CHAPTER 10

Soybean Production

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Minnesota ranks third in the nation for number of acres in soybean production. Organic soybean production in Minnesota ranges from 25,000 to 30,000 acres per year. Net returns for organic soybean production tend to be similar to those for conventional production (Table 10-1).

Organic soybeans are typically divided into two types: food-grade and feed-grade (Figure 10-2). The majority of food-grade organic soybeans are used in products such as tofu, miso, natto, tempeh, or soymilk produced in the U.S. or abroad. Soybeans can be clear-hilum or dark-hilum. Soybeans used for tofu are required to be clear-hilum, but products such as soymilk can utilize clear-hilum or dark-hilum beans. Feed-grade soybeans can be used for organic livestock feed and oil. Food-grade soybeans that do not meet standards (because of staining, immature beans, or other reasons) can be used as

Table 10-1. Net returns per acre of soybean in Minnesota for organic and conventional producers, 2006-2008. *Adapted from FINBIN, 2009.*

Operation	2006	2007	2008
Organic	-$20	$ 95	$163
Conventional	$33	$135	$87


DAVID L. HANSEN

Figure 10-1. *Soybeans.*

feed. A third type of soybean is a vegetable type used for edamame, where soybean pods are harvested green and soybeans are consumed while immature.

In the Upper Midwest, soybeans are an important part of organic producers' rotations. Soybean has lower fertility requirements than corn and because it is a nitrogen-fixing legume, a productive crop of soybean can provide some nitrogen to a subsequent crop. During the growing season, a crop of soybean can fix well over 100 pounds/acre of nitrogen. However, after harvest only about 30 to 40 pounds/acre of nitrogen remains, because most of the nitrogen is removed from the field with the harvested grain.

SCOTT BAUER, ARS.

Figure 10-2. Soybean types. *The largest soybean above is a tofu type, the one at right is a typical feed-grade soybean, and the smallest one at the bottom is used for fermented soy products.*

An organic producer from Lac Qui Parle County says these are the things he considers in order of importance when choosing a soybean variety:

1. Maturity date
2. Ability to canopy
3. Emergence
4. Competitiveness
5. Height

Variety selection

Organic producers must use organically grown seed unless unavailable, in which case, conventional seed is allowed if it is untreated and non-GMO.

There are several companies producing organically certified soybean seed as well as conventional non-GMO seed that can be used in organic systems. A list of some organic seed suppliers for the Upper Midwest is given in Chapter 8. Some can provide information from variety trials.

Soybean breeding at the University of Minnesota

Dr. James Orf has produced more than 100 varieties of soybeans during his career at the University, many of which benefit organic producers when they are bred using conventional rather than transgenic techniques. One example is 'MN1001SP', a small-seeded, natto type of soybean. Several superior natto types have been released. Natto types are used a fermented soybean-based food that is very popular in Japan. Other releases include 'MN1601SP', a large-seed type used in tofu and soymilk.

The University of Minnesota soybean breeding program periodically releases non-GMO varieties that are suitable for organic production. Recent examples include 'MN 1410', 'MN1011CN', and 'MN0101', which include disease resistance traits typically only found in GMO varieties. Information on new varieties is available at www.maes.umn.edu .

A portion of Dr. Orf's program includes a research project examining whether organic soybean would benefit from having a separate breeding program from conventional soybean. The results of this experiment may lead to lines of food-grade soybean that are particularly adapted to organic conditions.

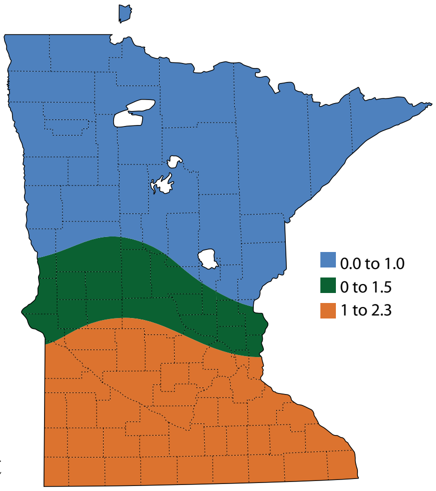
SELECTION FACTORS

The first consideration in buying seed should be the seed company quality control standards for seed conditioning, since seed vigor is influenced by drying and handling. Verification that seed is not GMO-contaminated is also important. High-quality seed with good germination that is uniform in size, clean, whole, and lacking discoloration makes for a high quality stand and valuable crop. Certified seed meets these requirements. Growers are encouraged to check with buyers to identify the characteristics (size, color, protein, and oil concentration) they require.

Soybean variety selection has several important considerations listed below in order of importance. These include:

Maturity
Yield potential
Disease resistance
Other traits

Many Minnesota organic soybean growers from the Southern Zone choose varieties with relative maturities in the range of 1.2 to 1.4.



Soybean Relative Maturities for Minnesota

Figure 10-3. ***Map of Minnesota and recommended maturities of soybean. Organic producers who delay planting will need to choose earlier-maturing varieties. Adapted from University of Minnesota Extension.***

Table 10-2. Soybean maturities recommended for late planting.
Adapted from Hicks and Naeve, 1999.

DATE	SOUTHERN	SOUTH CENTRAL	CENTRAL
June 20	1.5	0.6	0.6
July 1	0.6	0.0	00.7
July 10	0.0	00.7	00.7

Maturity group

Selection of a soybean variety will be based primarily on the relative maturity (RM) required for a given locale. Because soybeans are sensitive to changing day length, the date of maturity will be affected by latitude. Varieties have a narrow range (north to south) of adaptation. A variety must reach physiological maturity (95 percent of pods show their genetically determined mature color) before frost in order to obtain maximum yield and quality.

The recommended soybean relative maturities for the different regions of the state are shown in Figure 10-3. Because many organic farmers delay planting, their choices in relative maturities may be lower than conventional farmers. See Table 10-2 for maturities recommended when planting is delayed past mid-June.

Yield potential

Selecting varieties for high yield and a stable yield across many locations and multiple years will minimize risk. Data from seed company, independent, and University field trials are all good sources of information for assessing whether a variety will yield well over time. The University of Minnesota conducts variety trials under conventional conditions and includes non-GMO varieties in these trials. Occasionally, organic soybean trials are conducted. See http://www.soybeans.umn.edu/ for more information. Other universities in the Upper Midwest also conduct variety trials on soybean (Table 10-3).

Disease resistance

Several soybean diseases including soybean cyst nematode (SCN), sudden death syndrome (SDS), brown stem rot (BSR), iron deficiency chlorosis (IDC), and Phytophthora root/stem rot can seriously reduce soybean yield in the Upper Midwest. Many varieties have good resistance or tolerance to these diseases, and selection for both yield and resistance to known problematic diseases are important criterion for soybean selection. Variety trials often report information on disease resistance.

Other traits

Grain composition, plant height, lodging, and other special use characteristics such as size and color are additional traits the grower will need to consider in selecting a variety.

Oil, protein, and amino acid concentration are among the grain composition traits that need to be determined. The potential for lodging is enhanced with soybeans of taller heights. Lodging increases risk for preharvest losses and makes harvest more difficult. Some food-grade varieties are more susceptible to lodging (Table 10-4).

A producer's market or contract will also affect which variety is used. Most food-grade soybeans are grown under contract and may have special requirements such as grain characteristics or storage practices. Seed costs for food-grade soybean may be higher and yields can sometimes be lower, but they may also have higher premiums.

Table 10-4. Organic soybean variety trial in Clay County, MN, 2003. *Natto types like 'Nornatto' and 'Nannonatto' generally had lower yields and higher lodging. Adapted from Kandel and Porter.*

VARIETY	YIELD (BU/A)	LODGING (1-6)*
Atwood	31.9	1.0
S 08-80	31.6	1.0
Surge	31.3	1.0
Minori	30.4	1.5
Panther	29.9	1.0
Nornatto	27.6	4.0
Bravado	23.8	2.0
Nannonatto	23.6	4.0
Colibri	22.7	2.0

* Lodging score; 1 = no lodging
3 = some lodging
6 = significant lodging

Table 10-3. University soybean variety trials in the Upper Midwest.

UNIVERSITY/WEBSITE	NOTES
University of Minnesota Agricultural Experiment Station *http://www.maes.umn.edu/vartrials/soybean/index.asp*	Includes non-GMOs and specialty varieties
University of Minnesota *http://www.soybeans.umn.edu/*	Occasional organic on-farm trials
Iowa State University *http://extension.agron.iastate.edu/organicag/rr.html*	Dedicated trials to organic varieties
Iowa State University *http://www.croptesting.iastate.edu/soybeans/reports.php*	Includes non-GMOs
University of Wisconsin *http://soybean.uwex.edu/soytrials/printable/index.cfm*	Includes non-GMO varieities and some organic on-farm trials
University of Illinois at Urbana-Champaign *http://vt.cropsci.illinois.edu/soybean.html*	Includes non-GMOs
South Dakota State University *http://plantsci.sdstate.edu/rowcrops/soybean/index.cfm*	Includes non-GMOs
North Dakota State University *http://www.ag.ndsu.edu/varietytrials/soybean*	Includes non-GMOs and specialty varieties

Reducing risk: variety selection. **Choose more than one variety for your farm to spread out the risk. Consider planting different maturities to spread out the timing of field operations. Always choose the correct maturity for a location. Choose disease resistance traits for foreseeable disease issues. Food-grade soybeans generally require an established market. Food-grade soybean will be riskier to grow due to greater stringency in quality requirements. When trying a new variety, plant a small test plot strip before committing to a whole field.**

LYNN BETTS, NRCS

Figure 10-4. *Soybean varieties can vary dramatically in their size. Seeding rates are determined by seeds per acre rather than pounds per acre.*

Fertility

Soybean is a nitrogen-fixing legume crop that will provide its own nitrogen when the correct rhizobia bacterium is present in the soil and good nodulation is achieved. Inadequate nitrogen can be an issue if producers have persistent poor nodulation or are located on heavy soils that are commonly saturated, cold, and low in bacterium populations, such as in the Red River Valley in northwestern Minnesota. In such instances, soybean will generally need to be inoculated with the proper rhizobium (which must be approved for organic production) every time that it is planted. However, in most other areas of Minnesota and the Upper Midwest, inoculation is generally not needed if soybean has been grown within the last four years, and most likely will not increase yield.

Potassium and phosphorus will need to be provided when growing soybean if these nutrients are found to be low in soil tests. Usually in Minnesota, other secondary nutrients do not require direct supplementation as supplies in soil are adequate. Manure is a good source of the nutrients that soybean requires and can increase yields. However, manure application can lead to lodging and white mold.

Soil pH in the 6.0 to 7.3 range is optimum for soybean, and a wide variety of soils are tolerated. When soil pH is 7.4 or higher, soybean will exhibit symptoms of iron deficiency. At these pH levels, iron is present in adequate amounts in the soil, but it is not available. As a result, soybean plants will exhibit iron deficiency symptoms that include yellowing (chlorosis) on new growth. Some varieties are more susceptible to iron chlorosis than others, so choosing a variety with better resistance is a tactic to counter iron deficiency on high pH soils.

Reducing risk: fertility. **Use soil testing to determine possible deficiencies and use amendments only when necessary. If soil pH is 7.4 or above, choose varieties with resistance to iron chlorosis.**

Table 10-5. Organic soybean yield in bu/ac near Pittstown, NJ, under narrow and wide row systems. *In 2001, yields were not significantly different, but in 2002, wide-row systems had higher yields. Adapted from Kluchinski and Singer, 2005.*

	TREATMENT		
Row Width	Mechanical weed control	2001	2002
Narrow	1 rotary hoeing	45	27
Narrow	2 rotary hoeings (2nd hoeing 4 days later)	40	23
Narrow	2 rotary hoeings (2nd hoeing 8 days later)	40	33
Wide	2 rotary hoeings (2nd hoeing 8 days later)	46	39
Wide	1 rotary hoeing, 1 late cultivation	45	44
Wide	1 rotary hoeing, 2 cultivations	37	54

Planting

SEEDING RATE

Growers need to plant at a seeding rate to optimize yield and to make the crop competitive with weeds. The effects of lower planting rates on yield are shown in Figure 10-5. Seeding rate depends on a number of factors, including the variety grown and the productivity of the soil. Many organic producers in Minnesota plant at least 160,000 seeds/acre or more. A higher planting rate can help counter seedling losses that occur during weed control operations.

The row widths that organic producers use for soybean in Minnesota vary. Some plant in 22-inch rows, and feel that the narrower rows lead to soybeans that are more competitive because a faster-forming canopy closure will shade weeds better. Others plant in wider rows (30- to 38-inches). Wide-row systems may provide greater flexibility in equipment and timing for weed control operations (Table 10-5).

PLANTING DEPTH

An optimal planting depth for soybean is typically one to one-and-a-half inches depending on soil conditions. Soybeans should never be planted deeper than two inches. Soybean emergence results from elongation of the hypocotyls, or the region of the stem between the primary root and the cotyledons. The region of the hypocotyl nearest the cotyledons appears as an arch, and pulls the cotyledons out of the soil. When planted too deep, the hypocotyls may not be able to elongate enough. In addition,

PRODUCER PROFILE

A producer from Pipestone County uses 36-inch rows and plants soybean around May 20th. He uses bin-run seed of a clear hilum type. His goal is to rotary hoe at least twice for mustard control. He tends to get good yields of soybean, around 40 bushels/acre. After harvest, he sells his soybeans to an organic dairy.

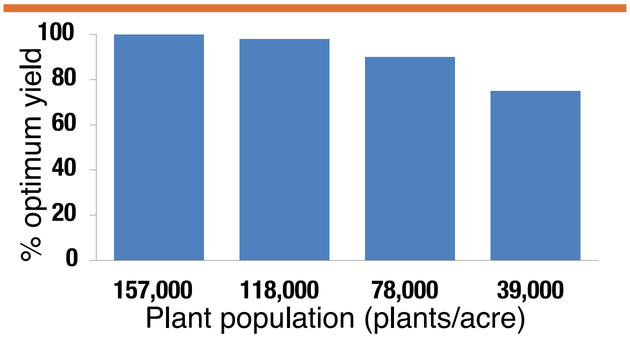


Figure 10-5. *Effect of population on yield. Less than optimum plant populations will lower yields. However, soybean can make up some yield under lower plant densities. Adapted from Hicks and Naeve, 1999.*

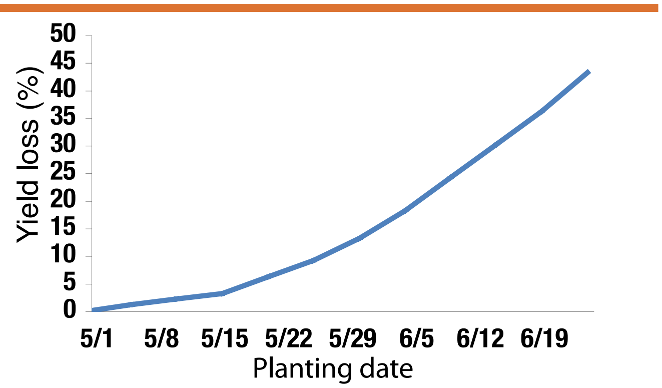


Figure 10-6. *Soybean losses due to late planting in Waseca and Lamberton, MN. Adapted from Hicks, 1999.*

Figure 10-7, at left. *Soybean rate and date study in Rosemount, MN. The larger soybean plants were planted earlier than the smaller ones.*

Soybean rate and date of planting study

With a grant from the Risk Management Agency, an experiment was conducted using various soybean varieties under different planting dates and seeding rates in organic production (Figure 10-7). The goal was to evaluate risks associated with delayed planting and seeding rates. The experiment was conducted in Rosemount, Waseca, and Lamberton, MN during 2006 to 2008. There were three planting dates: May 15, June 1, and June 15; and two seeding rates: 160,000 and 220,000 seeds per acre. The varieties included were IA1006, MN0901, MN1401, MN1503 and MN1604.

It was found that delayed planting resulted in lower yields (Figure 10-8). However, it was also found that delayed planting reduced weed populations. Plant population did not affect yield or weeds (Figure 10-9). MN1401 and IA1006 had the highest yields and MN1604 the lowest (Figure 10-10). Based on this study, it is not recommended that organic producers plant at the higher rate of 220,000 seeds per acre. Producers should plant soybean as early as they can, particularly on fields with low weed pressure, but delayed planting is still a valid option to manage weeds.

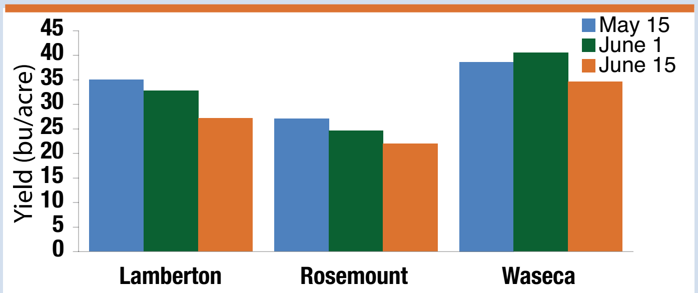


Figure 10-8. *Organic soybean yield by planting date at Lamberton, Rosemount, and Waseca, MN, in 2006-2008. The trend was for the earlier planting dates (May 15 and June 1) to yield better than the latest planting date (June 15).*

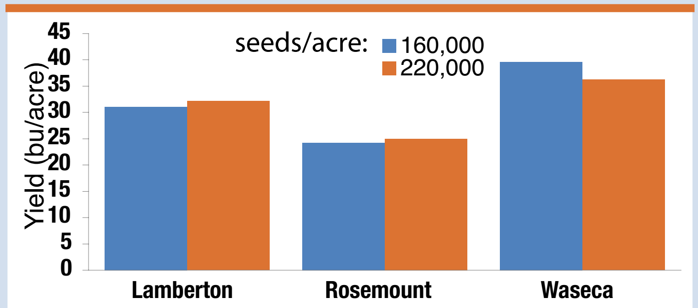


Figure 10-9. *Organic soybean yield by planting rate at Lamberton, Rosemount, and Waseca, MN, in 2006-2008. Increasing planting rate from 160,000 to 220,000 seeds/acre did not significantly increase yields.*

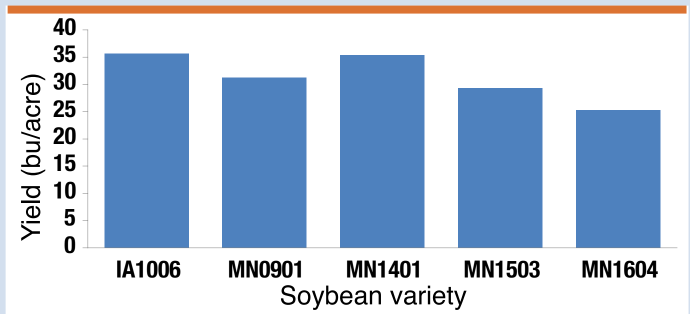


Figure 10-10. *Soybean yield by variety across Lamberton, Roasemount, and Waseca, MN. MN1401 and IA1006 had the highest yields and MN1604 the lowest.*

this hypocotyl arch can break during emergence when soybean is planted deep or if a soil crust is present. Soil crusting can result from heavy rains on recently tilled soil, particularly if the soil has high clay content. Soybean varieties are given emergence ratings based on their ability to emerge when planted deeper than two inches. Growers should be especially careful to avoid deep planting when using varieties with poor emergence ratings.

PLANTING DATE

Organic producers tend to plant soybean one to two weeks later than conventional growers, generally between May 20 and June 1. While delayed planting will reduce yield (Figure 10-6), it gives producers more time to manage weeds. Organic producers should choose earlier-maturing varieties when using later planting dates.

Reducing risk: planting. **Plant one to one-and-a-half inches deep, and never plant deeper than two inches. Adjust seeding rate to compensate for losses in stand resulting from weed control operations. Adjust maturities when planting late.**

Weed management

Weed management is important for maximizing organic soybean yield. Weeds that are problematic in organic soybean production include velvetleaf, giant ragweed, and cocklebur, among others. Tactics to manage weeds organically can be divided into cultural and mechanical control.

CULTURAL WEED CONTROL

Two effective cultural techniques for weed management are delayed planting and crop rotation. Delayed planting will balance yield gains from improved weed control against yield losses from later planting. Diversifying crop rotations to include non-row crops is another tactic for weed control. See Chapter 2-Rotation for more information.

MECHANICAL WEED CONTROL

Early-emerging weeds are the most competitive with soybean and are the most important ones to control. The first five weeks after soybean emergence are most critical for weed control in order to avoid yield reductions. Seedbed preparation to kill early-emerging weeds is the first step. Weed control operations can include a rotary hoe, harrow, or tine weeder. Rotary hoeing or harrowing and the first row cultivation are the most important operations to reduce losses to weeds (Tables 10-6 and 10-7). Rotary hoeing can be done post emergence, but it is important to not perform this operation when soybeans are just starting

PRODUCER PROFILE

Here's how an organic producer from Faribault County controls weeds in soybean. He practices pre-emergence harrowing. At soybean emergence, he does one rotary hoeing. This is followed by two to three in-row cultivations, depending on weed pressure. He times the cultivations to weeds being less than 1 inch in size. Although it can be risky, he will flame soybean when weeds get a jump on the crop as a rescue operation. He finds it is okay to flame soybean at cotyledon stage. He will not flame at the trifoliolate leaf stage as this causes considerable damage to the soybean.

An organic producer from Cottonwood County believes there is not just one row width at which to plant soybean. He says there will be a tradeoff regardless of choosing wide (longer for canopy closure) or narrow rows (fewer cultivations). Although he is happy with his results in using 22-inch rows, he thinks there may be an advantage for wider rows in controlling perennial weeds because they allow more chances to cultivate.

to emerge and at the crook stage (when the stem of the seedling is shaped like a hook and the cotyledons are closed). Rotary hoeing can be done after the crook stage once the soybeans are at the trifoliate stage, and can continue until the soybeans are three inches tall. Postemergence rotary hoeing can be risky because the seedlings are delicate and some will be lost due to the operation; however, producers can compensate for losses with higher seeding rates.

When soybeans are in the third trifoliolate stage (four to five inches tall), row cultivation can begin. A variety of options for mechanical in-row weed control exist, but soil conditions, equipment, and operator skill will determine which practices

Table 10-6. Influence of planting date and mechanical weed control on lambsquarters, pigweed and velvetleaf in soybean at Rosemount, MN, during 1989 - 1991. *Rotary hoeing with row cultivation was the most successful tactic compared to either operation on its own. Late planting particularly decreased velvetleaf. Adapted from Buhler and Gunsolus, 1996*

PLANTING DATE	WEED CONTROL	LAMBSQUARTERS	PIGWEEDS	VELVETLEAF
			% control	
Mid-May	Rotary hoe (RH)	71	72	44
	Cultivation	55	62	51
	RH + Row cult.	90	91	78
Early June	RH	82	65	64
	Cultivation	84	71	63
	RH + Row cult.	95	96	95

Table 10-7. Planting date and mechanical weed control effects on giant foxtail in soybean in Rosemount, MN during 1989 - 1991. *Rotary hoeing with row cultivation was the most successful tactic compared to either operation on its own. Late planting sometimes decreased giant foxtail. Adapted from Buhler and Gunsolus, 1996.*

PLANTING DATE	WEED CONTROL	1989	1990	1991
			% control	
Mid-May	Rotary hoe (RH)	61	36	77
	Row cultivation	59	48	70
	RH + Row cult.	89	75	93
Early June	RH	65	71	85
	Row cultivation	68	71	66
	RH + Row cult.	91	92	98

Table 10-8. Scouting for weeds in soybean.
Adapted from Potter, 1999.

SOYBEAN GROWTH STAGE	SCOUTING / PLANNING
Pre-plant	Plan pre-plant weed control operations based on field history
Emergence to seedling	Evaluate effectiveness of pre-plant weed control operations
	Examine conditions for post-emergent weed control operations
	Note factors that may affect subsequent crops
Canopy to early-flowering	Evaluate for rescue operations
Harvest	Evaluate weed escapees, plan fall tillage

are best suited to a given field. Row cultivation will be most effective when weeds are less than one inch in size. Many organic producers cultivate two to three times per season. After this, mechanical weed control is complete. If rescue operations for weeds are needed after this point, it will entail laborers to walk the rows.

Scouting for weeds in soybean is a good risk management strategy. It is important to assess the predominant weeds in midsummer of the previous year to be able to plan for weed management in the next year. Scouting for weeds in soybean is critical before canopy closure, or about six weeks after planting, in order to determine if rescue operations are needed for weed control (Table 10-8).

Reduce risk: weed management. Weeds are easiest to control when they are small. Use a diversity of mechanical weed control methods. Rotate with non-row crops if possible.

Pest Management

Soybean aphid, soybean cyst nematode, and white mold are some of the common pests that organic producers in the Upper Midwest have to manage. Crop rotation and selecting resistant varieties are the first lines of defense in organic pest management.

JIM KALISCH, ARS

Figure 10-11. *Soybean aphid.*

SOYBEAN APHID

Soybean aphids (Figure 10-11) can now be found in every soybean-growing county of Minnesota. Organic producers have stated in the Minnesota Department of Agriculture's survey of organic agriculture that soybean aphid is their top insect problem.

Identification: Soybean aphids are less than 1/16 inch in length when mature and yellow in color. There are winged and wingless forms. They are commonly found on the underside of the youngest leaves (Figure 10-12).

Life cycle: Soybean aphid lays its eggs on common buckthorn in the fall to overwinter. Eggs hatch in the spring and the aphids move to their secondary hosts, which include soybean and several other species, including crimson clover and red clover. Soybean aphid is also able to survive on Kura clover, white sweet clover, and yellow sweet clover.

PRODUCER PROFILE

An organic producer from Lac Qui Parle County, MN, likes planting soybean earlier (compared to some organic producers) and using a later-maturing variety. Depending on seasonal conditions, he would be comfortable planting soybean as late as May 20th. The soil is usually warm enough then for quick emergence. In his experience, the planting date for organic soybean is more flexible than for organic corn.

He plants at 160,000 seeds per acre. He used to plant at 140,000 seeds per acre, but now prefers higher rates because it allows soybean to be more competitive with weeds. He finds that weed management in soybean is easier than in corn.

Crop damage: Although the pest is small in size, the buildup of large populations causes significant damage to plants. Feeding diverts sugars produced by photosynthesis and results in reduced growth, pod set, and yield. In addition to direct damage to the plant, soybean aphid can transmit diseases that hinder growth or kill the plant. Honeydew, the sugary excretion produced by aphids, attracts sooty mold, a fungal pathogen that covers leaves and reduces photosynthesis.

Reducing risk: soybean aphid. Choose resistant varieties when available. Maintain natural grass or woodland areas to attract beneficial predators of soybean aphids. Beneficial predators include minute pirate bugs, lacewings, assassin bugs, and Asian lady beetles. Organic growers are limited in their options once aphids are established in a soybean field. While there are organically-approved products available to treat soybean aphid, results may vary under field conditions (Tables 10-9 and 10-10). Use caution when evaluating products that claim to control soybean aphid, and assess economic costs of these products carefully.

BAMPHITLHI TIROESELE, ARS

Figure 10-12. *Soybean infested with soybean aphid.*

Table 10-9. Effect of compost tea on soybean aphid at Lamberton, MN, in 2007.
The compost tea treatment was not significantly different from the control in aphid population level or soybean yield.

TREATMENT	APHIDS/ PLANT	YIELD (BU/ACRE)
Compost tea	239	41
No treatment	301	43

Table 10-10. The effect of Neem, insecticidal soap, and Pyganic on soybean aphid in Clay County, MN, in 2007.
Products were applied at a 50 aphids per plant threshold. None of the organic insecticides reduced the population growth of the aphids.
Adapted from Glogoza, 2008.

PRODUCT	APHID POPULATION DOUBLING TIME (DAYS)
Neem	3.4
Insecticidal soap	3.1
Neem + insecticidal soap	3.3
Pyganic	3.3
No treatment	3.2

Biocontrol control of soybean aphid

One way to reduce population levels of pest insects is through the use of natural predators and parasites. The University of Minnesota is conducting research on *Binodoxys communis*, a parasitoid wasp of soybean aphid that was found in China. This wasp lays eggs inside soybean aphids, eventually causing death to the aphid. Since this biological control insect occurs in regions of China with climate that parallels Minnesota, and because it is very effective in controlling soybean aphid in that country, it holds considerable promise as a biological control method for organic producers in Minnesota. Field trials are currently underway in Minnesota to determine if this wasp will be effective in reducing populations of soybean aphid, and if it can survive the winter. Other parasitic wasps are also being investigated.

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Figure 10-13. ***Female soybean cyst nematodes can be visible on plant roots.***

SOYBEAN CYST NEMATODE

Nematodes can be found in almost any soil sample. Most are beneficial, but a few, including soybean cyst nematode (SCN), are plant parasites. The known distribution on SCN is shown on Figure 10-14. It is predicted that this nematode will continue to spread throughout the rest of Minnesota. Organic farms are not immune from SCN (Table 10-11).

Figure 10-14. ***Known distribution of soybean cyst nematode in Minnesota. Adapted from University of Minnesota Extension.***

Identification: Soybean cyst nematodes are a type of roundworm. They are generally microscopic, but in July and August, adult female nematodes can be seen on soybean roots. They are lemon-shaped and about 1/40 inch long. Positive identification of soybean cyst nematode may require a soil sample to be submitted to a lab that tests for nematodes. Growers will generally see damage from SCN when eggs in the soil are above the threshold of 500 eggs per 100 cubic centimeters of soil.

Life cycle: Once a SCN hatches from its egg into the soil, it goes through several juvenile stages. The nematode attaches to a host plant's root, where it feeds and completes its life cycle. These nematodes can be found on other plant species in addition to soy

Table 10-11. Soybean cyst nematode in organic systems in MN. ***108 organic fields in southeast, southwest, west central, and northwest Minnesota were sampled for SCN in 2006. 37% of the organic fields had SCN. Some organic growers in the southeast and southwest had fields with damaging thresholds. No SCN were found in the northwest, but growers should not be complacent because the organism is spreading. Data courtesy of Senyu Chen, 2007***

REGION	% FIELDS with SCN	% FIELDS ABOVE THRESHOLD
Northwest	0	0
West-central	11	0
Southeast	45	23
Southwest	88	58

Table 10-12. Some hosts and non-hosts of the soybean cyst nematode. ***Adapted from Chen et al, 2001.***

NON-HOST CROPS	HOST CROPS	HOST WEEDS
alfalfa	common vetch	common chickweed
barley	cowpea	common mullein
corn	dry edible bean	henbit
oat	snap bean	medics
potato	soybean	milk vetch
sorghum	pea (poor host)	mouse-ear chickweed
sugar beet	sweet clover	purslane
sunflower	alsike clover	crown vetch
red clover	crimson clover	
wheat	birdsfoot trefoil	
canola	hairy vetch	
white clover		
rye		
forage grasses		

Table 10-13. Levels of soybean cyst nematode on organic farms in Minnesota in 2006 as affected by crop rotation. *Three different organic rotations were compared. The least diversified organic rotation (corn-soybean with cover crop) was significantly higher in SCN egg counts. Rotations with soybean every three years or more had SCN below the damage threshold. Data courtesy of Chen, 2007.*

ROTATION	SCN level (eggs/100cc)
Soybean every other year	3657
Soybean every two years	1306
Soybean every three years	496
No soybean	0

bean, but there are a number of other crops that do not serve as hosts (Table 10-12).

Crop damage: Infected plants are stunted and chlorotic. The nematodes damage roots and restrict uptake of water and nutrients by the plant.

Reducing risk: soybean cyst nematode.

Prevention is the first line of defense. Thoroughly clean all soil from potentially contaminated equipment before using. Options for organic farmers who have SCN in their fields primarily include crop rotation and resistant cultivars. A diversified rotation will help SCN levels stay below damaging thresholds (Table 10-13). At least three years of non-host crops will be needed to lower the nematode populations below the damage threshold. Some crops are better than others in reducing SCN populations. Be aware that once fields are infested, even five years of a non-host crop will not eliminate SCN.

WHITE MOLD

White mold (*Sclerotinia sclerotiorum*) is a pathogenic fungus with a wide host range including soybean, green and dry beans, sunflower, canola, forage legumes, tomatoes, potatoes and many other vegetable crops. It can also infect weeds like pigweed, ragweed, lambsquarters, and velvetleaf.

Identification: The fungus can be seen on the stem in the form of a white cottony growth. Hard and black, irregularly-shaped structures are formed within the stem. Leaves turn brown and die prematurely, but remain attached to the stem.

Life cycle: This fungus persists in the soil for years. Under cool and moist conditions, the fungus forms fruiting bodies that release spores and infect plants.

Crop damage: White mold can reduce yield and cause plant death. The black fungal structures within the stems of infected plants can contaminate harvested soybeans.

Reducing risk: white mold.

Management practices are vital for reducing the risk of white mold in organic soybeans. Row spacing and planting population are critical factors. Narrow rows and higher plant populations increase the risk of white mold in soybean. Rotation with non-susceptible crops such as corn or wheat will reduce the organism in the soil. Because of its wide host range and its ability to survive for many years in the soil, controlling it through the use of rotation is only slightly effective. Selecting resistant varieties is the best way to reduce risk.

Reducing SCN

Research at the University of Minnesota found that some crops in a rotation may be better than others for reducing SCN (Table 10-14). Nonhost or poor host crops may stimulate hatching, but not development and reproduction. They were superior in decreasing SCN populations.Grasses were the least effective in decreasing SCN numbers.

Table 10-14. Non-host crop effectiveness in reducing soybean cyst nematodes. *Adapted from Miller et al, 2006.*

MOST EFFECTIVE	LEAST EFFECTIVE
Alfalfa	Barley
Red clover	Corn
Pea	Oat
	Sorghum
	Wheat

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Figure 10-15. *Soybean harvest.*

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Figure 10-16. *These soybeans are past physiological maturity. Pods are brown and leaves have fallen.*

Harvesting

An indication of physiological maturity for soybean is when the pods have no green color remaining. Harvest will generally occur about two weeks after physiological maturity (Figure 10-16). Soybean is traded at a standard 13 percemt moisture concentration, but soybean grain moisture drops rapidly after physiological maturity. Soybeans can be harvested at up to 18 percent moisture, but artificial drying will be necessary. A general guideline is to begin harvest when grain moisture drops below 15 percent. Mold can occur when soybeans are harvested at moisture levels higher than 13 percent, while harvesting at lower moistures can cause beans to split and increases gathering losses resulting from shattering of pods when stems are hit by the combine's cutterbar.

Combine adjustments are critical when harvesting soybean. Harvest losses can be substantial if equipment settings are not optimized. Monitor losses regularly while in the field and make adjustments when necessary. Clean, intact soybeans will get the highest prices.

Soybeans can be kept at 13 percent moisture for short-term storage and at 11 percent for long-term storage. Once dry, aerate grain to maintain temperatures of 50° F or less. During the winter, stored soybeans should be checked at least once or twice a month.

Reducing risk: harvesting. Timely harvest is critical for minimizing harvest losses. Begin harvest when seed moisture drops below 15 percent. The potential for gathering losses and seed damage increase greatly as seed moisture decreases. Store at correct moisture and temperature, depending on the length of storage time.

Conclusion

Take the following quiz to determine your ability to minimize risk in organic soybean production.

Soybean Risk Management Quiz

	Points	Score
1. What type of seed do you usually use when growing soybean?		
Conventional, untreated	3	
Organic	4	
Saved seed	1	
2. What type of soybean do you usually grow?		
Feed grade	4	
Food grade	2	
Specialty	2	
3. Which of the following do you use to choose a new soybean variety? ***Score 2 points for each answer.***		
University trials in my state	2	
University trials in other states	2	
Seed companies	2	
Local on-farm trials	2	
Recommendations from other producers	2	
4. Do you select varieties using maturity and yield potential as the primary determining factors?		
Yes	3	
No	0	
5. Do you check with your certifier before using new seed types or seed treatments?		
Yes, always	3	
Yes, usually	1	
No	0	
6. Do you have your soil tested before growing soybean to ensure there are adequate nutrients for a good yielding crop?		
Yes, always	3	
Yes, usually	2	
No	0	
7. What is your soil pH?		
Below 7.3	5	
Above 7.3	0	
Not sure	1	
8. Do you inoculate your soybeans when grown on fields that have not had soybean for four years or more?		
Yes	3	
No	0	

	Points	Score
9. Do you consider weather and field conditions prior to planting so seed will come up quickly?		
Yes	1	
No	0	
10. How long is your rotation?		
3 years	0	
4 years	3	
5 or more years	6	
11. What planting rate (seed/acre) do you use for soybean?		
Less than 120,000	1	
120,000 to 140,000	2	
140,001 to 160,000	3	
161,001 to 180,000	4	
More than 180,000	1	
12. What your typical planting date for soybean?		
At the same time as conventional producers in my area	2	
One week later than conventional	3	
Two weeks later than conventional	3	
More than two weeks later than conventional	1	
13. What is the latest you would plant soybean for grain (in Minnesota)?		
End of May	5	
First week of June	5	
Second week of June	2	
Third week of June	0	
14. Do you vary maturities and varieties to spread out risk?		
Yes	3	
No	0	
15. Can you identify insect pests that attack soybean?		
Yes	3	
No	0	
16. Can you identify disease pests that attack soybean?		
Yes	3	
No	0	
17. Do you choose pest-resistant soybean varieties when available when those pests are in your fields?		
Yes	3	
No	0	

continued next page

Soybean Risk Management Quiz

	Points	Score
18. White mold can be managed by:		
Narrow rows	0	
High seeding rates	0	
Resistant varieties	2	
19. When using products to control soybean aphid, do you try the product on a test plot first to determine effectiveness under your conditions?		
Yes	5	
No	0	
Don't use these products	4	
20. If you live in an area where soybean cyst nematode (SCN) is found, have you tested for SCN?		
Yes	3	
No	0	
SCN not in my area	3	
21. Do you know which plants are hosts for SCN?		
Yes	3	
No	0	
22. How many different tools (i.e. equipment types) do you have for weed control?		
1	0	
2	3	
3	4	
4 or more	5	
23. How many weed control operations do you typically perform during the soybean growing season?		
1 to 2	1	
3	3	
4	5	
5 or more	3	
24. Do you scout your soybean fields at least 4 times throughout the season?		
Yes	3	
No	0	
25. Do you monitor harvest losses in the field and make adjustments as necessary?		
Yes, always	3	
Yes, usually	2	
No	0	

	Points	Score
26. Do you clean harvesting and grain transportation equipment thoroughly, particularly when using rented or borrowed equipment?		
Yes	2	
No	0	
27. Do you inspect and clean units prior to soybean storage?		
Yes	1	
No	0	
28. Do you ensure that GMO-crops are segregated during storage from non-GMO crops?		
Yes	1	
No	0	
Not applicable	1	
29. Do you keep samples of seed, harvested crop, and delivered crop until buyer is certain of quality?		
Yes	1	
No	0	
Not applicable	1	
30. What is your target harvest moisture for soybean?		
15%	1	
14%	2	
13%	3	
12% or less	2	
31. Do you monitor stored grain regularly?		
Yes, always	3	
Yes, usually	2	
No	0	
TOTAL		

If your score is:	Your risk is:
71 or above	Low
45 to 70	Moderate
44 or less	High

FOR MORE INFORMATION

Just for Growers – MN Soybean Production. http://www.soybeans.umn.edu/

Minnesota Crop Diseases – Soybean Diagnostic. http://www.extension.umn.edu/cropdiseases/soybean/diagnostic.html

Minnesota Crop Diseases – Soybean Diseases. http://www.extension.umn.edu/cropdiseases/soybean/index.html

Soybean aphid biocontrol project. www.entomology.wisc.edu/sabc/

North Central Region Soybean Aphid Suction Trap Network. www.ncipm.org/traps/

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