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Introduction

This BioIPM Workbook is written for growers and the vegetable industry. It is organized seasonally to provide a comprehensive, year-round self-assessment tool and reference on pest management and cultural practices of the snap bean production system. The workbook is organized into five chapters— preplant, planting, in-season, harvest/postharvest, and an appendix with individual pest profiles. Each chapter is further divided into pertinent topic sections with self-assessment statements followed by information on standard recommended practices as well as advancements to a biointensive production system.

This workbook is intended as a practical tool for growers' use throughout the entire production cycle. The workbook will help growers learn how to move toward a more biologically-based production system that is ecologically sound and economically profitable.

At the beginning of each topic there is a set of statements about the farm's current production practices. This self-evaluation section is formatted on a scale, with Category A being the minimal practices that could be used and Category D describing advanced, sometimes experimental, approaches. For most topics, the biointensive approach utilizes all categories. By checking all the statements that apply, growers can use the section to assess where their systems fall on various topics, such as selecting resistant cultivars or managing a certain pest. Growers can use the statements when making plans for the year ahead or to document practices or inputs used.

After each statement set, there is specific information expanding on the practices described in the categories A through D. Look to these paragraphs to learn how or why to implement specific activities and practices during various times of the year. The authors encourage growers to read about and consider the biologically based practices that may not currently be part of their growing system.



When the Wisconsin state symbol is noted, the information is specific to Wisconsin soils.

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Soil Sampling

Preplant



Soil sampling is a valuable tool for proper and efficient soil management. Soil samples should be collected and analyzed before planting snap bean into a field for the first time. Soil sampling should continue annually or as needed. Soil sampling as part of a management plan will help you determine how much fertilizer and soil amendments are needed to ensure crop productivity and environmental sustainability.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Soil samples are taken to determine soil nutrient, pH, and organic matter levels.**
- ☐ **B. Soil samples are taken in a manner recommended by UWEX.**
- ☐ **C. Soil test results are reviewed, and fertilizer needs are calculated.**
- ☐ **D. Organic matter levels are monitored, and practices that increase the organic matter content are implemented.**

A. How to sample soil

Taking accurate soil samples is the first step in determining nutrient needs, soil pH, and organic matter levels. The following is detailed information on how to sample soil and submit the soil for testing.



Quick Note

Soils samples should be taken to assay root rot severity and nematode populations prior to planting snap bean.

When to sample

Soil samples may be collected in the fall or in the spring before planting, whichever is most convenient. For early-planted snap bean, a fall sampling time may be necessary to ensure soil test results and fertilizer recommendations are received well before the planting date. Whichever sampling time you choose, you should attempt to be consistent from year to year.



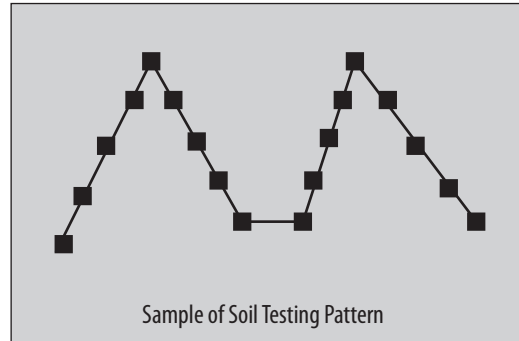
Sampling equipment

Use a stainless steel soil-sampling probe if you have one. These insert easily into the soil, bringing up a soil “core”. You may be able to borrow a soil sampling probe from your county extension office. You can also use a shovel and trowel. Dig into the soil with the shovel and carefully bring out a vertical slice of the soil, then use the trowel to take a slice of the first 0-6 inches.



Stainless steel soil probe

Be sure the tools are clean and free from rust. Do not use galvanized steel or brass equipment because they may contaminate the soil samples with metals.



How to take soil samples

One composite soil sample should be taken for every five acres within the field. A composite sample is a collection of 10-20 soil cores that are mixed together in a plastic or stainless steel bucket. The more soil cores you collect, the more representative the soil sample will be. Walking in a W-shaped sampling pattern is a good technique to use to ensure that you are collecting samples that represent the entire field.

If manure or crop residues are on the surface, push them aside. Insert the probe or trowel to plow depth, which is generally considered the top 6 to 8 inches of soil. Sample at the same depth from year to year so that soil test values can be compared accurately over time. Sampling deeper than the tillage layer can result in an underestimation of organic matter, phosphorus, and zinc.

After all of the cores for a field have been collected, mix the soil thoroughly to obtain a composite soil sample. Collect at least two cups of soil into a clean plastic bag (zip-lock bags work well) and discard the remaining soil. Identify the bag with your name, field identification number, and sample number.

If you are growing many different crops in an area of five acres or less, you may want to consider altering your sampling protocol and dividing your fields into smaller management zones. Each management zone would represent an area of the field that is managed differently than other parts of the field in any year. One composite sample would be collected for each management zone. This type of soil sampling protocol is especially beneficial if the management zones differ with respect to the type and intensity of tillage and use of manure or cover crops.

What to do with the soil samples

Routine soil analysis includes soil pH, soil test phosphorus, soil test potassium, and soil organic matter content. It should be noted that soil test P and K are not a measure of the total amount of P and K in the soil but instead a measure of the plant available P and exchangeable K in the soil. Soil tests can be requested for calcium, magnesium, and micronutrients as well. Other soil measures such as texture analysis, cation exchange capacity, and total nitrogen can be requested to learn more about your soil system. It is also important to note that nitrogen fertilizer recommendations for snap bean are not based on any soil tests for nitrogen.

also been developed for calcium, magnesium, boron, zinc, and manganese. Sulfur requirements are determined from a Sulfur Availability Index (SAI), which utilizes soil test S and OM%, as well as other estimated S

components. For a detailed description of soil test levels, see *Optimum Soil Test Levels for Wisconsin* (UW-Extension A3030) and *Nutrient application guidelines for field, vegetable, and fruit crops* (UW-Extension A2809).



Quick Note

Send your samples to a Wisconsin DATCP certified soil and manure testing laboratory. There are currently seven laboratories that are certified. Certification guarantees that analytical procedures used and nutrient recommendations are based on procedures and guidelines approved by the University of Wisconsin.



Quick Note

Use the information provided in your soil test to plan your fertility program. Soil test reports from WI DATCP certified labs will include recommended amounts of N, P, and K to apply based on the soil analysis, soil type, and crop demand.

B. Interpreting the soil test

The soil testing lab will send you a soil test report for each of the samples you submit. Most of these reports will include three sections: the soil analysis, the test interpretation, and the nutrient or fertilizer recommendations.

Nitrogen recommendations are based on results of field trials in Wisconsin and bordering states and the OM percentage of the soil. Soils with lower OM will have less natural supply of N and require larger fertilizer inputs compared to soils with greater OM. Soil test P and K values are converted into fertilizer recommendations by placing each value into a soil test category. The soil test category (low, medium, optimum, high, very high, extremely high) along with the crop demand level are used to determine the fertilizer recommendation. Vine crops are in the demand level five category of high demand vegetable crops. Soil test categories have

Finally, the soil test report will include nutrient or fertilizer recommendations. The recommendations are based on the crop demand for nutrients in a single season and are calculated to tell you how much (if any) of a particular nutrient is needed for optimum crop growth. Nutrient recommendations for snap bean are in the section **Soil Fertility and Plant Nutrition**.

Soil Names

Some soils and subsoils are naturally higher in nutrients than others. The University of Wisconsin fertilizer recommendations account for the contribution of nutrients from the subsoil, so it's important that the soil lab knows the name of the soil type in your field.

If you don't know the name of your soil, you will find it on county soil survey reports or your farm conservation plan. If you need help finding this information, contact your county Extension agent or the district conservationist at the Natural Resource Conservation Service (NRCS).



Quick Note

UW fertilizer guidelines are based on a build and maintain approach. When soils are in the optimum soil test category, then P and K recommendations are equivalent to the amount of P and K removed with the crop at harvest. Fertilizer recommendations for soil in the high and very high categories represent 50% and 25% of crop removal, respectively. No fertilizer is required for soils testing in the extremely high category. For soils testing in the low or very low categories, fertilizer guidelines represent application of the amount that the crop needs and is able to remove plus amounts needed to build soil test levels toward the optimum range over a 4-6 year period.

C. Recommended fertilizers

It is usually best to use a combination of both organic and inorganic fertilizers. Inorganic fertilizers are sometimes called chemical or commercial fertilizers because they are produced in an industrial manufacturing process. Examples of inorganic fertilizers include: urea, ammonium sulfate, ammonium nitrate, triple super phosphate, potassium chloride (muriate of potash), and potassium sulfate (sulfate of potash). An advantage of using inorganic fertilizers is that they are concentrated in nutrients, and the nutrients are water-soluble and thus immediately available for plant uptake. However, if inorganic fertilizers are not applied in synchrony with plant demand or applied in excess of plant demand, nutrients can be lost to the environment and become a water quality contaminant.

Organic fertilizers are fertilizer sources that originate from animal waste or plant material, such as animal manures, compost, or green manures (legume cover crops). An advantage of organic fertilizers is that nutrients are not all immediately available and thus are released throughout the growing sea-



Spreading manure

son. An additional advantage is that they provide soil quality benefits as well; additions of organic material can improve soil structure, water holding capacity, and biological activity of the soil. A disadvantage of organic fertilizers is they are not as nutrient-rich as inorganic fertilizers, and greater amounts of material will need to be applied.

There is also a third category of fertilizers that are OMRI-approved for certified organic production systems. Common fertilizers used are blood meal, composted animal manure, fish emulsion, feather meal, cottonseed meal, and alfalfa meal. Rock phosphate and bone meal are common organic fertilizers used to supply additional phosphorus. Amending soil with compost, cover crops (especially legumes), or crop residues also supplies significant plant nutrients in organic form.

Organic products must be decomposed by soil microorganisms before the nutrients become available to plants. Because it is a microbial process, decomposition depends on the type of material, the texture of the material, the temperature, and the moisture level. Sometimes the decomposition process isn't fast enough to provide enough nitrogen for a rapidly growing vine crop. It's a good idea to keep records of the organic materials you use and how the crop responds to them.

D. Building the organic matter content of the soil

A soil which receives regular additions of organic materials will have good nutrient- and water-holding capacity, will have good aeration for root development, will require less chemical fertilizer and water, and is easier to cultivate. Organic matter stabilizes soil particles, helping soil to resist compaction. It supports an active soil biota that competes with and suppresses soil-borne pathogens.

Implement practices in your IPM program that maintain or increase the organic matter content of the soil. Regular additions of manures and composts, planting and incorporating cover crops and green manures, reducing tillage, and practicing crop rotation are all practices that will achieve this. Even small increases in organic matter can have a beneficial effect.

Date Rec'd

9

UW Soil & Plant Analysis Lab
8452 Mineral Point Road
Verona, WI 53593
(608) 262-4364

The "Crop Nutrient Need" section is the field's nutrient recommendations based on your soil test results and crop to be grown. These recommendations have NOT been adjusted for any fertilizer credits.

The "Fertilizer Credit" section is based on the numbers entered on your soil test information form. If you didn't put them on the form but do have credits, you can subtract them from the "Crop Nutrient Need" to get the "Nutrients to Apply."

The "Nutrients to Apply" section tells you the actual pounds per acre of N, P₂O₅ and K₂O to apply. This recommendation has been adjusted to reflect any fertilizer credits you indicated.

LAB #:

County:	Washington		Account No.	000000
Date Received	6/26/2007		Date Processed	6/26/2007
Slope	Acres		Plow Depth	
1%	15		8"	
Soil Name	Sisson			
Field Name	1			
Previous Crop	Corn			

		NUTRIENT RECOMMENDATIONS									
Cropping Sequence	Yield Goal	Crop Nutrient Need			Legume N	Fertilizer Credit			Nutrients to Apply		
		N	P ₂ O ₅	K ₂ O		Manure N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
	per acre	lbs/a			lbs/a	lbs/a			lbs/a		
Corn, grain	151-170 bu	see below	0	0	0	60	60	144	see below	0	0
Sm grain silage, w/alf sdg	2-3.5 ton	20	0	0	0	20	10	115	0	0	0
Alfalfa, established	5.6-6.5 ton	0	0	90	0	10	5	9	0	0	90
Alfalfa, established	5.6-6.5 ton	0	0	90	0	0	0	0	0	0	90

There is no lime recommendation.

SUGGESTED N APPLICATION RATES FOR CORN (GRAIN) AT DIFFERENT N: CORN PRICE RATIOS								
Previous Crop	N: Corn Price Ratio (\$lb/N:\$/bu)							
	0.05		0.10		0.15		0.20	
High / Very High Yield Potential Soils	Rate ¹	Range	Rate ¹	Range	Rate ¹	Range	Rate ¹	Range
Corn, Forage legumes, Leguminous vegetables, Green manures ³	lb N/a (Total to Apply) ²							
	165	135-190	135	120-155	120	100-135	105	90-120
Soybean, Small grains ⁴	140	110-160	115	100-130	100	85-115	90	70-100

⁴ Subtract N credits for animal manures and 2nd year forage legumes.

Guidelines for choosing an appropriate N application rate for corn (grain)

- 1) If there is > 50% residue cover at planting, use the upper end of the range.
- 2) For small grains on medium and fine textured soils, the mid-to-low end of the profitable range is most appropriate.
- 3) If 100% of the N will come from organic sources, use the top end of the range. In addition, up to 20 lb N/a in starter fertilizer may be applied in this situation.
- 4) For medium and fine textured soils with: > 10% organic matter, use the low end of the range; < 2% organic matter, use the high end of the range.
- 5) If there is a likelihood of residual N (carry-over N), then use the low end of the range or use the high end of the range and subtract preplant nitrate test (PPNT) credits.
- 6) For corn following small grain on medium and fine textured soils, the middle to low end of the range is appropriate.

The N recommendations for corn are listed in this section. These rates are adjusted according to your cost of N fertilizer and your anticipated price for corn - expressed as one of four N:corn price ratios. Each price ratio suggests an N rate for maximum economic return and also a range of profitable N rates that are within \$1.00/acre of the maximum return rate. The guidelines below the table provide advice for selecting an N rate within the range.

ADDITIONAL INFORMATION

N.B. = Not required for calculation of lime requirement when soil pH is 6.6 or higher.

This section will have comments and suggestions for modifying the nutrient recommendations based on crop management practices.

	TEST INTERPRETATION					
Cropping Sequence	Very Low	Low	Optimum	High	Very High	Excessive
Corn, grain	P K	P K	P K	P K	P K	P K
Sm grain silage, w/alf sdg	P K	P K	P K	P K	P K	P K
Alfalfa, established	P K	P K	P K	P K	P K	P K
Alfalfa, established	P K	P K	P K	P K	P K	P K
Rotation pH	X	X	X	X	X	X

LABORATORY ANALYSIS

Sample Identification	Soil pH	O.M. %	Phosphorus ppm	Potassium ppm	60-69 Lime Req (T/a)	Calcium ppm	Magnesium ppm	Estimated CEC	Boron ppm	Manganese ppm	Zinc ppm	Sulfate-Sulfur ppm	Sulfur Avail. Index	Texture Code	Sample Density	Buffer pH
1	7.6	3.2	106	205	0							1.0	49	2	1.06	N.R.
2	7.4	2.9	96	195	0							1.0	48	2	1.04	N.R.
3	7.5	2.7	102	210	0							1.1	48	2	1.08	N.R.
Adjusted Averages	7.5	2.9	101	203								1.0	48			

Don't be misled by this section. The micronutrients that are listed are not analyzed unless you specify that they should be.

SECONDARY AND MICRONUTRIENTS RECOMMENDATIONS

Interpretations -----
Response to sulfur unlikely

In this example, the only micronutrient tested was sulfur. The sulfur result (Sulfur Available Index or SAI) is shown and interpreted as H (high). The others are left blank because they were not tested.

SAI-H

Field Selection

Preplant



A healthy snap bean crop begins with selecting a favorable planting site. The best snap bean crops are grown on moist, fertile, well-drained soil. Choosing a site where snap bean have not been grown for several years is one of the most effective ways to avoid pest and disease problems later in the season.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Snap bean has not been grown in the field for at least three years.**
- ☐ **B. Crop rotations are planned to prevent build-up of diseases, insects, and weeds and are spatially designed to limit serious pest concerns.**
- ☐ **C. Cover crops are planted prior to snap bean.**
- ☐ **D. Fields are mapped to monitor population levels.**

A. Crop rotation

Crop rotation is one of the most important cultural pest control strategies for snap bean. Longer crop rotations are encouraged, and the temporal (time in years) rotation should be at least three years between snap bean crops. Longer crop rotations can limit pest buildup and have soil quality and biodiversity benefits.

Several key pests of snap bean, including several soil born diseases such as Rhizoctonia root rot, Pythium root rot, and the damping off complex, need long crop rotations to limit disease build up and continued disease pressure. At harvest each year, roots of snap bean should be evaluated to determine soil borne disease problems. These should be kept on file and used to determine how long rotations need to be prior to determining when snap bean should be planted in that field again. If serious soil borne disease problems exist in the field, rotations of greater than four years should be used.



Quick Note

When concerns exist, soil samples can be taken to determine root rot levels as well as nematode problems. These results should be used in rotational decisions.

Notes:

[illegible]

B. Choosing rotational crops and spatial designs

Crops grown in rotation that will help limit pest pressure include oats, wheat, and rye. These will help limit soil borne disease pressures. Crops which are discouraged in rotation are other legume crops, including alfalfa, lentils, clover, and peas. These crops have a similar pest complex, which will cause concerns when snap bean are grown.

The distance between this year's snap bean crop and last season's snap bean crop can affect pest pressure. Snap bean should not be planted adjacent to fields that were previously planted to corn or sunflower crops. Corn and sunflowers can harbor serious disease and insect pests of snap bean, specifically white mold which is a fungus that overwinters as sclerotinia, and can be easily blown into neighboring fields the following year. Increase the distance between the crops in both the current cropping season and previous cropping year.

Snap bean should not be planted adjacently to alfalfa crops during the same year. Potato leafhopper and tarnished plant bugs are pest concerns for both alfalfa and snap bean fields. Once alfalfa is cut, both insects will search for the nearest field source, and if snap bean are nearby, they will feed on them quickly. This is especially a concern with potato leafhoppers, which will quickly infest snap bean crops.

Keep a record of the cropping history in each field, and use this information together with pest occurrence and management practices to help you in decision-making each year (see **General IPM** for more discussion).



Quick Note

Temporal rotation: refers to the number of years since snap bean were planted. A rotation of cole crops-snap bean-sweet-corn-potatoes is a three year rotation.

Spatial rotation: refers to the distance from the current snap bean field to last year's snap bean fields.

C. Planting of cover crops

Consider cover crops in the rotation scheme. In addition to breaking pest cycles, rotating with a cover crop has the additional benefits of adding organic matter, reducing wind erosion and suppressing weeds. When considering a cover crop in the rotation, you will need to consider what type to plant, when and how to plant, and how the crop will be killed and incorporated into the soil.

For snap bean, cover crops can also be planted in the spring prior to planting the bean crop. A grain crop, such as oats, should be used for this type of cover since it does not harbor the pests of the snap bean crop. The grain crop will help limit weed buildup, will aid in soil quality, and can reduce the need for herbicide application in the snap bean crop. This practice works when late planting of snap bean occurs.



Winter rye is a good cover crop choice for snap bean

Rotation Choices

Good rotational crops for snap bean: oats, wheat, rye, other cereal crops

Crops NOT to rotate with: alfalfa, clover, lentils, dry beans, peas, and other legume crops

D. Maps Fields to Monitor Pests Populations Over Time

Pest management and production practices are influenced by previous crops and rotational histories. Growers can be better managers by keeping field records of cropping history, pest populations, and management strategies. Field mapping systems should be used to designate possible field concerns. For example, if the field had soil borne pest problems, rotate to a non-host crop to reduce the pest populations.

Problem pests and concerns to record may include:

- ▶ **Insects**—such as potato leafhoppers, corn earworms, seed corn maggot, and European corn borer
- ▶ **Disease**—such as soil borne disease concerns, white mold
- ▶ **Weeds**—such as pigweed, lambsquarter, fox-tail, smartweed, mustards, horsetails, Canada thistle, and nutsedge
- ▶ Production information such as yields, quality, and marketability



Canada thistle flowers



Canada thistle, young plant

Seed Selection

Preplant



Seed selection is an important decision affecting the health and vigor of your crop. Careful selection and handling of seeds and transplants is an economical and effective way to avoid problems later in the season.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Varieties are chosen for quality of marketing or processing attributes.**
- ☐ **B. Varieties with disease or insect tolerance are chosen.**
- ☐ **C. Certified seed is planted.**
- ☐ **D. An insecticide and/or fungicide seed treatment is used.**

A. Attributes of good varieties

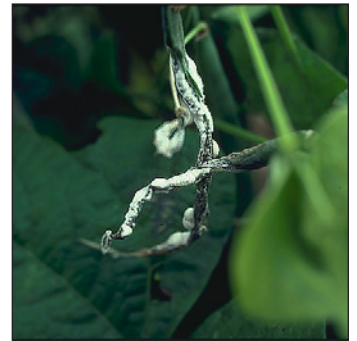
Get to know varieties that perform well in your growing area and that have good marketing characteristics. Choose varieties that will mature by the targeted delivery dates. Ask other growers which varieties have worked well for them and why. When trying a variety, do not use it exclusively. Grow new trials next to old standbys so you can compare the characteristics objectively. Planting multiple varieties reduces the risk of stress events limiting yields.



Healthy bean plants

varieties to grow in the future, and which ones to avoid because they are too susceptible to specific insect pests or diseases.

It's important to choose varieties that are resistant to or tolerant to soil borne disease or insect pests such as potato leafhopper. Currently, there are not any varieties which are tolerant to white mold.



Bean with white mold



Quick Note

Varieties are available for Bean Yellow Mosaic Virus (BYMV) resistance. Varieties which have hooked trichomes are tolerant to the potato leafhoppers.



Quick Note

Select upright-growing bean varieties to promote air movement, which reduces the likelihood of white mold development.

B. Choose varieties with disease and insect resistance

Selecting a plant variety that has resistance or tolerance to insects or diseases is a cornerstone of pest management. It is one of the most economical and effective ways to prevent in-season pest problems. Fortunately there are varieties of snap bean with resistance to the main pest and disease problems. Tolerance is a characteristic of some varieties that enables them to withstand or recover from insect or disease damage.

No variety is resistant or tolerant to all insects and diseases, so it's important to identify the pests and diseases that are the most damaging in your fields. Find varieties that have resistance, or at least some level of tolerance, by checking seed catalogues, cooperative extension publications, and with other farmers. Over time your own experiences in the field will also help you decide which

C. Certified seed is planted

Quality seed must meet phytosanitary standards established by the international seed trade industry. These standards reduce the possibility of the introduction of disease-causing or micro-organisms on seeds. Clean seed means it has a phytosanitary certificate, which can be found through seed sources. Phytosanitary standards have been specifically set for bacterial and halo blight of snap bean.

Be sure to plant only weed-free snap bean seed. Historically, crop seed has been a major source of new weed introductions in agriculture. Moreover, the weed seed found in crop seed often includes species that are difficult to manage and thus escaped control in the seed crop.



Quick Note

Consult with your seed supplier to determine growing conditions and/or disease concerns of your seed source.

D. Seed Treatment Applied

In snap bean, the use of a fungicide and/or insecticide seed treatment is encouraged as it limits the need for multiple pesticide applications later in the growing season. Insecticide seed treatments can be effective to limit seed corn maggot and early potato leafhopper populations. Fungicide seed treatments can be effective for soil borne diseases. Fungicide seed treatments can be a viable strategy if used correctly and in combination with other pest management applications.



Bean Seeds



Quick Note

Insecticide and/or fungicide seed treatments can be applied commercially by your seed supplier.

Notes:

[illegible]

Field Preparation

Planting



Fields should be prepared properly for planting. This includes weed control, incorporation of organic amendments, and preparing the soil in a way that maintains soil moisture and allows for root penetration and water infiltration.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ A. Preplant tillage is adequate for planting and weed control but not excessive.
- ☐ B. Soil moisture levels are monitored, and soil moisture is considered when planning tillage and planting operations.
- ☐ C. Cover crops, green manure, and other organic amendments are incorporated on a timely basis to add nitrogen and increase soil organic matter.
- ☐ D. Planter is calibrated prior to planting.

A. Pre-Tillage

Tillage is necessary for loosening the soil prior to planting, managing plant residues, and warming the soil early in the season. Avoid excessive tillage as it increases the cost of production, the likelihood of wind erosion, and the amount of soil compaction.



Incorporating residue

© Howard F. Schwarz

Pre-plant tillage is often an important part of a pest management program. Tillage effectively controls emerged annual weeds and when combined with herbicides can also manage perennial weeds and volunteer carrots. However, tillage can increase some perennial weed problems if underground storage organs are spread by tillage. It can also interfere with herbicide uptake by weeds if herbicides are sprayed too soon after a tillage operation.

Follow these general guidelines for pre-plant tillage:

- ▶ Do not till if soil moisture is greater than 80%.
- ▶ Clean tillage equipment of soil and plant residues when moving from field to field to prevent the spread of weeds and soil-borne pathogens.
- ▶ Vary the tillage depth from year to year to prevent the buildup of a hardpan just below the tillage level.
- ▶ If using heavy equipment, distribute the weight over multiple tires and axles to spread the load over as large an area as possible.



Quick Note

Wash all planting and cultivation equipment—this is a good time to clean your planting and cultivation equipment. This is done by pressure washing or sterilizing with a chlorine or other sanitizer. Cleaning equipment limits soil particle movement, which helps limit the spread of plant pathogens, nematodes, and weed seeds from field to field.

B. Rolled ball test for soil moisture

Soil moisture level at planting is an important factor contributing to seed piece decay. Plant when the soil moisture is at 70-80% of available soil water. Planting in soil wetter than this promotes seed decay regardless of the temperature.

Planting into hot dry soil often leads to excessive damping off as well. If the soils are excessively dry, irrigate prior to planting.

An easy method to estimate soil moisture levels is to use the ball test. To do this, simply take a handful of soil and try to form it into a ball. Then consult the **Feel Chart for Estimating Soil Moisture** in this section.



Estimating soil moisture

C. Incorporating cover crops and amendments

Snap bean crops grow best in healthy soils which provide steady nutrient and water supply. A healthy soil with adequate organic matter will have a greater capacity to moderate the uptake of fertilizers, supply micronutrients, and support vigorous plant growth that is less attractive to pests and more resistant to pest damage.

Implement practices which maintain and increase soil organic matter content in your IPM program. These can include tilling in plant residues, adding manures, composts and other organic amendments, and growing a cover crop or green manure. Cover crops grown as green manures have multiple benefits. In addition to adding nitrogen and organic matter to the soil, they can also break pest cycles, suppress weeds, and encourage beneficial insects. See **Soil Fertility and Plant Nutrition** for specific recommendations on soil amendments and green manures.

Planting Process

Planting



Careful planting and attention to environmental conditions at this stage will contribute to the quality and health of the final stand. Rapid, steady, early-season growth of the snap bean will improve resistance to pest and diseases.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Planting occurs at optimal row and planting spacing.**
- ☐ **B. Planting occurs at proper soil and air temperature.**
- ☐ **C. Fungicide is used on seeds.**
- ☐ **D. Cultural pest management strategies are utilized during the planting process.**

A. Optimal row & plant spacing

Snap bean can be planted anywhere from 90,000 to 115,000 plants per acre (75-140 lbs of seed per acre), depending on row spacing, variety, soil fertility, crop use, and harvesting. These planting densities balance the need for a dense canopy, which discourages weed growth, and an open canopy to discourage leaf wetness and limit disease pressure. Higher planting densities also limit bare ground, which reduces aphid landing and minimizes the spread of viruses.



Bean Field

Snap bean is planted just under the soil (1/2 to 2 inches deep) which encourages quick emergence. In warm soils, deeper planting can occur, and in cool, wet soils, shallower planting depths should be used. Conventional planting systems are planted between 30-36 inches apart in row spacing, with seed at a rate of 7-9 plants per running foot on irrigated fields and 6-8 plants per running foot on non-irrigated fields. Closed row snap bean planting can occur, with row spacing's of 19-24 inches and plants densities of 5-7 plants per running foot on any type of field. However, in closed spacing systems white mold must be monitored as more moisture is in the plants and under the canopy, which can increase white mold development.

count for longer periods of harvest. Snap bean should be planted in well drained soils when soil temperatures are at least 55 degrees F at four inches deep. Warm soil encourages early emergence. Optimal air temperatures for germination are between 60-70 degrees F. Snap bean crops generally mature in 50-60 days.



Quick Note

Plant beans parallel to the general wind direction—this promotes drying of the foliage, which will help limit white mold development.

C. Fungicide seed treatment

To limit disease concerns in the field, a fungicide seed treatment should be used. This will help prevent damping off prior to emergence and ensure good emergence and a healthy stand of beans. Pre-treated seed can be obtained by your seed supplier, and you should discuss the treatment and use of fungicide on the seed with your seed representative.

Notes:



Quick Note

In general, snap bean do not need more than 1-1/2 inches of water per week.

B. Optimal soil and air temperatures

In Wisconsin, snap bean is planted from May through July, with staggered planting dates to ac-

D. Cultural pest management strategies

A range of biologically-based pest management strategies can be used at planting to ensure limited pest populations later in the season. Some of these strategies may include:

- ▶ Clean machinery from field to field to limit plant pathogen and weed spread, which usually occurs at the field entrance and tillage before spreading them through the field. To clean, remove all soil from the implement and tires (pressure washing), and then spray with a disinfectant all equipment parts coming in contact with the soil. Disinfectant applications can be made with a simple hand sprayer and between each field.
- ▶ Use the stale seedbed method where seedbeds are prepared about two weeks prior to planting. Early-emerging weeds can then be controlled prior to planting with an appropriate non-residual herbicide, thus removing the first flush of weeds. The crop is then planted without additional tillage into a weed-free seedbed. Be sure to check the herbicide label for the required time between application and snap bean planting.
- ▶ Planting in fields that have recently been plowed down with a cover crop or have had manure applications should be monitored for seed corn maggots since these practices create ideal locations for the adult flies to lay their eggs. If you are incorporating a cover crop, it is recommended to incorporate it at least three weeks prior to planting to limit seed corn maggot egg laying, and using manure prior to planting is not encouraged. Seed corn maggot populations can be monitored by using degree day calculations for peak adult flights or by using a yellow dishpan in field to determine fly numbers – see information in the seed corn maggot pest profile.
- ▶ Planting and harvesting early can be a good cultural control method to limit potato leafhopper infestations.



Potato leafhopper nymph

Calculating Degree Days

Temperature affects the rate of development of plants and insects. Cold weather slows development, and warm weather speeds it up. For this reason, you can more accurately monitor crop development and predict pest behavior by using a system that measures the accumulation of heat with the passing of time. This system is called degree day accumulation (DD).

A degree day is a unit of measure that occurs for each degree above a certain base temperature during a 24-hour period. The base temperature is the temperature below which there is no plant or insect development. Specific insects have their specific base temperature. Most plants use a base temperature of 50 degrees F.

To calculate degree days you'll need a maximum/minimum thermometer to obtain the daily high and low temperatures. Calculate the degree days using the following equation:

$$(\text{Daily high temp} + \text{Daily low temp}) \div 2 = \text{Daily average temperature}$$

$$\text{Daily average temperature} - \text{Base temperature} = \text{Degree day accumulation (DD)}$$

Keep adding together the accumulated degree days to predict the peak emergence of each generation of pests you are monitoring. For example, the cabbage maggot has a developmental base temperature of 43 degrees F; if the temperature remains at 44 degrees F (or 1 degree above the developmental base temperature) for 24 hours, one degree-day is accumulated.

The Wisconsin Department of Agriculture also keeps track of degree days and posts them on their website at <http://www.doa.state.wi.us/degreedays>

General IPM

In-Season



Integrated pest management (IPM) is a long-term approach to managing pests that makes use of all available pest management tools in a way that minimizes economic, health, and environmental risks. Progress along the IPM continuum is made possible by greater reliance on pest management practices that are inherently prevention-oriented, which reduces the need for pesticides.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Basic IPM approaches are understood.**
- ☐ **B. Fields are scouted.**
- ☐ **C. Life cycles and ecology of insects, weeds, and diseases and economic thresholds of snap bean are reviewed, understood, and incorporated into IPM decision-making.**
- ☐ **D. Biologically-based, preventative IPM strategies are used throughout the season. These include cultural and mechanical controls, host resistance, and biological control.**

A. IPM 101

A practitioner of IPM anticipates pest problems that can occur in a crop and considers all available pest management strategies. These will include cultural practices, physical and mechanical controls, host resistance based on genetics, biological control, and chemical control.

Practicing IPM means looking at the cropping system as a whole and giving year-round attention to predicting, preventing, and managing pest problems. This is different than taking a single-season, single-pest approach to management.

The principal components of IPM programs are:

- Understanding the ecology and dynamics of the crop
- Understanding the ecology and dynamics of pests and their natural enemies
- Using a monitoring program such as scouting
- Using economic thresholds and other decision-making tools
- Considering all available pest management strategies and determining the most appropriate throughout the season

This section outlines general IPM principles. Specific IPM strategies for snap bean are given throughout the workbook.

B. Scouting and prediction

Scouting is the regular examination of the crop condition and is the cornerstone of IPM. It involves walking through a field and stopping at a number of locations to observe crop growth and check for the presence or signs of insect pests, beneficial insects, diseases, and weeds. Accurate and timely scouting helps you to identify potential problems before they become less manageable and will probably prevent unnecessary pesticide treatments.

The information recorded during scouting is useful in several ways. It aids in the day-to-day decision-making process, especially when combined with knowledge of pest life cycles and crop development. The field data obtained during scouting is

also extremely useful when planning for the next growing season.

How you scout depends on the crop growth stage and the insects, diseases, and weeds likely to be present. Scouting calendars and scouting guidelines for specific pests are given in the **Scouting** section of this workbook.

C. Common pests and diseases of snap bean

The more you know about the common pests of a crop, the more effective you will be in preventing pest problems and managing those that do occur. It helps you to anticipate which ones are likely to be a problem in your field and to recognize them quickly. Being familiar with the common pests helps you to be more effective with the control measures you use because you can target them to the pest's most vulnerable stages. You will be able to use many different control strategies throughout the season.

Accurate pest identification is a crucial first step for effective pest management. Following this section are two tables which provide brief descriptions of the major insect and disease pests of snap bean that you and your scouts should be able to recognize. Learn as much as you can about each of them.

Key Weed Identification

For weeds, understanding the difference between broadleaf and grass weeds is key to managing their control.

Broadleaf weeds are dicots with broad leaves and two cotyledons, or seed leaves. Seed leaves or cotyledons are the first pair of leaves to appear as the plant emerges through the soil and generally have a different shape and appearance than true leaves.

One key that aids in the identification of broadleaf weeds is the arrangement of the leaves, which vary by species. Some broadleaf weeds have leaves arranged alternately on the stem, some have leaves arranged opposite each other, and

Key Insect Pests of Snap Bean

These are the main pests and diseases of snap bean that you and your scout should be able to recognize. Detailed information on the life cycle, scouting, and integrated management of each pest and disease can be found in the **Appendix-Pest Profiles** section.

Corn Earworm



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Corn earworm is a periodic late-season pest of snap bean. They can damage beans when they move into the crop after corn is drying down. The highest populations of corn earworm appear in August, meaning that early snap bean harvested by mid-July will avoid the pests. The corn earworm larvae feed on leaves, pin beans, pods, and buds of snap bean, causing blemishes and pod rot and reducing yield. The larvae can also cause contamination problems in beans grown for processing. Corn earworms are best monitored by using pheromone traps.

European corn borer



European corn borer (ECB) is one of the most important insect pests of snap bean. ECB adults fly into bean fields and lay eggs, especially if a preferred host such as corn is not available. Flights can be predicted using heat units, and black light traps near bean fields can detect activity of adult male moths. ECB larvae feed on both plants and pods, but only pod damage is important. Most ECB damage is caused between mid-May and September, and peak moth emergence generally occurs in June and early August in southern Wisconsin.

Potato leafhopper



Potato leafhopper (PLH) is one of the more important insect pests of snap bean. Both adults and nymphs can cause damage. Adults fly north to Wisconsin from southern states, and both adults and nymphs cause damage by sucking nutrients from the plant and injecting toxins into the plant, which stunts growth and causes yellowing and death. The insects do not survive the Wisconsin winter, but two damaging generations typically appear each year before declining in August.

Seed corn maggot



Seed corn maggot (SCM) is an occasional pest in snap bean. SCM overwinter as pupae in the soil, and adults emerge and mate before laying eggs in field areas. Resulting larvae feed on seeds belowground. This cycle is repeated 3-5 times during the year. Infestations can be detected by checking plants for scars left behind after egg-laying. Plowing in crop debris post-harvest can remove their overwintering sites and prevent further infestations, and seeds treated with insecticides can control or destroy eggs and adults.

Tarnished plant bug



Tarnished plant bugs are occasional pests of snap bean. They have wide host ranges and will feed on beans when more preferred hosts are not available. Tarnished plant bugs cause injury to snap bean during feeding with their piercing-sucking mouthparts. In addition to the direct damage caused by feeding, the insect also injects a salivary secretion that is toxic to the plant. This toxin will cause blossoms and pods up to two inches long to fall off (bud blasting), prolonged pod set, and reduced yields. Tarnished plant bugs overwinter in Wisconsin as adults. They emerge in late April to early May. There may be two or three generations per year.

Notes:

Key Diseases of Snap Bean

These are the main diseases of snap bean that you and your scout should be able to recognize. Detailed information on scouting, disease cycles, and management are in the following chapters and in the **Appendix-Pest Profiles**.

Bacterial blights



Several bacterial leaf blights can be damaging to bean plants. Bacterial brown spot, halo blight, and common blight are the most common, and they may become epidemic in fields planted with infested seed under conducive weather conditions. Diseased plants, seed, and weeds provide ideal overwintering locations for these bacterial blights after the bacteria enter the plants through wounds or natural openings such as leaf stomata. Bacterial blight rarely kills the affected plant but may defoliate it and decrease yield.

Damping off & root rots



Damping off and root rot diseases are caused by soil-borne fungi, which cause root decay and poor stands. They are not easily eliminated even within a four year rotation. Wet conditions are conducive to development of these diseases, and the fungi can survive for many years in the soil as long as these environmental conditions are ideal. Scouting should be done prior to planting, including the collection and submission of a soil sample for testing.

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White mold



White mold is a fungal pathogen that may remain in the soil for up to five years and cause significant yield losses. It is one of the most serious diseases of snap bean but is generally only a problem in years of abundant rainfall, as wet conditions are conducive to disease development. Fields with severe infestations can lose plants or plant parts to wilting or death and may also have post-harvest losses. The pathogen overwinters in the soil and infects plants in the spring through ascospores. Scouting should be focused on especially wet areas or areas with history of white mold.

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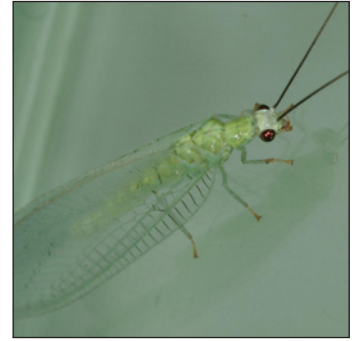
D. Biologically-based IPM (BioIPM)

In general, as IPM systems become more complex and prevention-oriented, pest managers will need to be as knowledgeable as possible about the pests, their natural enemies, and all possible control options.

Pest management strategies include cultural, mechanical, physical, host resistance, and biological controls that help prevent pest problems, and chemical controls when additional control measures are needed. Implementing a variety of pest management strategies throughout the growing season is the basis of biologically-based pest management (BioIPM).

- Cultural controls are decisions made in the production system that will avoid or suppress the build-up of pests and diseases. There are many examples of cultural controls, including crop rotation, site selection, modifying the planting date to avoid peak pest periods, improving the water-holding capacity and fertility of the soil, limiting weed competition, using disease-free seed and transplants, cleaning machinery to prevent spread of pathogens and weeds from field to field, and many more. Overhead irrigation can be limited to reduce the amount of time leaves remain wet and reduce foliar disease risk.
- Mechanical and physical controls are methods that exclude, bury, or kill pests to prevent population build-up. Some examples are the use of row covers to exclude insects, mulches to prevent weeds, treating seeds with hot water to remove seed-borne pathogens, cultivation to smother weeds and bury over-wintering pathogens, and maintaining proper temperatures and air flow in greenhouses and storage facilities to prevent the growth of disease organisms.
- Genetic control by selecting crop varieties with resistance or tolerance to insects and diseases is a highly effective strategy. Selecting varieties that have good horticultural characteristics that favor vigorous growth, such as rapid emergence and heat or cold tolerance, or that are not prone to physiological disorders, will also contribute to a healthy crop and high yield.

- Biological control is the use of naturally-occurring or introduced beneficial organisms to control or suppress pest populations. Common examples are parasitic wasps and predacious bugs, beetles, and spiders. Natural enemies of pests are common in the field and should be preserved.



Green lacewing adult

© Joseph Berger

- Chemical control by applying pesticides should be used together with preventative control measures and only when pest populations will cause economic damage. When possible, choose a selective pesticide that is specific for the pest you are trying to control with little or no detrimental effects on beneficial insects. Another category of pesticides is called biorational products, which have other attributes that make them less harmful to the user and the environment.
- Pesticides are formulations that kill many different kinds of pests as well as beneficial organisms. Pesticides can lead to a resurgence of pest populations due to a lack of natural controls or to secondary pest outbreaks and additional applications. For this reason, they should be used only if there are no other options to manage the pest. Proper pesticide application and resistance management techniques should be used to preserve the usefulness of available products.

Keep a record of crop production practices and other pest control strategies used throughout the season, as well as scouting information, weather, crop conditions, and yield. Good records will help you determine which pest control strategies are working and where improvements can be made each year.

IPM Components (Reprinted with permission from the Lodi-Woodbridge Winegrape Commission)

IPM is a long-term approach to managing pests by combining biological, cultural, and chemical tools in a way that minimizes economic, health, and environmental risks. In our program, there are five essential components to an IPM program.

1. Understanding the ecology and dynamics of the crop. It is important to gather all of the available knowledge about the crop we are growing. Most, if not all, pest problems can be directly related to the condition of the crop. The more we know about the ecology of the crop, the better pest management decisions we can make.

2. Understanding the ecology and dynamics of the pest(s) and their natural enemies. It is not only important to know what pests are present but also to know the details of their life cycles, what makes their populations change, whether any natural controls are present, and what effects these may have on the pests. By knowing as much about the pest as possible, we may find some weak point that we can exploit.

3. Instituting a monitoring program to assess levels of pests and their natural enemies. It is vitally important to continually monitor the pest levels in the field. This is a crucial aspect of the IPM approach. By knowing how many pests are present we can make the best decision about how much damage they might cause to the crop. If natural enemies are present, we need to know how many are present as well because they may take care of the pest problem for us.

4. Establishing an economic threshold for each pest. Effective monitoring and use of economic thresholds make up the core of any IPM program. What is an economic threshold? It is the level of a pest population above which, if a control action is not taken, the amount of damage caused by the pest will exceed the amount it costs to control that pest. In other words, it is the level of the pest population at which the control measure used pays for itself.

5. Considering available control techniques and determining which are most appropriate. A wide range of control techniques are available for crop pests. They can be divided into five broad categories: chemical controls, such as pesticides; cultural controls, such as controlling plant vigor or rotations; biological controls, such as natural enemy releases or conserving natural enemies; behavioral controls, such as the use of insect pheromones; and genetic controls, such as the use of resistant varieties.

It is very important to choose the right control technique based on the economic nature of the pest problem, the cost of the particular control technique, and the effects of this technique on the environment and people's health.

IPM is an 'Approach' and Changes with Time

IPM is not a technique or a recipe but rather an approach to identifying and solving pest problems. Particular techniques for pest management may vary from field to field, year to year, crop to crop, and grower to grower, but the overall approach is always the same, using the five essential components of an IPM program. It is important to point out that an IPM program is not a cookbook approach. It would be nice if we could tackle a pest problem the same way every time, but history has shown us that this will not work.

An IPM program is never complete and is a process of continuous improvement. The reason for this is that over time we learn more about our crop, our pests, and their natural enemies, and refine our monitoring programs. We also improve our economic thresholds and develop new control strategies. Furthermore, we periodically get new pests. As we gain more knowledge, we need to use it to refine our IPM programs to make them more effective and to ensure they will work in the long-term. This is the best way to minimize the economic impacts of pests in our production fields and the risks to our health and to the environment.

Scouting

In-Season



Effective scouting during the growing season will ensure that pests are treated only when they reach economically damaging levels and ensures the efficacy of the treatment. Scouting provides information on changes in pest populations over space and time and helps with decision-making.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Fields are occasionally scouted during the season.**
- ☐ **B. Fields are scouted weekly during the season and twice weekly at critical crop growth stages and peak pest emergence. Efforts are made to accurately identify pests and diseases.**
- ☐ **C. Proper scouting methods are used. Field notes are taken for later management decisions.**
- ☐ **D. Written records and field maps of pest "hot spots" are created for long-term comparisons of pest pressure and evaluation of management strategies.**

A. Crop scouting 101

Scouting is the regular examination of the crop condition and is the backbone of a successful IPM program. Scout at least weekly from crop emergence until harvest. Scouting involves walking through a field and stopping at a number of locations to observe crop growth and check for the presence of signs or symptoms of insect pests, beneficial insects, diseases, and weeds. Accurate and timely scouting may prevent unnecessary pesticide treatments, and it helps you to identify potential problems before they become less manageable. The recorded information is also useful to prevent problems in the future.

Implementing the University of Wisconsin-recommended scouting procedures will help you gain an accurate account of pest populations found in your fields. Crop scouts must be able to properly identify pests and diseases, use proper techniques, and provide an accurate analysis of field pest concerns and overall crop health. The University of Wisconsin IPM program offers a Vegetable Crop Scouting class. Contact the IPM Coordinator, Bryan Jensen, at (608) 263-4073 for more information.

B. Scouting methods

Implementing the University of Wisconsin-recommended scouting procedures will help growers receive an accurate account of pest populations found in their fields. Complete and accurate field diagnosis also provides information to improve the timing of chemical treatments. Specific instructions for scouting the important snap bean pests are provided in the table **Scouting Methods for Key Insect Pests of Snap Bean** in this section.

The number of scouting locations should be determined by field size. One scouting site per 10 acres is recommended. To ensure that the entire field is represented in the scouting process, a W-shaped pattern should be followed across the field. If that is not feasible, the scout should walk the pivot tracks and should make sure that a reasonable amount of the field is scouted, including the edges. Increasing the number of scouting locations provides better information to the crop manager for more informed management decisions.

Specific areas of the field should be scouted to look for certain pest concerns. For example, scout the field's edge for early season leafhoppers because the insects initially infest the field edges. Scouts and growers should completely inspect areas prone to disease development. These areas include locations near windbreaks, woodlots, low spots in the field, near irrigation pivots, or areas where fungicide applications are difficult to make such as underneath power lines or utility poles and near highways or residential areas. Scout these disease-prone areas throughout the growing season until harvest is completed.

C. Information gathering

Field scouting has many advantages beyond the simple determination of pest species and numbers. Scouting can provide information on the effectiveness of current management programs (including cultural, biological, physical, mechanical, and chemical control methods) and can aid in future management decisions. By tracking scouting data with management information, growers can determine the most effective, economical, and environmentally sustainable control method. It is recommended that pest population numbers and control strategy information be kept for 10 years for long-term analysis. If data are discarded, the information cannot be used to guide better management strategies in the future.

In general, as IPM systems get more complex and prevention-oriented, pest managers will need to keep good records about their production system and pest management strategies. Field records on cropping practices, combined with field scouting data, will provide a way to continually assess and improve the effectiveness of pest management strategies.

D. Field maps

Many growers find it useful to make farm and field maps which can be used as a basic template each year to keep track of rotation history, crop inputs, and production practices. If several crops are grown in a single field, each plot, row, or bed can be marked and numbered on the map. The field

map can be used as an activity log showing dates of plantings, planting rates, crops planted, varieties planted, seed sources, soil amendments, fertilizer applications, pest control applications, weed management strategies, and other cropping practices and inputs.

During the season, growers often find it useful to keep track of what they do in a pocket notebook or other form of recording. Field notes during tillage and planting, such as equipment settings and row spacings, general observations made on plant health, specific weed populations or problem locations, and weather conditions such as heavy rains or soil erosion are useful things to note during the season.



Scouting with a sweep net

Harvest records can be invaluable in planning for the future, especially to determine what crops were most profitable, which crops or varieties were most affected by pests or diseases, when to plant specific crops, or how much to grow in the future. Harvest records can include crop, variety, date of harvest, amount harvested, quality of harvest, and location where harvested.

Keep the records relevant and simple. They should be useful to you in making management decisions. At the end of the year or season, gather all the field maps, activity logs, scouting data, and field notes in one place. Be sure to review last year's records when making plans for the coming season. It is recommended that scouting data and field records be kept for 10 years for long-term analysis.

Long-term pest averages and numbers should be kept by the grower to watch the trends and changes in pest populations. Usually, there are areas within a field that are prone to pest infestations, especially with weeds and diseases, and for snap bean production, areas that are prone to cavity spot and nematodes can be verified and noticed in these areas. These areas of the field are known as "hot spots". For snap bean production, hot spots should be noted for weed concern, nematode locations, white mold field locations, and root rot

potential locations. Also, maps of insect overwintering sites (e.g., European corn borer and corn earworm) should also be noted. Hot spots may require more scouting or specific management strategies. You can map your field by hand, or with GPS systems, to assess the patterns and changes in these "hot spots" over time.

How to get started with a GPS unit & data logger and GIS based software:

GPS field boundaries are taken at any time in the fall or early spring to provide a general overview of the entire farm. Scouting points are marked anytime from planting time to plant emergence. Scouting points provide specific information within each field and are used the entire growing season.

Procedure:

1. Mark individual field boundaries using a GPS unit.
2. Mark all scouting points that will be used for management information throughout the year.
3. Enter field boundaries and scouting sites into the GIS based software.
4. Organize farmview and fieldview in the database by crop year.
5. Create maps according to present and future farming needs.
6. Analyze data to obtain pest control information and evaluate cost effectiveness of control practices and possible effects of production practices on pest distributions and dynamics.
7. Incorporate all crop year information into the GIS database.

Scouting Calendar

Insects	April	May	June	July	August	September	October
Seedcorn maggot							
European corn borer							
Potato leafhopper							
Corn earworm							
Tarnished plant bug							
Diseases	April	May	June	July	August	September	October
White mold							
Damping off & root rots							
Bacterial blights							

Peak activity: All appropriate IPM strategies should be implemented in advance of the expected peak activity. Scouting is essential during expected peak periods.

Off-peak activity: The pest may or may not be present during off-peak times. Scouting and other IPM activities performed may effectively help to identify and manage pest problems as they begin to develop.

Scouting Methods for Key Insect Pests of Snap Bean

These are the scouting methods for main pests of snap bean that you and your scout should be able to recognize. Detailed information on the life cycle, scouting, and integrated management of each pest can be found in the **Appendix-Pest Profiles**.

Seed corn maggot



Seed corn maggots are an occasional pest of bean crops in Wisconsin. They can limit emergence and reduce yields. Scouting should occur from mid-May through June, when seed corn maggot activity typically occurs. Predict populations using degree-day calculations, and use yellow water traps in the field to determine peak flights. Degree day information for seed corn maggot can be obtained by the Wisconsin Department of Agriculture (see **Calculating Degree Days** in the Planting Process section for more information).

Threshold: If seed corn maggots are of concern, an at-plant seed insecticide treatment should be considered.

European corn borer



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European corn borer is best monitored with black light or pheromone traps. Once increasing populations are indicated, walk field edges during the day. Egg masses may be scouted on volunteer or sentential corn plants in the field. Scout for egg masses on mid to lower leaves using 25 leaf samples per location. Look for wilted trifoliate, and examine the stem and pod for holes, checking for frass deposits at the point of entry and live borers inside. Degree-day calculations may also be considered as a scouting tool for peak flights—600 for the first generation and 1,700 for the second generation. Larvae feed on bean leaves and pods, causing contamination in beans used for processing. They mature in the spring when temperatures are over 50 degrees F, and peak moth emergence occurs in June for the overwintering generation and in August for the second generation.

European corn borer are night-flying, straw-colored moths with a one-inch wingspan. Males are slightly darker than females.

Threshold: Decisions regarding control should be based on the level of moth activity and the growth stage of the bean crop. Insecticide should be applied when beans are in early bloom and blacklight traps indicate over 15 moths per night for the first generation and over 100 moths per night for the second generation. Economic thresholds are 10 or more moths per trap for three consecutive nights.

Potato leafhopper



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Leafhoppers tend to migrate from alfalfa into other crops in early summer after alfalfa has been cut. Early symptoms include triangular brownish spots at the leaflet tip or at the leaf margins near veinlets. Leaf browning progresses inward, and leaf margins become dry and brittle. Scout adults by using sweep net sampling (25 sweeps per location). Scout nymphs with leaf samples (25 leaves per location). Adult scouting should occur twice weekly before first trifoliate and once per week from first trifoliate until harvest. Nymphs should be scouted weekly from first trifoliate until harvest.

Potato leafhoppers are 1/8 of an inch long, bright green, wedge-shaped insects with white spots on their heads and upper bodies. They will jump, fly, or crawl when disturbed. Nymphs will also crawl rapidly when dislodged.

Threshold: One adult per sweep or one nymph per 10 leaves and five or more per foot of row for both seedling snap bean and larger snap bean.

Corn earworm



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The best technique for monitoring earworms is through the use of pheromone traps (Hartstack) or black light traps. Traps should be placed 4-6 feet above the ground on the south or west side of fields and checked daily beginning in July. Pheromones should be changed every two weeks, and unused lures should be kept frozen until needed. If five or more moths are detected per night, or 10 or more over a three-night period, begin monitoring moth migration from southern production areas. Walk individual fields to check for adults, and examine volunteer corn for adults and/or larvae.

Corn earworm larvae are generally two inches long with yellow heads and 3-4 dark stripes along their backs when mature. Adults are grayish-brown moths with a wingspan of about 1-1/2 inches and irregular dark markings on the wings. They often have a dark comma-shaped marking on the front wings. Females lay single 1/32 of an inch, yellowish, hemispherical eggs.

Threshold: Five moths per black light trap or 10 per pheromone trap for beans 30-37 days before harvest and 25 moths per black light trap or 100 per pheromone trap for beans bloom to seven days before harvest. If there are less than five moths per blacklight trap or 10 moths per pheromone trap, treatment is unnecessary.

Tarnished plant bug



Tarnished plant bugs appear in appreciable numbers in mid-July and are best monitored with an insect sweep net. Take 25 sweeps per sample site with at least 10 sites per 100 acres scattered throughout the field.

Threshold: There are no set economic thresholds for tarnished plant bug on snap bean, but one per sweep is a good indicator that population levels are high.

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Scouting Methods for Key Diseases of Snap Bean

These are the scouting methods for main pests and diseases of snap bean that you and your scout should be able to recognize. Detailed information on the life cycle, scouting, and integrated management of each disease can be found in the **Appendix-Pest Profiles**.

Bacterial blights



halo blight



common leaf blight



bacterial brown spot

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Examine plants for early symptoms of bacterial leaf blights during routine insect monitoring, but pay special attention to examining plants for early symptoms of bacterial blight during periods of favorable environmental conditions, such as excessive rainfall or extended periods of leaf wetness and also wind or hail damage to foliage. The symptoms of bacterial brown

spot include reddish-brown water-soaked spots, which may turn gray and crack open, leaving a "shot hole." Lower leaf surface veins turn red or reddish brown, and in severe cases, the foliage is killed. Lesions may also appear on stems and pods. Common blight lesions appear on leaves, first as small water-soaked or light green spots and later becoming dry, brown spots bordered by a narrow yellow zone. Halo blight lesions also start as small water-soaked spots but enlarge and develop a one-inch, halo-like cone of greenish-yellow tissue outside the water-soaked area.

Threshold: No thresholds have been set for bacterial blights, but preventative measures should be in place to limit disease development.

Damping off & root rots



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Before planting beans, collect and submit a soil sample for testing to determine the level of root rot fungi in the soil. This sample should be taken from a "W" pattern over the entire field, and a gallon of soil from a sampling depth of 6 inches at multiple sites should be collected. The sample should be stored in closed (but not sealed) bags at 60-75 degrees F and submitted to the UW-Madison Department of Plant Pathology. During the season, monitor fields for signs of root rot by digging stunted or pale seedlings or plants and examining the roots for decay.

Threshold: Disease indices ranging from 0-50 are safe for planting beans, and those falling between 51 and 69 are considered questionable, meaning that fields rating in this range should not be planted to beans if possible. Beans should not be planted in fields with a soil test index greater than 70 for several years, and planting bean crops should not be attempted until the fields have been retested.



Pay special attention to areas that are poorly drained, where plants remain wet, or where white mold has occurred in the past. White mold's early symptoms usually occur about one week after bloom, and it can spread from inflected plants to uninfected plants. These symptoms include irregularly shaped water-soaked spots on stems, leaves, and pods followed by soft, watery decay, white cottony fungal growth, and sclerotia. White mold most commonly occurs when weather conditions are especially wet. Temperatures under 85 degrees F, normal or more than normal rainfall, soil moisture at or above field capacity, and fog and humidity can all provide good growing conditions for white mold.

Notes:

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Disease Management

In-Season



Snap bean diseases are more effectively prevented than cured. Planting resistant varieties, sanitation, and excluding pathogens from non-infested fields are important IPM strategies for snap bean diseases.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ A. Good growing practices are maintained to support crop vigor and resistance to plant disease.
- ☐ B. Targeted scouting for specific diseases occurs during susceptible crop growth stages or during periods of conducive weather conditions.
- ☐ C. Snap bean diseases are managed preventatively, using a combination of crop rotation, host resistance, and sanitation to avoid in-season disease problems.
- ☐ D. Long-term records are kept to assess the effectiveness of plant varieties and other management strategies.

A. Plant vigor & disease resistance

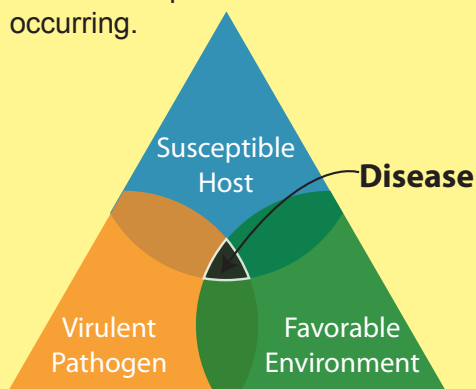
Diseases in plants occur when a pathogen is present, the host plant is susceptible, and the environment is favorable for the disease to develop. Altering any one of these three factors can prevent the disease from occurring. For example, if a pathogen is present, then choosing a resistant variety (the host) can effectively prevent the disease. If the pathogen is not present, taking precautions not to introduce it into uninfested fields is a very effective control strategy. You'll find that exclusion is an important tool in managing snap bean diseases.

Many pathogens are opportunistic and will infect plants that are already stressed by poor soil conditions, inadequate fertility, or insect feeding. Providing good growing conditions, particularly good soil conditions, will promote healthy root growth and more resistance to plant disease.

When starting transplants, provide optimum conditions of ventilation, watering, fertility, temperature, and light for growth. Maintain weed-free seedbeds and cold frames to avoid spreading pathogens from weeds to the crop. Transplant or direct-seed into fields that have warm, well-drained soil ready to support vigorous seedling growth. Be sure soil has adequate, balanced fertility, and continue to improve soil structure and tilth each year.

The Disease Triangle

Diseases in plants occur when a pathogen is present, the host plant is susceptible, and the environment is favorable for the disease to develop. This is called the disease triangle. Altering any one of these three factors can prevent the disease from occurring.



B. Scouting for diseases

Scouting for diseases should occur weekly from bean emergence until harvest. Monitoring should occur by observing a series of plants at multiple locations around the field, and in spots of concerns, such as near windbreaks, in low areas, or in wet areas of the field.

Plant diseases are highly dependent on weather conditions. Moist, humid conditions following periods of rainy weather is especially conducive to disease development. Monitor the crop closely for signs of disease during this kind of weather or when leaves remain wet during periods of high humidity, fog, drizzling rains, or heavy dew.

C. IPM strategies for snap bean crop diseases

Diseases of snap bean are much more easily prevented than cured. Fortunately, there are many effective ways to prevent snap bean crop diseases. Below are the general strategies for disease prevention that should be incorporated into the entire growing season, from pre-plant to harvest. Refer to the table at the end of the section for a summary of IPM strategies for specific snap bean crop diseases.

Crop rotation

Crop rotation is one of the most important pest control strategies for snap bean. Most pathogens of snap bean survive in the residues of previous crops. Crop rotation allows enough time for the residue to decompose completely and the pathogen to die out before the next susceptible crop is grown. If you have the land available, do not plant a bean crop more often than every three years in a field. Plow under debris soon after harvest to allow for rapid and thorough decomposition.

Host resistance

Choose resistant cultivars as much as possible, especially if you have had a specific disease problem in the past. Consult your seed catalogs, seed company representatives, and extension specialists about available resistant cultivars.

Nematodes Concerns

The root knot nematode and root lesion nematode can cause problems in snap bean crops and can cause stand loss of 10-80%. Although nematicides are commercially available, they are expensive and not economically viable in the system. Therefore, using cultural options to limit the nematodes is the best option for snap bean production. Options to limit the nematodes for snap bean are to:

- ▶ Control the nematodes in rotational crops.
- ▶ Rotate with non-host crops.
- ▶ Provide adequate weed control.
- ▶ Flood field with water to disrupt nematode.
- ▶ Deep plow fields.
- ▶ Provide long fallow periods.

Sanitation/Exclusion

Sanitation is the removal of a pathogen from seed, plants, or equipment and is a method of excluding a pathogen from an uninfected field or preventing it from spreading. It is one of the best ways to prevent disease problems. Sanitation of field equipment is important, as well as sanitation of people walking the fields. For the limiting of root rot and white mold concerns in snap bean, it is recommended that all field personnel sanitize their boots or use disposable boot covers when entering each new field.

Nearby weeds can harbor many viruses, which potentially can cause harm in snap bean, so mowing of weeds in and around the fields is encouraged.

Fungicides

There are several fungicides labeled for snap bean disease control. However, not all diseases can be managed with foliar-applied fungicides. Soilborne pathogens causing root rot cannot be limited with

fungicides but must be managed by use of varietal resistance, crop rotation, and practices which improve soil drainage. Bacterial pathogens require copper- or antibiotic-containing compounds for control. Consult the publication A3422 *Commercial Vegetable Production in Wisconsin* for fungicides currently labeled for snap bean diseases in Wisconsin.



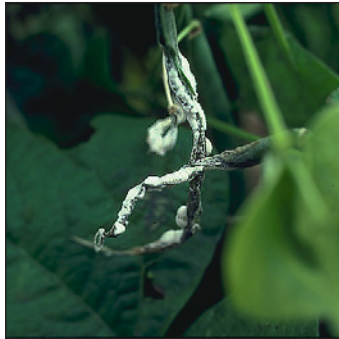
D. Keeping records

Keep records of diseases that occur in each field, the growth stage of the plant, and the weather conditions. Include field maps that indicate where particular diseases tend to occur—this will often be in low spots or places where dew dries more slowly. Include insect and weed infestations on the field maps.

Include the variety planted, date planted, soil amendments, rotation history, and other cultural practices in your records. Relate this information to yield at harvest. In this way, you will learn over time what to expect, how diseases and other pest problems affect your crops, and how to adjust your management practices to minimize damage due to diseases.

Notes:

Summary of IPM Strategies for Snap Bean Diseases

Bacterial blights	Preplant	Planting	In-Season/Harvest
	<p>Buy certified disease-free seed grown in blight-free regions.</p> <p>Check with your seed supplier as to the availability of resistant varieties.</p> <p>Use three-year or longer rotations.</p>	<p>Limit plant wounding or natural openings, which serve as infection sites.</p> <p>Scout for blight during periods of excessive rainfall or extended leaf wetness.</p> <p>Eliminate weed and volunteer sources.</p>	<p>Use foliar applications of copper hydroxide, copper ammonium complex, or copper salts of fatty or rosin acids to slow the spread of light infestations.</p> <p>Deep plow debris immediately after harvest.</p>
Damping off & root rots	Preplant	Planting	In-Season/Harvest
	<p>Use four-year or longer rotations.</p> <p>Plant wheat or another grain crop in rotation with snap bean.</p> <p>Use cover crops between planting and over winter.</p>	<p>Take soil samples and root assays to determine root rot potential.</p> <p>Minimize soil compaction.</p> <p>Plant fungicide-treated seeds to minimize damage from certain fungi.</p> <p>Plant shallowly and at later dates in warm, well-drained fields.</p>	<p>Plow down residue immediately after harvest.</p> <p>Maintain proper irrigation and fertility in each field.</p>
White mold	Preplant	Planting	In-Season/Harvest
	<p>Implement long rotations.</p> <p>Rotate with grain crops and corn.</p> <p>Limit rotations with host crops such as cucurbits (pumpkins, squash, zucchini), carrots, cabbage, parsnips, potatoes, and tomatoes.</p>	<p>Plant upright varieties in wide rows to promote air movement and rapid drying.</p> <p>Control broadleaf weeds.</p> <p>Plant varieties with a shorter flower period and an upright-bush habit, which are less likely to be severely affected.</p>	<p>Use biocontrol product <i>Coniothyrium minitans</i> (Contans WG) post-harvest before incorporating crop debris.</p> <p>Time fungicide applications during flowering, at 10% bloom, and seven days later, especially when the soil has been wet for 6-10 days before bloom.</p>

Pest Scouting Form

Date / Time _____

Field # _____

Crop _____

Grower _____

Field Location _____

Plant Height _____

Scout _____

Field Size _____

Growth Stage _____

Field Map: Draw a rough map of the field, noting the orientation, pattern in which you scouted, and any special field features.

Insects: Walk a W pattern in field, inspecting random plants (25 plants per field, 50 if the field is large). Note the name, size/ growth stage and tally how many you find. Then calculate the percentage of infestation (total number of pests/ number of plants x 100).

Weeds: Count the number of weeds per 10 feet of row for large infestations or every 100 feet of row for smaller infestations. Identify the weed, and mark what you find on the map.

Disease: Note whether there are any disease symptoms present, determine the extent of the symptoms, location, and how many plants are affected. If plants appear stunted, inspect roots.

Insect Management

In-Season



An integrated insect management program is prevention-based. Control strategies are implemented throughout the season—from pre-plant decisions to harvest—and include combinations of cultural, mechanical, and carefully-chosen chemical control methods.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ A. Insecticides are applied according to a calendar schedule or without regard to threshold levels.
- ☐ B. Insecticides are applied only when populations have reached economically damaging levels at critical crop growth stages.
- ☐ C. Insect pests are managed preventatively using a combination of pest phenology, host resistance, and cultural practices to avoid in-season pest problems.
- ☐ D. The impact of pesticide sprays on beneficial insects are known and considered when selecting and applying a chemical treatment.

A. Calendar spray program

Snap bean has relatively few insect pests, and the plant is fairly insect resistant. Historically, insecticides have been the primary form of insect management for many growers, and many sprays were made according to calendar schedules, not due to the specific presence and populations of insect pests.

Current insect management recommendations include scouting and precise timing of insecticide sprays. Insecticides are only applied when the insect pest is present at damaging levels, present at a vulnerable stage of a pest's life cycle, or present during a critical stage of crop development. Current IPM recommendations take a broader, more preventative approach to insect control and include cultural controls, host plant resistance, and biological control. One of the goals of IPM is to reduce pesticide use to the bare minimum. For beans, knowing the ecology and biology of pests and controlling them using alternative techniques has greatly reduced insecticide use in the crop.



Healthy snap bean plant

B. Determining threshold levels

There are several species of insect pests that are sporadic and sometimes frequent pests of all snap bean in the upper Midwest. These include:

- ▶ European corn borer
- ▶ Stalk borer
- ▶ Potato leafhoppers

You should be able to recognize these insects and be familiar with their life cycles so that you can scout effectively for them in your fields. See **Key Insect Pests of Snap Bean** in the General IPM chapter, **Scouting Methods for Key Insect Pests of Snap Bean** in the Scouting chapter, and the **Appendix-Pest Profiles** to learn about these insects.

Chemical controls should only be considered when insect populations have reached or exceeded a level that will cause economic damage if left untreated. This is commonly called the economic threshold level. Economic thresholds have been scientifically established for some pests of snap bean to help commercial growers weigh the costs of their pest management strategies against the potential economic impact of each pest.

It is impractical and usually impossible to have the crop completely pest-free. The financial and environmental cost of the controls would far exceed the benefit of controlling the last few insects. That's why it's important to carefully and routinely scout the field for pest activity, record the presence of each pest through the growing season, and note the threshold levels for that pest. Keeping records of weekly pest activity and relating these to actual insect damage at harvest provides extremely useful management information for future years. Follow the guidelines in the **Scouting** section of this workbook.



Stalk borer is a pest of the snap bean in the upper Midwest



Quick Note:

Selecting thricome hooked varieties that are tolerant to potato leafhoppers is an effective method to limit leafhopper damage.

C. IPM strategies for snap bean pests

Integrated pest management is the sound use of all available methods for insect control. These include cultural controls, mechanical controls, host plant resistance, biological controls, and application of insecticides. A summary of current recommended management options for specific insect pests of snap bean is at the end of this section.

Cultural control

There are many cultural practices that are effective in keeping insect pests below damaging levels. Choosing varieties with some resistance or tolerance to insect pests is highly recommended. Turning under crop residues after harvest and rotating snap bean to different fields each year disrupts the life cycles of many key pests.

Seed corn maggot can be limited by avoiding using green manures in the system. If green manures are used, these locations provide perfect egg laying sites and can cause damage at the seedling stage. Incorporate all green manures at least 7-10 days before planting.

European corn borers are a pest that can be culturally managed in the crop prior to the snap bean cropping system, specifically by getting rid of overwintering sites of the ECB larvae, previous year's crop residues. Avoid planting beans next to corn to limit ECB when possible. ECB can be adjusted to limit peak infestations by adjusting planting dates to avoid having the susceptible stages (bud to pinpod) during ECB flights (June to August).

Stalk borer migration into snap bean fields can be limited when field edges are mowed.

Potato leafhoppers migrate from southern states each year, have a wide host range (as they feed on potatoes, alfalfa, and beans), and can infect the crop quickly. Potato leafhoppers can easily migrate to the nearest host crop when alfalfa is cut, so be aware of adjacent alfalfa crops and watch for cutting dates. Once alfalfa is cut, scout snap bean for potato leafhopper quickly to avoid serious damage.

Biological control

Biological control occurs regularly in Midwest fields and can be highly effective in controlling populations of insect pests that feed on snap bean. Specifically, there are fungal pathogens and soil insects that can be helpful in reducing seed corn maggot infestations. Awareness of biological control activity and implement practices that do not disrupt the activity of natural enemies is an important part of insect management. Read the chapter on **Biological Control** for specific guidelines.

Chemical control

Carefully chosen and timed application of chemical insecticides may be necessary to augment cultural and biological controls, especially after crop heading. Selection of treatments depends on the pest species present and their developmental stage. For certain pests, you may be able to skip a

Soybean Aphids

A new pest, the soybean aphid, was first noted in Wisconsin in 2000. Although not a direct pest of snap bean, the soybean aphid reproduces prolifically on soybean and the winged migrants have become significant vectors of virus diseases on late planted beans. Cucumber mosaic virus (CMV) and alfalfa mosaic virus (AMV) are present in all Wisconsin production areas and can cause significant yield and quality losses. Additionally, feeding by the large flights of winged soybean aphids occurring from July through August have been associated with phytotoxicity symptoms on snap bean which can reduce yield.



Soybean aphids

treatment even if numbers of pests are beyond the economic threshold levels. For example, European corn borer populations can exceed threshold without an insecticide application as long as you are within two weeks of harvest.



Quick Note:

For a current list of insecticides labeled for snap bean, see *A3422 Commercial Vegetable Production in Wisconsin*.

D. Impact of insecticides on beneficial species

The choice of pesticides and timing of applications can have a big effect on beneficial insect species. Keep treatments to the bare minimum, and consider the effects of pesticides on non-target species when choosing a product. When possible, choose a selective insecticide that is specific for the pest you are trying to control, with little or no detrimental effects on non-target insects. Applying broad-spectrum materials, especially early in season, can lead to a resurgence of pest populations due to a lack of natural controls or to secondary pest outbreaks. Choose pesticides with little or no residual activity to control soil-inhabiting pests such as the cabbage maggot preserves beetles and other natural enemies.



Consider the timing and placement of the application. Spot-treating or banding rather than broadcasting the application helps to minimize non-target effects.



Hover flies and lady beetle larvae are important natural enemies of vegetable insect pests

Aphids & Virus transmission

An emerging issue in snap bean is virus concerns that are transmitted by aphids. Soybean aphids are one of the more recent pests in Wisconsin and are known to transmit viruses when found. A variety of emerging viruses—AMV, CMV, BYMV, BCMV, and CIYVV—are seen that can affect bean development and limit crop quality. These viruses are found when aphids feed upon an infected plant, then feed on beans, and spread the virus non-persistently (meaning that the virus is found in the aphid's stylet and is transmitted until the aphid has sufficiently fed to release the virus particle).



Soybean aphid

To limit virus problems, plant and harvest early before aphids are found in the crop. Use tactics to prevent aphids from landing in the crop by planting border or barrier crops. Try to separate crops from their virus sources (other vegetables, weed hosts) in both time and distances. **When applicable, use resistant varieties.** Finally, try to interfere with the aphids' ability to transmit the virus by using mineral and stylet oils.

Notes:

Summary of IPM Strategies for Insect Pests of Snap bean

Pest	Cultural control	Mechanical control / Exclusion	Host plant resistance	Biological control
Seedcorn maggot	<ul style="list-style-type: none"> ▶ Later planting dates ▶ Plant in warm soils ▶ Use degree day monitoring to limit peak flights 	<ul style="list-style-type: none"> ▶ Plow under crop debris after harvest ▶ Do not plant beans within seven days of green manure incorporation 	<ul style="list-style-type: none"> ▶ None 	<ul style="list-style-type: none"> ▶ Some egg parasitism
Corn Earworm	<ul style="list-style-type: none"> ▶ Plow down crop residue 	<ul style="list-style-type: none"> ▶ Plant far away from corn crop 	<ul style="list-style-type: none"> ▶ Some varieties have more tolerances, but no real resistance varieties are available 	<ul style="list-style-type: none"> ▶ Somewhat important
Tarnished Plant Bug	<ul style="list-style-type: none"> ▶ Weed control 	<ul style="list-style-type: none"> ▶ Remove weeds in and around fields ▶ Limit overwintering sites 		<ul style="list-style-type: none"> ▶ General insect predators
Potato Leafhopper	<ul style="list-style-type: none"> ▶ Keep plants healthy and green 	<ul style="list-style-type: none"> ▶ Watch from movements from adjacent crops, specifically after alfalfa is cut 	<ul style="list-style-type: none"> ▶ Some available 	<ul style="list-style-type: none"> ▶ None
European Corn Borer	<ul style="list-style-type: none"> ▶ Limit crop debris ▶ Use degree day forecasting to determine peak flights 	<ul style="list-style-type: none"> ▶ Plow down debris from previous years ▶ Limit overwintering sites 		<ul style="list-style-type: none"> ▶ Some importance

Weed Management

In-Season



Weeds can be one of the most challenging problems that a vegetable grower will face. Previous weed history in the field is a good guide with which to predict future weed problems. The most successful weed control programs combine multiple management strategies that minimize risk of control failure and provide season-long control.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ A. Weeds are controlled solely by chemical means.
- ☐ B. Weeds are managed preventatively, using a combination of methods to avoid in-season weed problems.
- ☐ C. Weeds are cultivated to prevent maturation and seed formation.
- ☐ D. Use multiple season-long, biologically-based strategies to limit weeds during the current and future growing season.

A. Chemical weed control

Some growers choose weed control programs that rely exclusively on herbicides to control weeds. Complete reliance on herbicides, however, can lead to control failure and concerns about weed resistance. Current bioIPM recommendations are to combine multiple



Weed competition in beans

management strategies that will minimize the risk of control failure and non-target effects of herbicides. Using multiple strategies prevents weed seed build-up and provides season-long control.

If a pre-emergence herbicide is part of your weed management program, use the information you have on previous weed history in that field to help you select an appropriate pre-emergence herbicide. Be sure to consider the rotational restrictions associated with an herbicide relative to your future cropping plans. Post-emergent herbicide applications should be based on scouting results and the weed species spectrum observed in the field.

Using herbicides with the same mode of action in the same field every year can result in the development of weed biotypes that are resistant to the herbicide. Weeds that are resistant to an herbicide grow normally even after an application that usually kills the weed. To avoid this problem, rotate herbicides by choosing products with a different mode of action each year.

To help growers choose herbicides with different modes of action, the Environmental Protection Agency (EPA) and the Herbicide Resistance Action Committees (HRAC) have developed a voluntary pesticide labeling proposal that groups pesticides with similar modes of action and designates them with a number. You will also find this information on the herbicide label. Herbicides are each also given a rating on their relative toxicity to mammals, beneficial organisms, bees, and the environment in general.



Quick Note

Both annual and perennial weeds affect snap bean. **Annual species** live for a single growing season and die at the end of the year after producing seed. **Perennial weeds** live for several years and regenerate shoots each year from underground roots and rhizomes. They are not dependent on seed for dispersal.



Quackgrass is a difficult perennial to control

B. Preventative strategies

By far the best management strategy for any weed is to prevent its introduction and dispersal. There are ways in which weeds are introduced into a field, and most of them are preventable. The most common sources of new weed seed on the farm are compost, manure, straw mulch, equipment, open irrigation water, contaminated crop seed, and transplant containers.

Consider how you might reduce entry of weeds into your fields throughout the rotation. For example, question providers about weed contamination before purchasing straw, compost, or manure. Clean any equipment used in one field that could be contaminated with weed seed or otherwise introduce weed species to other fields. Use a power washer or compressed air to help remove seed



Quick Note

Consult A3422 for herbicides currently labeled for snap bean.

Problem Weed: Buckthorn

Eliminating buckthorn in and around field edges will help limit soybean aphids populations. Buckthorn is the primary overwintering site for soybean aphids, so eliminating it greatly reduces populations in subsequent years.

and weed plant parts. Buy crop seed that is certified free of weed seed.

Prevention is also important in minimizing the spread of weeds already present on the farm. There are steps you can take before, during, and after the growing season to minimize weed seed production in the field and surrounding field margins. These include:

- ▶ Select sites where weed seed numbers have been reduced through crop rotation and that are free of very difficult to control perennial weeds such as quackgrass, Canada thistle, or yellow nutsedge.
- ▶ Identify weeds before you till them. Are they annual weeds or perennial weeds? Perennial species can be spread by cutting below-ground tissue.
- ▶ Consider planting and managing a boundary strip around the field margins. Use a non-invasive mix of species that will be highly competitive with weeds and provide habitat for beneficial insects. You might also harvest this boundary strip for hay.
- ▶ Help the crop suppress weeds by partitioning the resources to the crops and not the weeds. For example, band fertilizer near the crop, use drip irrigation rather than broadcast irrigation, and choose vigorous, well-adapted cultivars that can compete with weeds through rapid early season growth.
- ▶ Till or mow any remaining weeds after crop harvest but before weeds go to seed.
- ▶ Prevent weed seed production along irrigation canals, reservoirs, and other open water sources.

C. In-season cultivation

Timely cultivation is one of the most effective ways to control annual weeds. Cultivation is most effective with small, shallow-rooted annual weeds early in the season and less effective later in the season when weeds are larger. In small plantings, hand cultivation can keep small weed problems under control. For larger plantings, many different and innovative types of cultivation implements have been developed to control weeds in and between crop rows.

When planning your cultivation, pay special attention to soil stewardship practices, and never till when the soil is wet and susceptible to compaction. Cultivation is not a good way to control perennial weeds, which have underground plant parts that are cut and spread by tillage.

Many different types of cultivation implements have been developed to control weeds in and/or between rows. Between-row cultivators range

Resistance Management Guidelines

To prevent resistance developing in weeds in your fields, follow these guidelines:

- ▶ Reduce the need for herbicides by incorporating other preventative strategies.
- ▶ Rotate herbicides by choosing products with a different mode of action than the one(s) you used last year and during the current year. The active ingredient will be listed on the label. Some products are a combination of more than one active ingredient.
- ▶ Follow herbicide label instructions carefully.
- ▶ Prevent weed seed production by cultivating and mowing weed escapes before they set seed.
- ▶ Rotate crops or use different strategies to manage weeds in rotational years.



© D. Brainard

Some cultivators remove weeds both in and between the crop rows, such as the flex-tine weeders. The ground-driven, vibrating tines remove small weeds. These tools can be used to “blind harrow” prior to crop emergence, tilling above the planted crop seed to exposed, germinated weeds.

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The most successful weed control programs combine multiple management strategies. There are several benefits to an integrated program:

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Soil Fertility and Plant Nutrition

In-Season



Snap bean crops are heavy feeders and do best in fertile soils. A good fertilizer program at planting is crucial for vigorous growth during the early season. Good plant nutrition improves plant resistance to pests and diseases and increases the crop's competitiveness with weeds. Follow the University of Wisconsin research-based nutrient recommendations for snap bean.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ A. Fertilizer is applied in accordance with University of Wisconsin-Extension guidelines, which are based on soil test results.
- ☐ B. The fertilizer source will be considered when calculating fertilizer rates.
- ☐ C. Split applications of nitrogen are applied.
- ☐ D. Practices that maintain or build soil organic matter levels are implemented.

A. Plant nutrition & fertilization

Proper fertilization is essential for vigorous early season snap bean growth. Proper fertilization also improves plant resistance to pests and diseases and provides a competitive advantage for the crop against weeds. The University of Wisconsin provides guidelines for nutrient applications for snap bean.



Proper fertilization improves the plant's resistance to pest pressure

Using the fertilizer recommendations based on your soil test results provides the basis for good nutrient management. In addition to applying proper rates, you should also consider your soil type and texture, cropping history, and current soil conditions when determining when and how to fertilize. Just as under-fertilizing can lead to a reduction in profitability, so can over-fertilization. Unused fertilizer does not only represent an economic loss to your cropping system, but it can also cause unneeded nutrients to enter surface and groundwater. Over-application of fertilizer can also damage the crop. For example, excessive nitrogen can cause plant lodging for snap bean.

The University of Wisconsin has produced research-based fertilizer recommendations for snap bean. University of Wisconsin guidelines for P and K applications on snap bean are based entirely on soil test P and K levels. Soil testing every 2-4 years will ensure that you are making the most efficient use of P and K fertilizer. The University of Wisconsin guidelines for nitrogen applications are based entirely on soil organic matter concentrations. There has yet to be a reliable soil test for N that provides insight into how much N fertilizer is required. The soil organic matter concentration provides only a general indication of how much N the soil will supply (<2%, typical on sandy soils; 2-10%, common for most mineral soils; <10% for muck, peat, or organic soils). Research has been conducted across these soil organic matter concentration gradients.



Quick Note

UW fertilizer recommendations are based on the crop demand for P and K in a single season, minus the amount already in the soil and the amount expected to be supplied by the subsoil of your soil type. In this way, just the right amount of fertilizer is added each year.

B. Using soil tests and nutrient recommendations

Inorganic (or commercial) and organic fertilizers (or manures) can be used for snap bean production. Inorganic fertilizers are sometimes called chemical fertilizers because they are produced in an industrial manufacturing process. They often contain higher concentrations of nutrients compared to organic fertilizers, meaning that much less fertilizer material needs to be applied compared to organic fertilizers. Nutrients in inorganic fertilizers are water-soluble and immediately available for plants, while organic fertilizers require soil microorganisms to convert nutrients into plant-available forms. Animal manure is the most commonly used organic fertilizer, but the amount of nutrients that are available will vary from species to species (see A2809). Furthermore, application of animal manure can provide nutrients for the crop grown in the second year after application. For certified organic farming, other approved fertilizers include blood meal, bone meal, fish meal and powder, and feather meal. To learn more about fertilizer and plant nutrients, go to <http://www.soils.wisc.edu/extension/> to view additional learning materials.



Quick Note

Beans are sensitive to boron and may show toxicity in fields where boron is naturally high or where it has been added to meet rotation crop requirements of high boron demand crops such as broccoli and cabbage.

Annual Nitrogen recommendations for snap bean—total amount of N to apply per acre including starter fertilizer (Source: UW Extension publication A2809 Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin)

	Organic matter (%)	Amount to apply
Snap bean (yield range per acre: 1.5-6.5 ton)	Less than 2	60
	2.0-9.9	40
	10-20	20
	> 20	0

Annual Phosphorus fertilizer application rate guidelines for snap bean—total amount of P_2O_5 to apply per acre including starter fertilizer (Source: UW Extension publication A2809 Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin)

Yield goal	Soil Test Category				
	Very low	Low	Optimum	High	Excessively High
--tons/acre--	----- lb/ P_2O_5 per acre -----				
1.5-2.5	50	35	10	5	0
2.6-3.5	55	40	15	10	0
3.6-4.5	60	45	20	10	0
4.6-5.5	65	50	25	15	0
5.6-6.5	70	55	30	15	0

Annual Potassium fertilizer application rate guidelines for snap bean—total amount of K_2O to apply per acre including starter fertilizer (Source: UW Extension publication A2809 Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin)

Yield goal	Soil Test Category					
	Very low	Low	Optimum	High	Very High	Excessively High
--tons/acre--	----- lb/ K_2O per acre -----					
1.5-2.5	90	80	40	20	10	0
2.6-3.5	110	100	60	30	15	0
3.6-4.5	130	120	80	40	20	0
4.6-5.5	150	140	100	50	25	0
5.6-6.5	170	160	120	60	30	0

C. Split-season applications of nutrients

Nitrogen should be applied to beans at the trifoliolate stage. Fertilizer can be applied broadcast or banded two inches below and beside the seed. If the soil is sandy, split the nitrogen into two or more applications during the season. Split-applying nutrients, especially N, will improve the nutrient use efficiency of the system. More N will be taken up by the plant per unit N applied. Over-application of nitrogen (100-120 lb/acre of N) can result in yield decrease or plant lodging. When snap bean lodge they are more susceptible to disease and result in more residue collected when mechanically harvested.



Trifoliolate stage of bean

©Howard F. Schwartz, Colorado State University, Bugwood.org

D. Organic soil amendments and cover crops

Manure and composts

Cow, sheep, horse, and poultry manure and compost of various kinds can be added to soil for their nutritional and soil-building qualities. Most organic soil amendments are a good source of the main nutrients N, P, K, as well as micronutrients. Even more significantly, these materials feed and support the soil biota, which in turn increases the

Irrigation Management

Snap bean require 1-1.5 inches of water every week. Adequate moisture is essential during blossom to pod set. The upper 12 inches of soil should be kept at above 50 percent available soil moisture. When using irrigation scheduling programs, the allowable depletion (AD) value for snap bean on sandy soils is 1.3 inches and on silt loam soils is 2.5 inches.

nitrogen mineralization (release) rate of the soil. The soil therefore becomes more fertile.

The nutrient contribution of organic amendments can and should be calculated towards the total nutrient budget for the snap bean crop. Keep in mind, however, that if manures and composts are supplied in the amounts needed to supply enough N



Spreading manure

to the crop each year, the phosphorus levels would become excessive. These materials should therefore be considered as soil amendments to improve the soil and supplement the nutrient needs of the crop. Also be aware that manures and composts can contain weed seeds. If obtaining composts or amendments from off the farm, ask the supplier about the potential for weed seeds or pathogens.

The nutrient content and availability of manures depends on the animal species, bedding, manure storage, and whether or not the manure was applied to the surface or incorporated into the soil within three days of application. It's best to incorporate the manure as soon as possible so that nutrients aren't lost by volatilization or run-off. Estimates for first-year available nutrient content of various manures can be found in the UW Extension publication *A2809 Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops*. You can also send a sample of the manure, compost, or other soil amendment to the soil testing lab for nutrient analysis or have the UW Soil Testing lab make these calculations for you. For detailed information on applying manure to cropland, see the University of Wisconsin Extension publication *A3392 Guidelines to applying manure to cropland and pasture in Wisconsin*.

Cover crops and green manure

Green manuring is the practice of sowing a cover crop, often a legume, in early spring and tilling it in the next spring. It was once the conventional method of supplying nitrogen to crops and was widely practiced before inexpensive commercial nitrogen fertilizer became available. It is a more bal-

Maintaining Crop Health for Pest Control

Creating the best growing conditions as possible improves crop tolerance to pests. Practices such as optimizing soil fertility, building soil organic matter content, and minimizing soil compaction will support a vigorous crop that will be less attractive to pests such as aphids, and crop yield will be less affected by pest feeding and plant diseases.

anced way to provide nitrogen to the subsequent crop than the application of composted manure or other organic materials and is also an excellent soil builder. Consider the cover crop to be as valuable as the vegetable crop, with attention to when and how to plant, plant establishment and weed control, and how the crop will be harvested or incorporated into the soil.

Sweet clover was the traditional green manure crop in Wisconsin. Red clover (*Trifolium pratense*), hairy vetch (*Vicia villosa*), annual medic (*Medicago spp.*), and berseem clover (*Trifolium alexandrinum*) are other legume cover crops well-adapted to Wisconsin conditions. Grass and grain crops such as ryegrass or oats are productive soil builders because of their extensive root system, and they can capture excess nitrogen in the soil at the end of the season, thereby minimizing nitrogen leaching over the winter.

The amount of nitrogen and organic matter added to the soil from a legume or other cover crop depends on how long the crop has grown. A summer- or fall-seeded legume will have had little time to grow in comparison to one that is seeded in the spring or early summer. Growth of more than six inches



Red clover is a legume cover crop that should be carefully planned in a snap bean rotation

provides the most nitrogen, ranging from 40 to over 100 lb/a depending on the plant species.

Incorporate cover crops and organic amendments at least two weeks before planting to permit the decomposition of the cover crop.



Quick Note

Calculating nitrogen credits: Nutrient credits from animal manures, compost, green manures, leguminous crops, and other organic amendments can and should be calculated and your fertilizer rates reduced accordingly. Estimates of green manure nitrogen credits can be found in the UW Extension publication *A2809 Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops*. The UW soil testing lab can also make these calculations for you if you supply them with information on the cropping history and soil amendment applications you have made to your field.

Growing Legume Cover Crops

Red clover (*Trifolium pratense*), hairy vetch (*Vicia villosa*), sweetclover (*Melilotus officinalis*), annual medic (*Medicago* spp.), and berseem clover (*Trifolium alexandrinum*) are examples of legume cover crops well-adapted to Wisconsin conditions. When evaluating a new legume for use on your farm, start small. A given legume may or may not perform satisfactorily under your soil conditions and management. It may take a couple of years to find which legume will work for you.

Some guidelines for growing legumes for green manure are:

- ▶ Inoculate the seed with the proper strain of *Rhizobium* bacteria. Different legumes require different strains, and many commercial products contain strains for several species. Inoculation is an inexpensive way to ensure adequate nitrogen fixation will occur.
- ▶ Use common seed, but with a high germination rate. Low germination will reduce yield and may lead to a weed problem the following year. You do not need to plant an improved variety, how-

ever. The improved varieties have been bred for persistence – a trait unnecessary for legumes used as green manures.

- ▶ Provide good soil/seed contact. Legume seed needs good soil/seed contact to germinate rapidly. Cover seed when possible. This is especially true for large-seeded species such as hairy vetch.
- ▶ Minimize competition from weeds. Small-seeded legumes germinate and grow very slowly initially, making them poor competitors with weeds. Anything you can do to reduce or suppress weed competition will improve the chances for legume success.



Quick Note

Be careful with manure of cover crops as these may increase insect and disease concerns. Seed corn maggots will be attracted to manures and plant debris in the spring as viable egg laying sites. If root rot disease and damping off are a problem in the field, legumes should be avoided in those areas.

Soil organic matter

The sustainability of your cropping systems relies on maintaining the quality of your soil system. Building, or at least maintaining, soil organic matter in your soil will improve the water and nutrient holding capacity of your soil, increase nutrient availability, and improve soil tilth. Maintaining or building soil organic matter levels is a long-term achievement for a cropping system. It relies on a cut-back in unnecessary tillage operations and an increase of organic carbon to your soil. This organic carbon can come from animal manures or plant material (i.e. incorporated plant residues or green manure). Implement these practices in your IPM program that work best for you. Even small increases in organic matter have a beneficial effect.

Whatever the type of irrigation system, use irrigation scheduling to balance crop use with irrigation and rainfall. The simplest tool to use is a checkbook method to track water use and irrigation needs. In this approach, crop water use is calculated using evapotranspiration. When calculations show that the allowable depletion is reached, irrigation is applied to bring the available soil water back to desired levels. An irrigation scheduling spreadsheet which uses the checkbook method can be accessed at: <http://www.soils.wisc.edu/wimnext/water.html>.

- ▶ Allowable depletion value for the soil.
- ▶ Initial allowable depletion balance at crop emergence.
- ▶ Amount of rainfall and irrigation applied to the field.
- ▶ Daily evapotranspiration estimate.
- ▶ Percent canopy cover to adjust the evapotranspiration when the crop is less than full cover.

Notes:

[illegible]

Resistance Management

In-Season



Resistance of insects, weeds, and pathogens to specific pesticides is an increasing problem in agriculture. Once resistance has developed to a particular material, it no longer works as a control method. Pesticide resistance is prevented by minimizing pesticide use and avoiding consecutive use of products with a similar mode of action against the same target pest.



Admire® 2 Flowable Insecticide

For uses in pest management and suppression of insect vectored diseases and maintenance of plant health.

ACTIVE INGREDIENT:	
Imidacloprid, 1-[(6-Chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine	21.4%
OTHER INGREDIENTS:	
	78.6%
	100.0%

EPA Reg. No. 264-758	EPA Est. No. 3125-MO-001
Contains 2 pounds of imidacloprid per gallon.	SHAKE WELL BEFORE USING

GROUP 4A INSECTICIDE

Example of pesticide label with EPA Resistance Management Mode of Action (MoA) Group information.

Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ A. Pesticide resistance is considered when choosing a pesticide.
- ☐ B. Pesticides with different modes of action are used within a growing season and during rotation years.
- ☐ C. Strategies to minimize pesticide use are used to slow the development of resistance.
- ☐ D. Disease, insect, and weed populations are monitored for resistance development.

A. How resistance develops

Pesticide resistance is the inherited ability of a weed, pathogen, or insect to survive and reproduce after exposure to a dose of pesticide that would normally be lethal. In general, resistance develops through the natural selection of insects, weeds, or pathogens exposed to a particular family of pesticides over a period of years. The resistant organism then has the genetic potential to pass along the resistant traits to future generations.

Pesticides all have a specific way in which they affect pests. This is known as the pesticide's mode of action. When resistance develops, it is to the particular mode of action of that pesticide. The genetic alterations that create resistant populations occur most rapidly when pesticides with similar modes of action are applied in consecutive sprays, in a single season, over successive generations, or over several seasons. Therefore, it is essential to not spray the same product or similar products against the same target pest in consecutive applications. Rotation of different mode of actions is essential.

Complete reliance on pesticides for pest, weed, or disease control can greatly increase the likelihood of developing pesticide-resistant biotypes.

Herbicide Resistance: The development of herbicide-resistant weed species is an increasing problem in Wisconsin. Most weed species contain a tremendous amount of genetic variation that allows them to survive under a range of environmental conditions. Resistance develops through selection pressure imposed by repeated, often nearly continuous use of a herbicide, or of several herbicides that have the same mode of action. Long residual preemergence herbicides, repeated application of postemergence herbicides, or application rates that are too high or too low relative to the amount needed for weed control will further increase selection pressure.

Complete reliance on herbicides for weed control can greatly increase the likelihood of herbicide-resistant weeds. This can be especially true for no-till or reduced till systems. Weeds that are most likely to develop resistance are annual weeds with high seed production and high germination rate, especially those that produce more than one genera-

tion in a year or that are extremely sensitive to a particular herbicide.

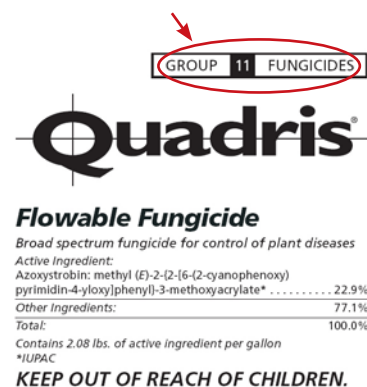
Insecticide Resistance: Concerns with insecticide resistance are relevant with certain insect pests to pyrethroid insecticides.

Fungicide resistance: There is a concern with any single site fungicide material when used in back to back applications.

B. Pesticide mode of action

The Environmental Protection Agency (EPA) and the Fungicide, Insecticide, and Herbicide Resistance Action Committees (FRAC, IRAC, HRAC) have developed a voluntary pesticide labeling proposal that groups pesticides with similar modes of action and designates them with a number. The purpose of the labeling is to help growers rotate pesticides by choosing different modes of action within a season and from year-to-year. In addition to minimizing pesticide use, this is the best way to reduce the likelihood that resistance to a particular active ingredient will develop.

You will find the EPA resistance MoA group code listed on the label of each pesticide product.



Pests to Watch for Resistance Development

Insects: European corn borer, corn earworm

Weeds: giant foxtail, green foxtail, velvetleaf, pigweed, large crabgrass, common lambsquarters, smartweeds, mustards, horsetails, Canada thistle, nutsedge

C. Strategies to minimize pesticide use and risk of resistance

The best way to minimize pesticide use is to prevent the introduction and spread of insects, pathogens, and weeds into your field. Many of the pest management strategies outlined in this workbook are prevention-based and aimed at keeping pest populations low.

When pesticides are needed, there are things you can do to prevent resistance from developing in your fields over time.

Strategies to prevent resistance

Herbicides

- ▶ Rotate crops
- ▶ Rotate herbicide families and use herbicides with different modes of action
- ▶ Spot treat when feasible and appropriate
- ▶ Mow or cultivate weedy escapes before they set seed
- ▶ Practice good sanitation to prevent the spread of weeds
- ▶ Integrate cultural, mechanical, and chemical weed control methods

Fungicides

- ▶ Rotate crops
- ▶ Use good sanitation methods to prevent pathogens from entering and spreading in the field
- ▶ Use fungicides only when necessary

Insecticides

- ▶ Rotate crops
- ▶ Use sanitation methods and other cultural controls to avoid introduction of pests into the field and keep populations low
- ▶ Treat only at economic thresholds
- ▶ Time application(s) to target the most vulnerable life stage of the pest and for least disruption of natural enemies
- ▶ Obtain good spray coverage
- ▶ Spot treat when feasible and appropriate



Quick Note

Luckily, resistance development of disease and insect pests in snap bean has not readily occurred. However, resistance can strike quickly to any pest, and therefore resistance management strategies should still be implemented in snap bean to limit resistance development.

D. Monitoring for pesticide resistance

Early detection is important if resistance is developing in a population of insects, pathogens, or weeds. When you scout your fields, be on the lookout for patterns that would indicate resistance. For weeds, look for patches in fields, scapes scattered in no particular pattern throughout the field, or patches of dense populations of weeds with some radiating out from the central patch. Whole fields infested with weeds or strips of weeds do not typically indicate resistance.

If you are concerned that a particular insect, weed or pathogen is becoming resistant, you can have it tested. University laboratories and private companies have procedures to test for resistant populations. Check with your county extension agent for further information about specific labs and how to take a sample.

Notes:

Biological Control

In-Season



Biological control is the use of living beneficial organisms, sometimes called natural enemies, for the control of pests. Several key insect pests of snap bean are frequently kept in check for much of the growing season by the activity of their natural enemies. Biological control can be easily and effectively supplemented with cultural and carefully-chosen chemical controls when necessary for a truly integrated pest management approach.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Biological control is considered as a pest management strategy for snap bean.**
- ☐ **B. Common beneficial insects are recognized.**
- ☐ **C. The presence of common natural enemies and signs of biological control are noted during scouting.**
- ☐ **D. Populations of beneficial insects are encouraged by preserving or planting suitable habitats. Release of specific natural enemies is considered when available.**

A. Role of biological control in snap bean IPM

Biological control is the use of living beneficial organisms, also called natural enemies, for the control of pests. Birds, mammals, and reptiles feed on insect pests, but the most important group of natural enemies are insects that feed on other insects. These beneficial insects occur abundantly in cropland and provide a significant amount of control of some crop pests.

It's important to recognize that the intent of biological control is not to eradicate the pest population, but to keep them at levels where they cause no appreciable harm or delay time until pests reach economic thresholds. In fact, because natural enemies require prey or hosts for survival, biological control works best when there is always a small population of pests to sustain their natural enemies. This is a major difference between biological control and the use of pesticides. Biological control can be easily and effectively supplemented with cultural and carefully chosen chemical controls when necessary.



Convergent lady beetle larvae

The use of broad-spectrum insecticides is one of the main obstacles to effective biological control because natural enemies are just as susceptible to the insecticide as the pest. Sometimes one pest will be under good biological control, but another one is reaching an economic threshold. This is a difficult situation, because if treated, the outcome can be a secondary pest outbreak in which the pest that was not causing damage becomes damaging after the treatment eliminated its natural enemies. A similar situation, called pest resurgence, occurs when the population of the treated



Aphid mummies

pest, often aphids, rebounds rapidly because of the elimination of its natural enemies.

You may want to consider augmenting the natural population of beneficial insects by purchasing and releasing additional beneficial insects into the field. There are companies that grow and supply natural enemies, including some specific for snap bean pests. See **Common Predators of Insect Pests** for a list of commercially available species. These releases can be effective, but because of the complex interactions between a pest, the host crop, its natural enemies, and the environment, some experimentation on your part will be necessary to achieve optimum pest management under your specific conditions.



Commercially packaged Green lacewing larvae

© Joseph LaForest, University of Georgia

Conserving the natural enemies in your fields

- Avoid the use of broad-spectrum insecticides.
- Reduce the impact of insecticide sprays by spot-treating, banding, timing treatments carefully, and choosing compounds with low toxicity and short persistence.
- Maintain plantings that provide nectar, pollen, alternate hosts, and humid resting places in or near the field. Sweet alyssum, cilantro, and goldenrod are particularly attractive to adult syrphid flies and parasitic wasps, but any noninvasive mix of plants that includes flowering plants and will be competitive with weeds will be beneficial.
- Maintain overwintering sites for beneficials on the border of fields.

B. Common beneficial insects

Natural enemies of insect pests fall into three categories: general predatory insects, parasitic insects, and insect pathogens (fungi, bacteria or nematodes).

Predatory insects are usually much larger than their prey. They are generally voracious feeders that eat a wide variety of insects. Ground beetles, minute pirate bugs, and lady beetles are examples of predatory insects. Most predators are fairly mobile and can search for their prey. Many predators are active in their immature larval or nymph stage and adults. You and your scout will learn to recognize common predatory insects in both their immature and adult stages.

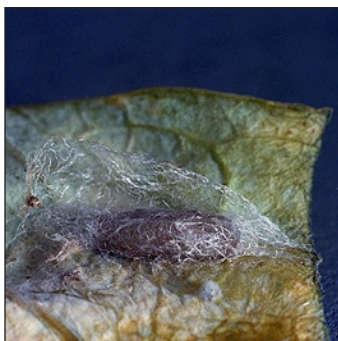


A predatory assassin bug

Predators are especially active and effective in small, diverse plantings and are often present even before pests arrive. They are also active in larger monocultures, but they may need augmentation or extra conservation methods to reach the same level of activity.

Some of the most effective natural enemies, however, are tiny and easily overlooked.

These are the **insect parasites**, also called parasitoids, which are often tiny, non-stinging wasps. Parasitic wasps are free-living in the adult stage but are parasitic on specific insects in the larval stage. Eggs are laid in the host, and the parasitic larvae eat their hosts from within, ultimately resulting in the death of the host insect. When scouting for this type of biological control activity, you will look for signs of the parasitized pest rather than the parasite itself.



A parasitized diamondback moth pupae

© Ken Gray, Oregon State University

Parasites often prefer a specific host insect. Their activity can be very effective in keeping pest popu-

lations in check, especially those of aphids and caterpillar pests.

Insect pathogens are microorganisms that cause lethal disease in insect pests. The most well-known insect pathogen is *Bacillus thuringiensis*, or Bt, which has been made into a commercially available microbial insecticide.

Fungi that attack insect pests are called entomophagous fungi and are fairly common. Under rainy, humid conditions, death caused by fungal infection can be a mortality factor for caterpillar larvae and aphids. Under some conditions, entire aphid populations can be wiped out. Most of the time, however, infection does not occur early enough or often enough to be an important control agent. Fungicide sprays may kill insect-infecting fungi.



A fungal-parasitized aphid

© Bill Stoneman

Insect-specific viruses can be effective natural controls of caterpillar pests, including the cabbage looper and imported cabbageworm. In some years, the combination of virus diseases and predation or parasitism can deplete the pest population.



Quick Note

The biological fungi *Coniothyrium minitans* (*C. minitans*) has been found to be a very useful biological control agent for the control of white mold. This material can be soil applied pre-plant. It is important to map hot spots of white mold concern, and to apply *C. minitans* to those areas.

Common Predators of Insect Pests

Most predatory insects are called generalist predators because they feed on a wide variety of insects, rather than on a few specific species. Aphids, moth eggs, larvae, and pupae, are just some of the important prey for generalist predators.

You and your scout should learn to recognize the presence of these beneficial insects. Note that some of them are active in both the larval and the adult stages.

Lady beetles

Hippodamia convergens and other species



Convergent lady beetle adult
© Frank Pearis



Convergent lady beetle larvae

Lady beetles are a large group of well-known beneficial insects. The convergent lady beetle, *Hippodamia convergens*, is one of the most common species on snap bean in the upper Midwest. Other common species include the twelve-spotted lady beetle, *Coleomegilla maculata*, and the seven-spotted lady beetle, *Coccinella septempunctata*. All are important aphid predators in both the larval and adult stages.

Learn to recognize the lesser-known larval stage of the lady beetle as well as the adult. Larvae are active, black, elongated insects with bright red or orange spots and long legs and resemble tiny alligators.

Availability for release: Lady beetles are available commercially, but their use has been limited by their tendency to disperse. The best time to release is when prey is abundant.

Ground beetles

Many species, including Lebia grandis



© Gyorgy Csoka, Hungary Forest
Research Institute

Ground beetles are probably the most numerous predatory insects in crop fields. There are hundreds of species of ground beetles, most of which are dark, shiny, and somewhat flattened. They live in cracks and burrows in the soil and debris and are fierce predators of caterpillars, larvae of other beetles, and seed maggots. They can consume their body weight in food daily.

Conserve ground beetles by reducing tillage to a minimum and not using broad-spectrum soil insecticides. Their survival will be enhanced by providing refuges and overwintering sites such as hedgerows or mulch.

Availability for release: Not available commercially

Syrphid or hover fly

Many species in the family Syrphidae



Hover fly adult



Hover fly larvae

© Clemson University - USDA Cooperative Extension Slide Series

Syrphid or hover flies, also called flower flies, are common and important natural enemies of vegetable pests. The larvae of many common species of the syrphid fly feed on aphids and caterpillar larvae in snap bean. The pale green to yellow maggots have a slug-like appearance and can consume 400 aphids each during their development.

The adult flies resemble bees or wasps and are often seen visiting flowers. There are many different species that range in size from less than one-fourth of an inch long to more than three-fourths of an inch long. Many have the typical black and yellow stripes on the abdomen that give them a bee-like appearance.

The adults need flowers as nectar and pollen sources. They are attracted to weedy borders or mixed plantings that are also infested with aphids. Some flowers that are especially attractive include wild carrot or Queen Anne's lace, wild mustard, sweet alyssum, coriander, dill, and other small-flowered herbs.

Availability for release: Not available commercially.

Green lacewings

Chrysoperla spp.



Green lacewing adult

© Joseph Berger



Green lacewing larvae

© Whitney Cranshaw, Colorado State Univ.

The adult lacewing is easily recognized as a slender flying insect with veined gauze-like wings, but it is the larvae, called aphid lions, that are the important predators. Aphid lions resemble little green alligators with mouthparts like ice tongs. They are voracious feeders that will consume more than 200 aphids a week, as well as insect eggs, thrips, and small caterpillars. They can detect the larvae of leafminers within the mines and will pierce the leaves in order to feed on the miners within.

Availability for release: Green lacewings are available from many commercial suppliers and can be extremely effective under certain conditions. Two or three successive releases at two-week intervals are usually better than a single release. Ask the supplier to recommend the most appropriate species and stage for your pest management needs.

Lacewings are usually supplied as eggs, but larvae and adults are also available. Eggs are shipped in a carrier material, which makes it easier to distribute them onto infested plants. Lacewings released as pre-fed adults ready to lay eggs can fly away immediately, so take care to provide adequate food and habitat to encourage their remaining and reproducing in the crop. They must have a source of nectar or pollen. A sprayable food supplement can be applied to the crop to encourage lacewings and other predators to remain in the crop.

Spined soldier bug

Podisus maculiventris



The spined soldier bug is reddish brown with two short spines sticking out from the middle edges of its shield-like body. It is a common predator of caterpillars and caterpillar eggs in snap bean. The nymphs look similar to the adults and are also active predators. One nymph may consume as many as 360 host eggs during its development.

Availability for release: The spined soldier bug is available commercially. The suggested release rate is five nymphs for every foot of row. Release when caterpillar larvae are peaking.

Damsel bugs, Big-eyed Bugs & Minute pirate bugs

Nabis spp., *Geocoris spp.*, and *Orius spp.*



Damsel bug

Damsel bugs, big-eyed bugs, and minute pirate bugs are common and active predators in crop fields.

Damsel bugs, *Nabis* spp., are one-half inch long tan or black bugs with wings. The nymphs are similar but do not have wings. The piercing mouthparts curve down from the head. Both the young nymphs and the adults are active predators that feed on important crops pests such as aphids and caterpillars.

Big-eyed bugs, *Geocoris* spp., are very small, only one-sixteenth inch and usually brown or black. Both adults and nymphs consume numerous aphids, flea beetles, small caterpillars, and spider mites. Big-eyed bugs are common in agricultural fields, especially when broad-spectrum insecticides have not been used.



Big-eyed bug

© Bradley Higbee

Minute pirate bug adults, *Orius* spp., are black, about one-fourth inch long with distinctively patterned black and white wings. The nymphs are yellow to light brown. Both nymphs and adults have prominent beaks and are active predators of thrips, mites, aphids, and caterpillar eggs. Minute pirate bugs are common in pastures, crop fields, and field margins, especially where broad spectrum insecticides are not routinely used.



Minute pirate bug

© John Ruberson, University of Georgia

Availability for release: *Orius* spp. and *Orius tristicolor* are available commercially. They are supplied as adults in a carrier material along with a food source. Shake the carrier onto the plants, and the bugs will readily disperse and locate prey. Ask your supplier for suggested release rates for your crop and pest situation.

C. Scouting for beneficiaries

Watch for natural predation at work. Note the presence of predators such as the syrphid fly, ladybeetles (adult and larvae), and lacewing larvae.

Several parasitic wasps feed extensively on aphid populations, and it is possible for these natural enemies to control aphid populations. To determine if natural enemies are attacking aphids, look for aphid mummies stuck to the leaf undersides. Parasitic wasps feeding on aphids result in the mummies. If a high number of aphid mummies are seen, insecticide applications may not be necessary.

The biological control occurring in your field can be a solid base of insect pest management that you can build on with cultural controls and carefully chosen chemical controls.

D. Conserving and releasing beneficial species

Providing food, water, and shelter for natural enemies will encourage them to stay in the crop area to feed and reproduce. Beneficial insects often need an alternate food supply in addition to the pest prey. Many natural enemies, including the adult lacewing and minute pirate bug, must have a source of nectar, pollen, or honeydew to feed on in the general vicinity of the pest. This will stimulate egg laying in the crop.

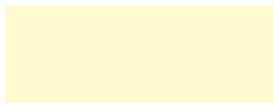
A more diverse landscape tends to harbor many more natural enemies than a large-area monoculture because it offers more food, water, and shelter to beneficials. Consider how you might supply these resources near your fields. Small patches of unmowed grass and flowering plants can provide a food source as well as sheltered, humid spots where beneficial insects can hide during the day without dehydration. A managed boundary around fields is also a good way to control weeds and provide overwintering sites for beneficials. .

Sprayable food supplements are available to encourage predators such as green lacewing to stay in the area during those times when the prey population is low. Examples are Pred-Feed or Good Bug Powder Meal.

Notes:

This image shows a vertical rectangular sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

Harvest and Storage



Harvesting at the optimal time with attention to environmental and pest management decisions are required to ensure a healthy crop. Postharvest activities can limit contaminants in processing and marketing.



Read the following statements in order and check all that apply. Refer to the corresponding sections on the following pages for more information.

- ☐ **A. Crops are harvested at maturity.**
- ☐ **B. Good harvest practices are followed to keep the crop dry and minimize injury.**
- ☐ **C. Snap bean residue is incorporated quickly after harvest. Pest overwintering sites are destroyed.**
- ☐ **D. Processing out practices are used to eliminate contaminants.**

A. Signs of crop maturity

Harvesting vegetables at the proper maturity greatly influences their market quality and shelf life. Learn to recognize the signs of a mature, quality crop. Generally, snap bean are harvested about eight weeks after planting and are fully mature 20-25 days after flowering. This timing ensure good bean flavor, sweetness, and moisture for best quality.



Harvesting snap bean

B. Harvesting procedures

Snap bean should be dry when harvested. Limiting wetness helps prevent diseases in the crop and in raw product.

Keys to Postharvest Quality

- ▶ Harvest produce at the appropriate maturity.
- ▶ Only harvest produce that is free of disease and damage.
- ▶ Handle the produce carefully during harvest and storage to keep bruising to a minimum.
- ▶ Keep the produce out of the sun.
- ▶ Cool the harvested produce within one hour of harvest.
- ▶ Clean the storage facility and boxes before the harvest season.
- ▶ Maintain optimum storage temperature, ventilation, and humidity.

C. Incorporating plant residue, limiting pest overwintering

Snap bean stubble and plant residue should be incorporated quickly after harvest. If possible, they should be incorporated within one week of harvest to reduce the spread of diseases, limit buildup of root rot, and prevent overwintering sites of insects such as European corn borer. If plant debris is infected with any pest concern, specifically a disease such as white mold, then the debris should be deep plowed and completely incorporated.

Certain pests, such as bean leaf beetles, like to overwinter in crop residues or adjacent to field edges. Destroying these overwintering sites limits protection of the beetle from cold weather and is very effective in limiting the number of adults found the following spring.



Bean leaf beetle

© Frank Peairs, Colorado State University, Bugwood.org

D. Processing out and eliminating contaminants

Contaminants can cause serious problems in marketing and processing of beans. Contaminants can consist of any unwanted organisms which are picked up in the field and causes problems in the processing process. Many contaminants are insect, disease, or weed organisms, and utilizing a good biologically based IPM program can help eliminate many of these concerns. Processing out should be considered in the field, prior to harvest, during harvest, and in the processing end.

Processing out components includes:

Pre-plant and In-season:

- ▶ Plant in areas with limited concerns of weed or insect pests (e.g., areas with known history of controlling problem pests)
- ▶ Schedule plantings and harvest to avoid high


risk of contaminants

- ▶ Adjust pest thresholds to keep pests below a level that would allow the processing plant to clean up contaminants
- ▶ Sample fields prior to harvest to identify potential contaminants
- ▶ Accurately identify pests in the field prior to harvest
- ▶ Monitor pest dispersal during the growing season

During Harvest

- ▶ Adjust raw product flow through the harvester to maximize cleaning effectiveness, e.g., slower flow for large plants that may harbor more pests
- ▶ Make mechanical adjustments to increase cleaning effectiveness (e.g., fan speed, screen size and configuration, drum pressure, head height, etc.)
- ▶ Adjust harvest time to avoid periods when contamination is more likely (e.g., wet foliage from dew or rain when contaminants adhere to belts)
- ▶ Conduct research to improve the cleaning capacity of harvesters

Post Harvest

- ▶ Reduce raw product flow rate to increase removal efficiency for high density contaminants
 - ▶ Use water flotation and/or scalping beds to remove heavy contaminants
 - ▶ Use cleaning fans to remove low density contaminants (e.g., beetles, stink bugs)
 - ▶ Use color/vision sorters to remove contaminants
 - ▶ Conduct research on processing out potential by running contaminant-spiked samples through the plant and making adjustments prior to full processing runs
 - ▶ Monitor and review consumer feedback
- 



Harvested beans

Notes:

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Notes:

Corn Earworm *Helicoverpa zea*

peak activity

April

May

June

July

August

September

October

Corn earworm can be a periodic late-season pest of snap bean. Also known as the tomato fruitworm, they feed on beans, tomatoes, lettuce, peppers, and sweet corn. The highest populations appear in August. Early snap bean harvested by mid-July will avoid corn earworms.

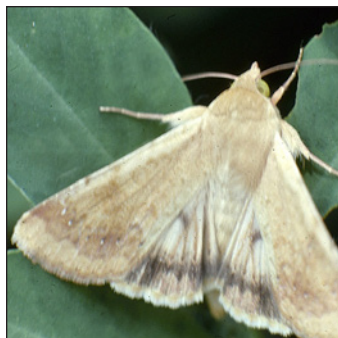
Corn earworm larvae feed on leaves and buds of snap bean, as well as pin beans and pods, reducing yield and causing blemishes and pod rot. Larvae may also pose a contamination problem in snap bean grown for processing, but they are not as serious as the internal pod-feeding European corn borer.

Few corn earworms overwinter in Wisconsin, and most migrate into the state annually from southern states. Corn earworms overwinter in warmer areas as pupae buried in the soil. Adults emerge in early May and begin their northward migration. The moths fly mainly at dusk or during warm, cloudy days and arrive in Wisconsin in early summer. The early summer generation generally does little damage on snap bean that have not reached a susceptible stage when moths arrive. After mating, females lay eggs individually; each fertilized female can deposit up to 1,000 eggs during her lifetime. Larvae begin feeding immediately upon hatching. Development from egg to adult requires about 30 days in midsummer. The more damaging second generation appears in August to early September.



Corn earworm larvae feed on the bean foliage, which results in holes. They also feed on the outside of the pod, which causes surface damage, and burrow into the pods to feed on seeds.

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Adult corn earworms are robust, grayish-brown moths with a wing span of about 1-1/2 inch with irregular dark markings on the wings. The most conspicuous mark is a dark comma-shaped marking on the front wings.

Scouting: The best technique for monitoring earworms is the use of pheromone traps. These traps use a special scent to attract male moths. Knowing when moths are present helps to determine when to treat fields. Black light traps can also be used. For information about trap designs and sources, contact an Extension entomologist at the University of Wisconsin-Madison. Place a trap 4-6 feet above the ground on the south or west side of fields. Traps should be checked daily beginning in July. Pheromones should be changed every two weeks with the unused lures kept frozen until needed. Hercon® pheromone lures have been very effective at attracting earworm moths. For accurate counts, be sure to remove used lures from the trap area.

If five or more corn earworm moths are detected per night, or 10 or more over a three-night period, begin monitoring moth migration from southern production areas—the Wisconsin Crop Manager (www.ipcm.wisc.edu) and the Wisconsin Pest Bulletin (www.pestbulletin.wi.gov) are two good sources of information. Start walking individual fields for adults. Examine volunteer corn for adults and/or larvae.

Threshold: If less than five moths/blacklight trap or less than 10/pheromone trap, treatment is unnecessary.

If five moths/blacklight trap or 10/pheromone trap are present, vulnerable beans (30-37 days before harvest) should be treated. Monitor blooming fields for adult and larval activity. Insecticides used for European corn borer should also control corn earworm.

If 25/blacklight trap or 100/pheromone trap are present, a reinfestation flight is occurring, and susceptible beans (bloom-7 days before harvest) should be treated.

If over 100/blacklight trap or 500/pheromone trap are present, a migration flight is occurring, and/or a local emergence of the late generation is occurring. Susceptible stage beans should be treated using high rates of an effective material.

Continued on next page...

Management Strategies

Cultural control

- ▶ Avoid planting snap bean next to sweet corn. Corn, especially tasseling corn, is very attractive to corn ear worm, which prefer to lay their eggs on corn silks.
- ▶ In small plantings, larvae can be handpicked and destroyed.

Biological control

- ▶ Corn earworm larvae will cannibalize other larvae on the same plant. The eggs are parasitized by *Trichogramma* wasps and preyed upon by the flower bug, *Orius tristicolor*. Larvae are also parasitized by a number of chalcid and braconid wasps.
- ▶ Currently, releasing commercially available beneficial insects is too costly and labor intensive to be worthwhile. Conserve existing populations of beneficial insects by treating fields only when needed and avoiding broad-spectrum insecticides.

Chemical control

- ▶ If insecticides are being used to control European corn borer, they will likely control corn earworm as well. Choose a material that is effective on both. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.
- ▶ Avoid spraying when snap bean or crops in neighboring fields are flowering. Although bees do not pollinate snap bean, they collect nectar and pollen from the bean flowers. If sprays are necessary during flowering, spray later in the evening when the bees are less likely to be gathering nectar or pollen in the field or garden.
- ▶ Zea-Later™ is an applicator that combines *Bacillus thuringiensis* var. *kurstaki* with vegetable oil. This organic method of control, if timed correctly, can provide 80-90% control.
- ▶ Some corn earworm larvae in the Midwest have been confirmed to be resistant to synthetic pyrethroid insecticides, signaling that this insecticide may cease to be an effective means of control. Do not spray the same product or products with a similar mode of action in consecutive applications or more than the recommended number of applications. Monitor the crop and insect populations for signs of resistance.



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The olive-brown larvae generally have 3 or 4 dark stripes along their back and measure 2 inches long when mature. The head is yellow and not spotted. The 1/32 of an inch yellowish, sculptured, hemispherical eggs are laid singly on foliage or corn silks.

European Corn Borer *Ostrinia nubilalis*

peak activity							
April	May	June	July	August	September	October	

The European corn borer is a major pest of snap bean. The foliage of snap bean provides an environment suitable for an "action site," where adults rest during the day and mate at night. If a preferred host, such as corn, is not available to attract European corn borers, eggs will be laid on snap bean plants. Larvae feed on bean leaves and pods and cause contamination problems in beans used for processing. The European corn borer is a frequent pest of several important vegetable crops, including corn, peppers, eggplants, tomato, and potato.

European corn borer feeding can cause economic damage, but the contamination tolerance limit is usually reached before this point. Tolerance of infested pods is quite low, and it varies among processors, ranging from 0.2-1 infested pod per 1,000 pods. The greatest risk for contamination is from the bud stage to the pin stage.

The European corn borer overwinters as mature larvae in corn stalks and stems of weed hosts. They pupate in the spring when temperatures are over 50 degrees F. Peak moth emergence for the overwintering generation is usually in June in southern Wisconsin. European corn borer infestation of snap bean occurs primarily in late spring (before corn is available), in midsummer, or in late summer in a late-planted crop.

The second generation moths peak in August when approximately 1700_{DD50} have been reached (1550-2100_{DD50}). If there is corn in the fresh silk stage nearby, the moths are more likely to lay eggs on corn than on any other host. If nearby corn is past the fresh silk stage, then moths are likely to lay eggs on leaves of beans or other hosts. Egg masses are deposited on leaves about the time of blooming. The larvae hatch in about four days and feed for a short time on the leaves before tunneling into stems and pods.



European corn borers damage beans by breaking stems and creating contamination issues by tunneling into developing pods. Shown here in corn.

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Scouting: Catch moths in black light traps placed near the bean field is the best indicator of potential European corn borer infestations. The presence of egg masses on nearby corn, if available, or in grassy sites (mating areas) is also a good indicator.

When black light traps or field observations indicate increasing moth populations, begin walking field edges during the day to gauge the level of European corn borer populations close to an individual field. Pay special attention to early fields following non-Bt field corn or sweet corn. Walk the field edges, look at volunteer corn plants for eggs and larvae, and examine grassy areas for adults and egg masses. If moths are seen in these areas, flight and egg-laying is likely reaching threshold levels. Look for wilted trifoliates, and examine the stem and pod for holes. Look for frass deposits at the point of entry and for live borers inside.

Threshold: The decision for control should be based on the stage of the bean crop and level of moth activity. Apply insecticide when beans are in the early bloom stage **and** moth catches in nearby blacklight traps exceed 15 moths per night for first generation or 100 moths per night for second generation. Once moth catches drop, delay applications until beans are one inch long. Make sure that treatment windows are emphasized prior to application.

Management Strategies

Cultural control

- ▶ Keep bean plantings as far away from corn plantings as possible.
- ▶ Remove grassy weeds from field edges where adult moths rest and mate during the day.
- ▶ Some bean varieties differ in their susceptibility, but there are no truly resistant varieties.
- ▶ The majority of overwintering larvae may be killed by plowing under the stubble of all susceptible crops after harvest, but soil erosion concerns in addition to the wide host range for European corn borer can limit the value of this technique.

Continued on next page...

Biological control

- ▶ A variety of natural enemies help suppress European corn borer infestations, including predatory lady beetles, minute pirate bugs, lacewings, and fly and wasp parasitoids. Bird predation can also be important.
- ▶ The parasitic wasps *Trichogramma* have been effective in some experiments and may be available commercially in the future.
- ▶ Weather conditions greatly influence European corn borer survival, particularly during the egg stage and before young larvae enter the stems and pods. Heavy rains can wash the egg masses and young larvae off the plants. Very hot, dry weather causes desiccation of the eggs and young larvae. These climatic events kill a significant number of young larvae each year.

Chemical control

- ▶ Insecticides are available to control European corn borer. Insecticide coverage must be thorough. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.
- ▶ Time insecticide applications to coincide with the peak moth flight and egg-laying period and when beans are in a susceptible growth stage. The time of greatest susceptibility is from bud stage to pin bean stage. Eggs laid during the last 12 days before harvest will not result in damage or contamination.
- ▶ *Bacillus thuringiensis* (Bt) can be effective in controlling early instar larvae.
- ▶ To avoid insecticide resistance, do not exceed the number of recommended applications. When possible, rotate products with a different mode of action.



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The adult European corn borer is a night-flying, straw-colored moth with a 1 inch wing span.

Males are slightly smaller and distinctly darker than females.

Potato Leafhopper *Empoasca fabae*

peak activity

April

May

June

July

August

September

October

The potato leafhopper can be a serious annual pest of snap bean in Wisconsin. Both nymphs and adults feed by sucking juices from the leaves and other plant parts, causing a curling and browning of the leaf tip called "hopper-burn". Adults are small, wedge-shaped, pale green insects with whitish spots on the head and upper body. They are extremely active insects that jump, fly, or crawl sideways or backwards when disturbed. Potato leafhoppers feed on a wide range of plants including potatoes, all types of beans, alfalfa, eggplant, strawberries, rhubarb, clover, apples, dahlia, other bedding plants, and many weed species.

Leafhopper feeding causes stunting, poor root growth, blossom blast, and reduced yield and vigor. Nymphs can be more injurious than adults. Damage may be more severe in hot, dry years.

Potato leafhoppers do not survive the Wisconsin winter. Populations build up on legumes early in the year in the Gulf state region and migrate northward in April and May on warm southerly winds. The first migrants, primarily females, reach Wisconsin in mid- to late May. Large influxes of migrants occur in June and early July, causing populations to increase rapidly. Adult females lay about three eggs each day for about a month by inserting eggs into the stems or large leaf veins of susceptible crops. Nymphs hatch seven to ten days later and are similar in appearance to the adults except they are yellow-green in color and do not have fully developed wings. Nymphs molt five times over a period of about two weeks before turning into adults. There are typically two generations per year in Wisconsin, and populations decline significantly in August.



Adult potato leafhoppers are small (1/8 inch long), bright green, wedge-shaped insects with white spots on their head and upper body (left); nymphs are smaller (right).

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Scouting: Snap bean should be scouted regularly for leafhoppers. Leafhoppers tend to migrate from alfalfa into other crops in early summer after alfalfa has been cut. This is the key time to watch for early migrations into vegetable plantings. Monitor fields using an insect sweep net or by examining leaves. Take 25 sweeps per sample site, and sample from at least five sites per 30 acres. Sites should be scattered throughout the field. Nymphs are less mobile and are best scouted by sampling leaves. Carefully turn over 25 leaves per sample site and count nymphs. Select leaves from the middle portion of the plant. Record the number of pests and the plant growth stage.

Threshold:

Life Stage	Seedling Threshold	Larger Snap Bean Threshold
Nymphs	1 per 10 leaves	1 per 10 leaves
Adults	1 per two sweeps	1 per sweep

Management Strategies

Cultural control

- ▶ Healthy, vigorously growing plants will withstand leafhopper feeding much better than stressed plants. Follow good cultural practices, and keep soil adequately moist.
- ▶ Varieties differ in their sensitivity to leafhopper feeding and the toxin causing hopperburn.
- ▶ Do not plant next to alfalfa fields if possible to avoid mid-summer migration of leafhoppers when alfalfa is cut.

Biological control

- ▶ The impact of natural enemies on potato leafhopper populations is not well known.

Chemical control

- ▶ Many foliar insecticides used for other pests, including European corn borer, are also effective for potato leafhoppers. Systemic insecticide seed treatments are also available. Refer to UWEX publication A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.
- ▶ To avoid resistance development, do not exceed the number of recommended applications. Rotate with products with a different mode of action when possible.

Seedcorn Maggot

peak activity

April

May

June

July

August

September

October

The seedcorn maggot feeds on germinating seeds or young plants. It is generally only a pest early in the season before the soil is thoroughly warm. Seedcorn maggots are particularly damaging when residues of the previous crop or other soil amendments have not thoroughly decayed before planting beans.



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Seedcorn maggot damage on young bean plants (right). Seedcorn maggot adult.



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Scouting: Scout from mid-May through June, when seed corn maggot activity typically occurs. Predict populations using degree-day calculations, and use yellow water traps in the field to determine peak flights.

Threshold: There are no thresholds for this pest; preventative action is necessary for control.

Management Strategies

Cultural control

- Plow in crop debris after harvest, and do not plant within seven days of crop and/or cover incorporation.

Biological control

- Parasitism by an egg parasitoid, *Anaphes* sp., is a significant control factor and should be encouraged by maintaining border areas that offer habitat and pollen for the parasitoid.

Chemical control

- Use of fungicide-treated seeds will minimize damping off and root rots caused by *Pythium* and *Rhizoctonia* but not rot caused by *Aphanomyces*. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.
- Some commercial seed is pre-treated with fungicide, which may help control pre-emergence decay and damping-off.

PEST PROFILES

Tarnished Plant Bug *Lygus lineolaris*

peak activity

April

May

June

July

August

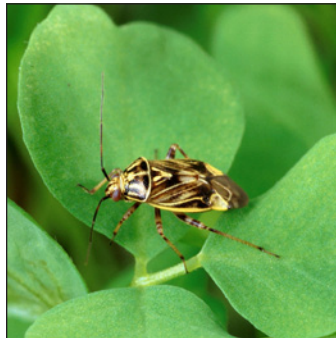
September

October

Tarnished plant bugs have a wide host range and are an occasional pest of snap bean. They feed on alfalfa, beans, cucumber, celery, beet, chard, cabbage, cauliflower, turnip, potatoes, strawberries and other small fruit, tree fruit, and many flowering plants. The tarnished plant bug causes injury to snap bean during feeding with their piercing-sucking mouthparts.

In addition to the direct damage caused by feeding, the insect also injects a salivary secretion that is toxic to the plant. This toxin will cause blossoms and pods up to two inches long to fall off (bud blasting), prolonged pod set, and reduced yields. Pits can form on older pods.

Tarnished plant bugs overwinter as adults under leaf mold, stones, and tree bark and among the stubble of clover and alfalfa. Adults begin to emerge in late April to early May. After feeding for a few weeks, they migrate to weeds, vegetables, and flowers where eggs are inserted into the stems, petioles, or midribs of leaves. Eggs hatch in about 10 days. Nymphs pass through five growth stages over 20-30 days before becoming adults. Second generation adults begin to emerge in late June-July. There may be two or three generations per year until adults enter hibernation in October or November.



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Tarnished plant bug adults (left) are 1/4 inch long, generally brown with splotches of white, yellow, reddish-brown and black. There is a clear yellow triangle tipped with a smaller black triangle on the rear end of the abdomen. Nymphs are smaller and lack the distinct markings.

Scouting: Appreciable numbers of plant bugs are not seen on snap bean until mid-July. Monitor populations with an insect sweep net. Take 25 sweeps per sample site, with at least 10 sites per 100 acres scattered throughout the field.

Threshold: Although no economic thresholds have been determined for this pest on snap bean, one/sweep is a good indication that population levels are high.

Management Strategies

Cultural control

- Remove weeds, especially those that stand semi-erect during winter, to reduce overwintering sites.

Biological control

- A few insect predators feed on the tarnished plant bug, including a predaceous stink bug, assassin bugs, the big-eyed bug, and damsel bugs. The amount of control provided by natural predators is not well known.

Chemical control

- Insecticide programs to control European corn borer and/or potato leafhoppers will also control tarnished plant bug. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.



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Tarnished plant bug nymph feeding on a broccoli plant, note the piercing-sucking mouthparts.

Bean Root Rot

Aphanomyces euteiches f. sp. *phaseoli*,
Pythium spp., *Rhizoctonia solani*

April

May

June

July

August

September

October

Bean root rot is a problematic disease of snap bean in Wisconsin. Several common soil fungi cause root rots, including *Pythium* species, *Aphanomyces euteiches* f. sp. *phaseoli*—a bean strain of the pea root rot pathogen—and *Rhizoctonia solani*. Often more than one pathogen is involved in causing root rot, making control strategies difficult to develop.

Several species of *Pythium* cause root rot and damping-off of seedlings. Together with *Aphanomyces*, *Pythium* causes what is called the Common Root Rot Complex in beans, one of the major reasons for poor crop stands. *Pythium* infects plants at any stage of development, from an ungerminated seed to a mature plant. Older plants are more tolerant. The disease is especially common where intensive cropping of beans has occurred. Yield losses may reach 100%.

Aphanomyces euteiches is an important pathogen of peas in Wisconsin. A bean strain of this fungus has recently been found that causes severe root rot of bean. The fungus infects bean from the seedling stage through maturity but does not cause pre-emergence damping-off.

Rhizoctonia solani is a common and widespread soil fungus that causes root rot most severely on two to three week old bean plants. Unlike *Pythium*, soil water conditions have little effect on disease severity. Seedlings infected by



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Root rots caused by *Rhizoctonia* (left) and other soil fungi are common.

Wet soil favors the development of root rots.

Scouting: Prior to planting beans, a soil sample should be collected and submitted for testing to determine the level of root rot fungi in the soil. Collect soil in the spring or fall prior to planting. Cover the entire field in a “W” pattern and collect about a gallon of soil from multiple sites. A sampling depth of six inches is recommended. Store the soil samples at 60-75 degrees F. Keep them moist by storing in closed, but not sealed, bags. Do not store samples at cool temperatures or in car trunks or on truck beds where temperatures may fluctuate widely. Samples should be submitted to the UW-Madison Department of Plant Pathology to determine the disease index.

Monitor fields throughout the growing season for signs of root rot. Dig seedlings or plants that are stunted or pale, carefully wash off the soil, and examine the roots for decay. It is often difficult or impossible to differentiate the common types of root rot, especially in an advanced stage, but the presence of root rots should be noted to make adjustments in planting practices and seed treatment for subsequent crops.

Threshold: Disease indices that range between 0-50 are safe for planting beans. Indices falling within 51-69 are considered questionable. Fields which rate in the questionable range should not be planted to beans whenever possible. Fields with a soil test index greater than 70 should not be planted to snap bean for several years and should be retested before planting is considered.

Management Strategies

Cultural control

- ▶ Continuous cropping of susceptible plants will eventually lead to a buildup of these fungi in the soil. Rotate with non-legumes and use cover crops between planting and over winter. Rotate away from vegetables when possible. One or two years with a grain crop such as barley, oats, rye, wheat, or corn will prevent severe root rot development when practiced on relatively clean fields; longer rotations are necessary in heavily infested fields.
- ▶ Minimize soil compaction. Subsoiling to 20-22 inches can promote deep rooting.

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- ▶ Plant in warm soil with good drainage. Plant shallowly to promote rapid emergence. Avoid planting seeds too close together. *Rhizoctonia* and other root rots cause less damage under conditions that favor the growth of vigorous plants.
- ▶ Research continues at UW-Madison and seed companies on development of root rot tolerant breeding lines.
- ▶ If symptoms appear, timely irrigation can promote new feeder root development.
- ▶ Plow under previous crop residue rather than disking it.

Chemical control

- ▶ Use of fungicide-treated seeds will minimize damping off and root rots caused by *Pythium* and *Rhizoctonia* but not rot caused by *Aphanomyces*. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.
- ▶ Some commercial seed is pre-treated with fungicide which may help control pre-emergence decay and damping-off.
- ▶ Once infection has occurred, fungicide treatments are not effective.



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The fungi that cause root rots will build up in soils where beans and other legumes are continually planted.



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Root rot fungi can infect plants at all stages, but older plants are less susceptible to damage. Above are pods infected with *Pythium*.

Rhizoctonia are weakened or may wilt and collapse from a water-soaked rot of the stem near the soil line. Losses of 5-10% are common. Plant age plays an important role in the development of the disease. Younger plants are very susceptible to infection, and older plants generally are not.

Pythium fungi can survive for many years in the soil. Resting oospores germinate and infect plants when environmental conditions are ideal. Soils that hold moisture for long periods favor the development of damping-off because motile *Pythium* zoospores, which cause secondary infections, require soil water to move to new infection sites. Low spots in fields also favor the disease.

Oospores of *Aphanomyces* also persist for many years in the soil. Oospores germinate and infect roots during warm weather and high soil moisture. Resting oospores are responsible for the initial infection, while oospores produced in diseased tissue cause secondary infections throughout the season.

Rhizoctonia survives between crops as sclerotia or mycelia in the soil. Sclerotia are dense, compacted aggregates of dormant hyphae, resistant to unfavorable environmental conditions. Sclerotia in infested soil or plant debris can be moved throughout the field by wind, rain, irrigation water, and farm implements. Once soil becomes infested, it remains infested. In the spring, sclerotia germinate into fungal strands that can directly infect the plant.

Bacterial Leaf Blights *Pseudomonas syringae* pv. *syringae*, *Xanthomonas campestris* pv. *phaseoli*, *Pseudomonas syringae* pv. *phaseolicola*

peak activity

April

May

June

July

August

September

October

Bean plants are susceptible to several leaf blight diseases caused by bacteria. Bacterial brown spot is the most common leaf blight of beans in Wisconsin, with halo blight and common blight occurring in some years. Bacterial blights can become epidemic in fields where infested seed is planted and when weather conditions are conducive. Fortunately, planting clean seed generally provides adequate control of bean bacterial diseases.

The brown spot bacterium, *Pseudomonas syringae* pv. *syringae*, has a wide host range that includes most types of beans, cowpea, hairy vetch, *Prunus* spp. (peach, plum, cherry family), pea, lilac, clover, Sudan grass, sweet corn, sweet sorghum, poplar, forsythia, buckwheat, rose, and many other plants. Common blight and halo blight are mainly pathogens of legumes.

All bacterial blights are capable of serious losses and epidemics in fields where diseased seeds are planted. Once introduced on seed, the severity of the disease varies depending on weather conditions. Losses may range from a trace up to 60% in beans. Bacterial brown spot rarely kills the affected plant, but severe infections may defoliate it and lower yields.

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Three different leaf blights caused by bacteria can develop on beans. Most common in Wisconsin is bacterial brown spot (left). The bacteria are seed transmitted, and infected seed produces diseased plants.

Scouting: Examine plants for early symptoms of bacterial leaf blights during routine insect monitoring visits, especially during periods of favorable environmental conditions, such as excessive rainfall, long periods of leaf wetness, and wind or hail damage to the foliage.

Bacterial brown spot first appears on leaves as water-soaked spots that remain very small and become reddish-brown in color. The spots are irregularly circular and are somewhat sunken. As the dead cells dry, the center of the spot turns gray and may crack open or fall away, leaving a "shot hole". On the lower leaf surface, the veins turn red or reddish brown. In the most severe infections, the foliage is killed. More elongated spots than those on the leaves are produced on stems. Stem lesions are sunken and pod lesions are often surrounded by pale brown halos, about one-half inch in diameter.

Lesions of common blight first appear on leaves as small, water-soaked, or light green areas. As the spots develop, the centers become dry and brown and are bordered by a narrow yellow zone. On more susceptible varieties, the spots continue to enlarge until lesions cover much of the leaf surface or combine with other lesions to kill the leaflet. Pod infection appears as water-soaked spots on beans. Water-soaked cankers may form at nodes so that young plants are weakened and often break at the nodes. The entire plant is seldom killed unless the stem is girdled.

The first symptoms of halo blight on seedlings are small, angular, water-soaked spots on the lower leaf surface. As the disease progresses, these lesions enlarge and a halo-like cone of greenish-yellow tissue about one inch in diameter develops outside the water-soaked area. This halo symptom helps to distinguish halo blight from common blight.

Threshold: None, management is preventative.

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Management Strategies

Cultural control

- ▶ Plant certified, disease-free seed grown in blight-free regions.
- ▶ Resistant varieties are under development. Check with your seed supplier. Some varieties are more tolerant than others.
- ▶ Eliminate weeds and volunteer bean hosts.
- ▶ A three-year rotation which excludes beans will reduce inoculum build-up.
- ▶ Good sanitation practices will prevent the spread of bacterial blight into non-infected fields. Do not cultivate or handle plants that are wet with dew or rain. If halo blight is observed in a field, this field should be scouted last in the day.
- ▶ Deep plow debris immediately after harvest.

Biological control

- ▶ A variety of natural enemies help suppress European corn borer infestations, including predatory lady beetles, minute pirate bugs, lacewings, and fly and wasp parasitoids. Bird predation can also be important.
- ▶ The parasitic wasps *Trichogramma* have been effective in some experiments and may be available commercially in the future.
- ▶ Weather conditions greatly influence European corn borer survival, particularly during the egg stage and before young larvae enter the stems and pods. Heavy rains can wash the egg masses and young larvae off the plants. Very hot, dry weather causes desiccation of the eggs and young larvae. These climatic events kill a significant number of young larvae each year.

Chemical control

- ▶ Foliar applications of copper hydroxide, copper ammonium complex, or copper salts of fatty or rosin acids, may slow the spread of light infestations but will not be effective under heavy disease pressure. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.



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Symptoms of common blight—lesions become large, dry, dark brown



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Symptoms of Halo blight—small brown lesions, surrounded by large yellow halo

Pseudomonas syringae pv. *syringae*, the brown spot pathogen, overwinters on weeds such as hairy vetch and other perennials which remain green throughout the winter. In moist weather, diseased plant leaves may be covered with bacterial exudate, which is splashed by rain or irrigation water. The organism enters the plant through natural openings such as the leaf stomata. New lesions appear in 3-5 days under a wide temperature range of 60-90 degrees F. Bacterial diseases are spread from plant to plant by insects, animals, rain, wind, tools, equipment, and clothing to other plants or fields.

The common blight pathogen, *Xanthomonas campestris* pv. *phaseoli*, overwinters in diseased plants and in seed. Infections begin with the contamination of the cotyledons as the seed germinates. The infection then spreads to the leaves. The bacteria may enter the foliage directly through the stomata or wounds or they may be translocated upward in the plant through the xylem from sites of root infection. Common blight develops rapidly under relatively high air temperatures (75-90 degrees F) and high humidity or leaf wetness.

Pseudomonas syringae pv. *phaseolicola*, the causal organism of halo blight, overwinters in diseased plants and in seed. Because the bacterium is so infectious, only one infected seed in several thousand is sufficient to cause a severe infection. The bacterium enters the leaves through the stomata or wounds. Pod infection can occur either directly from splashing water carrying the bacteria or it may travel in the plant's vascular system from other plant parts. Halo blight develops rapidly when the weather is cool (60-68 degrees F) and humid.



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Symptoms of bacterial brown spot—brown lesions of varying size with no halos

White Mold *Sclerotinia sclerotiorum*

April

May

June

July

August

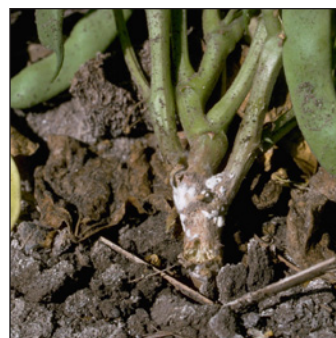
September

October

White mold is one of the most serious diseases of snap bean. The pathogen *Sclerotinia sclerotiorum*, is a widely distributed fungus that is capable of surviving for many years in the soil. It has a wide host range that includes all types of beans as well as most vegetables and many ornamentals. Fortunately, white mold is not a problem every year, only in years of abundant rainfall, especially during flowering, and dense canopy cover. Corn, small grains and grasses have not been reported as susceptible to the fungus and are useful rotation crops for white mold management. A computer program that aids in assessing the risk from white mold is available. Contact Dr. Amanda Gevens at the Department of Plant Pathology, UW Madison.

White mold is capable of severe damage to snap bean fields, especially in fields with a history of white mold. In severely-infested fields, infection can progress to the point of girdling the main stem or branches, causing the plant or plant parts to wilt and die. The fungus can also cause post-harvest losses.

Sclerotinia sclerotiorum overwinters as hard, black structures called sclerotia in the soil. In late spring and early summer, sclerotia in the top two inches of soil produce mushroom-like structures called apothecia, in which ascospores are produced. Ascospores are the source of nearly all the infections seen in beans. They are discharged into the air and can travel on wind currents as far as one-half mile. The bean blossoms are usually the plant part first infected by the fungus. Infection of healthy pods, leaves, and stems, is usually from an infected flower that has fallen onto or come in contact with other plant tissues. Shortly after infection, white, fluffy cottony growth on blossoms, stems and pods appears. As the fungus grows, these mounds of white mycelium harden and darken to form sclerotia, thus completing the life cycle.



White, cottony fungal growth on affected plants is diagnostic for white mold.

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Scouting: There are no recommended scouting procedures for monitoring white mold in beans other than to scout areas where plants are likely to remain wet for long periods, poorly-drained areas, or where there is a history of white mold. It's important to know whether the white mold pathogen is present in a field so that adjustments can be made to rotation sequence and planting of subsequent crops.

The first symptoms of white mold typically occur about one week after bloom. If sufficient moisture is present, the fungus will spread from infected, aging flowers to stems, leaves, and pods. Irregularly shaped water-soaked spots on these plant parts enlarge, and a soft watery decay soon follows. Leaves on affected plants begin to turn yellow or brown and fall off. White, cottony fungal growth called mycelium may be present on affected parts if weather conditions remain warm and wet. This growth is diagnostic for white mold. Later, sclerotia begin to develop within the mycelium, which is another diagnostic sign of white mold.

White mold development is heavily dependent on weather conditions at the time of flowering. Cool temperatures (less than 85 degrees F.), normal or above normal rainfall, field capacity or above soil moisture, prolonged morning fog, and leaf wetness, including high canopy humidity at and following flowering into early pod development, are very conducive for the development of white mold.

Threshold: None, management is preventative.

Management Strategies

Cultural control

- ▶ White mold is managed by choosing cropping practices that prevent or slow the introduction of the white mold pathogen into a field and that steadily work towards reducing the population of the fungus in the soil.
- ▶ Varieties differ in resistance or tolerance to white mold, although there are not yet resistant varieties that will hold up to heavy disease pressure. Varieties with a shorter flowering period and an upright-bush habit are less likely to be severely affected.

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- ▶ Promote an open canopy by planting rows parallel to prevailing winds and using a wide row spacing. Choose fields with good internal soil drainage, and avoid cultural practices which promote excessive canopy growth. In areas prone to disease or with a field history, do not irrigate before and during the bloom period.
- ▶ Soil populations of the white mold pathogen will gradually increase if other host crops are grown. Highly susceptible crops are soybean, dry beans, snap bean, lima bean, sunflowers, canola, carrots, and cabbage. If there is a field history of white mold, beans should not be preceded by a bean, tomato, potato, lettuce, or crucifer crop. Pea, potato, alfalfa, and red clover are hosts but are much less susceptible. Examples of non-host crops are corn, small grains, and all forage grasses. Sclerotia will germinate in soil under these non-hosts and thus the inoculum potential of the soil is decreased.
- ▶ Control broadleaf weeds. Some herbicides used in rotation systems may be suppressive to white mold
- ▶ A timely harvest with rapid cooling and pod storage at 45-50 degrees F will provide an effective postharvest control.

Biological control

- ▶ The microbe *Coniothyrium minitans*, a native organism in many soils, parasitizes sclerotia of *Sclerotinia sclerotiorum*. It is also available commercially. *C. minitans* requires 2-3 months with soil temperatures between 40-77 degrees F to be effective at parasitizing sclerotia. Apply post-harvest to fields with white mold before incorporating crop debris. It is known to survive for several years after initial application. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for more information.

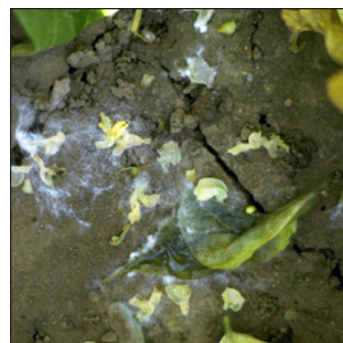
Chemical control

- ▶ Fungicides are available that can be effective. Fungicide sprays are needed only when the soil has been wet for 6-10 days before bloom. Timing and good coverage are essential. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.



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White mold is a serious fungal disease of snap bean and other vegetables. It is mainly a problem in years of abundant rainfall and extensive canopy cover at flowering, especially in fields with a history of white mold.



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White, cottony, mycelial growth of the white mold pathogen on the surface of wet soil, beneath snap bean plant canopy.

Bean Yellow Mosaic Virus

peak activity

April

May

June

July

August

September

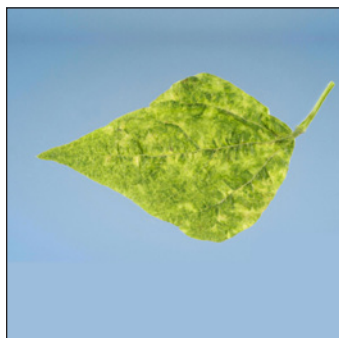
October

Bean yellow mosaic is a common and widespread disease of bean. It is transmitted by aphids from plant to plant and can cause considerable losses. Bean yellow mosaic virus is in the same virus family as bean common mosaic virus, another common and widespread virus of bean.

Bean yellow mosaic has a wide host range in legumes and can readily overwinter in perennial legume crops and weeds such as alfalfa, clovers, and vetch. Aphids can efficiently spread the virus within a field, resulting in high rates of infection. Disease usually spreads inward from field edges as aphids migrate. Many legumes are hosts for BYMV, including snap bean, broad bean, lima bean, chickpea, sweet pea, green pea, white sweet clover, soybean, crimson clover, red clover, white clover, vetch, alfalfa, gladiolus, poppy, tobacco, white lupine, lambsquarters, and Canada thistle.

Plants infected at a young age are stunted and produce few or no pods. Maturity is delayed. Damage will vary depending on the variety grown, the growth stage at the time of infection, and environmental factors and can be severe on susceptible varieties. Virus expression is lower when the crop has adequate water. Irrigating in dry years may help mitigate the impact of virus infection.

The virus is transmitted by several species of aphids, including the pea, green peach, potato, and black bean aphid. Beans become infected when virus-carrying aphids move into bean fields. Transmission of the virus occurs within seconds once aphids begin feeding on the crop. The virus overwinters in perennial leguminous weeds and is transmitted to bean in the spring when the aphids become active. Bean yellow mosaic virus is not known to be seed-transmitted in beans, while bean common mosaic virus is commonly transmitted in seed.



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Bean yellow mosaic virus (left) has striking yellow symptoms compared to bean common mosaic virus (right), which has light and dark green symptoms.

Scouting: The diagnostic symptom of bean yellow mosaic is the bright yellow mottled appearance of infected leaves, which is most apparent on older leaves. The striking yellow mosaic symptoms differentiate bean yellow mosaic infections from those of bean common mosaic, which causes light and dark green mosaic patterns in leaves. Plants infected with yellow mosaic virus may also have varying degrees of leaf distortion, curling, and wrinkling. Leaflets of infected plants are more brittle than normal.

Insecticides generally provide little protection against virus spread during the season, but some limited control may be achieved if sprays are applied early in the season or to nearby fields of aphid-infested forage legumes. If insecticides are considered, monitor aphid populations beginning early in the season, as well as aphid populations in nearby fields of small grains and alfalfa.

Threshold: Manage aphid pests.

Management Strategies

Cultural control

- ▶ Locate bean fields as far away from perennial legumes (alfalfa, clover, vetch) and gladiola fields as possible.
- ▶ Planting resistant varieties is the best way to control virus diseases. Most commercial varieties have resistance genes to bean common mosaic virus. Fewer varieties resistant to bean yellow mosaic virus are available. Check with your seed supplier.
- ▶ Note that bean common mosaic disease can be spread through seed. Planting either certified seed or a resistant variety is essential. Bean yellow common virus is not known to be seed-transmitted.
- ▶ Rogueing out the first infected plants as soon as they are observed will help slow the spread of the virus, but if the number of infections increases rapidly, this may become impractical.

Chemical control

- ▶ These viruses are spread by aphids in a nonpersistent manner and insecticide sprays to reduce the rate of spread of the virus by aphids are generally not effective. Some limited control may be achieved if applied to nearby fields of forage legumes or to bean fields early in the season. Refer to A3422 *Commercial Vegetable Production in Wisconsin* for currently labeled products.