for All Farms in the Southwestern Minnesota Farm Business Management Association, 1994-1997

Year	avg. %				% change	
	1994	1995	1996	1997	of listed '94 to '97	
Number of fields	281	297	325	351		
Number of farms	153	159	159	164		
Acres	99	112	109	108		
Yield (bushels per acre)	46	43	41	42		

**DIRECT EXPENSES PER ACRE**  
(\$/acre)

Seed	13.61	13.76	14.46	15.72	6.6%	15.5%
Crop						
Chemicals	27.45	28.30	29.58	30.21	13.3%	10.1%
Crop						
Insurance	7.36	7.45	8.88	10.00	3.9%	35.9%
Fuel & oil	6.75	7.05	7.58	7.99	3.4%	18.4%
Repairs	14.08	15.65	15.43	16.75	7.1%	19.0%
Custom						
Hire	3.07	3.50	4.47	2.71	1.6%	-11.7%
Land rent	78.84	84.19	86.26	89.40	39.1%	13.4%
Operating						
interest	6.94	8.63	7.46	7.62	3.5%	9.8%
Miscellaneous	3.49	4.17	3.30	6.86	2.1%	96.6%
Total direct expenses	161.59	172.70	177.42	187.26	80.7%	15.9%



UNIVERSITY OF MINNESOTA  
**EXTENSION**



## OVERHEAD EXPENSES PER ACRE

Hired labor	3.71	5.09	5.06	5.28	2.2%	42.3%
Interest	2.83	3.91	4.92	5.03	1.9%	77.7%
Mach. & bldg. depreciation	20.75	22.04	23.64	27.90	10.9%	34.5%
Miscellaneous	8.01	9.09	9.12	11.32	4.3%	41.3%
Total overhead expenses	35.30	40.13	42.74	49.53	19.3%	40.3%
 Total listed expenses	 196.89	 212.83	 220.16	 236.79	 100.0%	 20.3%

Table 2. Comparison of tenant's and landowner's costs based on information from the Southwestern Minnesota Farm Business Management Association

<b>Tenant's Share: Long Range Plan Owner's</b>			
	Corn	Soybeans	Share
<b>REVENUE</b>			
Yield	120	40	
Price	2.25	6.00	
Transition payment	39	1	
Other income	1	2	
<b>Total</b>	<b>310</b>	<b>243</b>	<b>0</b>

<b>DIRECT EXPENSES</b>			
<b>(except rent)</b>			
Seed	33	16	
Fertilizer	48	5	
Chemicals	29	30	
Crop Insurance	6	10	
Drying fuel	5	-	
Fuel & oil	10	8	
Repairs	21	17	
Misc.	7	4	
Operating interest	10	8	
<b>Total</b>	<b>169</b>	<b>98</b>	<b>0</b>

## OVERHEAD EXPENSES

Hired labor	7	5	-
R. E. Taxes	-	-	15
Farm insurance	3	3	3
Utilities	3	2	1
Interest (opp.)	7	5	88
Depreciation	35	28	5
Miscellaneous	8	7	4
Total overhead	63	50	116
Labor & Management	25	25	5
Total Listed Expenses	257	173	121
Net Return (w/o rent)	53	70	-121
Average Net Return	62		-121

### DEVELOPING AN ENTERPRISE BUDGET FOR SOYBEANS FROM YOUR FARM'S RECORDS

If you don't keep detailed records by enterprise, whole-farm costs and returns can be allocated to individual enterprises, such as soybeans, by using the following steps. By using this method, you can estimate what your soybean costs are, and compare them to the costs in Table 1.

1. Determine the costs of separate items for the whole farm. If your whole-farm records are in good order, they should show expense figures by individual items (e.g., seed, fertilizer, feed for dairy calves, etc.). If these records are not up to date, or individual items are not specified, these data must be gathered and organized before costs can be allocated to specific enterprises.
2. Identify the enterprises on the farm. Most farms grow more than one crop and/or raise more than one category of livestock. These enterprises also need to be described more specifically if detailed questions need to be answered. For example, soybean fields could be split into different land types or different tenure arrangements. The dairy herd could be divided into the milking herd and calves, and replacement heifers. The farrow-to-finish hog enterprise could be split into feeder pig production and hog finishing. These divisions are done to have a better idea of how each part of the business is doing. The divisions can be made even though all the activity takes place on the same farm.

3. Classify the costs as direct or indirect. Direct costs are those costs that can be attributed to a specific enterprise. Examples of direct costs are chemicals applied to soybeans, or custom-hire expenses for soybeans. Indirect costs are those costs that cannot be associated with a specific enterprise. These would include, for example, costs for hired labor, or a truck used for several crops (or general farm duties).
4. Allocate the direct costs and returns. Direct costs and returns are easily allocated to enterprises because they are used or produced by that enterprise directly. Soybean harvesting costs are allocated to soybeans. Weed control for soybeans is allocated to soybeans. Veterinary expenses for dairy cows are allocated to dairy.
5. Determine the best way to allocate indirect costs. Indirect costs can be allocated to enterprises by determining how they are related to those enterprises. There are three or four main ways to allocate indirect costs:
  - a. **On the basis of use** Machinery-use hours can be used to allocate fuel, repairs, and other machine costs to soybeans. Total crop acreage can be used as the basis for allocating costs, such as insurance or erosion control, to the various enterprises which benefit from them. For example, general farm liability insurance for bare land can be allocated to soybeans based on the average cost of that insurance spread over all crop acres.
  - b. **On the share of gross income** Office expenses (e.g., telephone, accountant, computer) may be correlated to the farm's total expected income. Thus, an enterprise's contribution to total gross income for the farm may be the best basis for allocating those costs. For example, office expenses can be allocated to soybeans, or to another enterprise, based on each enterprise's share of total expected gross income.
  - c. **On the share of variable costs** Some costs may be allocated based on that enterprises share of total variable costs for the whole farm. For example, an employee may spend more time on those enterprises that have the largest costs. Thus, the employee's salary should be allocated based on each enterprise's share in total variable costs, rather than on gross income. Such a share in costs more accurately reflects each enterprise's share of the employee's salary.

- d. ***With a combination*** Choosing among the three main methods is an arbitrary decision. The goal is to obtain accurate enterprise budgets for analysis and planning. Sometimes, a combination of the three methods will provide the most accurate allocation between enterprises.
6. Calculate the percentage of total use, gross income, and variable costs for each enterprise.
    - After the best allocation method has been chosen, the shares or percentages to be used for allocating those costs must be calculated.
    - Shares of gross income are calculated by:
      - (1) determining the actual or expected acreage, production, and price for each enterprise;
      - (2) calculating the gross income for each enterprise; and
      - (3) calculating each enterprise's share in the gross income for the whole farm.
    - Shares of variable costs are calculated by:
      - (1) determining the actual (or expected) variable costs for each enterprise;
      - (2) calculating the total variable costs for the whole farm; and
      - (3) calculating each enterprise's share in the total variable costs.
  7. Allocate the indirect costs. At this point, whole-farm indirect costs are allocated to soybeans, for example, on the basis of soybeans' shares of use, gross income, or variable costs.
  8. Calculate costs per acre. The cost per acre for soybeans is calculated by dividing soybeans' share of the total costs by the number of soybean acres grown in that year. These steps can also be used for other enterprises (e.g., corn or dairy) by simply adjusting the calculations of shares and using the corn acreage or herd size.

Controlling your production costs by thoughtful analysis of carefully-kept records is rewarding in two ways:

- 1) The process will help you make more money
- 2) You will be in control of your farm and its many enterprises

Kent Olson  
Department of Applied Economics  
University of Minnesota Extension  
612-625-7723  
[kolson@dept.agecon.umn.edu](mailto:kolson@dept.agecon.umn.edu)



# SEEDBED, TILLAGE, AND RESIDUE

## OVERVIEW

Most soybeans in Minnesota are grown in rotation following corn. Seedbed preparation usually consists of chopping the corn stalks, followed by fall chisel or moldboard plowing, and spring cultivation prior to planting. These tillage operations firm the soil for good seed-to-soil contact and ensure a consistent seed planting depth of about 2 inches.

## SOIL PREPARATION

The goal of soil preparation for soybean production is to produce a firm seedbed that will give optimum germination and stand establishment. Germination is controlled by soil moisture, temperature, and good seed-to-soil contact. Soybeans are grown under several different tillage systems in Minnesota, and each must provide for these conditions.

## TILLAGE

Firming the soil enough for good seed-to-soil contact is essential. This is commonly done as a secondary-tillage operation with a field cultivator. Besides improving the seed-to-soil contact, this firm seedbed ensures a more consistent seed depth (about 2 inches) by the planter.

Some soybeans are planted with reduced or no tillage. The reasons for this management system are prevention of soil erosion, lower fuel and equipment costs, and advantageous time management. For ridge tillage, and no-tillage situations, a major concern on heavier textured soils is getting the planter into the ground for the optimum planting depth. The best solution is a heavy planter equipped with springs that can exert significant down-pressure on each row. Down-pressure will need to be adjusted depending on residue levels, soil type, and soil moisture conditions.

## RESIDUE

Residue management is especially important in the case of land that is considered highly erodible. Residue amounts can be managed by tillage operations with different types of equipment. Values of residue reduction by tillage can be found in Midwest Planning Service's bulletin MWPS-45 entitled *Conservation Tillage Systems and Management*, or at a Natural Resources Conservation Service office.

In no-tillage situations corn stalks should not be shredded. That allows for better planting conditions. Anchored residue will not “hairpin” as easily as shredded residue, and can flow better through the planter.

For all conservation tillage systems a sharp coulter should be used on the front of the planter. The coulter will cut the residue so the planter can get through without plugging. It will also prevent hairpinning of residue in the seed row. Hairpinning can affect the seed-to-soil contact, and the soil moisture conditions around the seed, so it is an important obstacle to be overcome.

John Lamb  
Department of Soil, Water, and Climate  
University of Minnesota  
(651) 625-1772  
[jlamb@soils.umn.edu](mailto:jlamb@soils.umn.edu)



# PLANTING RATE

## OVERVIEW

No early aspect of soybean production is more important than correct planting. Planting rate should be based on a seed count to ensure planting enough seeds.

## SEED COUNT

You will need to know the following to calculate the rate:

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

The following is an example for calculating plant-ing rate:

1. Desired population at harvest is 150,000 plants per acre
2. Normal stand loss is 5%
3. Seed germination is 95%
4. Soybeans have a seed count of 2150 seeds per pound, or  
129,000 seeds per bushel

Then:  $129,000 \text{ seeds per bushel} \div 60 \text{ lbs/bu} \times .95 = 2,042 \text{ viable seeds per pound}$ .

Desired plant population at harvest is  $150,000 \text{ plants} \times 1.05 \text{ (.05\% stand loss)} = 157,500 \text{ viable seeds needed per acre}$ .

$157,500 \text{ seeds} \div 2,042 \text{ viable seeds per pound} = 77 \text{ pounds/acre}$  of soybeans need to be planted.

## PLANTING GUIDE

To determine the number of seeds per acre, add seed to your planter or drill and operate it on a firm soil surface so seed is visible on the surface. Operate it for a short distance close to your normal operating speed. Then, go back and count the number of seeds dropped in one linear foot of planter row. Make several counts and determine an average. Refer to one

of the following charts to see that you are planting the number of seeds that you calculated in the earlier section.

**Soybeans seeds per linear foot of row  
(Seed count of 2,500 seeds per pound)**

<i>Approx lbs. Live seed per acre</i>	<i>Desired seeds per acre</i>	<i>Seeds per foot of row with spacing (in.) of: inches</i>			
		6	12	22	30
40	100,000	1.2	2.3	4.2	5.7
50	125,000	1.4	2.7	5.3	7.2
60	150,000	1.7	3.4	6.3	8.6
70	175,000	2.0	4.0	7.4	10.0
80	200,000	2.3	4.6	8.4	11.5

**Soybeans seeds per linear foot of row  
(Seed count of 2,000 seeds per pound)**

<i>Approx lbs. Live seed per acre</i>	<i>Desired seeds per acre</i>	<i>Seeds per foot of row with spacing (in.) of: inches</i>			
		6	12	22	30
40	80,000	0.9	1.8	3.4	4.6
50	100,000	1.2	2.3	4.2	5.7
60	120,000	1.4	2.8	5.0	6.9
70	140,000	1.6	3.2	5.9	8.0
80	160,000	1.8	3.7	6.7	9.2
100	200,000	2.3	4.6	8.4	11.5

**AIR SEEDER CALIBRATION**

Calibrating an air seeder requires collecting seed from seed openers. Probably the easiest method is to place a tarp under the openers, collect seed over an area or distance (1/10 acre) and weigh the pounds of seed collected.

First, you need to determine the pounds of seed to plant as calculated in the planting rate section of this chapter.

Then, (1) determine the circumference (feet) of seed meter drive wheel on your seeder using the following formula:

$$C = \frac{\text{diameter in inches} \times 3.14}{12 \text{ inches per foot}} = \text{circumference in feet}$$



(2) Determine the drive wheel revolutions required to equal 1/10 acre. Use the following chart to calculate this number which is based on the width of your air seeder.

### Travel distance to equal 1/10 acre

Drill width (ft)	Distance (ft)
16	272
20	218
24	181
28	156
32	136
36	121
40	109
44	99
48	91

(3) Next, calculate the metering wheel revolutions to cover this distance:

$$\text{Metering wheel rev} = \frac{\text{distance to cover 1/10 acre}}{\text{Circumference of drive wheel (ft)}}$$

(4) Place the seed in the air seeder bin and start the air delivery system. Manually turn the metering wheel the number of revolutions that were calculated to cover 1/10 acre.

(5) Weigh the seed collected on the tarp and multiply times 10. This number should equal the pounds of seed you determined earlier or the amount you want to plant.

Drill calibration is becoming extremely important to ensure you are planting the correct amount of seed. If the amount of seed determined with either method is not equal to the amount of seed you desire, make an adjustment to the feed rate, and recheck your seeder.

This method also works for determining the pounds of fertilizer to be applied.

Vern Hofman  
Department of Agricultural and Biosystems Engineering  
North Dakota State University Extension  
(701) 231-7240  
[vhofman@ndsuent.nodak.edu](mailto:vhofman@ndsuent.nodak.edu)



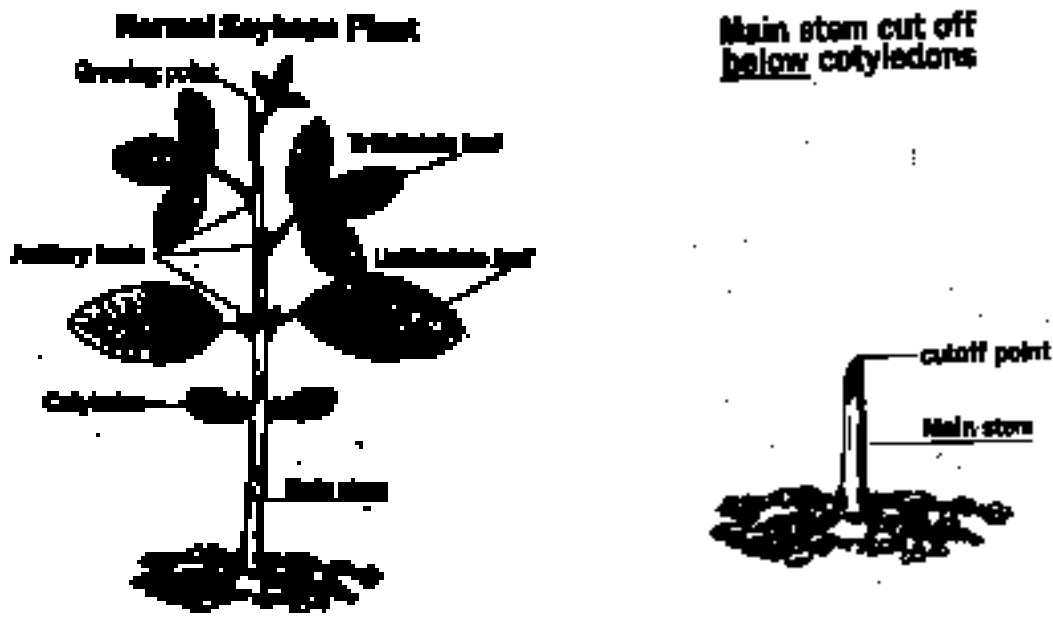
# EVALUATING HAIL-DAMAGED SOYBEANS

## OVERVIEW

Hail frequently damages field crops in Minnesota. When hail damages soybeans early in the season, replanting is possible, but the facts needed to make a decision can be difficult to obtain. Stage of plant growth, calendar date, severity of plant damage, plant population, weed control, seed availability, and labor and equipment costs must be considered in making the decision. This process is called "economic threshold."

This chapter of *The Minnesota Soybean Field Book* can help you evaluate the extent and severity of hail damage to soybean plants. It can also help you compare expected yield losses due to reduced stands as a result of late planting. Varieties recommended for late planting are listed on the last page.

Figure 1 is a sketch of a normal soybean plant, identifying various plant parts and a description of their functions. Others sketches show soybean plants with different kinds and degrees of hail injury, and regrowth. The relationship between soybean yield and population, leaf damage, and plant-ing date is also covered in this chapter.



At the end there is a comparison worksheet to help you calculate the expected differences in yield between a replanted field and a damaged field.

## Plant Part Functions

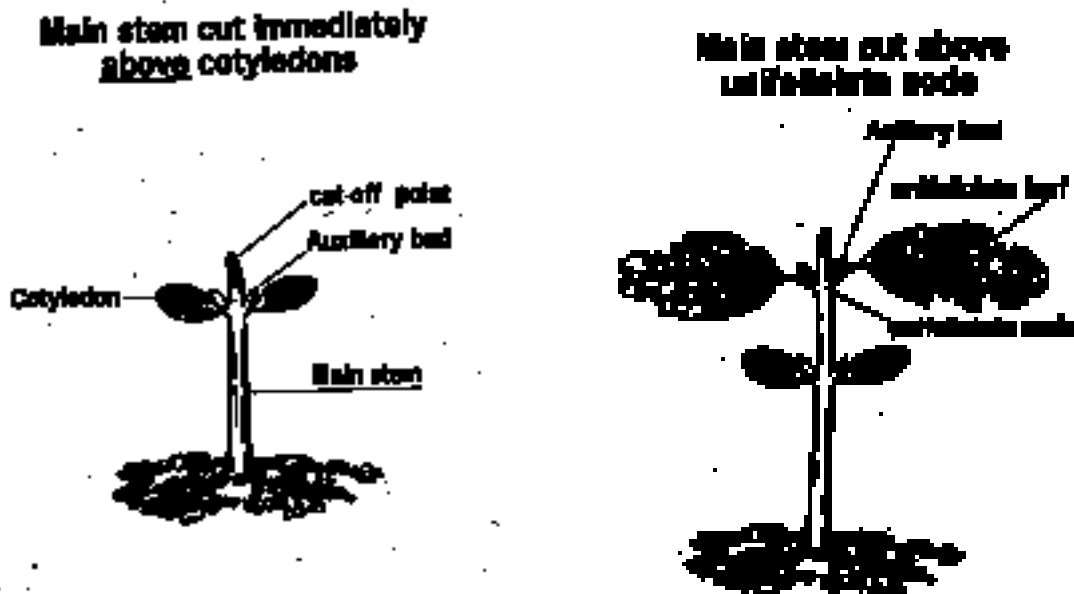
### Cotyledons

Food stored in the cotyledons provides energy for the young plant until it has developed enough leaves to manufacture its own food.

### Leaves

One function of leaf tissue is to intercept light (solar energy) and convert it into food (chemical energy). This food is used by the young plant to develop roots, stems, and more leaves. Rate of growth depends partially on the amount of leaf area on the plant.

### Growing Plant



The growing point at the top of the plant is a group of rapidly dividing cells where new leaves are forming.

### Axillary Buds

These buds are also growing points, but are semi-dormant as long as the point at the plant top is alive. Branches grow from these axillary buds when soybean stands are sparse. Flowers and pods may form from these buds.

## Hail-Damaged Plants

Plants cut off below the cotyledons will not recover. In any plant stand evaluation, count these plants (Figure 2) as dead. While some hail damaged plants (Figure 3) eventually die, most regrow from either one or both of the axillary buds located at the point where the cotyledons are attached to the main stem. The rate of regrowth is influenced by the amount of cotyledonary tissue remaining.

## Main Stem cut above unifoliate node

Plants cut off above the unifoliate node (Figure 4) can regrow from any of the four axillary buds, but are most likely to regrow from one or both of the upper buds.



Green leaf tissue is what's important in generating regrowth. Even though the unifoliate leaves may be shredded and torn, the remaining green tissue is still able to generate regrowth. This regrowth should be visible within three to four days if growing conditions are favorable.

## TYPICAL REGROWTH PATTERN

One or more axillary buds may develop after a main stem has been cut. Usually one becomes dominant (Figure 5) because it develops to a greater degree than other "branches." Later, it can easily be mistaken for the original main stem unless the lower plant section is carefully inspected to locate the cutoff point.

In addition to shredding and cutting stems, hail may bruise plant stems (Figure 6). Bruises usually occur on the lower portion of the stem. The intensity of bruising ranges from a mild bruise, which is a simple break in

the outer stem tissue, to a severe bruise, which exposes the central stem tissue.

Plants with bruised stems that recover after a hail storm may break any time before harvest. Such broken-over (lodged) plants usually produce pods and seed. Since they are lying on the ground, however, harvesting them may not be possible.

It is impossible, shortly after damage, to accurately determine which plants will break over at a later time. Yield is not affected on bruised plants that do not break over.

## **PLANT POPULATION**

When stands are reduced by hail early in the growing season, plants compensate for skips within the row by producing additional branches. If all these branches are harvested, the seed yield of soybeans is reduced only slightly, even if more than half the plants are missing. As plant density within the row decreases (fewer plants/foot), distribution of the remaining plants within the row becomes important in producing yields comparable to those from fields with higher densities.

Table 1 shows the effects of plant population on soybean yield. This relationship is valid for all soybean row spacings. For example, when stands are reduced to 50 percent of optimum population, yields are reduced only 10 percent (assuming weeds do not compete with remaining plants). Replanting just to re-establish a full stand is not usually economically justified when weeds are not a problem.

**Table 1. Effect of population reduction on yield**

<b>Plants per acre</b>	<b>Percent of optimum</b>	<b>Percent yield produced</b>
157,000	100%	100%
118,000	75%	98%
78,000	50%	90%
39,000	25%	75%

The first step is to determine the population of live plants remaining in your field. Do this by comparing the previous pictures with plants in several areas of the damaged field. Count the actual number of living plants per foot of row in these several areas. Multiply your average number of plants per foot of row by the linear feet of row per acre for your row spacing (Table 2) to obtain total plant population. Convert this number to a

percentage by dividing it by 157,000. Finally, determine the expected yield reduction from the reduced stands using Table 1.

**Table 2. Linear feet of row per acre at various row spacings**

Row spacings	Linear feet/acre
40 inches	13,068
30	17,424
20	26,136
15	34,848
6	87,120

### LEAF LOSS

Determine the amount of leaf tissue removed from plants in the same areas of the field used for the stand counts. It is the actual amount of leaf tissue removed or destroyed that reduces final grain yield. You must also determine the number of trifoliolate (3-lobed) leaves present immediately before hail damage in order to translate leaf damage into yield loss.

**Table 3. Effect of leaf stage and damage on yield**

	Percent leaf tissue damage			
Trifoliolate leaf stage before hail	25%	50%	75%	100%
2-4 leaves	1% yield loss	6% yield loss	7% yield loss	21% yield loss
6-8 leaves	2%	7%	9%	24%

### LATE-PLANTING YIELD LOSS

Since early May plantings usually result in maximum yields, a yield penalty should be assigned to replantings after that period. Table 4 lists penalties for various planting dates. Another consideration is the delayed maturity of replanted fields.



UNIVERSITY OF MINNESOTA  
**EXTENSION**

**Table 4. Soybean yield losses due to planting after May 5 (Waseca and Lamberton)**

<b>Planting Date</b>	<b>Yield loss</b>
May 1	0%
May 5	1%
May 10	2
May 15	3
May 20	6
May 25	9
May 30	13
June 4	18
June 9	24
June14	30
June 19	36
June24	43

### **Other Considerations**

Other considerations in making the replant decision include:

n Weed situation

n Replant costs — seed, labor, fuel (currently 15 percent of total replanting loss)

n Seed availability

### **Comparison Worksheet**

You have calculated the yield reduction likely from reduced stand and damaged leaves. Total them below to determine expected loss if field is not replanted.

You have also estimated yield loss from late planting. Add that to the predetermined “other costs” to calculate replanting loss. Then, compare the two losses and consider your weed situation and seed availability in reaching a decision.



## n Field Not Replanted

Expected loss due to:

Reduced stand \_\_\_\_\_ %

Damaged leaves \_\_\_\_\_ %

Total loss \_\_\_\_\_ %

## n Field Replanted

Expected loss due to:

Late planting \_\_\_\_\_ %

Other costs \_\_\_\_\_ 15%

Total loss \_\_\_\_\_ %

If your decision is to replant, select an appropriate variety from Table 5 based on your planting date and location. Public varieties and their maturities are listed in Table 5. If using private varieties, choose varieties with these recommended maturities.

**Table 5. Recommended varieties for delayed planting**

Planting date	ZONE		
	Southern	South Central	Central
June 20	Parker (1.5)	Evans (0.6)	Evans (0.6)
July 1	Evans (0.6)	Agassiz (0.0)	McCall (00.7)
July 10	Agassiz (0.0)	McCall (00.7)	McCall (00.7)

*Using this worksheet can help you evaluate the economics of the replant decision, and help minimize the trauma that hail damage can inflict on you and your soybean fields.*

Dale Hicks  
Department of Agronomy  
University of Minnesota Extension  
(612) 625-1796  
[dhicks@extension.umn.edu](mailto:dhicks@extension.umn.edu)



# IRRIGATION MANAGEMENT FOR SOYBEANS

## OVERVIEW

Soybeans will use at least 14 to 18 inches of soil-water per season depending on maturity group and climatic conditions. Daily crop water use or evapotranspiration (ET) generally peaks between first flower and upper pod development (R1-R6) and can range from 0.10 to over 0.25 inches depending on air temperature, humidity and cloud cover. Table 1 shows estimated daily ET rates for different stages of growth and maximum daily air temperatures in central Minnesota. Daily ET rates may be slightly higher for narrow rows, or solid seeded soybeans, during early vegetative growth than the typical 30 inch spacing.

**Table 1. Estimated daily crop ET for soybeans in central Minnesota— inches/day**

**Table 1. Estimated daily crop ET for soybeans in central Minnesota - inches/day**

Daily Max. Temp. °F	Week after emergence																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
50-59	.02	.02	.04	.04	.06	.07	.08	.09	.09	.09	.08	.07	.05	.05	.03	.02	
60-69	.02	.03	.05	.07	.09	.10	.11	.13	.13	.13	.11	.10	.08	.07	.04	.02	
70-79	.03	.05	.07	.09	.12	.13	.15	.17	.18	.17	.15	.13	.10	.09	.05	.03	
80-89	.04	.06	.10	.13	.16	.19	.20	.21	.22	.21	.18	.16	.13	.11	.06	.03	
90-99	.05	.07	.11	.14	.17	.20	.22	.23	.26	.25	.22	.19	.16	.13	.08	.05	

← vegetative → reproductive →

↑ 3<sup>rd</sup> trifoliate      ↑ 1<sup>st</sup> flower R1      ↑ 2<sup>nd</sup> flower R2      ↑ upper pod filling R6      ↑ 1<sup>st</sup> Yellow pod R7

← growth stages →

Supplemental sprinkler irrigation in central Minnesota is most feasible for many crops when grown on soils that have 4 inches of available water holding capacity (AWHC) or less in the active root zone. To be effective during the drier years, a center pivot sprinkler system should have a pumping capacity of at least 6 gallons per minute per acre under irrigation. This pumping capacity should be increased if on droughty soils or if the irrigation system cannot operate at least 22 hours per day. For fields with AWHC greater than 4 inches in the root zone the pumping capacity may be reduced slightly.

The total available water holding capacity for a given location depends on the soil texture, organic matter, and rooting depth. Soybeans typically can have roots to a depth of 30 to 60 inches if the soil profile has no shallower restrictive layers. A majority of the roots, however, are usually within the top 18 - 24 inches, or less. AWHC estimations can be obtained from the local Soil and Water Conservation District office or county soil survey.

Table 2 shows AWHC estimations for some typical soil textures in Minnesota.

When irrigating the soil, water status in the most active root zone should be monitored regularly to decide when to apply irrigation. The timing of irrigation applications over the growing season depends on the AWHC in the soil root zone, rainfall frequency, and daily ET.

**Table 2. Available water holding capacities for several Minnesota soils**

<b>Available Water Holding Capacity</b>		
<b>Soil Texture</b>	<b>Inches per inch of soil</b>	<b>Inches per foot of soil</b>
Loamy fine sand	.08 - .12	0.96 – 1.44
Sandy loam	.10 - .18	1.20 – 2.16
Loam	.14 - .22	1.68 – 2.64
Silt loam	.18 - .23	2.16 – 2.76
Clay loam	.16 - .18	1.92 – 2.16

## **IRRIGATION STRATEGY**

After planting, if soil moisture is variable in the planting and early rooting zone, irrigate to encourage uniform germination and root development. After emergence, the soil-water level should be allowed to dry to 40% to 50% of the total available water capacity (50% to 60% soil-water deficit) during vegetative development before the first irrigation. This strategy will encourage maximum root development, and prevent excessive early foliage growth that may encourage lodging and increase white mold disease pressure. The depth of irrigation applied during this time should generally be somewhat less than the soil-water deficit to provide some soil-water storage reserve for rainfall

During flowering and early pod development, the soil-water status should be maintained a little wetter than in the vegetative stage (30% to 40% soil-water deficit), so the daily crop ET demands are most easily met. This growth period is the most sensitive to water stress and can cause significant yield losses if water stress occurs. This period is also the most sensitive to white mold development, so the irrigation frequency should be kept to at least 3 to 5 days by applying at least 3/4 to 1 inch of water each irrigation. Lighter irrigations will cause soil surface and foliage to be wetted more frequently, and that may encourage white mold development.

Once the upper soybean pods start filling, the soil-water status can be allowed to become drier, so that by maturity the soil-water deficit is near 50 to 60 percent of the total soil-water-holding capacity in the active rooting zone. Table 3 shows the number of days and estimated soybean crop ET needs to maturity in central Minnesota from various plant growth stages. Generally, once the lower pods start to turn brown, and about 75%-80% of the leaves have started to yellow, irrigation can be terminated for the season.

**Table 3. Estimated soybean crop ET needs and time to maturity from selected growth stages in central Minnesota**

<b>Stage of Plant Growth</b>	<b>Days to Maturity</b>	<b>Inches of ET to Maturity</b>
full flower - R2	48 - 54	6.8 - 7.6
full pod - R4	35 - 39	4.0 - 4.8
begin seed fill -R5	27 - 31	2.7 - 3.3
full seed fill - R6	16 - 18	1.1 - 1.4
begin maturity - R7	9 - 11	0.4 - 0.7

## **SOIL-WATER MONITORING**

Two common ways of estimating soil-water deficit to assist an operator in irrigation scheduling are (1) the feel and appearance method with the soil probe, and (2) the checkbook accounting method, where daily soil-water accounting is done by keeping track of daily crop ET, rainfall, and irrigation amounts.

The ***feel/appearance method*** involves collecting soil samples in the root zone with a probe or a spade. The soil-water depletion of each sample can be estimated by feeling the soil and comparing its appearance to Table 4. Soil samples should be taken at several depths in the root zone, and at several locations in the field. Sum up the estimations from various depths for one location to estimate the total soil-water depletion in the root zone. This method requires frequent practice by the operator to develop the art of estimating soil-water consistently.



UNIVERSITY OF MINNESOTA  
**EXTENSION**



More information on the checkbook method, and in-field soil moisture monitoring tools, can be found in University of Minnesota Extension Service bulletins *Irrigation Scheduling Checkbook Method*, AG-FO-1322, and *Irrigation Water Management Considerations for Sandy Soils in Minnesota*, AG-FO-3875, which are available at local county extension offices, or which can be ordered online at <http://www.extension.umn.edu/>.

Table 5. Soil-Water BALANCE SHEET

Field \_\_\_\_\_ Crop \_\_\_\_\_ Emergence date \_\_\_\_\_

**Available Water Capacity:**

	_____ inches of water in _____ inches of soil root zone		
Growth Stage	Vegetative	Critical Growth	Maturing
Allowable	_____%	_____%	_____%
Soil-Water Deficit	_____inches	_____inches	_____inches

Jerry Wright  
 West Central Experiment Station Engineer  
 University of Minnesota  
 (320) 634-4306  
[jwright@tc.umn.edu](mailto:jwright@tc.umn.edu)



UNIVERSITY OF MINNESOTA  
**EXTENSION**

# FARMLAND DRAINAGE

## OVERVIEW

Drainage is a necessary soil-water management practice on many Minnesota farmlands to maintain a profitable soybean production system. Surface and subsurface drainage offer several production advantages. No long-term yield response has been measured by Minnesota researchers, but studies in neighboring states, like Iowa, suggest that a 4 to 15 bushel soybean response might be expected with subsurface tile on moderate to very poorly-drained land. Ohio data indicate a 6 to 14 bushel gain on poorly-drained silty clay soils with good surface drainage. Other sources for potential yield response information related to improved drainage that should be checked include your neighbors, county Extension offices, and the local Soil and Water Conservation District (SWCD) office.

Before developing a drainage plan, consult the Minnesota Drainage Design Guide, and assess local drainage experiences, soil survey information, site topography surveys, field evaluation (surface and subsurface), wetland restrictions, state drainage laws, outlet limitations, discharge impacts, and economic feasibility. Visiting the local Natural Resources Conservation Service (NRCS), SWCD, and Watershed office is an important first step in interpreting current “wetlands” and local restrictions.

## OUTLET

Location must provide for free discharge into a ditch or waterway where the flow can be carried away from the field. A drainage design for any field or farm must begin at the outlet. Tile line outlets are typically located 3 to 5 feet below the soil surface. The bottom of an outlet pipe must be located above the water level in the receiving ditch or waterway, except when at flood levels. Drainage outlets must be kept clean of weeds, trash, and rodents, and be protected from erosion around the outlet and from damage by machinery or cattle.

**Outlet and tile size** should be selected to provide for the desired amount of water removal, commonly referred to as the “drainage coefficient.” This will typically range from 3/8 to 1/2 inch of water removed per day. If some surface water is to be drained by open surface inlets, the drainage coefficient for that area should be increased to 3/4 to 1 inch per day. Refinement of these guidelines should be done in consultation with local experts. Table 1 shows the maximum land area that different tile sizes can support at selected grades for a 1/2 inch drainage coefficient. For other

sizes, grades, and drainage coefficients consult a drainage engineer, contractor, or the Minnesota Drainage Guide.

**Tile line spacing** should be based on soil type, soil permeability, drain depth, desired drainage coefficient, and degree of surface drainage. Table 2 shows some general spacing options that might be considered during early planning phases for a new or improved system. These data should be refined with information from the Minnesota Drainage Guide, and local experience.

**Surface inlets** offer timely removal of ponded water within a field. These inlets, however, can provide a direct pathway to downstream rivers for surface waters that may carry sediment and other pollutants which otherwise may have been trapped in the field. The general public, researchers, and others are concerned about the potential impacts these inlets may have on the downstream waters in both quantity and quality. Some farmers are converting their open inlet structures to a blind type of structure. University researchers and others are investigating the hydraulic and water quality impacts of alternative surface inlet designs such as raised pipe, blind inlets with various types of media, grass buffer strips, and reduced tillage.

**Table 1. Potential Acres Drained by Selected Tile Sizes, Grades and Types**

<u>For a Drainage Coefficient of 1/2 Inch per Day</u>							
Corrugated Plastic Tubing (CP) and Concrete Tile (CL/CO)							
Grade ft./100 ft.	Tile Type	Tile Sizes					
		4"	5"	6"	8"	10"	12"
.10	CP	2.0	4.5	8	15	25	40
	CO	3.0	5.5	9	20	35	55
.25	CP	4.0	7.5	12	25	40	65
	CO	4.6	8.1	13	29	52	85
.50	CP	6.0	11	17	36	58	92
	CO	6.5	12	19	41	74	121
1.00	CP	8.0	14	23	50	80	130
	CO	9.1	16	27	58	104	171
2.00	CP	12	20	32	72	118	185
	CO	13	23	38	82	148	241

**Table 2. General Parallel Tile Laterals Spacing and Depths for Different Soils**

Type of Soil	Subsoil Perm.	Tile Spacing in Feet for			Tile Depth in Feet
		Fair Drainage 1/4" d.c.	Good Drainage 3/8" d.c.	Excellent Drainage 1/2" d.c.	
Clay	Very low	70	50	35	3.0 - 3.5
Silty clay	Low	95	65	45	3.3 - 3.8
Silt	Mod low	130	90	60	3.5 - 4.0
Loam	Moderate	200	140	95	3.8 - 4.3
Sandy	Mod high	300	210	150	4.0 - 4.5

**For additional information and advice you may consult the following publications:**

**Minnesota Drainage Guide.** USDA- Natural Resource Conservation Service (available in each SWCD/NRCS office).

**Design and Construction of Subsurface Drains in Humid Areas.** ASAE Standards. EP260.4 December 1993.

Planning A Subsurface Drainage System. **National Corn Handbook.** C. Drablos, University of Illinois, and S. Melvin, Iowa State University.

Agricultural Drainage - **Water Quality Impacts & Subsurface Drainage Studies in Midwest.** Zucker, L.A. and L. C. Brown, Ohio State University, Bulletin 871, 1998.

**Will Tiling Pay on My Farm?** Landlord/Tenant Option. Paul Brown. Iowa State University, 1996.

Jerry Wright  
West Central Experiment Station Engineer  
University of Minnesota  
(320) 634-4306  
[jwright@tc.umn.edu](mailto:jwright@tc.umn.edu)

Gary Sands  
Biosystems and Agricultural Engineering  
University of Minnesota  
(612) 625-9733  
[grsands@tc.umn.edu](mailto:grsands@tc.umn.edu)





# FERTILIZING SOYBEANS

## OVERVIEW

In Minnesota, the soybean crop is frequently neglected when growers plan a fertilizer program for the total farm enterprise. Yet, where levels of essential nutrients in soils are not adequate, the addition of the needed nutrients to a fertilizer program can produce profitable increases in yield.

## NITROGEN MANAGEMENT

The soybean plant is a legume and, when nodulated, will use the nitrogen (N) from the air for growth and development. Except for soybeans grown in the Red River Valley, the addition of fertilizer nitrogen will not increase bean yields.

If there is no previous history of growing soybeans in the rotation, and a measurement of nitrate-nitrogen (NO<sub>3</sub>-N) to a depth of 2 feet shows less than 75 pounds per acre, an application of 50 pounds N per acre is suggested for the Red River Valley. The application of fertilizer N, either before planting or during the growing season, is not recommended for the remainder of Minnesota.

## PHOSPHATE AND POTASH

The suggested rates of phosphate and potash fertilizers are based on yield goal and soil test values for phosphorus (P) and potassium (K). These suggestions are listed in the following tables.

**Table 1. Phosphate fertilizer suggestions for soybean 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+

---



	very low	low	medium	high	very high
<b>bu./acre</b>	<b>P2O5 to apply (lb./acre)</b>				
less than	40	20	10	0	0
30-39	50	25	10	0	0
40-49	60	30	10	0	0
50-59	70	40	15	0	0
60 or more	80	45	15	0	0

*\* Use one of the following equations if a P2O5 recommendation for a specific soil test value and a specific yield goal is desired.*

$$\text{P2O5 Rec} = [1.55 - (.10) (\text{Soil Test P, Bray, ppm})] (\text{Yield Goal})$$

$$\text{P2O5 Rec} = [1.55 - (.14) (\text{Soil Test P, Olsen, ppm})] (\text{Yield Goal})$$

**Table 2. Potash suggestions for soybean production in Minnesota**

**Potassium (K) Soil Test (ppm)\***

Yield Goal	v low	low	medium	high	v high
	0-40	41-80	81-120	120-160	161+

<b>bu./acre</b>	<b>K2O to apply (lb./acre)</b>				
less than 30	55	30	10	0	0
30-39	65	40	15	0	0
40-49	80	50	15	0	0
50-59	100	60	20	0	0
60 or more	110	70	20	0	0

*\* Use one of the following equations to calculate potash recommendations for a specific yield goal and a specific soil test for K.*

$$\text{K2O Rec} = [2.20 - (.0183) (\text{Soil Test K, ppm})] (\text{Yield Goal})$$

Phosphate and/or potash should be broadcast and incorporated before planting, if possible. The grower can apply all or some of the needed phosphate and/or potash in a starter, or some other band, near the seed at planting. This is especially true for ridge-till or no-till planting systems.

Soybean seed is very sensitive to salt injury. Therefore, no fertilizer should be applied in contact with the seed at planting. There should be soil between seed and fertilizer if a banded application is used. The standard 2

x 2 placement (2 inches to the side of and 2 inches below the seed) at planting is satisfactory for starter fertilizer placement for the soybean crop.

## **Other Nutrients**

Frequently, soybeans that are grown on fields that have a pH in excess of 7.3 turn yellow, and, in severe cases, some die. This condition has been described as iron chlorosis. Because of soil and/or environmental conditions, the soybean plant is not able to take up the amount of iron (Fe) that is needed for normal growth and development, even though there is no deficiency or shortage of Fe in the soil.

Foliar applications of an iron chelate have been evaluated as a management practice to correct the problem. This application must be made at the third trifoliolate stage of development. There is, however, no guarantee of success. Variety selection, cultivation, and inoculation of the seed at planting are possible management practices that can be used to partially overcome iron chlorosis.

Extensive research in Minnesota, at several locations and over several years, indicates that soybeans may not respond to the application of sulfur (S), magnesium (Mg), zinc (Zn), manganese (Mn), copper (Cu), or boron (B). Therefore, these nutrients are not necessary for good soybean fertilization.

George Rehm  
Department of Soil, Water, and Climate  
University of Minnesota Extension  
(612) 625-6210  
[grehm@soils.umn.edu](mailto:grehm@soils.umn.edu)

John Lamb  
Department of Soil, Water, and Climate  
University of Minnesota Extension  
(651) 625-1772  
[jlamb@soils.umn.edu](mailto:jlamb@soils.umn.edu)

Mike Schmitt  
Department of Soil, Water, and Climate  
University of Minnesota Extension  
(612)625-7071  
[schmi009@tc.umn.edu](mailto:schmi009@tc.umn.edu)



# **MANURE MANAGEMENT**

## **OVERVIEW**

The numbers of livestock are increasing for many livestock operators, while the number of cropland acres are remaining constant. This trend has resulted in many producers considering manure applications for soybeans. Research studies in Minnesota have evaluated pre-plant manure applications for soybeans. The overall effects of manure for soybeans have been positive, but there are situations that have the potential for negative effects, if not properly managed.

## **FIELD SELECTION**

Soybean fields should not be selected for manure applications until after all the non-leguminous crops have been considered. Soybeans do not require applied nitrogen (N), and their phosphorus (P) demand is less than that of corn and small grains. If soybean fields are being chosen for manure applications, the greatest agronomic return will be on those fields that test low for plant nutrients, or that could benefit from the addition of organic materials, or both.

Observation and research have also indicated that preplant manure applications can magnify or promote most current pest problems in a field. While this primarily applies to the soybean disease of white mold, preplant manure can increase most organisms. The manure creates an environment that promotes disease growth (i.e. lush vegetative growth). Manure's nutrients and weed seed population can also stimulate and expand a weed problem in certain fields. Manure should not be applied to fields with known white mold histories or other pest problems.

## **APPLICATION METHOD**

For air and surface water quality reasons all manure should be injected or otherwise incorporated into the soil. Agronomically, there is also good justification for not broadcasting the manure and leaving it on the soil surface. Soybean seed germination and early seedling growth are very sensitive to ammonia and salts which are contained in animal manure. Corn or small-grain crops are not so easily affected. Therefore, it is important that the germinating seed or young seedling does not come in direct contact with zones of concentrated manure, or injury can result. To avoid this injury risk, either inject the manure beneath the seeding zone, or thoroughly incorporate the manure into the entire topsoil zone — each of

these methods minimize “hot” areas created by the manure. Tillage for seedbed preparation will usually alleviate these concerns.

The application method has a direct influence on the amount of Nitrogen (N) that will be available to the soybean. Table 1 lists the N availability amounts for the year of application, and predicted availability the following year. Regardless of the method of application one is using, it is of utmost importance that the manure be uniformly applied to the field.

## **RATE SELECTION**

The rate of manure to be applied should be calculated so that the amount of available N supplied by the manure does not exceed the amount of nitrogen (N) that is removed by the soybean crop. Applying manure at greater rates will result in creating an environmental liability from excess N. Also, excessive manure rates can also enhance any of the potential agronomic concerns created by manure applications such as excessive lodging, diseases such as white mold, seedling injury, and others.

Three things to consider when determining rates of manure application are:

- 1) the amount of nutrients in the manure (see Table 2 or your most recent manure analysis report sheet)
- 2) the availability of N in the manure which is based on your method of application (Table 1)
- 3) the nutrient needs of the soybeans

The following equation provides this calculation:

$$\text{Rate (1000 gal/A)} = \{\text{Nutrient Need (lb/A)} \times [(\text{Manure content, lb/1000 gal})/\text{Availability, \%}]\}$$

Or

$$\text{Rate (tons/A)} = \{\text{Nutrient Need (lb/A)} \times [(\text{Manure content, lb/ton})/\text{Availability, \%}]\}$$

## **SUPPLEMENTAL FERTILIZER**

There is no need for commercial fertilizer when manure is applied for soybeans. Most often, phosphorus (P) is the primary nutrient recommended for soybeans, and with even the lowest rates of manure applied to the soil, the P needs are met. All other nutrients are applied at

rates that exceed nutrient recommendations. Table 3 lists some of the micronutrient quantities excreted per animal, per year. Most animal manure will supply a complete set of nutrients.

A concern is often raised that if manure (or commercial N fertilizer) is applied to soybeans, the nodules will become inhibited and not function for the remainder of the growing season; thus, prompting the notion that mid-to late-season N applications need to be made. Although manure N will greatly decrease the activity of soybean's nodules, once soil N levels become low the nodule activity will increase to meet the demand of the soybean.

Manure applications for soybean fields can be made with minimal risk if proper precautions are taken. Selecting fields that will benefit from manure's nutrients and that have few pest problems will be advantageous. Manure should be applied at agronomically-based rates that account for method of application, and the nutrient needs of the soybean crop. Avoid seeding soybeans into an area that contains a relatively high concentration of manure. No supplemental fertilizer will be required.

**Table 1. Manure nitrogen availability and loss as affected by method of application and animal species**

Species	Broadcast Incorporation *1			Injection	
	None	<4d	<12 hr	Sweep	Knife
<b>% Total N</b>					
<b>Dairy</b>					
Avail.Yr 1	20	40	55	55	50
Avail.Yr 2	40	40	35	40	40
Lost (*2)	40	20	10	5	10
<b>Swine</b>					
Avail.Yr 1	35	55	75	80	70
Avail.Yr 2	15	15	15	15	15
Lost	50	30	10	5	15
<b>Beef</b>					
Avail.Yr 1	25	45	60	60	50
Avail.Yr 2	35	35	35	35	40
Lost	40	20	5	5	10
<b>Poultry</b>					
Avail.Yr 1	45	55	70	NA	NA
Avail.Yr 2	25	25	25	NA	NA
Lost	30	20	5	NA	NA

\*1 These categories refer to the length of time between manure application and incorporation.–

\* 2 Lost refers to estimated volatilization and denitrification processes

**Table 2. Summary of manure nutrient analyses based on type of livestock operation**

	Liquid		Solid		N	P2KO5	K2O
	N	P2O5	K2O	N			
	lb/1000		gal.			lb/ton	
<b>Swine</b>							
Farrowing	27	27	15				
Nursery	34	25	18				
Gestation	40	42	18	22	27	14	
Finishing	53	39	29	22	22	17	
<b>Dairy</b>							
Cows	25	15	27	11	7	9	
Heifers				13	12	19	
<b>Beef</b>							
Cows				15	10	9	
Steers							
<b>Poultry</b>							
Turkeys				44	63	34	



**Table 3. Estimated quantities of livestock and poultry micronutrients excreted in manure (from Gilbertson, et al)**

<b>Micronutrient</b>	<b>Dairy</b>	<b>Swine</b> <i>—lb/animal Calcium—</i>	<b>Beef</b>	<b>Turkey</b>
Zinc	0.045	0.409	0.041	0.028
Calcium	14.7	2.32	2.36	0.73
Magnesium	4.5	0.59	1.18	0.007
Iron	0.318	0.045	0.409	0.094
Copper	0.018	0.018	<0.001	<0.001
Manganese	0.045	0.136	0.041	0.002

*Animal weights are considered to be Dairy and Beef-1000 lbs./; Swine-200 lbs.; Turkey-10 lbs.*

Michael Schmitt  
 Department of Soil, Water, and Climate  
 University of Minnesota  
 (612) 625-7017  
[mschmitt@soils.umn.edu](mailto:mschmitt@soils.umn.edu)





# SCOUTING

## OVERVIEW

Scouting is an important component of making informed crop management decisions. Scouting is time-consuming and expensive, but failing to scout will cost the grower through yield loss, or unnecessary insecticide applications, neither of which is acceptable. By knowing the kind, number, and location of insect, weed, and disease damage within a field, the producer can make sound decisions about insect management and can often save several times the cost of scouting.

Scouting techniques are designed around the pest's life history and the crop's growing stages. They must provide an accurate representation of pest populations before damage is done to the crop. To properly scout for pests, the grower must know where they live, what they look like, and how to find and count them. Information on pest life cycles, and the timing and type of damage inflicted to the crop is essential.

## FREQUENCY OF SAMPLES

Scouting should be conducted throughout the growing season. The frequency of sampling depends on the nature of the pest threat. Scouting is ideally done weekly, but sample periods can be lengthened in cooler weather, or shortened in higher temperatures. This requires a significant amount of time, and this is another reason to develop simple and fast scouting methods.

## NUMBER AND LOCATION OF SAMPLE SITES

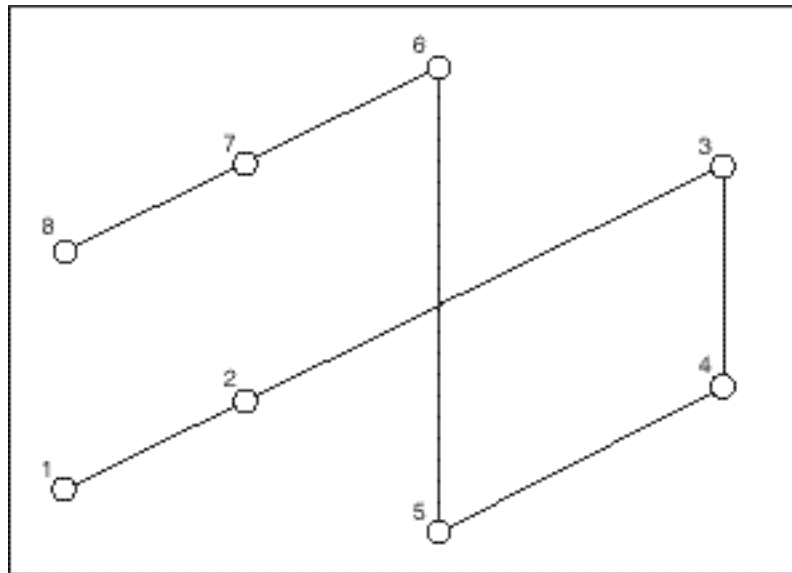
There should be a sufficient number of samples taken to accurately reflect the population of the pests within a field. Scouting location and pattern depends on the within-field distribution of the pest being monitored. Obviously, other factors such as field size, shape, and access will also influence how and from where samples are taken.

There are 3 general scouting patterns:

1. If the pest is evenly distributed throughout the entire field, a transect in a circular, "W", or adapted "Z" pattern should be used (Figure 1). These patterns have been designed to ensure that the entire pest population has an equal opportunity to be sampled.
2. Some pests are associated with particular field conditions, such as low/high, wet/dry, or low/high organic content. Sampling effort must, therefore, be concentrated in these areas.

3. Some pests generally concentrate on the edges of fields, but may get into the field as well. Scouting the margins of fields first will provide a good indication as to whether sampling within the field is required. Be aware that most of these species have different action thresholds within the field and at the edges.

**Figure 1. Adapted “Z” sample pattern used with evenly distributed insect pests. From Hutchison, 1993**



## **SAMPLING METHODS**

There are a number of standard techniques to sample insects, weeds, and plant diseases. The most common method of scouting for pests is simply conducting visual inspections. This technique generally involves selecting a number of plants, leaves, stems, or roots and examining them for the presence of pests or damage. This may require the dissection of plant material or simply walking through the sample area. Visual inspections can be quantitative, or presence/absence, depending on the species being monitored. Generally, presence/absence techniques are used where thresholds are very low, or numbers are very high, and actual counts would not be possible. In either case, careful examination of the plant material is necessary.

Soil inhabiting insects can be sampled using solar baits. To do this, dig a 4"-6" deep hole, about 10" in diameter, and fill it with a 1:1 mixture of corn/wheat seed (soaking the mixture for 24 hours facilitates germination).

Place 1/2 cup of the mixture into the hole, cover with soil, and then cover the soil over the bait with a black plastic trash bag to warm the surface and speed germination. Cover the edges of the bag with soil to prevent wind from blowing away the plastic. Four traps per acre will give a reliable estimate of wireworm population, but this trap density may be unrealistic because of the time and effort involved in the scouting process. As a compromise, at least 10 traps should be used in each field. Collect the samples after one week, count the number of wireworms in each trap, and determine the average.

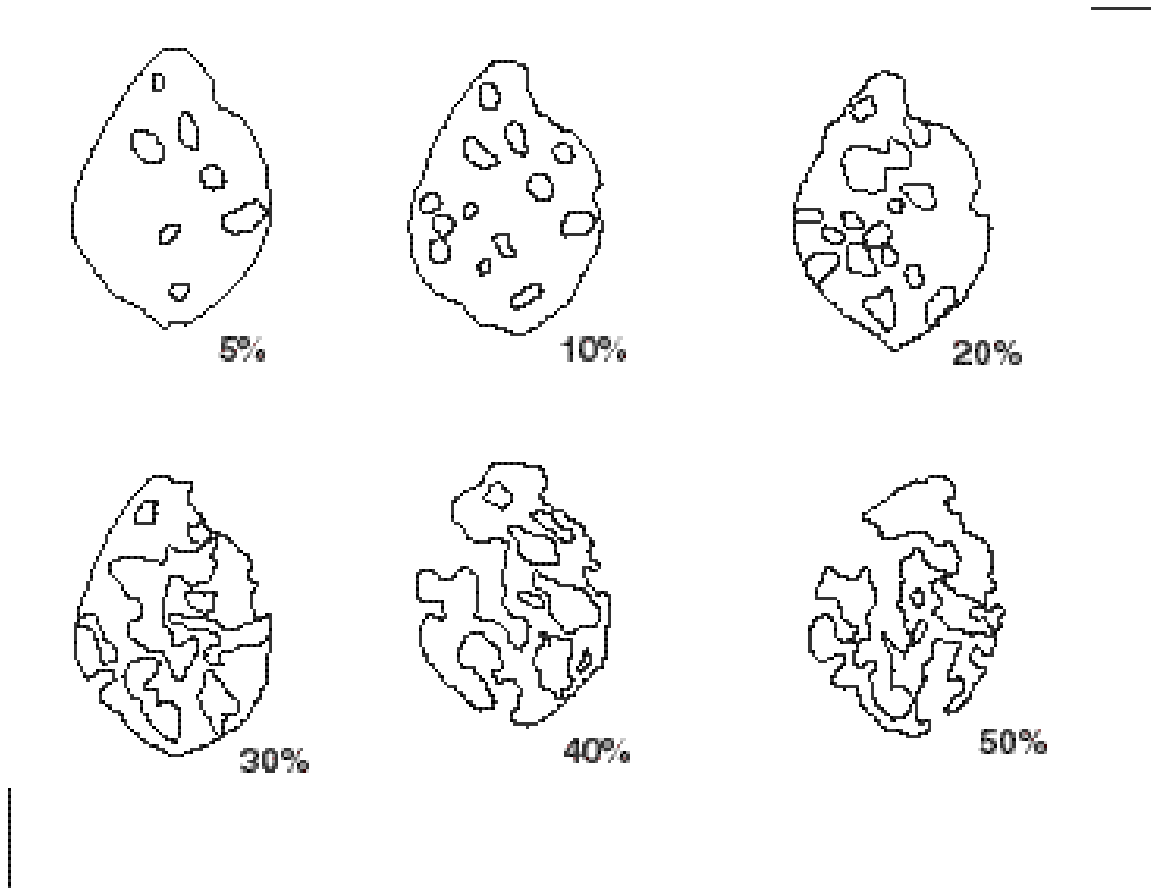
During emergence of soybeans, damage assessment is based on the potential for stand loss. Stand loss is estimated by checking 20 row feet of soybeans in at least 5 locations of the field and determining the percentage of plants cut or destroyed. If 20% of plants are cut, and the stand has gaps of > 1 foot, or if at least one seedling per row foot is destroyed, treatment is economically beneficial.

After trifoliolate leaves have formed, damage assessment is based on estimates of defoliation. To estimate defoliation, the following procedure is recommended:

1. Pick a trifoliolate leaf from the top, middle, and bottom third of 10 randomly selected plants. Place into a plastic storage bag and estimate damage to all leaves at one time (this decreases errors in defoliation estimates).
2. From each trifoliolate, discard the most and least damaged leaflets, leaving 30 leaflets to estimate defoliation.
3. Compare the selected leaflets to Figure 2 and record the average level of defoliation.



**Figure 2. Defoliation assessment guide**



Ian MacRae  
Department of Entomology  
University of Minnesota Northwest Experiment Station  
(218) 281-8611  
[imacrae@mail.crk.umn.edu](mailto:imacrae@mail.crk.umn.edu)



TIMING	WEED SCOUTING	INSECT SCOUTING	DISEASE SCOUTING
Pre-Plant	Pre-plan herbicide program based on field history.		Take SCN soil samples to determine the need for resistant varieties.
Emergence-Seedling	<p>Plan for subsequent crops by noting weed species and abundance.</p> <p>Evaluate pre-emerge herbicide programs.</p> <p>Scout for post-emerge herbicide / cultivation programs and timing.</p>	<p>At emergence: Evaluate stand for losses from Seed Corn Maggot, Cutworm, White Grubs</p> <p>Evaluate defoliation from Bean Leaf Beetle</p> <p>Scout for grasshopper nymphs (include adjacent production areas)</p>	<p>At emergence: Scout for stand loss from damping off fungi (Pythium, and Phytophthora)</p> <p>At seedling stage evaluate stand for loss from Phytophthora (note resistance gene in soybean cultivar where problems occur), Rhizoctonia, and Fusarium root rots.</p> <p>Evaluate Bacterial Blight and Downy Mildew from Mildew seed born infection.</p>
Canopy/Early Flowering	Evaluate problem fields for rescue treatments	<p>Scout for grasshoppers</p> <p>Scout for defoliators</p>	<p>Evaluate and record mid-season Phytophthora (note resistance genes where problems occur), Fusarium, and Rhizoctonia root rot.</p> <p>Evaluate Stem canker, Septoria, and Bacterial blight.</p> <p>Scout for SCN symptoms and examine roots for</p>

			cysts.
Pod Fill		Scout for late season defoliators (Green Cloverworm, woollybear)  Note areas where grasshopper egg laying is occurring	Evaluate late season problems from root rots, Pod and Stem Blight, Anthracnose, Downy Mildew, Viral diseases, Brown Stem rot (R5 stage) and Sclerotinia stem rot (R5-R6 stage).  Note fields free of seed transmissible disease for seed production.
Harvest	Plan for subsequent years by evaluating field for weed escapes		Note poor-yielding areas of the field and record cause.  Take SCN soil samples for management decisions.

Bruce Potter  
Integrated Pest Management Specialist  
University of Minnesota Southwest Experiment Station  
(507) 345-7506  
[bpotter@tc.umn.edu](mailto:bpotter@tc.umn.edu)



# WEED MANAGEMENT

## OVERVIEW

Weeds growing with soybeans compete with the crop for light, moisture, and nutrients. Uncontrolled, weeds reduce soybean yields and interfere with harvest. A 1992 report of the Weed Science Society of America estimated that weeds cause more than a \$52 million loss in Minnesota soybean production each year.

An effective weed management program requires understanding potential weed problems, and planning, to control weeds in a timely manner. Soybeans are very competitive with weeds once the soybeans develop a canopy, but early emerging weeds, if left uncontrolled, can cause significant yield loss. Early season weed control (generally before weeds reach 4 inches in height) is the key to providing soybeans with a competitive advantage by minimizing the impact of weeds. The most effective control programs include a variety of control practices in an integrated weed management system.

## COMMON WEED PROBLEMS

### Annuals

Summer annual grass and broadleaf weeds such as foxtails, woolly cupgrass, tall waterhemp, common ragweed, and common cocklebur can be problems in soybeans. These weeds germinate in the spring and summer and produce seed before they die in the fall. A well-timed cultivation or herbicide treatment can greatly reduce annual weed populations. Annual weeds have a fairly predictable pattern of emergence, but their germination depends on soil moisture and temperature. Please refer to the Iowa State University, Leopold Center publication, ***Relative Emergence Sequence for Weeds of Corn and Soybeans*** for more details. This publication can be ordered from the University of Minnesota Extension Service Distribution Center as FO-6958 at no charge.

### Winter annuals and biennials

Winter annual weeds such as mustards and horseweed (marestalk), and annual/biennial weeds such as biennial wormwood, are a problem in no-till soybeans. These weeds germinate in the fall and become a noticeable problem by early to mid-summer of the next growing season. They can be controlled with tillage or burndown herbicide treatments before soybean planting.

## **Perennials**

Perennial weeds that regrow each year from an established rhizome or root system are very competitive and difficult to control. Perennial broadleaf weeds such as Canada thistle, common milkweed, and hemp dogbane are difficult to manage in soybeans. Spot spraying, weed wipers, or herbicide resistant crops tolerant to nonselective herbicides such as Roundup, will help manage these perennial broadleaf weeds. Crop rotation, or treatment in the fall, best manages these weeds after soybean removal.

## **WEED IDENTIFICATION**

Proper weed identification is the foundation of a successful weed management program. Being able to identify weeds at the seedling stage of development is a critical component of profitable soybean production because, in weed control, timing is everything.

Therefore, we have included in this chapter the unique broadleaf weed seedling and grassy weed seedling identification keys created by Beverly R. Durgan. Also, because weed identification is essential to producing a profitable soybean crop, you will find included 60 outstanding color photographs of a wide variety of weeds, developed by Gerald R. Miller and Oliver E. Strand. These picture sheets can be found in the center section of the *Minnesota Soybean Field Book*.

## **INTEGRATED WEED MANAGEMENT**

Effective weed control usually results from a combination of cultural, mechanical, and chemical practices. The ideal combination for each field will depend on a number of considerations including 1) The kinds of weeds present, 2) The level of weed infestation, 3) The soil type, 4) The cropping system, 5) The availability of time and labor to complete the control tactic in a timely manner.

## **Weed-Soybean competition**

Weeds are vigorous competitors with soybeans. Weeds usually germinate and emerge with the soybeans; therefore, soybeans do not get ahead of the weeds. Soybeans are relatively short and consequently susceptible to shading from taller weeds. Weeds can also compete with soybeans for nutrients and water. Since soybeans are especially sensitive to moisture deficiencies in early- to mid-summer, nearly-complete weed control must be accomplished within four to five weeks after soybean emergence in order to avoid yield losses due to early emerging weeds. Planting narrow



rows, and following production practices that encourage vigorous soybean growth, will increase the crop's competitive advantage over the weeds. The idea is to "shade out" late emerging weeds. In a wider row spacing, a producer should strive to have the soybeans lapped in the row middles as soon as possible. Generally, weeds that emerge four to five weeks after the soybean planting date will not be competitive with the soybean crop.

### **Crop rotation practices**

Crop rotation can be an important component of a weed management program. For example, most annual broadleaf weeds can be more easily and economically managed in corn than in soybeans. The opposite is true for most annual grass weeds. Crop rotation can encourage (over time) the use of different types of herbicides, with different sites of action. This helps to prevent the development of herbicide resistant or tolerant weeds. See "Herbicide Resistant Weeds," FO-6077, University of Minnesota Extension Service Distribution Center.

### **Tillage Practices**

Several tillage practices aid weed management in soybeans. Seedbed preparation immediately prior to planting will kill weeds that have germinated. In the absence of seedbed tillage, a burndown herbicide treatment is often required. Killing the weeds that germinate prior to, or at the time of, soybean planting, regardless of the tillage system employed, is important because these will be the most competitive weeds.

For pre-emergence herbicides to be effective, they must be moved into the soil by rainfall before the weed seeds germinate. If rainfall has not been sufficient for herbicide activation, the weed seedlings should be controlled with a rotary hoe, or harrow, as soon as they emerge. Cultivation of weed escapes is also an effective and economical weed control tool. Cultivation should be done when weeds are small (1 inch) and the cultivation should be shallow (1 to 2 inches) to avoid soybean root damage.

### **Herbicides**

Herbicides are used on almost all soybean acreage because they are an efficient weed management tool. However, far too many growers equate weed management solely with herbicides. University of Minnesota research trials indicate weed management is most consistently successful and economical when a diversity of weed management tools are used in an integrated approach. For example, one cultivation following your planned herbicide program, or a sequential pre-plant incorporated / post-emergence herbicide program, is more consistently successful than a one-

pass post-emergence weed control program. Also, a more diversified weed management approach will prevent unwanted weed species shifts.

## **SELECTING HERBICIDES**

Selection of an appropriate herbicide or combination of herbicides should be based on consideration of the following factors:

- n Label approved for use
- n Ground and surface water pollution concerns
- n Use of the crop
- n Crop and variety tolerance
- n Potential for soil residues that may affect following crops
- n Kinds of weeds
- n Soil texture
- n Soil pH
- n Soil organic matter
- n Potential for drift problems
- n Tillage practices
- n Herbicide performance
- n Herbicide cost
- n Availability of a fully-adapted herbicide-resistant crop

### **Timing**

Proper application of chemicals is essential for obtaining satisfactory results. Carefully follow the suggested rates on the labels for specific soil and weed situations. Apply herbicides at the weed and crop stages specified. Delayed applications usually result in poorer weed control, and may injure the crop.

### **Weather**

Weather conditions will also affect herbicide performance. Temperature and moisture affect the weed control and crop injury potential of a herbicide. Temperatures below 50° F and above 90° F often limit the soybean's ability to degrade the herbicide, and application may result in crop injury. Dry soil conditions or cold temperatures (below 50° F) may limit the weed's ability to take up enough herbicide to provide adequate weed control. Heavy rainfall may move a herbicide downward in the soil, resulting in poor weed control or crop injury. When applying herbicides, observe label precautions regarding weather conditions, as well as crop and weed size.

## **Early pre-plant treatment**

Emerged weeds must be controlled at planting for soybeans to be successful. Certain herbicides can be applied before soybeans are planted in the spring to control emerged weeds, and/or for residual control of late-emerging weeds. Many residual herbicides applied early need to be applied before weeds germinate. They usually require precipitation or incorporation for herbicide activation. If weeds have already emerged at treatment time in no-till planted soybeans, addition of a burndown herbicide with foliar activity is often required. Early pre-plant herbicides need enough residual activity to control weeds before and after planting, or else they require follow up treatments of post-emergence herbicides, or cultivation.

## **Pre-plant incorporated herbicides**

Certain residual herbicides can (or must) be applied and incorporated into the soil before planting to control susceptible weeds. These pre-plant herbicides need to be incorporated thoroughly to the proper soil depth, as directed on the label. Incorporation is more uniform with dry, mellow soil than with damp or cloddy soil. Pre-plant-incorporated herbicides are less dependent on rainfall for their effectiveness because they have been mechanically placed in the weed emergence zone. Avoid furrowing too deep at planting time, and thereby moving too much treated soil out of the planted row, or weed escapes will occur in the row.

## **Pre-emergence herbicides**

Some residual herbicides can be applied to the soil surface after the crop is planted, but before soybean and weed emergence. Rainfall or irrigation of about 0.5-0.75 inch of water is required after application to move the herbicide into the soil where it can be absorbed by the germinating weeds. Too little or too much rainfall after herbicide application can cause poor weed control. In Minnesota, the south central and southeastern sections of the state have the greatest probability of timely rainfalls that will successfully activate pre-emergence herbicides. In southwestern, west central, and northwestern Minnesota, the probability of such a timely rainfall is lower, and pre-plant- incorporated herbicides tend to be the more effective soil-applied herbicide option. Also, if there is insufficient rain, a rotary hoe can be used to control small weeds and help incorporate the herbicide.

Pre-emergence herbicides can also be applied in a band over the row at planting time. Band applications are generally 12 to 14 inches wide. With a planned cultivation after crop emergence to control weeds between the

rows, banding provides an opportunity to reduce herbicide inputs without sacrificing yields.

### **Post-emergence herbicides**

Post-emergence herbicides control weeds after the crop and weeds have emerged from the soil. Some post-emergence herbicides have soil residual activity (e.g. Pursuit) and some do not (e.g. Roundup Ultra). Application rate, weed and crop size, environmental conditions, and adjuvants (effectiveness enhancements) greatly influence post-emergence herbicide performance. Post-emergence herbicides are most effective when applied to small weeds that are actively growing. Application to larger weeds or plants growing under environmental stress may result in poor weed control and increased crop injury.

In Minnesota, it takes approximately four weeks for an annual weed such as giant foxtail to reach four inches in height. In five weeks, giant foxtail can be five to six inches tall, and in six weeks the foxtail may be eight inches tall. For many herbicides the ideal foxtail height for post-emergence application is three to four inches. Therefore, the window of opportunity for effective post-emergence control is approximately one week. Many post-emergence herbicides require adjuvants to improve plant uptake. Without the necessary adjuvants poor weed control may result. However, using the wrong type of adjuvant, under the wrong environmental conditions, can also increase herbicide crop injury potential. Use adjuvants according to herbicide label recommendations.

### **HERBICIDE MODE OF ACTION**

Herbicide mode of action is the process by which herbicides kill weeds. Different herbicides can affect different plant processes, resulting in the death of the weed (and not the soybeans). Herbicide mode of action is also a convenient way to categorize the numerous herbicides in the marketplace. Herbicides can be classified into families based on their chemical similarity. In some cases, herbicides from different families target the same biochemical process (site of action) within the plant and result in the same herbicide crop injury response in the plant. Herbicide mode of action explains how a herbicide kills a plant, and herbicide site of action tells you what plant process is affected.

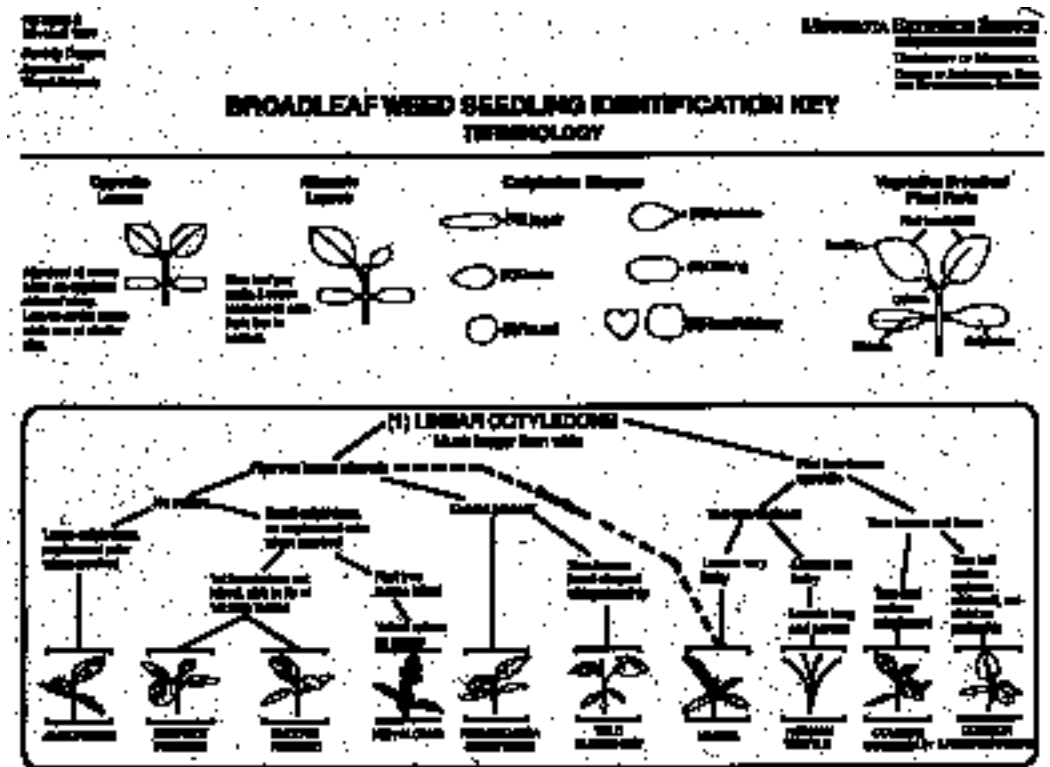
Learning herbicide mode of action processes will help you understand the events that relate to herbicide effectiveness. For example, the ways temperature can influence the effectiveness and crop injury potential of a particular herbicide.

Understanding herbicide mode of action will improve: 1) Crop injury diagnostic skills. 2) Herbicide selection and application skills. 3) Herbicide resistance management strategies. See the **“Herbicide Mode of Action and Crop Injury Symptoms”** publication for more details. This publication can be ordered from the University of Minnesota Extension Service Distribution Center as BU-3832.

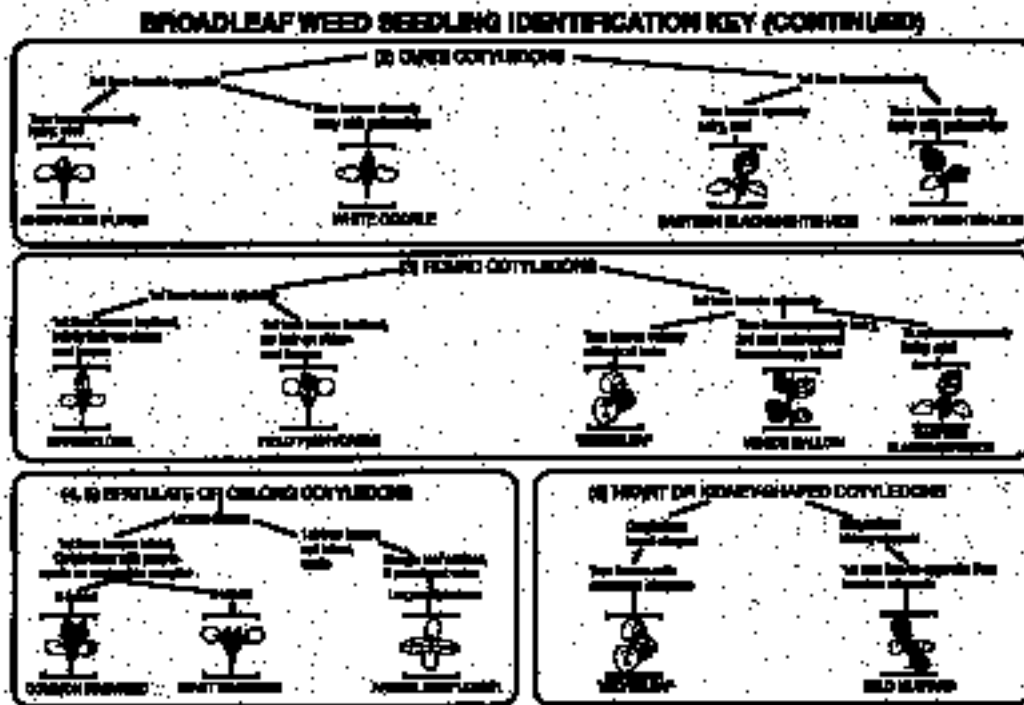
## HERBICIDE RESISTANT WEEDS

Weed species, and different biotypes within species, vary in susceptibility to herbicides. A population that is initially susceptible to a herbicide, but contains a small percentage of resistant biotypes, may develop into a resistant population. Selection for resistance is most likely with the repeated use of a highly effective herbicide program. It is important to use different weed management tactics (e.g. herbicides, cultivation, rotary hoeing), crop rotation, and employing herbicides that affect different sites of action in the target weeds. See the **“Herbicide Resistant Weeds”** publication for more details. This publication can be ordered from the University of Minnesota Extension Service Distribution Center as FO-6077.

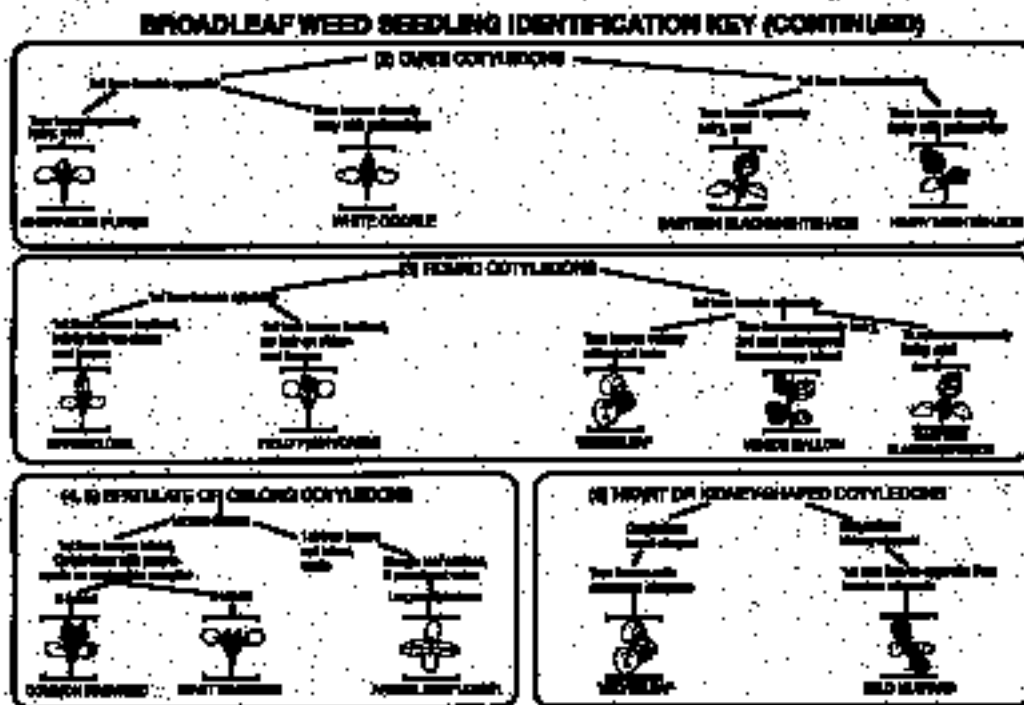
## BROADLEAF SEEDLING IDENTIFICATION KEY TERMINOLOGY



## BROADLEAF SEEDLING IDENTIFICATION KEY (continued)



## BROADLEAF SEEDLING IDENTIFICATION KEY (continued)





## HERBICIDE RESISTANT SOYBEANS

Herbicide resistant soybeans allow the use of herbicides that would otherwise seriously injure or kill the soybeans. Herbicide resistant soybeans that have been developed include STS soybeans (for use with Reliance STS) and Roundup Ready soybeans (for use with Roundup Ultra). In the near future, Liberty Link soybeans should be available (for use with Liberty). Reliance STS is a broadleaf herbicide, and Roundup Ultra and Liberty are broad-spectrum herbicides that have grass and broadleaf weed activity. STS soybeans were developed by conventional breeding techniques. Roundup Ready and Liberty Link soybeans were developed through genetic engineering. As with any weed management practice, use of a herbicide resistant crop, and the corresponding herbicide, should be part of an integrated weed management program.

## HERBICIDE EFFECTIVENESS TABLE

The following Table (S2) shows the soybean and weed response to various herbicides used in conventional and herbicide resistant soybean varieties. Also included is a reference to each herbicide site of action. Herbicides with the same number share the same site of action. Over-reliance of any particular site of action group increases the potential for inadvertently selecting for herbicide resistant weeds. Always consult the label and follow directions concerning application rates, timing, spray additives (adjuvants), application techniques, personal protective equipment, and any other restrictions when using herbicides.









# INSECT MANAGEMENT

## OVERVIEW

Insects and mites rarely threaten soybean production in Minnesota. This pleasant situation has resulted from the introduction of clean soybeans from Korea and China without importing insect pests. The pests highlighted in this chapter have adapted to soybeans from other native U.S. plants. Consequently, insect problems are infrequent and localized. For example, infestations over the last 10 years have included two-spotted spider mites in 1988, grasshoppers in 1989-90 and 1997-98, green cloverworms in 1991, thistle caterpillars in 1992, seedcorn maggots in 1993, and white grubs in 1998. Infrequent infestations pose three problems:

- n Since few people are scouting for these insects, infestations may not be detected promptly
- n Even if symptoms are noticed, growers and crop advisors may have difficulty diagnosing problem insects and mites
- n Sporadic problems mean most growers or crop advisors lack management expertise, especially for spotty problems that may occur only once every 10 to 20 years

Geographical variation is typical with migratory insect problems, such as green cloverworms and potato leafhoppers, which are more common in southern Minnesota. There can also be drought-related insect problems such as grasshoppers and two-spotted spider mites, which are more common in western Minnesota. No area is immune to insect outbreaks. As soybean acreage expands in northern Minnesota, more insect problems could emerge. This chapter reviews the insect pests that potentially affect soybean production in both northern and southern Minnesota.

The importance of accurate insect identification has pointed out the need to include color photographs of the 18 most important insects for Minnesota growers to recognize. These picture sheets, the work of Kenneth Ostlie, Ian MacRae, and David Noetzel, can be found in the center section of the *Minnesota Soybean Field Book*.

## TYPES OF INSECT DAMAGE

Insects and mites attacking soybeans can be grouped by the type of damage they cause, and can be categorized as ***stand-reducing, leaf-feeding, and pod-feeding***.

**Stand-reducing** insects attack germinating seeds or the roots or underground stems of young plants, and they can cut off the plants. Examples include seedcorn maggots, wireworms, white grubs, and cutworms. Three factors influence stand reduction and management decisions. First, because the seed rises out of the ground during emergence, its exposure to seed-feeding insects is greatly reduced. Second, because the growing point rapidly moves above ground, the risk of stand loss from cutworms is increased. Third, soybeans compensate quite well for stand loss; reductions in stand from 160K to 105 K may not cause detectable yield loss. While rescue treatments are not available for most stand-reducing insects, if promptly detected, cutworm infestations can be easily controlled with insecticides.

**Table 1. Yield Loss (%) from Stand Reduction**

Original (1000s/acre)	Stand Dead and Missing Plants (1000s / acre)												
	17.5	18	35	52	70	87	104.5	122	139	157	174	191.5	209
209	1	2	5	8	13	19	26	35	49	62	78	100	
191.5	2	3	6	11	17	24	32	47	62	77	100		
174	2	5	8	14	22	31	45	60	77	100			
157	3	7	11	19	28	43	59	76	100				
139	5	8	15	25	39	56	75	100					
122	6	11	20	35	53	73	100						
104.5	8	15	31	50	71	100							
87	9	25	45	68	100								
70	18	37	64	100									

**Source: NCIA Soybean Loss Instructions #6302, Rev. 1979**

## **STAND REDUCING INSECTS**

### **Cutworms**

There are a number of species of cutworms which are variable in color. All have a hardened shield on top of the body behind the head. Cutworms are active just under the soil surface and will curl into a ball if disturbed (not to be confused with white grubs, or Japanese beetle grubs, which are C-shaped). Cutworms can attack seedling plants by girdling or cutting through young stems. Some cutworms, such as the dingy cutworm, also prefer to lay eggs in soybean fields, and can contribute to high populations in corn if it follows in the rotation.

## **Seedcorn Maggot**

The larvae are typical maggots, less than 1/4 inch long, legless and cylindrical, tapering to a point at the head, dirty-white to creamy-yellow in color. Seedcorn maggots feed underground on cotyledons and can also burrow into seeds. Damage from this insect is accentuated when cool, wet weather delays sprouting and emergence. The adult flies, similar to house flies, are attracted to decaying organic matter.

## **White Grubs**

White grubs are white to cream-colored C-shaped grubs (1/4 inch to 1 1/4 inches long) that feed on the fibrous roots of soybeans. The predominant grubs in Minnesota have a long life cycle of generally 3 years. They attack soybeans following sod throughout the state. In western Minnesota one species may attack soybeans in sandy soil near cottonwoods, poplars, or willows. Their root pruning can lead to stunting and death of plants. No rescue treatments are available and soil insecticides are labeled for white grubs in soybeans. If a problem is anticipated, or if abundant grubs are detected at tillage, consider planting corn with a soil insecticide.

## **Wireworms**

Wireworms are rarely a problem for soybeans, but they can attack germinating seeds and the soft, underground part of the stem. Damage has been reported when soybeans follow sod, such as pasture or Conservation Research Program (CRP) land that was reclaimed for crop production. Low-lying areas of fields already in production can also experience problems, particularly if weather after planting is cool and wet enough to delay germination. Seed treatments are typically recommended in these higher-risk situations.

**Leaf-feeding insects** remove or damage leaves, which may affect future growth, pod-set, or pod-fill. Examples of defoliating insects include grasshoppers, bean leaf beetles, and several caterpillars (green cloverworms, yellow woollybears, thistle caterpillars or webworms). Each defoliating insect produces a unique type of feeding damage. In contrast, the potato leafhopper uses its piercing/sucking mouthparts to damage leaf plumbing. Two-spotted spider mites suck out leaf cells.

Leaf feeding is initially obscure but may rapidly escalate. Defoliation always appears worse than the resulting yield loss, because soybean canopies have more leaf area than they need to produce a good bean crop. The impacts of insect defoliation on yield can be estimated from hail loss tables. (See Evaluating Hail-Damaged Soybeans.)

**Table 2. Yield Loss (%) from Soybean Defoliation**

<i>Growth Stage</i>	<i>% Defoliation</i>									
	10	20	30	40	50	60	70	80	90	100
VE-V4	-	-	1	3	4	5	6	7	13	20
V5-12	-	1	2	4	5	6	7	9	15	22
R1-2	-	2	3	5	6	7	9	12	16	23
R2.5	1	2	3	5	7	9	11	15	20	28
R3	2	3	4	6	8	11	14	18	24	33
R3.5	3	4	5	7	10	13	18	24	31	45
R4	3	5	7	9	12	16	22	30	39	56
R4.5	4	6	9	11	15	20	27	37	49	65
R5-5.5	4	7	10	13	17	23	31	43	58	75
R6	1	6	9	11	14	18	23	31	41	53

**Source: NCIA Soybean Loss Instructions #6302**

Keep in mind that hail is a one-time event, whereas ongoing insect defoliation or mite injury at the same level causes more yield loss. Factors affecting good canopy formation, such as drought, disease, or stand loss will accentuate defoliation impacts on yield. Soybean susceptibility to defoliation also varies with growth stage. The greatest susceptibility occurs during pod-fill.

**Table 3. Action thresholds for adult and nymphal grasshoppers**

Rating	<i>Nymphs/yd<sup>2</sup></i>		<i>Adults/yd<sup>2</sup></i>	
	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threat	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very severe	200+	120+	80+	29+

**WARNING:** Do not overreact to insect defoliation. Carefully examine the extent of defoliation that has actually occurred. Make sure the insect infestation has not matured before committing to an expensive (and useless) insecticide application.



## LEAF FEEDING INSECTS

### *Bean Leaf Beetle - see Pod Feeding Insects*

### Grasshoppers

Grasshopper populations develop during dry springs following long, warm autumns. Under moderate or high moisture, fungal diseases normally keep grasshopper populations in check. Grasshoppers tend to prefer to lay their eggs in untilled soil, such as roadsides and ditches. Damage, therefore, will likely first occur at the margin of fields. An exception is soybeans planted in last years soybean or alfalfa fields; certain grasshopper species will lay eggs in both cropping systems. Grasshopper nymphs look very much like adults, but lack fully developed wings. Grasshoppers feed on leaves and, as soybeans mature, on developing pods.

Scouting for grasshoppers should start early in the growing season (late April, early May), because early detection is often instrumental in control. Scouting should start at field edges, fence rows, dirt roads, and ditches. Consider field-edge applications unless grasshoppers occur throughout the field. Thresholds can be based on either grasshopper numbers or soybean defoliation. Thresholds based on grasshopper populations can be estimated by scouting the field (see Scouting) and treatment decisions made according to Table 1. Thresholds based on defoliation include treating when defoliation inside the field exceeds 30% prebloom, or 20% blooming-to-pod-fill. (Be aware that certain species of grasshoppers will lay eggs in soybeans and alfalfa.)

**Table 4. Summer phenology of 3 major cropland grasshoppers in Minnesota**

	<b>May</b>	<b>June</b>	<b>July</b>	<b>August</b>
<b>Grasshopper</b>	early/mid/late	early/mid/late	early/mid/late	early/mid/late
<b>Two-striped</b>	(adult)			(nymph)
<b>Redlegged</b>	(nymph)			(adult)
<b>Differential</b>	(nymph)		(adult)	

### Green Cloverworm

This migratory moth is common throughout the soybean-growing areas of the eastern United States and the Great Plains, but seldom reaches pest status. The caterpillar is green with white and typically has two generations per year. Because it attacks early in the season, however, plants usually compensate for foliage loss before pods are set. Many entomologists consider the green clover worm a valuable food source for beneficial insects and diseases. This reservoir of beneficials often controls pests of

more economic importance later in the season. Treat only if defoliation reaches 40% in prebloom, 20% during bloom and pod-fill, and 35% from pod-fill to harvest.

### **Japanese Beetle**

The Japanese beetle has a wide variety of plant hosts and will attack soybeans both early and late in the growing season. A soybean-feeding variant does not occur in Minnesota at this time. Adult beetles feed on foliage, skeletonizing the leaves. They are long, have a hard shell, are metallic green, and have bronze-colored wing covers. Small white squares (actually tufts of hair) are visible around the outside edge of the wing covers.

### **Potato Leafhopper**

Potato leafhoppers are very small (~1/8 inches), wedge-shaped insects. They are bright green, quick moving, and have piercing/sucking mouthparts. When feeding, they inject a toxic saliva which causes localized stippling, yellowish to reddish-yellow discoloration of leaves (especially at the tips), leaf crinkling and cupping. This injury may appear similar to herbicide damage. Extensive feeding damage can result in plants that are stunted. The thick pubescence on soybean leaves tends to prevent this small insect from getting close enough to implant its mouthparts. However, young plants without heavy pubescence are vulnerable to leafhopper attack. Stressed plants are also more vulnerable to injury from potato leafhopper than are healthy plants. In addition, due to this insect's host preference, soybean fields adjacent to alfalfa fields should be considered at a greater risk from potato leafhopper infestation due to movement when alfalfa is cut. Scout for potato leafhopper by examining fields with two trifoliolates or less, and treat if populations exceed 1/plant at V2, or if seedling plants with dying leaves are present.

### **Saltmarsh and Woollybear Caterpillars**

These hairy, robust caterpillars may be white or multicolored, solid, or banded. They often feed in the upper canopy where they are noticeable, so populations are frequently overestimated. Smaller larvae tend to feed in the lower canopy or on the underside of leaves, so early infestations can go unnoticed. This insect is only an occasional problem in Minnesota, except for drought years.





## **Two-spotted Spider Mites**

In most years, spider mite populations are kept in check by fungal diseases and predators. Both mortality factors require cooler temperatures and higher humidities. In very warm, dry years spider mite populations can rapidly increase and cause widespread damage through soybean fields. Early infestations will kill soybeans, while later infestations cause premature senescence and reductions in yields up to 40%-50%. Soybeans planted next to alfalfa are at high risk during favorable mite conditions, and should be scouted first. Look for stippling and bronzing of soybean leaves. Fully grown adult mites will be barely visible to the naked eye on the underside of leaves, while younger stages will have to be observed with a hand lens. Treat only in outbreak conditions when mites are present throughout the field, and stippling is present on leaves. Reinfestations may occur because some of the insecticides used may not be effective against eggs. The eggs will hatch in several days, and the infestation may begin again, so continued scouting is recommended. Border-treating fields may be effective if the problem is caught early enough. Be advised that if an outbreak has occurred, subsequent rain alone may not solve the problem of spider mite infestations, because the fungal diseases which attack them will be too late.

## **Thistle Caterpillars**

The caterpillars of the painted lady butterfly rarely cause problems in soybeans unless an unusually large spring migration of the butterflies occurs from the U.S. desert Southwest or Mexico. The caterpillars are commonly found on thistles, but will also attack early vegetative soybeans. The larvae (up to 1.5 inches long) feed on the top leaves and web them together with silk. Their appearance is quite distinctive. The body is black with yellow spots and has numerous multi-pronged spines. Treatment is recommended if defoliation exceeds 50%.

## **Webworms**

These are green caterpillars with 3 dark spots arranged in a triangle on the side of each body segment. At least one hair originates from each spot. The larvae web leaves with silk, and skeletonize leaves by feeding. This insect is rarely a problem in Minnesota, and has never reached economic threshold levels here.

Pod-feeding insects attack developing pods, or even cut pods off the plant. Examples include grasshoppers and bean leaf beetles. Because the soybean's investment in yield is nearly completed, this type of attack is the most destructive. Pod-feeding is difficult to anticipate. Equivalent

infestation levels may or may not produce economic loss. Assessment of seed damage or pod loss can indicate when to treat an infestation. However, this approach can only prevent further losses from that point on. Table 3 provides an indication of the seed destruction required for economic loss. To convert to pod loss, divide by the number of seeds per pod (e.g. 3).

Market Price (\$)	\$5/bu				\$6/bu				\$7/bu			
	7	8	9	10	7	8	9	10	7	8	9	10
Row width = 7"	3	3	3	4	2	2.5	2.8	3.2	1.9	2.2	2.4	2.7
15"	6	7	7	8	5	5.4	6.1	6.7	4.1	4.6	5.2	5.8
22"	8.5	9.8	11	12.2	7.1	8.1	9.1	10	6.3	7	7.8	8.7
30"	11.3	13	14.6	16.2	9.4	10.8	12.1	13.5	8.1	9.3	10.4	11.6
36"	13.6	15.5	17.5	19.4	11.3	13	14.6	16.2	9.7	11.1	12.5	13.9
38"	14.4	16.4	18.5	20.5	12	13.7	15.4	17.1	10.3	11.7	13.2	14.6
40"	15.1	17.3	19.4	21.6	12.6	14.4	16.2	18	10.8	12.3	13.9	15.4

*Adapted from Purdue Corn and Soybean Field Guide. Based on 141,000 beans per bushel.*

## POD FEEDING INSECTS

### Bean Leaf Beetle

These small (1/4 inch) yellowish-buff to reddish beetles usually sport four distinct black spots on their back. A small proportion of the beetles lack spots, but all color forms have a black triangle at the base of the wing covers. The bean leaf beetle attacks soybeans throughout the growing season. Overwintering adults colonize early-emerging soybean fields, but beetle feeding on cotyledons and unifoliolate leaves does not reach economic threshold. There is one generation in the north and two in the south of Minnesota per year. Larvae feed underground on soybean roots and nodules, but this feeding does not appear to affect yield. Emerging adults from the first generation feed on soybean leaves in July and should be treated if defoliation exceeds 35% and beetles are still feeding. Adults from the second generation should be treated in late August if defoliation exceeds 25% during pod-set and pod-fill. These adults also feed on pods, which affects seed development and allows disease entry. Consequently, these beetles should be treated if damaged pods exceed 10%, or if adults exceed 0.5 per plant, during pod-fill. Heavy populations should be watched closely and treated aggressively if pod clipping is noted.



Table 6. Economic thresholds for Bean Leaf Beetle at pod-fill (# per acre)

Market Value (\$ / bu)	Management Costs (\$ / acre)					
	7	8	9	10	11	12
5	95.8	109.8	156.8	174.2	191.7	209.1
6	80.2	90.6	102.8	113.3	125.5	135.9
7	68.0	76.7	87.1	97.8	106.3	116.7
8	61.0	69.7	78.4	87.1	95.8	104.5
9	54.0	61.0	69.7	76.7	85.4	92.3
10	48.8	55.8	62.7	69.7	74.9	81.9

**Grasshopper** - see Leaf-Feeding Insects

## **INSECT INTERACTIONS OF SOYBEANS WITH OTHER CROPS**

### **Cutworms**

Dingy cutworm and black cutworm problems in corn are more severe following soybeans. Dingy cutworms prefer laying eggs in soybeans and alfalfa when adults are active in August and September. Consequently, crops following soybeans have a higher risk of attack from this cutworm. The black cutworm migrates north each spring. Arriving moths lay eggs in crop and weed residue, and soybean residue is a preferred egg-laying site. The timing and extent of tillage have important implications for risk of cutworm attack. Ridge-till and no-till corn after soybean often have the most severe infestations.

### **Stalk Borer and Giant Ragweed**

Giant ragweed has emerged as a weed control problem in some soybean herbicide programs. This weed is a preferred egg-laying site for stalk borers. Corn planted the next year may suffer severe infestations, particularly if the weed control program in corn forces any stalk borers in giant ragweed into corn. While stalk borers are more commonly recognized as an insect problem in corn, they may also attack soybeans.

### **Crop Rotation and Corn Rootworms**

Rotation to a non-corn crop, such as soybeans, is a highly-preferred and effective way to avoid corn rootworm problems. Recently, corn rootworms have demonstrated their capability to survive crop rotation. The northern corn rootworm retains its egg laying preference for corn, but a larger proportion of eggs overwinter two or more years. The western corn rootworm has shifted its egg laying to soybeans in the eastern portion of

the corn belt (Illinois, Indiana, Ohio, Michigan). These problems could affect crop rotations throughout the corn belt, including Minnesota.

Insects cause sporadic and localized outbreaks in Minnesota soybeans. Yield losses may occur through stand reductions, defoliation, and pod feeding. Because outbreaks are infrequent, growers and crop advisors may fail to recognize or diagnose an emerging outbreak. The critical times to scout soybeans for insect problems include the first two weeks of emergence for stand loss problems, late July and August for defoliation, and late August and September for pod feeding. Learn to recognize the insects and their injury symptoms. Check your fields as often as you can. Stay alert for reports of soybean insect problems anywhere in Minnesota or neighboring states.

**Table 7. Soybean insecticide recommendations**

Insect	Product - Rate/Use	Applications
Bean Leaf Hopper	Ambush 2E <sup>®</sup> - 1.2-5.4 fl.oz. Asuma XL <sup>®</sup> - 5.8-9.6 fl.oz. Lambert 4E - 1-3 pt. Pounce 3.2E <sup>®</sup> - 2-4 fl.oz. Sovis XLR Plus - 0.5-1 qt. Warrior <sup>®</sup> - 1.93-3.29 fl.oz.	60 day pht. Notes 1,2 21 day pht. Notes 1,2 28 day pht. Notes 2,3 60 day pht. Notes 1,2 0 day pht. Storage, gleaning. Notes 2,4 45 day pht. Do not gress or harvest storage, straw or hay for livestock feed. Do not apply more than 0.48 pt. per acre per season.
Blister Beetles	Sovis XLR Plus - 0.5-1 qt. Warrior <sup>®</sup> - 1.93-3.29 fl.oz.	0 days pht. Storage, gleaning. Notes 2,4 45 day pht. Do not gress or harvest storage, straw or hay for livestock feed. Do not apply more than 0.48 pt. per acre per season.
Greenhopper	Asuma XL <sup>®</sup> - 5.8-9.6 fl.oz. Olanthione 4E - 1 pt. Pounce 4E <sup>®</sup> - 0.25-0.5 pt. Lambert 4E - 0.5-1 pt. Sovis XLR Plus - 1-1.5 qt. Warrior <sup>®</sup> - 1.93-3.29 fl.oz.	21 day pht. Notes 1,2 21 day pht. Note 1 21 day pht. Note 1 28 day pht. Notes 2,3 0 day pht. Storage, gleaning. Notes 2,4 45 day pht. Do not gress or harvest storage, straw or hay for livestock feed. Do not apply more than 0.48 pt. per acre per season.
Bean Leafhopper	Ambush 2E <sup>®</sup> - 1.2-5.4 fl.oz. Asuma XL <sup>®</sup> - 5.8-9.6 fl.oz. Pounce 3.2E <sup>®</sup> - 2-4 fl.oz. Warrior <sup>®</sup> - 1.93-3.29 fl.oz.	60 day pht. Notes 1,2 21 day pht. Notes 1,2 60 day pht. Notes 1,2 45 day pht. Do not gress or harvest storage, straw or hay for livestock feed. Do not apply more than 0.48 pt. per acre per season.
Green Cloverworm	Ambush 2E <sup>®</sup> - 1.2-5.4 fl.oz. Asuma XL <sup>®</sup> - 5.8-9.6 fl.oz. Lambert 4E - 0.5-1 pt. Pounce 3.2E <sup>®</sup> - 2-4 fl.oz. Sovis XLR Plus - 0.5-1 qt. Warrior <sup>®</sup> - 1.93-3.29 fl.oz.	60 day pht. Notes 1,2 21 day pht. Notes 1,2 28 day pht. Notes 2,3 60 day pht. Notes 1,2 0 day pht. Storage, gleaning. Notes 2,4 45 day pht. Do not gress or harvest storage, straw or hay for livestock feed. Do not apply more than 0.48 pt. per acre per season.
Blackstem Caterpillar	Ambush 2E <sup>®</sup> - 1.2-5.4 fl.oz. Asuma XL <sup>®</sup> - 5.8-9.6 fl.oz. Pounce 3.2E <sup>®</sup> - 2-4 fl.oz. Sovis XLR Plus - 0.5-1 qt.	60 day pht. Notes 1,2 21 day pht. Notes 1,2 60 day pht. Notes 1,2 0 day pht. Storage, gleaning. Notes 2,4 45 day pht. Do not gress or harvest storage, straw or hay for livestock feed. Do not apply more than 0.48 pt. per acre per season.

	Wyper® - 1.92-3.20 gals.	less than 0.44 gal. per acre per season.
Small Grain Maggots	High risk fields include those planted into tilled soil or fields, or soils with high levels of decomposing organic matter. Check fields prior to planting to determine if seed treatment is required.	
Two-spotted Spittlebug	Disulfoton 4E - 1 pt. Lorsban 4E - 0.5-1 pt. Wyper® - 1.94-3.20 gals.	21 day ph. Note 3 30 day ph. Note 2,3 43 day ph. Do not graze or harvest forage, straw or hay for livestock feed. Do not apply within 0.44 gal. per acre per season.
Wireworms	High risk fields similar to seed corn maggot. Check fields prior to planting with color ball trays to determine if seed treatment is required.	

\* Restricted use pesticide

\*\* All pesticides listed labeled for use in 1998. Check the label and your county extension office for current registration information.

- 1 Do not feed or graze livestock on treated plants
- 2 May be applied through sprinkler irrigation systems (see label).
- 3 Do not graze or feed treated forage, hay, or straw. Do not apply less than 2 months prior to 14 days prior, nor apply more than 6 pints per acre per season.
- 4 Do not apply a combination of this product and 2,4-D herbicides to soybeans as crop injury may result.
- 5 Do not graze or feed within 3 days of last application.

**ALWAYS read the label!**

There are numerous sources for information on soybean insects on the Internet. When using the Internet for information it is important to be aware that some of the information may be coming from commercial sites, and that not all sites will have information that relates to your geographical area. Some Internet sources that have information that might be useful in Minnesota are:

The Wisconsin Crop Manager at

<http://ipcm.wisc.edu/wcm/insects.html>

The Illinois Soybean Association at <http://www.ilsoy.org>

Iowa State Extension's Insect & Mite Publications at

<http://www.ipm.iastate.edu/ipm/icm/indices/insectsandmites.html>

The Northern Plains Cropbase at <http://www.mnipm.umn.edu/>

A searchable database of Extension factsheets by region can be found at <http://www.hcs.ohio-state.edu/factsheet.html>

Ken Ostlie

Department of Entomology

University of Minnesota Extension

(612) 624- 7436

[kostlie@extension.umn.edu](mailto:kostlie@extension.umn.edu)

Ian MacRae

Department of Entomology

University of Minnesota

Northwest Experiment Station

(218) 281-8611

[imacrae@mail.crk.umn.edu](mailto:imacrae@mail.crk.umn.edu)



UNIVERSITY OF MINNESOTA  
EXTENSION

# SOYBEAN INOCULATION

## OVERVIEW

The soybean plant is a legume, and is therefore capable of manufacturing the nitrogen needed for growth and development from the nitrogen gas (N<sub>2</sub>) in the atmosphere. This occurs when there is an active cooperative working relationship between the soybean plant and the rhizobia bacteria. The transformation of atmospheric N to N used by the plant is referred to as N<sub>2</sub> fixation.

The management practice of inoculating the seed just prior to planting is used to help to ensure that this cooperative relationship will take place in soils. Where soybeans have been grown, the soil itself probably already contains abundant rhizobia. However, this native soil population of rhizobia is probably less effective in N<sub>2</sub> fixation than the strains added via seed inoculation.

## INOCULATING SOYBEANS

Replacing the native soil-derived rhizobia with an improved strain of rhizobia is an attempt to place the more effective rhizobia close to the seed. The rhizobia from the seed inoculant have an advantage around the seed. However, the native soil rhizobia will be more numerous in the bulk soil. Some research has shown a yield increase of 1.5 to 2.0 bushels per acre resulting from seed inoculation where soybeans have been grown previously in rotation. In general, the measured yield increases have been highly variable.

Studies have shown that rhizobia can be found in soils 15 years after inoculation. However, one should inoculate if a crop of soybeans has not been grown in a given field for four years.

Several conditions will also affect the development of nodules on the soybean root system. Some of these conditions are: 1) low soil pH (less than 5.5), 2) high soil temperature, 3) drought, and 4) seed treatments which put inoculant rhizobia in contact with fungicides or molybdenum. Inoculation of the soybean seed is a recommended management practice every time when planting soybeans in the Red River Valley of Minnesota. This practice will help to ensure active nodule formation on the roots and reduce the potential for yield reduction caused by iron chlorosis.

## **INOCULATION PROCEDURES**

The inoculant supplying the rhizobia can be applied: 1) to the seed at planting, 2) in the seed furrow with the seed, 3) below the seed, or 4) watered into the soil after planting. The most commonly suggested method for inoculation is to mix the inoculant with a sticker such as corn syrup, sugar solution, or milk and then apply this mixture of inoculant and sticker to the soybean seed. Because of a concern for time, there is a tendency for many to dribble the inoculant onto the seed in the planter box. This is not a desirable practice when nothing is done to ensure the sticking of the inoculant to the seed. To make the inoculation process easier, some companies now produce seed inoculant preparations with the sticker already added.

Inoculants may be purchased as: 1) with sterile peat as a carrier, 2) with non-sterile peat as a carrier, 3) a liquid preparation, and 4) a clay based formulation. At this time, there has been little research to document the comparative effectiveness of these various formulations.

Research has shown that high levels of nitrate-nitrogen (NO<sub>3</sub>-N) in the soil, or the addition of high rates of nitrogen fertilizer, can inhibit nodule formation as well as reduce nitrogen fixation by nodules which are already formed on the plant. When high soil N levels or high rates of fertilizer N at the beginning of the growing season limit nodulation and nitrogen fixation, the N supplied by the soil without nodulation may not be adequate to meet the nitrogen requirements of the soybean crop throughout the growing season. Yields are reduced when this occurs. Therefore, pre-plant nitrogen fertilizers and nitrogen applied during the growing season are not recommended practices for soybean production in southern Minnesota.

Research with soybeans grown in the Red River Valley has shown that the application of pre-plant nitrogen fertilizer has increased the yield of both inoculated and non-inoculated soybeans. This is especially true when a measurement of residual NO<sub>3</sub>-N shows less than 75 pounds N per acre in the 0 to 24 inches of soil. The amount of nitrogen fertilizer needed in this region is not well defined. At the present time, a rate of 75 to 100 pounds N is suggested for pre-plant applications in the region.

Good nodulation is essential for a high-yielding soybean crop. Inoculation of the seed at planting will ensure nodulation unless there is an excessive amount of nitrogen in the soil. With the frequency of soybeans grown in the corn/soybean rotation, there is no evidence that inoculation is necessary for soybean production in southern Minnesota. However, this practice could prove to be very beneficial for soybean growers in the Red River Valley.

George Rehm  
Department of Soil, Water, and Climate  
University of Minnesota Extension  
(612) 625-6210  
[grehm@soils.umn.edu](mailto:grehm@soils.umn.edu)

John Lamb  
Department of Soil, Water, and Climate  
University of Minnesota Extension  
(651) 625-1772  
[Jlamb@soils.umn.edu](mailto:Jlamb@soils.umn.edu)

Mike Schmitt  
Department of Soil, Water, and Climate  
University of Minnesota Extension  
(612) 625-7071  
[schmi009@tc.umn.edu](mailto:schmi009@tc.umn.edu)





# DISEASE MANAGEMENT

## OVERVIEW

A serious problem for Minnesota soybean producers is underestimation of disease-incurred yield reductions. This portion of the **Field Book** lists and describes diseases one should recognize in order to increase soybean profitability.

### **Sclerotinia Stem Rot** *Sclerotinia sclerotiorum*

Flower petals are infected and mycelium colonizes the stem and pods. Stem tissue becomes tan or white and may be covered with white mycelium and black sclerotia (round, oblong, hard, black structures). The top of the plant dies and turns brown. This is often the first symptom observed. Stem lesions may increase lodging. Sclerotia on the stem fall to the ground and others inside the pith are released when seed is harvested. Sclerotia can be found with the seed. The fungus survives winter as a sclerotia and can remain alive in soil for many years. Sclerotia germinate in warm/wet spring, summer, or fall periods and release spores that are wind-borne. Soybean infection requires moisture on the flower petals, and is favored by closely-spaced plants that form a dense canopy early.

### **Phytophthora Seedling Blight Root, and Stem Rot** *Phytophthora megasperma*

Symptoms include stand reduction, root rots, and basal stem decay. Seed rot and pre-emergence damping-off are often credited to water damage. Taproots are usually dark brown, and small feeder roots are rotted or missing, on plants that survive the seedling phase. Stem discoloration, dark brown surface from the soil line up 6 inches, is less common on more tolerant/resistant varieties. Leaves on older plants become chlorotic, stunted and may wilt, die, turn brown, and remain attached to the plant for some time. This fungus survives as an “oospore” in infected crop debris. The oospore germinates in wet soils and releases many “zoospores” that swim to developing soybean roots and infect. Disease and infection is favored by wet conditions and soil temperatures near 60°F. Low, poorly drained compacted soils, or soils with high clay content, or sites that are normally well-drained but wet, increase disease severity.

### ***Pythium* Seed Decay, Seedling Blight and Root Rot** *Pythium* species

Seed rotted in soil, commonly soft, wet, and overgrown by other fungi are usually killed before emergence by this fungus. Rapid death prevents accurate diagnosis. Roots are brown, watery, soft and often completely decayed. Limited infection may produce brown lesions on roots, hypocotyl, or cotyledons. Death of meristem tissue may result in a swollen hypocotyl. These species are often called “Water Molds.” They survive in soil and in plant residue. Cool (50°F to 60°F) and wet soils favor release of “swimming” spores and infection develops rapidly. Younger seedlings are most susceptible because soybeans become more resistant as they age.

### ***Rhizoctonia* Root Rot and Lower Stem Decay** *Rhizoctonia solani*

Post-emergence damage is a bigger problem than is pre-emergence death. Root symptoms are confined to lateral root decay and outer root surface damage only. A red-brown discoloration of the hypocotyl and lower stem does not extend above the soil line. Slow growing plants are damaged most, and symptoms, wilting, and death develop following warm, dry weather early in the season. This is another soil inhabitant that survives in soil as sclerotia or as “resting” mycelium in crop residue. Infection is favored by wet and cool conditions followed by warm and dry periods that stress the plant. Young plants are most susceptible, but stressed older plants may die if moisture is limited.

### ***Fusarium* Root Rot** *Fusarium oxysporum* & other *F.* species

A problem on seedlings and young plant roots that develop in wet, cool soils, below 58°F. Seedling growth can be slowed and plants usually are stunted and weak. Infection is often limited to lower taproots, and lower lateral roots which may be destroyed. New roots can develop from the upper taproot providing a shallow fibrous root system that is prone to fail in dry soils. The vascular system can be affected, turns brown or black, and this increases late season plant wilt under moisture limiting conditions. Stress from soybean cyst nematodes, or other nematodes, and DNA herbicides predispose plants to infection. These soil born-fungi survive as chlamydospores and as mycelium in plant residues. *Fusarium solani*, reported to be the cause of **Sudden Death Syndrome (SDS)**, has been reported to be near Minnesota, but isolates of this “Blue Strain” from Minnesota soils have not been confirmed to be like the isolates from Iowa or Illinois. Symptoms of SDS are interveinal chlorosis, necrosis, and leaf defoliation. Petioles remain firmly attached. The central pith (when stems are split) should be white with no discoloration or decay. It is believed that certain isolates produce a toxin that translocates to the upper leaves

causing the above symptoms. Others report this fungus can be isolated from cyst nematodes.

### **Brown Stem Rot** - *Phialophora gregata*

Root infection precedes discoloration of water conducting vessels and at mid-season the vascular elements and stem pith show a reddish-brown color. The brown color develops first at the stem base and moves up, often most evident at nodes. Yield reduction increases with greater discoloration. Leaf symptoms develop later in the season. Look for wilt, interveinal browning and green tissue over the vein, leaf drying, and early leaf drop. Plants do not mature normally, and appear to be frost damaged. This fungus survives in crop debris and increased inoculum levels are reported following tolerant varieties. Cool weather leads to more stem browning and warm dry conditions increase foliar symptoms, especially during the reproductive stage.

### **Pod and Stem Blight and Seed Decay** -*Diaporthe phaseolorum var. sojae*

Linear rows of brown to black fruiting bodies, “pycnidia,” are seen on stems, but are scattered on pods. Infection of healthy plants is common, but the pycnidia are produced only on dead or dying tissue. Seeds in infected pods have a white, moldy growth, are wrinkled, smaller, and germinate poorly. Seed infection tends to be greater when warm wet or humid weather delays harvest. Plants that are killed early, or plants that are harvested late in wet or warm humid late summer, often have pycnidia present. Infected seed can produce infected plants, but most infection comes from inoculum in infested crop residue. Spores splash on plants during wet weather and infection is favored by injuries, hail, or lesions caused by other pathogens.

### **Anthracnose** *Colletotrichum truncatum* & *C. destructivum*

Symptoms appear at early reproductive stages on stems, pods, and petioles. Watch for leaf rolling, petiole cankers, veinal necrosis, and early leaf drop. Stem and pods have black fruiting bodies, “acervuli,” with black hairs, “setae.” Seed are shriveled, moldy, and stained brown or dark. Early season infection can be from seed inoculum, while infection during flowering is mostly from infected plant residue. High plant populations and wet canopies favor disease development.



**Bacterial Blight** *Pseudomonas syringae*

Small, angular, water-soaked spots on leaves turn red-brown to black as tissue dies and dries. Spots may have a water-soaked margin and a yellow halo. As leaves grow and flex, dead tissue falls out, and leaves may appear tattered and ragged. Seed may be colonized, becoming shriveled with sunken, discolored lesions. Infected soybean residue or seed borne inoculum is spread to plants by wind-driven rains. Early infections may appear severe, especially in wet weather, but hot dry conditions stop disease development.

**Brown Spot** *Septoria glycines*

Primarily an early season leaf disease. Cotyledons, primary leaves and lower trifoliolates show brown to red pinpoint spots up to 1/4 inch. Some may grow together and become irregularly shaped spots. Look for black dots, “pycnidia,” in center of mature spots. Severe infection can cause leaves to yellow and drop early, especially the lower canopy. Spores are splashed or wind blown to wet leaves, mostly in mid-spring. It can develop in warm moist periods at any time. Hot, dry weather stops this disease, but it can develop again before plants mature.

**Purple Seed Stain and Leaf Blight** *Cercospora kikuchii*

Seed discoloration varies from pink to pale or dark purple and the area affected ranges from specks to blotches, possibly the entire seed coat. Infected seed may not show symptoms, but infected cotyledons shrivel, turn dark purple, and drop early. Plants can be killed or stunted. This fungus survives as mycelium on the seed coat or on crop residue. Spores from infected seed cotyledons are splashed or wind-borne to leaves and stems. Small, red-purple, angular lesions develop on both sides of sun-exposed upper leaves during seed set. Leaf symptoms begin as a light purple color that extends over the leaf and develops a leathery appearance. Infection is favored by high temperatures (80°F plus) and humid conditions.

**Downy Mildew** *Peronospora manshurica*

Pale green to light yellow spots on the upper surface of young leaves which, may enlarge, forming bright yellow lesions of indefinite size. Older infected spots turn gray-brown. Spots on the lower leaf surface, especially in moist weather, have tufts of gray mycelium and spores easily seen with a lens. Older leaves are more resistant, but young leaves are susceptible. Pods may be infected without any symptom, and seeds are partly or

completely covered by white mycelia and oospores, which are easy to see. Seed from infected pods may be smaller and have cracks in the seed coat.

### **Powdery Mildew** *Microsphaera diffusa*

White powderlike patches of mycelia and conidia are seen on all above-ground plant parts. Additional symptoms develop on some susceptible varieties, such as chlorosis, green islands, rusty patches, and defoliation. Disease develops in cooler than normal years with reduced plant growth.

### **Stem Canker** *Diaporthae phaseolorum var caulivora*

Infection symptoms develop during early reproductive stages at nodes as a small red-brown lesion. Over time, the lesion expands, forming a darker brown, elongated sunken canker. Leaf tissue yellows between the veins and, with reduced water flow, death of leaves is common. At times, top growth ceases and a shepherd's crook curl develops. Girdling and toxin production are responsible for symptoms and death. Symptoms in Minnesota often are field and seedlot specific, and may have resulted from seed contamination. However, the fungus is reported to survive on infested debris. Most soybean cultivars can be infected, but only those that are susceptible allow the disease to develop.

## **Virus Diseases**

Large numbers of viruses infect plants, and soybeans, have more than a hundred virus or virus strains reported. New virus problems are expected to be seen as soybean seed production occurs in many new environments.

### **Soybean Mosaic Virus or Crinkle**

Infected plant leaves are spindly, narrower than normal, have dark green swellings along veins. Plants are stunted, petioles are short, as are the internodes. Infected pods are small, flat, have less hair, and are curved more. Seed germination may be reduced. This virus is seed-borne, can overwinter in perennial weeds, and is spread by aphid species.

### **Bean Pod Mottle**

A mild-yellow mottling is seen on the youngest leaves during rapid growth in cool weather. The mottle disappears as plants mature and plants may be slightly stunted, with distorted foliage, misshapen pods, and smaller seeds. The virus overwinters in legumes, clover, or alfalfa and is spread by insect feeding; especially the bean leaf beetle. Symptoms are masked by high temperatures, and are not seen after pod set.

## **Nematodes**

Large numbers of nematodes exist in soils, but only a few are of economic importance on soybeans. Nematode damage can be direct and/or indirect. Soybean nematode damage is significant and difficult to accurately diagnosis without proper sample collection, including soil and root samples.

### **Cyst Nematode** *Heterodera glycines*.

Low levels of infection can remain undetected for some time as no diagnostic above ground symptom exists. Stunted, chlorotic, vigorless beans with reduced root systems and few nitrogen nodules are typical of low infection levels in high fertility sites. Egg numbers do increase and symptom severity increases, reducing soybean yields. Carefully dig and examine roots for white to tan females containing eggs any time after late June through September. The cysts are spread by soil movement from equipment, or with water or wind. Birds can carry the cysts considerable distances. Most farms have some level of infestation.

### **Lesion Nematode** *Pratylenchus species*.

Lesion nematodes are found world-wide. They attack the root cortex. Roots develop dark lesions and an overall brown color. Loss of the epidermis and cortex decreases root growth nutrient and water uptake. Under stress, plants yellow, become stunted, and have reduced yields.

### **Sting Nematode** *Belonolaimus species*.

Seedlings can be killed, reducing stands. Larger plants are not killed, but appear stunted, chlorotic, and gray-green as if moisture deficient. Small, dark, sunken lesions are present on roots to the tip. Terminal root growth stops and roots appear stubby or have abnormal root proliferation. Damage is usually found in sandy soils. Sting nematodes feed on many host plants, especially grasses, and can also attack corn.

Disease diagnosis assistance is available at the Plant Disease Clinic, 495 Borlaug Hall, 1991 Upper Buford Circle, University of Minnesota, St. Paul, MN 55108-6030, (612) 625-1275. Symptoms you see should be summarized, and representative plant samples such as leaves, stems, and roots should be delivered to the clinic soon after collecting. (Some field symptoms are not conclusive evidence that a specific disease caused the problem.)

Ward Stienstra  
Department of Plant Pathology  
University of Minnesota Extension  
(612) 625-6290  
[wsteinstra@extension.umn.edu](mailto:wsteinstra@extension.umn.edu)

*\*Please note that in the center section of the Minnesota Soybean Field Book there are 18 full-color photographs of soybean diseases, and their effects on the plants. Photo credits for that section include:*

**University of Minnesota Extension Service**  
**University of Illinois Extension Service**  
**North Dakota State University Extension Service**

W. J. Walla  
R. W. Samson  
W. O. Scott  
G.W. Simone  
J. M. Dunleavy  
W. C. Stienstra



# PESTICIDES

## OVERVIEW

For more complete information about pesticides, pesticide laws and regulations, safe handling of pesticides, and protecting applicators, the public, and the environment see the ***Private Pesticide Applicator Training Manual*** available at your local University of Minnesota Extension Service county office.

“Pesticide” is a broad term that represents many types of chemicals used for pest control. The legal definition of a pesticide, according to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is:

...any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating insects, rodents, nematodes, fungi, or weeds, or any other forms of life declared to be pests; and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Not all pesticides are designed to kill target organisms. Some pesticides interact with the site that pests inhabit. Other pesticides target either the host plant or animal.

## PESTICIDES CLASSIFIED BY FUNCTION

The term “pest control” refers to a pesticide's function, such as preventing, destroying, repelling, or controlling pests.

<b>Pesticide classification</b>	<b>Pests managed</b>
Biocide	Microbial organisms
Fungicide	Fungi
Insecticide	Insects & other related animals
Herbicide	Weeds
Miticide	Mites
Nematocide	Nematodes
Rodenticide	Rodents
Avicide	Birds
Ovicide	Eggs of organisms
Predacide	Vertebrates



**Other chemicals  
classified as pesticides**

**Function**

---

Growth regulator	Modifies plant or insect development
Defoliant	Removes plant foliage
Desiccant	Dries plant foliage
Repellent	Diverts a pest
Attractant	Lures a pest
Pheromone	May attract pests or disrupt behavior
Sterilant	Renders pest unable to reproduce

**PESTICIDES CLASSIFIED BY CHEMICAL GROUPS**

**INORGANIC AND ORGANIC**

Pesticides that are categorized by chemical groups are generally divided first into organic and inorganic pesticides. Inorganic pesticides do not contain carbon and are usually of mineral origin. Most pesticides in use today are organic pesticides. They may be either natural or synthetic. Organic pesticides include naturally occurring chemicals such as botanical and microbial pesticides.

**MODE OF ACTION**

Another way that pesticides may be grouped or classified is by their mode of action in controlling the target pest organism. Generally, pesticides within a chemical class have the same mode of action on specific types of pests. They may also have similar characteristics such as chemical structure, persistence in the environment, and types of formulations. There are a number of pesticide families. For more information about herbicide mode of action see the publication:

Herbicide Mode of Action and Injury Symptoms  
BU-3832-GO  
University of Minnesota Extension Service  
North Central Regional Extension Publication No. 377



## **TYPE OF INJURY**

Several common terms describe how pesticides interact with the site, host plant or animal, target pest, and environment. Certain terms listed below are more appropriate to a specific functional class of pesticide (such as insecticide, fungicide, or herbicide) than others.

### **Broad-spectrums**

Pesticides that control more than one pest are considered nonselective. For instance, where no plant growth is wanted, such as fence rows, ditch banks, and greenhouse floors, a nonselective herbicide may be used.

### **Contacts**

Pesticides that kill pests by touching the pest are known as contact pesticides.

### **Nonpersistent**

Pesticides that control pests at the time of application and then break down quickly are nonpersistent.

### **Persistent**

Persistent pesticides remain active for a period of time after application, giving continued protection against the pest. These may also be referred to as residual pesticides.

### **Protectants**

Pesticides applied to plants, animals, structures, mechanical systems, and products to prevent pest establishment are considered protectants. These may include repellents. Many fungicides are used as protectants and are intended to be applied before or during infection of the host by the pathogen.

### **Selective**

A pesticide is selective if it is effective against one organism and not another. Selectivity can be accomplished through the pesticide's chemistry, timing and/or placement, environmental conditions, and characteristics of the target pest.

## **Sterilants**

Pesticides that manage pests by rendering them incapable of normal reproduction.

## **Systemics**

Pesticides that are absorbed by one part of the animal or plant and distributed internally to other parts of the animal or plant. Systemic pesticides kill the pest without harming the host.

## **PESTICIDES CLASSIFIED BY TYPE OF APPLICATION**

Types of pesticides grouped by methods of application include:

### **Aerial**

Spraying a field from the air to provide better coverage than ground applications.

### **Band**

Placing the pesticide in a strip or band over a row or on the soil next to the row (before or after crop or weed emerges).

### **Broadcast**

Covering an entire field or area with the pesticide (before or after plants emerge).

### **Directed-spray**

Spraying a pesticide directly at the target plants.

### **Early pre-plant**

Applied onto the soil up to a week before planting.

### **Furrow**

Placing an insecticide or fungicide in a narrow line or furrow in the soil directly over the seed at planting time.

### **Foliar**

Applied directly to the above ground parts of a plant.

### **Incorporation**

Soil applied pesticides which are mixed into the soil after or during application.

### **Post emergence**

Applied after weeds or crops emerge from the ground.

### **Preemergence**

Applied on to the soil before or after crop planting, but before crops or weeds emerge from the ground.

### **Sidedress**

Applied alongside the crop row.

### **Soil applied**

Applied directly to the soil.

### **Spot treatment**

Applying a pesticide to a small area or spot in a field.

## **PESTICIDES CLASSIFIED BY FORMULATIONS**

A pesticide product consists of two parts: active and inert ingredients. Active ingredients are chemicals that actually control the pest. Inert ingredients are all other materials in a pesticide product. An active ingredient usually must be "formulated" with inert ingredients in a manner that increases pesticide effectiveness in the field, improves safety features, and enhances handling qualities. Formulations are classified as solids or liquids on the basis of their physical state in the container at the time of purchase.

## LIQUID FORMULATIONS

### **Emulsifiable concentrates** (EC or E)

A concentrate containing a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion.

### **Solutions** (S)

Pesticides which readily dissolve in water or a petroleum-based solvent to form a solution.

### **Ready-to-use** (RTU) **solution**

Products that contain the correct amount of solvent when purchased, requiring no further dilution before application.

### **Concentrate solutions** (C or LC)

Solutions sold as concentrates, which must be further diluted with a liquid solvent before application.

### **Ultra-low-volume** (ULV)

Concentrates which may approach 100 percent active ingredient and designed to be used as is or to be diluted with only small quantities of specified solvents.

### **Flowables** (F or L)

Insoluble finely ground active ingredients mixed with a liquid, along with inert ingredients, to form a suspension. Flowables are mixed with water for application.

### **Aerosols** (A)

Active ingredients mixed with a solvent and applied directly under pressure as fine droplets.

### **Invert emulsions**

Water-soluble pesticide dispersed in an oil carrier.

## **DRY FORMULATIONS**

### **Dusts** (D)

Usually low percentage of active ingredient plus a very fine, dry, inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash and applied dry.

### **Baits** (B)

An active ingredient mixed with food or another attractive substance to attract the pests or is placed where the pests will find it.

### **Granules** (G)

Dusts, but with larger and heavier particles made from an absorptive material such as clay, corn cobs, or walnut shells.

### **Wettable powders** (WP or W)

Dry, finely ground formulations that look like dusts. Usually they must be mixed with water for application as a spray.

### **Soluble powders** (SP or WSP)

Look like wettable powders but, when mixed with water, dissolve readily and form a true solution.

### **Water-soluble packets** (WSP)

Measured amounts of pesticide formulation are packaged in bags that dissolve when they are put into water. Not a specific formulation--rather a package for wettable powders, soluble powders, and gels.

### **Mic s**

Persistent Protectant Microencapsulated formulations are particles of pesticides (liquid or dry) surrounded by a plastic coating. The formulated product is mixed with water and applied as a spray.

### **Water-dispersible granus** Selective Sterilants mics

Like wettable powder formulations, except that the active ingredient is prepared as granule-sized particles and, when mixed in water, the granules break apart into fine powder.

## **OTHER FORMULATIONS**

### **Impregnates**

Active ingredients formulated into plastic, soap, wood, fertilizer, or other hard material.

### **Fumigants**

Form poisonous gases when applied.

## **ADJUVANTS**

An adjuvant is a chemical added to help increase the effectiveness of the active ingredient. Some of the most common adjuvants are surfactants - "surface active ingredients" - that alter the dispersing, spreading, and wetting properties of spray droplets. Common adjuvants include:

### **Wetting agents**

Allow wettable powders to mix with water.

### **Emulsifiers**

Allow petroleum-based pesticides (ECs) to mix with water.

### **Invert emulsifiers**

Allow water-based pesticides to mix with a petroleum carrier.

### **Spreaders**

Allow pesticides to form a uniform coating layer over the treated surface.

### **Stickers**

Allow pesticides to stay on the treated surface.

### **Penetrants**

Allow the pesticide to get through the outer surface to the inside of the treated area.

### **Foaming agents**

Reduce drift or can be used for marking treated sections of the target site.

### **Thickeners**

Reduce drift by increasing droplet size.

### **Safeners**

Reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.

### **Compatibility agents**

Aid in combining pesticides (and fertilizers) effectively.

### **Buffers**

Allow pesticides to be mixed with adjuvants or other pesticides of different acidity or alkalinity.

### **Anti-foaming agents**

Reduce foaming of spray mixtures that require vigorous agitation.

## **READING PESTICIDE LABELS**

**“Always Read and Follow the Label Directions!”**

**“Label directions are legal requirements!”**

Pesticide product labeling is the main method pesticide manufacturers use to communicate with pesticide users. Pesticide labeling is also the ***United States Environmental Agency’s*** primary tool for regulating all aspects of pesticide use. The information printed on or attached to the pesticide container is the label. Labeling includes the label itself, plus all other information you receive from the manufacturer about the product you buy. Pesticide users are required by law to comply with all the instructions and directions for use in pesticide labeling.





## TYPES OF REGISTRATION

Always check the label for registration information. All pesticides sold in the United States must be registered with the US-EPA. All pesticides sold in Minnesota must be also be registered with the Minnesota Department of Agriculture. All pesticides must list both the EPA registration and the EPA establishment numbers. You may also encounter two other types of registration:

- \* ***SLN: Special Local Needs registration***
- \* ***Emergency exemptions from registration***

Supplemental labeling must be provided for each SLN registration. Applicators must have a copy of the SLN labeling in their possession in order to apply the pesticide for that purpose. Emergency exemptions from registration are used when an emergency pest situation arises for which no pesticide is registered. Known as, "**Section 18 exemptions**," these registrations are handled by the highest governing official involved - usually a state governor or federal agency head.

## INFORMATION ON THE LABEL

Pesticide labeling contains basic information that helps users clearly identify the product. Some of these items will be on the front panel of every label by EPA requirements.

Pesticide Name

Brand, trade, or product name

Ingredients statement

Chemical name  
Net contents  
Formulation  
If it is a Restricted Use Pesticide

Directions for Use (sites, pests, type of application, rates, and so on)

Preharvest intervals  
Warnings and Precautions  
Signal Words:

**DANGER/POISON**, with a skull and crossbones, means the product is highly hazardous--just a taste to a teaspoonful taken by mouth can kill.

**DANGER** means the product is either a severe skin or eye irritant or is corrosive.

**WARNING** means the product is moderately hazardous - as little as a teaspoonful to a tablespoonful by mouth could kill an average-sized adult.

**CAUTION** means the product is slightly hazardous to relatively nontoxic - an ounce to more than a pint taken by mouth could kill an adult.

Route of entry/hazards to humans statement  
Personal Protective Equipment  
Safe handling  
First aid  
Environmental hazards  
Physical or chemical hazards  
Reentry intervals or restricted entry intervals  
Storage and disposal

## **PROTECTING THE APPLICATOR**

There are four main routes by which pesticides can enter your body:

*n Dermal exposure (when you get a pesticide on your skin)*

*n Oral exposure (when you swallow a pesticide)\* Inhalation exposure (when you breathe in pesticide vapors or dusts)*

*n Eye exposure*

The highest risk of pesticide exposure resulting in a pesticide poisoning occurs when mixing and loading undiluted pesticide products.

Some pesticides are more toxic than others, but toxicity is not the only factor that creates a poisoning risk. The risk of pesticide poisoning depends on the following conditions:

*n The class of pesticide and the chemical make-up of the pesticide. Some chemical compounds in pesticides are more dangerous to humans than others.*

*n The dosage of pesticide that enters the body. With some pesticides, a very small dose could cause permanent harm or even death.*

*n The amount of time the body is exposed to the pesticide. In general, the longer the exposure, the more harm the poison can do.*

*n The route of entry (the way the pesticide enters the body). For example, one pesticide may be less harmful if it gets on the skin than if it is swallowed.*

Handling a toxic pesticide safely reduces exposure and risk of poisoning. A simple formula to keep in mind is:

$$\text{Risk} = \text{Exposure} \times \text{Toxicity}$$

It is not always easy to tell if an illness is due to pesticide poisoning. Some illnesses (such as heat exhaustion, asthma, the flu, or food poisoning) may show the same symptoms as pesticide poisoning. When someone who handles pesticides becomes ill, however, be aware that pesticide poisoning may be the cause. If you feel ill, think about whether the symptoms occurred before or after you used pesticides. If you need to see a doctor, be sure to mention any pesticides you have used.

### **What to Do if Someone Is Poisoned**

Be prepared! If an accident happens, you need to know exactly what to do. Don't wait for an emergency to find out what to do. Any delay could lead to death. Keep the pesticide label on hand at all times. Have a first aid kit ready. Learn CPR. Post emergency phone numbers next to all telephones. There are three poison centers for Minnesota. They provide information on all types of poisoning. They can be reached 24 hours a day.

***Hennepin Regional Poison Center  
for Minneapolis and nearby counties of Minnesota  
Hennepin County Medical Center  
701 Park Ave.  
Minneapolis MN 55415  
Emergency Phone: (612) 347-3141  
Petline: (612) 337-7387  
TDD (612) 337-7474***

***Minnesota Regional Poison Center  
for East Metro Area of Twin Cities, Greater Minnesota,  
some nearby Iowa counties  
8100 34th Avenue S.  
PO Box 1309  
Minneapolis, MN 55440-1309  
Emergency Phone: (612) 221-2113, (800) 222-1222 (MN Only)***

**North Dakota Poison Information Center  
for Northwestern Minnesota  
MeritCare Medical Center  
720 4th Street North  
Fargo, ND 58122  
Emergency Phone: (701) 234-5575; (800) 732-2200 (ND, MN, SD only)**

## **PERSONAL PROTECTIVE EQUIPMENT**

Wearing protective clothing and equipment when applying pesticides can reduce the risk of pesticide poisoning because it reduces the chance of exposure. If specific clothing such as goggles or a full protective suit is not listed on the label, use the signal words, precautionary statements, and the product formulation as guidelines. The minimum PPE requirements for anyone handling or applying pesticides (pesticide labels often require additional PPE) are:

*n Always wear work clothing with long pants and long sleeves.*

*n Wear unlined, liquid-proof, chemical-resistant gloves; unlined neoprene or rubber boots; and a wide-brimmed hat.*

*n At the very least, in addition to the above, wear a chemical-resistant apron over cloth coveralls when mixing, loading, or handling undiluted pesticides.*

*n Wear liquid-proof, chemical-resistant coveralls or suit with a hood, or wide-brimmed hat if there is any chance of becoming wet with spray.*

*n Wear a respirator when there is a risk of inhaling pesticide vapors, fumes, or dust.*

*n Wear eye or face shields when there is a risk of pesticide coming in contact with the eyes.*

### ***Clothing worn while applying pesticides should be washed every day:***

*n Wear waterproof gloves when handling clothing with pesticides on it.*

*n Wash gloves, boots, aprons, suits, goggles, and respirators with detergent and water. Hang or store away from other clothing. When handling pesticides, rinse gloves before removing from hands.*

*n Empty pesticide granules from cuffs and pockets before washing.*

*n Prerinse or presoak the clothing.*

*n Wash items separate from family laundry.*

*n Wash only a few items at a time. Use the highest water level and longest wash time available on your machine.*

*n Wash items soiled with hard-to-remove pesticides two or three times. This is especially important when clothing is soiled with highly toxic pesticides.*

*n Do small loads with a high water level. Run a second cycle with washers that use less water (such as a front-loading washer).*

*n Use hot water for washing (146 degrees F.).*

*n Use heavy-duty detergents and liquid detergents.*

*n Clean the washing machine by running a complete cycle with detergent.*

*n Line dry clothing. Sunlight helps break down some pesticides.*

*n If undiluted emulsifiable concentrates have spilled on clothing, discard it as washing will not remove enough of the pesticide.*

## **SAFE HANDLING OF PESTICIDES**

### **Storing Pesticides**

Read the label to see if any special steps should be taken before storing the pesticide. Legal requirements for pesticide storage areas may change and the storage of bulk pesticides have additional requirements. Contact the Minnesota Department of Agriculture for current storage regulations.

**“Never keep pesticides where children or unqualified adults can reach them!”**

Store pesticides only in their original containers with the labels intact. The storage area should be a locked room or cabinet where children, unauthorized persons and animals cannot enter. The storage area should have a concrete floor which is impermeable (that is, it will not let fluids

pass through) and easy to wash. One of the best ways to reduce the need for storage is to buy only the amount needed for immediate use.

For complete information about pesticide storage **see *The Private Pesticide Applicator Training Manual*** from the University of Minnesota Extension Service.

### **Disposing of Pesticide Wastes**

Pesticide users are responsible for properly disposing of empty pesticide containers, excess usable pesticides, and waste material that contain pesticides or their residues. Improper disposal of pesticide wastes can create serious hazards for humans and the environment. It is illegal to bury or burn any type of pesticide container in Minnesota.

Minnesota Department of Agriculture sponsors a Waste Pesticide Collection Program and a Pesticide Container Recycling Program. For more information contact your local county extension office or call the Minnesota Department of Agriculture.

***"Be sure to triple rinse, or pressure rinse, all pesticide containers immediately after use!"***

### **Report pesticide spills**

State law mandates that you immediately report incidents involving pesticides, even ones that you may consider minor. This includes leaking containers, spills, exposure, poisoning, motor vehicle accidents, tornadoes, fires, and floods. When you call to report a spill, give the following information: Your name; Where you can be reached; Where the spill is; Type of pesticide; What time the spill occurred; The source of the spill; How much material was spilled (and for how long); Whether the material is spreading; and Nearby surface water or wells.

To report pesticide spills call:

*Minnesota Department of Public Safety  
Division of Emergency Management (DEM) - available 24 hours a day  
Twin Cities call (612) 649-5451 Greater Minnesota call 1-800-422-0798  
Ask the DEM to notify all appropriate state agencies for you, including the  
Minnesota Department of Agriculture.*

***Local emergency response or fire call 911.***

***Here is a list of things to do if a spill occurs:***

1. Act quickly. If a spill occurs, it must be taken care of immediately. Any delay could cause serious contamination.
2. Notify the authorities. In addition to the DEM alert state, county, or local police using 911 if the spill occurs on a public road.
3. Protect yourself. Do not expose yourself to the chemical. Wear protective clothing and equipment as required by the pesticide label.
4. Control the spill. Stop the leak or spill if it is possible to do so safely. If a small container is leaking, put it into a larger container to contain the chemical.
5. Contain the spill. Prevent the spill from spreading if it can be done safely. Keep it in as small an area as possible. Keep it from getting into any body of water, including storm sewers and tile lines. Do not hose down the area.
6. Guard the site. Isolate the contaminated area to keep people away. Rope it off if possible.
7. Clean up the spill. The Minnesota Department of Agriculture will give you guidance and assistance on cleaning up a spill and handling contaminated materials.

**Protecting the Environment**

It is important for applicators to understand what happens to pesticides in the environment and how pesticides pollute water, soil, and air and may affect non-target organisms. Responsible pesticide users know and follow good practices that achieve effective pest management with little risk of environmental damage. Labeling statements may alert you to particular environmental concerns that a pesticide product poses.

Pesticides move in several ways, including:

n In air; through wind or, indoors, through air currents generated by ventilation systems.

n In water; through runoff to surface waters or leaching to ground water.

n In or on objects, plants, or animals (including humans) that move or are moved off-site.

Pesticide drift is the movement by air of pesticides to areas other than the target area of application. Drift can be in the form of a spray, dust, or vapor. Large droplets are less likely to drift than small droplets. Droplets with diameters smaller than 50 microns are likely to drift under normal conditions. The following table shows how drift varies with droplet size.

Distance water droplets drift while falling 10 feet in a 3 mph wind:

<b>Droplet diameter</b>	<b>Classification*</b>	<b>Drift(in microns*) (in feet)</b>
30	Cloud	500
100	Mist	50
200	Drizzle	16
500	Light Rain*	7

- *1 micron = 1/25,000 inch*

Lower pressure and coarse nozzles produce larger droplets with less drift potential. Droplets that are released closer to the ground are less likely to drift, since they are in the air for less time.

### **How to Reduce Drift**

The type of pesticide, the application equipment, and the weather all have an effect on pesticide drift and the damage it causes. When you apply pesticides, think about how you can control drift. Pay attention to each of the factors affecting pesticide drift listed above:

n Use low-volatility formulations.

n Use the proper size nozzle for the job, preferably the largest practical nozzle.

n Operate at the lower end of the rated pressure range of the nozzle.

n Release spray near the crop or soil surface.

n Avoid spraying at high temperatures.

n Spray when the wind is low and blowing away from sensitive crops or sensitive areas.



Pesticides and soils each have certain characteristics that affect leaching into ground water and runoff into surface waters. It is no single characteristic, but their combination, that determines whether a particular pesticide will leach or run off on a particular soil:

1. Characteristics of the pesticide.
2. Characteristics of the site and soils.
3. The applicator's management practices.

Here are some ways to protect water quality:

n First and foremost, the applicator has a responsibility to follow label directions and all Minnesota regulations for handling and applying pesticides.

n Use Integrated Pest Management Practices to avoid unnecessary pesticide use.

n Choose pesticides that have less potential for leaching or for surface runoff, particularly in vulnerable areas.

n Spot spray or band pesticides when possible.

n Keep all pesticide preparation areas, supply tanks, and storage areas at least 150 feet from any water well.

n Use a rinse pad facility or mix, load, and clean application equipment in the field.

n Prevent back-siphoning into wells by installing backflow prevention devices.

n Plant vegetative covers as buffer zones around surface water.

n Report all spills or back-siphonages.

n Determine the soil characteristics at the application site. Soil texture and organic matter content influence chemical movement.



## Pesticide Application Equipment

### *Types of nozzles:*

When choosing a nozzle, think about:

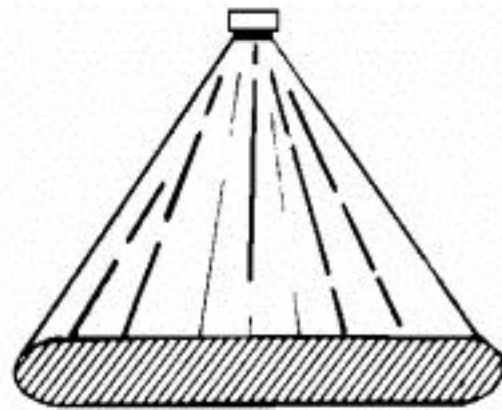
***The size of droplets needed***

***The spray pattern wanted***

***The rate of application***

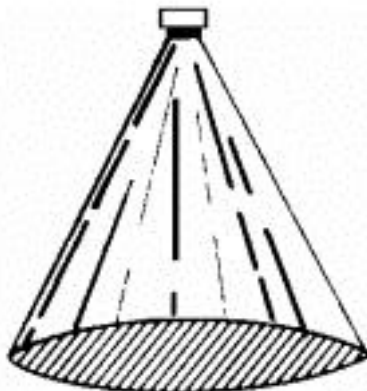
The label may recommend a droplet size and spray pattern. Select nozzles that meet those requirements and also provide the rate of application required by the label. Nozzle charts, found in nozzle manuals available from dealers, show the application rate at certain pressures and ground speeds.

***Flat spray nozzles*** produce medium-sized droplets in a fan-shaped pattern. There are three kinds of flat spray nozzles: regular flat fan spray nozzles, even spray nozzles, and off-set spray nozzles.



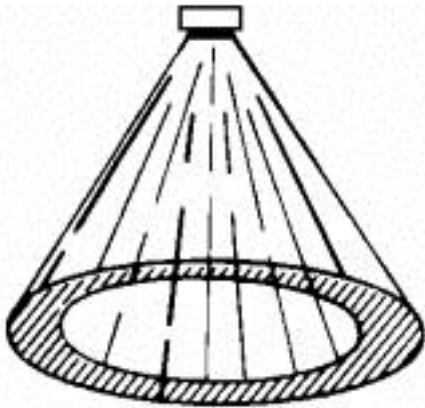
Even Flat Fan

***Regular flat fan*** spray nozzles give uniform coverage when overlapped in a boom sprayer. Even ***spray nozzles*** are used for band applications. Off-set or off-center spray nozzles are used in clusters for boomless broadcast applications.

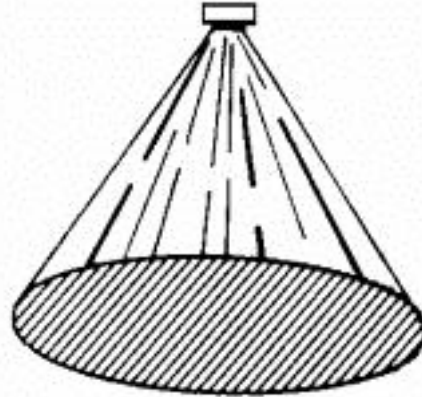


Regular Flat Fan

**Cone nozzles** produce smaller droplets in a round pattern. They are used in directed sprays to apply fungicide and insecticides because they produce the smaller droplets needed for these applications. They do not provide even coverage in a row when mounted on a boom.

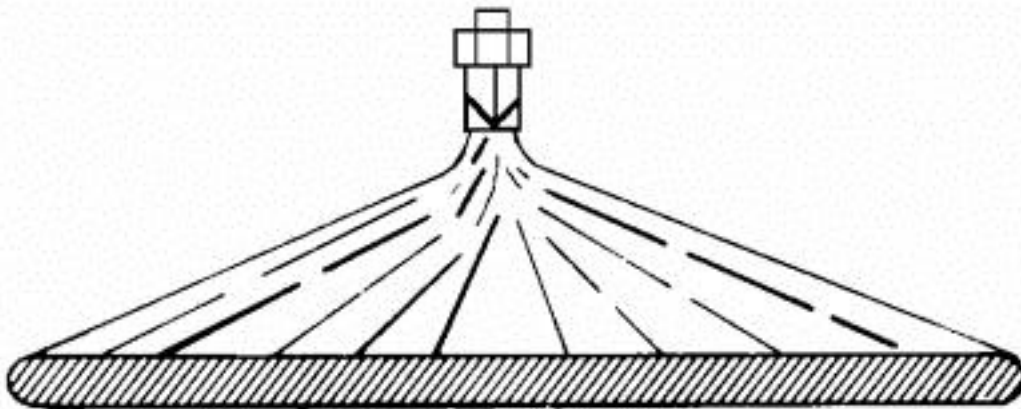


Hollow Cone



Solid cone

**Flooding spray nozzles** produce large droplets in a wide pattern. They are used close to the ground, and at low pressures. They can be mounted on a boom to provide even coverage. Because they are used close to the ground and produce large droplets, they are excellent for preventing drift.



Flooding spray



## Calibrating Broadcast Boom Sprayers

Tractor speedometers are usually not accurate enough for calibration. With the following method, you do not have to rely on your tractor speed to calibrate a broadcast boom sprayer.

GPA = gallons per acre. Application rates are usually given in GPA.

MPH = miles per hour. The sprayer speed is measured in MPH.

GPM = gallons per minute. The output of nozzles is stated in GPM.

GPH = gallons per hour. The output of nozzles or pumps may be given in GPH.

1. Fill the spray tank with water.
2. Check the nozzles. Is the flow the same for all nozzles? Are any nozzles clogged? Are the nozzles all the same size? If not, replace nozzles so the GPM of every nozzle is within 5% of the average output of all the nozzles.
3. Measure and mark off a course in a field with the same soil conditions as the one you will be spraying. It should be at least 300 feet long.
4. Set the pressure that is correct for your nozzles. Refer to nozzle charts provided by nozzle manufacturers to select pressures and speeds.
5. Select a ground speed that is safe.
6. Spray the test course with water. Record the time it takes to cover the course.
7. Park the sprayer and, keeping the pressure the same, collect the output from the nozzles for the same amount of time it took to run the test course. If you have checked that the flow for each nozzle is the same (within a range of 5 percent), then you may not have to check the output from all the nozzles-just collect the water from at least two nozzles, average this output, and multiply by the total number of nozzles.

8. Calculate the application rate (GPA), using this formula:

$$\text{GPA} = \frac{43,560 \times \text{gal}}{L \times W}$$

43,560 = number of square feet in an acre

Gal = total gallons of spray from all nozzles for the test time.

L = length of the test course, in feet

W = width of the spray pattern, in feet

Example: If you sprayed a test course 300 feet long, using a spray boom that covers a width of 40 feet, and collected a total of 4 gallons of spray from all the nozzles during the test time, your formula would be:

$$43,560 \times 4 = 14.52$$

$$300 \times 40$$

Thus, your application rate is 14.52 gallons per acre.

To adjust the application rate use one of these methods and then repeat the steps above:

To increase GPA: reduce tractor speed; increase pump pressure; use larger nozzles.

To decrease GPA: increase tractor speed; decrease pump pressure; use smaller nozzles.

To figure out the amount of pesticide needed per tankful. First find out how many acres each tankful will cover. Here are the formulas to use:

$$\text{Acres per tankful} = \text{tank capacity} \div \text{GPA}$$

Next use this formula:

Amount of pesticide per tankful = acres per tankful x rate of pesticide per acre.



## **Pesticides and Your Responsibility**

Not only pesticide applicators have responsibility for using pesticides. Farmers who hire others to apply pesticides on their crops share the responsibility for good management of the pesticides used on their farm. It is farmers who need to make sure the choice to use a pesticide is part of a sound Integrated Pest Management program, adequate measures are taken to protect water and non-target organisms, pesticides are handled and stored in ways to prevent children and others from exposure, and to understand the public's concern over the use of pesticides in the production of their food.

Dean Herzfeld  
Minnesota Health, Environmental, and Pesticide Safety Program  
University of Minnesota Extension Service  
(612) 624-3477  
[deanh@tc.umn.edu](mailto:deanh@tc.umn.edu)

Liza Allen  
Department of Rhetoric (Graduate Student)  
University of Minnesota

Kate Fitzgerald  
Professional Education and Conferencing  
University of Minnesota Extension Service



# HARVESTING SOYBEANS

## OVERVIEW

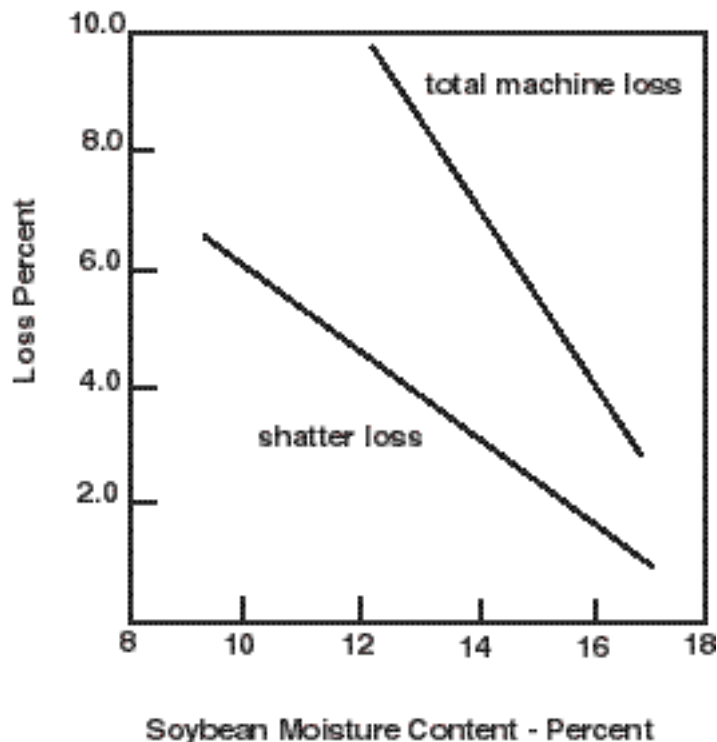
Field studies in soybean harvesting have shown that a 10% or higher harvest loss is not uncommon, but studies have also shown that harvest loss can be reduced to 3% or less. To keep losses low, you need to know where harvest losses occur, how to measure loss, what is a reasonable level of loss, and the equipment adjustments and operating practices that will help reduce high losses.

## SOYBEAN LOSS

Soybeans should be harvested when bean moisture content first reaches 13% (Figure 1). However, if beans are ready for harvest, and are then subjected to alternating periods of wet and dry weather, pre-harvest or shatter loss can be high. Pre-harvest losses are influenced by the time of harvest and can be reduced by harvesting early. Pre-harvest losses are beans that have dropped on the ground prior to harvest.

**Figure 1. Shatter and machine loss**

Soybean loss measurement from “Harvesting Soybeans,”  
Kansas State University, Ag Facts,  
1986 Cooperative Extension Service, AF155 Manhattan, KS



Gathering or header losses can account for more than 80% of the total losses in soybean harvest, and these include:

- n Shatter loss — shelled beans and detached bean pods that are shattered from stalks by the header and fall to the ground.

- n Stubble loss — beans remaining on stubble.

- n Stalk loss — beans in pods attached to stalks, which were cut, fell to the ground, and were not run through the combine.

- n Lodged stalks — beans remaining in pods attached to stalks that are lying on the soil or, if cut, were cut at lengths higher than stubble height.

Soybeans are an easy crop to thresh, separate, and clean. They are easy to remove from the pod, and their size and shape make them easy to clean. But, small errors in adjustment can cause serious bean loss. Follow the settings recommended in the operator's manual for cylinder speed and concave spacing, along with air flow and shoe settings. Then, operate it in the field and check for loss. Usually, only small adjustments need to be made in the field.

## **GATHERING EQUIPMENT**

Several machinery developments have occurred to improve the soybean gathering efficiency over a conventional rigid cutter bar platform. These include the integral flexible - floating cutter bar, the row crop head, pickup finger reels, narrow pitch knives (1 1/2 inches), and combination pickup finger and air reel. These attachments provide significant reductions in soybean loss. The flexible-floating cutter bar is able to cut shorter stubble, thereby reducing the number of pods left on the stalks. Pickup reels help lift lodged stalks so the cutter bar can slide under and retrieve them. Narrow pitch knives help reduce side movement of plants and the resulting shatter loss. Combination finger and air reel helps push cut stalks and pods back into the feeder housing to reduce bean pods from building up on the cutter bar (which causes bean loss).

These attachments have been shown to reduce bean loss, but there is a cost factor to consider before the equipment can be economically justified.



For example, a grower needs to complete a cost reduction estimate to determine how much money can be spent on the attachments. A grower must estimate how many acres of beans will be harvested, crop yield, and a loss-level improvement plan for soybean harvesting should be made.

## COMBINE ADJUSTMENTS

Reel speed and position are extremely important to reduce bean loss. Reels with pickup fingers will cause the least disturbance to the standing plants and, when positioned correctly, will place cut plants to convey smoothly along the header auger and into the feeder.

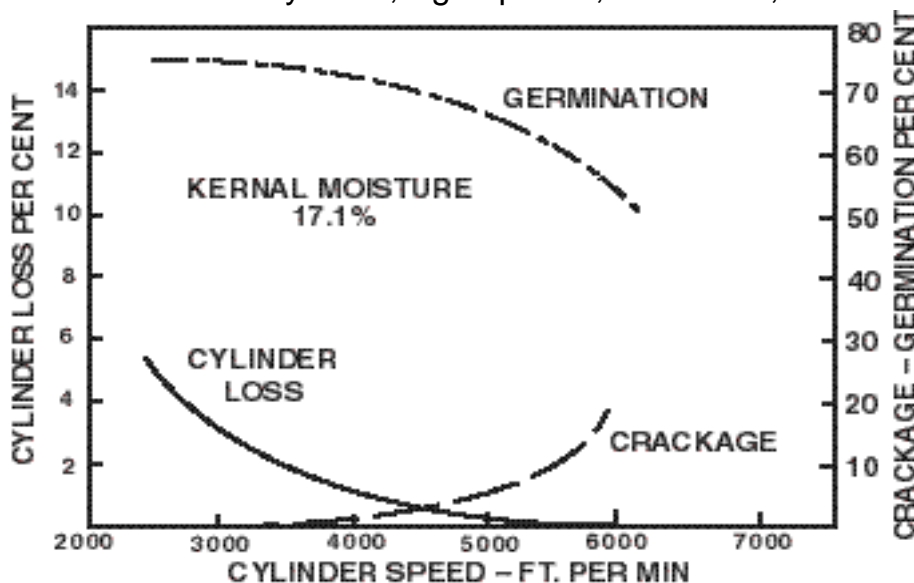
Proper reel speed is 25% to 50% faster than forward travel speed. The axis of the reel should be positioned 8 to 12 inches ahead of the cutter bar.

## HARVESTING QUALITY SEED

Cylinder or rotor speed has more effect on seed damage than does cylinder-concave clearance (Figure 2). It is important to operate the cylinder only fast enough to remove the beans from the pods. It is also important to slow cylinder speed during the day as beans dry. Illinois tests found that rotary combines produced significantly fewer splits than conventional cylinder-concave type machines. But, both types of machines can easily produce high quality soybeans.

**Figure 2. Relationships of cylinder speed to loss**

Figures 1 and 2 are from “Combines and Combining,” Ohio Agriculture Education Curriculum Services, Harlem Ridenour, Ohio State University 1981, Ag dept 745, Columbus, Ohio

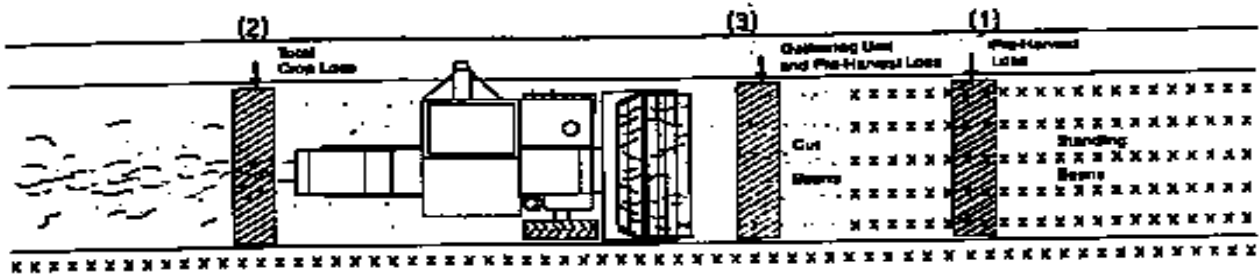


## MEASURING HARVEST LOSS

It is important to identify where harvest losses are occurring so measures can be taken to eliminate or minimize loss. Soybean seed loss from various field areas is determined by making several seed counts inside a measured area. The measured area is best completed by forming a one-foot by one-foot square. This is done by forming a heavy piece of wire (Number 9 is good) into a square. Then, the square is used in the field to make seed counts in the bean field (Figure 3). and record your seed counts in Table 1. The procedure to use in the field is:

- 1) Operate the combine in the field and stop. Back up the combine about 20 feet.

**Figure 3. Location of areas to make seed loss counts.**



- 2) Using the one-foot-square frame, count all beans in the frame as the frame is moved across the width of the cutter bar. Refer to Figure 3.
  - a) Count beans in the uncut area to determine "pre-harvest shatter loss." This is location 1 in Figure 3.
  - b) Count beans behind the combine to find the "total crop loss." This is location 2 in Figure 1.
- 3) Enter the bean counts for "pre-harvest losses" and "total crop losses" in Table 1.
- 4) Divide that number by the number of frame counts that were completed across the cutting width of the combine. This number is the average number of beans per frame.
- 5) Divide Number 4 by 4, because approximately 4 beans per square foot equals 1 bushel per acre. If the beans you are raising are large, then 3 beans per square foot will equal 1 bushel per acre.

**Table 1. Loss table**

<i># of Beans</i>	<i># of Frames (counts)</i>	<i>Avg # of Beans Per Frame</i>	<i>BU/Acre</i>
A. Total Crop Loss		÷4	
B. Pre-harvest Losses		÷4	
C. Machine Loss (A-B)		÷4	
D. Gathering Unit Losses			
a+b+c=d - B			
a. shatter loss		÷4	
b. loose stalk loss		÷4	
c. lodged stalk loss		÷4	
d. stubble loss		÷4	
E. Cylinder and Separation Losses (C-D)			

6) Subtract the pre-harvest loss from the total harvest loss. This is the machine loss due to combine operation. Then, estimate your crop yield and divide the bushels/acre loss by the yield. For example:

$$35 \text{ bushels/acre yield } \% \text{ loss} = \frac{1.2 \text{ bushels/acre} \times 1.2 \text{ bushels/acre loss}}{35 \text{ bushels}} \times 100 = 3.4\%$$

If the machine loss is more than 3% of crop yield, further investigation into the source of loss may be needed.

7) Gathering loss is determined and measured between the combine header and the unharvested crop (location 3). Again, measurements should be made across the entire width of the header.

a. Shatter loss is calculated by counting all loose beans and beans in loose pods on the ground. Enter this number under shatter losses in Table 1.

b. Loose stalk loss is determined by counting all beans on loose stalks that were cut and are lying on the ground. Add this to Table 1.

- c. Lodged stalk loss is determined by counting all beans in pods on stalks still attached to the ground and lying flat. Add to Table 1. (Lift-up guards on the cutter bar may reduce this loss considerably.)
- d. Stubble loss is determined by counting all beans in pods still attached to the stubble. Add this to Table 1.

Add the four gathering unit losses and subtract the pre-harvest loss from the gathering unit loss. This figure will reveal the gathering unit loss. Subtract unit loss from the machine loss to find the cylinder and separation loss. Follow the step-by-step procedure in Table 1.

Vern Hofman  
Department of Agricultural and Biosystems Engineering  
North Dakota State University Extension  
(701) 231-7240  
[vhofman@ndsuent.nodak.edu](mailto:vhofman@ndsuent.nodak.edu)



# SOYBEAN DRYING, HANDLING, AND STORAGE

## OVERVIEW

Soybeans are usually traded on a 13% moisture basis, so it is to the seller's advantage to harvest, store, and sell soybeans as close to 13% moisture (wet basis) as possible. Soybeans that are wetter than 13% moisture are likely to mold under warm conditions, and buyers usually apply shrink factors and drying charges when wet beans are delivered. On the other hand, soybeans that are drier than 13% moisture are more likely to split during handling and, since they weigh less, fewer bushels are available for sale. If the storage temperature is kept below about 60°F, soybeans can usually be held for at least six months at 13% moisture without mold problems. For storage under warmer temperatures or for storage times longer than six months, however, the recommended moisture content is 11%.

## STORAGE MANAGEMENT FOR 11 TO 13 PERCENT – MOISTURE SOYBEANS

Soybeans that are harvested at 11% to 13% moisture can be placed directly into ordinary storage bins equipped with simple aeration systems (perforated ducts or pads and relatively small fans). The suggested winter storage temperature for grains and oilseeds in the upper Midwest is 20°F to 30°F. Since soybeans are usually harvested at temperatures well above 30°F, it is necessary to cool them by operating aeration fans during cool weather. Rather than waiting until outdoor temperatures drop to 20°F to 30°F before cooling stored beans, it is best to cool them in 10 to 20 degree stages as average temperatures drop in the fall. For example, if beans are harvested at 55°F, you could wait a few weeks until average outdoor temperatures drop to 40°F and run the fans long enough to cool all the beans in the bin to 40°F. Then shut the fan off for a few weeks and repeat the cycle when average outdoor temperatures fall to about 25°F.

The airflow provided by aeration fans is usually expressed as cubic feet of air per minute per bushel of beans, or cfm/bu. You can estimate the amount of fan operation time to cool an entire bin of beans by dividing the number 15 by the airflow in cfm/bu. For example, many on-farm storage bins have an airflow of about 0.1 cfm/bu, so cooling time would be about 150 hours, [15 divided by 0.1] which is about 6 days. You can use this formula to estimate cooling time, but you should actually measure bean temperature at several different points in the bin to make sure cooling is complete.

When you are operating aeration fans to cool beans that are 11% to 13% moisture, you don't need to worry too much about relative humidity. Beans near the point where air enters the bin will rewet during very humid weather and some overdrying will occur during very dry weather, but if fans are operated no longer than necessary to cool the bin, overall moisture change will be quite small. It takes about 50 times as long to change the moisture of a crop as it does to change its temperature, which means you can move a temperature front through 50 ft. of beans by the time you've changed the moisture of a 1 ft. layer. If you are concerned about operating the fan during weather that is too humid or too dry, however, it is possible to install controls that will operate the fan only during weather conditions that do not cause drying or rewetting. These types of controls will keep the fan from operating a high percentage of the time, but it will take much longer to cool the entire bin than it would without the controls.

Once soybeans have been cooled to 20°F to 30°F, check them every two to four weeks during winter months to make sure the temperature is stable and that no mold, insect, and crusting problems are developing. If you find problems, or if bean temperature has moved above or below the desired range, operate the aeration fan during 20°F to 30°F weather to run a temperature front through the bin. If you need to hold the beans into spring and summer, increase your frequency of checking the bins to once a week, but unless a problem develops, it is not necessary to operate the aeration fans. If you need to aerate during spring or summer, do so during the coolest weather available and make sure that you keep bean temperature less than 60°F.

When spoilage problems develop in stored beans, they often start in pockets of accumulated "fines" (small pieces of broken seeds, weed seeds, and stem material) and foreign material. This material is difficult to aerate and it is often wetter and more susceptible to mold growth than are whole seeds. Try to keep fines and foreign material out of the bin by setting combines for maximum cleaning or by running beans through a grain cleaner on the way into the bin. Or, at least prevent the fines and material from accumulating in one spot by using grain spreaders to fill bins, by frequently moving spouts during bin filling, or by "coring" bins (removing some beans through the center unloading sump) after they are full. For more information about grain and oilseed storage, obtain ***Management of Stored Grain with Aeration***, AG-FO-1327, from the UMN Extension Distribution Center, or ***Crop Storage Management***, AE-791, from the NDSU Distribution Center.



## **SOYBEAN HANDLING**

Soybeans are subject to splitting during handling, so handle them gently. Belt conveyors, bucket elevators, and drag or mass conveyors provide the gentlest handling. But normal grain augers can be used if they are operated slow and full, and pneumatic or air-type conveyors can be used if the air to grain ratio is set properly, and if lines are laid out with a minimum number of very gradual curves.

Avoid long drops in bean handling by frequently adjusting the position of conveyors or by using bean ladders or other devices that break long drops into a series of shorter drops. One handler of food-grade soybeans recommends 10 feet as the maximum height for any single drop.

## **ARTIFICIAL DRYING**

Most years, fall weather conditions in the upper Midwest will dry soybeans to 11% to 13% moisture in the field. But some years, weather conditions prevent soybeans from drying to 13% moisture, and sometimes, growers harvest at moistures higher than 13% to avoid the harvest losses that can occur at lower moisture contents. Soybeans can be harvested without too much damage up to about 18% moisture. But, artificial drying is necessary when soybeans are harvested at a moisture content higher than 13%,.

There is not much published research on soybean drying. Most of our drying recommendations are based on limited experience or are extrapolated from corn drying recommendations. In most cases, dryers that were designed for corn can be adapted for use with soybeans.

## **NATURAL-AIR DRYING**

Using unheated air to dry soybeans usually works well, but it is a slow process (two to six weeks, depending on initial moisture, airflow, and weather). Bins used for natural-air drying should have full-perforated floors and fairly large drying fans. Fan power requirements depend on desired airflow and depth of beans. For example, delivery of 1.0 cfm/bu (cubic feet of air per minute per bushel of beans in the bin) through an 18 ft. depth of soybeans would require about 0.6 hp (horsepower) per 1000 bushels of beans in the bin, while delivery of 1.5 cfm/bu through 18 ft. of beans would take about 1.6 hp/1000 bu.

Management of natural-air soybean dryers is similar to that for natural-air corn dryers, except that soybean moisture values need to be about two percentage points lower than those recommended for corn. In southern Minnesota, use an airflow of 1 cfm/bu to dry 17% to 18% moisture beans, 0.75 cfm/bu for 15% to 17% moisture beans, and 0.5 cfm/bu for 13% to

15% moisture beans. In North Dakota and northern Minnesota, higher airflow is needed since fewer days are available for drying in the fall. In northern areas, use 1.0 cfm/bu to dry soybeans that are 16% moisture or less, 1.25 cfm/bu for 17% moisture beans, and 1.5 cfm/bu for 18% moisture beans. **See *Natural-Air Corn Drying in the Upper Midwest*, BU-6577**, available from the UMN Distribution Center or ***Natural-Air/Low-Temperature Crop Drying*, EB-35**, from the NDSU Distribution Center for information on equipping and managing natural-air dryers.

Because natural-air drying is a slow process, it will be difficult to use one bin to dry both beans and corn in the same year. Don't plan on having the beans dry before corn harvest unless the soybeans are only slightly wetter than 13%, or unless you use a shallow drying depth.

## **LOW-TEMPERATURE DRYING**

Early in the fall, especially in years with warm, dry weather, it is possible to dry soybeans to less than 13% moisture with no supplemental heat. (See previous section on natural-air drying.) However, late in the fall, or in years with cool, damp weather, soybeans might not dry to 13%, and it might be helpful to add a small amount of supplemental heat to the air in natural-air dryers. Do not heat the air more than 3 to 5 degrees F, though, or you will overdry the beans and you might cause an increase in splitting. Research has shown that exposing soybeans to relative humidities of less than 40% can cause excessive splitting. For every 20 degrees F that you heat air, you cut its relative humidity approximately in half, so it doesn't take much heat to produce relative humidities less than 40%.

Some alternatives to adding supplemental heat to natural-air drying bins include:

- n Turn off the fan when weather gets cold in the fall, keeping beans cold during winter, and resume drying when average temperatures climb above freezing in the spring.
  
- n Install bigger fans in order to finish drying earlier in the fall when weather is warmer.
  
- n Use manual or automatic control to turn off the fan during periods of high humidity. Fan control will increase the amount of time required for drying, but it will result in drier beans.





## **HIGH-TEMPERATURE DRYING**

Many kinds of gas-fired corn dryers can be used to dry soybeans, but be careful. Soybeans split easily if they are dried too fast or are handled roughly. Set the drying air temperature lower than you would for corn and avoid dryers that recirculate the crop during drying. Column-type dryers can often be operated at 120°F to 140°F without causing too much soybean damage, although some trial and error might be required to set dryers properly. Examine beans leaving the dryer carefully and reduce the temperature if you're getting too many splits. If the soybeans will be saved for seed, keep drying temperatures under 110°F to avoid killing the embryo.

Remember that crops dried in gas-fired dryers must be cooled within a day or two to remove dryer heat. This can be done in the dryer or in aerated storage bins. Stored beans should be aerated again later in the fall to cool them to 20°F to 30°F for winter storage.

## **IMMATURE, FROSTED, OR GREEN-COLORED BEANS**

In years when frost kills soybean plants before the seeds are fully mature, make sure you remove as much chaff and green plant material as possible before binning the beans. Immature beans can be stored without significant molding, but concentrations of green chaff can lead to heating in storage. Although it is commonly stated that green soybeans will eventually turn yellow in storage, the color change observed in a University of Minnesota laboratory study was minimal. It might still be worthwhile to store green soybeans for a few months after harvest though, to avoid the high discounts that are applied in years when large quantities of green beans are delivered during harvest. Ensure that any green beans going into storage are clean, evenly distributed throughout the bin, and cooled as soon as possible after harvest.

## **RECONDITIONING OVERDRY SOYBEANS**

In years with exceptionally warm, dry falls, soybeans are sometimes harvested at moisture contents well under 13% moisture. Although it is illegal to add water to increase soybean moisture, it is possible, given enough time and a high enough airflow per bushel, to increase the moisture content of soybeans by aerating them with humid air. But here are some practical concerns and limitations:

n The process is quite slow - even with the high airflow per bushel (0.75 to 1.0 cfm/bu) available on bins equipped for drying. It would

be difficult to accomplish significant reconditioning using the low airflow aeration systems common on storage bins.

n Fan control is tricky and some beans could end up too wet for safe storage.

n You are likely to end up with layers of wet beans and dry beans unless you can find some way to mix them in the bin or during unloading of the bin.

n Swelling that accompanies rewetting will increase stress on bin walls.

Table 1 shows the moisture content that soybeans would come to if exposed to different combinations of temperature and relative humidity for long periods of time. If you continuously aerated a bin of beans, they would tend to lose moisture during periods of low humidity and tend to gain moisture during periods of high humidity. To recondition soybeans to 13% moisture during normal fall temperatures of 30°F to 60°F, you would need to control the fan so that it operates during weather that has an average relative humidity of 65% to 70%. Table 1 indicates that bean moisture increases sharply as relative humidity increases, which means that it is quite easy to rewet a layer of soybeans to a moisture content that is too high for safe storage.

**Table 1. Equilibrium moisture values (percent wet basis) for Soybeans**

<i>Temperature</i>	<i>Relative Humidity</i>				
	<i>(%)</i>				
(F)	50	60	70	80	90
32	10.0	11.8	13.7	16.2	19.8
40	9.8	11.5	13.5	16.0	19.6
50	9.5	11.2	13.2	15.7	19.4
60	9.2	11.0	13.0	15.4	19.1
70	8.9	10.7	12.7	15.2	18.9
80	8.6	10.4	12.5	15.0	18.7

During reconditioning, the moisture of the whole bin doesn't change all at once. A rewetting zone develops and moves slowly through the bin in the direction that the airflow is moving. This is similar to the way a drying zone moves through a drying bin. In most cases, there are not enough high

humidity hours available in the fall to move a rewetting zone all the way through the bin. And in many cases, depending on how the fan is controlled, the parts of the bin that have been rewet will be too wet for safe storage. It would be best to mix the wet layers with the dry layers to reduce spoilage risk and to avoid drying charges for the wet layers when the beans are sold. Mixing can be accomplished to a limited extent by emptying the bin and moving the beans through a grain handling system. The most effective way to mix the beans, though, would be to use an in-bin stirring system. In fact, bin dryers equipped with stirring augers are a good choice for reconditioning soybeans.

If the initial moisture content of the beans is 10% or less, controlling the fan so that it only runs when relative humidity of the air reaching the beans is greater than about 55% should result in rewetting. If you use a single humidistat to turn the fan on anytime humidity is greater than 55%, average humidity during the hours the fan operates should be well above 55% and the beans are likely to rewet to at least 13%. Since humidity is almost always higher at night than it is during the day, an alternative to a humidistat would be a timer set to run the fan only during nighttime hours. If you aren't equipped to mix beans after reconditioning, you need to avoid rewetting them to moisture levels that are too high for safe storage.

Approaches to prevent excessive rewetting include:

- n Reducing the humidity setting on the humidistat that controls the fan so that the fan runs during drier conditions.
- n Adding a second humidistat that stops the fan when relative humidity reaches very high levels.
- n Installing a sophisticated microprocessor-based controller that monitors both temperature and humidity and only runs the fan when air conditions will bring the crop to the desired moisture content (for either drying or rewetting).

The disadvantage of the last two approaches is that the fan doesn't run as many hours as it would with a single-humidistat control and less total moisture would be added. Running the fan at high humidities and then mixing the wet and dry beans would result in greater average moisture content.



Reconditioning time depends primarily on airflow per bushel and weather conditions. It is fastest when airflow per bushel is high and air is warm and humid. Reconditioning will be most successful in a bin equipped as a drying bin - one that has a full perforated floor and a fan that can deliver at least 0.75 cfm/bu. Even with this airflow, it would probably take at least a month of fan operation to move a rewetting front all the way through the bin. And keep in mind that you can't run the fan continuously because in a typical fall, continuous fan operation would result in drying rather than rewetting. Attempts to use storage bins equipped with low-airflow aeration systems to recondition crops are usually not very successful—mainly because it just takes too long to move the rewetting front very far into the bin.

Soybeans swell when they absorb moisture, and experiences during floods indicate that soaking the bottom few feet of beans in a bin can result in enough pressure to rupture bin walls. There is not currently enough information on reconditioning soybeans through use of airflow to know whether this procedure can damage bins, but the process will definitely increase stress on the walls. Using a vertical stirring auger to mix layers of dry and wet beans might be one way to reduce outward pressure generated during rewetting.

To increase chances of success in using airflow to recondition soybeans:

- n Use a bin equipped with a full perforated floor and a fan that can deliver at least 0.75 cfm/bu.
- n If possible, use a bin equipped with stirring equipment. If stirring equipment is not available, consider transferring the beans to another bin to mix the wet and dry layers.
- n Use timers, humidistats, programmable controllers, or some other type of automatic control to limit fan operation to weather conditions that will cause rewetting.
- n Keep reconditioned beans cool (20°F to 30°F is the suggested winter storage temperature in the upper Midwest) to reduce chances of spoilage.
- n Watch carefully for signs of moldy beans and for excessive stress on the bin.

Bill Wilcke  
Biosystems and Agricultural Engineering Department  
University of Minnesota Extension  
612-625-8205  
[wwilcke@extension.umn.edu](mailto:wwilcke@extension.umn.edu)

Ken Hellevang  
Department of Agricultural and Biosystems Engineering  
North Dakota State University Extension  
701-231-7243  
[kjh-eng@ndsuent.nodak.edu](mailto:kjh-eng@ndsuent.nodak.edu)

Vance Morey  
Biosystems and Agricultural Engineering Department  
University of Minnesota Extension  
(612) 625-8775  
[rvmorey@tc.umn.edu](mailto:rvmorey@tc.umn.edu)



# SOYBEAN MARKETING

## OVERVIEW

Anyone planning to successfully market soybeans must develop a solid plan. This marketing plan should include price or profit objectives, and a time plan for action. An old saying among commodity traders is, "Plan your trades, and then trade your plan." A consistent trading plan is necessary to protect sellers from changing plans in response to the market emotions of the moment. The most dangerous emotions in grain marketing are fear and greed. These emotions can and will affect your selling decisions. A solid trading plan is the only effective weapon against these emotions. It is said that when a trader with no plan crawls into bed at night, his old buddies, fear and greed, will crawl in with him.

Other elements are important considerations in the development of a grain marketing plan. These include:

- n know and control your costs
  
- n treat grain marketing as a year-round task
  
- n respect seasonal price trends
  
- n know your basis

## KNOW AND CONTROL YOUR COSTS

Soybeans are commodities and, for long-term survival in a commodity market, producers must continually strive to keep production costs low. Recent changes in government programs have created a number of new opportunities. However, they also expose all growers to lower market prices if and when supplies are ample to meet demands in the market.

For growers seeking to get a better handle on their costs and cash flow, I recommend FINPACK, a popular farm financial software package. FINPACK was developed by the University of Minnesota Center for Farm Financial Management, 249 Classroom Office Building, St. Paul, MN, 55108. A description and demonstration of FINPACK can also be found on the web at [www.cffm.umn.edu](http://www.cffm.umn.edu).

## TREAT GRAIN MARKETING AS A YEAR-ROUND TASK

Too many soybean producers approach grain marketing as a task to be dealt with after their grain is harvested. For many, this is the only certain way to deal with production risks. However, in today's environment of increased price volatility, pricing opportunities can develop any time, sometimes well before the crop is harvested. Weather scares and new crop uncertainty can push prices higher in a developing crop. Many research studies have shown that pre-harvest pricing strategies, ones that take advantage of these market bulges, are more profitable than post-harvest strategies.

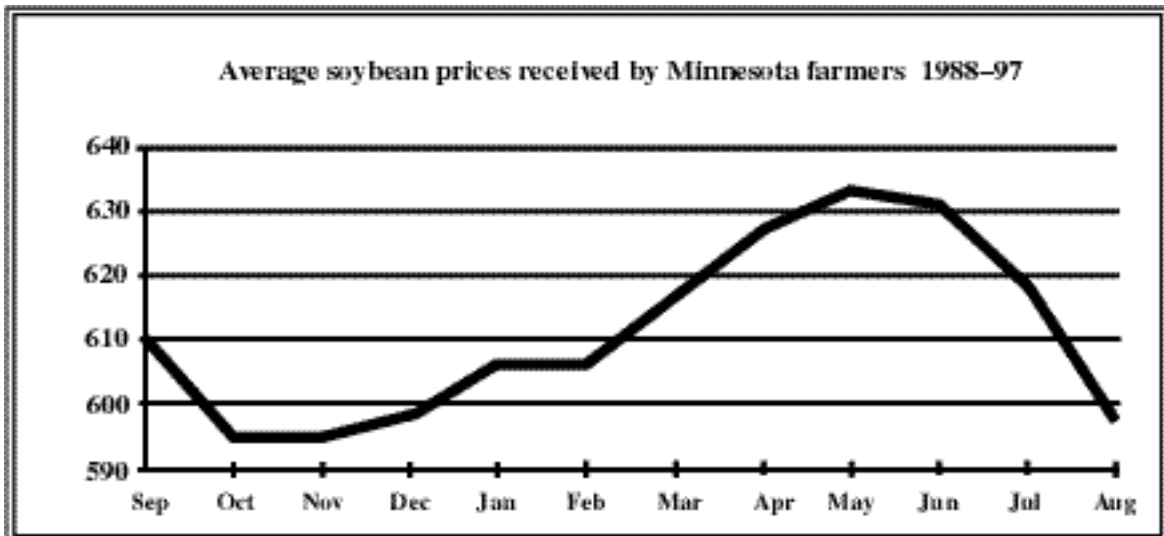
There are several ways to price grain before harvest. Among the tools available are the forward contract, futures contract, and the hedge-to-arrive contract. To sell futures against your developing crop, you will need to open an account with a broker and post margins. With the hedge-to-arrive contract, your local elevator sells futures for you, relieving you of any margin issues. The forward contract is the simplest way is to establish a price for your soybeans. With the forward contract, you can establish a price for your grain with your local elevator well in advance of harvest, with no worry about margin calls.

To learn more about the effectiveness of pre-harvest pricing strategies, contact the United Soybean Board and ask for an article by Roy L. Smith titled ***Profitable Marketing Strategies for Soybean Farmers***.

## RESPECT SEASONAL PRICE TRENDS

All commodity prices tend to follow some well-defined patterns throughout the marketing year. Shown in Figure 1 is a ten-year history of average monthly Minnesota soybean prices received by farmers. While not every year is the same, we can define certain times in the year as better selling opportunities. For example, this chart clearly points to higher average soybean prices in the spring, particularly the April-June time period. The harvest period is often a low period in prices (one more reason to seriously consider pre-harvest pricing strategies), particularly if the crop has developed in an uneventful manner.

Figure 1



## KNOW YOUR BASIS

The effective use of marketing tools demands a solid knowledge of cash-futures price relationships. In the grain trade, soybean prices are usually quoted as so many cents “under” or “over” the futures price. This difference between cash and futures prices is commonly known as the “basis.” The basis is simply the difference between a cash price at a specific location (e.g. soybean prices in Mankato) and the price of a particular futures market (e.g. November futures prices in Chicago).

Basis is the link between the general price level (the futures market) and the cash price at some specific location. Local cash prices reflect not only the general price level but also local economic values. These local differences include: 1) transportation costs and availability, 2) local supply and demand for the commodity, and 3) the availability of local storage. What really makes basis a valuable decision tool is that basis levels are **more predictable** than cash and futures prices.

The basis for storable commodities display distinct seasonal patterns (see the following chart). With grain stocks and the demand for storage high at harvest, cash prices are often at their largest discount to the futures (i.e. the basis is weakest at harvest). As the crop is put away and some is used, the supply of storage increases relative to the demand for its use, and the basis narrows. The following chart shows how the soybean basis in Minnesota is at its narrowest point in July and August, at the end of the crop year. Astute decision-makers will gather a 3-5 year history of their local basis, using daily or weekly data.



The number of marketing tactics that employ a knowledge of the basis are too numerous to cover here. But one tactic is worthy of discussion. More and more farmers are examining the possibility of “paper farming.” Paper farming is the term used to describe the strategy of selling your harvested grain and replacing the sale with the purchase of futures or call options. The advantages of this strategy are two-fold. First, the farmer is able to generate cash from the sale of soybeans. Second, the costs (mainly shrink and interest), and hazards of storing grain are avoided. Let’s examine this idea further by taking into consideration the local basis.

As an example, consider the logic of the following strategy when the basis is “weak.” A weak basis simply means that your cash price is lower than normal relative to the futures market. In this situation does it make sense to sell low (sell the depressed cash market) and buy high? Sell low and buy high? That doesn’t seem prudent. In another situation, however, if the basis is strong—cash prices are high relative to futures—this strategy may make very good sense. Paper farming in this situation involves selling the high-priced market and buying the low-priced market.

This one example serves as a reminder of the significance of basis as one very important factor in your marketing decisions.

Many observers of agriculture believe that crop marketing is the largest current challenge facing farmers today. Recent changes in farm legislation will create a number of opportunities for farmers, but they will also pose challenges as grain and oilseed prices are now fully exposed to world events. Success in the future will demand new efforts in marketing that rival the current efforts placed on production.

Edward C. Usset  
Teaching Specialist in Applied Economics  
University of Minnesota  
(612) 681-7999  
[usset001@tc.umn.edu](mailto:usset001@tc.umn.edu)

# INTERESTING AND USEFUL SOYBEAN WEB SITES

## SOYBEAN MANAGEMENT

Minnesota Precision Agriculture

<http://precision.agri.umn.edu/>

Soybean Growth and Development Information for Replant Decisions

Discusses various seed and plant parts and how the soybean plant develops. Provides information about factors affecting growth and development of a soybean plant. Describes how to ...

<http://www.extension.umn.edu/Documents/D/C/DC5701.html>

How a Soybean Plant Develops

<http://www.agron.iastate.edu/soybean/beangrows.html>

Tillage in Corn-Soybean Rotations

<http://www.extension.umn.edu/Documents/D/D/DD6676.html>

Twenty-inch rows for soybeans offer advantages

January 13, 1998 Twenty-inch rows for soybeans offer advantages A 20-inch row spacing offers yield and weed management benefits for soybeans as well as corn, according to recent...

<http://www.extension.umn.edu/Documents/J/O/JO1002.html>

Michigan State University Crop Advisory Newsletter

<http://www.msue.msu.edu/ipm/fieldCAT.htm>

University of Minnesota Replant Decisions

<http://www.extension.umn.edu/Documents/D/C/DC5701.html>

Iowa State University Extension Crops Publications

<http://www.exnet.iastate.edu/Pages/pubs/CropsLiv.html>

Iowa State University Weed Science

<http://www.weeds.iastate.edu/>

Stored soybeans can spoil due to green trash in bin October 19, 1998

Stored soybeans can spoil due to green trash in bin Green trash in your soybean storage bin could cause the beans to spoil. An engineer with the University of ...

<http://www.extension.umn.edu/Documents/J/O/JO1263.html>

Rewetting may be option for dry stored soybeans

November 14, 1997 Rewetting may be option for dry stored soybeans The drycondition of some of the soybeans harvested this fall has prompted some interest in adding moisture to the beans ...  
<http://www.extension.umn.edu/Documents/J/N/JN1301.html>

Planting soybeans after CRP makes good use of nitrogen

August 12, 1997 Planting soybeans after CRP makes good use of nitrogen Soybeans are a logical crop to plant the first year in fields that are coming out of the Conservation Reserve ...  
<http://www.extension.umn.edu/Documents/J/N/JN1209.html>

## **Fertility**

Setting Realistic Crop Yield Goals

<http://www.extension.umn.edu/Documents/D/C/DC3873.html>

Postharvest to Postemergence Fertilizer Management

<http://www.extension.umn.edu/Documents/D/C/DC6702.html>

Rhizobium Research Laboratory <http://www.rhizobium.umn.edu/>

Fertilizer Suggestions for Soybeans From Fertilizer Recommendations for Agronomic Crops in Minnesota by George Rehm, Michael Schmitt and Robert Munter. Nitrogen: In general, the application of nitrogen (N) is not suggested for ...  
<http://www.extension.umn.edu/Documents/D/C/Other/6240o.html>

Fertilizing Soybeans in Minnesota Provides updated fertilizer recommendations to soybean  
<http://www.extension.umn.edu/Documents/D/C/DC3813.html>

## **Nematology**

Resistant soybean varieties aid nematode management March 10, 1998

Resistant soybean varieties aid nematode management Planting soybean varieties resistant to the destructive soybean cyst nematode is an effective strategy for managing the ...  
<http://www.extension.umn.edu/Documents/J/O/JO1046.html>

Planting soybeans not recommended where nematode population high

January 30, 1998 Planting soybeans not recommended where nematode population high The population density of soybean cyst nematodes is high in many fields in southern Minnesota. It ...  
<http://www.extension.umn.edu/Documents/J/O/JO1018.html>

The SCN Coalition

<http://www.exnet.iastate.edu/Pages/plantpath/tylka/coalinfo.html>

The Tylka Lab — Iowa State University

<http://www.exnet.iastate.edu/Pages/plantpath/tylka/Frames.html>

## **Pathology**

Controlling Indianmeal Moths in Shelled Corn and Soybeans Identifies in words and pictures the Indianmeal moth. Describes their habits, tells how to prevent infestations and how to detect their presence. Gives control information. For growers ...

<http://www.extension.umn.edu/Documents/D/C/DC0996.html>

Iowa State University Plant Diseases and Damage

<http://www.ent.iastate.edu/imagegal/plantpath/>

University of Illinois Plant Pathology

<http://cygnus.tamu.edu/Textlab/Fiber/Soybean/sbtop.html>

University of Minnesota Plant Pathology

<http://www.plpa.agri.umn.edu/>

Iowa State University Plant Disease Clinic

<http://www.exnet.iastate.edu/Pages/plantpath/pdcintro.html>

Iowa State University Pathology Bulletins

<http://www.ag.iastate.edu/departments/plantpath/soybeans.html>

## **Commodity Groups and University Support**

United Soybean Board

<http://stratsoy.ag.uiuc.edu/~usb/welcome.html>

American Soybean Association

<http://www.oilseeds.org/asa/>

Minnesota Soybean

<http://www.mnsoybean.org/>

Minnesota Crop Improvement Association

<http://www.rtrade.org/mcia/>

Minnesota Management Education Programs

<http://www.mgt.org/>

Alabama Soybean Home Page

<http://www.acesag.auburn.edu/department/cotton/soybean.html>

University of North Dakota

<http://www.und.edu/>

University of Illinois Extension

<http://ext.agn.uiuc.edu/extension/crop/soy.htm>

University of Minnesota Extension - Crop Systems

<http://www.extension.umn.edu/Crops/>

University of Minnesota Extension Service

<http://www.extension.umn.edu/>

Iowa State University Integrated Pest Management

<http://www.extension.umn.edu/http://www.exnet.iastate.edu/Pages/communications/ag/pestman.html>

University of Minnesota Agriculture Experiment Station

<http://www3.extension.umn.edu/maes/>

## **Soybean search engines**

@griculture Online

<http://www.agriculture.com/>

StratSoy

<http://www.ag.uiuc.edu/~stratsoy/new/>

SeedQuest

<http://www.seedquest.com/>

## **Miscellaneous**

ARS Image Gallery

<http://www.ars.usda.gov/is/graphics/photos/index.html>

Iowa State University Plants

<http://www.ent.iastate.edu/imagegal/plants/>

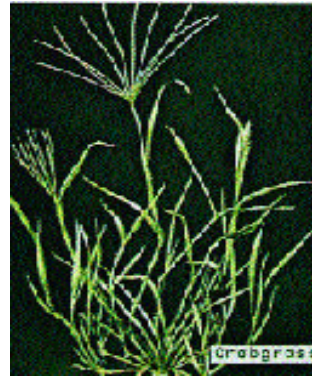
# Soybean Weeds



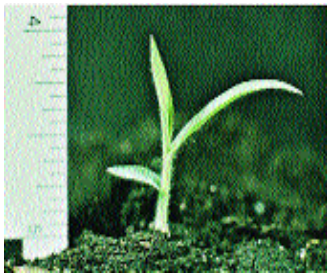
Barnyardgrass



Barnyardgrass



Crabgrass, large



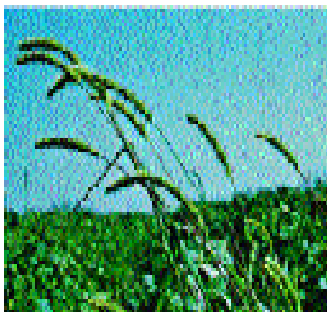
Crabgrass, large



Foxtail, giant



Foxtail, giant



Foxtail, yellow



Foxtail, yellow



Foxtail, green

PS-1

# Soybean Weeds

---



Foxtail, green



Oat, wild



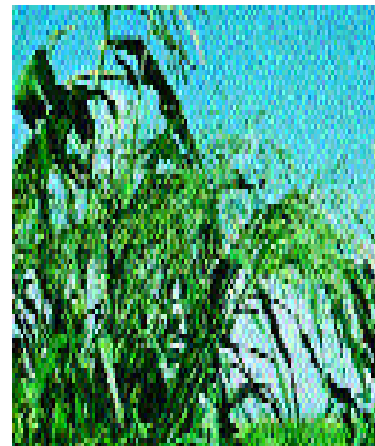
Oat, wild



Panicum, fall



Panicum, fall



Proso millet, wild

# Soybean Weeds

---



Proso millet, wild



Artichoke, Jerusalem



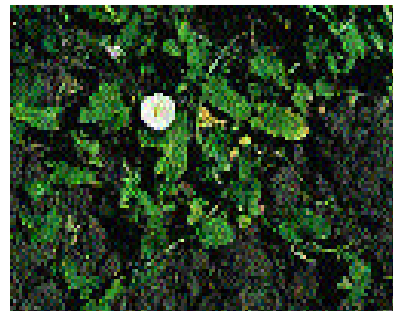
Artichoke, Jerusalem



Quackgrass



Quackgrass



Bindweed, field



# Soybean Weeds

---



Bindweed, field



Bindweed, hedge



Bindweed, hedge



Sowthistle, perennial



Sowthistle, perennial



Nutsedge, yellow

# Soybean Weeds

---



Nutsedge, yellow



Thistle, Canada



Thistle, Canada



Buckwheat, wild



Buckwheat, wild



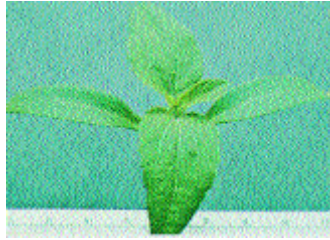
Buffalobur

# Soybean Weeds

---



Buffalobur



Cocklebur, common



Cocklebur, common



Lambsquarters, common



Lambsquarters, common



Marshelder



Marshelder



Kochia



Kochia

PS-6

# Soybean Weeds

---



Mustard, wild



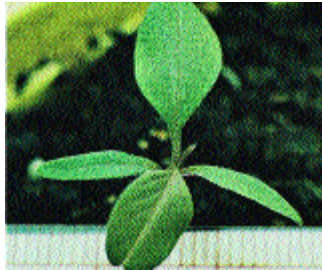
Mustard, wild



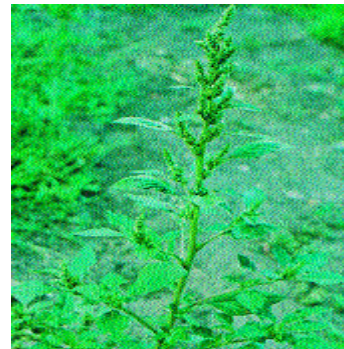
Nightshade, black



Nightshade, black



Pigweed



Pigweed



PS-7

# Soybean Weeds

---



Ragweed, common



Ragweed, common



Ragweed, giant



Ragweed, giant



Smartweed, Pennsylvania



Smartweed, Pennsylvania

PS-8



# Soybean Weeds



Sunflower, wild



Sunflower, wild



Thistle, Russian



Thistle, Russian



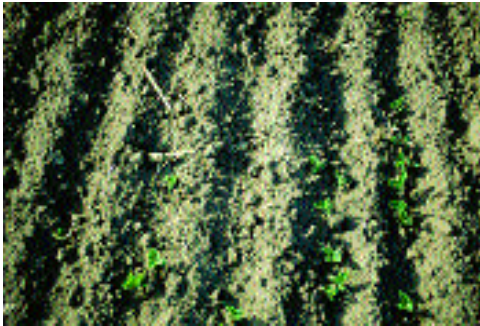
Velvetleaf



Velvetleaf

# Soybean Insects

---



Seedcorn maggot-  
stand loss



Seedcorn maggot



Wireworms



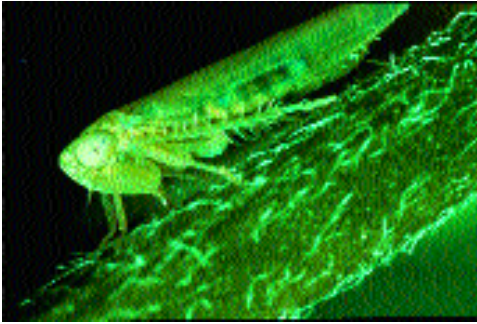
White grub



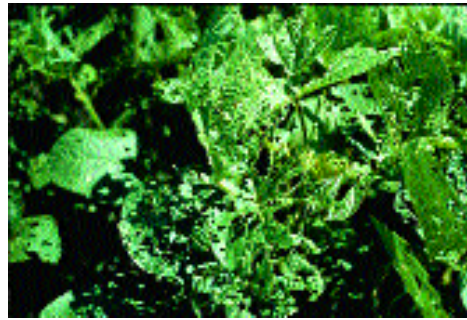
Dingy  
cutworm

# Soybean Insects

---



Potato leafhopper



Insect defoliation



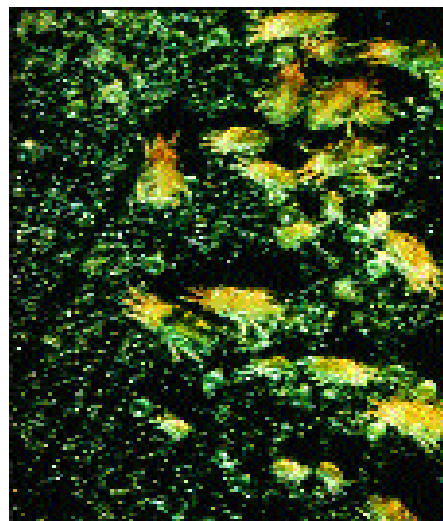
Green cloverworm  
larva



Yellow woollybear  
caterpillar



Thistle caterpillar



Two-spotted spider mites  
on underside of leaf



PS-11



# Soybean Insects

---



Leaf damage by two-spotted spider mites



Twostriped Grasshopper



Redlegged Grasshopper



Differential Grasshopper

# Soybean Insects

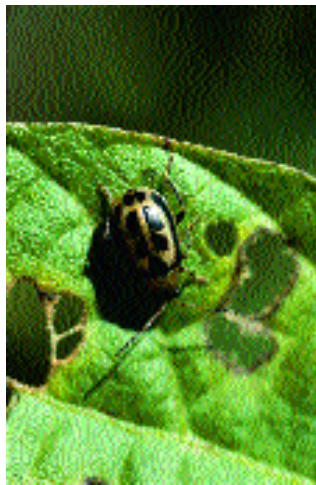
---



Early grasshopper  
defoliation



Severe  
grasshopper  
defoliation



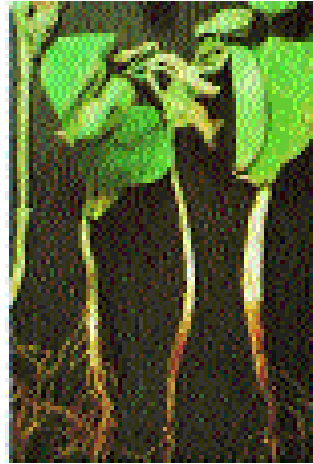
Bean leaf beetle

# Soybean Diseases

---



Soybean cyst nematode



Rhizoctonia root rot



Phytophthora root and stem rot



Powdery mildew

# Soybean Diseases



Brown stem rot



Septoria brown spot



Anthracnose



Pod and stem blight. L, pycnidia on stems and pod; R, infected seed

PS-15

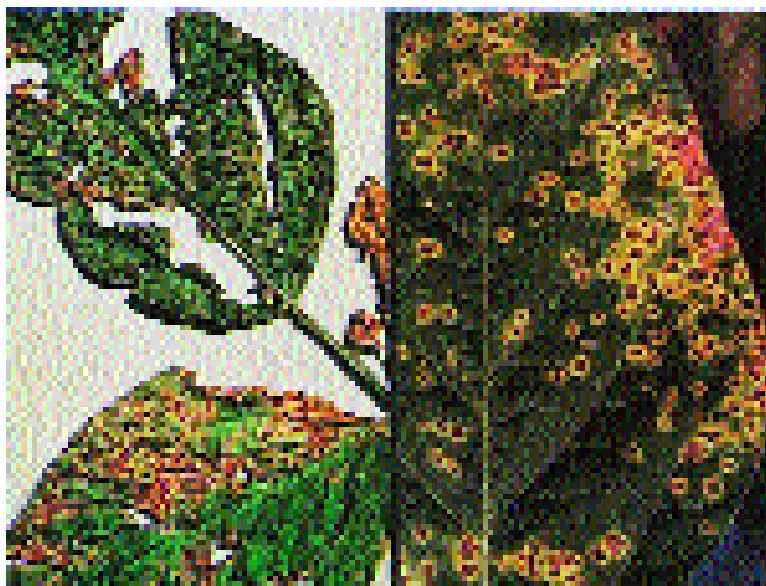


# Soybean Diseases

---

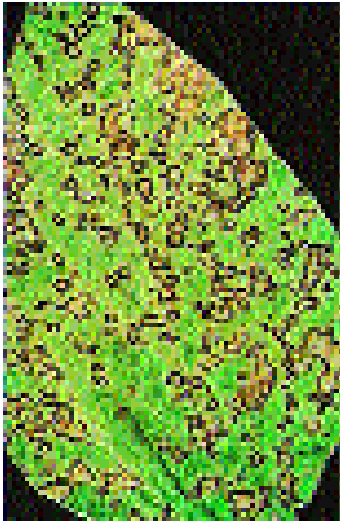


Downy mildew. L, upper and R.  
lower leaf surface



Bacterial blight

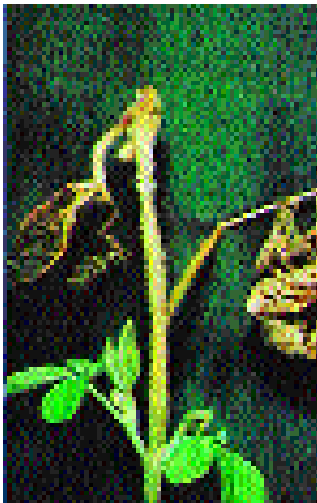
# Soybean Diseases



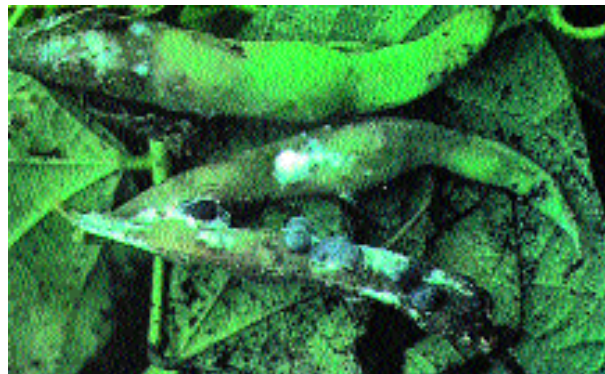
Frogeye leaf spot



Sclerotinia stem rot. L, cottony mycelium: R, sclerotia on stems



Frost damage



White mold



PS-17