NEW JERSEY SOYBEAN HANDBOOK

NJSB
NEW JERSEY SOYBEAN BOARD
Progress Powered by U.S. Farmers

INTRODUCTION BY NEW JERSEY SOYBEAN BOARD

Dear Fellow Soybean Farmers:

This New Jersey Soybean Handbook is provided to you as part of a cooperative program of the New Jersey Soybean Board (NJSB) and the United Soybean Board (USB). NJSB administers your soy checkoff program in the state, and USB administers your soy checkoff at the national level. Various research and extension personnel, with the New Jersey Agricultural Experiment Station and Rutgers Cooperative Extension, and their colleagues across the nation contributed to the content of this handbook.

NJSB hopes that you will find this handbook useful in making management decisions for your farm throughout the year that will ultimately improve your profitability.

This book represents only one of the many benefits resulting from investments made by NJSB and USB. We invite you to visit the following websites to learn how your checkoff dollars benefit you and other soybean farmers throughout the state.

www.UnitedSoybean.org

www.NJSoybean.org

We thank you for your support of the program and hope to continue to support research, marketing and education projects that will be of use to you.

Sincerely,

NEW JERSEY SOYBEAN BOARD MEMBERS

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CHAPTER 1

SOYBEAN GROWTH AND DEVELOPMENT

Soybean (*Glycine max. L.*) is an annual broadleaf legume plant grown for its seed that is high in protein and oil. Soybeans exhibit both vegetative and reproductive stages of growth from planting to harvest.

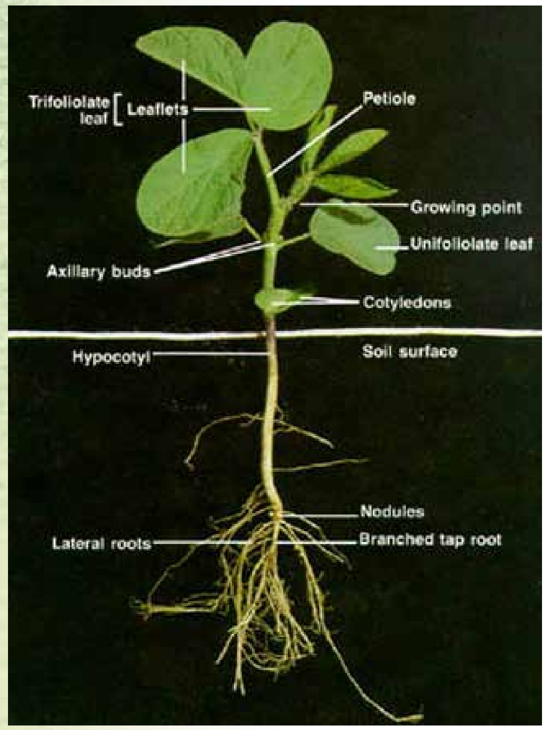
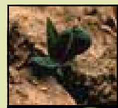
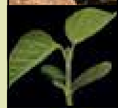
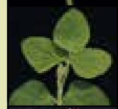
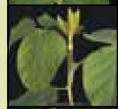
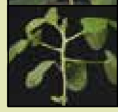


Fig. 1.1
Source: Illinois Soybean Production Guide, United Soybean Board, 2012 (Image from D.A. McWilliams, D.R. Berglund and G.J. Endres. 2004. Soybean Growth and Management Quick Guide. North Dakota State University Extension Service.)

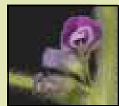
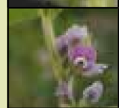
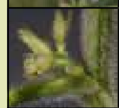
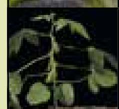
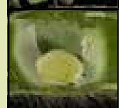
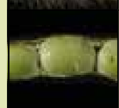
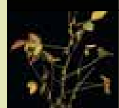
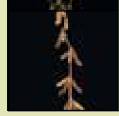
Fig. 1.1 illustrates the parts of a young soybean plant. The various stages and descriptions of growth are illustrated in Fig. 1.2 and Fig. 1.3. Soybeans grown in New Jersey are of the indeterminate type, which means they add more leaves and vegetative height even after reproductive (flowering) stages begin.

Soybeans grown in the South are determinate types and stop additional vegetative growth once flowering begins. Knowledge and understanding of these stages are necessary in various production decisions during the season, including assessment of plant and stand damage, pest-control strategies and irrigation scheduling.

VEGETATIVE GROWTH STAGES Fig. 1.2

	VE	**Emergence** – cotyledons have been pulled through the soil surface.
	VC	**Unrolled unifoliate leaves** – unfolding of the unifoliate leaves.
	V1	**First trifoliate** – one set of unfolded trifoliate leaves.
	V2	**Second trifoliate** – two sets of unfolded trifoliate leaves.
	V3-Vn	**Fourth trifoliate** – four unfolded trifoliate leaves.

REPRODUCTIVE STAGES Fig. 1.3

	R1	**Beginning flowering** – plants have at least one flower on any node.
	R2	**Full flowering** – there is an open flower at one of the two uppermost nodes.
	R3	**Beginning pod** – pods are 3/16 inch (5 mm) at one of the four uppermost nodes.
	R4	**Full pod** – pods are 3/4 inch (2 cm) at one of the four uppermost nodes.
	R5	**Beginning seed** – seed is 1/8 inch long (3 mm) in the pod at one of the four uppermost nodes on the main stem.
	R6	**Full seed** – pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem.
	R7	**Beginning maturity** – one normal pod on the main stem has reached its mature pod color.
	R8	**Full maturity** – 95 percent of the pods have reached their full mature color.

Images courtesy of Iowa State University, used with permission.

CHAPTER 2

VARIETY SELECTION

The selection of which varieties to grow is among the most important decisions made by a farmer each year. Varieties differ in their yield performance, days to maturity, pest tolerance, standability, herbicide resistance and more. The classification of soybean varieties into maturity groups relates to the latitudes where they can be grown (see Fig. 2.1). In New Jersey, recommendations are as follows for most planting dates except for the latest double-crop dates:

- Northern counties: Late group II and early group IIIs.
- Central counties: Mid-group IIIs to early group IVs.
- Southern counties: Late group IIIs to mid-group IVs.

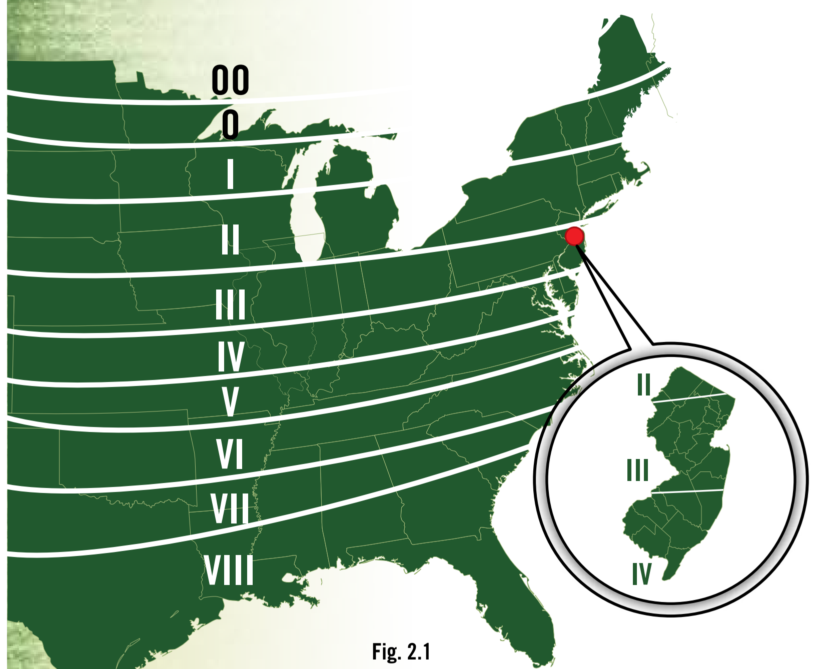


Fig. 2.1

Each seed company has its own designation for variety names, but numerous companies use the following style, as an example:

B3922RR

- **B** represents the company or brand name (may be whole words).
- **3** represents maturity group III.
- **9** is the relative earliness or lateness within the maturity group. In this case, the 9 signifies late, whereas a 2 would mean early.
- **22** represents a particular variety (may be preceded by a letter or additional numbers).
- **RR** (or other ending letters) often represents a herbicide- or pest-resistance designation.

Yield is an important selection criterion because it is reflective not only of the genetic potential of the soybean but also of proper maturity, pest tolerance, lodging resistance and similar agronomic traits. Farmers making variety selection decisions can benefit from obtaining yield test results from university and demonstration trials in other states or from their own testing. Evaluating results from similar latitudes (maturity groups) and soil-moisture conditions is most helpful.

Farmers should also consider seed quality when selecting varieties, looking for varieties with germination rates at 90 percent or above and purity approaching 100 percent. Seed treatments, including fungicides and insecticides, are increasingly common and may be helpful when planting occurs in stressed soil and environmental conditions.

HIGH OLEIC SOYBEANS

INTRODUCTION

High oleic soybeans produce oil with improved functionality for key soybean-oil customers. This soybean oil offers a longer fry life and longer shelf life without the need for hydrogenation. Commodity soybean oil requires hydrogenation for increased stability, but the partial hydrogenation process also creates trans fats in the oil. Due to a lack of trans fats and a higher level of monounsaturated fats compared with traditional soybean oil, high oleic soybean oil can also help food companies make healthier products. The greater functionality extends to industrial uses as well. The oil has higher heat functionality, making it attractive for uses such as motor oil and lubricants. Although the identity of these soybeans must be preserved, the new varieties otherwise perform similarly in the field to conventional soybean varieties.

VARIETY DEVELOPMENT

The soy checkoff invested in accelerating two seed companies' existing efforts to integrate the high oleic trait into varieties in maturity groups 1-5. Through the checkoff's investment, seed companies ramped up breeding resources, analysis and the number of crosses being made and populations growing during summer and winter operations. These efforts were in addition to the original plans each company had for high oleic trait integration in late 2 and early 3 maturity groups.

To date, USB has partnered with the two seed companies that have patents for high oleic soybean technology and are marketing varieties for farmer use: Dupont Pioneer and Monsanto. In addition, USB adopted a board policy that lays out how other companies can also request funding, should they obtain patents or access to other high oleic traits. Licensing of technology to other companies may also be a business strategy by the seed companies as they develop their own commercialization plans for high oleic soybeans. Several universities have also been working on high oleic soybeans.

Currently, high oleic soybeans are offered in late-2 to mid-3 maturity groups and grown in select areas of Delaware, Illinois, Indiana, Ohio, Maryland, Michigan and Pennsylvania. ADM, Bunge, Cargill, Perdue and Zeeland all offer contracts, accepting high oleic soybeans at select locations in these states. In 2014, the projected acreage for high oleic plantings nationwide is nearly 200,000 acres, more than triple the acreage in 2013.

Production practices are similar to commodity soybean varieties. These new varieties yield on par with existing varieties and come with many of the pest-resistance and other agronomic traits typically desired by farmers.

FOOD INDUSTRY VALUE

High oleic soybean oil will be used first by the frying and light baking industries. These are the customers that need oil with more functionality for high-heat situations. High oleic soybean oil extends fry life and shelf life of products, compared with commodity soybean oil.

High oleic isn't the silver bullet to replace partially hydrogenated oil. Like standard soybean oil, high oleic oil does not have a solid/crystal structure needed for most bakery shortenings and similar uses. It does, however, offer an excellent blending option for food companies that need a solid fat-based oil to replace partially hydrogenated soybean oil. High oleic soybean oil can be blended with palm oil or another solid fat to meet the food industry's needs.

MARKETING

Marketing of high oleic soybeans is based on individual contracts with processing facilities. Depending on the outlined agreements with the processor, farmers may be able deliver newly harvested high oleic soybeans to multiple locations in the fall. Others may need to store the soybeans on the farm to preserve their identity and wait for a specified delivery time. As more high oleic soybeans are grown, processors will offer more options for delivery.

The premiums for high oleic soybeans will be set based on what the market will bear. Competitive oils already exist in the marketplace, so high oleic soybean oil needs to be priced to compete with those oils. Premiums vary based on processor and delivery options. Currently in New Jersey, farmers may not see premiums above those available for some other marketing opportunities for conventional soybeans.

CHAPTER 3
FERTILITY

Soybean fertilization differs from corn, small grains and other crops. As a legume, soybeans produce their own nitrogen (N) from N fixing bacteria in the soil, which can be used by other plants the following year (see Fig. 6.9). In fields where soybeans have not been grown for a long period, adding a viable rhizobia inoculant to the seed right before planting will be beneficial.

Soil environments not supportive of long-term bacteria survival could also be a reason we see some positive yield responses when fields are re-inoculated. Factors that could increase mortality of soil bacteria include the soil pH, temperature, texture, water content and presence of fungicide.

Soils with carryover N or organic N (i.e., manure) may actually enhance soybean yields, but only if not in excessive amounts that cause lodging or limit natural N fixation. Each bushel of

soybeans harvested removes the equivalent of approximately 0.9 lb./acre of phosphorus (P2O5) and 1.4 lbs./acre of potassium (K2O). During a crop rotation with soybeans, these nutrients and others should be replenished. It has long been observed that soybeans do not respond significantly to direct fertilization unless soil-test results show low levels, so most farmers fertilize other crops in the rotation more heavily.

Potassium deficiency is sometimes encountered in the southern portion of the state, in part due to the predominance of sandy, low-cation-exchange-capacity soils. Nearly 60 percent of the total potassium transfer to the seed in soybeans occurs during pod fill and is removed when the crop is harvested.

Potassium-deficiency symptoms (see Fig. 3.1) are evident by yellowing (chlorosis) along the edges of mature leaves or leaf death (necrosis). The youngest leaves usually appear to be normal. Potassium deficiencies are difficult to correct in a standing crop, so prevention is the best management practice.

Fig. 3.1. Potassium Deficiency. Source: Daren Mueller, Iowa State University, Bugwood.org

Fig. 3.2. Manganese Deficiency. Source: IPNI/ R.J. Gehl, Photographer

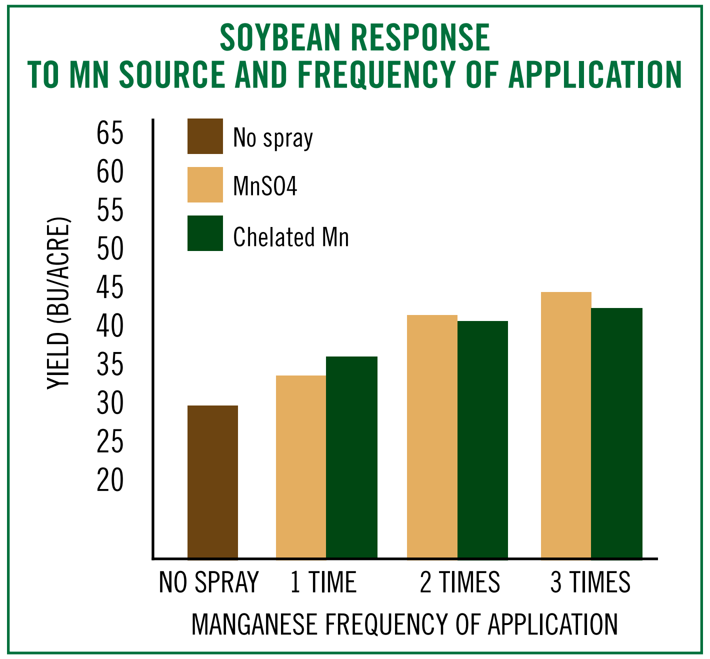


Fig. 3.2. Source: J. Heckman, Rutgers University, New Jersey Agricultural Experiment Station

Soil pH is important and should be maintained between 6.0 and 7.0 for optimal production. If soil tests call for additions of liming materials, it's preferable to apply in the fall.

Among the micronutrients, manganese (Mn) deficiency most frequently shows up in central New Jersey counties where soils are heavier and pH levels are high. It is characterized by interveinal yellowing, but with dark green veins remaining. Banded starter fertilizer with micronutrients can be helpful to combat this problem, but often foliar applications of manganese sulfate or chelated Mn will be needed one to three times during the early to middle part of the growing season (see Fig. 3.2; results reported courtesy of the New Jersey soybean checkoff). For more information, visit ***www.njaes.rutgers.edu*** and search for "fertility recommendations for soybeans."

CHAPTER 4

PLANTING PRACTICES

Important factors for good stands and favorable yields include planting date and rate, row spacing and planting depth.

PLANTING DATE

The typical planting period in New Jersey runs from late April through early June. If a farmer plans to plant corn as part of the crop rotation, it is a good practice to plant corn first, followed by soybeans, because corn can tolerate cooler soil temperatures (50 F) vs. soybeans (55 F). Later plantings do not cause soybean yields to decrease as much as corn yields.

ROW WIDTH

Research has shown the potential to increase yield by 5 bu/acre or more by planting drilled soybeans in 6- to 10-inch rows compared with using row planters with widths of 30 inches or greater, assuming fertility, moisture and other factors are not limiting. Drilled beans become even more advantageous in double-crop systems.

RECOMMENDED SEEDING RATES

Fig. 4.1 (developed with checkoff funds) provides recommended seeding rates and desired plant populations, along with adjustments for various situations.

PLANTING DEPTH

Under most conditions, the ideal planting depth is 1½ inches. Soybeans should never be planted deeper than 2 inches or shallower than 1 inch. Planting speed is one factor that most affects uniform depth. Planting faster than 5 mph often causes "planter-unit hop," so slowing down or more down pressure may be needed to maintain a uniform, desired depth.

RECOMMENDED SOYBEAN SEEDING RATES Fig. 4.1

Approximate Allowable Storage Time (Days)

Row width (inches)	Approximate lbs. of seed needed/acre			Seeds to plant per 10 ft. of row†	Seeds per acre	Expected plants per 10 ft. of row†	Expected final plants/ acre†
	@ 3,200 seeds/lb.	@3,000 seeds/lb.	@2,600 seeds/lb.				
30	40	42	49	73	127,000	51-58	89-102
15	52	56	64	48	167,000	34-38	117-134
Drill (6-8)	63	67	77	23-31	200,000	17-23	140-161

†Assuming between 70% and 80% emergence of planted seed, based on 90% germination seed and average soil conditions.

Increase seeding rate by: (not cumulative) 5% for each rotary hoeing planned; 10-15% for very early or very late planting; 10-15% for short-season varieties; 10% for cold soils; 10% for no-till; 10% for rough seedbeds or high-speed planting.

Decrease the seeding rate by: 10% if lodging has been a problem; or 10% if planting under ideal soil conditions with high-quality seed (greater than 90% germination).

CHAPTER 5

STAND DAMAGE AND REPLANTING DECISIONS

Numerous factors must be considered when deciding whether to replant, such as cause of damage, extent of stand loss, seed and fuel costs, crop insurance and herbicides planned and used. If the crop is insured, contact the agency representative first. If young stands contain some contiguously damaged areas, the planter can be driven through the field to replant the affected areas, assuming all problems have been alleviated. If the field sustained more random and substantial plant loss, conducting a stand count is essential.

With soybeans, if it's late May or June and you have four plants per row foot in 30-inch rows or one plant per row foot in drilled beans that is reasonably spaced, there is probably no benefit to replanting, especially if weather conditions won't allow field access for a week or more. If you do replant, use the same varieties you originally planted and modify other factors that are related to the cause of the problem.

Sometimes hail, insects and other problems can damage plant vegetation and stands. If the crop is insured, the insurance provider should be consulted immediately. Soybeans in the vegetative stages have a significant ability to compensate for even severe damage. Those in the early flowering stages can often compensate enough to recover sufficiently that no corrective action is needed. Damage caused by insects or disease during later reproductive stages may warrant the need for pesticides or other input applications. Alternatives should be considered if damage is great enough to cause economic loss (see Chapter 6). The U.S. Department of Agriculture – Risk Management Agency Soybean Loss Adjustment handbook details yield losses and can be found on the Risk Management Agency website, ***www.rma.usda.gov.***

Search "replanting decisions" on the Iowa State Extension website, *http://www.extension.iastate.edu, for more details.*

CHAPTER 6
PESTS AND RELATED PROBLEMS

Soybean pests include weeds, diseases, insects, nematodes and environmental stress problems. Because the number of pests that can affect soybeans totals is in the hundreds, this publication cannot provide details on all. References to other publications and websites will be offered to provide more detailed information. For assessing and treating many pest problems, follow integrated-pest-management (IPM) principles. This generally involves identification of the pest(s) or problem; the severity of the problem field-wide and on individual plants; agronomic aspects of the crop, such as growth stage; evaluation of chemical and nonchemical control measures; and the economics of the choices. Additional information on pest management may be found by searching "pest management recommendations for field crops" at ***www.extension.umd.edu***.

WEEDS

Most farmers in New Jersey plant with herbicide-resistant soybean varieties, which allow for the use of herbicides to control most unwanted vegetation while leaving the soybeans unharmed. Farmers must monitor fields to be sure these herbicides control all weeds present and that common problem weeds are not building up resistance.

Several herbicide-resistant weed species can be found in New Jersey, with Palmer amaranth being the latest discovery (Fig. 6.1). Rotating crops and herbicides can slow the development of weed resistance. Sometimes, lack of canopy closure, late rains and other conditions will cause a late outbreak of weeds. Unless severe, they normally do not cause economic losses unless they make combining difficult or harbor other pests.

The Soybean Weed Management Guide for Delaware and New Jersey is a good resource for farmers to use when making herbicide-management decisions. The guide can be found on the University of Delaware Extension website, ***http://extension.udel.edu***.

Fig. 6.1. Palmer amaranth

An additional weed indentification guide may be found by searching "weed identification" at ***www.iasoybeans.com***.

INSECTS

In most years, insects do not reach economic thresholds in New Jersey. Nevertheless, farmers must be diligent in scouting fields to look for outbreaks. During periods of drought, two-spotted spider mites, stink bugs (Fig. 6.2), grasshoppers, thrips, soybean aphids and some other insects may cause problems. Slugs can be a problem with early-planted soybeans on moist ground. Slugs mostly affect no-till plantings and fields with significant crop residue. Mexican bean beetles (Fig. 6.3) previously presented problems, but a biological control program conducted by the New Jersey Department of Agriculture (partially funded by soy checkoff dollars through the New Jersey Soybean Board) has all but eliminated this problem. Figures 6.4 and 6.5 demonstrate the significantly high levels of damage from a variety of leaf-feeding insects that is needed to cause economic yield losses in soybeans during vegetative and early reproductive growth. During stages R4 to R6, timely scouting is essential to keep on top of any pest problems since lower levels of damage can directly affect yields. The Soybean Insect Identification Guide from the Mississippi State University Extension may be helpful to identify insects in fields. Visit ***www.msucares.com*** and search for "Insect Identification Guide."

Fig. 6.2. Brown marmorated stink bug (left) Source: David R. Lance, USDA-APHISPPQ, Bugwood.org; Green stink bug (right) Source: Kevin D. Arvin, Bugwood.org

Fig. 6.3. Mexican bean beetle. Source: Eugene E. Nelson, Bugwood.org.

INJURY THRESHOLD OF DEFOLIATION BY STAGES OF GROWTH **Fig. 6.4**

STAGE OF GROWTH		PERCENT DEFOLIATION
VE, VC, V1, V2, V3	(cotyledon to 6 nodes - 10-12″)	50-65
V4-V(n)	(8-14 nodes)	40-50
R1	(1 open flower)	35-40
R2	(flower below top node)	30-35
R3	(pod visible at top node)	30
R4	(full podding)	25-30
R5	(beginning seed)	20
R6	(full seed)	25
R7	(physiological maturity)	45-50
R8	(maturity)	

Source: Missouri Soybean Handbook

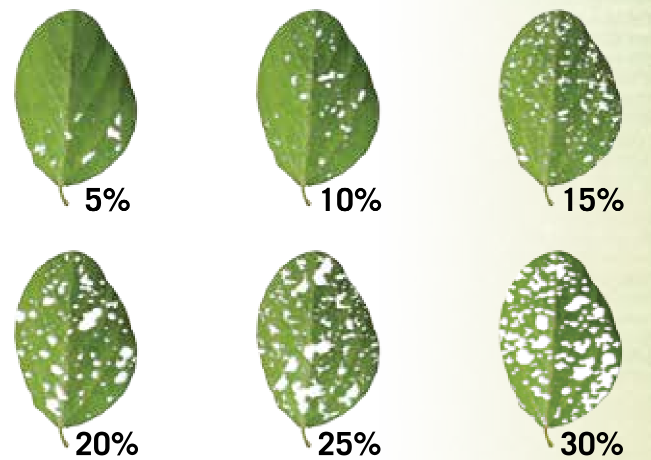


Fig. 6.5 Insect Feeding Damage

DISEASES

As with most crops, soybeans do best in well-drained soils. Wet soils, particularly when also cool, can cause various seedling and root rots such as pythium, phytophthora and damping-off diseases (Fig. 6.6). Various leaf diseases can occur during warm, wet summer periods but often do not reach economic-threshold levels unless they continue into late summer and early fall, when pod fill and seed quality may become a problem. Be aware of potentially new problems like soybean rust (Fig. 6.7) and reoccurring problems like purple seed stain (Fig. 6.8).

Fig. 6.6 Root and Stem Rot. Source: Martin Draper, USDA-NIFA, Bugwood.org

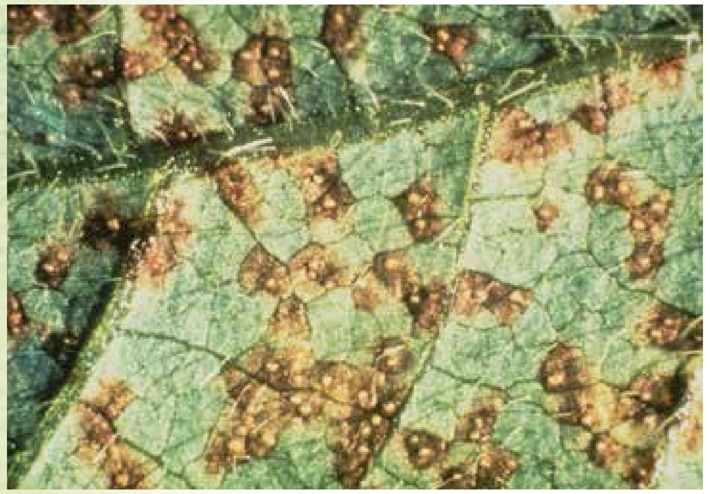


Fig. 6.7. Soybean Rust. Source: Florida Division of Plant Industry Archive, Florida Department of Agriculture and Consumer Services, Bugwood.org

Additional information on soybean diseases may be found by visiting ***www.iasoybeans.com*** and searching for "soybean diseases."

Fig. 6.8. Purple Seed Stain. Source: Adam Sisson, Iowa State University, Bugwood.org

NEMATODES

One of the most serious problems New Jersey soybean farmers face is soybean cyst nematode (SCN). The damage caused by SCN can reduce yields by 20 percent or more. SCN is most frequently found in the central part of the state in fields that have been continuously planted with soybeans (Fig. 6.9, denotes very small, cream colored cysts).

County extension agricultural agents can help identify the problem and may confirm the problem by submitting soil samples to the Rutgers Cooperative Extension Plant Diagnostics Lab.

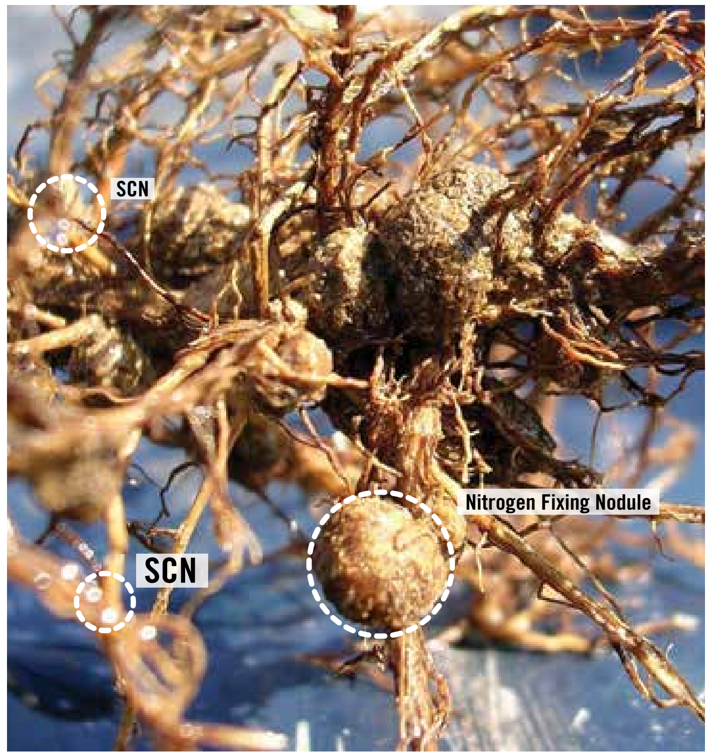


Fig. 6.9. Soybean roots affected by SCN

Once nematodes are confirmed in a field, farmers should rotate the field frequently with other crops, use nematode-resistant varieties and clean any soil from machinery leaving those fields. Visit the University of Missouri Extension website for information on identifying and managing SCN. Visit ***http://extension.missouri.edu*** and search for "SCN."

GREEN STEM SYNDROME (GSS)

Soybean plants affected by GSS (Fig. 6.10) do not dry down properly, and seed may mature before the stem turns brown or the leaves drop. Yield loss often occurs due to a delay in harvest and resulting pod shatter. GSS is thought to be caused by a combination of disease (usually viral), insect damage and environmental stress (typically drought) during the reproductive stage of the plant. The green stems are tough, hard to cut and more likely to plug the combine. The most common insects thought to be associated with GSS include stink bugs and corn earworm. To maintain yield and quality, seed should be harvested as seed moisture approaches 13 percent. Delaying harvest after the seeds reach maturity can increase the incidence of pod and stem blight (Phomopsis seed decay).

Fig. 6.10. Green Stem Syndrome. Source: W. Bamka, WSAES, Rutgers University

OTHER PROBLEMS

Compacted soils, nutrient deficiencies, storm damage and other environmental problems may also cause problems in New Jersey soybean fields. Should such damage be covered by a crop insurance policy, the first call should be to your insurance representative. With pests and other problems, Rutgers Cooperative Extension agents are often available to assist in identifying problems and recommending solutions. Rutgers Cooperative Extension also maintains a fee-based Plant Diagnostic Lab where difficult problems can be assessed.

Plant Diagnostic Laboratory
Rutgers New Jersey Agricultural
Experiment Station (NJAES)
P.O. Box 550
Milltown, NJ 08850-0550
Telephone: 732-932-9140

Flood damage. Source: Daren Mueller, Iowa State University. www.bugwood.org

CHAPTER 7
MOISTURE MANAGEMENT

Because the soybean varieties grown in New Jersey are indeterminate, meaning they continue to flower and add vegetative growth during reproductive stages, they can often tolerate longer periods of drought during vegetative stages without significant yield loss compared with most other crops. Adequate moisture is particularly important during pod set and fill and is the No. 1 factor in determining yield.

AVAILABLE WATER-HOLDING CAPACITY
Fig. 7.1

SOIL TYPES		*in./ft.*
Sandy clay loam		2.0
Silty clay loam		1.8
Clay loam		1.8
Loam		
Very fine sandy loam	low OM*	2.0
Silt loam		
Loam		
Very fine sandy loam	high OM*	2.5
Silt loam		
Fine sandy loam		1.8
Sandy loam		1.4
Loamy sand		1.1
Fine sands		1.0
Silty sands, clay		1.6

**Organic Matter*

Source: Modified from National Corn Handbook

Good moisture management begins with having well-drained fields, a good base of organic matter in the soil and limited tillage to minimize compaction. As a rule of thumb, soybeans are the last crop on a farm to receive irrigation in terms of both priority and date.

Unless a severe drought occurs early, soybeans' greatest water needs occur from stages R2-R6, which occur in late July through August for full-season soybeans and in late August to September for double-crop soybeans.

The availability of water at planting and shortly thereafter on double-crop soybeans can be very helpful for germination and height on the plants, allowing for potentially higher yields.

The following charts provide useful information on scheduling irrigation. Figures 7.1 and 7.2 indicate how much available water a soil type can store and how fast water can be applied without runoff.

SUGGESTED MAXIMUM WATER INTAKE RATES FOR VARIOUS SOIL TYPES
Fig. 7.2

SOIL TYPES	INTAKE RATE (*Inches/hour)*
Sands	2.0
Loamy sands	1.8
Sandy loams	1.5
Loams	1.0
Silt and clay loams	0.5
Clays	0.2

Assumes a full crop cover. For bare soil, reduce the rate by one-half.

Source: Michigan State University CES Ag Fact 137

Fig. 7.3 provides the rooting depth of soybeans at various growth stages, thus indicating the depth to which available water can be used. The water needed each day by soybeans is affected by stage of growth (% crop canopy cover) and climatic conditions that affect evapotranspiration (water loss through leaf pores) and can be seen in Fig. 7.4.

SUGGESTED MAXIMUM WATER INTAKE RATES FOR VARIOUS SOIL TYPES
Fig. 7.3

CORN STAGE	EFFECTIVE ROOT DEPTH (*ft.*)	SOYBEAN STAGE	EFFECTIVE ROOT DEPTH (*ft.*)
V10-12	2.0	V6	1
V16-VT	2.5	R1	1.5
R1	3.0	R3	2.0
R2	3.5	R6	2.0+
R3-5	4.0		

Source: Michigan State University CES Ag Fact 137

ESTIMATED* AVERAGE DAILY EVAPOTRANSPIRATION (IN/DAY) NJ
Fig. 7.4

		% CROP COVER		
MONTH	PAN EVAP	0-30%	30%-70%	70%-100%
MAY	.18	.05	.09	.18
JUNE	.21	.06	.10	.21
JULY	.22	.07	.11	.22
AUG	.19	.05	.09	.19
SEPT	.14	.04	.07	.14

**Assumes a full crop cover. For bare soil, reduce the rate by one-half.*

Source: Adapted from Michigan State University CES Ag Fact 137

CHAPTER 8

HARVEST, DRYING AND STORAGE

HARVEST

The two keys to harvest are minimizing losses and maintaining good seed quality. Losses can occur both prior to harvesting and as a direct result of the combining operation. Preharvest losses include lodged soybeans, seed shattering, weathering and pest damage. Variety selection and timely harvest can be helpful in reducing one or more of these losses. Combine losses result primarily from adjustments to the reel, header, cylinder, straw walkers and combine speed in the field. Modern combines allow for adjustments to these elements on the go. It is helpful for combine operators to stop periodically to check for losses and evaluate seed quality. After combining field edges, where initial adjustments can be made, the combine can be stopped in the main part of the field and backed up the approximate length of the combine, and then the operator can dismount to examine losses in three areas. A summary follows but a more complete description can be found on the University of Georgia College of Agricultural and Environmental Sciences website. Visit ***www.caes.uga.edu*** and search for "harvest loss."

DETERMINING FIELD LOSS

First, the number of beans per square foot behind the combine should be determined. This is total loss (preharvest and combine loss). Then, the number of beans per square foot on the soil surface in the areas unharvested should be counted. This number can be subtracted from the total loss to determine the losses resulting from the header and other parts of the combine. Normally, it is good practice to look at a 1- to 2-foot-wide area over the entire width of the header to make these measurements. With medium to larger size seed, 4 seeds/ft^2 equals 1 bu/acre loss. With smaller seeds, 5 seeds/ft^2 equals a bu/acre loss. Unless there are significant preharvest losses due to weathering or other issues, combining losses should be 2 to 3 bu/acre at most. Combine losses in excess of 2 bushels should be evaluated to determine where the specific losses occur. Farmers should also examine seed in the hopper to look for foreign material, split beans and damaged hulls, all signs of the need for combine adjustments.

For additional details on drying and storage, the following website can be consulted: *www.ag.ndsu.edu/graindrying*

DRYING AND STORAGE

Soybeans may be one of the easiest crops to dry and store, but they can also go "out of condition" faster than other crops. Unless harvested during an extremely wet, humid fall, most soybeans can be harvested 1 to 4 percentage points above the standard storage moisture of 13 percent and dried with natural air.

It is most important, however, to start with clean, high-quality seed going into the storage unit. When using supplemental heat, keep temperature increases to less than 20 degrees and preferably below 110 F for continuous-flow dryers. Keeping temperatures below this for as short of time as possible will minimize seed coat damage and seed splits while also minimizing energy costs.

During the winter and spring, especially during rapidly fluctuating temperatures and humidity, beans can go out of condition if they're not monitored closely.

It is essential to have monitoring sensors for temperature and moisture in the storage structure, as well as outside, to be able to make adjustments to air flow, drying and overall conditions. Fig. 8.1 provides approximate storage times at various grain temperatures and moisture.

"APPROXIMATE" ALLOWABLE STORAGE TIME FOR SOYBEANS

Fig. 8.1

GRAIN TEMPERATURE (F)						
Moisture Content (%)	30	40	50	60	70	80
Approximate Allowable Storage Time (Days)						
11	*	*	*	*	200	140
12	*	*	*	240	125	70
13	*	*	230	120	70	40
14	*	280	130	75	45	20
15	*	200	90	50	30	15
16	*	140	70	35	20	10
17	*	90	50	25	14	7
19	190	60	30	15	8	3
21	130	40	15	10	6	2
23	90	35	12	8	5	2
25	70	30	10	7	4	2
27	60	25	5	5	3	1

Source: K. Hellevang, NDSU

**Allowable storage time exceeds 300 days*
- Allowable storage time is the storage period before quality loss is expected to affect grain quality.
- Airflow through the grain permits maintaining the grain temperature, but does not extend the allowable storage time beyond that listed in the table.
- Allowable storage time is cumulative. If 16 percent moisture soybeans were stored for 35 days at 50 F, one-half of the storage life has been used. If the soybeans are cooled to 40 F, the allowable storage time at 40 F is only 70 days.

NATURAL-AIR DRYING

In some years, weather conditions or harvest scheduling results in soybeans being harvested above the desired 13 percent. 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. Using unheated air to dry soybeans usually works well, but it is a slow process (4 to 6 weeks, depending on initial moisture, airflow and weather). Bins used for natural-air drying should have fully perforated floors and fairly large drying fans. Fan power requirements depend on desired airflow and depth of beans. For example, delivery of 1 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 horsepower (hp) per 1,000 bushels of beans in the bin. Delivery of 1.5 cfm/bu through 18 feet of beans would take about 1.6 hp/1,000 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 2 percentage points lower than those recommended for corn. Use an airflow rate 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.

LOW-TEMPERATURE DRYING

Early in the fall, especially in years with warm, dry weather, drying soybeans to less than 13 percent moisture is possible 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 adding a small amount of supplemental heat to the air in natural-air dryers might be helpful. Do not heat the air more than 3 to 5 degrees or you will over-dry the beans and might cause an increase in splitting.

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 often be can 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. Research has shown that exposing soybeans to relative humidity 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 producing relative humidity less than 40 percent doesn't take very much heat. 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 aerated storage bins. Stored beans should be aerated again later in the fall to cool them to about 35 F for winter storage.

RECONDITIONING OVERLY DRY SOYBEANS

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

The process is quite slow and would be difficult 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. Or you end up with layers of wet and dry beans, making mixing necessary. Swelling that accompanies rewetting will increase stress on bin walls. Some bin manufacturers will not warranty a bin if moisture has been added to the grain. Limit the moisture content increase to a point or two.

Fig. 8.2 presents equilibrium moisture values that soybeans would reach 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 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 it operates during weather that has an average relative humidity of 65 to 70 percent. The table indicates that bean moisture increases sharply as relative humidity increases, which means that rewetting a layer of soybeans to a moisture content that is too high for safe storage is quite easy.

EQUILIBRIUM MOISTURE VALUES (PERCENT WET BASIS) FOR SOYBEANS

Fig. 8.2

	RELATIVE HUMIDITY (PERCENT)				
	50	60	70	80	90
	SOYBEAN MOISTURE CONTENT				
32 F	10.0	11.8	13.7	16.2	19.8
40 F	9.8	11.5	13.5	16.0	19.6
50 F	9.5	11.2	13.2	15.7	19.4
60 F	9.2	11.0	13.0	15.4	19.1
70 F	8.9	10.7	12.7	15.2	18.9

Source: K. Hellevang, NDSU

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RESOURCES

The Agronomy Guide
Penn State Extension
www.extension.psu.edu/agronomy-guide

Guide to Soybean Growth Stages
Mississippi State University Extension Service
http://msucares.com/pubs/publications/p2588.pdf

Illinois Agronomy Handbook
University of Illinois
http://extension.cropsci.illinois.edu/handbook/

Illinois Grower's Guide to Superior Soybean Production
University of Illinois
College of Agriculture Cooperative Extension Circular 1200

Modern Corn and Soybean Production
by Robert Hoeft, Emerson Nafziger, Richard Johnson and Samuel Aldrich
First edition, copyright 2000, from MCSP Publications, Champaign, IL 61822

Soybean Management
Ohio State University
http://ohioline.osu.edu/b827/pdf/Soybean_Management.pdf

Soybean Production
Iowa State University Soybean Extension and Research Program
http://extension.agron.iastate.edu/soybean/production_growthstages.html

Top 10 Yield Limiting Factors in Wisconsin Soybeans
University of Wisconsin-Extension
http://fyi.uwex.edu/fieldcroppathology/2012/02/15/10_soybean_yield_factors/

NOTES:

NJSB
NEW JERSEY SOYBEAN BOARD
Progress Powered by U.S. Farmers

www.njsoybean.org

Whitehorse Executive Center
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Our Soy Checkoff
Progress Powered by U.S. Farmers

www.UnitedSoybean.org