What a Certified Crop Advisor Should Know About Green Beans

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Green beans, also called snap beans, are grown on about 5000 acres and 400 farms in Indiana (Table 1). Over 90% of the acreage, but less than 12% of the farms, produces beans for processing. Total Indiana production averaged 16,000 tons in 2005–2008. The value of the processing crop averaged $3.1 million during that period. In 2008, Indiana ranked 8th among the states for production of the nation's processed green beans, with 1.7% of the total. Wisconsin is the lead producer. Other northern states including New York, Michigan, Illinois, Pennsylvania, Minnesota, and Oregon in the West, also contribute significant quantities. Green beans for fresh market are produced on 348 farms with a total of 391 acres in Indiana, according to the 2007 Ag Census.

Green beans are members of the legume family. Classified as *Phaseolus vulgaris*, they are the same species as edible dry beans such as kidney beans, navy beans, and pinto beans, and are closely related to lima beans, *Phaseolus lunatus*. Varieties adapted for machine harvest have a determinate bush growth habit and pods that can withstand machine harvest. Varieties grown for hand harvest vary from determinate bush to indeterminate climbing types.

Green bean seeds are large with two fleshy cotyledons. Emergence is epigeal. The first true leaf is unifoliate; subsequent leaves are trifoliate. Under typical growing conditions, a new mainstem leaf and node is produced every 3 days. Common terms to describe growth stages include seedling, vegetative (described by number of trifoliate leaves), bud (approximately 30 days after emergence), flowering, 10% bloom (approximately 2 days after first flower and before blossoms have fallen), and pin beans (about 18 days before harvest). About 14 days before harvest beans are easily seen.

Good soils for beans are well-drained with a pH between 6.0 and 6.8. It is best to avoid fields where legumes were planted in the previous four years. Sandy soils with irrigation produce the highest yields because beans don't like wet feet and they need generous rainfall from pod-set until harvesting. Soil preparation is typically done with a chisel or moldboard plow. Because machine-harvested crops are cut extremely close to the soil surface, a clean seedbed is needed. As little trash as possible on the surface is preferred.

Although green beans are legumes, determinate bush varieties do not typically fix enough nitrogen for good yields and so nitrogen is included in fertilizer applications. Fertilizer recommendations are based on cation exchange capacity, soil tests, field history, and expected yield. A general recommendation would be 40 lb. N, 10 lb. P_2O_5, and 44 lb. K_2O per acre. All of the potash may be broadcast and incorporated before planting. At planting, band fertilizer 2 inches to the side and 2 inches below the seed. In the band, apply 30 lb. N, all of the phosphorus, and up to 40 lb. of the required K_2O per

acre. If nitrogen and phosphorus are not banded, they may be broadcast and incorporated before planting. Manganese (Mn) deficiency may occur and is more likely if soil pH is over 6.5. On high pH soils, manganese may be included in the band at planting at a rate of 2 lb. Mn per acre, or a foliar application of 1 to 2 lb. Mn per acre may be applied when beans are about 6 inches tall. Beans are particularly sensitive to boron and may show injury symptoms if soil levels are high.

An example of a fertilizer program used in northern Indiana is: Apply 5 gallons of 28% nitrogen solution (UAN) and 5 gallons of 10-34-0 per acre as a starter fertilizer. This provides the 10 lb. N and 10-15 lb. P_2O_5 per acre needed to get beans off to a good start. On sandy soils, make a preplant application of 100 lb. potassium chloride (0-0-60) and 100 lb. ammonium sulfate (21-0-0) per acre. About 20 to 23 days after emergence, sidedress calcium nitrate (13-0-0-9Ca) at 100 to 150 lbs. per acre.

Planting is scheduled based on desired harvest date. From planting to harvest generally requires 50 to 60 days, or 1,050 to 1150 growing degree days (base 50°F). The earliest spring planting date is limited by soil temperature and frost free date. The soil temperature should be at least 55–60°F. Warmer soil is better, up to the optimum of 75–85°F. Planting depth is 1 to 1.25 inches. It is very important not to plant too deep or the large cotyledon will not be able to pull up through the soil. Beans should emerge in 6–12 days, depending on soil temperature. Summer plantings must be made early enough that beans will mature before the first fall frost.

For machine harvest, beans are usually planted in rows 18 to 36 inches apart, at a population of 90,000 – 115,000 plants per acre. A common practice in Indiana is to plant 120,000 seeds per acre in 30-inch rows at 17 to 21 seeds per three feet, aiming for a final stand of 100,000 to 105,000 plants per acre.

A variety of issues prevent good stand establishment in snap beans. Crusted soils can reduce emergence. Salt injury can be a problem if fertilizer is improperly applied or applied in excess. Damping off organisms kill seedlings and are a bigger problem when cool conditions prevent quick germination.

Determinate bush green bean cultivars grown for processing are typically day neutral with respect to flowering. Under good growing conditions, the warmer it is, the shorter the time to bloom. The first flower buds form on a raceme in the axil of the topmost leaf on the mainstem. Later flower buds will develop farther down the mainstem and on branches. Flowers are self-pollinating. Usually only the first flowers produce marketable pods, creating a concentrated set suitable for once-over harvest. Later-formed structures may fall off at the bud, flower, or young pod stage. From flowering to harvest takes about 20–25 days.

Unfavorable environmental conditions can interfere with flower development and pod set. High temperatures (above 85°F) at flowering can cause flower buds, flowers, and young pods to fall off, and can lead to poor seed development in pods. Low temperatures (below 55°F) can reduce seed set. Stress from drought, waterlogged soils, or other factors can also cause abscission of reproductive structures. If the first flowers do not set, or have only a partial set, later clusters are likely to produce more pods than usual, creating a plant with pods of varying ages that are not adaptable to once-over machine harvest.

Green beans use about the same amount of water on a weekly basis as other vegetables, but due to their relatively shallow root systems and short growing period, they have a relatively high risk for yield loss if dry spells occur. Once canopy closure has

occurred, green beans require roughly 1 to 1.5 inches of water a week. Adequate moisture is especially critical during flower development and pod set; if these structures abort due to stress, yield is affected directly. Green beans have a rooting depth of about 2 feet, but practices that promote deep rooting can help reduce the risk of drought stress. Irrigation is a valuable tool. Irrigation scheduling software and other resources are available that will help producers optimize water use and crop yields.

Weeds must be managed to prevent yield loss from competition and to prevent contamination of mechanically harvested crops with material that can not be sorted out. It is advisable to select a field with a history of good weed control and where few weeds produced seed the previous year. High plant populations improve crop competitiveness with weeds. Inter-row cultivation, where practical, can help to control small weeds early in the season. Herbicides registered for use in green beans differ from state to state. Be sure to obtain the appropriate label for your state before using any herbicide (or other pesticide). Before seeding, emerged weeds may be killed with glyphosate, paraquat (Gramoxone®), or, for broadleaves only, carfentrazone (Aim®). If emerged weeds are present after seeding, paraquat or carfentrazone may be used before the crop emerges. Many grasses and broadleaves are managed using preemergent herbicides. These include clomazone (Command 3ME®), s-metolachlor (Dual (II) Magnum®), ETPC (Eptam®), trifluralin, and pendimethalin. Halosulfuron (Sandea®) may be used preemergence or postemergence (directed spray recommended) to control broadleaves. Emerged broadleaves may also be controlled with bentazon (Basagran®) or fomesafen (Reflex®). Imazamox (Raptor®) is also available to control emerged broadleaves as well as grasses. Emerged grasses may be controlled with quizalofop (Assure II®, Targa®), or sethoxydim (Poast®).

There is a narrow margin of safety for the broadleaf herbicides. Beans can be injured if proper method, timing, and rate of application are not followed.

Three common herbicide programs in Indiana are:

1. Treflan®, Dual Magnum® and Eptam® preplant incorporated
2. Prowl® and Command 3ME® preplant incorporated
3. Dual Magnum® preemergence followed by Reflex®, Basagran® and crop oil postemergence.

Insect pests can be a problem throughout the growth cycle of green beans. Cost effective management requires monitoring the pest population level and timing treatment so that it is most effective. Seedcorn maggots attack seeds and young plants, preventing germination or causing severe injury to the seedling. They are more likely to cause damage in early plantings when weather is cool and wet, and in fields with high levels of fresh organic matter. If experience and conditions indicate that damage is likely for a particular planting, systemic neonicotinoid insecticides applied as a seed treatment can be helpful.

Potato leafhoppers blow in from warmer areas where they overwinter, and can be expected every year. They feed on leaves, causing reduction in yield and plant vigor. Crops should be monitored from emergence to the bud stage and treatment applied when thresholds are exceeded (2 leafhoppers per foot of row in the seedling stage or 5 leafhoppers per foot of row after the 3rd trifoliate forms). If a systemic neonicotinoid seed treatment is used, it should provide good control of leafhoppers until the crop starts to produce pods.

European corn borers (ECBs) feed on pods and contaminate harvested beans. They are a concern every year. Management involves monitoring ECB moth activity and treating when activity exceeds the threshold (more than 10 moths per night in a blacklight trap for 3 consecutive nights) IF beans are at or past the bud stage and harvest is more than 12 days away. Insecticides applied to control corn borers will also control potato leafhoppers. Corn earworm is also an annual problem south of I-80 and a periodic problem in late season crops north of I-80. Larvae feed on leaves and pods. Management involves monitoring adult moth flights and treating when thresholds are exceeded (more than 10 moths per night in a pheromone trap) IF beans are at or past the bud stage and harvest is more than 7 days away.

Bean leaf beetle is an annual problem south of I-80 and an occasional problem north of I-80. It can cause yield loss and/or pod damage depending on when it feeds on the bean. Management involves monitoring for beetles and damage and treating when thresholds are exceeded (1 BLB/foot of row). Systemic seed treatments provide control of first generation beetles and may make sense if bean leaf beetles have been a problem in the past.

Soybean aphids are a periodic problem in green beans. Although they do not reproduce on green beans, high populations can migrate from soybeans into green beans and cause reduced crop vigor and yield loss. They can also transmit viruses to green beans, which is a more serious problem. Systemic seed treatments are effective for controlling loss of crop vigor and yield, but do not prevent virus transmission. Stay abreast of aphid population activity in soybeans to predict whether they are likely to disperse to green beans.

Diseases of importance in green beans include damping off, root, and stem rot, bacterial foliar diseases, white and gray mold, and viruses. Damping off, root, and stem rot are caused by a complex of soilborne fungi including *Rhizoctonia solani*, *Fusarium oxysporum* f. sp. *phaseoli*, *Pythium* spp. and *Thielaviopsis basicola*. Problems are worse when cool, wet weather at planting time is followed by hot dry conditions. The diseases may cause reduced stands, stunted plants, chlorosis, and wilting. Fall tillage and crop rotations of at least 4 years between legume crops is recommended. In instances where snap beans are double cropped and the first crop is affected by root/foot rot complex, deep tillage between crops may help reduce severity of the disease in the second crop. Avoid growing beans in fields with a history of the disease. Poor drainage and soil compaction may exacerbate the disease problem. Seed treatments may help to reduce damping-off. Soil drenches may be labeled for some pathogen/host combinations.

White mold caused by *Sclerotinia sclerotium* may form lesions on pods, leaves, branches, and stems. Under moist conditions, a white fungus can be observed on affected parts. Death of portions of plants or entire plants may result. Hard, black irregularly shaped fungal structures (sclerotia) may form on the outside or inside of plants. Sclerotia function as survival structures in the soil for 5 years or more. A mushroom smaller than a penny may arise from the sclerotia. Spores produced from mushrooms infect senescent flowers. Therefore, bean plants become infected only after flowering has started. *S. sclerotinia* causes disease on over 360 species of plants. Some cultivars are known to have partial resistance to white mold. Systemic fungicide applications during flowering may help to reduce severity of white mold. Crop rotations to non-hosts including cereals and corn may help to reduce initial inoculum. Gray mold caused by *Botryotinia*

fuckeliana is similar to white mold, typically infecting dead flowers first and then moving to pods and other parts of the plant. Treatments for white mold should also control gray mold.

Bacterial diseases of green beans include brown spot, caused by *Pseudomonas syringae* pv. *syringae*, common blight, caused by (*Xanthamonas campestris* pv. *phaseoli*, and halo blight, caused by *Pseudomonas phaseolicola*. These diseases cause lesions on leaves and pods. If disease is severe, defoliation may reduce yields. In less severe cases, pod quality may be reduced by distortion and spots. Excessive rain and injury from hail or wind promote disease spread. Management includes rotation out of beans for 2 to 3 years, selecting resistant varieties, controlling weed hosts (especially hairy vetch), and using clean seed. During the season, monitor the crop for disease and treat if warranted. Bacteriacides available for use during the season (copper hydroxide products) provide poor to fair control.

Additional fungal diseases that cause problems in some years include rust (*Uromyces appendiculatus*) and anthracnose (*Colletotrichum lindemuthianum*).

A number of viruses infect snap beans. Most are spread by aphids in a non-persistent manner—just one feeding probe by an aphid can spread the virus. Some viruses are also seedborne in beans or weeds. Viruses may overwinter in weeds or other crops (e.g., alfalfa) which can then serve as a source of inoculum the following year. Symptoms include mosaic, leaf cupping, blistering, mottling, malformed pods and leaves, and stunting. Yield and crop quality may be reduced. Management measures include using disease-free seed, selecting resistant varieties if available, controlling weed hosts, and choosing fields away from crops which may serve as a source of inoculum.

Green beans for processing are harvested by machine in a once-over destructive harvest. Harvest is scheduled when pods reach the desired diameter, or sieve size, usually when 50% of the beans are sieve size 4 (21/64 to 24/64 inch). There is a harvest window of about 36 hours to provide the most yield and highest quality beans. Fresh market beans may be machine-harvested or hand-harvested. If hand-harvested, multiple harvests are possible. Fresh market beans are harvested while the pod is bright green and fleshy and the seeds are small and green.

Fresh market beans should be cooled to remove field heat. Suitable cooling methods include room cooling, hydrocooling, and forced-air cooling. Beans should be stored at 41-45°F and 95% relative humidity. If stored below 41°F chilling injury may occur. Symptoms of chilling injury include opaque discoloration of the entire bean and pitting on the surface. Even at 41°–45°F chilling injury may show up if beans are stored for 8 days or more. At this temperature, chilling injury looks like rusty brown spots.

Green bean quality attributes include pod and seed color, length and diameter, fiber content, and shape. All of these are influenced by genetics. Pod color may vary from light to dark green, or yellow in the case of “wax” beans. Seed color may be white or brown. Brown seeds often are more tolerant of cold soil, but white seeds are preferred in processed product. Fresh market snap bean length is 5 to 7 inches with most being 5 to 6.5 inches. Diameter in fresh market sales is not related to any grade standard. There are grade standards for processing beans related to sieve size (diameter). Sieve sizes range from 14.5- to 18.5-64ths of an inch (sieve 1) to 27- to 30-64ths of an inch (sieve 6). Snap beans increase in fiber as they mature. Fresh-market snap beans generally have higher fiber content than processing varieties. Higher fiber content results in less breakage

during harvest and handling. Fiber development parallels seed development in those varieties having fiber. When seed development is noticeable in the pod by the swelling each seed causes in the pod, the beans are near the limit of suitability for marketing. Curved pods and pods with missing seeds are the most common defects in shape. The percentage of curved pods increases in plants with pods set low in the plants or plants that lodge allowing pods to touch the soil. Pods are more likely to have missing seeds if the plant is under stress at the time of pod set.

Most growers contract processing green bean production with a broker who then has contracts with a cannery. Central Produce, Twin City Foods, Pictsweet, and Razorback are examples of brokers working in Indiana; there may be others. Brokers usually provide the seed, the harvester, and the scouting. Growers provide the land, equipment, herbicides, and irrigation, if needed. The broker pays the grower $150 to $200 per ton, minus the cost of seed and harvest, which is usually about $200 per acre. Yields in Indiana may range from 3 to 7 tons per acre.

Fresh vegetable buyers are increasingly asking producers to provide proof that Good Agricultural Practices and Good Handling Practices have been followed during crop production and packing. These practices involve managing the environment, personnel, and inputs to minimize the risk of microbial hazards in food. Excellent resources are available online from the National GAPS program at www.gaps.cornell.edu.

Additional information about green bean production is available from resources listed in Table 2.

Table 1. Green beans for processing and fresh market in Indiana: farms, acreage, yield, value, and rank.

Use	Year	Farms	Harvested Acres	Production	Value	U.S. Rank
				tons	*$ million*	
Processing	2008	no data	4,500	13,980	2.96	8
"	2007	44	5,000	15,770	3.16	6
"	2006	no data	5,300	16,860	3.25	7
"	2005	no data	5,500	17,200	3.14	7
Fresh Market	2007	348	391	no data	no data	no data

Sources: USDA, NASS, Indiana Field Office. 2009. Indiana Agricultural Statistics, 2008–2009. Retrieved 10/19/09 from www.nass.usda.gov/Statistics_by_State/Indiana/Publications/Annual_Statistical_Bulletin/0809/09index.asp

USDA, NASS. 2009. Vegetables 2008 Summary.

USDA, NASS. 2007 Census of Agriculture. Retrieved 10/20/09 from http://151.121.3.59/results/AD670247-93A2-3CAC-9A81-657FFA4883DB.

Table 2. Useful references for green bean production in Indiana.

Current Pest Management Recommendations
Midwest Vegetable Production Guide for Commercial Growers 2009. Purdue Extension Bulletin ID-56. Purdue University Cooperative Extension, W. Lafayette, Indiana. Available online at www.btny.purdue.edu/Pubs/ID/ID-56, or from Purdue Education Store at 1-888-EXT-INFO or www.extension.purdue.edu/store/.
Insect Biology and Management
Vegetable Insect Management. Edited by R. Foster and B.R. Flood. Meister Media Worldwide, Willoughby, Ohio. ISBN 1-892829-15-0.
Disease Biology and Management
Compendium of Bean Diseases, Second Edition. Edited by Howard F. Schwartz, James R. Steadman, Robert Hall, and Robert L. Forster. APS Press, St. Paul, Minn. ISBN: 0-89054-328-3. Available from APS at 1-800-328-7560 or http://shopapspress.stores.yahoo.net/coofbedi2nde.html.

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Zitter, T.A., 1984. *Virus Diseases of Snap and Dry Beans*. Fact Sheet Page 729.30. Cornell University Cooperative Extension. Retrieved from http://vegetablemdonline.ppath.cornell.edu/factsheets/Virus_Beans.htm.