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Soybean Production Field Guide

for

North Dakota

and

Northwestern Minnesota

NDSU Extension Service

North Dakota Soybean Council

Minnesota
Soybean Research
and
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Introduction

Soybean production management

Fluctuating weather, with varied rainfall amounts and stored soil moisture levels, requires soybean growers to make careful decisions as to tillage system, fertility management, variety selection, seedbed preparation, weed control strategies, rotations, and soybean pest management practices.

This field guide has been developed to help you make timely management decisions. However, detailed and extensive details on any one area are not provided because of limited space. More detailed and complete discussions of soil fertility, weed, disease, and insect control, variety performance, harvesting and storage are available in other Extension circulars as listed in the back pages.

The pesticide use suggestions in this guide are based on federal label clearances and on some state labels in North Dakota. Also suggestions are based on research information collected in North Dakota State University trials or trials in other states. All pesticides listed had a federal or state label at the time of this publication. Check all pesticide labels at time of use for the most current label registration.

Modern technology, fluctuating export markets, changing USDA farm policies, and environmental regulations all contribute to soybean growers' needs for careful planning and management to assure high yields and profitable production.

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Soybean growth and development

The soybean is a dicot plant that has epigeal emergence (above the surface). After seed germination the cotyledons are pulled through the soil surface by an elongating hypocotyl. The soil penetrating structure is the hypocotyl arch. Once emerged the green cotyledons (seed halves) open and supply the new seedling with stored energy while capturing a small amount of light energy. The first true vegetative leaves formed are the unifoliolate leaves. These two single leaves form directly opposite one another above the cotyledonary node. All other leaves are trifoliolates and are comprised of three leaflets. Don't count a new trifoliolate leaf until the leaflets are totally unfolded.

Soybean emergence

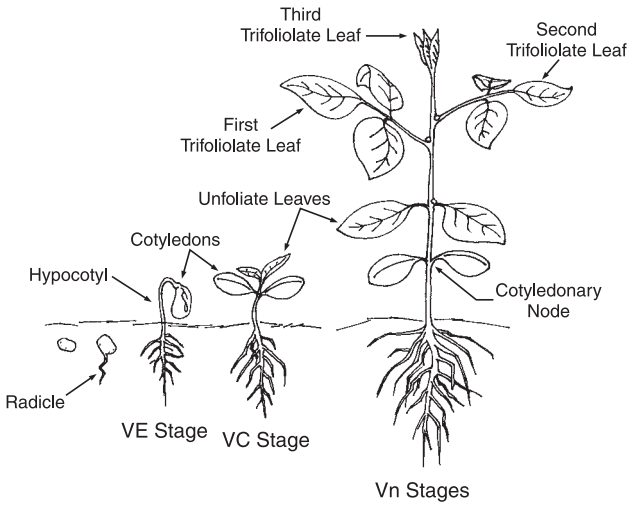


Figure 1. Soybean emergence.

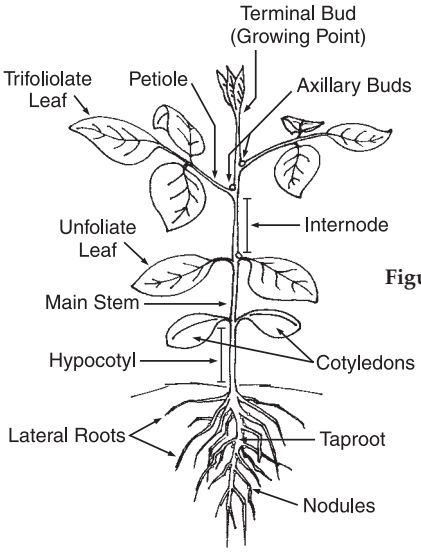


Figure 2. The soybean plant in V2 stage of development.

Growth stages

Soybean development is characterized by two distinct growth phases. The first is the vegetative (V) stages that cover growth from emergence to flowering. The reproductive (R) stages cover growth from flowering through maturation.

Plant stages are determined by classifying leaf, flower, pod, and 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.

Vegetative stages (V)

Stage	Description
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** – The "n" represents the number of nodes on the main stem with fully developed leaves beginning with the unifoliolate leaves.

From *Fehr and Caviness*

Reproductive stages (R)

Stage	Description
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 leaf.
R3	**Beginning pod** – Pod 3/16 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf.
R4	**Full pod** – Pod 3/4 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf.
R5	**Beginning seed** – Seed 1/8 inch 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*

Number of days between stages

Stages	Average Days	Range in Days
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*

Extremes in growing conditions, such as temperature, rainfall and soils, can greatly alter the development of soybeans. Many post-applied herbicides are labeled for applying at certain soybean growth stages. To avoid herbicide injury, it is highly recommended to identify development by growth stage and not use plant height, planting dates or row closure as a basis for application timing.

Variety selection and adaptation

Soybean variety selection should be based on maturity, yield, lodging and disease reaction. Comparative maturity and yield of public and some private soybean varieties can be obtained from a current copy of Extension Circular A-843, "North Dakota Soybean Variety Performance Testing."

Later maturing varieties tend to yield more than early maturing varieties when evaluated at the same location. For this reason, it is only relevant to compare yield of varieties that are of similar maturity. Although later maturity increases yield potential, late maturity also increases the risk of fall freeze damage. Later maturing cultivars are more risky to grow than earlier maturing cultivars because an early fall frost may kill a late maturing cultivar before the beans have filled the pods, and which will greatly reduce yield.

Maturity is the first consideration when choosing a variety suited to your geographical region. Cultivars of Maturity Groups 00,0 and 1 are suitable to eastern North Dakota and northwestern Minnesota. Maturity Group 00 is very early and primarily grown in the northern Red River Valley and east central North Dakota. Maturity Group 0 is adapted to Traill, Cass, Richland, Barnes, Sargent, and Richland counties. Maturity Group 1 is primarily suitable for southern areas. These maturity groups are further subdivided. For example, a 0.1 Maturity Group is an early Group 0 variety, and a 0.9 is a late Maturity Group 0 variety.

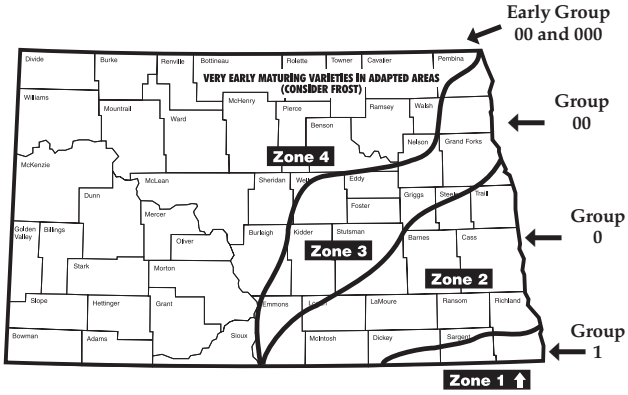


Figure 3. North Dakota soybean maturity ratings.

Generalized areas of adaptation in North Dakota are indicated by zones in Figure 3. In general, choose seed Maturity Group 1 in Zone 1, Maturity Group 0 in Zone 2, Maturity Group 00 in Zone 3 and as early a Group 00 as possible for Zone 4. Minnesota Maturity zones are indicated in Figure 4.When evaluating private company performance data and descriptions, make comparisons with public varieties grown for several years in your local area.

The best way to select a high yielding variety is to use data averaged across several locations and years. Because weather conditions are unknown in advance, averaging across several past years' data will identify a variety that yields well across different weather conditions. For example, in one year there may be a dry August and in another year adequate moisture during seed filling in August. Selecting a variety that has performed well in both dry and moist conditions is the best way to identify a cultivar that does well regardless of weather fluctuations.

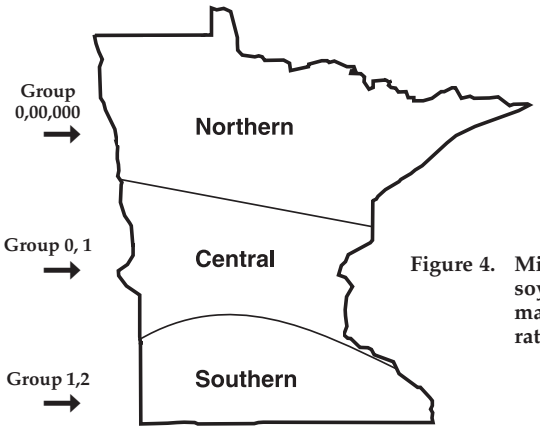


Figure 4. Minnesota soybean maturity ratings.

Some varieties have phytophthora root rot resistance genes. Each gene for resistance confers resistance to different races of phytophthora. A gene may confer resistance to race 3 but not race 4. Select a cultivar that has resistance to the common races in your area. Race 3 is most common in the Red River Valley and race 4 and 9 are also present. Phytophthora root rot tends to be more of a problem in the southern part of the Valley and more of a problem on poorly drained heavy soils.

There are genetic differences among varieties for tolerance to white mold. Varieties that are less susceptible to white mold should be grown on fields where white mold has a past history of causing problems. Ratings on white mold tolerance is available in the NDSU Extension Circular A-843, "North Dakota Soybean Variety Performance Testing."

Iron chlorosis is a major problem and is caused by the fact that iron is less available as soil pH increases. Iron chlorosis symptoms are present in the two to seven trifoliate leaf stage. Plants tend to recover and start to turn green again during the flowering and pod filling stages. However, iron chlorosis during the early vegetative stages can severely reduce yield. Some varieties are more tolerant to iron chlorosis than others. For high pH soils, select an iron chlorosis tolerant variety of suitable maturity that is high yielding. Data on genetic differences for iron chlorosis tolerance is available in the Circular A-843.

Speciality soybeans

Food soybeans

Some soybean varieties have been developed for human consumption and have special food processing characteristics. Tofu is a white curd that is primarily consumed in Asian countries. Special varieties have been developed that are high in protein and make smooth-textured tofu. These high-protein tofu types are lower yielding than the oilseed varieties that are sold to the elevator. Natto is another

human food product made from soybean. Natto is a fermented product made from whole soybeans that are cooked. Natto cultivars are very small seeded and tend to yield even less than the specialty cultivars developed for the tofu market. Growers should consult university bulletins on soybean variety performance to determine how much less these specialty varieties yield compared to oilseed soybeans. Based on the lower yield, a higher price per bushel can be determined to economically justify growing these specialty soybeans. A contract should be arranged prior to growing these special types so that a market will be available.

Oil modified

Soybean cultivars with modified oil content are being developed. Different fatty acid compositions modify the type of oil the soybean plant produces in the seed. Low saturated fats are desirable because this type of oil is better for human health. High oleic, low palmitic, low stearic, and low linolenic acid content are all genetic modifications that produce a more healthy oil for human consumption. There is no indication that these modifications reduce yield. However, yield of specific cultivars with modified oil content should be evaluated to determine whether high yield has been incorporated with the modified oil content. When these specialty cultivars are commercially available they will be produced using identity preserved (IP) marketing.

Plant Variety Protection (PVP)

Plant variety protection provides owners of a variety legal control over who can produce and market the variety they develop. A Certificate of Plant Variety Protection can be issued with a requirement that the variety be certified by an official seed certifying agency (Title V option) or the certificate can be issued giving the owner or designee the exclusive right to produce and market the variety as seed. Marketing of protected varieties without the Title V option is usually restricted to those that are authorized through a licensing agreement or dealer network.

Title V option – Allows anyone to condition or sell the variety for seed providing it has met all of the certification requirements.

1994 Amendment – Farmers were excluded from the Title V option on varieties developed prior to 1994, which required the certification of seed being sold. No exclusions exist for conditioning or sale of varieties protected after passage of the 1994 Amendment to the Plant Variety Protection Act.

Seed certification

The purpose of seed certification is to maintain and make available to the public high quality seed of crop varieties that are produced, conditioned, and distributed as to insure proper identity and genetic purity. This process of maintaining genetic purity is done through an internationally recognized seed certification system. Each state has an authorized agency that establishes minimum standards for genetic purity and other seed quality factors for each class of certified seed. These minimum standards must meet or exceed the standards set by the Association of Official Seed Certifying Agencies.

Seed of all certified classes shall have an official certification tag attached or printed on each container. Tags will come in three colors. A white tag represents the Foundation seed class. A purple tag represents the Registered class seed and a blue tag represents Certified class seed. These are the only tag colors that are recognized by the Association of Official Seed Certifying Agencies.

Certified seed may also be delivered in bulk quantities in certain states. An official bulk certificate printed by the certifying agency must accompany each certified seed sale.

Quality assurance

Owners of varieties may elect to have official seed certification agencies inspect their seed production fields for genetic purity following the standards established for Certified class seed. Laboratory tests are typically conducted by a laboratory selected by the producer of the seed. Quality Assurance tags or certificates are provided by agencies representing the Association of Official Seed Certifying Agencies.

Maintaining seed quality

High quality soybean seed has been harvested, stored, conditioned, and delivered with care. Exposure to moisture, insects or rodents during storage prior to planting will reduce the seed quality. Mechanical seed damage during loading or planting may reduce seed germination or vigor significantly. Seed should not be dropped onto bin floors or into steel truck boxes. Belt conveyors are the preferred means for transferring soybean seed. If augers are used to transfer seed, keep them fully loaded.

Transgenic soybeans

Transgenic soybeans are the result of incorporating a foreign gene into the DNA of the soybean plant. The most popular example currently of a transgenic soybean is resistance to a non-selective (glyphosate) herbicide. These transgenic soybeans are referred to as Roundup Ready soybeans and will be planted on an estimated 50 percent of North Dakota soybean acres in 2002. Varieties with maturity adapted for the northern soybean growing regions are now available. NDSU researchers include the RR soybeans in variety performance trials for comparisons on an annual basis. In 2001 the conventional soybeans and RR soybeans were approximately equivalent in yield performance at most locations. The economics of transgenic soybeans must also be taken into account when preparing

crop budgets. Farmer saved seed or bin run seed is not allowed under the RR soybean seed technical contract. Ease of use, wide spectrum of weeds controlled and no-till options are major reasons farmers have switched to RR soybean. In the near future other types of transgenic soybeans with end use traits can be expected. Some examples will be soybeans with various fatty-acid profiles for certain food and industrial uses, and altering soy protein for special feed and food uses. A system of identity preservation (IP) will need to be implemented by farmers and others to maintain variety purity for end users.

Non-GM soybeans

These are soybeans that are simply conventional soybeans and meet a select market demand. The use of non-GM soybeans in a select food and feed market emphasizes the use of soybeans that do not have any transgenic modification. As some markets move away from the use of genetically modified products, non-GM soybeans can demand some premiums due to identity preserved requirements of the market. Many organic soybean producers can take advantage of this type of market. Non-GM soybean certification must be proven by providing a paper trail of documentation. This all begins with variety identity and seed source, plus confirming every process from planting through harvest until delivery of the final product.

Planting date

Soybean is susceptible to frost and prolonged exposure to near freezing conditions in spring and fall. Plant soybean after the soil has warmed to 50 F and air temperatures are favorable. Soybean generally should not be planted earlier than five days before the average last killing frost. This provides less than a 50 percent chance of frost killing the soybean. Delaying seeding until after the average last frost date allows time to kill early germinating weeds with tillage. Earlier planting in cool, wet soil may result in low

germination, increased incidence of seedling diseases and poor stands.

Planting dates between May 10 and 25 appear to be favorable for higher yields with a reduced risk of frost injury. Plant as early as the frost date permits on fields where weeds are not a serious problem so soybean can take full advantage of the entire growing season and produce maximum yields. Earlier seeding allows the use of full-season varieties, which typically yield more than shorter season varieties.

Four years' data from date-of-planting studies at the NDSU Fargo Experiment Station show that late plantings had lower seed yields, poorer seed quality, lower oil content, shorter plant height, and pods set closer to the ground as compared to optimum planting dates. Some early maturing varieties have had acceptable yields when weather factors like hail, late spring frost, floods, etc., necessitate very late planting or replanting.

In a cooler-than-normal growing season with an early fall freeze, planting between May 10 and 25 increased yields of adapted Maturity Group 0 cultivars. The risk of planting early is that a spring freeze may destroy the seedlings. If a spring freeze does occur, however, producers have the option of replanting. The replanted crop may still produce a good yield, provided an early fall freeze does not occur. Most samples of soybean prematurely killed by a fall freeze produced marketable grain that could be sold without a quality discount. When the plants were killed as early as stage R6 (bean fills the pod at the top nodes) and allowed to mature in the pod before harvest, most samples were U.S. Grade No. 1.

Soybean stands with poor emergence often are replanted without considering the yield compensating ability of the plants in the initial stand. The yield of an initial planting at less than full stand must be compared to the yield of the replanted crop to determine whether replanting is justified.

Replanting costs include seed, tillage, and labor. The yield of a replanted crop must be sufficiently greater than the yield of the initial planting to cover the expenses associated with replanting. Risk of fall freeze damage to the replanted crop must be considered when deciding the maturity of the cultivar selected for replanting.

Planting delayed past the optimum time can decrease yield. Replanting delays maturity of the crop. In the Midwest, the average maturity date is retarded approximately one day for each three days delay in planting.

Planting in rows is the most common method used and permits cultivation for weed control. Seeding can be done with row crop planter with the proper plates, air planters, finger pickups, grain drills, and air seeders. The seed metering system of grain drills must be adjusted carefully to avoid seed damage. Plugging every other spout may be necessary with some drills to obtain uniform seeding of undamaged seeds. Plant to cover seed 1 to 1¾ inches deep and place the seed in moist soil. Planting deeper than 2 inches or in a soil that crusts may result in poor emergence and stand.

Planting rate

Soybean yields have not varied significantly over a wide range of plant populations. A plant population of approximately 150,000 plants per acre is desirable regardless of row spacing. One pound of medium sized soybean will contain about 3000 seeds. A bushel of soybean will produce about 150,000 plants per acre assuming 90 percent germination. This would give plants about 1.5 inches apart within the row at a 30-inch row spacing. Seed per pound in currently available varieties ranges from 2200 to 3400. Seeding rates should be based on the number of viable seeds planted per foot of row.

High planting rates may cause yields to decrease in low rainfall years because of drought stress, and in good

rainfall years high planting populations may lodge more than low populations. Low plant populations reduce lodging but contribute to low pod set and excessive branching. Extreme low seed number per foot of row may result in erratic stands due to lack of seedling energy necessary to break the soil surface. This may be critical in solid seeded stands where soils are prone to crusting.

Seeding rates should be increased (5 to 7%) to compensate for unavoidable plant thinning such as with rotary hoeing for early season weed control. Slightly higher seedling rates may also be advantageous with June plantings or with no-till plantings, where soil temperatures are lower. If planting in narrow row spacings or solid seeding, it's suggested that soybean seeding rates be adjusted upward. Seeding rates of 175,000 seeds per acre in 12- to 15- inch row spacings and 200,000 seeds per acre when drill seeding (6- to 8-inch row spacings) are recommended. To ensure planting enough soybean seed, the planting rate should be based on a 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 planting rate:

1. Desired population at harvest is 150,000 plants per acre.
2. Normal stand loss is 5%.
3. Seed germination is 95%.
4. Soybean seed has a seed count of 3000 seeds per pound or 180,000 seeds per bushel.

Then 180,000 seeds per bushel ÷ 60 lbs/bu x .95 = 2,850 viable seeds per pound.

Desired plant population at harvest is
150,000 plants x 1.05 (5% stand loss) =
157,000 viable seeds needed per acre.

157,000 seeds ÷ 2,850 viable seeds per pound =
55 pounds/acre of soybean seed needs 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 1 lineal 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.

Soybean seeds per lineal ft. of row (seed count of 2,500 seeds per pound).

Approx lbs. Live Seed per Acre	Seeds per Acre	Seeds per foot of row with row spacing (in.) of:			
		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

Soybean Seeds per Lineal Ft. of Row (seed count of 3000 seeds per pound).

Approx lbs. Live seed per Acre	Seeds per Acre	Seeds per foot of row with row spacing (in.) of:			
		6	12	22	30
40	120,000	1.4	2.8	5.0	6.9
50	150,000	1.7	3.5	6.3	8.7
60	180,000	2.1	4.2	7.5	10.4
70	210,000	2.5	4.9	8.8	12.1
80	240,000	2.8	5.6	10.0	13.8

Air seeder calibration

Calibrating an air seeder is usually done by following the directions listed in the operator's manual. It will usually tell you to hand turn the seed metering system a number of turns for a predetermined area. This is often listed for 1/10 or 1/4 acre. Then the metered seed needs to be weighed on a scale. Sometimes these scales are provided with the air seeder. The weights need to be multiplied by 10 for 1/10 acre or multiplied by 4 for 1/4 acre, then adjustments can be made based on the previous calculated amounts.

Another method for calibrating an air seeder requires collecting seed from the 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, determine the pounds of seed to plant as calculated in the planting rate section of this publication.

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

$$c_{(ft)} = \frac{\text{diameter in inches x } 3.14}{\text{12 inches per foot}} = \text{circum. in ft.}$$

(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:

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

(4) Place 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 lbs of seed you want to plant.

Drill calibration is becoming extremely important so you can be sure 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.

Hula Hoop method for determining population of drilled soybeans*.

	— Inside Diameter of Hula Hoop —				
No. of Plants	**30"**	**32"**	**34"**	**36"**	**38"**
10	89	78	69	62	55
12	107	94	83	74	66
14	124	109	97	86	77
16	142	125	110	99	89
18	160	140	124	111	100
20	178	156	138	123	111
22	196	172	152	136	122
24	213	187	166	148	133
26	231	203	179	160	144
28	249	218	193	173	155
30	266	234	207	185	166
32	284	250	221	197	177
34	302	265	235	209	188
36	—	281	249	222	199
38	—	297	362	234	210
40	—	—	277	247	221
42	—	—	290	259	232
44	—	—	304	271	243
46	—	—	—	284	255

* Example: If you count 24 plants inside a 32" Hula Hoop, your plant population is 187,000 per acre. Make at least 10 random counts in representative areas per field.

Row spacing

Soybean producers are planting soybean in narrower rows as a result of several NDSU research studies. The research demonstrated that higher yields of soybean can be obtained in narrow rows if stands are well established and weeds are adequately controlled. Research demonstrated that narrow row soybean out-yielded wider spaced soybean by an average of 3 to 10 bu/A. Currently an estimated 66 percent of soybean is planted in row spacings of 15 inches or less.

The advantages for narrow row soybean are increased yield, reduced erosion, increased harvesting efficiency, early crop canopy closure to help control weeds, and the convenience of using existing small grain equipment for some planting and harvesting operations. The primary disadvantages of narrow row production (solid seeding) are increased potential for weed and disease problems, seedling emergence problems if soil crusts easily, inability to use a row-crop cultivator and increased herbicide costs.

Close drilled or solid seeded soybean will produce satisfactory yields only if the land is relatively free of weeds, has good fertility and has adequate soil moisture during the pod filling portion of the growing season. Some weed control early in the season can be obtained with a harrow or rotary hoe, but mechanical weed control often is not satisfactory, so chemical control is necessary for acceptable weed control in solid-seeded soybean.

Soybean soil fertility

Soybeans have a need, as do most crops, for the 13 mineral nutrients: nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), manganese (Mn), copper (Cu), iron (Fe), boron (B), chloride (Cl) and molybdenum (Mo). Of these, North Dakota soils provide adequate amounts except for nitrogen, phosphorus, potassium, sulfur and iron. Rare instances of manganese and zinc deficiency have also been seen, but their occurrence is of only minor importance.

Nitrogen fixation

Although the atmosphere is 78 percent nitrogen gas, plants cannot use it directly. Plants can use only ammonium-N or nitrate-N. Soybean is a legume and should normally provide itself N through a symbiotic relationship with N-fixing bacteria of the species *Bradyrhizobium japonicum*.

In this symbiotic relationship, carbohydrates and minerals are supplied to the bacteria, and the bacteria transform nitrogen gas from the atmosphere into ammonium-N for use by the plant.

The process of soybean infection by N-fixing bacteria and symbiotic N fixation is a complex process between the bacteria and the plant. The right species of N-fixing bacteria must be present in the soil either through residual populations from inoculation of previous soybean crops, or through inoculation of the seed or seed zone at planting.

N-fixing bacteria are attracted to the roots by chemical signals from the soybean root. Once in contact with the root hairs, a root compound binds the bacteria to the root hair cell wall. The bacteria releases a chemical that causes curling and cracking of the root hair, allowing the bacteria to invade the interior of the cells, and begins to change the plant cell structure to form nodules. The bacteria live in compartments, up to 10,000 in a nodule, called bacteroids. Each of the bacteroids is bathed in nutrients from the host plant, and the bacteroid takes N_2 gas from the soil air and converts it to ammonium-N using the enzyme nitrogenase, which consists of one Fe-Mo (iron-molybdenum) based protein and two Fe (iron)-based proteins. Fe and Mo deficiencies are therefore a problem in certain soybean growing areas.

N-fixation of nitrogenase must take place in an environment without oxygen. However, bacteria and roots have to respire, which requires oxygen. To get around this problem, nodules use the same strategy humans do in oxygen transfer in our blood. The transfer compound is leghemoglobin (closely related to our hemoglobin). It results in a pink-red color of active nodule interiors.

N-fixation is very energy intensive and does not come without cost to the soybean. Ten pounds of carbohydrate are needed for each pound of N produced.

Some researchers refer to carbohydrate movement in soybeans as the "source-sink" relationship. Early in the growing season, the source of carbohydrates is leaves and the main sink is the nodule, in addition to the growing points of the plant. After flowering, the activity of nodules decreases rapidly and eventually stops due to lack of nutrient supply. The plant changes the sink from the nodules to the seed production. Nodules disintegrate and bacteria are released once again into the soil.

There are environmental conditions that limit N fixation:

Cold and heat. A temperature of 60-80 degrees F is ideal, while levels above or below this reduce bacterial activity.

When soil N levels are too high, nodule number and activity decrease. Roots do not attract bacteria or allow infection, so N fixation is limited or nonexistent.

Drought. Poor plant growth does not allow the plants to sustain nodules and plant growth. The nodule activity is sacrificed.

Excessive wetness. If soil pores are filled with water, not air, there is no N to fix.

Compaction. Compaction has been shown to affect nodulation soybeans more than N fertilized legumes. If there is no air, there is no N to fix.

Competition is possible from native strains of Rhizobium bacteria which are less efficient than inoculum. Nodules from initial inoculation tend to be located on the main tap root near the surface, while native strains tend to grow on the branches away from the seed zone. Native strains are sometimes much better at infecting roots and can limit inoculation effectiveness. Native strains also siphon off nutrients from the host, lowering the N-fixing ability of more efficient strains.

Using inoculants

Inoculation is the application of specific bacteria (rhizobia) to the soybean seed prior to planting. Brands of inoculants can be purchased in various formulations including: liquids, frozen prep, peat based, dry powder based and granular.

Proper storage is critical. Make certain the inoculant is fresh and has been stored in a manner recommended by the manufacturer. Inoculation ahead of seeding is possible, but check with the manufacturer to see if the shelf life of the product will allow it. Some seed treatments are toxic to inoculum. Captan and PCNB are very toxic to inoculum. Vitatvax is relatively safe up to 24 hours before seeding. Thiram produces effects in between these two groups. Planter box treatments using dry materials or auger treatments with liquids, fresh or frozen are all acceptable if they give good coverage of all seed. Granular treatments applied separately in a band at seeding also work well but are more expensive than planter box or auger treatments. Follow product instructions and get uniform coverage on the seed. Err on the high side of application rate, especially for new growers and first time fields. Its suggested to double treat inoculum or use the granule form when growing soybeans on a field for the very first time. On CRP breakout or on previously flooded lands it is highly recommended to inoculate soybean seed. Seed as soon as possible after inoculating (4 hours for liquids and 24 hours for dry material). Always keep the inoculant and inoculated seed out of the sun in a cool place by tarping the truck or keeping it in a shaded area. Inoculant strains do vary and are becoming more efficient. It's suggested that new inoculant strains be used every few years for improving soybean yields.

Nitrogen recommendations for soybeans

In the central U. S. soybean belt, it is uncommon to see responses of soybeans to preplant fertilizer N applications. However, North Dakota soybeans are grown in a very different soil environment. Research at NDSU has shown that as soil salt and carbonate levels increase, nodule infection is reduced. Minnesota research at Crookston has demonstrated that a modest level of N supplied to soybeans before or at planting increases yields, probably due to increased early season plant health, which results in improved nodulation.

If soil test N levels to 2 feet in depth are less than 50-75 lb/acre, then apply the difference up to the 75 lb/acre level to compensate for low early N-fixing activity. Do not apply additional N if levels are over 75 lb/acre, as this will reduce the potential for any significant later season nodule activity. Since a 40 bushel soybean crop requires nearly 200 lb/acre of N to reach maturity, a large contribution by the nodules is necessary. Soybeans can be grown without nodules if N is supplied, but the expenses are similar to those required by a corn crop. It is better to apply more modest levels of N and inoculate.

There have been occasional references to soybean responses from late season N applications. Responses are most consistent in irrigated fields with spoon-fed applications up to 40-50 lb/acre N total. Dryland fields have only been occasionally responsive, and only when yields above 50 bu/acre are possible. Because of inconsistency of response and the cost of the practice, late-season N applications are not advised.

Phosphorus

Soybeans react better to broadcast applications of P than to banded applications with or near the seed. Soybeans appear to prefer their entire rooting zone bathed in nutrients rather than have nutrients concentrated in a small area of the root zone. Soybeans have a different, more tap-rooted

habit than grassy plants like wheat and corn, which often respond more efficiently to banded fertilizer. There are several recent studies that confirm that broadcast application of P is better than banded P.

If soil test levels are low to very low, then application of a separate application of broadcast P is justified. However, if soil test levels are medium or higher, the level of response of soybean to P fertilizer is small, not justifying a separate P application. Soybeans are excellent scavengers of P at medium or higher soil test levels. It would be better at medium or higher soil test levels to front-load the crop prior to soybeans or apply more to the crop following soybeans than to apply an application of P to that soybean crop. The most common fertilizer application in the central soybean belt is applying extra P to the previous corn crop and allowing soybeans to scavenge what is left. The practice has been successful for over 30 years.

Even though a broadcast application of P may result in several more bushels of soybeans than a banded application, some producers will elect to apply P with the seed. NO fertilizer of any kind is recommended with soybean seed in a 15-inch row or wider. However, using a double-disk drill with 6-inch spacings, up to 10 lb N/acre may be applied to soybeans as a P fertilizer (do not use urea). With air-seeders, risk to soybeans with fertilizer spread across the seed zone will be decreased. Even though it is possible to apply up to 10 lb N/acre with a 6-inch row spacing, dry weather at planting will increase the risk of injury. It is therefore prudent for the producer not to push rates too hard toward the limit because there is variability within fields in both sand content and moisture. Sandier textures and low moisture soils may show more stand injury than other areas of the field. Again, the best recommendation for P application is to broadcast it.

Potassium

Most soils in North Dakota have high K levels. However, some sandier textured soils in the beach ridges west or east of the Red River Valley are found to be lower in K. Some sandier hilltops in the glacial till plain or in residual materials west of the Missouri River may also be lower in K. Some limited soil testing based on general landscape will show whether K is needed in these areas. When soils are dry, even high K soils can show K deficiencies. Ridge-till producers often include K in their 2-by-2 banded starter fertilizer applications to compensate for limited soil K availability in these droughty cropping systems. Potassium should be either broadcast or banded, with the seed and fertilizer separated. Do not apply potassium fertilizers with the seed.

Sulfur

Although sulfur deficiency is possible there have been few reports of sulfur deficiencies. Deficiencies are most possible on sandier hilltops and eroded areas with low organic matter.

Soil pH

Soybeans grow best around a pH of 6.5. Lowering pH is usually not an option because of the cost of amendments and the formation of salt if the application is successful. However, low pH levels have been found around North Dakota. Sampling by landscape position reveals much better information regarding soil pH than composite testing. Application of limestone would be justified if soil pH was lower than 6.

Zinc

Soybeans are usually not sensitive to low soil zinc levels and grow well at zinc test levels much lower than sensitive crops like dry beans and corn. A recent North Dakota study with 10 locations, nine varieties with and without zinc revealed no significant differences even at soil test levels as

low as 0.2 ppm. Although rare zinc deficiencies have been observed in North Dakota, it is not a problem most producers need consider. Zinc deficiency is expressed as a light green color developing in between the veins of younger leaves on sandy, low organic matter soils with very low (less than 0.2 ppm) zinc levels.

Iron

Soybeans are susceptible to low soil iron availability. Iron deficiency is expressed as yellowing in between veins on younger leaves. Iron chlorosis is not seen until the first trifoliar leaf emerges, since before that time iron from the seed is translocated to new growth. At emergence of the first true leaves, iron becomes an immobile nutrient and the plant must rely on soil availability to supply iron needs. This yellowing is called "chlorosis."

Iron chlorosis in this region is different than chlorosis historically reported in the central soybean growing belt. High soil carbonates, increased solubility of bicarbonate caused by soil wetness, and the presence of high levels of soluble salts have been shown to influence the presence and severity of iron chlorosis in soybeans in North Dakota and northwestern Minnesota. Cold temperatures also aggravate the problem in some spring seasons. Application of harsh contact herbicides and systemic residual herbicides postemergence are discouraged on severely stressed soybeans.

Application of iron-EDDHA chelate appears to be most helpful in correcting chlorosis, but it is very expensive at present rates. Research is under way to determine if a combination of seed-treatment and foliar application may be effective in combating chlorosis.

To combat chlorosis, plant the most iron chlorosis tolerant varieties available in your maturity range. See the web page *www.soilsci.ndsu.nodak.edu/yellowsoybeans/* for the latest updates on varietal screening in our area.

Nutrient recommendations for soybean

Yield Goal	N Bray Olsen	Soil test P, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 20+ 16+	Soil test K, ppm VL 0-40	L 41-80	M 81-120	H 160	VH 121-160+
bu/a		LB P_2O_5/acre					lb K_2O/acre				
30	50-75*	35	20	10	0	0	55	35	10	0	0
40		50	30	10	0	0	75	45	15	0	0
50		60	35	10	0	0	90	55	20	0	0
60		70	40	10	0	0	110	65	20	0	0

Bray-P1 recommendation = (1.55-0.1 STP)YG
Olsen P recommendation = (1.55- 0.14 STP)YG
Potassium recommendations = (2.2-0.0183 STK)YG
*Total of soil test N to 2 ft. and supplemental N

The abbreviations used in the equations are as follows:
YG = yield goal
STP = soil test phosphorus
STK = soil test potassium

Disease Management and Identification

There are important diseases of soybean in the North Dakota/Minnesota region that may affect yield and quality of the crop. Recognition of the problem is the first step in managing these diseases. These are general guidelines for managing soybean diseases.

- Use high quality seed. Certified seed will minimize the introduction of soybean pathogens. Avoid using seed produced on fields with the soybean cyst nematode or other important diseases.
- Use crop rotation. Soybean diseases, especially root rot, build up when soybeans are in close rotations. Lengthening rotations to three or four years between soybean crops allows natural processes to reduce pathogen populations. Some crops such as dry beans and sugarbeets may be infected by pathogens that attack soybean. Have diseases positively identified so sound decisions can be made on the use of rotation crops.
- Scout fields for disease. Record the incidence of disease, because such information can be used to make good decisions on management practices.
- Strengthen the soybean plant. Use good cultivation practices to promote growth of soybean. Provide adequate soil fertility, avoid soil compaction, enhance drainage, control weeds, and avoid herbicide damage.

Two web sites that provide information on diseases in this region are:

http://www.ndsu.nodak.edu/soydiseases/

http://www.soybeans.umn.edu/crop/diseases/diseases.htm

Phytophthora root rot

Phytophthora root rot is a major disease of soybean, especially in areas where soybeans have been cultivated for many years. The disease is caused by the fungus *Phytophthora sojae*. Yield losses can be substantial; entire fields have been destroyed. The disease is common in the Red River Valley. The pathogen survives in soil as spores called oospores which are produced in infected plants. When there is high soil moisture the spores germinate and infect the roots. Infection and disease development can occur at any stage of plant development, but are most commonly observed and damaging at the seedling or young plant stage. Disease is most common in heavy, compacted clay soils and fields subject to flooding. Flooding rains, especially near planting, favor disease development. Reduced tillage, especially no-till, is reported to increase damage. The pathogen does not naturally infect other crops grown in this region. Only three *Lupinis* spp. and soybeans are natural hosts. There are more than 40 races of *P. sojae*. The most prevalent in this area is race 3, but race 4 and others are also found in fields.

The symptoms are seed rot and pre- and post-emergence damping-off and wilting of young plants. These are common in flooded soils and are often misidentified as water damage. On older plants, leaves may become yellow and plants will wilt with wilted leaves remaining on the plant. The lateral and tap roots are destroyed. A dark brown discoloration often appears on the lower portion of the stem. Disease is usually patchy in the field, often occurring in low or flooded areas.

Management. Planting resistant cultivars is the best method to control Phytophthora root rot. Choose a resistant cultivar that contains a gene for control of race 3, since that is the most prevalent race. Three genes that will control race 3 and are often used in resistant varieties adapted to this region are Rps lc, Rps lk, and Rps 6. The genes Rps lk and Rps 6 will also control race 4, but Rps lc will not. The gene

Rps la, which is found in some cultivars, will not control race 3. If you are using a cultivar resistant to race 3 and you observe Phytophthora root rot, it indicates that another race is appearing in the field. Some cultivars are reported to have tolerance to Phytophthora root rot. These cultivars may not be as susceptible under low to moderate disease pressure, but can be severely damaged under high disease pressure. Crop rotation is not an effective method to reduce disease because the oospores are very long lived in soil. Metalaxyl and mefenoxam seed treatments will protect seedlings but not older plants.

White mold (Sclerotinia stem rot)

White mold of soybeans is a common disease caused by the fungus *Sclerotinia sclerotiorum*. It can cause major seed yield reductions when soybeans are planted in infested soil and there is a dense plant canopy with prolonged periods of wet weather (a major factor in disease development). The disease is rarely observed during dry periods in July and August. Besides seed yield reductions, the disease also results in reduced seed quality and seed contaminated with the black sclerotia of the fungus. *Sclerotinia* overwinters as sclerotia in soil. The sclerotia germinate to form small mushrooms called apothecia that produce spores termed ascospores. The ascospores infect senescing flower tissue and then infect the stems of the plant; disease is closely tied to flowering.

Symptoms usually are observed after the canopy has closed. Dead plants are generally the first symptom observed. An inspection under the canopy will reveal a cottony, white mycelial (fungus threads) growth on stems, leaves or pods. Lesions develop on main stems and side branches. Stems appear bleached and sometimes shredded from advanced decay. Large sclerotia form in and on diseased tissue. Seeds in diseased pods are usually shriveled and may be infected by the fungus or replaced by sclerotia.

When a field with white mold is harvested the seed is almost always contaminated with sclerotia. Yield losses usually occur when incidence of disease is 15% or greater. Yield losses can range from to 1.3 to 3.7 bu/A for every 10% increase in disease incidence.

The pathogen has an extensive host range of over 370 plant species and causes diseases on a wide variety of crops such as sunflower, dry bean, canola, alfalfa, buckwheat, lupine, mustard, potato, Jerusalem artichoke, safflower, lentil, flax, field peas and many vegetables. There are also many common broadleaf weed hosts such as marsh elder, lambsquarters, pigweed, Canada thistle and wild mustard. The fungus that causes white mold on soybean is the same one that causes white mold of sunflower, dry beans, canola, and other crops.

Management. The most important controls for white mold of soybean are to choose less susceptible cultivars, avoid planting on soils heavily infested with *Sclerotinia*, and to maintain open rows so air movement through the crop reduces plant wetness. Cultural practices, such as wider row-spacing, which reduce environmental conditions favoring disease are helpful. Orienting the rows toward the prevailing wind, for example, will help dry the crop following precipitation. Under very prolonged rainy periods or in protected areas such as along shelterbelts where humidity is higher, disease may develop even in an open canopy.

Soybean fields should be monitored for disease incidence. Check the seed hopper at harvest for the presence of sclerotia. As disease begins to increase in a field, the rotation time to non-susceptible crops such as small grains and corn should be increased. Crop rotation will reduce populations of sclerotia in soil, but will not entirely eliminate the pathogen. Do not plant highly susceptible crops such as drybeans and sunflowers during the rotation. If you rent land, find out the disease and cropping history before making planting decisions.

Although common soybean cultivars adapted for this region are susceptible to white mold, some cultivars are less susceptible than others. Information on cultivar susceptibility is available from the NDSU Extension Service. Do not use seed from a white mold infected crop. Seed quality could be low, and sclerotia may be introduced into the field along with the seed. Also, maintain good control of broadleaf weeds, since they can be hosts of **Sclerotinia**. When growing soybeans under irrigation avoid practices that favor a dense canopy and free water on the plant during flowering, since these will create ideal conditions for disease development.

Soybean cyst nematode

The soybean cyst nematode (SCN), *Heterodera glycines*, is the most important pathogen of soybean in the United States. SCN is a microscopic roundworm that infects soybean roots. Extensive losses occur throughout infested areas. In southern Minnesota, SCN can cause a 20 bushel/acre loss during a dry year when the nematode is abundant in the soil. SCN has not been confirmed in ND or northern MN as of 2001.

Above ground symptoms include stunting and yellowing, poor stands, or just unthrifty plants. The roots can appear dark and decayed and there are few, if any, nitrogen-fixing nodules. A diagnostic characteristic is the presence of white to yellowish lemon-shaped female nematodes (about 1 mm in diameter) on the roots. These can be observed if the plant is carefully removed from the soil with a shovel and the soil is gently washed or shaken off the roots. The severity of disease is directly related to the amount of SCN in the soil. Warm and dry growing seasons tend to increase severity of the above ground symptoms, while cool, wet years tend to decrease severity. Severity also tends to be higher in sandy soils rather than heavy soils.

SCN is easily spread form field to field by equipment contaminated with infested soil. The nematode can also spread in wind blown soil or be carried by animals. In addition, SCN can be carried in soil "peds," small clumps of soil often found in soybean seed.

Management. Maintain fields free of SCN by cleaning any equipment that was previously used in an infested area. Reduce the potential spread of SCN from infested fields to adjacent clean fields by reduced tillage operations and practices that limit wind erosion and movement of soil. Also, use good quality seed free of soil "peds." Do not use seed harvested from SCN infested fields.

Management begins by confirming the presence of *H. glycines* in the field. Economic thresholds for SCN levels in the soil have not been established for North Dakota. In southern Minnesota, approximately 100-200 viable eggs per 100 grams of dry soil are associated with reduced yields. Growers can sample the soils in their fields and send the samples to public or private laboratories where egg counts can be determined. Soil tests can be used to determine if a field is infested, if an extended rotation is necessary, or if a resistant cultivar should be used. Soil testing is highly recommended if there is a potential SCN infestation. Information is available on the correct soil sampling procedures.

Crop rotation is an effective method to control SCN. Rotation to non-host crops for three-four years will usually reduce nematode populations to below economic thresholds, except in heavily infested fields, which may require up to five years. Non-host crops are corn, sugarbeets, alfalfa, potato, small grains, and sunflower. Beans, certain lupines, vetch and peas are hosts of SCN. Consult a list of susceptible crops before growing specialty crops in SCN infested fields. Weed control is important because SCN will reproduce on a wide variety of weeds.

Resistant cultivars are available to control SCN, but there are few available in the early maturing groups adapted to

North Dakota and northern Minnesota. Resistance is usually combined with crop rotation to manage SCN. Use cultural practices such as high fertility to help soybeans become established and grow strongly to reduce the negative effects of SCN. Soil fumigants can be used to control SCN, but application procedures are difficult and costly.

Rhizoctonia damping-off and root rot

The fungus *Rhizoctonia solani* causes pre- and post-emergence damping-off and root rot of young and adult plants. When soil populations of *Rhizoctonia* are high, pre- and post-emergence damping-off can reduce stands by 50 percent or greater. Generally, *Rhizoctonia* on soybeans is a seedling disease, but damage has been observed on older plants. The pathogen survives in the soil and is common in this region.

Symptoms consist of seed decay and brown to reddish lesions on seedling stems and roots just below the soil line. These lesions may girdle stems and kill the plant. On older plants, the pathogen causes a reddish brown cortical root rot which may extend into the base of the stem. Plants may appear unthrifty or, less commonly, will die. Root rot can greatly reduce nodulation.

Damage from *Rhizoctonia* is commonly observed in areas when there is a long history of soybean production with close rotations or during weather conditions not favorable for seed germination and rapid growth of seedlings. There are various anastomosis groups (AG) of *R. solani*. AG-4 and AG-5 are most common on soybeans but AG-2-2 and AG-3 are occasionally found. AG-3, generally found on potatoes, is weakly pathogenic on soybeans, but AG-2-2 can be highly pathogenic, especially at high temperatures. AG-4 and AG-2-2 are common on sugarbeet. Because *R. solani* has a wide host range that includes many crops grown in this region, crop rotation practices may affect severity of disease. Disease severity appears greater in plants showing iron chlorosis.

Management. Crop rotation to non-susceptible hosts such as small grains will reduce populations of *Rhizoctonia* in the soil. Avoid close rotations with sugarbeets if there is evidence of *Rhizoctonia* in the field. Close rotations with dry beans may also increase incidence of disease. Protective seed treatments and good seedbed preparation can reduce damping-off. Cultivating soil to hill up around stem promotes lateral root growth and may lessen the effect of root rot on older plants.

Fusarium root rot

Fusarium root rot caused by *Fusarium solani* can cause damping-off of seedlings and root rot on older plants. Infected seedlings can result in poor stands, late emergence or stunted plants. Infected seedling roots will show reddish or dark brown discoloration and decay. The disease at this stage may be misdiagnosed as *Rhizoctonia* because symptoms are similar. Symptoms on older plants consist of reddish brown lesions on lateral roots and the tap root. In advanced stages of disease, there is decay of the cortex, the roots are black, and there are fissures in the dead surface tissues of the tap root. There may be few nitrogen fixing nodules in the roots. Plants may appear stunted or unthrifty, and there can be a yellowing of the leaves with the veins remaining green for a short time. The leaves eventually become completely yellow, then die from the edges inward and fall from the petioles.

Fusarium root rot has often been observed in association with stressed plants, such as in drought conditions or with herbicide damage. High populations of the pathogen in the soil, however, may result in disease development under good growing conditions. The pathogen may interact with other pathogens such as *Rhizoctonia* or the soybean cyst nematode to cause disease. Disease severity may be greater in plants showing iron chlorosis.

Management. Crop rotation will lower populations of the pathogen in the soil. When there is evidence of this disease, avoid dry beans in close rotations because the pathogen can infect dry beans. Most cultivars appear to be susceptible to Fusarium root rot. Fungicide seed treatments can reduce damping-off by *F. solani*. Damage to seedlings often occurs during weather conditions not conducive to rapid seed germination and plant emergence. Ridging soil around the base of the plants can promote root growth and reduce damage to root rot in older plants. Use high quality seed, plant in warm well drained soils, reduce soil compaction and provide good fertility.

Sudden death syndrome

Sudden death syndrome (SDS) has not been reported in North Dakota or northern Minnesota but may appear in the near future. The disease is caused by specific strains of *Fusarium solani* that differ from the strains that cause Fusarium root rot. Yield losses from SDS can be severe when symptoms occur early during flowering.

The symptoms of SDS generally begin on the leaves at or just after flowering. Symptoms are scattered circular to irregular shaped yellow spots, at first interveinal, that produce a mottled appearance to the leaves. Eventually the yellow tissue dies and green tissue remains only along the major leaf veins. The upper leaves are the first to defoliate; complete defoliation can occur when disease is severe. Flower and pod abortion occurs. Plants showing severe leaf symptoms also will have extensive decay of roots and plants are easily pulled from the soil. Diseased plants or groups of diseased plants are typically scattered in the field. Disease development is associated with wet, cool conditions early in the growth of soybean plants, but with warmer temperatures during and after flowering. SDS appears to be more severe in non-tilled than tilled soybeans. SDS foliar symptoms can be similar to those caused by brown stem rot.

Management. There are differences in cultivar susceptibility to SDS, but highly resistant cultivars adapted for North Dakota and northern Minnesota have not yet been identified. If the soybean cyst nematode is present in fields with SDS, control of the nematode will help reduce SDS severity. There is some evidence that crop rotation will reduce populations of the SDS fungus in the soil. Dry beans, however, may be a host of the SDS strains of *F. solani*. Because SDS is favored by excess soil moisture, practices that encourage drainage will help minimize disease development. Reducing soil compaction can reduce severity of SDS.

Septoria brown spot

Septoria brown spot is a common leaf disease that may develop throughout the season. Pinpoint brown spots develop on the leaves. These spots may remain small or enlarge up to 3/16 inch, becoming irregular and angular in shape and reddish brown to dark brown with age. Severely diseased leaves turn yellow and fall off, with defoliation beginning on the lower leaves and progressing up the plant. Brown, irregularly shaped spots may develop on the stems, petioles and pods. Yield losses of 8-15 percent have been reported in other states.

Septoria brown spot is favored by warm, humid weather. Rainy weather is especially favorable since *Septoria* spreads by splash-dispersed spores. Disease development also is favored in areas with poor drainage. The brown spot fungus survives on soybean crop refuse and may be seed borne.

Management. Use crop rotation, keeping the field out of soybeans for at least one year. Bury crop refuse with tillage. Do not use seed from a severely diseased field. No resistant varieties are available at present.

Bacterial blight

Bacterial blight also is a common disease. First symptoms are small greasy green, angular water-soaked spots; later they turn yellow, and then reddish-brown. The spots are surrounded by a narrow yellow border. As the spots coalesce, portions of the leaf tissue fall out, and the leaves become torn and ragged. Infected young leaves may be distorted and stunted. Severely diseased leaves may drop off. Occasionally large black spots may develop on stems, petioles and pods. Seeds in infected pods may become slimy.

Bacterial blight is favored by cool, humid weather. The blight bacteria can be seed borne and they also survive on soybean crop residue. Bacteria readily enter wounds in the leaf, and rapid spread may occur following late spring or early summer rain storms or cultivation when the plants are wet.

Management. Do not use seed from a diseased field. Use crop rotation and bury soybean crop residue with tillage. Do not cultivate when the plants are wet. Some cultivars are less susceptible.

Downy mildew

Downy mildew develops sporadically, primarily in years with extended periods of cool, humid weather. Symptoms include yellow-green to yellow spots on the upper leaf surface and a purplish or grayish downy fungal growth on the lower leaf surface, opposite the yellow-green patches on the upper leaf surface. The yellow spots turn brown later in the season. Pod infection may result in seeds that are dull white, cracked or covered with a white crust of overwintering oospores. If these white or encrusted seeds are planted, a small percentage of the emerging seedlings may be systemically infected with the downy mildew fungus, resulting in stunted plants. Leaves of systemically infected plants will have areas of green-yellow tissues along the main veins and the leaf edges will be curled downward. Downy mildew may cause losses up to 10-13 percent.

Management. Use crop rotation and bury infected crop residue by tillage. Use a seed treatment if planting seed from an infected field or seed that has a white crust on it.

Pod and stem blight

This disease is common in states farther south but is uncommon in North Dakota and northern Minnesota. Rows of raised black fruiting bodies develop on the stem, and a random pattern of raised fruiting bodies develops on the pods. Infected stems often are killed. Infected seeds are shriveled and cracked and may be covered with white fungal growth.

The pod and stem blight fungus survives on infected soybean crop refuse and can be seed borne. It is favored by wet weather and crop injury as the crop nears maturity. If infected seeds are planted, plants may die on emergence.

Management. Use crop rotation. Use tillage to bury infected soybean crop residues. Plant high quality seed that is nearly free of the pod and stem blight pathogen or use a seed treatment. Harvest promptly at maturity. Maintain adequate potash levels.

Brown stem rot

Although the brown stem rot fungus has not been confirmed in North Dakota, symptoms resembling brown stem rot have occasionally been observed, suggesting that the disease may be present. Infection occurs through the roots and develops slowly until podding. Symptoms usually do not appear until late in the season. Leaf symptoms develop sporadically, consisting of a rapid yellowing followed by browning of tissues between the main veins. The veins remain green. Foliar symptoms can be similar to those caused by sudden death syndrome. The most reliable symptoms develop inside the lower stem. When the stem is split open with a knife, the pith (central tissues) will be brown. The internal browning may extend several inches above the soil

line. The best time to assess for brown stem rot is the R5 stage, when seeds are beginning to develop in pods at the four uppermost nodes. Any time that a field suddenly turns brown late in the season, rather than yellow green, the lower stems should be split and examined for brown stem rot.

The brown stem rot fungus survives several years in soybean crop residue. The disease develops during cool or moderate temperatures. The greatest damage occurs when cool weather occurs during the early reproductive stage and is followed by hot and dry weather.

Management. No resistant varieties with suitable maturity for North Dakota are available. Use crop rotation, planting non-host crops for three years. Small grains and corn are not hosts. Alfalfa and red clover are hosts and should be avoided in a rotation to manage brown stem rot. Bury soybean crop residue to hasten its decomposition.

Virus diseases

Virus diseases have not been a serious problem in this area, but in soybean producing areas to the south viruses have become a problem in recent years. The recent introduction of the soybean aphid into this area may result in virus problems because aphids are virus victors. The two viruses that are most likely to occur are soybean mosaic virus (SMV) and bean pod mottle virus (BPMV), but there are numerous other viruses. Identification of a virus disease requires special techniques. It is very difficult to identify a virus based on symptoms.

Virus symptoms vary greatly but may consist of stunting, fewer pods, leaf mosaic (light and dark green areas), puckering, blistering, distortion, chlorosis or necrosis. Seed mottling can occur, which is very detrimental to the quality of food beans. The severity of disease and the effect on yield is greatly affected by the plant stage at infection, the environmental conditions and the susceptibility of the cultivar. Yield losses can be substantial under heavy disease

pressure. SMV can be seed transmitted and is vectored by aphids. BPMV is vectored by the bean leaf beetle (*Cerotoma trifurcata*). Another symptom of virus infection is the presence of green stems after the pods have matured. Green stems interfere with harvesting the crop.

Seed treatment of soybeans

Soybean seeds may be treated with fungicides to improve stand, protect against seedling infection by some pathogens, and reduce the spread of diseases which may be carried on or in the seeds. Most soybean seed is sold untreated, however. The use of seed treatments may not be necessary if healthy seed is planted under conditions favoring rapid emergence.

When planting into less than ideal conditions, such as cool, poorly drained, or no-till/reduced tillage soil, of seed treatments will provide a more uniform stand, but not always a yield advantage. Seed treatments containing mefenoxam or metalaxyl such as Allegiance FL, Apron XL LS, ApronMaxx RTA, Delta-Coat AD, Prevail, Soygard, Stiletto, and Warden RTA are effective against downy mildew and against seedling infection by *Phytophthora* and *Pythium*. Season-long management of *Phytophthora* can be obtained through the use of resistant varieties, however. Products that contain carboxin, PCNB, or fludioxonil, such as ApronMaxx, Delta-Coat AD, Maxim 4FS, or any of the Vitavax products, may provide some protection for seeds and seedlings against *Rhizoctonia*. Kodiak is a new biological seed treatment that contains spores of the bacteria *Bacillus subtilis*. It is labeled for suppression of *Fusarium* and *Rhizoctonia* infection.

White mold (Sclerotinia stem rot) may be spread through infected seed. It has been shown that fludioxonil, thiram, and captan + PCNB + TBZ will reduce disease spread by seeds. Avoiding "bin-run" seed and planting certified disease-free seed is most important in managing the spread of white mold through seeds, however.

On-Farm Seed Treatment. Since most seed is sold untreated, it may be necessary to use on-farm seed treatment. Some seed treatments are available as hopper-box formulations. It is important that seed be uniformly coated if the seed treatment is to be effective. Check with manufacturers' labels for specific instructions.

Seed Treatment Fungicides and *Rhizobium* Inoculants. Some seed treatment fungicides have an adverse effect on *Rhizobium* inoculants. Captan and PCNB severely reduce survival of *Rhizobium* on treated seed and reduce nodulation compared to inoculated seed with no fungicide. If captan or PCNB treated seed is to be planted, it might be best to use an in-furrow inoculant. Carboxin has a moderate effect on *Rhizobium* and could be used if the seed is inoculated immediately before planting. Mefenoxam and metalaxyl have little or no adverse effect on *Rhizobium*, and thiram has no adverse effect.

No tillage or minimum tillage soybeans

Minimum or no till production practices create an environment favorable for pathogens to damage plants in the seed or young seedling stages. The cool, moist soil conditions favored by these practices can delay germination, decrease seedling vigor, and slow seedling emergence. This is especially true during cool, wet springs and when soybeans are planted early. In the first 14 days following planting, soybean plants are susceptible to stress from a variety of factors such as high or low soil moisture and temperature, crusted soils, compaction, deep planting, and reduced seed quality. Pathogens that can become active and damage soybeans in seedling stages could be *Rhizoctonia*, *Fusarium*, *Phytophthora*, *Pythium* or some of the seed borne fungi. Seed treatments with a broad spectrum fungicide will protect the crop during the critical seed germination and emergence period.

Weed Control

The weed control suggestions in this production guide are based on the assumption that all herbicides mentioned will have a registered label with the Environmental Protection Agency. Soybeans treated with a non-registered herbicide may have an illegal residue which, if detected, could cause condemnation of the crop. Federal law makes liable for seizure any raw agricultural commodity that possesses a pesticide residue for which no exemption or tolerance has been established or that exceeds the tolerances established by the Food and Drug Administration. Persons using herbicides in a manner contrary to label instructions are subject to penalty under federal and state laws. North Dakota State University or its officers or employees makes no claims or representations that the chemicals discussed will or will not result in residues on agricultural commodities and assume no responsibility for results from using herbicides.

Instructions for registered uses of herbicides are given on container labels. Read and follow label instructions carefully. **USE PESTICIDES ONLY AS LABELED.**

Herbicide labels can also be found on the web at:

http://www.cdms.net/manuf/manuf.asp

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Chemical Weed Control in Soybean				
Glyphosate	**0.5 to 2 pt of a 3 lb ae/gal conc. or 0.4 to 1.6 pt of a 3.7 lb ae/gal conc or 0.38 to 1.5 pt of a 4 lb ae/gal conc.** (0.19 to 0.75)	Emerged grass and broadleaf weeds.	Preplant or anytime prior to crop emergence.	Non-selective, non-residual, systemic, foliar herbicide. **Apply** with AMS fertilizer. See label for adjuvant use. Commercial mixtures available: glyphosate + 2,4-D = RT Master, GlyMix MT (see labels)
Paraquat *(RUP)*	**1 to 2.7 pt of a 3 lb/gal conc.** (0.375 to 1)			Non-selective, non-residual, contact, foliar herbicide. Apply with a NIS.
Harmony GT (thifensulfuron)	**3/10 to 6/10 oz DF** (0.225 to 0.45 oz)	Broadleaf weeds including wild buckwheat.		May be tank-mixed with glyphosate. Improves broadleaf weed control including wild buckwheat. Add NIS at 0.25 to 0.5% v/v.
2,4-D	**1 to 2 pt of a 4 lb/gal conc.** (0.5 to 1)	Preplant burndown of emerged annual broadleaf weeds.	Days before seeding 1 pt amine: 15 days 1 pt ester: 7 days 2 pt am or es: 30 d.	A preplant application for use only in reduced tillage. Soybean injury may occur. Seed at least 1.5 to 2 inches deep to ensure seed is separated from the herbicide.
Prowl **Pendimax** (pendimethalin)	**2.4 to 3.6 pt** **1.67 to 2.5 lb DG** (1 to 1.5)	Annual grass and some broadleaf weeds.	PPI or PRE.	Adjust rate according to soil type. Do not apply Sonalan or trifluralin PRE. No wild mustard and poor wild oat control.

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Sonalan **Sonalan 10G** (ethalfluralin)	**1.5 to 3.5 pt** **5.5 to 13 10G** (0.55 to 1.3)		PPI. Fall from Oct 1 to Dec 31 or spring.	Green foxtail has become resistant to DNA herbicides in North Dakota. Commercial mixtures available: Trifluralin + alachlor = Freedom Prowl + Pursuit = Pursuit Plus
Trifluralin	**1 to 2 pt** **5 to 10 lb 10G** (0.5 to 1)		PPI. Fall or spring.	
Pursuit Plus (imazethapyr + pendimethalin)	**1.8 pt** (0.75 oz + 0.72)	Grass and broadleaf weeds including wild mustard.	PPI.	ND state label allows reduced use rate. 1.8 pt/A is equivalent to 3 fl oz/A Pursuit and 1.75 pt Prowl. Additional Prowl at 1.75 pt/A improves weed control.
Sencor (metribuzin)	**0.33 to 0.5 lb DF** Soil pH <7.5.			Apply with soil-applied grass herbicide. Use 0.33 to 0.5 lb/A on soils with pH < 7.5. Use 0.25 lb/A on soils with pH > 7.5. Sencor may injure certain soybean varieties.
	0.25 lb DF Soil pH >7.5.			
Axiom* (flufenacet + metribuzin)	**7 to 13 oz WDG** (0.24 to 0.44 + 1 to 1.77 oz)	Grass and some broadleaf weeds.	PPI or PRE.	Poor wild oat control. Dual, Lasso, and Outlook gives poor wild mustard control. PPI gives more consistent control than PRE. PRE requires precipitation for herbicide activation. Adjust rate according to soil type and OM. Outlook gives greater nightshade control. Refer
Domain* (flufenacet + metribuzin)	**9 to 16 oz WDG** (0.135 to 0.24 + 3.25 to 5.75 oz)		EPP, PPI, and PRE.	

* No aerial application

Dual Magnum **Dual II Magnum** (metolachlor)	**1 to 2 pt** (1 to 2)		PPI or PRE.	to label for tank-mix options and grazing or feeding restrictions. Commercial mixtures available: Lasso + trifluralin = Freedom. Dual + metribuzin = Boundry
Lasso (alachlor) *(RUP)*	**2 to 3 qt EC/MT** **13 to 23 lb 15G** (2 to 3)			
Outlook (dimethenamid-P)	**16 to 21 fl oz** (0.75 to 1)		PPI, PRE or EPOST.	
Valor* (flumioxazin)	**2 to 3 oz WDG** (1 to 1.5 oz)	Broadleaf weeds including kochia, nightshade, lambsquarters, pigweed, biennial wormwood.	EPP, PPI, and PRE.	Adjust rate according to soil texture and OM. Requires precipitation to activate herbicide. EPP provides burndown of some broadleaf weeds. See label or narrative for tank-mix options, application information, rate structure, and crop rotation restrictions.
Authority* (sulfentrazone)	**4 to 5.33 oz WDG** (3 to 4 oz)	Broadleaf weeds including kochia, nightshade, biennial wormwood. Controls many large-seeded broadleaf weeds.	EPP, PPI, and PRE.	Use lower rates on soil with OM <3. Use higher rates on soil with OM >3. Do not use on sand with < 1% OM. Requires precipitation to activate herbicide. EPP provides burndown of some broadleaf weeds. Allow a 65 day PHI. See label or narrative for tank-mix options, application information, rate structure, and crop rotation restrictions.
Guantlet* (sulfentrazone + cloransulam)	**Copack:** **5.33 to 6.67 oz WG** **+ 0.6 to 0.75 oz WG** (0.25 to 0.31 lb + (0.25 to 0.31 lb + 0.31 to 0.39 oz)			

* No aerial application

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Python* (flumetsulam)	**0.8 to 1.33 oz WDG or 5 to 3 A/pack** (0.64 to 1.06 oz)	Broadleaf weeds including nightshade and biennial wormwood.	EPP, PPI, or PRE.	Adjust rate according to soil texture and OM. Requires precipitation to activate herbicide. Do not apply to soil with greater than 7.8 pH. See label for tank-mix options. Allow an 85 days PHI. Commercial mixtures available: Broadstrike + Treflan at 1.5 to 2.25 pt/A
POST Herbicides				
Basagran (bentazon)	**1 to 2 pt** (0.5 to 1)	Wild mustard, cocklebur, volunteer sunflower. Suppression of biennial wormwood and Canada thistle.	POST. Soybean: Any stage. Mustard: 4- to 6-leaf. Canada thistle: 6 to 8 inches. See label for more information.	Contact herbicide, non-residual herbicide. Thorough coverage required. Apply with oil additive at 1 qt/A. Rosette technique: Repeated in-crop applications controls Canada thistle during the growing season but allows fall rosette growth.
Rezult (bentazon + sethoxydim)	**3.2 pt** (1+ 0.2)	Grass and broadleaf weeds.	POST. Soybean: Emergence to 30 days prior to harvest.	Apply with oil adjuvants at 1 to 2 pt/A. Provides economical weed control. Refer to Basagran and Poast sections for additional information.

* No aerial application

Ultra Blazer (acifluorfen)	**0.5 to 1.5 pt** (0.125 to 0.375)	Wild mustard, redroot pigweed, and volunteer flax.	POST. Soybean: 1 to 2 trifoliates. Weeds: 1 to 4 inches tall.	Contact herbicide. Thorough coverage required. Use low rate on wild mustard, pigweed and volunteer flax. Use higher rate on larger weeds. Apply when temperature exceeds 70 F.
Cobra Phoenix (lactofen)	**6 to 12.5 fl oz Cobra 8 to 12.5 fl oz Phnix** (1.5 to 3.2 oz)	Broadleaf weeds including wild mustard, waterhemp, ragweed, and lanceleaf sage.	POST. Soybean: 1 to 2 trifoliates. Weeds: 2 to 6 leaves.	Contact herbicide. Thorough coverage required. Apply Cobra with oil adjuvant at 1 to 2 pt/A. Apply Phoenix with NIS at 0.125 to 0.25% v/v. Refer to narrative for environmental response, tank-mix options, and for white mold suppression.
Flexstar (fomesafen + adjuvants)	**0.75 to 1 pt** (0.176 to 0.24)	Broadleaf weeds including cocklebur, pigweed, mustard, ragweed, Venice mallow, smartweed, black nightshade, kochia including ALS resistant. Poor hairy nightshade control.	POST. Weeds: 2- to 4-leaf stage.	Contact herbicide. Thorough coverage required. Use at 1pt/A in ND east of I-29 and south of I-94 and at 1 pt/A in MN south of I-94. Use 0.75 pt/A in ND east of Hwy 281 and in MN south of US Hwy 2. See label for crop rotation restrictions. Use MSO adjuvants at 1% v/v + AMS at 10 lb/100 gal water. Follow restrictions for each geographic region. To improve kochia control, apply with oil adjuvant, at high water volume, and to kochia less than 2 inches tall. Sequential applications may be necessary.

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Aim (carfentrazone) + broadleaf herbicide	**1/6 oz DF** **1/4 oz EW** (0.067 oz)	Redroot pigweed, lambsquarters, nightshade, and waterhemp.	POST. Soybean: Up to 3rd trifoliate. Weeds: Small.	Apply with NIS at 0.25% v/v. Aim may cause cosmetic speckling/ spotting on soybean leaves intercepting spray. Do not apply under high moisture conditions (wet soil and or foliage). Refer to label or narrative for adjuvant and tank-mix options to increase spectrum of broadleaf weeds controlled.
Amplify **FirstRate** (cloransulam)	**0.3 oz WDG or** **10 A/pack** (0.25 oz)	Venice mallow, cocklebur, mares-tail, ragweed, sunflower, and wild mustard.	POST. Soybean: Up to 50% flowering. Weeds: Up to 10 inches tall or 8 leaves.	Apply with NIS at 0.125% v/v + 28% UAN at 2.5% v/v, or oil adjuvant at 1.2% v/v alone or with 28% UAN at 2.5% v/v. See label or narrative or label for weed size, tank-mix options and crop rotation restrictions. 50% flowering = when 1 of 2 plants are flowering.
Harmony GT (thifensulfuron)	**1/12 oz 75DF** (0.062 oz)	Wild mustard, pigweed, and lambsquarters. No ALS kochia control.	POST. Soybean: Fully expanded 1st trifoliate leaf until 60 days prior to harvest.	Apply with a NIS at 0.25% v/v or oil additive plus 28% UAN or AMS. Refer to label for tank-mix options.
Pursuit **Pursuit DG** (imazethapyr)	**3 fl oz S** 1.08 oz WDG (0.75 oz)	Annual broadleaf weeds including black nightshade, kochia, pigweed, and mustard.	POST. Soybean: Fully expanded first trifoliate leaf but **prior to flowering.**	Apply with NIS or oil adjuvant and liquid fertilizer. MSO type oil adjuvants have given greater Pursuit enhancement than petroleum oil or NIS. See narrative for rotational

			Weeds: Small and actively growing.	restrictions. Poor common lambsquarters, wild buckwheat and biennial wormwood control. No control of ALS resistant kochia. Avoid drift.
Pursuit **Pursuit DG** (imazethapyr) + **Flexstar** (fomesafen & adjuvants)	**3 fl oz** 1.08 oz WDG + **0.75 pt/A** (0.75 oz + 0.176)	For improved ragweed control and control of kochia including ALS resistant.		See label for geographic region restrictions, adjuvant use, and crop rotation restrictions. Use MSO adjuvants at 1%v/v + AMS at 10 lb/100 gal water.
Raptor (imazamox)	**4 fl oz** (0.5 oz) if following a soil-applied grass herbicide **or** **0.5 fl oz** if applied alone. (0.625 oz)	Annual grass and broadleaf weeds. Poor common ragweed, wild buckwheat and biennial wormwood control.	POST. Soybean: Fully expanded first trifoliate leaf but **prior to flowering**. Weeds: 2 to 6 inches.	Apply with NIS or oil additive with 28% UAN. Do not use oil adjuvant + 28% UAN during high temperature and humidity. See narrative for application information, weed size, crop rotation restrictions, and other use information. Reduced risk of herbicide carryover as compared to Pursuit. No control of ALS resistant kochia.
Raptor (imazamox) + **Flexstar** (fomesafen & adjuvants)	**4 to 5 fl oz + 0.75 pt/A** (0.75 oz + 0.176)	For improved ragweed control and control of kochia including ALS resistant.		See label for geographic region restrictions, crop rotation restrictions. Use MSO adjuvants at 1%v/v + AMS at 10 lb/100 gal water. Refer to Flexstar comments for kochia control.

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Assure II (quizalofop)	**7 to 10 fl oz** (0.77 to 1.1 oz)	Annual grasses and quackgrass.	POST. Soybean: Up to pod set. Grass weeds: 2 to 6 inches tall.	Apply with oil adjuvant to actively growing grasses. Apply: Assure II with oil additive at 1% v/v. Fusilade with oil additive at 1% v/v. Fusion with oil additive at 1% v/v. Poast with oil additive at 1 qt/A. Select with oil additive at 1qt/A. Apply Assure II with nitrogen when weeds are drought stressed. See narrative for rates by weed species. Treat volunteer corn from 6 to 18 inches tall. Grass control is reduced by tank mixtures or close interval application of POST broadleaf control herbicides. The antagonism generally can be avoided by applying a higher rate of grass herbicide or apply the grass control herbicide 1 or more days before or 5 to 7 days after the broadleaf control herbicide. Do not cultivate prior to 5 days before or 7 days after application. Reduced yellow foxtail control may result if Assure II is applied at rates lower than 8 fl oz/A, if used with broadleaf herbicides, or applied to stressed or
Fusilade DX (fluazifop-P)	**5 to 12 fl oz** (1.25 to 3 oz)		POST. Soybean: Before bloom. Grass weeds: 2 to 4 inches.	
Fusion (fluazifop-P + fenoxaprop)	**4 to 12 fl oz** (1 to 3 oz + 0.32 to 0.96 oz)		POST. Soybean: Before bloom. Grass weeds: 2 to 6 inches tall.	
Poast (sethoxydim)	**0.5 to 1.5 pt** (0.09 to 0.28)	Annual grasses.	POST. Soybean: All stages. Grass: Up to 8 inches tall.	
Select Prism (clethodim)	**4 to 16 fl oz 8.5 to 34 fl oz** (1 to 4 oz)	Annual grasses and quackgrass.	POST. Soybean: All stages. Annual grasses: 2 to 6 inches tall.	

			Quackgrass: 4 to 12 inches tall.	larger yellow foxtail. See label or narrative for tank-mix option allowed. See supplemental labels allowing reduced rates on small grass weeds.
Preharvest Application				
Glyphosate	**1 to 2 qt of a** 3 lb ae/gal conc. **or** 1.6 to 3.2 pt of a **3.7 lb ae/gal conc. or** 1.5 to 3 pt of a 4 lb ae/gal conc. **or 18.5 to 37 oz of a 65% SG** (0.75 to 1.5)	Preharvest weed control.	Prior to harvest.	Apply after pods have set and lost all green color. Allow a 7 day PHI. Apply with AMS fertilizer. Refer to narrative for adjuvant use. **Do not apply on soybean grown for seed because reduced germination/vigor may occur.**
Paraquat ***(RUP)***	**5.5 to 11 fl oz of a 3 lb/gal conc.** (0.13 to 0.25)	Desiccant.	Prior to harvest.	Add a NIS at 0.125% v/v. Do not apply within 15 days of harvest. Apply when at least 65% of the seed pods are a mature brown color or when seed moisture is 30% or less.
Drexel Defol (sodium chlorate)	**1 gal of a 6 lb/gal conc.** (6)		7 to 10 days prior to harvest and after pods are brown.	Thorough coverage of plant is essential. Apply in 5 to 10 gpa by air or 20 to 30 gpa by ground.

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Herbicide Resistant Soybean Roundup (Glyphosate) Resistant Soybean				
Glyphosate	**1 to 6 pt of a** 3 lb ae/gal conc. **or** 0.8 to 4.8 pt of a **3.7 lb ae/gal conc. or** 0.75 to 4.5 pt of a 4 lb ae/gal conc. **or** **9.4 to 54.4 oz of a 65% SG** (0.38 to 2.25)	Annual and perennial grass and broadleaf weeds.	POST. Soybean: Emergence through full flowering. Allow a 14 day PHI. Apply as single or multiple applications.	**Apply only to glyphosate resistant soybean varieties.** Apply with AMS fertilizer. Do not apply more than 1.5 lb ae/A (4 pt/A of a 3 lb ae/gal or 1.6 qt of 3.7 lb ae/gal product) for each single in-crop application or an application made during ae/A (6 pt/A of a 3 lb ae/gal or 2.4 qt of a 3.7 lb ae/gal product) for the total multiple in-crop applications from emergence through flowering. Multiple applications may be necessary for weed flushes. Drift and off-site movement may cause injury or death to other plants and crops. Refer to label for weeds controlled, application information, adjuvant use, tank-mix options with residual herbicides and restrictions. **Cannot save harvested seed.**
Extreme (imazethapyr + glyphosate)	**2.25 pt** (0.75 oz + 0.42)		POST. Soybean: Fully expanded first trifoliate leaf but **prior to flowering.** Allow a 14 day PHI.	**Apply only to glyphosate resistant soybean varieties.** Apply with NIS at 0.25% v/v and AMS fertilizer. Drift and off-site movement may cause injury or death to other plants and crops. Refer to label for weeds controlled, application information, adjuvant use, and restrictions. **Cannot save harvested seed.**

Package mixtures available For soybean

Trade Name	Common Name	Product/A
Axiom	flufenacet + metribuzin	7 to 13 fl oz
Boundary	s-metolachlor + metribuzin	1.5 to 2.5 pt
Brdstrike+Treflan	flumetsulam + trifluralin	1.5 to 2.25 pt
Domain	flufenacet + metribuzin	9 to 16 oz
Extreme	imazethapyr + glyphosate	2.25 pt
Freedom	alachlor + trifluralin	3 to 4.5 qt
Fusion	fenoxaprop-P+fluazifop-P	6 to 12 fl oz
Galaxy	acifluorfen + bentazon	2 pt
Gauntlet	cloransulam+sulfentrazone	0.6-0.75/5.3-6.7
Pursuit Plus	imazethapyr+pendimethln	1.75 pt
Rezult	bentazon + sethoxydim	3.2 pt
Stellar	flumiclorac + lactofen	5 fl oz
Storm	acifluorfen + bentazon	1.5 pt

Herbicide comments

Soybean is a poor competitor with weeds when cool soil temperatures cause slow germination and growth but competes effectively in warm soils when germination and growth are rapid. Management practices such as thorough seedbed preparation, adequate soil fertility, choice of a well-adapted variety, and use of good quality seed all contribute to conditions allowing good competition with weeds. Soybean production requires good cultural practices. Prepare the seedbed prior to planting to kill germinating weeds. A rotary hoe or harrow may be used to control weeds after planting but before the soybean emerge or after emergence when soybean are in the 1 to 2 trifoliate leaf stage. Rotary hoe or harrow help activate PRE herbicides under dry conditions and increase weed control. The rotary hoe is an effective and economical weed control method when the ground is not trashy, lumpy or wet and when weeds are beginning to emerge. Cultivation is most effective when the soybean are slightly wilted during the warm part of the day,

because the crop is less susceptible to breakage and the weeds will die quickly.

Preplant applications with 2,4-D at 0.75 to 1 pt/A of a 4 lb/gal concentrate may be applied 7 or more days prior to planting for the ester formulation or 14 or more days prior to planting for the amine formulation. 2,4-D amine or ester at 1 to 2 pt/A may be applied 30 or more days prior to planting. Plant soybean seed at least 1.5 inches deep. Planter press wheels should completely cover seed and separate seed from the herbicide layer. 2,4-D may be tank-mixed with glyphosate, paraquat or other herbicides registered for preplant soybean application. Risk of soybean injury from preplant 2,4-D will depend on weather, rainfall, amount of weed vegetation, and previous crop residue. 2,4-D should not be applied if risk of injury and possible stand and yield loss cannot be accepted. Use only 2,4-D products that allow preplant application prior to planting soybean. Always read and follow 2,4-D label directions.

Aim (carfentrazone) at 0.167 (1/6) oz 75DF/A or 0.25 fl oz 2EW applied POST controls mustards, nightshade, pigweed, lambsquarters, and may control or suppress kochia (including ALS resistant types) and wild buckwheat. Add NIS at 0.25% v/v. See label of tank-mix pardner for tank-mixing instructions. Aim is a contact herbicide, requires application to small weeds, and may produce speckling and spotting on leaves receiving spray. Symptoms should soon disappear after new growth appears. Higher humidity and rainfall at zapplication increase risk of leaf burn but usually the crop quickly recovers. Research has shown that Aim may provide control of field bindweed top-growth.

Assure II (quizalofop) at 7 to 10 fl oz/A plus petroleum oil adjuvant at 1% v/v applied POST controls annual grasses and quackgrass. See table in the soybean section for rates of Assure II according to weed species and weed size. Quackgrass regrowth should be retreated when 4 to 8 inches tall at 8 fl oz/A. Most broadleaf herbicides tank mixed with

Assure II reduce grass control compared to Assure II alone. Reduced grass control can be avoided by applying Assure II at least 1 day before or 5 days after application of a broadleaf herbicide. MSO type oils have performed equal to petroleum based oil additives with Assure II. Assure II may provide excellent green foxtail control but less yellow foxtail control. Lower yellow foxtail may result from applying Assure II at reduced rates, with broadleaf herbicides, or to large or stressed plants. Addition of fertilizer may enhance yellow foxtail control and control of stressed grasses.

Authority (sulfentrazone) at 4 to 5.33 oz/A applied PPI or PRE controls most annual small-seeded broadleaf weeds including kochia, pigweed species, lambsquarters, nightshade, smartweed, Russian thistle and biennial wormwood and may suppress other weeds like buckwheat, marshelder, mustard, ragweed, Venice mallow, and Russian thistle. Authority controls ALS resistant weeds but provides little grass and no perennial weed control. Adjust rate for OM. Authority provides excellent burndown weed control and may be applied up to 30 days prior to planting, but use the higher rate in the appropriate rate range. Authority can be tank-mixed with most PPI/PRE herbicides registered in soybean. NDSU research has shown excellent weed control in many different environments throughout the Great Plains region. However, at least 0.75 inch rainfall prior to weed emergence is required for partial grass control and for acceptable control of marginally susceptible broadleaf weeds. Herbicide solubility and phytotoxicity increases as soil pH increases. Authority will leave a residue in soil for more than one year. Refer to label or crop rotation restriction section for additional information.

Basagran (bentazon) at 0.5 to 1 qt/A applied POST controls wild mustard, common cocklebur, and sunflower and suppresses biennial wormwood and Canada thistle. Apply with oil additive at 1.25% v/v (1 pt/A by air) or a maximum of 2 pt/A. Basagran is safe to soybean at all stages.

For Canada thistle control, apply at 1 qt/A when plants are 8 inches tall to bud stage and make a second application at 1 qt/A 7 to 10 days later. Basagran is commonly combined with fertilizer micronutrients which may cause incompatibility problems causing the zinc to precipitate. Chelated zinc materials (black in color) have greater incompatibility problems than unchelated material (clear). Recommendations to prevent precipitation are to fill sprayer with water, add Basagran and thoroughly agitate, then add zinc fertilizer material.

Broadstrike + Treflan (flumetsulam + trifluralin) at 1.5 to 2.25 pt/A of premix product or 0.05 to 0.07 of the Python component + 0.64 to 0.96 lb/A of the trifluralin component applied PPI will control most grass and broadleaf weeds in soybean. NDSU research has shown excellent weed control from Broadstrike + Treflan on most grass and broadleaf weeds ONLY after receiving adequate rainfall within the first 7 to 10 days after application. Broadstrike + Treflan will not control large-seeded broadleaf weeds. Use the higher rates on medium to fine textured soils and the lower rates on coarse textured soils. PPI applications may be made 30 days before planting. Shallow incorporate uniformly into the top 2 inches for PPI applications. Do not apply to soils with a pH greater than 8.0 as crop injury may result.

Cobra (lactofen) at 4 to 12.5 fl oz/A or **Phoenix** (lactofen + adjuvant) at 8 to 12.5 fl oz/A applied POST with other registered herbicides will control some broadleaf weeds, including lanceleaf sage. Apply Cobra with oil additive at 0.5 to 1 pt/A and apply Phoenix ONLY with NIS at 0.125% to 0.25% v/v. AMS or liquid nitrogen can be included. The adjuvant system included in the Phoenix formulation enhances weed control of the tank-mix partner with minimal crop response. Do not apply Phoenix with oil adjuvants. Apply Phoenix at 6 to 8 fl oz/A for white mold suppression. Cobra and Phoenix are contact herbicides and require thorough spray coverage for good weed control. Soybean

beyond the third trifoliate leaf stage may interfere with spray interception and reduce weed control. Cobra will burn soybean leaves but usually recover. Apply between daytime temperatures of 70 to 85 F. See label to suppress white mold.

FirstRate/Amplify (cloransulam) applied at 0.6 to 0.75 oz WDG/A PPI or PRE controls common cocklebur, common lambsquarters, horseweed (marestail), pigweed species, annual smartweeds, common and giant ragweed, sunflower, and velvetleaf or at 0.3 oz 80WDG/A applied POST to soybean prior to flowering controls cocklebur, Venice mallow, horseweed (marestail), common ragweed, annual smartweed, sunflower, and velvetleaf and suppresses giant ragweed. Apply to broadleaf weeds less than 10 inches tall. FirstRate gives no nightshade control. Apply with NIS at 0.125 to 0.25% v/v + 28% UAN at 2.5% v/v. Oil additive can be used with or without fertilizer. FirstRate is affected by soil pH. High soil pH increases herbicide activity and speed of herbicide degradation, but also increases risk of crop injury. Some soybean stunting may occur under poor growing conditions on soils with pH greater than 7.8. FirstRate may increase iron chlorosis symptoms on soils where symptoms have been observed earlier. Do not apply to soils with a pH greater than 7.8 as crop injury may result. See label for tank-mix options.

Flexstar (fomesafen + adjuvants) applied POST at 0.75 to 1 pt/A controls common cocklebur, annual smartweed, wild mustard, nightshade, pigweed, waterhemp, common and giant ragweed, Venice mallow and small kochia (including ALS resistant). Apply to broadleaf weeds in the 2 to 4 inch stage. Apply 1 pt/A in ND east of I-29 and south of I-94 and in MN south of I-94. Apply at 0.75 pt/A in ND east of Hwy 281 and in MN south of U.S. Hwy 2. Apply with NIS at 0.25 to 0.5% v/v or oil adjuvant at 0.5 to 1% v/v. Oil adjuvant increase weed control but also increase risk of soybean injury. NDSU research has shown good to excellent kochia control when Flexstar is applied at high spray volumes

(>17 gpa), with oil adjuvants (especially MSO type), at labeled rates, and to kochia less than 2 inches tall.

Flexstar may be applied with POST herbicides labeled in soybean. Soybean injury may result when Flexstar is tank-mixing with EC formulation herbicides. Emulsifiers in the EC formulations acts as additional adjuvant and may significantly increases crop injury. Activity of fomesafen increases and risk of crop injury increases as temperature and humidity increases. A maximum of 0.75 pt/A is allowed in most of ND while 1 pt/A is allowed through the midwest. The reduced fomesafen rate reduces carryover and crop rotation restrictions but requires more management for adequate weed control. Flexstar contains adjuvants lacking in the Reflex formulation. Reflex may give less consistent weed control than Flexstar and will require better management strategies to achieve adequate weed control.

Fusilade DX (fluazifop_P) at 5 to 12 fl oz/A or **Fusion** (fluazifop-P + fenoxaprop-P) at 4 to 12 fl oz/A plus oil additive at 1% v/v applied POST controls annual grasses and quackgrass. See table in the soybean section for information on the rate according to weed species and weed size. Fusilade DX and Fusion provides quackgrass suppression with only one application. Quackgrass regrowth should be retreated at 3 to 5 leaves with Fusilade DX at 12 fl oz/A. Reduced grass control may result if applied with broadleaf herbicides. Reduced grass control can be avoided by applying Fusilade DX or Fusion at least 1 day before or 5 days after application of a broadleaf herbicide.

Gauntlet is sold as a co-pack of Authority (sulfentrazone) and FirstRate (cloransulam). Gauntlet applied PPI or PRE at 5.33 to 6.67 oz/A of Authority + 0.6 to 0.75 oz/A of FirstRate controls most annual broadleaf weeds. See label or paragraphs on Authority and FirstRate for weed controls,

rates, conditions for activity, and crop rotation restrictions. Both Authority and FirstRate will leave a residue in soil for more than one year.

Harmony GT (thifensulfuron) at 1/12 oz 75DF/A applied POST controls wild mustard, common lambsquarters, and pigweed and suppresses other broadleaf weeds. Apply Harmony GT with NIS at 0.125 to 0.25% v/v or oil adjuvants at 0.5% v/v plus liquid fertilizer at 4% v/v. DO NOT apply Harmony GT with oil adjuvants when tank-mixing with any other herbicide or severe crop injury may occur. See label or Pursuit paragraph for precautions when tank-mixing with Pursuit and other herbicides. Harmony GT as spray drift or sprayer contamination may cause severe injury to susceptible crops such as sugarbeet and sunflower. Thoroughly clean sprayer to prevent contamination of subsequent sprays and injury to susceptible crops.

Lasso at 2 to 3 qt/A applied PPI or PRE, **Dual Magnum, Dual II Magnum** at 1 to 2 pt applied PPI or PRE, **Frontier** at 1 to 2 pt/A applied PPI, PRE, or EPOST up to third trifoliate, or **Axiom** at 7 to 13 fl oz/A or **Domain** at 9 to 16 oz WDG/A applied PPI or PRE control annual grass and some broadleaf weeds, including redroot pigweed and common lambsquarters but are ineffective against wild oat. Apply the higher rate on clay soils high in organic matter. Soybean has good tolerance and incorporation improves consistency of weed control. Dual products may be surface applied or incorporated in the fall after September 30 but before ground freezes or applied in the spring.

Poast (sethoxydim) at 0.5 to 1.5 pt/A plus oil additive at 1 qt/A controls annual grasses in soybean. Apply with oil adjuvants. See table for rates according to weed species and weed size. Poast only suppresses quackgrass. Poast mixed with most broadleaf herbicides reduce grass control compared to Poast with oil additive. Poast with oil additives frequently has increased crop injury when combined with

Betanex, Betamix, Ultra Blazer or Cobra. Reduced grass control and crop injury can be avoided by applying Poast at least 1 day before or 5 days after application of a broadleaf herbicide. 28% UAN at 2 to 4 qt/A or 2.5 lb/A of AMS with the oil additive may increase control of volunteer corn, cereal grains and quackgrass.

Pursuit (imazethapyr) at 3 fl oz/A or Pursuit DG at 1.08 oz or 6.67 acres per water soluble packet applied POST controls nightshade, ALS susceptible kochia, wild mustard and pigweed species and may control or suppress many other broadleaf weeds not listed on the label. Pursuit has controlled foxtail, marshelder, Russian thistle, common cocklebur, sunflower, smartweed, and lanceleaf sage in NDSU field trials. Pursuit may give poor control of Venice mallow, wild buckwheat, horsetail, common lambsquarters and common ragweed greater than 1 inch tall. Soil residual from POST applications may not control subsequent flushes of these weeds. Poor residual control of eastern black nightshade may result when only a small amount of herbicide reaches the soil surface with POST application. However, even a small amount of Pursuit may give a reduction in number and intensity of flushes of other weeds. Pursuit should be applied with basic blend adjuvants at 1% v/v, or MSO type oil adjuvants at 1.5 pt/A or oil concentrate at 0.5% v/v, or NIS at 0.125 to 0.25% v/v, with 28% UAN liquid fertilizer at 4% v/v control. 28% UAN improves control of common lambsquarters. NDSU research has shown enhanced weed control by using MSO type oil adjuvants or basic blend adjuvants as compared to NIS or some oil additives with or without 28% UAN.

Pursuit at a reduced rate of 2 to 3 fl oz/A can be tank-mixed with Basagran, Cobra or Harmony GT to increase the spectrum of weeds controlled such as, common cocklebur, common lambsquarters, common ragweed, Venice mallow, and wild buckwheat. Crop injury from sequential postemergence applications of Pursuit following Harmony

GT is greater than with either product alone OR the tank-mix of Pursuit plus Harmony GT. In sequential application, the herbicide applied first reduces the ability of the soybean plant to metabolize the second herbicide. Pursuit and Harmony GT applied as sequential treatments can result in severe crop injury. Weeds not controlled by the first herbicide may not be controlled after the second herbicide is applied. This is particularly important for common lambsquarters. Weeds that escape control from the first herbicide may be larger than labeled size by the time the soybean can safely be treated with the second herbicide. Cultivation before, during or within 7 days after application may also result in reduced weed control. Cultivation approximately 14 days after application is preferred. Tank-mixtures of Pursuit with Assure II, Fusilade DX, Fusion, or Select may result in reduced grass control. Reduced grass control can be avoided by applying the POST grass herbicide either 1 or more days prior or at least 5 days after Pursuit.

Pursuit Plus (imazethapyr + pendimethalin) at 1.8 pt/A applied PPI controls most annual grass and broadleaf weeds. ND state labeling allows use in ND only south of State Highway 2 at a reduced rate of 1.8 pt/A which is 75% of the full labeled rate. Pursuit Plus at 1.8 pt/A contains the equivalent of Pursuit at 3 fl oz/A or 1.08 oz WDG/A plus 1.75 pt/A of Prowl. Add additional Prowl at 1.75 pt/A for more consistent weed control. Thoroughly incorporate into the top 1 to 2 inches of soil. Refer to paragraphs on Pursuit and Prowl for additional information on use and restrictions.

Python (flumetsulam) at 0.8 to 1.33 oz 80WDG/A applied PPI or PRE will control many annual broadleaf weeds in soybean. Python is active on small-seeded broadleaf weeds like nightshade, pigweed, kochia, biennial wormwood, common lambsquarters, mustard, annual smartweed, Venice mallow, and Russian thistle. Python gives poor

control of large-seeded broadleaf weeds like common and giant ragweed and common cocklebur. As with all soil applied herbicides, Python requires soil moisture for optimum weed control. Good soil moisture and timely rains shortly after application are needed to ensure adequate herbicide performance. Python is also strongly affected by soil pH. High soil pH increases herbicide activity and increases speed of herbicide degradation, but also increases risk of crop injury. Excellent broad spectrum weed control may occur when applied on soils with above 7.5 pH, when significant precipitation occurs after application, when rates are based on soil texture and organic matter content, and under light to moderate weed infestations. Some stunting may occur under poor growing conditions on soils with pH greater than 8.0.

Use the higher rates on medium to fine textured soils and the lower rates on coarse textured soils. PPI applications may be made 30 days before planting. Incorporate uniformly into the top 2 inches for PPI applications. Do not apply to soils with a pH greater than 8.0 as crop injury may result. Python is registered as a tank-mixture with most soil applied herbicides labeled in soybean.

Raptor (imazamox) at 4 fl oz/A POST plus a soil applied grass herbicide or Raptor alone at 5 fl oz/A alone POST controls nearly all annual grass and broadleaf weeds in soybean. Grass weeds controlled are barnyard grass, crabgrass, foxtail, wild proso millet, field sandbur, volunteer corn and small grains. Broadleaf weeds controlled are cocklebur, ALS susceptible kochia, lambsquarters, mustard species, nightshade species, pigweed species, giant ragweed, annual smartweed, and sunflower. Raptor provides no or poor control of wild buckwheat, large common lambsquarters, common and giant ragweed, Venice mallow, biennial wormwood, and ALS resistant kochia. In NDSU field trails,

Raptor has controlled weeds listed above plus marsh elder, Russian thistle, and lanceleaf sage less than 1 inch tall. Raptor gives poor control of Venice mallow, wild buckwheat, horsetail (marestail), large lambsquarters and common ragweed. Low soil residue of Raptor may not control late germinating weeds or weeds flushes later in the growing season after rain events. Raptor, as compared to Pursuit has greater grass and broadleaf weed control, provides improved common lambsquarters control, and has less carryover and crop rotation restrictions.

Apply **Raptor** with basic blend adjuvant at 1% v/v or MSO type adjuvants at 1.5 pt/A. Alternatively, apply with NIS at 0.125 to 0.25% v/v or oil concentrate at 0.5% v/v plus 28% UAN liquid fertilizer at 4% v/v. Use of 28% UAN improves control of some weeds like common lambsquarters. MSO type oil additives should be used when weeds are large and/or stressed. NDSU research has shown enhanced weed control by using MSO type oil adjuvants or basic blend adjuvants as compared to NIS or some oil additives with or without 28% UAN. However, Raptor applied with MSO + 28% UAN may result in crop injury at temperatures greater than 88 F and greater than 80% relative humidity.

Refer to label and paragraph on Pursuit for information and restrictions when applying Raptor before or after Harmony GT or tank-mixing Raptor with Harmony GT or other POST herbicides. Crop rotation restrictions are less with Raptor than Pursuit. However, like Pursuit, Raptor carryover is affected by soil pH. As soil pH increases, rate of Raptor degradation increases. At soil pH less than 6.5, rate of breakdown is slow and injury to sugarbeet and other sensitive crops may occur if planted before allowed time interval. See label of Raptor for information on crop rotation restrictions.

Rezult (bentazon + sethoxydim) at 3.2 pt (1.6 pt/A Rezult G and 1.6 pt/A Rezult B) applied POST controls some grass and broadleaf weeds. Apply with oil adjuvants at 1 to 2 pt/A. Refer to label or narrative for tank-mix options. Rezult is priced economically compared to other POST herbicide programs. Refer to Poast sections for additional information.

Select (clethodim) at 4 to 16 fl oz/A or **Prism** at 8.5 to 34 fl oz/A plus oil additive at 1 qt/A applied POST controls annual grass weeds and quackgrass. See table in the soybean section for rates of Select according to weed species and weed size. Quackgrass can be controlled with sequential applications at 8 to 16 fl oz/A. Tank-mixing Ultra Blazer, Basagran, Cobra or Pursuit with Select may reduce grass control. Reduced grass control can be avoided by applying Select at least 1 day before or 5 days after application of a broadleaf herbicide.

Sencor (metribuzin) at 0.25 to 0.5 lb 75DF/A controls annual broadleaf weeds, including wild mustard. Adjust rate according to soil type, pH, and % organic matter. Some soybean varieties are susceptible to metribuzin; consult label for list of susceptible varieties. Soybean injury can be reduced by using herbicide combinations with lower rates of metribuzin.

Sonalan (ethalfluralin) at 1.3 to 3.5 pt/A, **Trifluralin** at 1 to 2 pt 4E/A, or **Prowl** at 2 to 3 pt/A EC or 0.83 to 2.5 lb DG applied PPI controls most annual grasses and some small-seeded broadleaf weeds. They give no wild mustard, common cocklebur and sunflower control. Requirements for proper timing and depth of incorporation differ for each herbicide. Adjust rate according to soil type. Trifluralin must be incorporate in the top 2 to 3 inches of soil within 2 days of application. Trifluralin incorporation may be delayed up to 24 hours if applied to a cool, dry soil. Incorporation of Sonalan 10G can delayed 3 to 5 days after application.

Herbicides can be applied with most soil PPI herbicides labeled in soybean. Sonalan has less soil residue than trifluralin or Prowl and is more active at comparable rates.

Ultra Blazer (acifluorfen) applied POST at 0.5 to 1.5 pt/A controls many broadleaf weeds. Low rates control wild mustard and redroot pigweed but higher rates are needed for nightshade and smartweed. Ultra Blazer will not adequately control volunteer sunflower. Ultra Blazer is a contact herbicide and requires thorough coverage. Apply to weeds 1 to 4 inches tall that are actively growing and first to second trifoliate soybean. Soybean beyond the third trifoliate leaf stage may intercept the spray and prevent thorough coverage of the weeds. Best results are obtained with Ultra Blazer applied at maximum daytime temperatures of 70 to 85 F. NIS (80% active ingredient) generally should be added to the tank at the rate of 0.12% v/v. See the label for additional information on spray additives. Allow a 50 day PHI and do not use treated plants for feed or forage.

Valor (flumioxazin) at 2 to 3 oz/A applied EPP or PRE controls most small-seeded broadleaf weeds including kochia (including ALS resistant), nightshade, pigweed species, lambsquarters, and Venice mallow and may suppress common and giant ragweed, annual smartweed, Russian thistle, and foxtail. Valor does not control perennial weeds. Apply Valor from 14 days prior to seeding to just before soybean emergence. Valor can be applied with most PRE herbicides labeled in soybean and can be tank-mixed with glyphosate in early burndown systems. Valor requires a minimum of 0.25 inch of rain for activation and requires a bioassay prior to planting sensitive crops. See label for additional information.

Roundup (Glyphosate) resistant soybean

Gyphosate at 1 to 2 pt/A of a 3 lb ae/gal concentrate applied only to glyphosate resistant soybean will control most annual and perennial weeds. Refer to label for adjuvant use. Apply with AMS. Application timing may not be appropriate for effective perennial weed control.

Glyphosate is a non-selective, non-residual, systemic herbicide that can control grasses at rates as low as 0.25 pt/A. Labeled rates are required for broadleaf weeds. However, some broadleaf weeds like kochia, nightshade, wild buckwheat, horseweed (marestail), dandelion, and lambsquarters may not be adequately controlled by one application of glyphosate. Refer to label for weeds controlled, application information, timing, tank-mix options, and other restrictions. Glyphosate will control weeds resistant to other herbicides.

POST Grass Herbicides

Herbicide	Weed Size	Rate
	(inches)	
Green and Yellow Foxtail		
Assure II	2 to 4	8 fl oz
Fusilade DX	2 to 4	10 to 12 fl oz
Fusion	2 to 4	8 fl oz
Poast	1 to 8	1 pt
Prism	2 to 8	8.5 to 12.8 fl oz
Select	2 to 8	4 to 6 fl oz
Wild Oat		
Assure II	2 to 6	8 fl oz
Fusilade DX	2 to 6	8 fl oz
Fusion	2 to 6	8 fl oz
Poast	1 to 4	1 pt
Prism	2 to 6	12.8 fl oz
Select	2 to 6	6 fl oz

Herbicide	Weed Size	Rate
	(inches)	
Field Sandbur		
Assure II	2 to 6	8 fl oz
Fusilade DX	2 to 4	10 to 12 fl oz
Fusion	2 to 4	8 fl oz
Poast	1 to 3	1.5 pt
Prism	2 to 6	12.8 fl oz
Select	2 to 6	6 fl oz
Wild Proso Millet		
Assure II	2 to 6	8 fl oz
Fusilade DX	4 to 8	6 fl oz
Fusion	4 to 8	6 fl oz
Poast	4 to 10	0.5 pt
Prism	1 to 10	8.5 to 12.8 fl oz
Select	1 to 10	4 to 6 fl oz
Volunteer Small Grains		
Assure II	2 to 6	8 fl oz
Fusilade DX	2 to 6	8 fl oz
Fusion	2 to 6	8 fl oz
Poast	1 to 4	1.5 pt
Prism	2 to 6	12.8 fl oz
Select	2 to 6	6 fl oz
Volunteer Corn		
Assure II	6 to 18	5 fl oz
Fusilade DX	12 to 24	6 to 8 fl oz
Fusion	12 to 24	6 fl oz
Poast	1 to 20	1 pt
Prism	4 to 12	8.5 fl oz
Prism	12 to 24	12.8 fl oz
Select	4 to 12	4 fl oz
Select	12 to 24	6 fl oz
Quackgrass (first treatment/regrowth)		
Assure II	6 to 10	10/8 fl oz
Fusilade DX	6 to 10	12/8 fl oz
Fusion	6 to 10	12/12 fl oz
Poast	6 to 8	1.5/1 pt
Prism	4 to 12	17/17 fl oz
Select	4 to 12	8/8 fl oz

Control of problem weeds

Wild buckwheat: Authority, Sonalan, and Sencor will suppress wild buckwheat. Roundup may control wild buckwheat less than 1 to 2 inches tall but requires two applications.

Flax, volunteer: Flexstar and Ultra Blazer will control volunteer flax.

Kochia: Most kochia in North Dakota is resistant to the ALS herbicides Python, Raptor, Pursuit, and Harmony GT. Trifluralin does not give consistent kochia control but Sonalan may improve control compared to trifluralin. Soil applied Authority or Valor in soybean gives excellent kochia control. Flexstar applied with MSO type adjuvant in high water volumes of 20 gpa to kochia less than 3 inches tall may give good postemergence control.

Nightshades have become a serious weed problem in North Dakota. Nightshade biotypes are tolerant to many classes of herbicide, including SUs. Eastern black nightshade resistance to imidazolinone herbicides has been documented in several counties in eastern North Dakota and western Minnesota. Authority, Python, and Valor will control nightshade for 10 to 12 weeks control and Frontier/Outlook will control nightshade for 2 to 3 weeks control. Sonalan will only suppress nightshade. POST Flexstar will control ALS resistant and susceptible nightshade and Pursuit, Raptor will control only ALS susceptible nightshade. Basagran may control Hairy nightshade but not Eastern Black nightshade. Basagran, Cobra, and Ultra Blazer controls only small nightshade (less than 2 inches). Flexstar gives poor hairy nightshade control. Only Authority, Valor, Python, Extreme and Pursuit gives residual control of multiple flushes but these herbicides may restrict seeding of some crops one or more years after application

Pigweed/Waterhemp: Most soybean herbicides control redroot pigweed. However, waterhemp has been

documented in eastern North Dakota and western Minnesota. Waterhemp, a related pigweed species, has biotypes that are tolerant to Pursuit and Raptor and can survive low rates of glyphosate. Non ALS herbicides like Authority, Valor, and Flexstar will control waterhemp.

Wormwood, annual or biennial: Biennial wormwood survives most PPI, PRE, and POST herbicides, is then detected and misidentified as common ragweed when plants are larger. Rescue treatments are made with herbicides that control common ragweed, such as Ultra Blazer and FirstRate but have little or no effect on wormwood. Biennial wormwood is difficult to control because of an extended emergence period and tolerance to many PPI, PRE (e.g. Treflan, Sonalan, Prowl, Lasso, Dual) and POST (e.g. most ALS herbicides and Ultra Blazer) herbicides used in soybean. Also, Biennial wormwood can emerge late after most POST herbicides have been applied and is often confused with common ragweed. Other herbicides that control wormwood are soil applied Authority, Python, Sencor and post applied glyphosate in Roundup ready soybean. Limited research and experience indicates Basagran applied as split applications — first split when wormwood is 1.5 inches tall and second split when wormwood is 3 inches tall will improve control. Compared to a single treatment. Wormwood apparently rapidly becomes tolerant to herbicides as plant size increases.

Perennial weeds in soybean

Canada thistle is a major problem in North Dakota due to reduced tillage, wet weather, and lack of persistence in control. In conventional soybean, multiple applications of Basagran is the only product that will suppress Canada thistle. Spray rosettes of actively growing plants using the rosette technique. See Basagran in the Table section for more information on the rosette technique for control of Canada thistle in soybean. Multiple applications of glyphosate in Roundup Ready soybean will control Canada thistle.

Common milkweed. No herbicides control common milkweed except multiple applications of glyphosate in Roundup Ready soybean.

Milkweed requires multiple application and control is expensive. Individual plants and small patches are easier and less expensive to treat than entire fields. Patch spraying covers only a fraction of the area of a broadcast application. Patch-spray glyphosate at 4 to 6 pt/A when milkweed is in the late-bud to flowering stage and actively growing. Apply glyphosate with AMS at 4 to 8.5 lb/100 gallons of water.

Glyphosate at 2 to 4 pt/A of a 3 lb ae/gal concentrate can be applied as a preharvest application or as a spot treatment in conventional and Roundup Ready soybean for perennial weed control in soybean. Spot treatments must be made prior to initial pod set on soybean. Glyphosate is non-selective, so the conventional soybean in the treated area will be killed. Avoid drift outside the target area. Glyphosate is non-residual so perennial shoots may emerge after treatment and unaffected roots from perennials will continue to grow. Preharvest applications of glyphosate at 2 pt/A gives good Canada thistle and quackgrass control. Preharvest applications will give greater Canada thistle control than post-harvest applications when tillage is used after harvest.

Soybean herbicide injury/symptomology

Acetanilide (Lasso, Dual, etc)	Leaf stunting, puckering, and the 'draw string' affect on the central vein or leaf midrib.
DNA (Trifluralin, Sonalan, Prowl)	Excessive rates with stress conditions may cause pruned roots and swollen or cracked hypocotyls.
Plant Growth Regulators	Leaf puckering along with stem and branch twisting and epinasty.
ALS Inhibitors	Misapplication, drift, or carryover of some ALS herbicides not registered on soybean may stunt soybean plants and cause yellow or chlorotic blotches on leaves. Labeled herbicides like Raptor and Pursuit may intensify the symptoms of iron chlorosis. Tankmixes of Harmony GT with Pursuit or Raptor is not recommended due to severe soybean stunting and leaf burn.
Contact - Soil applied (Authority and Valor)	Authority: Some soybean varieties are susceptible to injury. See your seed dealer for a list. Symptoms are stunting and yellowing of soybean leaves. Valor may cause localized speckling from a "splash affect" after a rain storm. Speckling may only occur on bare soil where no crop residue exist.
Contact - POST (Aim, Blazer, Cobra, Flexstar)	Aim, Blazer and Flexstar may show localized speckling of soybean leaves. More serious injury may result if Aim applied in wet or dew conditions. Injury from Cobra my variable from speckling to severe leaf burn. New soybean growth after contact herbicide application is unaffected.
Contact - POST (Basagran)	Yellow chlorotic mottling in small patches on leaves. Areas of leaf burn may occur under stress conditions or hot temperatures. Injury is cosmetic and new growth is unaffected.
Triazine	Symptoms of atrazine carryover from high rates and high soil pH may be visible as leaf burn and desiccation from the bottom leaves progressing up the plant and from leaf tips inward. Symptoms from metribuzin may be similar to atrazine where high rates are used.
Glyphosate (Conventional soybean)	Symptoms from drift is expressed early on new growth as stunting and leaf yellowing. Symptoms will progress to older plant tissue. Plants may remain stunted and affected plant tissue may die within 7 to 14 days after exposure depending on herbicide concentration and growing conditions.

Insect Management in Soybean

In general, insects have not been a major production problem for soybeans within the region. The potential does exist each year for certain insects to cause injury. With the recent discovery of the soybean aphid, *Aphis glycines*, there will be greater need for monitoring fields for insect pests in the future. Other important soybean insects in the region are seedcorn maggot, potato leafhopper, cutworm, and various caterpillars.

Estimating defoliation damage

In soybeans, field scouting to assess insect populations is based on either the number of insects per foot of row, insects per plant, or the level of defoliation.

Insects per foot of row is determined by shaking plants over the inter-row space, on which a strip of cloth has been laid. Count the total number of insect pests per foot of row that fall on the cloth. If sampling narrow row or drilled soybeans, the use of a "Texas vertical beat sheet" should be considered. The vertical beat sheet is made from a piece of galvanized metal flashing or similar stiff material 36 inches wide, 32 inches tall and crimped at the bottom to form a collecting trough 4 inches wide. Place the device next to the row and shake the plants against the vertical surface. Insects dislodged from plants collect in the trough where they can be counted or collected.

Percent defoliation is determined by estimating the amount of leaf loss based on visual inspection of randomly selected plants.

The growth stage of the soybean plant is important. Under most conditions, moderate defoliation early in the season has little effect on final bean yield. As plants reach the flowering and pod filling stages, defoliation poses a greater threat to yield. For example, research indicates that the soybean plant can sustain a 35 percent leaf loss prior to

the pre-bloom period. From pod-set to maturity, the plant can tolerate only a 20 percent defoliation level.

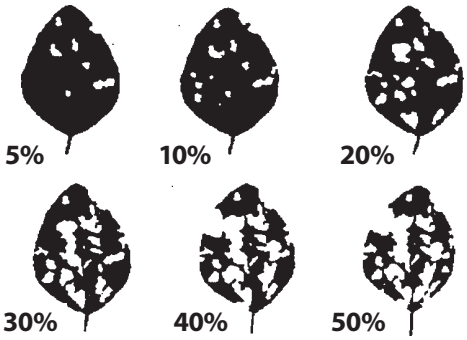
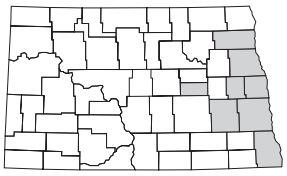


Figure 5. Soybean defoliation levels

Soybean aphid



A new aphid pest feeding on soybeans was found in the midwestern states of Michigan, Illinois, Wisconsin, Iowa, and Minnesota in late July and early August of 2000. It was confirmed that this aphid was the **soybean aphid**, *Aphis glycines*, an aphid native to Asia but never reported in the United States prior to this discovery. Soybean aphid was found in North Dakota in August 2001.

The soybean aphid is light yellow with black cornicles ("tail-pipes") and a pale colored cauda (tail projection). As with other aphids, the soybean aphid is small, about the size of a pinhead. Nymphs are smaller.

Aphids suck fluid from plants. When infestations are large, infested leaves are wilted or curled. The aphids excrete honeydew, a sweet substance that accumulates on surfaces of lower leaves and promotes the growth of sooty

mold. This aphid colonizes tender leaves and branches from seedling to blooming. Later, as the growing point slows, the aphids slow their reproductive rate, move down to the middle and lower part of the plant, and feed on the undersides of leaves. Toward the end of the season the colonies again begin to rapidly increase in number. These increases are followed by a migration to the overwintering alternate host, buckthorn. Future observations will lead to a better understanding of what soybean aphid will do in the U.S.

For more information, see NDSU Extension Service circular E-1232, Soybean Aphid, *Aphis glycines*, Management in North Dakota – 2002.

Though no economic infestations were found in North Dakota during the 2001 season, field inspections are encouraged.

Threshold:

Unfortunately, the treatment threshold is still vague, and future research and experience will better define it. Currently, the guidelines for making soybean aphid treatment decisions are:

- Begin scouting soybean fields at the V3 to V4 stage to determine if soybean aphids are present in fields. No treatment is recommended at this time and is discouraged so insecticides do not reduce the presence of predators and parasites;
- The critical growth stage for making most soybean aphid treatment decisions appears to be the late vegetative to early reproductive (V*n* to R2). Assessing aphid populations at this time is critical.
- **Treatment to manage soybean aphid would be recommended at early flowering when aphids are abundant on most plants.** University of Wisconsin research trials during 2001 found that a population of 200 aphids/plant during susceptible growth stages (R2 to R4) resulted in a yield loss of about 6 bushels/acre, a yield loss near or above the break-even point for the cost of an insecticide application.

SOYBEAN APHID

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Asana XL *(RUP)*	0.03 to 0.05	5.8 to 9.6 fl oz	Do not apply within 21 days of harvest. Do not feed or graze livestock on treated plants.
Furadan 4F *(RUP)*	0.25 to 0.5	4 to 8 fl oz	Do not apply within 21 days of harvest. Apply in sufficient water for thorough coverage (minimum gallons: air - 2 gal/acre, ground - 20 gal/acre).
Lorsban 4E *(RUP)*	0.5 to 1.0	1 to 2 pts	Do not apply within 28 days of harvest. Do not graze or feed forage to dairy or meat animals within 14 days after application. Do not feed straw from treated soybeans to meat or dairy animals within 28 days after application.
Pounce *(RUP)*	0.1 to 0.2	4 to 8 fl oz	Do not apply within 60 days of harvest. Do not feed or graze livestock on treated plants.
Warrior *(RUP)*	0.015 to 0.025	1.92 to 3.2 fl oz	Do not apply within 45 days of harvest. For control of first and second instars only. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Armyworms

Armyworms are greenish-brown with longitudinal stripes. Full grown larvae are smooth, striped and almost hairless. Armyworms feed for three to four weeks. When full grown, larvae are 1½ to 2 inches long. Armyworm larvae have six growth stages, or instars. The armyworms' final instar lasts about 10 days, and they consume large amounts of plant material during that time. Armyworms are inactive during the day, resting under plant trash, clumps of grass or lodged plants. They feed at night or on cloudy days, crawling up on plants and consuming foliage. Due to their habit of feeding at night, armyworms may go undetected until significant damage has occurred.

Armyworms do not overwinter in the region. The moths migrate from southern states in late spring and early summer. This helps explain the sporadic infestations that occur. When moths arrive, they prefer to lay their eggs in moist, shady areas, usually where grasses have lodged. Infestations that develop within soybean fields are often due to grassy weed problems.

Armyworms are more of a problem in small grains and corn. Damage to soybeans can occur when the armyworms usual host plants become exhausted due to feeding or dry conditions. When their food is depleted in the hatching site, the armyworms may move in large numbers or "armies" eating and destroying plants or crops in their path.

Threshold:

Control of armyworms is recommended when 25 to 30 percent of the foliage is destroyed or if significant injury to pods is evident. Most often in soybeans, infestations are due to migrating armyworms. Under these circumstances, treatment of a couple of swaths ahead of the migrating armyworms to establish a barrier strip and prevent further migration and injury may be all that is needed.

ARMYWORMS

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
carbaryl (Sevin)	1 to 1.5	rate varies by formulation	Do not apply within 21 days of harvest or 14 days of grazing or harvest for forage.
Lorsban 4E *(RUP)*	0.5 to 0.75	1 to 1.5 pts	Do not apply within 28 days of harvest. Do not graze or feed forage to dairy or meat animals within 14 days after application. Do not feed straw from treated soybeans to meat or dairy animals within 28 days after application.
Scout X-TRA *(RUP)*	0.016 to 0.024	2.28 to 3.41 fl oz	Do not apply within 21 days of harvest for soybeans. Optimum gallons: Use a minimum of 3 to 5 gal water/acre for aerial application and 5 gal water/acre for ground application. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. Do not apply more than 27 fl oz/acre on soybeans in 1 growing season.
Tracer (spinosad)	0.047 - 0.062	1.5 - 2 fl oz	Do not apply within 28 days of harvest. Do not feed treated forage or hay to meat or dairy animals.
Warrior *(RUP)*	0.015 to 0.025	1.92 to 3.2 fl oz	Do not apply within 45 days of harvest. For control of first and second instars only. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Cutworms

Several cutworm species affect regional crops. The dingy cutworm, *Feltia jaculifera*, overwinters as a partially grown larva and is one of the first cutworm species to cause problems during crop emergence from early to mid May. The moth of the dingy cutworm is known to lay her eggs on sunflower heads from mid July through September. Soybeans and other crops following sunflowers in rotation are at greatest risk of injury by this cutworm. Other cutworms, the red-backed, *Exoa ochregaster*, and the darksided, *Exoa messoria*, overwinter as eggs which hatch in mid to late May. Eggs are laid in the fall and survive in weedy, wet and reduced tillage areas. Feeding injury by these cutworms normally occurs in late May to early June.

Most damage by cutworms occurs when soybean plants are in the early stage of development. Damage consists of young plants being chewed off slightly below or at ground level. Some cutworm feeding injury may occur on foliage. Cutworms primarily feed at night. When checking soybean fields for cutworms during the day, dig down into soil an inch or two around recently damaged plants; there you can find the gray to gray-brown larva.

Threshold:

Economic thresholds for cutworm treatment decisions are not well established. Treatment guidelines used over the years include when one cutworm or more is found per 3 feet of row and the larvae are small (<¾ inch long). Another guideline is when 20 percent of plants are cut or when gaps of 1 foot or more exist in the plant row. When making a final decision, consider that surviving soybeans are able to compensate for early stand reductions because of the plant's long growth period.

CUTWORMS

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Asana XL *(RUP)*	0.03 to 0.05	5.8 to 9.6 fl oz	Do not apply within 21 days of harvest. Do not feed or graze livestock on treated plants.
carbaryl (Sevin)	1 to 1.5	rate varies by formulation	Do not apply within 21 days of harvest or 14 days of grazing or harvest for forage. For cutworm control, this product is effective against species which feed on the upper portions of the plants.
Lorsban 4E *(RUP)*	0.5 to 1	1 to 2 pts	Rotary hoe after application if soil is dry for several days. Restrictions same as for armyworm.
permethrin Pounce *(RUP)*	0.05 to 0.1	2 to 4 fl oz	Do not apply within 60 days of harvest. Do not graze or feed soybean forage or hay. Apply a minimum of 1 gal of finished spray per acre by air or 5 gals by ground.
Scout X-TRA *(RUP)*	0.016 to 0.024	2.28 to 3.41 fl oz	Do not apply within 21 days of harvest for soybeans. Optimum gallonage: Use a minimum of 3 to 5 gal water/acre for aerial application and 5 gal water/acre for ground application. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. Do not apply more than 27 fl oz/acre on soybeans in 1 growing season.
Warrior *(RUP)*	0.015 to 0.025	1.92 to 3.2 fl oz	Do not apply within 45 days of harvest. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Foliage feeding caterpillars

Green Cloverworm, Cabbage Looper, Velvetbean Caterpillar, Thistle Caterpillar, and Alfalfa Webworm

Populations of these caterpillars have been negligible in North Dakota and little treatment to control them has been required. Sampling for these insects is accomplished through the use of a drop cloth or a vertical beat sheet placed between two rows of plants. The larvae are dislodged from the plants and counted on the cloth or collection tray to arrive at an estimate of the number per row feet.

Green cloverworm: These caterpillars are green with two narrow, white stripes down the side. When mature, the worms are 1¼ inches long. These caterpillars have only three pairs of fleshy prolegs on the abdomen, plus the pair on the back tip. When moving, the worms move by arching the middle of the body, or "looping." Young worms scrape leaf tissue creating a transparent skin, or "window," on the leaf surface. Older clover worms eat holes in the leaves.

Cabbage looper: These caterpillars are light to dark green with lighter colored stripes along the side and on the top, running the length of the body. When mature, the worms are 1 ½ inches long. These caterpillars have only two pairs of fleshy prolegs on the abdomen, plus the pair on the back tip. When moving, the caterpillars move by arching the middle of the body, or "looping." These worms feed on leaves on the interior and lower portion of the plant. As defoliation occurs, worms feed higher in the plant. Feeding injury is similar to the cloverworm.

Velvetbean caterpillar: This insect does not overwinter in the region. Instead, moths migrate from southern locations. These caterpillars have dark lines bordered by lighter colored, narrower, lines running the length of the body. The background color ranges from a pale yellow-green to brown or black. These larvae have four pairs of fleshy prolegs to

distinguish them from the cloverworm and the looper. Young velvetbean caterpillars feed on the underside of leaves in the upper portion of the plant. Older larvae consume the entire leaf, except for the leaf veins.

Thistle caterpillar: This insect is the larva of the butterfly known as the painted lady. This butterfly does not overwinter in the region but migrates from southern locations each spring. These caterpillars are brown to black in color with yellow stripes along each side of the body. They are covered with spiny-hairs that give the caterpillar a prickly appearance. Full grown larvae are about 1½ inches long. The caterpillars feed on the leaves, webbing them together at the feeding site.

Alfalfa webworm: These larvae are 1 inch long when full grown. They are greenish to nearly black with a light stripe that runs down the middle of the back. There are three dark spots, each with hairs, on the side of each segment. These larvae feed for about three+ weeks. Infestations are characterized by light webbing over the leaves. Beneath the web is where the larvae feed, consuming the leaves. These larvae move very rapidly, forward or backward, when disturbed.

Threshold:

Control of these different caterpillars is normally not warranted until greater than 30 percent of the foliage is destroyed prior to bloom, or when 20 percent of the foliage is destroyed after bloom, pod set or fill has been reached. This usually requires an average infestation of four to eight larvae per row foot.

FOLIAGE FEEDING CATERPILLARS

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Asana XL *(RUP)*	0.015 to 0.03	2.9 to 5.8 fl. oz.	Do not apply within 21 days of harvest. Do not feed or graze livestock on treated vines. Recommended application rates for Cabbage looper are slightly higher at 5.8 to 9.6 fl oz.
carbaryl (Sevin)	0.5 to 1.5	rate varies by formulation	Do not apply within 21 days of harvest or 14 days of grazing or harvest for forage.
Lannate LV *(RUP)*	0.11 to 0.45	0.4 to 1.5 pts	Do not apply within 14 days of harvest. Do not make more than 3 applications per crop.
Lorsban 4E *(RUP)*	0.25 to 0.5	0.5 to 1 pt	Do not apply last treatment within 28 days of harvest nor apply last treatment closer than 14 days apart. Do not graze or feed treated forage to meat or dairy animals.
Penncap-M *(RUP)*	0.5	2 pts.	Do not apply within 20 days of harvest or grazing. Do not apply more than twice per season. Do not enter treated fields within 48 hours after application. Fields must be posted.
permethrin Pounce Ambush *(RUP)*	0.05 to 0.1	 2 to 4 fl oz 3.2 to 6.4 fl oz	Do not apply within 60 days of harvest. Do not graze or feed soybean forage or hay. For Pounce, apply a minimum of 1 gal of finished spray per acre by air or 5 gals by ground. For Ambush, apply a minimum of 2 gals of finished spray per acre by air or 10 gals by ground.

Scout X-TRA *(RUP)*	0.012 to 0.016	1.7 to 2.28 fl oz	Do not apply within 21 days of harvest. Optimum gallonage: Use a minimum of 3-5 gal water/acre for aerial application and 5 gal water/acre for ground application. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. Do not apply more than 27 fl oz/acre on soybeans in 1 growing season.
Tracer (spinosad)	0.031 - 0.062	1 - 2 fl oz	Do not apply within 28 days of harvest. Do not feed treated forage or hay to meat or dairy animals.
Warrior *(RUP)*	0.015 to 0.025	1.92 to 3.2 fl oz	Do not apply within 45 days of harvest. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Grasshoppers

In the northern plains, grasshopper egg hatch normally begins in late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground. Soybean growers should expect to find grasshoppers feeding first along bean field margins adjacent to non-crop sites where the nymphs are hatching. Later infestations may develop when grasshopper adults migrate from harvested small grain fields. Grasshoppers will feed on leaves and pods, chewing holes in them. A result of these migrations is soybean fields becoming sites for significant egg laying.

Threshold:

Grasshopper control is advised whenever 50 or more small nymphs per square yard can be found in adjacent, non-crop areas, or when 30 or more nymphs per square yard can be found within the field. When 20 or more adults per square yard are found in field margins or eight to 14 adults per square yard are occurring in the crop, treatment would be justified.

Many of the grasshopper infestations in soybeans will be the heaviest on the field margins. Treating these areas may lessen the total numbers of grasshoppers successfully entering a field.

Soybeans are most sensitive to defoliation during pod development (Growth stages R4 to R6). During this time, plants can only tolerate up to 20 percent defoliation. The greater concern would be direct feeding damage to pods and seeds by grasshoppers. Grasshoppers are able to chew directly through the pod walls and damage seed directly. If more than 5 to 10 percent of the pods are injured by grasshoppers, an insecticide application would be recommended.

GRASSHOPPERS

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Asana XL *(RUP)*	0.03 to 0.05	5.8 to 9.6 fl oz	Do not apply within 21 days of harvest. Do not feed or graze livestock on treated plants. A **reduced rate** has been issued as a state 2 (ee) label. These lower rates are for control of first and second stage grasshoppers, ONLY. The reduced rate application has a range of 3.9 - 5.8 fl oz.
carbaryl (Sevin)	1 to 1.5	rate varies by formulation	Do not apply within 21 days of harvest or 14 days of grazing or harvest for forage. Recommended use rates vary according the age of the grasshoppers.
dimethoate (Digon 400, Dimethoate 400)	0.5	1 pt	Do not harvest within 21 days of last application. Do not feedor graze within 5 days of last application. Do not enter treated fields without protective clothing until sprays have dried.
Furadan 4F *(RUP)*	0.125 to 0.25	0.25 to 0.5 pt	Do not make more than 2 foliar applications per season. Do not apply within 21 days of harvest. Do not graze or feed foliar treated forage to livestock or cut for silage or hay. Minimum gallonage requirements: 20 gals of finished spray per acre with ground equip, 1½ gals per acre with aircraft.
Lorsban 4E *(RUP)*	0.25 to 0.5	0.5 to 1 pt	Low rate effective on 1st and 2nd instar nymphs. Do not apply last treatment within 28 days of harvest nor apply last treatment closer than 14 days apart. Do not graze or feed treated forage to meat or dairy animals.

continued

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Penncap-M (RUP)	0.5 to 0.75	2 to 3 pts	Do not apply within 20 days of harvest or grazing. Do not apply more than twice per season. Do not enter treated fields within 48 hours after application. Fields must be posted.
Scout X-TRA *(RUP)*	0.016 to 0.024	2.28 to 3.4 fl oz	Do not apply within 21 days of harvest. Optimum gallonage: Use a minimum of 3-5 gal water/acre for aerial application and 5 gal water/acre for ground application. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. Do not apply more than 27 fl oz/acre on soybeans in 1 growing season.
Warrior *(RUP)*	0.025 to 0.03	3.2 to 3.84 fl oz	Do not apply within 45 days of harvest. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Bean leaf beetle

This beetle can vary in color from yellow to reddish brown and may have three to four black spots with a black border on the wing covers. Adults emerge from overwintering, moving into bean fields as the seedlings emerge. The white larvae develop in the soil, feeding on the roots and nodules. New adults emerging in August feed on foliage and pods. Feeding injury to leaves appears as small round holes between the leaf veins. Injury to pods appears as lesions similar in size and shape to leaf feeding holes. The injury to pods results in secondary infections by fungi and bacteria, causing rotting and discoloration.

Threshold:

Due to low incidence of this insect in North Dakota, no local control guidelines have been developed. Based on information from other regions where these insects are a common pest, use a sweep net to determine if bean leaf beetles are present. Treatment would be recommended when three to seven beetles per sweep are found.

BEAN LEAF BEETLE

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Asana XL *(RUP)*	0.03 to 0.05	5.8 to 9.6 fl. oz.	Do not apply within 21 days of harvest. Do not feed or graze livestock on treated vines.
carbaryl (Sevin)	0.5 to 1.5	rate varies by formulation	Do not apply within 21 days of harvest or 14 days of grazing or harvest for forage.
dimethoate (Digon 400, Dimethoate 400)	0.5	1 pt	Do not harvest within 21 days of last application. Do not feed or graze within 5 days of last application. Do not enter treated fields without protective clothing until sprays have dried.
Furadan 4F *(RUP)*	0.25 to 0.5	4 to 8 fl oz	Do not apply within 21 days of harvest. Apply in sufficient water for thorough coverage (minimum gallons: air – 2 gal/acre, ground – 20 gal/acre).
Lannate LV *(RUP)*	0.23 to 0.45	0.75 to 1.5 pts	Do not apply within 14 days of harvest. Do not make more than 3 applications per crop.
Lorsban 4E *(RUP)*	0.5 to 1	1 to 2 pts	Do not apply last treatment within 28 days of harvest nor apply last treatment closer than 14 days apart. Do not graze or feed treated forage to meat or dairy animals.
Penncap-M *(RUP)*	0.5 to 0.75	2 to 3 pts.	Do not apply within 20 days of harvest or grazing. Do not apply more than twice per season. Do not enter treated fields within 48 hours after application. Fields must be posted.

permethrin Pounce Ambush *(RUP)*	0.05 to 0.1	 2 to 4 fl oz 3.2 to 6.4 fl oz	Do not apply within 60 days of harvest. Do not graze or feed soybean forage or hay. For Pounce, apply a minimum of 1 gal of finished spray per acre by air or 5 gals by ground. For Ambush, apply a minimum of 2 gals of finished spray per acre by air or 10 gals by ground.
Warrior *(RUP)*	0.015 to 0.025	1.92 to 3.2 fl oz	Do not apply within 45 days of harvest. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Potato leafhopper

The adult is wedge-shaped and pale green in color. Adults are very active, jumping or flying when disturbed. Nymphs are wingless. Both adults and nymphs run backwards or sideways rapidly when disturbed. Nymphs feed on the underside of the leaf, usually completing their growth on the leaves near where they hatched. Large numbers of adults may appear early in the season, but their presence is dependent on migration from the eastern U.S.

Soybeans with moderate to dense pubescence, or plant hairs, are tolerant to leafhopper infestations. The short plant hairs form a barrier that discourages leafhoppers from feeding and laying eggs on plant tissue. When feeding does occur, damage by leafhoppers is referred to as hopper-burn. Foliage becomes dwarfed, crinkled, and curled. Small triangular brown areas appear at the tips of leaves, gradually spreading around the entire leaf margin. Potential damage to soybeans by potato leafhopper is not fully understood. Damage would be more likely when drier growing conditions occur.

Threshold:

The threshold for basing spray decisions is when an average of five leafhoppers per plant are found in the vegetative stages, and nine leafhoppers per plant in early bloom stages.

POTATO LEAFHOPPER

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
Asana XL *(RUP)*	0.015 to 0.03	2.9 to 5.8 fl. oz.	Do not apply within 21 days of harvest. Do not feed or graze livestock on treated vines.
carbaryl (Sevin)	1	rate varies by formulation	Do not apply within 21 days of harvest or 14 days of grazing or harvest for forage.
dimethoate (Digon 400, Dimethoate 400)	0.5	1 pt	Do not harvest within 21 days of last application. Do not feed or graze within 5 days of last application. Do not enter treated fields without protective clothing until sprays have dried.
Penncap-M *(RUP)*	0.5 to 0.75	2 to 3 pts.	Do not apply within 20 days of harvest or grazing. Do not apply more than twice per season. Do not enter treated fields within 48 hours after application. Fields must be posted.
permethrin *(RUP)* Pounce Ambush	0.05 to 0.1	 2 to 4 fl oz 3.2 to 6.4 fl oz	Do not apply within 60 days of harvest. Do not graze or feed soybean forage or hay. For Pounce, apply a minimum of 1 gal of finished spray per acre by air or 5 gals by ground. For Ambush, apply a minimum of 2 gals of finished spray per acre by air or 10 gals by ground.
Scout X-TRA *(RUP)*	0.012 to 0.016	1.7 to 2.28 fl oz	Do not apply within 21 days of harvest. Optimum gallonage: Use a minimum of 3-5 gal water/acre for aerial application and 5 gal water/acre for ground application. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. Do not apply more than 27 fl oz/acre on soybeans in 1 growing season.
Warrior *(RUP)*	0.015 to 0.025	1.92 to 3.2 fl oz	Do not apply within 45 days of harvest. Do not graze or harvest treated soybean forage, straw or hay for livestock feed. When applying by air, apply in a minimum of 2 gallons of water per acre.

RUP – Restricted use pesticide

Seedcorn maggot

Seedcorn maggot attack soybean seed, preventing sprouting or weakening the seedlings. The yellowish white maggot is found burrowing in the seed, emerging stem, or the cotyledon leaves. Damage to the seedlings results in a condition called "snakeheads," or plants without cotyledon leaves.

The adult flies emerge in spring when soil temperatures reach 50F. They deposit eggs in soil where there is abundant organic matter and decaying crop residue, or on the seed or seedling. Injury from seedcorn maggots is usually most severe during wet, cold springs and in fields with high organic matter soils. When cool, wet conditions occur during planting, the slow emergence of the seedling extends the period of time it is vulnerable to feeding by the maggot.

Threshold:

When conditions are wet and cool, or when planting into high crop residue conditions, seed treatments provide the best defense against injury.

SEEDCORN MAGGOT

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
diazinon	*see specific labels for rates*		Products currently available are: Agrox DL Plus®, Germate Plus®, and Kernel Guard®. Treated seed must not be used for, or mixed with, food or animal feed, or processed for oil.
lindane	*see specific labels for rates*		Lindane treated seed must not be used for, or mixed with, food or animal feed, or processed for oil.

Spider mites

Mites are small and magnification is required to see them. A quick sampling procedure to determine whether mites are present is to hold a piece of white paper below leaves, then slap them to dislodge the mites. The mites appear as tiny dust specks; however, they will move after being knocked off the leaf. Feeding damage by mites first appears as small yellow spots ("stipples"). As feeding activity increases, leaves become yellow, bronzed, brown, and eventually shed from the plant.

Mites usually become a problem when hot, dry weather occurs. These environmental conditions stress the plant, whether mites are present or not. If conditions continue, treating for mites is no guarantee plants will recover. In addition, products labeled for mite control often do not give adequate control and the population of mites may rebound quickly to pretreatment levels or higher. When rain and humidity are present, natural reductions in mite populations occur due to infection by a fungal pathogen. Conditions that are good for the development of the pathogen are temperatures cooler than 85F, with at least 90 percent R.H. for 12 to 24 hours.

Threshold:

Deciding whether to treat is difficult. There is no economic threshold that has clearly been defined. Kansas State University suggests that treatments may be beneficial if significant pod or seed filling remain and leaves have not already yellowed. Plants that lose 50 percent of their foliage during bloom and pod set will stop producing flowering structures until favorable growing conditions resume or lost leaf area is replaced. If mite injury is evident within the interior of the field, and hot, dry conditions continue, the potential exists for economic populations throughout the field in one to two weeks.

SPIDER MITES

Insecticide	Dosage in lb a.i./acre	Product per Acre	Restrictions on use
dimethoate (Digon 400, Dimethoate 400)	0.5	1 pt	Do not harvest within 21 days of last application. Do not feed or graze within 5 days of last application. Do not enter treated fields without protective clothing until sprays have dried.
Lorsban 4E *(RUP)*	0.25 to 0.5	0.5 to 1 pt	Do not apply last treatment within 28 days of harvest nor apply last treatment closer than 14 days apart. Do not graze or feed treated forage to meat or dairy animals.

RUP - Restricted use pesticide

Hail damage

A hailstorm can cause yield losses in soybeans ranging from slight to total destruction of the crop. Extensive research has been conducted to accurately predict the effects of hail damage on soybean yields. Results from these studies are used by hail insurance companies to assess yield losses and consequent adjustment made to clients.

Yield loss predictions are based on two factors: a) stage of growth at the time of damage, and b) the degree of plant damage. Plant damage is classified as leaf defoliation, stand reduction, stem damage, and pod damage**.**

Stand reduction is a measure of the number of plants killed by the storm. The pre-storm plant population is compared to the remaining stand seven to 10 days after the storm to determine the yield loss due to stand reduction.

To determine the pre-storm population, count the original number of plants in 10 feet of row. Repeat this step several times throughout the field to get a representative sample. Now convert the average stand per 10 feet of row to plants per acre, using the following formula:

$$\frac{\text{(avg. number of plants in 10 foot row)}}{\text{(row spacing in inches)}} \times 52{,}250 = \text{\# plants per acre}$$

Using the same procedure, determine the remaining live plant population.

Percent field loss of soybean as affected by the amount of stand reduction (all stand figures in 1,000 plants/acre).

Original Stand	Remaining Stand										
	120	110	100	90	80	70	60	50	40	30	20	10
	Percent											
125	1	3	6	10	14	18	24	30	36	44	54	65
120	0	1	5	9	13	17	23	29	35	43	53	64
110	–	0	3	7	11	15	21	27	33	41	51	62
100	–	–	0	3	7	11	17	23	29	37	45	59
90	–	–	–	0	3	7	13	19	25	33	43	55
80	–	–	–	–	0	4	10	16	22	30	40	52
70	–	–	–	–	–	0	6	12	18	25	35	48
60	–	–	–	–	–	–	0	7	13	20	30	45
50	–	–	–	–	–	–	–	0	8	16	25	41
40	–	–	–	–	–	–	–	–	0	11	23	39

Defoliation is measured as a percentage of the leaf area destroyed by the storm. Leaf tissue that is green and still attached to the plant will continue to produce photosynthate and is *not* considered leaf area destroyed. Research has shown that leaf loss during vegetative stages has little effect on yield. Defoliation loss is measured only in the reproductive stages for indeterminate varieties.

Percent yield loss of indeterminant soybean varieties as affected by degree of defoliation.

Growth Stage	Defoliation (Percent leaf area destroyed)									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
R1-2	0	2	3	5	6	7	9	12	16	23
R3	2	3	4	6	8	11	14	18	24	33
R4	3	5	7	9	12	16	22	30	39	56
R5	4	7	10	13	17	23	31	43	58	75
R6	1	6	9	11	14	18	23	31	41	53

These tables are only intended to be general guidelines to soybean yield losses due to hail injury. Percent reduction of nodes cut off or broken over were not included. Even though early season soybean defoliation appears to be very devastating, research has shown that soybean plants can recover and yield fairly well under good growing conditions. The pod setting and pod full periods are very susceptible to severe injury. Hail adjusters will usually defer in final yield loss determinations until later in the season. These tables and guides are continually being revised and updated as research becomes available. Specific loss predictions should be left to trained hail adjusters.

Source: National Crop Insurance Association - Soybean Loss Instruction - Pub. No. 6302.

Frost damage

Soybeans are easily damaged by frost in the 28 to 32 F range. Temperatures of 28 F for any extended period of time can completely kill soybean plants (stems and leaves).

During early seedling stage (VE to VC), soybeans have some tolerance to temperatures of 29 - 30 F for short periods of time. If the seedlings have been somewhat hardened off by cool temperatures for several days, then temperatures as cool as 28 F can be tolerated. Once true leaves emerge (V_1 and V_2) soybeans become more susceptible to freezing temperatures below 32 F for any extended period of time. Unifoliolate leaf stage is slightly more frost tolerant than first or second trifoliolate stages.

Late season frost damage

Research information from Wisconsin has shown that all varieties tested had reduced yields when frost occurred at or before R6. Earlier maturing varieties sustained economic yield losses from frost at more advanced growth stages than later maturing varieties. The greatest yield losses occurred when frost occurred at stage R5. Number of beans per plant and reduced bean size all contributed to overall yield loss. Maturity was hastened by some frost treatments and was not delayed in any of the trials studied.

Soybean seed on frost-damaged plants will many times mature and change color as early or even earlier than non-frosted beans.

The leaves do remain on the frost damaged soybean plants. Seed moisture maybe slightly higher and seed size is usually reduced as the soybeans dry and shrink. A frost will not hurt soybean yields if the soybean growth stage is beyond R7. A frost between R6 and R7 may or may not affect yield depending on the temperature and duration of the freeze.

Beans that are still green and soft will shrivel. Stalks rapidly turn dark green to brown and will not recover. Beans in pods that have turned yellow will mature normally. Some green beans will turn yellow after 30 to 40 days of storage.

Growers and researchers over the years have tried color keys of yellow soybean leaves, yellow pods and brown pods to estimate soybean maturity and safety from frost. Usually these methods didn't work because of differences in varieties regarding symptoms of maturity.

However, studies do show that "yellow" pods sprinkled with brown are the best clue of physiological maturity. It is suggested to open pods and check shrinking of beans and look for separation of beans from the white membrane inside the pod. This indicates the soybeans are physiological mature and fairly safe from frost injury. Pods do not all mature evenly.

It's been noted that if one or two pods on any of the upper four nodes have turned brown and other pods are light yellow to tan, the soybeans are fairly tolerant to a killing frost.

In the event of a leaf killing frost when pods are still light green or yellow, wait until the pods are mature in color before combining.

The most significant effect of an early frost on soybean may be in the reduction of quality to use as a future source of seed.

Generally speaking, soybean fields planted to narrow row spacings (6-7 to 12 inches) may have slightly more tolerance to light frosts than soybeans planted in wider rows (30-36 inches). The heavy plant canopy of the solid-seeded, closely drilled beans tends to hold the soil heat better and protects the plants to some degree.

Estimating soybean yields

Soybean yield estimates are most accurate within three weeks of maturity, but are still only estimates. Assume 2.3 beans per pod.

- Determine the number of feet of row needed to make 1/1000 of an acre *(table on following page).*

- Count the number of plants in ten (10) different randomly selected sample areas. Calculate the average.

  Avg. = _____ = A (plants/A)

- Count the number of pods per plant on ten (10) randomly selected sample areas. Calculate the average.

  Avg. = _____ = B (pods/plant)

- Calculate pods/acre by multiplying plant population by pods/plant.

  A X B = _____ = C (pods/acre)

- Calculate seeds/acre by multiplying pods per acre by an estimate of 2.3 seeds/pod.

  2.3 X C = _____ = D (seeds/A)

- Calculate pounds/acre by dividing seeds/acre by an estimate of 3000 seeds/pound.

  D ÷ 3,000 = _____ = E (lbs/A)

- Estimate yield by dividing pounds/acre by 60 pounds/bu.

  E ÷ 60 = _____ = Yield (bu/A)

Row length equal to 1/1000 acre.

Row Width (in.)	Length of a Single Row Equal to 1/1000 of an Acre
6	87' 1"
7	74' 8"
8	65' 4"
10	52' 3"
15	34' 10"
20	26' 2"
28	18' 8"
30	17' 5"
32	16' 4"
36	14' 6"
38	13' 9"
40	13' 1"

Harvesting Soybeans

Field studies in soybean harvesting have shown that a 10 percent or higher harvest loss is not uncommon, but studies have also shown that harvest loss can be reduced to 3 percent 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 losses.

Soybean loss

Soybeans should be harvested when bean moisture content reaches 13 percent on the first dry down (Figure 6). However, if beans are ready for harvest and then are subjected to alternating periods of wet and dry weather, preharvest or shatter loss can be high. Preharvest losses are influenced by the time of harvest and can be reduced by harvesting early. Preharvest losses are beans that have dropped on the ground prior to harvest.

Gathering or header losses can account for more than 80 percent of the total loss in soybean harvesting. These include all losses occurring at the header caused by actions of the cutter bar, reel, and feeder auger, and losses from soybeans left on uncut stubble.

Gathering losses are divided as follows:

- **Shatter loss** – shelled beans and detached bean pods that are shattered from stalks by the header and fall to the ground.
- **Stubble loss** – beans remaining on stubble.
- **Stalk loss** – beans in pods attached to stalks which were cut, fell on the ground and not run through the combine.
- **Lodged stalks** – beans remaining in pods attached to stalks that are laying on the soil or if cut, were cut at lengths larger 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 operators' manual for cylinder speed and concave spacing along with air flow and shoe settings. Then, operate the combine in the field and check for loss. Usually, only small adjustments need to be made in the field. Remember to run the cylinder at as slow a speed as possible but it must be fast enough to thresh the beans from the pods. Excessive cylinder or rotor speed is usually the main reason for cracked bean seeds.

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, pickup guards, narrow pitch knives (1½ inches vs 3 inches) and combination pickup finger/air reels. These attachments provide significant reductions in soybean loss. The flexible-floating cutter bar is able to follow soil slopes better and cut a shorter stubble, 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. Pickup guards ride on the soil surface sliding under lodged bean stalks so they are cut and directed into the combine header. Combination finger/air reel help push cut stalks and pods back into the feeder housing to reduce bean pods and seed from building up on the cutter bar with the resulting shelling and bean loss.

All 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 he can afford to spend on the attachments. A grower must estimate how many acres of beans will be harvested, crop yield and a loss level improvement regarding soybean harvesting.

For example, a producer may grow 500 acres of soybeans and be able to reduce loss by 3 to 5 percent. With a 35 bu/ac yield and a 3 to 5 percent reduction in loss, a grower could see a return of 1 to 1¾ bu/ac more beans in the bin. Multiplied times 500 acres, an extra 500 to 875 bushels of soybeans could be saved. Spread the investment over five or more years, and a significant amount of money can be justified to reduce harvest loss of beans. Interest costs on the money should be included, along with repairs, insurance and resale value.

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 percent faster than forward travel speed. Faster reel speeds will rip bean pods off stalks and result in increased bean loss. 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 cylinder-concave clearance (Figure 7). It is important to operate the cylinder only fast enough to remove the beans from the pods and no faster. It is important to slow cylinder speed during the day as beans dry. This is more important for conventional combines than rotary, as Illinois tests found that rotary combines produced significantly less splits than conventional cylinder-concave type machines. But, both types of machines could easily produce high quality soybeans. Or, if cylinder or rotor speeds are too fast, damaged soybeans will result.

Measuring harvest loss

It is important to identify where harvest losses are occurring so measures can be taken to eliminate or minimize the loss. Soybean seed loss from the various areas are determined by making several seed counts inside a measured area. The measured area is best completed by forming a 1-foot by 1-foot square. This is best done by forming a heavy piece of wire (No. 9 is good) into a square. Then, this is used in the field to make seed counts.

Refer to figure 8 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.

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 8.

   a. Count beans in the uncut area to determine "preharvest shatter loss." This is location 1 in Figure 8.

   b. Count beans behind the combine to find the "total crop loss." This is location 2 in Figure 8.

3. Enter the bean counts for "preharvest losses" and "total crop loss" into 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 No. 4 by 4, because approximately four beans per square foot equals 1 bushel per acre. If the beans you are raising are large in size, then three beans per square foot would equal 1 bushel per acre.

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

35 bu/ac yield
1.2 bu/ac loss

$$\text{percent loss} = \frac{1.2 \text{ bu/ac}}{35 \text{ bu}} \times 100 = 3.4 \text{ percent}$$

If the machine loss is more than 3 percent of crop yield, further investigation as to 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 done 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 laying 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 laying flat. Add to table 1. Pick 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 preharvest loss from the gathering unit loss. This figure will give the gathering unit loss. Subtract the gathering unit loss from the machine loss to give the cylinder and separation loss. Follow the step by step procedure in table 1.

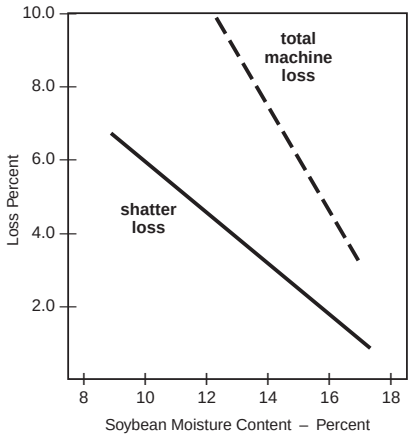


Figure 6. Shatter and machine loss related to moisture content at harvest.

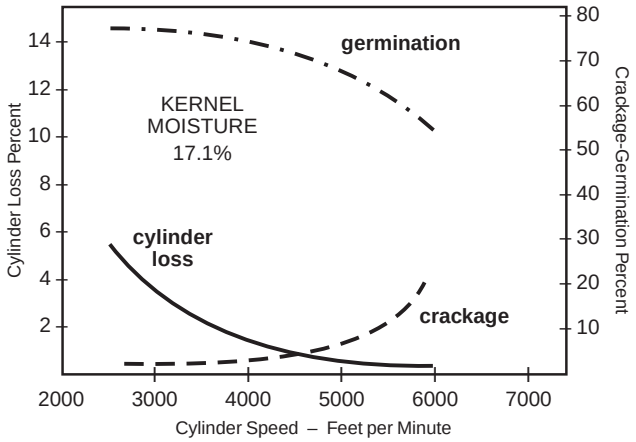


Figure 7. Relationship of cylinder speed to cylinder loss, germination and soybean crackage.

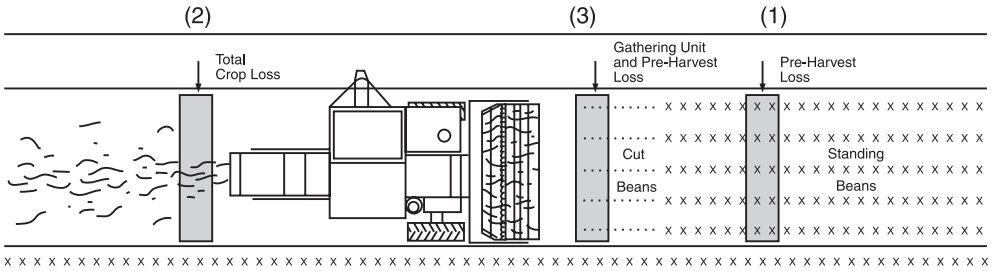


Figure 8. Location of areas to make seed loss counts.

Table 1. Loss table.				
	No. of Beans	No. of Frames (counts)	Avg No. of Beans per Frame	BU/Acre
A. Total Crop Loss			÷ 4	
B. Preharvest 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)				

Soybean drying, handling and storage

Soybeans are usually traded on a 13 percent moisture basis, so it is to the farmer's advantage to harvest, store, and sell soybeans as close to 13 percent moisture (wet basis) as possible. Soybeans that are wetter than 13 percent 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 percent moisture are more likely to split during handling and, since they weigh less, fewer bushels are

available for sale. If the temperature of the stored beans is kept below about 60 F, soybeans can usually be held for at least six months at 13 percent moisture without mold problems. For storage under warmer temperatures or for storage times longer than six months, however, the recommended moisture content is 11 percent.

Storage management for 11 to 13 percent moisture soybeans

Soybeans that are harvested at 11 to 13 percent 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 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 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 40F. Then shut the fan off for a few more 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 15 divided by 0.1 or 150 hours, which is about six 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 that cooling is complete.

When you are operating aeration fans to cool beans that are 11 to 13 percent moisture, you don't need to worry too much about relative humidity. Beans near the point where air enters the bin will rewet some 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 feet of beans by the time you've changed the moisture of a 1-foot 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. Keep in mind that these types of controls will limit the time that the fan operates and it will take longer to cool the entire bin than it would without the controls.

Once soybeans have been cooled to 20 to 30 F, check them every two to four weeks during winter months to make sure that 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 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 every one to two weeks, but unless a problem develops, it is not necessary to operate the aeration fans. If you do 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 University of Minnesota 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 drop heights 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 percent moisture in the field. But some years, weather conditions prevent soybeans from drying to 13 percent moisture, and sometimes, growers harvest at moistures greater than 13 percent to avoid the harvest losses that can occur at lower moisture contents. (Soybeans can be harvested without too much damage up

to about 18 percent moisture.) If soybeans are harvested at a moisture content much above 13 percent, artificial drying is necessary.

There is not much published research on soybean drying. Most 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 foot 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 feet 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 percent moisture beans, 0.75 cfm/bu for 15 to 17 percent moisture beans, and 0.5 cfm/bu for 13 to 15 percent 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 percent moisture or less, 1.25 cfm/bu for 17 percent moisture beans, and 1.5 cfm/bu for 18 percent moisture beans. See "Natural-Air Corn Drying in the Upper Midwest," BU-6577, available from the University of Minnesota 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 percent, 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 percent 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 percent 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, 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 percent can cause excessive splitting. For every 20 degrees that you heat air, you cut its relative humidity approximately in half, so it doesn't take very much heat to produce relative humidities less than 40 percent.

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

1. Turning off the fan when weather gets cold in the fall, keeping beans cold during winter, and resuming drying when average temperatures climb above freezing in the spring.
2. Installing bigger fans so that you can finish drying earlier in the fall when weather is better.
3. Using 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 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.

Don't forget that crops dried in gas-fired dryers must be cooled within a day or so 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 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, to avoid the high discounts that are applied in years when large quantities of green beans are delivered during harvest. Just make sure 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 percent moisture. Although it is illegal to add liquid 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:

- 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 will be similar to the speed of drying. It would be difficult to accomplish significant reconditioning using the low airflow aeration systems common on storage bins.
- Fan control is tricky and some beans could end up too wet for safe storage.
- 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.
- 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 percent moisture during normal fall temperatures of 30 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 percent. 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.

	Relative Humidity (%)				
Temperature	**50**	**60**	**70**	**80**	**90**
(F)					
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 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 percent or less, controlling the fan so that it only runs when relative humidity of the air reaching the beans is greater than about 55 percent should result in rewetting. If you use a single humidistat to turn the fan on anytime humidity is greater

than 55 percent, average humidity during the hours the fan operates should be well above 55 percent and the beans are likely to rewet to at least 13 percent. 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:

- Reducing the humidity setting on the humidistat that controls the fan so that the fan runs during drier conditions.
- Adding a second humidistat that stops the fan when relative humidity reaches very high levels.
- 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.

Soybeans swell when they absorb moisture, and experience during floods indicates that soaking the bottom few feet of beans in a bin can result in enough pressure to rupture bin walls. We don't have 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:

- Use a bin equipped with a full perforated floor and a fan that can deliver at least 0.75 cfm/bu.
- If it is available, 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.
- Use timers, humidistats, programmable controllers, or some other type of automatic control to limit fan operation to weather conditions that will cause rewetting.
- Keep reconditioned beans cool (20 to 30 F is the suggested winter storage temperature in the upper Midwest) to reduce chances of spoilage.
- Watch carefully for signs of moldy beans and for excessive stress on the bin.

Food or high value soybeans

More care is required with high value soybeans primarily to minimize the amount of cracked skins and beans. The optimum moisture content for harvest is about 13 percent to 15 percent. At moisture contents below about 13 percent, there are more split beans, germination is reduced due to more damage during harvest and handling, field loss will be greater, and there is a loss of about $0.07 per bushel per point of moisture below 13 percent due to a less weight.

To minimize damage during handling, belt conveyors are preferred to augers. If augers are used, they should be operated at a slow speed and be kept full. Pneumatic conveyors can be used if the proper air to grain ratio is maintained, gentle curves are used in the conveying tubes, and a low conveying velocity is used. Drop heights should be minimized, so bean ladders are recommended in bins or other locations where the beans may fall during conveying. Cold beans are more susceptible to damage during handling. Care must be used in drying beans since much of the damage that occurs during handling is due to stresses created during drying.

Damage during drying occurs when the relative humidity of the drying air is below about 40 percent. Generally, the drying air in a high temperature dryer should not be heated more than 20 degrees to minimize the potential for damage to the seed coat. One study showed with a 100F drying temperature there were 10-60 percent of the skins cracked and 5-20 percent of the beans cracked. Another study showed about 15 percent of the seed coats cracked with the drying air at 40 percent relative humidity and 30 percent of the seed coats cracked with a 30 percent relative humidity.

United States standards for soybeans – grades and grade requirements.

Grading Factors	Grades U.S. Nos. 1	2	3	4
	Minimum pound limits of			
Test Weight (lbs./bu.)	56.0	54.0	52.0	49.0
	Maximum percent limits of			
Damaged Kernels				
Heat (part of total)	0.2	0.5	1.0	3.0
Total	2.0	3.0	5.0	8.0
Foreign Materials	1.0	2.0	3.0	5.0
Splits	10.0	20.0	30.0	40.0
Soybeans of other colors*	1.0	2.0	5.0	10.0
	Maximum count limits of			
Other Materials				
Animal filth	9	9	9	9
Castor beans	1	1	1	1
Crotalaria seeds	2	2	2	2
Glass	0	0	0	0
Stones**	3	3	3	3
Unknown foreign substance	3	3	3	3
Total***	10	10	10	10

U.S. Sample grade are soybeans that:
(a) Do not meet the requirements for U.S. Nos. 1, 2, 3, or 4; or
(b) Have a musty, sour, or commercially objectionable foreign odor (except garlic odor); or
(c) Are heating or otherwise of distinctly low quality.

* Disregard for Mixed soybeans.
** In addition to the maximum count limit, stones must exceed 0.1 percent of the sample weight.
*** Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, and unknown foreign substances. The weight of stones is not applicable for total other material.

Special Grades and Special Grade Requirements

810.1605 Special grades and special grade requirements.

a. **Garlicky soybeans.** Soybeans that contain five or more green garlic bulblets or an equivalent quantity of dry or partly dry bulblets in a 1,000-gram portion.

b. **Purple mottled or stained.** Soybeans with pink or purple seed coats as determined on a portion of approximately 400 grams with the use of an FGIS Interpretive Line Photograph.

Contributors to Soybean Production Field Guide

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- ***Richard Zollinger***
  Weed Specialist, NDSU Extension Service

Resource Publications

North Dakota State University –

- Soybean Production (A-250)
- North Dakota Soybean Performance Testing (current year) (A-843)
- Agricultural Weed Control Guide (current year) (W-253)
- Field Crop Fungicide Guide (current year) (PP-622)
- Crop Rotations for North Dakota (EB-48)
- Profitable Midwest No-Till Soybean Production (NCR-580)
- Soybean Seedling Diseases (Video #337)
- Soybean Soil Fertility (SF-1164)
- Crop Rotations for Managing Plant Disease (PP-705)
- Mechanical Weed Control with Harrow and Rotary Hoe (W-1134)
- Soybean Aphid, *Aphis glycines*, Management in North Dakota – 2002 (E-1232)

University of Minnesota –

- The Minnesota Soybean Field Book (MI-7290-S)
- Fertilizing Soybeans in Minnesota (FS-3813)
- Minnesota Variety Trials Results (MR-7314)
- Relative Emergence Sequence for Weeds of Corn and Soybeans (FO-6958)
- Soybean Growth and Development Information for Replant Decisions (FO-5701)
- Soybean Disease (SS-2634)
- Tillage Best Management Practices for Corn-Soybean Rotations (FO-6676)

Resource Contact Information

Extension Offices

North Dakota State University	
Plant Sciences	701/231-8135
Economics-Markets and Budgets	701/231-7393
Engineering	701/231-7236
Entomology	701/231-7581
Plant Pathology	701/231-7056
Soils	701/231-8884
Weeds	701/231-8157
University of Minnesota	
Agronomy	612/625-8700
Economics-Markets and Budgets	612/625-1226
Engineering	612/625-9733
Entomology	612/624-9272
Plant Pathology	612/625-6290
Soil Sciences	612/625-5797

Ag Statistics Services, USDA

North Dakota Ag Statistics Service 701/239-5306
PO Box 3166
Fargo, ND 58108

Minnesota Ag Statistics Service 612/296-2230
8 East Fourth Street Suite 500
St. Paul, MN 55101

Plant Diagnostic Labs

NDSU - Plant Diagnostic Lab 701/231-7584
206 Waldron Hall
North Dakota State University
Fargo, ND 58105

University of Minnesota 612/625-1275
Plant Disease Clinic
495 Borlaug Hall
1991 Buford Circle
St. Paul, MN 55108

North Dakota State Seed Dept. 701/231-5400
Seed Testing Labs
PO Box 5257
Fargo, ND 58105

Minnesota State Seed Lab 612/296-6123
Dept. of Agriculture
90 West Plato Blvd.
334-6360
St. Paul, MN 55107

Minnesota Soybean Growers Association and Minnesota Soybean Research and Promotion Council

360 Pierce Avenue, Suite 110
N Mankato MN 56003

507/388-1635
www.mnsoybean.org/

North Dakota Soybean Growers Association and North Dakota Soybean Council

1411 32nd Street SW
Fargo, ND 58103

701/239-7194 or 888-469-6409
Fax: 701/239-7195
www.ndsoybean.org

Interesting and Useful Soybean Web Sites

Soybean Production Management

- North Dakota State University Extension Service
  www.ext.nodak.edu/extpubs/
- North Dakota State University Research/Extension Centers
  www.ag.ndsu.nodak.edu/recenthp.htm
- North Dakota State University Pro-Crop
  http://ag.ndsu.nodak.edu/aginfo/procrop/
- North Dakota Agricultural Research On-line Journal
  www.ag.ndsu.nodak.edu/ndagres/ndagres.htm
- North Dakota State University Weed-Pro
  www.ext.nodak.edu/extnews/weedpro/
- NDSU Seedstock and other related seed links
  www.ag.ndsu.nodak.edu/aginfo/seedstock/fss/SEEDLINK.htm
- NDSU Soybean Disease Information for the Region
  www.ndsu.nodak.edu/soydiseases/
- NDSU Insect Updates for North Dakota
  www.ag.ndsu.nodak.edu/aginfo/entomology/entupdates/index.htm
- How a Soybean Plant Develops
  www.agron.iastate.edu/soybean/beangrows.html
- University of Minnesota Extension-Crop Systems
  www.extension.umn.edu/farm/
- Iowa State University Extension Crops Publications
  www.extension.iasstate.edu/pubs/

- University of Minnesota Agriculture Experiment Station
  www.maes.umn.edu
- University of Nebraska Extension
  www.ianr.unl.edu/pubs/index.htm
- University of Illinois Extension
  www.extension.uiuc.edu/welcome.htm

Commodity Groups and Organizations

- United Soybean Board (includes Diagnostic Guide)
  www.unitedsoybean.org/
- American Soybean Association
  www.soygrowers.com/
- Minnesota Soybean
  www.mnsoybean.org/
- Minnesota Crop Improvement Association
  www.mncia.org
- North Dakota Soybean Council
  www.ndsoybean.org/
- Northern Crops Institute
  www.northern-crops.com/

Soybean Search Engines

- @griculture Online
  www.agriculture.com/
- StratSoy
  www.ag.uiuc.edu/~stratsoy/new/
- SeedQuest
  www.seedquest.com/

Notes

2002

JANUARY

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For more information on this and other topics, see:
www.ag.ndsu.nodak.edu

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