Pest Management Strategic Plan

for

Succulent Edible Legumes

in the

North Central Region

Apr 2003
(Updated Sep 2003)

Table of Contents

Strategic Plan Development: An Overview

The purpose of a Pest Management Strategic Plan is to provide a document that communicates the role of pesticides and pest management strategies used to control crop pests from an industry perspective, with cooperation and verification from pest management specialists at Land Grant institutions. While this information is primarily used by the Environmental Protection Agency (EPA), it also provides to the USDA, Land Grant Universities, and pest management stakeholders a prioritized "to do" list of research, education, and regulatory issues. Strategic Plans may also be helpful to the industry as a means of evaluating progress on those issues.

This document has been prepared to convey to the reader the pest management challenges confronting Midwestern snap bean, pea, and lima bean producers. Though it is not all-inclusive, it is meant to be generally representative of pest management for these crops in the North Central Region.

This initial version of the Pest Management Strategic Plan is based on information assimilated from previously completed profiles from Minnesota, Wisconsin, and Delaware. The document was further developed from input gathered from producers, consultants, and other technical experts attending a workshop in Madison, Wisconsin on the 10th and 11th of March, 2003. In addition to providing input on pests and pest control methodologies, attendees identified research, education and regulatory issues that impact producer profitability and environmental quality. The final task of the attendees was to prioritize the issues that they thought were the most critical to pest management.

Data completeness and accuracy:

The intent of this report is to provide the EPA with the pest management perspectives of producers, consultants, and other pest management specialists. As such, it primarily reflects the comments and inputs of those parties who attended the workshops. As with any group of individuals, the scope of knowledge as well as opinions of participants vary greatly, and in its current form this document captures that scope and diversity.

Another factor which affected the completeness of information was the method used to collect information during the meetings. Time constraints typically dictated that only those pests which are consistently a problem be addressed during the meeting. Although the document was widely circulated for review to correct the lack of attention given to less common pests, there yet remains some uneven completeness of data. The editors and reviewers have taken significant measures to excise faulty or misleading information, but it has not been our intent to remove or alter information which was provided at the workshops that does not harmonize with "conventional wisdom". This Strategic Plan should be viewed as a work in progress; future versions will undoubtably result in an improved product.

Executive summary:

The North Central Region produces about one half of the snap bean, pea, and lima bean production of the United States. Most of this production resides within an area from Michigan through northern Illinois, and southern Wisconsin and Minnesota. Although some legumes are consumed as part of the fresh market crop the vast majority is processed as canned or frozen produce. The total value of these crops to the region is about $300 million per year. This Pest Management Strategic Plan offers a glimpse into the opportunities and challenges producers face in trying to maintain a profitable and secure industry.

The original draft of this Pest Management Strategic Plan was developed from crop profiles from the states of Wisconsin, Minnesota, and Delaware and from input provided by land grant pest specialists. The draft was then presented to industry representatives at a workshop held in Madison, Wisconsin on the 10th and 11th of March, 2003. Within the context of this workshop participants discussed their greatest pest management challenges and outlined their priorities for research, education, and regulatory action. The process of developing the Strategic Plan was facilitated by Dr. David Pike, the Illinois project leader for the North Central Pest Management Center (PMC). Supporting Dr Pike in this effort was Lynnae Jess (PMC assistant-director) and Karen Delahaut, the Wisconsin PMC project leader.

During the meeting participants identified a number of issues as priorities for research, education, and regulatory action. The following items were among the top priorities identified, although they are presented in no particular order.

- Research is needed to address virus-aphid etiology, epidemiology and management models in snap beans. Viral diseases can be devastating and producers feel vulnerable to the possibility of major losses.
- Research is needed to evaluate soil borne diseases on edible legumes. This would include a quantitative assay and a threshold model of disease development.
- More research is needed to establish a systems approach to weed management in legumes, including herbicides and non-chemical approaches. A systems approach should include factors such as nightshade control, crop injury, herbicide carryover, tillage/no-till problems with harvesting and weed biology and ecology.
- The impact of Farm Programs on legume enterprises should be evaluated. Many growers feel that there is a loss of production options for pest management and minor crop production which results from growing non-base commodities.
- Plant breeders need to maintain efforts to identify available germplasm for resistance to diseases (e.g. white mold, root rot pathogens, viruses) and insects (e.g. leaf hoppers, ear worm, corn borer, aphids) for edible legumes. Producers realize that varietal improvement is an ongoing and important need.
- Agricultural engineers are encouraged to investigate technologies to remove contaminants either at harvesting or processing plant stage. Although some progress has been made in this area, producers felt that further improvements in these technologies may alleviate the need for some insecticide sprays used to lower insect contaminant levels.
- Educational tools should be developed to help growers improve resistance management of all edible legume pests. A part of this effort might include improving label clarity.
- An important part of pest management is being able to predict the development, dispersal, and distribution of weeds, insects and diseases of edible legumes. Participants suggested that a regional pest mapping system for all major pests might significantly improve their ability to control seasonal pests.
- There are several products which are as yet unregistered for edible legumes that would benefit growers. Of these, BASF 510 (to replace Benomyl and Ronilan) and Switch (for white mold) would be especially useful. Cruiser, an insecticide, should also be considered for fast track registration in group 6 crops as a replacement for threatened OPs. Registration of Reflex for puncture vine (and tankmixing with Basagran) would also be a great asset.
- There is also a continuing need for new non-pyrethroid materials for enhanced insect resistance management.

Participants:

Dave Pike	PMC Project leader 217 352 6405	airs-inc@insightbb.com
Walt Stevenson	Univ of Wisc, Plant Path	wrs@plantpath.wisc.edu
Karen Delahaut	Univ of Wisc, Entom.	kadelaha@facstaff.wisc.edu
Lynnae Jess	Mich State Univ, PMC	jess@msue.msu.edu
Tom Rabaey	General Mills Ag Res	tom.rabaey@genmills.com
Brian Flood	DelMonte Foods	brian.r.flood@delmonte.com
Wayne Wells	Chiquita Processed Foods	wwells@chiquita.com
Craig Grau	Univ of Wisc, Plant Path	cg6@plantpath.wisc.edu
Dennis Dixon	Hartung Bro.	DennisD@hartungbrothers.com
Kevin Johnson	Greenline Produce Company	johnson.1442@osu.edu
Larry Binning	Univ Of Wisc, Weed Sci	lbinning@facstaff.wisc.edu
Barbara Vantil	Reg 5 EPA	vantil.barbara@epa.gov
Satoru Miyasaki	Mich State Univ, IR-4	ncrir4@pilot.msu.edu
Jeff Wyman	Univ of Wisc, Entom.	wyman@entomology.wisc.edu
Chris Falak	Gerber Products	chris.falak@ch.novartis.com
Allan Brooks	Grower	aljan@dotnet.com

General Production Information

The United States produces more than 1 million tons of succulent edible legumes annually with a production value of 600 million dollars. Approximately one half of all processed peas, snap beans, and lima beans are produced in the North Central Region. The production area for this region is primarily in Minnesota, Wisconsin, and Illinois. Fresh market snap beans and lima beans are also produced in the Midwest but on a lesser scale. Fresh market production may extend into Iowa, Ohio, Michigan and Indiana. (See table 1 for tabular data and Appendix G for production maps).

Table 1. Production data for succulent edible legumes, 2002.

Lima beans (Fresh market)	Acres	Cwt	Value
US total	7,200	202,000	$5,861,000
Snap beans (Fresh Market)	Acres	Cwt	Value
US total	94,200	5,958,000	$273,173,000
MI	4,400	194,000	
OH	2,000		
Lima beans (processed)	Acres	Tons	Value
US total	51,100	66,900	$30,710,000
Snap beans (processed)	Acres	Tons	Value
US total	225,100	831,260	$112,692,000
IL	22,400	62,300	
IN	6,200	17,860	
MI	9,000	32,000	
MN	16,700	60,030	
WI	73,100	317,070	
Green peas (processed)	Acres	Tons	Value
US total	228,500	386,770	$192,376,000
MN	80,500	98,370	
WI	42,100	67,230	

Cultural Practices

Peas

Peas are a cool season, annual crop planted in rotation with other processing crops such as potatoes, sweet corn, field corn, soybeans, and snap beans. Peas are members of the legume family and as such, they provide a good source of protein and can utilize atmospheric nitrogen for growth and development.

Plant growth habit may be either determinate or indeterminate, the latter producing a vining plant that flowers indefinitely and is often used in fresh market production. Most processing pea varieties however have a determinate growth habit to assure a uniform crop that is ready for a once-over, destructive harvest.

Peas require a well-drained, sandy to loamy soil that warms quickly in the spring to facilitate early planting. Crop rotation is necessary to prevent the build-up of root rot pathogens that can cause serious yield loss problems. Ideally, fields should be planted out of peas or other legumes for 7 years. Fields should have uniform fertility and have an adequate amount of organic matter to hold soil moisture and prevent drought. Phosphorus levels should be at least 50 ppm while potassium should be between 120-180 ppm with levels around 160 ppm being optimum. Although peas require adequate moisture, too much or too little reduces yield. An excess of soil moisture starves the root zone of oxygen so that normal root respiration cannot occur and nitrogen-fixing bacteria cannot function efficiently and root rot organisms become more destructive.

From mid to late season, peas do not compete well with weeds although some post emergence herbicide options exist. The best time to control weeds is before planting. Canada thistle is particularly troublesome because its flower buds are hard to remove from shelled peas and greatly reduce the pea grade. Eastern black and hairy nightshades also produces berries that can contaminate shelled peas, particularly in crops harvested after July 4, making nightshade another serious weed. Mustard pods can also present an increased contamination risk. Fields should be chosen based on the absence of major weed problems.

Peas typically follow corn in a rotation. They are sometimes planted in a double crop system whereby snap beans, soybeans, or winter wheat are planted mid-season, after the peas have been harvested.

Seedbeds are tilled to a depth of 4-5 inches early in the season. It is important not to overwork the soil or crusting will result, causing germination problems. Pea/soybean drills are used to plant peas and the seeding rate depends on the cultivar and is usually determined by the processor. Early and light-vined varieties such as Alsweet should have at least 672,000 plants per acre (9 plants per foot in 7 inch rows). Later peas, including Perfection or Freezer varieties, need a minimum population of 450,000 plants per acre (6 plants per foot in 7 inch rows). Full stands of vigorous plants provide the needed competition against weeds. Most seed for commercial planting is treated with a fungicide to protect the seed and seedling from root rotting fungi. Nitrogen-fixing bacteria may be put in the planter box along with the seed to provide inoculum, particularly if peas haven't been planted in a particular field for more than 5 years.

Peas are harvested approximately 3 weeks after full bloom. The optimum harvest time is when the pods are filled and the peas are still soft and immature. Degree day accumulation is used to determine when peas are ready to harvest. Pea cultivars mature once 1100- 1600 degree days using a base temperature of 40F have accumulated. A tenderometer is used to determine when the pea quality is optimum. All processing peas are harvested mechanically with a self-propelled combine that separate the peas from the vines.

Snap beans

Snap beans are planted from May through August. Commercial growers will stagger planting dates to allow adequate time to harvest the crop over several weeks late in the summer. Seeds are typically planted l - 2 inches deep and plants are seeded at 8-12 plants/foot. Rows are typically spaced 18- 36 inches apart. The recommended density for planting is 50- 70 pounds of seed/acre or approximately 90- 115,000 plants/acre. Seeds will germinate 6-12 days after planting with temperatures of 65- 85 degrees F. Beans mature in 50- 60 days and can be harvested 20- 25 days after plants flower. Pods will be bright green and fleshy and contain small, white seeds. Later harvests result in high fiber, larger seed, and rougher skinned pods.

Snap beans thrive in silt-loam fields with good soil structure and internal drainage. Fields that are crusted over are less than ideal for snap bean production. Snap beans grow quickly with adequate moisture and nutrients. The crop requires 1-1.5 inches of water every 4-5 days for ideal growth. Common soil amendments used in snap bean production are: nitrogen, phosphorus, potassium, and lime. Snap beans can be grown in acidic soils where lime has been added to maintain soil pH of 6- 6.8. Beans do well in neutral-slightly acidic soils. Nitrogen is recommended as a pre-plant treatment where fields have < 3% organic matter and/or were not planted in soybean, alfalfa, or grass-legume hay crops during the previous year. When nitrogen is to be added, the recommended rate is 40 lbs./A when <3% OM and 40-80 lbs./A for fields previously planted into corn, rye, oats, wheat, or vegetables. Recommended rates of phosphorus and potassium are 0- 75 lbs./A and 0- 100 lbs./A, respectively.

Lima Beans

Lima beans are usually planted from mid May until mid June in the Midwest (slightly earlier in IL), after the soil temperature has warmed to 65 degrees and remains stable at this temperature. Seeding rates vary from 60- 100 pounds per acre. Lima beans are planted in rows or drilled (similar to soybeans). Lima beans are more drought tolerant than most crops, but are sensitive to plant moisture needs from flower set through pod fill.

Many factors influence lima bean yields, but weather conditions that affect flower bud development, pollination, and pod maturation have the most impact on yields. Low lima bean yields are associated with profuse abscission of flowers and developing pods. High temperatures, low relative humidity, and low soil moisture lead to reduced pod set and retention. Temperatures of 90 degrees Fahrenheit or above reduce pollination and pod set. Prolonged drought (7 days or more with less than 1 inch of water) also negatively affects yield. Fogs, heavy dews, and their moderating effects on temperature are helpful in pollination and pod set. High night temperatures also adversely affect yields, because energy is consumed through respiration, thereby limiting the plants physiological ability to set and retain pods.

The pH of the soil should be adjusted to 5.8 to 6.5. On most soil types, a pH in this range provides the optimum availability of plant nutrients. A pH of 6.5 to 7.0 will generally not be detrimental to lima bean yields, although manganese deficiencies could occur on sandy soils at a pH higher than 6.5. Liming to reach a pH of 6.5 or greater is unnecessary.

Baby lima beans may be planted as early as May 15 and as late as July 15. Fordhook lima beans cannot be planted after July 10, because their long maturity will not escape frost at the later dates. The earliest plantings are subject to reduced stand due to cold soils. Minimum soil temperature for best germination is 65 degrees. The latest plantings must mature before frost, hence early-maturing varieties must be planted after July 10. The optimum range is May 30 to July 10. Early plantings that mature in August and early September are subject to reduced yields from heat and drought.

Research completed in the `50s, `60s, and early `70s in Delaware indicated a positive response from irrigation, especially on lighter, sandy soils. However, temperatures above 90 degrees can override the possible benefits of irrigation by causing blossoms to drop. Growers face the management decision of what crops offer the best potential return under irrigation. However, there is little doubt than even in late-season conditions, irrigation reduces risks and offers better yield potential than non-irrigated conditions.

Critical Pesticides: Growers indicated that some pesticides were considered critical to the production of edible legumes. These pesticides included: bentazon for broadleaf weed control, sethoxydim for post emergence grass control, pyrethroids, especially bifenthrin and esfenvalerate for control of insects, and thiophanate methyl for white mold control. The loss of any of these compounds would result in significant alterations in production practices and increases in the cost of pest control.

Pea Insect Pests

Pea Aphid (*Acyrthosiphon pisum*)

Biology and life cycle:

- The pea aphid is a small, green aphid approximately ¼ inch long and one-third as wide. Nymphs resemble adults except for their smaller size and lack of wings. Eyes are red and their legs and cornicles may be tipped with yellow.
- The pea aphid overwinters as eggs on plant tissue of alfalfa, clover, leguminous weeds, and other leguminous plants. The following spring, the eggs hatch into wingless females which give rise to the next generation of aphids without engaging in sexual reproduction. In late May or June when the first cutting of alfalfa takes place, winged adults migrate into pea fields. As the season progresses and peas no longer provide adequate food supplies for aphid populations, winged forms again appear and migrate back to alfalfa. Late in the season male aphids are produced and sexual reproduction occurs. Black eggs are laid on the stems and leaves of alfalfa plants for overwintering.

Distribution and importance:

- The pea aphid is a sporadic, economically-important insect pest of peas.
- Wilting, stunting and chlorosis are commonly associated with aphid feeding particularly when insect populations are high.
- In addition to the direct injury to pods caused by feeding activity, the pea aphid is a vector of several virus diseases of peas. Also, aphids excrete a sticky substance called honeydew. Sooty molds or other fungi which grow on honeydew-covered plant parts may lead to harvesting problems.
- A regional problem where there are forage legumes (Wisconsin) 25% of region has a problem - 1 out of 10 have some economic level. Could be a serious problem without insecticides.
- Pea aphids are both a quality and yield loss issue.
- Weather patterns make a difference (more rain, less problem).

Non-chemical controls:

- Early planting has less or little problems (crop is harvested before aphids move out of cut hay)
- Control of aphids in alfalfa is often key to control in peas

Chemical Controls

Dimethoate (Cygon EC, Dimethoate EC)

- Used to control pea aphids at a rate of 0.16 lb a.i./A
- Level of control = good on pea aphids, specific to pea aphids
- Reregistration is pending
- Only one application of dimethoate is made per season
- REI= 48hrs PHI= 0d

Esfenvalerate (Asana XL)

- A restricted-use pesticide
- Level of control = good
- Used at a rate of 0.015-0.025 lb a.i./A for aphids
- REI=12hrs PHI= 3d

Methomyl (Lannate L)

- A restricted-use pesticide
- Level of control =poor, not used for aphids
- Used at a rate of 0.45-0.9 lb a.i./A.
- REI = 48hr PHI =1d (Lima) 3d (snap)
- Hasn't been used since Asana was labeled
- May cause aphid flare

Pyrethroids:

Bifenthrin (Capture)

- Level of control = good
- RUP
- REI = 12hrs PHI= 3d
- 1 ½ ounces to kill aphids but not adult lepidoptera insects
- Broad spectrum at higher rates

Zeta-cypermethrin (Mustang Max)

- Level of control = fair
- Broad spectrum
- REI = 12hrs PHI= 1d

Pipeline products:

- Fulfill (Pymetrozine)
- Neonicotinoids
- Warrior (lambda-cyhalothrin)

To do List:

Research:

- Additional research is needed with monitoring/forecasting pea aphid.

Education:

- A regional monitoring and reporting system with pest maps would be helpful to monitor and plan for appropriate pest control measures.

Regulatory:

- Non-pyrethroid alternatives for resistance management are needed. There are insufficient products with other modes of action to use to control this pest if pyrethroids fail.

Insect Contaminants of Peas

There are many insect species that are potential contaminants of processed peas; however the six species listed below are the most common. Although they typically do not pose a threat in terms of direct yield loss, contamination by any one of these insects poses a serious quality issue and can result in a processor rejecting the crop from an entire field.

Cabbage Looper (*Trichoplusia ni*)

- The cabbage looper is a potential contaminant in late-season peas. Adults are greyish-brown moths with a wing span of 1½ ". The caterpillar (larva) is up to 1½ " long, with a greenish body that tapers at the head end.
- Cabbage loopers don't overwinter in large numbers in the Midwest, but migrate in from southern states in mid-July through September. Pupae overwintering in the southern US give rise to the first generation adults in spring. Once these migrants reach Wisconsin, Minnesota, and adjacent states, they mate and lay eggs singly on the lower leaf surfaces in July. Larvae mature through 5 successively larger instars over the next 4-5 weeks before pupating. Adults emerge in 10-14 days, and mate and lay eggs which give rise to the second generation.

Alfalfa Looper (*Autographa californica*)

- The alfalfa looper caterpillars may range in color from light to dark green, and may reach 1¼" in length. They pose a risk of contamination throughout the entire growing season.
- Adult moths are silvery-grey with a darker fringe along the wing edges.
- The alfalfa looper overwinters as an adult moth which emerges when temperatures warm to 40F in the spring. After mating, females lay from 500-1500 small, white eggs on wild crucifers. The eggs hatch within a week, and larvae are active for two weeks before pupating and giving rise to the next generation of adults.

Celery Looper (*Anagrapha falcifera*)

- Celery loopers are late season contaminants in peas.
- This is another moth with greyish-brown forewings and a patch of rust-colored scales outlined by silver. Larvae resemble that of the previous two pests ranging in color from light to dark green. At maturity, larvae are 1¼" long.
- The celery looper overwinters as pupae in the soil. When springtime temperatures reach 50-55 F, adult moths emerge and seek out host plants on which to lay their eggs. There are three generations per year.

Alfalfa Caterpillar (*Plathypena scabra*)

- The adult alfalfa caterpillar is a sulfur-yellow butterfly with distinct black markings along the margins of both the fore- and hind-wings. Larvae are dark brown, becoming green once they begin to feed. At maturity the larvae are 1½ " long.
- The alfalfa caterpillar overwinters as pupae on alfalfa plants. In the spring, adults emerge, mate and lay between 200-500 eggs singly on the lower leaf surface of alfalfa leaves. The larvae complete their development within two weeks of egg hatch at which time they enter the pupal stage without spinning a cocoon. There are two generations per year.

Imported Cabbageworm (*Pieris papae*)

- The adult imported cabbageworm is a white butterfly with a 2 inch wingspan. Bullet-shaped, yellow-orange eggs are laid on the leaves of host plants. Newly hatched larvae are yellow in color but become green once they begin to feed. Larvae have 5 pair of abdominal prolegs. The pupa is grey-brown with 2 angular projections at the head end. The imported cabbageworm overwinters as pupae. Adult butterflies emerge in late April or early May. The first generation eggs are laid on the leaves of cruciferous weeds. These eggs hatch in about one week, and in another 2 weeks, the larvae have completed development and pupate yielding the second generation adults one to two weeks later.

Armyworm (*Pseudaletic unipunctata*)

- These sand-colored moths have a wing span of 1½ " with definitive white dots in the center of each forewing, and dark markings on the hind wings. The brownish-green larvae are hairless, and about 2 inches long when fully grown. Pupae are dark brown and approximately ¾" in length. The armyworm moths usually appear in late April and early May. After mating, clusters of greenish-white eggs are laid. Larvae emerge 7-10 days after the eggs are laid and feed for 3-4 weeks. The full-grown larvae pupate for an additional two weeks and emerge as adults. There are three generations per season, with each generation lasting 5-6 weeks.

Colorado Potato Beetles (*Leptinotarsa decemlineata*)

- Colorado potato beetles overwinter as adults in the soil, often at field margins. Adults become active in the spring.
- Females will lay up to 500 bright yellow eggs in clusters of 15-25 on the lower leaf surfaces before dying. Eggs hatch in 4-9 days and larvae begin feeding immediately. After passing through four instars over the course of 2-3 weeks, larvae return to the soil to pupate. Within 10-14 days, adult beetles emerge.
- There are 1-2 generations per year in northern states and 3-5 generations in the south.
- Only a pest on volunteer potato or certain weeds in peas.

Brown Stink bug (e.g. *Euschistus servus*)

- The brown stink bug's size is approximately that of the shelled peas.
- Adult stink bugs are shield-shaped and brown in color. Immatures are called nymphs and resemble the adults except for their smaller size and lack of wings.
- Brightly-colored, barrel-shaped eggs are laid in clusters on the lower leaf surface.

Distribution and Importance:

- Sporadically important on all fields (100% acres). Not a yield issue - a contaminant issue only. Down graded product is the result. 80% of acres are treated annually to prevent contamination. 5-10% of packs are downgraded despite treatment.
- Contamination of the processed product is both a consumer acceptance issue and an issue of government regulation controlling levels of acceptable contamination.

Chemical Control:

- Organophosphates are seldom used because pyrethroids are more efficacious and industry has adopted products with lower human toxicity.
- Generally a synergist should be used for control of Colorado Potato Beetle.

Pyrethroids;

Esfenvalerate (Asana XL)

- A restricted-use pesticide
- Level of control = fair to good
- Alfalfa caterpillars, armyworms, cutworms, and loopers
- Used at a rate of 0.03-0.05 lb a.i./A
- REI=12hrs PHI =3d

Bifenthrin (Capture)

- Level of control = good to excellent
- RUP
- REI= 12hrs PHI= 3d
- Broad spectrum at higher rates
- Does better job on CPB

Zeta-cypermethrin (Mustang Max)

- Level of control = good
- Broad spectrum
- REI=12hrs PHI= 1d

Carbamates

Methomyl (Lannate L)

- A restricted-use pesticide
- Level of control = fair, limited use
- Typical use = Alfalfa caterpillars, armyworms, and loopers
- Used at a rate of 0.45-0.9 lb a.i./A.

, REI = 48hr PHI =1d (Lima) 3d (snap) 1d

Spinosad (Tracer)

, Level of control = fair, selective for Lepidoptera insects
, Expensive
, PHI = 3d REI = 4hrs

Non-chemical controls:

, Processing equipment - sorters, fans, washers, blowers, people
, Managing weeds in the field reduces insect contaminant problems

“To Do” List

Research

, Research is needed to improve detection/monitoring for stink bugs and alfalfa caterpillar
, Research is needed to develop a prediction model for insect growth and development
, Improvements are needed for sorters and other in-processing plant technology for removal of contaminant insects.
, Improvements are also desirable for in-field harvesting systems to eliminate insect contaminants

Education

, Regional, web-based pest maps, similar to VegEdge (http://vegedge.umn.edu/), would be very useful to producers who wish to minimize pesticide applications while minimizing pests.

Snap Bean and Lima Bean Insect Pests

European corn borer (*Ostrinia nubilalis* Hübner)

Biology and Life Cycle

- Larvae feed on the interior of plant stems and bean pods.
- European corn borers overwinter as larvae and emerge as adults starting in June and continuing through August as two distinct generations are typically observed.
- Adults have wingspans of 1 inch; females are pale-yellow in color while the males are a darker brown. Adults are active at night.

Distribution and Importance:

- 85% of acres are treated with 2-3% loss on these acres.
- The most significant pest, there would be 100% loss on the 85% of acres without treatment.

Non-chemical Controls:

- In fall, winter, or early spring, it is beneficial to destroy corn crop residue that may harbor overwintering larvae. However, because of the mobility of these insects the practice is of little value unless it is practiced on a very large scale.
- Adults can be monitored using blacklight traps.

Chemical Controls:

Organophosphates

Acephate (Orthene 75 S, 97S)

, 1 to 1 1/3 lb(14 days) (75S), 0.75 (97 S)
, Level of Control = good to excellent
, PHI = 14 days, 0days for lima beans REI=24hrs

Carbamates:

Carbaryl (Sevin) 80 S

, 1 ½ lb or XLR Plus, 1 to 1 ½ qt (3 days)
, Level of Control = poor to fair
, PHI = 3 days (Snap) PHI=0d REI=12hr (Lima)
, Kills beneficial insects

Methomyl (Lannate)

, ½ to 1lb SP or 1 ½ to 3 pt LV (3 day)
, A Restricted Use Pesticide
, Level of Control = fair, no residual control

- REI = 48hr PHI =1d (Lima) 3d (snap)

Pyrethroids:

Esfenvalerate (Asana XL)

- 5.8 to 9.6 oz
- Level of Control = fair
- A Restricted Use Pesticide
- REI=12hrs PHI =3d

Bifenthrin (Capture)

- Level of control = good to excellent
- RUP
- 3 day PHI; 12 hour REI
- Broad spectrum at higher rates

Zeta-cypermethrin (Mustang Max)

- Level of control = good
- Broad spectrum
- REI = 12hrs PHI = 1d

Other:

Spinosad (Tracer)

- Level of control = fair, selective for Lepidoptera insects
- Expensive
- PHI = 3d REI = 4hrs

Bt (Bacillus thruingiensis)

- Level of control = fair to good

Pipeline Products:

- Warrior (Control = good)

"To Do" List

Research

- Research is needed on the movement and ecology of corn borer in relation to agricultural systems (crop rotations, tillage, weather).
- Research is also needed to determine the impact of Bt and non-Bt crops on corn borer populations.

Education

- Regional, web-based pest maps, similar to VegEdge, would be very useful to producers who wish to minimize pesticide applications while minimizing pests.

Regulatory

- Non-pyrethroid materials are needed for resistance management.

Corn Earworm (*Helicoverpa zea* Boddie)

Life Cycle and Biology

- Corn earworm, similar to European corn borer, is usually found in sweet corn. However, the insect can be attracted to snap bean, as well.
- Higher pressure can be found in late season beans (both) after area corn is drying down and the beans are the most succulent crop to be found.
- Adults originate from the southern U.S. because they are a major pest of cotton and are unable to overwinter in northern climates. Adults are 0.75-1 inch long with a wingspan of 1.5-2.0 inches and are tan/buff colored.
- Adult females lay eggs on foliage, eggs hatch in 5-7 days, and larvae pass through six instars before pupating. Larvae can posses green, tan, pink, dark brown or black coloration and inhabit stems and/or pods. Leaf buds from newly emerging leaves may also be eaten.

Distribution and Importance:

- Proper timing of insecticide applications is critical as there are no control options once larvae enter the protective covering of the stem or pod. In addition to reducing pod quality, heavy infestations have been shown to reduce yield.
- This pest can be serious in lima beans. Feeding damage from one large corn earworm can cause a

loss of 30 to 40 lima beans. Northern Indiana, Illinois, Southern MI and Southern Ontario have a severe problem. 50% of acres have economic population level with 2-3% quality loss even with treatment. If no treatment was available loses would be about 50%.

- This pest is controlled when corn borer insecticide applications are made.

Chemical Control:

Organophosphates

Acephate (Orthene)

- PHI = 14 days, 0days for lima beans   REI=24hrs
- 0.67 - 1.33 lb/A
- 1 application
- Level of control = poor

Carbamates

Methomyl (Lannate LV)

- REI = 48hr   PHI =1d (Lima) 3d (snap)
- 1.5-2 pt/A; 1-3 applications (3 only in years of extreme pressure) up to 30% of the acreage; This rate will only control small corn earworms.
- Level of control = fair

Pyrethroids

Bifenthrin (Capture)

- REI = 12hrs PHI = 3d
- 2.1-6.4 oz/A
- Level of control = good to excellent

Zeta-cypermethrin (Mustang Max)

- REI = 12hrs PHI = 1d
- 3.0 - 4.3 oz/A; 1application
- Labeled in 2002
- Level of control = good

Esfenvalerate (Asana)

- Level of control = good
- REI=12hrs   PHI =3d

Spinosad (Tracer)

- Level of control = fair to good
- PHI = 3d REI = 4hrs

Bt (Bacillus thuringiensis)

- Level of control = fair to good

Other pesticides currently used (including biologicals) to manage this pest:

- None.

Biological Controls:

- Naturally occurring parasites, predators and disease can play an important role in controlling the corn earworm. Therefore, the use of an economic threshold becomes critical, A fungal disease present during cool, moist periods in September can help to reduce corn earworm populations. **Caution:** These natural controls often do not work quick enough to prevent losses in lima bean yield and quality during years of heavy population pressure.

Cultural:

- None

Pipeline pest management tools:

- Warrior
- Control = good

"To Do" List

Research

- Researchers need to screen all available products for efficacy against this pest.
- Researches should also look into pyrethroid resistance management and the movement of

resistance from Southern U.S. to north. This information would be helpful to producer's pest management plans.

- Research on the use of UV inhibitors with Bts would improve the efficacy of these products and help extend their useful life and utility.

Education

- Regional, web-based pest maps, similar to VegEdge, would be very useful to producers who wish to minimize pesticide applications while minimizing pests.

Regulatory

- Non-pyrethroid alternatives are needed for this pest.
- The registration of Intrepid (methoxyfenozide) would be a useful addition to pest management for edible legumes.

Stinkbug and Lygus Bug Species:

Biology and Life Cycle

- Immature and adult insect feed on growing points, buds, flowers, and pin stage fruit. These insects can inject a toxin that results in wilting, pod abortion, and fruit loss.

Distribution and Importance:

- A primary pest of snap and lima bean production
- Yield losses can occur from adults or nymphs feeding on the blossoms resulting in blossom abortion. However, the primary losses occur for processors when feeding damage occurs on pin stage beans. These feeding scars can result in the loss of an entire load with significant economic loss to the processor

Chemical Controls

Organo-phosphates

Dimethoate (Cygon 4EC)

- REI = 48 hrs PHI = 0d
- 0.5 - 1 pt/A; 1 application
- Only effective on lygus bugs species.

Carbamates

Methomyl (Lannate LV)

- REI = 48hr PHI =1d (Lima) 3d (snap)
- 1.5-2 pt/A; 1-2 applications
- Works on lygus species and stinkbug
- Level of control = Good

Pyrethroids

Bifenthrin (Capture)

- REI = 12 hrs PHI = 3d
- 2.1-6.4 oz/A; 2-3 applications
- Level of control = good, but need higher rates for stink bug

Zeta-cypermethrin (Mustang)

- REI = 12 hrs PHI = 1d
- 3.0 - 4.3 oz/A; 1application
- Labeled in 2002
- Level of control = good

Biological controls

- None

Cultural Controls:

- None

Pipeline pest management tools:

- None

"To Do" List

None listed

Spider mites:
Biology and Life Cycle
- Mites are a secondary pest to bean production.
- Mites feed on sap, especially on the underside of the leaves. In large populations they can severely decrease plant yield.
- Mite populations increase greatly under hot, dry conditions.
- Larvae hatch from eggs and begin feeding on leaves in 3 to 19 days.
- Mites can produce several generations each season and take from 5 to 20 days to mature to adults.Distribution and Importance
- Spider mites can be a problem, especially during hot, dry weather.
- Damage will generally first appear in late June and early July as a white stippling on the leaves with eventual plant death if economic levels go undetected. They are primarily found on the undersides of leaves causing the leaves to appear tan or yellow in color. Mites feed on the plant sap and can defoliate fields in a few weeks in hot, dry weather. Defoliated plants will produce poor yields and quality beans.
- Although not documented in beans, resistance has been documented with these products in other crops.

Chemical Controls:
Organo-phosphates
Dimethoate (Cygon 4EC)
- REI = 48 hrs PHI = 0d
- 1 pt/A; applied 2- 4 times
- Level of control = poor. This may be a result of poor coverage, resistance, storage conditions of the chemical, and/or high pH/iron content of the spray water.

Pyrethroids
Bifenthrin (Capture)
- REI = 12 hrs PHI = 3d
- 5.12-6.4 oz/acre; applied 1-2 times
- Level of Control = good
- Can cause aphids to flair if used frequently

Dicofol (Kelthane MF)
- REI = 12 hrs PHI = 7d
- 1 pt/A; Applied 2- 3 times per acre
- Level of control = fair to good

Biological Controls:
- None

Cultural Controls:
- None

Pipe line management tools:
- Acramite, Agri-Mek

"To Do" List
None listed

Seed Corn Maggot (*Delia platura*)
Biology and Life Cycle:
- Seed corn maggots are the larval form of small flies. Maggots feed on germinating seeds and are more prevalent during cool, wet summers.
- Seed corn maggots are attracted to rotting plant debris, recently manured, or recently plowed fields. It is good practice to plow under winter cover early in the spring. Removing plant debris also decreases egg-laying sites. Later planting dates and shallow seeding depths encourage fast and early germination, which also shortens the time seed is susceptible to corn seed maggot feeding and damage.
- Additionally, seeds should be handled carefully so they do not develop cracks as they encourage

seed corn maggot damage

Distribution and Importance:

Chemical Controls:

Organo-phosphates

Currently available seed treatments and soil insecticides provide only fair control, especially under heavy seed corn maggot pressure.

Chlorpyrifos (Lorsban 50SL)

- Level of control =
- 2 oz/100 lbs. of seed
- Slurry treatment for seed
- PHI = NA REI=24hrs

Biological controls

- None

Non-Chemical methods:

Cultural Control:

- 1) plow down cover crops at least 3-4 weeks before planting or transplanting,
- 2) completely bury cover crops or previous crop residue to reduce fly attraction to rotting organic matter on the soil surface, and
- 3) avoid the use of heavy manure applications close to planting.

Pipeline pest management tools:

- Cruiser (thiamethoxam) seed treatment from Syngenta -- slated for a 2003 bean label but not sure it will say seed corn maggot control.

"To Do" List

None listed

Potato leafhoppers (*Empoasca fabae* Harris)

Biology and Life Cycle

- Leafhoppers are approximately 1/8 inch in length and can be green, light brown or grayish in color.
- They inflict damage with their piercing-sucking mouth parts which, in extreme cases, cause foliage to discolor and die.
- Eggs are deposited inside plant tissue as opposed to on the surface. The larvae go through a total of five nymph stages, and all of the stages including the adults, feed on the sap. Examples of damage include: stripping the plant of its nutrients, transmitting viruses and the feeding damage itself.
- Plants appear yellow and stunted, with the typical "hopper burn" damage on the tips of the leaves.

Distribution and Importance:

- Both yields and plant maturity can be affected by leafhopper feeding from the seedling to pre-bud stage. Once pods are present, economic damage is less likely to occur.
- 100% acres are infested, with 5-10% loss in spite of treatment. Multiple applications may be required. 50% loss of yield if acres weren't treated.
- Migrate into the Midwest every year.

Chemical Control

Organophosphates

Dimethoate (Cygon 4EC)

- 0.5- 1pt
- Level of Control = good to excellent
- REI = 48hrs PHI = 0d

Acephate (Orthene 75 S)

- 2/3 to 1 1/3 lb
- REI = 24hrs PHI = 14 days, 0days for lima beans
- Level of Control = good to excellent

Phorate (Thimet)

- Level of control = good
- REI = 48hrs PHI = 60d (with 55d crop)

Disulfoton (Di-syston)
- Level of control = good
- Pytotoxicity problems
- REI = 48hrs PHI is too long, 60d on a 55 day crop

Carbamates

Carbaryl (Sevin) 80 S
- 1-1/4 lb or XLR Plus, 1 qt
- Level of Control = fair to good
- PHI = 3 days (Snap)   PHI=0d REI=12hr (Lima)

Methomyl (Lannate SP)
- Level of Control = good
- REI = 48hr PHI =1d (Lima) 3d (snap)

Pyrethroids

Pyrethroids typically used at lowest use rates

Esfenvalerate (Asana XL)
- 5.8 to 9.6 oz
- Level of Control = good to excellent
- REI=12hrs   PHI =3d

Bifenthrin (Capture)
- REI = 12hrs PH(I = 3d
- Level of control = good to excellent

Zeta-cypermethrin (Mustang Max)
- REI - 12hrs PHI = 1d
- 3.0 - 4.3 oz/A; 1application
- Labeled in 2002
- Level of control = good to excellent

Others:

Imidacloprid (Provado, Gaucho seed treatment)
- Level of control = good
- PHI = 7d
- Can delay applications of other products while Gaucho is present

Biological Controls:
- None

Cultural Controls:
- Controlling weeds is an important way to decrease the leafhopper population.
- Controlling in adjacent fields will decrease numbers in beans.

Pipeline pest management tools:
- Cruiser commercial applied seed treatment
- Warrior (Control = good)
- Other neonicotinoids

"To Do" List

Research
- Research is needed to determine varietal resistance/tolerance to leafhoppers
- Varieties should be screened for different thresholds to leafhoppers

Education
- Regional, web-based pest maps, similar to veg edge, would be very useful to producers who wish to minimize pesticide applications while minimizing pests.

Regulatory
- Keep inexpensive OPs registered (dimethoate in succulent beans for before bloom treatments at low use rates).
- Register Cruiser.

Bean leaf beetle (Cerotoma trifurcata)

Biology and Life Cycle

- Bean leaf beetles are red, orange, tan, or gray with dots or strips on their backs.
- The adults overwinter in leaf debris in wooded areas next to fields and have a characteristic black triangle behind their thorax.
- Adults emerge in the spring and lay eggs in the soil. Upon hatching, larvae feed on the parts of the plant that are under the soil for 3-6 weeks. They will pupate and emerge as adults one week later in mid July. These adults will mate and lay eggs and a second generation will occur in September. The second generation will overwinter.

Distribution and Importance:

- Adults inflict the most severe damage by feeding on the underside of leaves and pods making small round holes. Beetles can clip off entire pods if feeding occurs at the base of the pod and other tissue damage on pods allows moisture to enter which allows disease to enter which causes mold, discoloration, and shrunken pods.
- Serious problem in regional areas in snap beans with areas further north having less of a problem. In areas where it's a problem it is found in 100% of the fields. Losses with treatment would be 10-15%. Without treatment, there is a window between generations, but outside that would be 75% loss.

Chemical Control:

Organophosphates

Acephate (Orthene)

- 0.5 to 1 lb
- REI=24hrs PHI = 14d, 0d for lima beans
- Level of control = poor to fair

Dimethoate (Cygon)

- 0.25 to 0.5 lb
- REI = 48hrs PHI = 0d
- Level of control = none to poor

Carbamates

Carbaryl (Sevin)

- 1 lb
- REI=12hr PHI = 3 days (Snap) 0d (Lima)
- Level of control = good

Pyrethroids

Bifenthrin (Capture)

- 0.033 to 0.1 lb
- REI= 12hrs PHI= 3d
- Level of control = good to excellent

Esfenvalerate (Asana)

- Level of control = good
- REI=12hrs PHI =3d

Zeta-cypermethrin (Mustang Max)

- Level of control = good to excellent
- REI =12hrs PHI = 1d

Biological Control

- None

Cultural Controls

- None available

Pipeline Products

- Warrior (Control = good)
- Cruiser
- Gaucho

"To Do" List

Research

- Research is needed to determine Bean Leaf Beetle thresholds for treatment
- Research is also needed to evaluate the transmission of bean pod mottle and other viruses by Bean Leaf Beetle

Regulatory

- Cruiser registration
- Register Gaucho, need to add bean leaf beetle to the label

Mexican bean beetle (*Epilachna varivestis*)

- These beetles are ¼ inch long and copper brown in color. In addition, they possess eight black spots on each wing.
- Mexican bean beetle adults overwinter in plant debris and as such, it is very important manage crop debris to minimize infestations.
- Upon plant emergence, beetles will move from their winter shelters and begin feeding on the underside of the leaves only, leaving the top-side intact. Larvae also feed on foliage, but the damage creates a lace like appearance on the leaves..

Distribution and Importance

- This species is most common in the southern region of the Midwest.
- With a heavy infestation, beetles will also feed on stems and pods, sometimes killing the host plant

Chemical Control

Organophosphates

Disyston 15G (disulfoton)

- REI = 48hrs PHI = 60d
- 6 - 12 oz per 1000 foot of row
- Level of control = Fair

Endosulfan (Thiodan) 3 EC

- 2 pt or 50 WP
- 1 ½ lb
- PHI= 3days
- Level of control =

Diazinon 500-AG

- 1 pt
- REI = 12-24hrs PHI= 7d
- Level of control =

Methyl Parathion (Penncap-M)

- 2 pt
- REI = 48hrs PHI =3d
- Level of control =

Acephate (Orthene 75 S)

- 2/3 to 1 1/3 lb
- REI=24hrs PHI = 14d, 0d for lima beans
- Level of control = good

Malathion 57 EC

- 1 ½ pt
- PHI = 1 day
- Level of control

Thimet 20G (phorate)

- REI = 48hrs PHI = 60d
- 4.6 - 6.9 oz per 1000 foot of row
- Level of control = fair

Carbamates

Carbaryl (Sevin) 80 S

- 1 ¼ lb or XLR, 1pt
- REI=12hr PHI = 3d (Snap) 0d(Lima)
- Level of Control =

Methomyl (Lannate SP)
- ¼ to 1 lb or LV, ¾ to 3 pt
- REI = 48hr PHI =1d (Lima) 3d (snap)
- Level of control = good

Pyrethroids

Zeta-cypermethrin (Mustang)
- REI = 12hrs PHI = 1d
- 3.0 - 4.3 oz/A; 1application
- Level of control = good

Cultural Controls
- Plowing crop debris after harvest helps minimize attractive sites for beetles
- Altered planting dates can be effective means of controlling beetles.
- Use of early or late maturing varieties can be very effective as most damage is done during July and August.
- Use of a early planted trap crop (for late planted beans)

Biological controls:
- On farms with a succession of bean plantings, the release of the parasite, *Pediobius foveolatus,* may provide effective control. **Caution:** This system has only been demonstrated on soybeans and additional information will be needed to demonstrate its effectiveness on lima beans.

Pipe line products:
- Avaunt

"To Do" List

None listed

Soybean Aphids (e.g. *Aphis fabae*)

Biology and Life Cycle
- Aphids are small, green, yellow, or black colored insects that can be either winged or wingless
- They reproduce both sexually and asexually. During the summer months, reproduction occurs asexually by females who produce live offspring. At the end of the season, as fall approaches, females and males will reproduce sexually.
- Eggs produced by male/female mating will overwinter in the host crop.

Distribution and Importance
- Aphids inflict damage with their piercing-sucking mouthparts making leaves curl and appear wilted due to the honeydew (waste) substance they excrete.
- Aphids have not previously caused much damage to snap beans in the Midwest. However, recent infestations in the Midwest indicate that the incidence of several bean viruses may be increasing. Many of these are vectored by aphids.
- Soybean aphid does not reproduce on beans.

Chemical Controls: not effective in reducing primary spread of virus (initial infection), does help reduce secondary spread (plant to plant).

Organophosphates

Acephate (Orthene)
- 0.5 to 1 lb
- Level of Control = fair to good
- REI=24hrs PHI = 14d, 0d for lima beans

Dimethoate (Cygon)
- 0.25 to 0.5 lb
- REI= 48hrs PHI = 0d
- Level of control = fair

Malathion 57 EC
- 1 ½ pt
- PHI = 1 d
- Level of control =not used, too short persistence

Disulfoton (Di-syston)

- Level of control = fair
- REI = 48hrs PHI = 60d with 55 day crop

Phorate (Thimet)
- Level of control = fair
- REI = 48hrs PHI = 60d (with 55d crop)_

Carbamate

Methomyl (Lannate SP)
- ¼ to 1 lb or LV, ¾ to 3 pt
- REI = 48hr PHI =1d (Lima) 3d (snap)
- Level of control = not used, need too high of a rate
- Expensive

Pyrethroids

Bifenthrin (Capture)
- 0.033 to 0.1 lb
- REI = 12hrs PHI = 3d
- Level of control = good to excellent

Esfenvalerate (Asana)
- Level of control = fair to good
- REI=12hrs PHI =3d

Zeta-cypermethrin (Mustang Max)
- Level of control = fair to good
- REI = 12hrs PHI = 1d

Neonicotinoids

Imidacloprid (Admire, Gaucho (seed trt), Provado)
- PHI = 7d
- Level of Control = good
- Max 3 applications
- Total of 0.5 lb a.i./acre/season

Cultural Controls
- Control buckthorn
- Early planting of beans

Biological Controls:
- None

Pipeline products
- Cruiser
- Warrior (Control = good)

"To Do" List

Research

Because aphids are the principal vector of viruses the research and regulatory issues presented will be the same for each.
- Research is needed to develop vector models, to include the impact of weather on the movement and dispersal of aphids, This model may also investigate possible links with soybean cropping systems and with leaf hoppers.
- Research is also needed to develop a systems approach to maintaining low levels of insects to keep virus levels down.
- More needs to be known about field relevant host plants, overwintering sites, and inoculum sources for the virus.
- Plant breeders need to maintain a strong effort to breed virus resistance into plants.

Regulatory:
- Registration of Cruiser on soybean could prove to be an advantage for edible legumes in reducing aphid, but there are issues with Cruiser's risk cup being full.
- If buckthorn were managed more carefully (it is a noxious weed) the viral inoculum level would be reduced and fewer insecticides would be necessary.

Bean aphid:
Biology and Life Cycle

- The black bean aphid overwinters in the egg stage on euonymus shrubs and migrates to weed hosts in the spring. Movement from weed host to lima beans generally occurs in June. Aphids are found on the undersurface of leaves and on the terminal buds.
- Infested plants appear yellow with puckered foliage. Feeding damage results in bud and blossom abortion.
- A dark sooty mold also grows on the honeydew excreted by the aphids resulting in reduced photosynthesis and reduced yields.

Distribution and Importance:

- A pest of secondary importance to edible legumes throughout the region.

Chemical Control:
Organo-phosphates:
Dimethoate (dimethoate)

- REI = 48hrs PHI = 0d
- 1 pt/A; applied 1 time
- Level of control = fair

Acephate (Orthene)

- REI=24hrs PHI = 14d, 0d for lima beans
- 0.67 - 1.33 lb/A; 1 application
- Level of control = good

Carbamates
Methomyl (Lannate LV)

- REI = 48hr PHI = 1d (Lima) 3d (snap)
- 1.5-3 pt /A; 1 application
- Level of control = good

Neonicotinoids
Imidacloprid (Gaucho seed treatment)

- 2-4 oz per hundredweight of seed
- Level of control = good
- PHI = 7d

Biological Controls

- None

Cultural Controls

- None

Pipeline products:

- Cruiser seed applied insecticide - potential label 2003

"To Do" List
None listed

Green cloverworm *(Plathypena scabra)*

Biology and Life Cycle

- The green cloverworm moth is dark brown and about one inch long. The head is elongated slightly into a pointed snout caused by protruding palps that are associated with the mouthparts. When sitting the moths form a triangular or inverted V shape.
- The green cloverworm feeds primarily on legumes. The caterpillar is slender and green with two thin white stripes on each side. The full caterpillar is about one inch long.

Distribution and Importance:

- They feed on foliage and also cause damage to the pods.
- Most years the caterpillars are decimated by fungal disease that keeps their numbers low.
- The green cloverworm overwinters as pupae and go through 2-3 generations per year.

Chemical Controls
Pyrethroids:

Esfenvalerate (Asana XL)
- 5.8 to 9.6 oz
- REI = 12hrs PHI = 3d
- Level of control =

Organophosphates
Methyl Parathion (Pencap-M)
- 2pt
- Level of Control =
- REI = 48hrs   PHI =3d

Cultural Controls
- Fields should be inspected regularly for larvae or signs of foliar injury or injury to the bean pods.

Biological Control:
- None

Pipeline Products
- None

"To Do" List
None listed

Table 2. Insecticide Use on Edible Legumes (estimated for 2003)

Insecticide	Percent crop treated			Number of Appl.			Avg lbs a.i. per appl.		
	Snap	Lima	Pea	Snap	Lima	Pea	Snap	Lima	Pea
Acephate (Orthene 75S or 97S)	10	10	-	1	1	-	.33	.38	-
Bifenthrin (Capture)	50	80	40	2	1.2	1	.05	-	.025
Bt(Bacillus thuringiensis)	1	-	X	1	-	X	-	-	X
Carbaryl (Sevin 80S)	-	-	X	-	-	X	-	-	X
Chlorpyrifos (seed trtmt)	-	100	X	1	-	X	-	--	X
Diazinon 500Ag	-	-	X	-	-	X	-	-	X
Dicofol (KelthaneMF)	-	-	X	-	-	X	-	-	X
Dimethoate (Cygon)	30	40	5	1	1.2	1	.25	-	-
Disulfoton (Di-syston)	-	-	X	-	-	X	-	-	X
Endosulfan (Thiodan 3EC)	-	-	X	-	-	X	-	-	X
Esfenvalerate (Asana XL)	10	20	20	1	1	1	-	-	-
Imidacloprid (Admire, Gaucho)	1	-	X	1	-	X	-	-	X
Malathion 57EC	-	-	X	-	-	X	-	-	X
Methomyl (Lannate)	-	-	2	-	-	1	-	-	-
Phorate (Thimet)	-	-	X	-	-	X	-	-	X
Spinosad (Tracer)	-	-	2	-	-	1	-	-	-
Zeta-cypermethrin (Mustang Max)	40	-	20	2	-	1	.05	-	.025

Lambda cyhalothrin	30	30	X	2	1	X	.04	-	X

Pea Diseases

Non Chemical Disease Control

- Rotation of pea crops with non legume crops is essential to control such soil borne diseases as common root rot and Fusarium wilt. Other diseases such as Ascochyta leaf blight and anthracnose are easily controlled if peas are rotated with non legume crops such as small grains, corn or non legume vegetable crops. Use of a 3-5 year rotation will be helpful in the long term health of a field.
- Prior to planting a field to peas, a soil sample representative of the field should be evaluated for root rot potential. Establishing the risk of root rot before planting helps growers to avoid the high risk fields and more profitably grow peas in fields at low risk from common root rot.
- Pea breeders are investing time and money in the development of cultivars with resistance to key pea diseases. It is possible to purchase cultivars with resistance to some virus and fungal pathogens. While resistance to root rot has been particularly elusive, breeders continue work toward the goal of developing improved levels of resistance to common root rot.

Critical Disease Control Issues

- Developing improved resistance to common root rot is the highest priority for the pea industry. There are few fungicides registered for use on peas other than captan and thiram. Loss of either or both of these materials through FQPA enforcement would have an enormous impact on the pea industry.

Aphanomyces Root Rot (*Aphanomyces euteiches* f. sp. *pisi*)

Biology and Life Cycle

- *Aphanomyces* root rot is a soil-borne fungus capable of infecting pea plants at all stages of growth. The fungus produces such a large number of spores that it can be readily disseminated over large areas through movement of water and in contaminated soil carried from one field to another by farm implements and machinery.
- Warm temperatures (72-82F) and high soil moisture favor disease development and symptom expression.
- Infection usually occurs at the time of crop emergence. Initial symptoms appear as long, soft, water-soaked areas on the surface of the lower stem and roots. As the disease progresses, these discolored areas become light tan and spread over the entire root system. Plants that are infected while very young are stunted and weakened.
- Pods on infected plants may have only one or two peas and these are inclined to be large and irregularly shaped. Peas of this type are usually poor in quality. In severe cases, infected plants wilt, turn yellow, shrivel and die prematurely.

Distribution and Importance

- Aphanomyces is the most important pea disease in the Midwest and is widely distributed in the Midwest.
- Annual yield losses of 10% have been observed and in some fields,100% loss may be realized. The disease not only destroys individual vines, but also reduces the quality of shelled peas by making them irregular in size, variable in harvesting maturity, and lacking in sugar content. Fields infested with *Aphanomyces* may remain unsuitable for planting susceptible crops for up to 10 years. Weather driven, related to moisture.

Chemical Control (seed treatments)

- No effective treatments available although reduced infection is usually noted when the crop follows potatoes that have been fumigated with Vapam.
- Anecdotal evidence suggests that the use of dinitroanaline herbicides may reduce the impact of the disease, though not reliably so.

Non - Chemical Control

- Rotate field out of crop for at least 4 to 5 years. Include a crop of oats just prior to planting peas. The U of MN has done some research suggesting that oats may be efficacious in reducing disease level. Once the disease found, crop rotation doesn't help much.
- Select varieties with greater tolerance
- Control weeds that host Aphanomyces.

- Kill the crop immediately after harvest to reduce inoculum levels
- Avoid compaction from tillage or poorly-drained soils

Pipeline Products:

- None

“To Do” List

Research

- More research needs to be done to determine variety tolerance
- Research needs to develop a systems approach of chemical and non-chemical techniques for minimizing this diseases to include previous cropping history to control or modify the form of the pathogen that is predominant, cover crops (allelopathic effects)
- Researcher should also develop a quantitative assay for the disease with a workable threshold
- The discovery of effective seed treatments would also greatly benefit growers.

Ascochyta Leaf Spot (*Ascochyta pisi* Lib.)

Biology and Life Cycle

- The fungus overwinters in infected plant debris and is spread by rain or irrigation water. Consequently, wet weather favors disease outbreaks.
- Symptoms appear as small, purple spots with distinct margins on leaves, stems and pods that later become black in color. Pod lesions may be somewhat sunken and reduce the quality of the pea seed within.

Distribution and Importance

- Ascochyta is an occasional, economically-important disease of late-season peas grown in the Midwest.
- It is less of a problem when fields are mold board plowed but can be a challenge in minimum tillage.
- Diseased peas become inedible.

Chemical Control (seed treatment)

- No effective treatment available

Non-Chemical Control

- Control can be achieved through the practice of a 3-4 year rotation out of peas and the incorporation of infected debris immediately after the crop has been harvested.
- Disease-free seed is another important means of preventing infection.
- Less of a problem behind mold board plowing
- Variety resistance, have to break linkage between mildew resistance and Ascochyta

Pipeline Products:

- Strobilurins ???

“To Do” List

Research

- Need to determine when is it going to be a problem. Development of a forecasting model would be very helpful
- New products need to be screened and registered for use

Fusarium Wilt (*Fusarium oxysporum* f. sp. *pisi*)

Biology and Life Cycle

- Fusarium is a destructive disease of peas that attacks plants of all ages and reduces yields by killing the plants before they mature.
- The fungus overwinters as resting spores in the upper soil layers where it can survive indefinitely. In the spring, the fungus invades the root system of developing pea plants. It may be carried on seed to other fields.
- The fungus does not appear to be sensitive to soil moisture levels or alkalinity, although the incidence of wilt is slightly greater where the soil is moderate in moisture content.
- Plants can become infected at any stage of development from the youngest seedlings to mature vines. The first signs of disease are pale leaflets and downward curling of stipules and leaflets.
- Leaves of infected plants wilt, beginning with the lower leaves and progressing upward. The entire

plant eventually wilts, and the stem shrivels. Pod formation is usually reduced, and seeds rarely develop in affected pods.

Distribution and Importance

Chemical Control

Metalaxyl (Apron XL LS)

- Level of Control
- REI = NA   PHI = NA

Thiram

- Level of Control
- REI = NA   PHI = NA

Non - Chemical Control

- Rotate field with a history of root rot for at least 4 to 5 years. Include a crop of oats just prior to planting peas
- Grow resistant varieties
- Plant as early as possible in well drained soil

Pipeline Products:

- None

"To Do" List

None listed

Rhizoctonia Seedling Blight (*Rhizoctonia solani*)

Biology and Life Cycle

- The fungus can live indefinitely in the soil and is disseminated by any means that moves infested soil from one area to another. Infection occurs directly through intact plant tissue. As seedlings age, they become less susceptible to attack.
- Disease development is temperature dependent and is most severe when soil surface. temperatures are between 75-85 F. Because sandy soils warm up relatively rapidly, *Rhizoctonia* seedling blight is often more serious on these soils.
- The browning of stems and death of very young pea seedlings is the most common above-ground symptom. Up to ½ inch of the terminal shoot is affected just as it emerges through the soil and before the leaves expand. Often one or two auxiliary shoots arise from the seed within a few days after the first shoot dies back. These auxiliary shoots also may become infected or they may produce a normal, but late plant.

Distribution and Importance

- Rhizoctonia is an occasional disease of peas and is generally considered to be of minor importance.
- Seedling emergence is delayed which can cause problems.
- More of a problem in sandy soils.
- A 15% loss will occur on 33 percent of delayed emergence fields.

Chemical Control

Thiram

- Level of Control=Fair
- REI = NA   PHI = NA

Captan

Level of Control=Fair

Fludioxonil (Maxim)

Level of Control = likely good

Non - Chemical Control

- Rotate field with a history of root rot for at least 4 to 5 years. Include a cover crop of oats just prior to planting peas.
- Avoid practices that delay emergence.

Pipeline Products:

- Protege (azoxystrobin)
- Moncut (Flutalonil)

"To Do" List

Research

- Researcher should develop a quantitative assay to include a threshold model of disease development
- New compounds should be screened for efficacy and registered where possible

Powdery Mildew (*Erysiphe polygoni*)

Biology and Life Cycle

- Early symptoms include discolored spots on the upper leaf surface that later become powdery in appearance as they enlarge. Small, oval, black fruiting bodies may be seen in older lesions. Dry weather favors disease development.
- Drought stress also accelerates disease development by stressing the host plant.
- The pathogen that causes powdery mildew is seed-borne and therefore the use of disease-free seed is recommended to prevent infection. Sulfur fungicides are useful in protecting healthy foliage in infected fields.

Distribution and Importance:

- Powdery Mildew is rarely economically important to the pea crop.

Chemical Controls

Sulfur dust or spray

- Level of Control =

Non-chemical Controls:

- Plant resistant varieties

Pipeline Products:

- None

"To Do" List

None listed

Downy Mildew (*Peronospora pisi*)

Biology and Life Cycle:

- Downy mildew develops when night temperatures are relatively low and fogs or prolonged periods of dew are prevalent.
- The symptoms of downy mildew first appear on the lower leaf surface as fluffy, white to grey patches of the fungus. These patches often turn darker with age. On the upper side of the foliage there are yellow to brown areas with indistinct margins.
- The disease may appear on the pods without foliar infection. Young pods are particularly susceptible. Several yellow-brown diseased areas of indefinite size and shape are apparent in pod infections. On the inside of the pod, opposite the outer diseased area, there may be a white, felt-like growth of the pod endocarp. Peas developing near these areas remain small and may have brown, sunken spots.

Distribution and Importance:

- Downy Mildew is a common and troublesome pea disease where peas are grown under cool, moist conditions. In most of the pea-growing areas of the US, the disease is present during the early part of the growing season but is seldom of economic importance.

Chemical Controls

- None listed

Non-Chemical Controls:

- None listed

Pipeline Products:

- None listed

"To Do" List

None listed

Bean Diseases

Damping off

Biology and Life Cycle:

, Damping off is caused primarily by soilborne fungi.

, Damping off before emergence results from fungal attack of germinating seed and/or young seedlings while they are still in the ground. Infected seeds may fail to germinate, become soft and mushy and finally disintegrate. Slightly water-soaked lesions may be visible on stems of young seedlings. Infected areas enlarge quite rapidly, and seedlings may die shortly after infection, prior to emergence from soil.

, Roots or stems of seedlings that have already emerged also can be attacked at or below the soil line resulting in damping-off. Infected roots are usually discolored or rotted and sometimes reddish brown lesions develop on the tap root. Infected stem tissues are soft and colorless to dark-brown. Basal portions of invaded stems may be much thinner than the areas above the lesion, a condition called "wire-stem", resulting in the seedling falling over and dying.

Distribution and Importance:

, Damping-off disease of seedlings is widely distributed all over the world. It affects seeds, seedlings, and older plants of almost all kinds of vegetables, flowers, cereals, and fruit and forest trees. The greatest damage is done to the seed and seedling roots during germination either before or after emergence.

, Significant losses may occur to susceptible varieties, especially if cool, wet weather conditions prevail for the first few weeks after seedling and then are followed by hot, dry weather.

, Damping-off is a major cause of poor stand establishments in bean plantings. Older plants may also be attacked by these fungi. Later infections are usually confined to roots, which may result in stunting, wilting, or plant death.

Cultural Controls:

, Do not grow beans continually in the same location. A 4-5 year rotation is desirable, avoiding fields known to be heavily infested with root-rot fungi.

, Plant beans only on well drained soils. Delay planting until the soil is warm (above 65 F) and seed shallow to insure rapid emergence.

, Avoid planting seeds to close together.

, Do not over fertilize, especially with nitrogen.

, To diagnose bean root rots, suspected plants should be carefully dug up and washed.

Chemical Controls:

Metalaxyl

, Level of Control =

, PHI =NA REI = NA

Captan

, Level of Control =

, PHI =NA REI = NA

Quintozene

, Level of Control =

, PHI = NA REI = 12hrs

Thiram

, Level of Control =

, PHI = NA REI = NA

Metalaxyl and Mancozeb

, Level of Control =

, PHI = NA REI = NA

Pipeline Products:

, None

“To Do” List

None listed

Root and Stem Rot

Biology and Life Cycle

- In root rot of beans the tap roots of the young plants at first show a slightly reddish discoloration.

This later becomes darker red to brown and larger, more or less covering the taproot and the stem below the soil line without a definite margin, or appearing as streaks extending up to the soil line. Longitudinal fissures appear along the main root, while the small lateral roots are killed.

- Plant growth is generally retarded and in dry weather the leaves may turn yellow and even fall off. Sometimes infected plants develop secondary roots and a large number of rootlets just below the soil line. These roots, under favorable conditions, may be sufficient to carry the plant to maturity and to production of a fairly good crop. In many cases the infected plants decline and die with or without wilt symptoms.

Distribution and Importance:

- Widespread, would happen every year if treatment didn't occur. About 7% of yield is lost every year (due to stand loss).
- A cold spell after planting increases disease severity and sandy soils may lose 20-30% of stands.
- Aerial pythium - 10% of fields annually seeing 25% loss after a heavy pounding rain (splash effect). It has become a problem in last few years. Some varietal differences do exist.

Non-chemical Controls:

- Do not grow beans continually in the same location. A 4-5 year rotation is desirable, avoiding fields known to be heavily infested with root/stem-rot fungi.
- Plant beans only on well drained soils. Delay planting until the soil is warm(above 65 F) and seed shallow to insure rapid emergence.
- To diagnose bean root rots, suspected plants should be carefully dug up and washed.
- Cultivate - throw soil up around roots, fertilizer, don't irrigate 3-5 days after planting.
- Assay to assess risk.
- After harvest, kill plants promptly to reduce inoculum.
- Non-legume cover crops are an important component of crop rotations.

Chemical Controls:

The use of Vapam on potatoes in the year preceding beans tends to reduce inoculum levels and disease severity.

Metalaxyl (Apron)

- Level of Control = good on pythium, none on Aphanomyces
- PHI =   REI = 12hrs

Captan

- Level of Control = fair control for rhizoctonia, good on fusarium

Thiram

- Level of Control = fair control for rhizoctonia, good on fusarium

Maxim

- Level of Control = good on rhizoctonia, good on fusarium

Pipeline Products:

- Protege ??

"To Do" List

Research

- Research is needed to develop a threshold model including a quantitative assay
- A reliable fungicide would very likely be widely used for Aphanomyces control. Development of promising compounds would be very helpful
- Research is needed to determine the potential for allelopathic effects of cover crops, and the effects of a systematic approach (non-chemical) for Aphanomyces control.

Anthracnose (Colletotrichum lindemuthianum)

Biology and Life Cycle:

- Bean plants in all stages of growth are subject to anthracnose. The fungus is often present in or on the seed produced in infected pods. Infected seed may show yellowish to brown sunken lesions of various sizes. When infected seeds are planted, many of the germinating seedlings are killed before emergence.
- Dark brown, sunken lesions with pink mass of spores in the center are often present on the cotyledons of young seedlings. The fungus may kill one or both of the cotyledons, while its spores

spread onto the hypocotyl and the mycelium moves into the stem.

- On the stem the fungus produces numerous small, shallow, reddish-brown specks that subsequently enlarge, become elongated and finally sunken. The lesions are covered with myriads of pink- to rust- colored spores. If conditions are humid, the lesions may be so numerous that they girdle and weaken the stem to the point where it cannot support the top of the plant.
- The fungus also attacks the petioles and the veins of the underside of the leaves, on which it causes long, dark, brick-red to purplish colored lesions that later turn dark brown to almost black.
- On pods , small, flesh- to rust- colored elongated lesions appear, which later become sunken, circular, and about 5-8 mm in diameter. Lesions developing on young pods may extend through the pod and even to the seed, while in older pods the lesions do not extend beyond the pod. As the pod matures, the margin of the lesions is generally slightly raised, while the pink spore masses of the lesions dry down to gray, brown, or black granulations or to small pimple-like protrusions.

Distribution and Importance:

- Glomerella Anthracnose disease is present wherever their hosts are grown and are more severe in warm to cool, humid areas and are generally not a problem under dry conditions.

Cultural Controls:

- Control damping off and wirestem in the greenhouse and field seedbeds by using sanitized media and containers and avoiding overwatering.
- Whenever possible use disease free seeds, although infected seeds can be treated by hot water.
- Planting seeds on raised beds with good aeration between plants can decrease occurrence.
- A three year crop rotation will reduce infection rates.

Chemical Controls:

Foliar Treatment

Copper Sulfate (Basicop 53WP)

- 2 lb. Apply at 7- to 10- day intervals.
- Level of Control =
- REI = 24-48hrs PHI = 0d

Thiophanate-Methyl (Topsin M WSB)

- 1 to 1 ½ lb
- Level of Control =
- PHI = Before beans begin to form REI = 48hrs

Thiram (42-S or 50 WP Dyed)

- Used as a seed treatment at a rate of 8 oz/100 lb seed.
- Level of Control =
- PHI = NA REI = NA

Non-Chemical Control:

- No information available

Pipeline Products

- None

“To Do” List

None listed

Gray Mold (*Botrytis cinerea*)

Biology and Life Cycle:

- Gray mold is a disease caused by the fungus *Botrytis cinerea* and can infect all vegetable transplants at any stage of growth resulting in irregular brown spotting or blight of leaves and stem cankers.
- Key disease of lima beans, especially after the peak temperatures of the season and under wet fall conditions.
- Under humid conditions, Botrytis produces gray and powdery propagules (conidia) on diseased plant parts that can be transported on air currents to cause disease on nearby healthy plants.
- Gray Mold can be prevalent during cloudy periods in the spring when conditions in the greenhouse are humid and foliage remains wet for an extended period of time. The fungus that causes gray

mold requires a film of water to penetrate the plant.

Distribution and Importance:

- Information not provided.

Cultural Controls:

No information available

Chemical Controls:

Thiophanate-Methyl (Topsin M WSB or 70 W)

- 1 ½ to 2 lb
- Level of Control =
- PHI = Before beans begin to form REI = 48hrs

Chlorothalonil (Bravo Weather Stik)

- 3pt or Bravo 720, or Bravo 500, 2 ½ pt or Bravo Ultrex 82.5 WDG, 1.25 to 2.7lb
- Level of Control =
- PHI =42d   REI = 48hrs

Supanil 720 or Terranil 6L,

- 3 pt
- Level of Control =
- PHI =7d   REI =

Vinclozolin (Ronilan EG)

- 1 lb
- Level of Control =
- PHI = 10d REI = 12hrs

Iprodione (Rovral 50W or WG)

- (1 ½ to 2 pt)
- Level of Control =
- PHI = 14d REI = 12hrs

Pipeline Products:

No information available

"To Do" List

None listed

White mold (*Sclerotinia sclerotiorum*)

Biology and Life Cycle

- White mold is caused by the fungus *Sclerotinia sclerotiorum*. It is a fungus that is highly distributed throughout the U.S. and attacks many vegetable and field crops.
- Small black, hard bodies called sclerotia are produced on and in the stems and pods of infected plants. At harvest the sclerotia are scattered over the soil surface, but below the surface they can lie dormant for up to five years. Sclerotia serve as sources in the year following the one in which they were produced. They germinate to form stems which can be up to 3cm long. After the stems reach the soil surface they are stimulated by light to form another structure, the apothecium, at their tips. These produce ascospores which are discharged into the air and can travel as far as one-half of a mile before landing on plant parts such as leaves or flowers.
- Ascospores are the source of nearly all the infections seen in beans. They normally only infect dead or dying plant material, especially aging flowers. Wounds by hail or cultivation are sites of infection. Infection of healthy pods, leaves and stems generally results from an infected flower that has fallen onto or come in contact with other plant tissues.
- Shortly after infection white masses of mold appear on infected tissues and black sclerotia begin to form in these areas within the stems, thus completing the life cycle. Secondary spread down rows occurs when infected plant tissues come into contact with health tissues.
- The fungus will often girdle the main stem or its branches causing the plant or plant parts to wilt and die. The leaves turn bright yellow and then brown. Infected pods become soft and mushy, but later dry out and are light colored and shriveled.

Distribution and Importance:

- Widely distributed in the midwest. Losses occur under conditions of high humidity and abundant

rainfall in fields with heavy vine growth.
- Less damage is seen in the varieties with an upright bush habit than in older vine-type varieties. The more open growth habit of bush-type varieties reduces the time that soils are excessively wet and leaves and flowers are covered with free water.
- 60% of the acres that bloom after August 15. Not as much a problem in Central Illinois.

Non-chemical Controls:

, All bean varieties are susceptible to white mold. Varieties with a shorter flowering period and an upright-bush habit may be less likely to be severely affected under heavy disease pressure. These varieties also respond better to chemical control because of shorter times needed for protection and because of a less extensive canopy.

, Using cultural practices that allow for the plants to dry out rapidly. Precision planting diminishes problem.

, Attempts to control white mold with deep plowing have been unsuccessful. Once high populations of sclerotia have built up in the soil rotation has little effect on reducing the white mold pathogen because of the longevity of sclerotia in the soil.

, Reducing tillage allows the sclerotia to stay on the soil surface and reduce inoculum load.

, Inoculum can survive 5 or more years.

, Other numerous crops and weeds are host to white mold also. (Sunflowers, soybeans, Jerusalem artichokes, broad host range).

, White mold is not a problem every year, but only in years of abundant rainfall and extensive canopy cover. Chemical control may not be advisable as a normal management practice. Also related to temperature - temps above 80 degrees will dry white mold out.

, Excess levels of nitrogen can cause problems.

Chemical Controls:

Chemical control can be effective when:

, The chemical is applied before infection has occurred.

, The chemical adheres to the plant for a considerable length of time.

, The chemical penetrates the canopy and reaches the flowers which are the most important sites of initial infection.

, These conditions require that timing of sprays be adjusted so that a maximum number of flowers are protected by a chemical that moves into the canopy before the canopy closes. Growers should look for 10 days of continuously wet soils between emergence and flowering. Plan on spraying at peak bloom. This occurs between 10 and 14 days after the appearance of the first flower in a field, or about 6 to 8 days after a single flower has been observed on 50% of the plants in the field.

, Timing of chemical application is critical. Spraying after peak bloom will be considerably less effective because a large percentage of the flowers may already be infected, and later sprays may not reach the flowers because of the canopy cover. Spraying earlier than peak bloom will result in too many of the flowers being protected.

, In normal years, one spray should be adequate. In very wet years two sprays may be needed. The second spray, if needed, should be applied 7 to 10 days after the first spray. Using wet flowers to determine disease does not leave enough lead time to apply chemical for effective control.

, Application of chemical can be made by airplane or ground spray equipment. Ground equipment may be more effective if field conditions permit and if the plants are not severely damaged. Ground equipment should be equipped with a single over-the-row nozzle and drop nozzles between the rows about 5 inches above the ground. Use 25 to 50 gallons of water per acre for ground application at 60 to 100 psi. Use 5 gallons of water per acre for air applications.

, Chemical control of white mold is a preventative measure and should be started when a disease problem is predicted and not after the disease has started and is easily observed in the field.

Chemical Controls:

Benomyl (Benlate 50 WP or Sp) (can be used through 2003)

, 24 to 32 oz.

, Level of Control = fair to good

, REI = 24hrs PHI = 14d

Thiophanate-Methyl (Topsin M WSB or 70 W)

- 1 ½ to 2 lb
- Level of Control = fair to good
- REI = 48hrs PHI = 14d for snap beans and lima beans

DCNA (Botran 75-W)
- 2 ¼ lb(bush beans) or 4lb (pole beans)
- Level of Control = None used, poor control
- PHI =   REI =

Vinclozolin (Ronilan EG)
- 1 lb
- Level of Control = good, but feeding restriction of processing plant waste
- REI = 12hrs PHI =10d

Iprodione (Rovral 50W or WG)
- 1 ½ to 2 pt
- Level of Control = fair to good, timing critical, may need to spray twice
- REI = 12hrs PHI = 14d
- expensive

PCNB (Terraclor 75 W)
- 2 ¾ lb or Terraclor 2 E, 4 qt as a band spray per 14500 ft row.
- Level of Control = None used, very poor control
- REI = 12hrs PHI =

Intercept (Coninthyrium)
- Biological product
- 1-4 lbs/A (most commonly use 2 lbs)
- Level of control = fair, farm management tool
- Works best when apply to crop with white mold and immediately disk it in

Pipeline Products:
- BASF 510 - should be available fall 2003 - NEED IN SPRING 2003!!!!!!
- Switch by Syngenta
- Omega (fluazinam)

“To Do” List

Research
- Research is needed on Serenade (a biological) on how to use and its potential efficacy

Regulatory
- Pipeline products, especially BASF 510, should have their registration accelerated in order to replace Benomyl and Ronilan and Switch

Downey Mildew

Biology and Life Cycle
- A new race “E” is the main problem in some bean production areas. Resistant strains to this race are not yet available.
- Conditions favorable for disease development: >1.2 inches rain/7 days + average daily temperatures < 78^{o}F (25.6^{o}C). Periods of fog or heavy dew lower the amount of rainfall necessary for infection.
- If a period of 90^{o}F occurs, the cycle is broken and an additional 7 day period with the above weather conditions is necessary to start infection.

Distribution and Importance:
- Information not provide

Chemical Controls:
- Information not provided

Pipeline Products
- None listed

Non-Chemical Controls:
- None listed

“To Do” List

None listed

Bacterial Brown Spot (*Pseudomonas syringae* PV. Syringae)

Biology and Life Cycle:

- Caused by a rod-shaped gram -negative bacteria.
- Overwinters in weeds such as hairy vetch and other perennials that remain green throughout the winter.
- In wet weather, diseased plant leaves may be covered with bacterial exudate, which is splashed to healthy tissue by rain or irrigation.
- Enters the plant through stomata or injuries.
- Optimum temperature for disease development is 60-90 degrees F.
- Disease is worse when there is excessive rain, long periods of leaf wetness, or wind or hail damage.
- Have to have 1 million bacterium per leaf to have inoculation.

Distirbution and Importance:

- Rarely kills the affected plant. In severe infestation all foliage may be destroyed and yields reduced.
- More of an issue with pod quality as it distorts and blemishes pods.
- 20% to 30% of acres affected each year and lower value by >20% because of early harvest.
- Weather and variety response. Storms cause damage to crop making it more susceptible.
- Not economically important on lima beans

Non-Chemical Controls:

- Resistant varieties
- Control weed hosts - especially hairy vetch
- Quality seed from arid seed production area

Chemical Controls:

Streptomycin sulfate

- Level of Control = seed treatment only, controls seed borne risk, doesn't have any effect on foliar infection because of in-field sources of inoculum
- REI = ? PHI = ?

Copper hydroxide (Kocide, Champ)

- Level of Control = poor to fair, variable control, depends on timing and weather pressure
- Need good coverage, high volume of application
- REI =   PHI =0d

Pipeline Products

- None listed

"To Do" List

Research

- Research the efficacy of Oxidate on beans in the Midwest (now only used in Florida)
- Develop better varieties with field tolerance to bacterial brown spot
- Evaluate the efficacy of TM 416???
- Develop a disease prediction based on assay, etc

Viruses

Mosaic virus disease outbreaks in peas can result in economic loss, but this is usually not the case. The pea mosaic viruses survive between crops in weeds and ornamental plants. In the spring, pea and potato aphids (*Acyrthosiphon pisum* & *Macrosiphon euphorbiae*) acquire the viruses as they feed on these infected plants. As the winged aphids migrate, the viruses are spread to the peas. Symptom expression usually occurs 10-13 days following inoculation. In years with mild winters and dry springs, aphids can survive in larger numbers and the likelihood of virus infection is increased.

Bean yellow mosaic virus is characterized by a yellow mottling on the stipules and leaves between the veins. Patches of normal green tissue of various sizes are scattered irregularly over the surfaces of both leaves and stipules. Plants become stunted if they are infected when young. The upper leaves and stipules become wrinkled and twisted or otherwise malformed. Pods may be fewer and smaller than normal. Severity of symptoms depends on the pea cultivar and environment.

Pea enation mosaic causes blister-like outgrowths from the lower leaf surface and pods. Scattered chlorotic areas may be apparent on the foliage. As the chlorosis progresses, a translucent 'window' may appear. Infected pods are severely deformed.

Red clover vein mosaic virus infections result in extremely stunted plants with veins cleared and a proliferation of axillary buds. The most conspicuous symptom is the brown to purple streaks that develop on pea stems. Barren pods may develop brown or purple spots.

Pea streak virus infection can kill seedlings of most pea cultivars. Plants infected later in the season exhibit leaf and stem spots and streaks that yellow the vascular system. Pod symptoms include spots and sunken lesions.

Cucumber mosaic virus

Distribution and importance:

- Alfalfa mosaic and cucumber mosaic are most important and can affect >30% of acres in the Midwest with annual average yield losses of 10-20%. Alfalfa mosaic may infest 30% of late plantings and cucumber mosaic 60% of late plantings. Alfalfa mosaic also affects lima beans.
- Virus severity correlates with annual distribution and activity of soybean aphid -they are known vectors.
- Not a problem in central Illinois yet.
- An issue of growing significance

Non-chemical controls:

- Some varieties vary in their response.
- Adjust planting date - less pressure in early planting.

Chemical Control:

- Aphid controls do not control the initial infection but can reduce the secondary spread (plant to plant).

To do List:

Research:

Because aphids are the principal vector of viruses the research and regulatory issues presented will be the same for each.

- Research is needed to develop vector models, to include the impact of weather on the movement and dispersal of aphids, This model may also investigate possible links with soybean cropping systems and with leaf hoppers.
- Research is also needed to develop a systems approach to maintaining low levels of insects to keep virus levels down.
- More needs to be known about field relevant host plants, overwintering sites, and inoculum sources for the virus.
- Plant breeders need to maintain a strong effort to breed virus resistance into plants.

Regulatory:

- Registration of Cruiser on soybean could prove to be an advantage for edible legumes in reducing aphids, and there are issues with Cruiser’s risk cup being full.
- If buckthorn were managed more carefully (it is a noxious weed) the viral inoculum level would be reduced and fewer insecticides would be necessary.

Table 3. Fungicide use on Edible Legumes (Estimated for 2003)

	Percent Crop Treated			Number of Appl.			Avg lbs a.i. per appl.		
	Snap	Lima	Pea	Snap	Lima	Pea	Snap	Lima	Pea
BASF 510									
Captan (seed trtmt)	70	80	100	-	-	50			
Chlorothalonil (Bravo)		10			1				
Copper Sulfate (Basicop 53WP)	20	10		1	1		1.0		

DCNA (Botran 75W)									
Coninthyrium (Intercept)									
Iprodione (Rovral 50W, WG)		10			1				
Maxim (Seed treatment)	40	40	100	-	-	-			
Metalaxyl (Apron seed trt)			100	-	-	-			
PCNB (Terraclor 75W)									
Quintozene									
Streptomycin sulfate	100								
Supranil 720 or Terranil 6L									
Thiophanate M (Topsin M)	50	80		1.2	1		1.4		
Thiram (seed treatment)	60	80		-	-	-			
Vinclozolin (Ronilan EG)	2	10		1	1				

Weeds in Peas and Beans

Non-chemical Weed Management Strategies:

- Non-chemical weed management practices that are beneficial are high plant populations, early planting dates, and crop rotation. At the high planting rates, the crop has better competitive abilities against weeds.
- For peas, early planting can aid weed suppression because as a cool season crop, they emerge prior to some of the weeds. This improves the pea's competitive ability against weeds.
- Crop rotation may reduce weed density during the year prior to peas or beans.
- Cultivation, where practical, is not a weed control option because the peas are drilled in narrow rows.
- Killing weeds immediately prior to planting is important to prevent weeds from emerging before the crop. Weeds that emerge before the crop are much more competitive than late emerging weeds.

Critical Weed Control Issues

- Broadleaf weed control, especially eastern black nightshade and Canada thistle control, is not as good as desired because the available herbicides often injure pea and bean plants. Despite such shortcomings in controlling certain weeds, there are no major crises in weed management as long as the current herbicide registrations, and the Section 18 for Reflex) are maintained.
- A key point is the lack of alternative herbicides to any current products due to either herbicide resistance or discontinued product registration. A major hole in weed control would quickly develop in the production system.

1. Annual grasses

Biology and Life Cycle:

- Grass weeds germinate at soil depths from 1/8th of an inch to 2 or 3 inches. Seed size and dormancy are the controlling factors for when and where these seeds emerge. Large seeded weeds have greater seed food reserves and can emerge from greater soil depths where moisture is less variable than near the soil surface.
- Weeds germinate at various times throughout the season depending on environmental cues such as moisture availability and soil temperature.
- Weeds produce prolific numbers of seeds which may lie dormant for very brief (2 weeks) or very long (30-50 yrs) periods before germination.
- Weed seeds are distributed by wind, rain, birds, and mechanical harvesting equipment.
- Cultivation is a significant factor for beans but not for peas.

Distribution and Importance:

- Annual grasses infest approximately 98% of all crop acres. Many of these are controlled with herbicide applications and tillage.
- Foxtails, wild proso millet, sandbur, and crabgrass are principle drivers in weed management decisions.
- Foxtails are the predominate grass weed but relatively easy to control with current herbicides.
- Crabgrass and sandbur are especially troublesome on sandy soils throughout the region.
- Grass weeds contribute to insect pressures and contamination in peas.
- Due to current herbicides, losses are minimal.

1a. Foxtails (*Setaria* spp.)

There are three important foxtail species: giant foxtail (*Setaria faberi),* yellow foxtail *(Setaria glauca)*, and green foxtail (*Setaria viridis).* At least one of these species can be found in nearly any field in the North Central Region. While low populations cause little crop competition, because of seed production an unchecked population can quickly become a severe problem. A primary control method for foxtail spp. is the application of preemergence grass herbicides. These provide early season control, reducing early season competition.

1b. Woolly cupgrass (*Eriochloa villosa* [Thunb.] Kunth.)

Woolly cupgrass is a relatively new and potentially serious weed problem in the states of Iowa, Illinois, Wisconsin and Minnesota. Its spread has increased rapidly in the last 10 to 15 years. This annual grass weed demonstrates biological, biochemical, and morphological characteristics that make it economically damaging and adds to the difficulty in developing effective management strategies. Woolly cupgrass is a prolific seed producer. The seed tends to germinate earlier and at higher populations than many other annual grass weeds. Woolly cupgrass has demonstrated tolerance to herbicides commonly used for control of annual grasses.

1c. Fall panicum (*Panicum dichotomiflorum*)

Fall panicum is a summer annual that grows best in warm, wet, fertile soils. The plant tillers profusely and in late August and September the tillers open and scatter hard-coated seeds. These seeds may remain viable for years, and fall panicum is most often a problem in reduced or no-till fields whose undisturbed soils are favorable for germination. Fall panicum has shown some tolerance to atrazine (used on corn crops), and can be a serious grass weeds in the region.

1d. Wild proso millet (*Panicum miliaceum*)

Wild proso millet is a summer annual that tends to be less common in no-till fields and in areas where popcorn and sweet corn production are prevalent. Legumes rotated with these crops may also be infested.

1e. Barnyardgrass (*Echinochloa crusgalli*)

This summer annual germinates from 0 to 4 inches deep in the soil. The seeds remain viable for several years, and plants may emerge throughout the summer. Barnyardgrass is most troublesome in low, moist, warm areas.

1f. Field sandbur (*Cenchrus pauciflorus*, also *C. longispinus*)

Field sandbur is a summer annual weed common in sandy soils. The bur of field sandbur can be a serious problem if it is harvested with the legume crop.

1g. Crabgrass spp. (*Digitaria* spp.)

A warm season grass most often troublesome in the southern region of the Corn Belt. The plants root at the nodes and due to a high root to shoot ratio may be very competitive where moisture is limiting. May be most severe during the late part of the growing season after herbicides have degraded and/or holes remain in the canopy. Tillage and row cultivation also help control.

1h. Volunteer corn (*Zea maize*)

Commonly found in any crop rotated with field corn. Most serious in years after infestations of stalk boring insects.

1i. Brome grasses (*Bromus* spp.)

Brome grasses include downy brome, Japanese brome, and cheat. If left uncontrolled these grasses will continue to pose a competitive threat to the crop.

1j. Bluegrass (*Poa annua*)

Bluegrass can become more of a problem under continuous no-till. Though populations do not grow at an explosive rate, control without tillage can be difficult.

Non Chemical Controls: See **Non-chemical Weed Management Strategies above**.

Chemical controls:

Acetamides:

Alachlor (Lasso)

- Level of control = fair to good, only labeled for lima beans
- Not used much
- REI= NA PHI 30d

Metolachlor (Dual II, Magnum, Cinch)

- Level of Control = fair to good control of foxtails
- Applied as a pre-emergence herbicide
- Used at a rate of 0.66 - 2.0 pt/A
- REI= 12hrs PHI = 50d
- Cool, wet weather can cause crop injury

Thiocarbamates:

EPTC (Eptam)

- Level of control = fair to good, only labeled on snap beans
- In some local areas, a product of choice

- Good tank mix with trifluralin for snap beans
- REI= 12hrs PHI = 50d

ACCase inhibitors:

Quizalofop (Assure II)

- Level of Control = good
- Antagonistic with broadleaf herbicides (should be applied either 7 days before or 24 hours after applications of Assure II.)
- Applied at a rate of 6-12 oz/A
- REI= 12hrs PHI = 30d

Sethoxydim (Poast)

- Level of Control = good
- Applied at a rate of 0.5-1.0 pt/A
- The higher rate can be used to control foxtails, fall panicum, barnyardgrass, and woolly cupgrass.
- REI = 12hrs PHI = 15d

Carotinoid inhibitors:

Clomazone (Command 4EC, 3ME) PEAS AND SNAP BEANS ONLY

- Level of Control = fair to poor
- Applied at a rate of 1/3 to 1 pt/A as a pre-plant incorporated treatment
- REI = 12hrs PHI = 45d
- Can cause carry over problems

EPSP Inhibitors:

Glyphosate (Roundup Ultra)

- Level of Control = excellent
- Applied pre-plow before planting peas at a rate of 1-3 qt/A.
- REI= 12hrs PHI = 65d
- Stale seed bed, preemergence only

Photosynthetic Inhibitors

Paraquat (Gramoxone MAX)

- Stale seed bed, preemergence only
- Used on replant acres or second plantings
- Level of control = good
- Works better for tank mixing than Roundup
- REI = 12hrs PHI =

ALS Inhibitors

Imazethapyr (Pursuit DG) regional label only (IL, MN, WI)

- Level of control = fair to good
- It can stunt peas and beans if cool and/or wet weather follows treatment
- Applied as a preplant treatment within 7 days of planting
- Used at 0.54 (snaps) and 0.54 to 1.08 (peas & limas) oz/A
- REI = 12hrs PHI = 30d

Imazimox (Raptor)

- Peas only in Midwest states
- Level of control = fair to good
- 4 oz.
- High potential for crop injury
- Use in sandy soil

Cell Division Inhibitors

Pendimethalin (Prowl)

- Level of Control = fair to good
- Applied as a preplant incorporated treatment
- Used at a rate of 1.2-3.6 pt/A
- Good crop tolerance on peas
- REI =12hrs PHI = 14d

Trifluralin (Treflan MTF)

- Level of Control = fair to good
- Used as a preplant incorporated treatment at a rate of 1.0-1.5 pt/A
- Trifluralin also helps to suppress *Aphanomyces* root rot
- REI = 12hrs PHI = 50d
- good crop tolerance

Other

DCPA (Dacthal)

- Level of control = good
- 6-14 lbs/A of 75W
- Plugs equipment easily
- REI = 12hrs PHI =

Pipeline products:

- Clethodim (Select)

2. Perennial grasses and sedges

Biology and Life Cycle:

- Although perennial grasses and nutsedges produce seed each year the primary mechanism of reproduction is through vegetative propagation.
- Tillage can be an effective mechanism of controlling perennial grasses but when done improperly may further distribute the weed throughout the field and exacerbate the problem.
- Quackgrass is a cool weather plant and grows aggressively early in the spring and in the fall. The other perennials listed tend to grow more actively during the late spring and summer.

Pest Distribution and Importance:

- Perennial grasses were once a severe problem prior to herbicides and when pasture was a standard part of the crop rotation. With the introduction of effective herbicides and decline in pasture rotations, many perennial grasses have declined in importance.
- Horsetail is a problem in some no-till fields. It is very hard to control as there are no herbicides that are effective.
- Quackgrass is the principle problem.
- Wirestem Muhly and yellow nutsedge are problems in lima beans due to lima beans being a longer season crop.
- Host to insect oviposition site causing contamination concern.
- Minimal losses with current controls.

2a. Quackgrass (*Elytrigia repens*)

Quackgrass is a perennial grass that spreads by rhizomes. These rhizomes are effectively spread by tillage, increasing the scope of the population in a field. Tillage is an effective control by depleting food reserves and bringing rhizomes to the surface.

2b. Wirestem muhly (*Muhlenbergia frondosa*)

Wirestem muhly is a perennial grass that reproduces by seeds and underground rhizomes. It is native to the Midwest. It was not considered a common row crop weed until the 1950's when serious infestations developed in cultivated fields. Delayed seedbed preparation will help control wirestem muhly by bringing rhizomes to the soil surface to dry out.

2c. Yellow Nutsedge (*Cyperus esculentus*)

Yellow nutsedge causes the most severe perennial weed infestations and is quite serious across the region. It reproduces from tubers as the seed does not survive overwintering, and tubers can adapt to almost any soil type and conditions. Tubers germinate at depths of up to 12 inches and may remain viable for up to three years in many soils.

2d. Horsetail (*Equisetum* spp.)

A problem in some very localized areas. Although seldom presenting an economic problem only tillage is effective for control.

Non Chemical Control: See **Non-chemical Weed Management Strategies:** above.

Chemical Control:

Acetamides:

Alachlor (Lasso)
- Level of control = fair to good, only labeled for lima beans
- Not used much
- Nutsedge only, no control of established perennial grasses
- REI= NA PHI 30d

Metolachlor (Dual II, Magnum, Cinch)
- Level of Control = fair control of nutsedge, no control of perennial grasses
- Applied as a pre-emergence herbicide
- Used at a rate of 0.66 - 2.0 pt/A
- REI= 12hrs PHI = 50d
- Cool, wet weather can cause crop injury

Thiocarbamates:

EPTC (Eptam)
- Level of control = poor to fair, only labeled on snap beans
- In some local areas, a product of choice
- Good tank mix with treflan for snap beans
- Suppresses nutsedge and quackgrass
- PHI = 50d REI= 12hrs

ACCase Inhibitors

Quizalofop (Assure II)
- Level of Control = fair to good control
- Antagonistic with broadleaf herbicides (should be applied either 7 days before or 24 hours after applications of Assure II.)
- Applied at a rate of 6-12 oz/A
- No control of nutsedge
- REI= 12hrs PHI = 30d

Sethoxydim (Poast)
- Level of Control = fair to good control
- Applied at a rate of 0.5-1.5 pt/A, high rate used
- The higher rate can be used to control perennial grasses
- No control of nutsedge
- REI = 12hrs PHI = 15d

EPSP Inhibitors

Glyphosate (Roundup Ultra)
- Level of Control = excellent
- Applied pre-plow before planting peas at a rate of 1-4 pt/A.
- REI= 12hrs PHI = 65d
- Stale seed bed, preemergence only

Photosynthetic Inhibitors

Paraquat (Gramoxone MAX)
- Stale seed bed, preemergence only
- Used on replant acres or second plantings
- Level of control = fair
- 1-2 pt/A
- Works better for tank mixing than Roundup
- REI = 12hrs PHI =

Pipeline products:
- Clethodim (Select)

3. Annual broadleaf weeds

Biology and Life Cycle:
- Broadleaf weeds germinate at soil depths from 1/8th of an inch to 3 or 4 inches. Seed size and dormancy are the controlling factors for when and where these seeds emerge. Large seeded broadleaf weeds have greater seed food reserves and can emerge from greater soil depths where

moisture is less variable than near the soil surface.

- Weeds germinate at various times throughout the season depending on environmental cues such as moisture availability and soil temperature.
- Weeds produce prolific numbers of seeds which may lie dormant for very brief (2 weeks) or very long (30-50 yrs) periods before germination.
- Weed seeds are distributed by wind, rain, birds, and mechanical harvesting equipment.

Distribution and Importance:

- Processors have contaminant issues with Nightshade, cocklebur, horsenettle, puncture vine, mustard, wild radish - plants run slower 10-15% of time.
- Growers have concerns with pigweeds, velvetleaf, lambsquarter.
- Harvest concerns with stem sections, seed heads and pods.
- Solanaceae species are a health risk.
- Harvest equipment capacity reduced 10-15% of the time, plants run slower 10-15% of time, growers see up to 30% yield reduction.
- Not uncommon to see crop injury from herbicides.

3a. Nightshade (*Solanum spp*)

This summer annual can produce thousands of berries; each berry contains up to 50 seeds. This weed is especially noxious in pea production where the berries can infest the harvested crop. While nightshade is generally not considered a serious pest in the Corn Belt, severe infestations in individual fields do occur. Tillage and row cultivation are effective for early, newly emerged seedlings.

3b. Common Cocklebur (*Xanthium strumarium*)

Common cocklebur is a summer annual weed. Its seeds are spread by attaching to animal fur or by tillage or harvesting equipment. Cocklebur is a serious competitor for moisture. Cultivation and tillage will all help control cocklebur establishment.

3c. Common Lambsquarters (*Chenopodium album*)

Common lambsquarters produce numerous small seeds which germinate after an overwintering process. Optimal temperature for germination is 70F, but can germinate between 40 to 94, which suggests early germination capabilities. Survival is favored by rains that dilute or leach herbicides from the soil surface.

3d. Common Ragweed (*Ambrosia artemisiifolia*)

Common ragweed is a summer annual that is favored by moist soils and can be a serious problem in individual fields. Control of common ragweed with tillage or row cultivation is effective in controlling small seedlings.

3e. Giant Ragweed (*Ambrosia trifida*)

Wet weather favors giant ragweed, and this summer annual may be a severe problem in isolated fields. The seeds of giant ragweed may remain viable in the soil for several years. Small seedlings can be controlled with row cultivation and tillage.

3f. Jimsonweed (*Datura stramonium*)

Jimsonweed produces several hundred hard-coated seeds per plant that may remain viable in the soil for years. This summer annual grows best under warm temperatures and moist soils. Jimsonweed infestations harm crops via competition for water, especially in dry years. The shade of its leaves in shorter crops increases yield loss due to decreased nutrient uptake. Jimsonweed also contains the alkaloids, atropine, hyoscyamine, and hyoscine, which are toxic. Even small amounts of jimsonweed can cause harvest problems.

3g. Kochia (*Kochia scoparia*)

Kochia is similar to common lambsquarters in many respects. It produces numerous small seeds and can germinate early in the season. Kochia has also developed resistance to a number of herbicides including triazines and ALS compounds. Although not distributed as widely as lambsquarters, kochia has been expanding from small infestations started along rail and road systems where seed has been carried in.

3h. Morningglories (*Ipomoea* spp.)

Tall morningglory and ivyleaf morningglory are the two major annual morningglory species found in the Corn Belt. The seeds of these summer annuals may survive for several years in soil. Infestations are most common in moist soils along river bottomland, but these plants can be found most anywhere in the states. Annual morningglories adapt to crops by vining about the crop, so shading by the canopy is not particularly successful in reducing growth. Newly emerged seedlings can be controlled by tillage and cultivation, but this may result in conditions that favor emergence by weeds deeper in the soil profile. After vines begin to twine about the stems of the crop, cultivation may not be as effective.

3i. Pennsylvania Smartweed (*Polygonum pensylvanicum*)

This summer annual grows best on wet soils and is widely distributed across the Midwest. Smartweed emerges early in the spring and can be a severe problem if tillage is delayed to wet soils, as seedbed preparation may result in transplanting larger plants rather than destroying them.

3j. Pigweeds (*Amaranthus retroflexus*, *A. hybridus*, *A. powellii*)

Pigweeds are prolific seed producers, and one plant can produce over 100,000 seeds in one growing season. The seeds of this plant may remain viable for years. Pigweeds are a problem in no-till systems because undisturbed soils favor germination of the minuscule seeds, and the debris keeps the field moist and allows for extended germination. Other favorable germination locations are where excess nitrogen is available, and where no soil applied herbicides have been used. Localized populations of some biotypes of pigweed have shown triazine or acetolactate synthase (ALS)-inhibitor resistance.

3k. Velvetleaf (*Abutilon theophrasti*)

Velvetleaf is a serious competitor for moisture in drought conditions. Cultivation can somewhat control velvetleaf when used in the early season. Velvetleaf seed pods are a serious contaminant of snap beans with current commercial harvesters. This weed also can be a host of Bacterial Brown Spot, Cucumber Mosaic Virus, and white mold. Velvetleaf is a larger seed with longer longevity for seed germination.

3l. Waterhemp (*Amaranthus tuberculatus*, *A. rudis*)

Common waterhemp is a native species and is a serious weed problem throughout the Corn Belt. Changes in agricultural practices that favor this weed include reductions in tillage, herbicide selection, simplified crop rotations, and recent weather patterns. There are also many indigenous factors that have contributed to the increase in common waterhemp populations. These include seedling emergence late in the growing season, high seed production and an ability to germinate from shallow soil depths. Control of common waterhemp has become increasingly difficult due to resistance to many common herbicides. Waterhemp has demonstrated cross-resistance to herbicides with the ALS inhibition mode of action, as well as to triazine compounds.

3m. Wild Buckwheat (*Polygonum convolvulus*)

An occasional summer annual weed. Wild buckwheat has a vining habit and is usually difficult to control with most herbicides.

3n. Common sunflower (*Helianthus annuus*)

Commonly found throughout the Midwest. Common sunflower is an annual weed that can germinate from depths of 3 or 4 inches in the soil and grows to 4 to 9 feet in height.

3o. Marsh Elder (*Iva xanthifolia*)

An occasional weed in row crops more typically found west of the Mississippi river. Usually found along roadsides, ditches, and in pastures or farm yards.

3p. Wild radish (*Raphanus raphanistrum*)

An annual or winter annual weed of Minnesota, Wisconsin and Michigan. Commonly found in cereal crops and in wastelands.

3q. Mustards

Mustard species include field pennycress (*Thlaspi arvense*), wild mustard (*Brassica kaber*), tansy mustard (Descurainia pinnata), shepherd's-purse (Capsella bursa-pastoris), yellow rocket (*Barbarea vulgaris*), and the pepperweeds (*Lepidium* spp.) Although a number of herbicides may control some mustard species, the presence of mature (large) mustards in the fields early in the season often limits which herbicides may be applied. Though usually less aggressive than henbit and common chickweed in terms of population expansion, they are serious competitors with crops. Mustard seed pods are a serious noxious contaminant of processed peas.

3r. Puncture vine (*Tribulus terrestis*)

A summer annual that produces seeds with stiff spines. Puncturevine seed pods are a serious contaminant of processed snap beans, as they stick to the fleshy pods and are carried into finished product, causing serious injury when the consumer chews the beans.

3s. Common purslane (*Portulaca oleracae*)

A low growing weed that has fleshy leaves and stems that can often survive mechanical cultivation.

3t. Volunteer potato (*Solanum tuberosum*)

A common problem in many fields that are rotated with potato production fields. Volunteer potatoes are a host for insect pests of snap beans and peas as well.

3u. Galinsoga (Galinsoga ciliata)

Produces seed prolifically. Moderate growth height.

3v. Pineapple weed (Matricaria discoidea)

A weed with aromatic characteristics. Grows early in the season. The seed head can easily become a contaminant of peas.

3w. Common Chickweed (*Stellaria media*)

A common weed which produces prolific amounts of seed and a thick mat of low vegetative growth. Can remove much soil moisture and, if untreated, can seriously affect crop establishment and growth in dry years.

3x. Horseweed (Marestail) (*Conyza canadensis*)(previously *Erigeron canadensis*)

This weed is becoming much more common throughout the Midwest due to reduced tillage. It produces a large amount of seed that is wind borne. Resistant biotypes of this weed to glyphosate have been identified.

3y. Henbit (*Lamium amplexicaule*)

This plant is a low growing (5 to 9 inches) winter annual. It can produce a thick mat of growth early in the season and pull needed moisture from the soil.

3z. Field Pansy (*Viola sp*)

A low growing winter annual plant (4 inches or less) that is an occasional weed. Field Pansy has yellow to blue flowers and sets seed in May. While they do compete for water early in the season they are much less of a concern later in the season as they tend to decline in hot weather.

3aa. Wild Lettuce (*Lactuca spp*)

Encompasses annuals, winter annuals, and perennial species. They are usually quite noticeable early in the spring and will be much more of a problem in minimum till fields.

Non Chemical Control: See **Non-chemical Weed Management Strategies:** above

Chemical Control:

Acetamides:

Alachlor (Lasso)

- Level of control = fair to good, only labeled for lima beans
- Not used much
- REI= NA PHI 30d

Metolachlor (Dual II, Magnum, Cinch)

- Level of Control = fair to good
- Applied as a pre-emergence herbicide
- Used at a rate of 0.66 - 2.0 pt/A
- REI= 12hrs PHI = 50d
- Cool, wet weather can cause crop injury

Thiocarbamates:

EPTC (Eptam)

- Level of control = fair to good, only labeled on snap beans
- In some local areas, a product of choice
- Good tank mix with treflan for snap beans
- PHI = 50d REI= 12hrs

Carotenoid inhibitors

Clomazone (Command 4EC, 3ME) Peas and snap beans only

- Level of Control = excellent (control of velvetleaf only)
- Applied at a rate of 1/3 to 1 pt/A as a pre-plant incorporated treatment
- REI = 12hrs PHI = 45d
- Can cause carry over problems

EPSP Inhibitors

Glyphosate (Roundup Ultra)

- Level of Control = excellent
- Applied pre-plow before planting peas at a rate of 1-4 pt/A.
- REI= 12hrs PHI = 65d
- Stale seed bed, preemergence only

ALS Inhibitors

Imazethapyr (Pursuit DG) regional label only (IL, MN, WI)

- Level of control = fair to good
- It can stunt peas and beans if cool and/or wet weather follows treatment.
- Applied as a preplant treatment within 7 days of planting
- Used at 0.54 (snaps) and 0.54 to 1.08 (peas & limas) oz/A
- REI = 12hrs PHI = 30d
- Nightshade material only on snap beans
- Rotation restriction issues

Imazimox (Raptor)

- Peas only in Midwest states
- Level of control = fair to good
- 4 oz.
- High potential for crop injury
- Use in sandy soil
- For control of nightshade only

Halosulfuron (Sandea) SNAP BEANS ONLY

- New label
- Plant back restrictions
- Level of control = fair, good on nutsedge and sand bur
- REI = PHI =

Dinitroanilines

Pendimethalin (Prowl)

- Level of Control = fair to good
- Applied as a preplant incorporated treatment
- Used at a rate of 1.2-3.6 pt/A
- Good crop tolerance on peas
- REI =12hrs PHI = 14d

Trifluralin (Treflan MTF)

- Level of Control = fair to good
- Used as a preplant incorporated treatment at a rate of 1.0-1.5 pt/A
- Trifluralin also helps to suppress *Aphanomyces* root rot
- REI = 12hrs PHI = 50d
- Good crop tolerance

Other herbicides

DCPA (Dacthal)

- Level of control = good
- 6-14 lbs/A of 75W
- Plugs equipment easily

Photosynthetic Inhibitors

Paraquat (Gramoxone MAX)

- Stale seed bed, preemergence only
- Used on replant acres or second plantings
- Level of control = good

- , Works better for tank mixing than Roundup
- , REI = 12hrs PHI =

Bentazon (Basagran)

- , Level of control = fair to good post emergence control of velvetleaf and wild mustard and provides partial control of hairy nightshade, common lambsquarters, when applied to very small seedlings.
- , Applied at a rate of 1.5-2.0 pt/A
- , PHI = 30d REI = 12hrs
- , Can't use crop oil in peas
- , Under stressed conditions, run risk of crop injury

MCPA (MCPA) PEAS ONLY

- , Level of control = fair control. However, it is weak on Eastern black nightshade and smartwee.
- , Applied at a rate of 0.25-0.75 pt/A
- , It is important not to use MCPA when temperatures exceed 80 F to prevent burning of plants
- , Applied post emergence
- , PHI = REI =

MCPB (Thistrol) PEAS ONLY

- , Applied post emergence
- , Level of Control = fair to good control of many annual broadleaf weeds. It is not effective in controlling smartweed, mustards. Good on giant ragweed.
- , Applied at a rate of 2-3 pt/A, and should not be applied if soils are waterlogged or during drought
- , PHI = REI =

Pipeline Products:

Fomesafen (Reflex) - snap beans only

puncture vine control

tank mix with Basagran provides excellent weed control

Halosulfuron (Sandea) - for peas

Flufenacet (Axiom) - for snap beans

some trial work has been done on peas

Sulfentrazone (Authority, Spartan) - for peas

4. Perennial broadleaf weeds

Biology and life cycle:

- While perennial weeds do produce seeds, the majority of plants listed propagate through vegetative means.
- Most perennial weeds begin growth early in the season before crops are planted and may also have a very active period of growth after the crop has been harvested.
- Tillage can be effective for controlling many perennial weeds but it may also distribute viable rhizomes, roots, and tubers throughout the field if done improperly.

Distribution and Importance;

- Canada thistle - bud contaminant and serious yield loss problem
- Horsenettle is a contaminant in peas, snap and lima beans
- Hemp dogbane and field bindweed are patchy weed or edge problems
- Losses account for 2-5% overall, 10% of fields have problems

4a. Common Milkweed (*Asclepias syrica* L.)

This perennial weed reproduces by seeds and adventitious buds that sprout from underground roots. Seedlings produce vegetative buds 18-21 days after germination, and seeds may remain viable for up to three years. Seeds may germinate from as deep as 2 inches in the soil, and undisturbed fields or fields with reduced tillage and moist soils are favored. Problems with common milkweed have been increasing due to the decrease in tillage and row cultivation.

4b. Canada thistle (*Cirsium arvense*)

Canada thistle is a perennial weed with a vigorous, rhizome-like root system. Propagation is by rootstock and seeds; only female plants produce seed. Preplant tillage and row cultivation can control small seedlings but are less effective in controlling plants arising from rootstocks. The flower bud from this plant can be a contaminant in pea production and is especially noxious.

4c. Field bindweed (*Convolvulus arvensis*) and hedge bindweed (*Calystegia sepium*)

These weeds are vining weeds commonly found in both cultivated and no-till fields. These weeds can rapidly engulf the rows in vines reducing growth and yield. The extensive mass of vines also makes harvest very difficult.

4d. Hemp dogbane (*Apocynum cannabium*)

This perennial weed is capable of regrowth from perennating rootstock within six weeks of emergence. The underground root system may extend laterally 20 feet per year and downward as far as 14 feet. The central portion of the Corn Belt is usually most severely infested with dogbane. Tillage can reduce dogbane infestations, but is ineffective once populations are established.

4e. Swamp smartweed (*Polygonum amphibium* Muhl. ex Willd)

Swamp smartweed is commonly found in low, wet areas of fields. Because of an extensive root system it is a strong competitor and difficult to eradicate. Because of its similarity to Pennsylvania smartweed, an annual, many producers incorrectly identify this weed.

4f. Bigroot Morningglory (*Ipomoea pandurata*)

Bigroot morningglory is becoming more common. It produces a tuber that can reach eight inches in diameter and several feet deep. When the new vines emerge they are purplish in color. Control almost invariably will require many repeated treatments.

4g. Pokeweed (*Phytolacca americana*)

Pokeweed is becoming more important as a weed throughout the eastern section of the Corn Belt. It tends to be hard to kill and severe infestations can cause contamination of grain that can result in its rejection by elevators.

4h. Dandelion (*Taraxacum officinale*)

Dandelion is a common perennial throughout the Midwest. It is an opportunistic plant, colonizing areas of disturbed soil or open spaces. It produces numerous seeds that may be widely dispersed.

4i. White Cockle (*Lychnis alba*)

A biennial or short lived perennial that reproduces primarily by seed. It flowers throughout the summer and will be more of a problem where reduced tillage systems are common.

4j. Horsenettle (*Solanum carolinense*)

Propagates by rhizomes and seed. Mostly a problem in minimum tilled fields, or in fields not recently tilled. Horsenettle berries are a serious noxious contaminant of snap beans and lima beans.

Non Chemical Control: See **Non-chemical Weed Management Strategies:** above

Chemical Control:

EPSP Inhibitors

Glyphosate (Roundup Ultra)

- Level of control = excellent
- Applied pre-plow before planting peas at a rate of 1-4 pt/A
- REI= 12hrs PHI = 65d
- Stale seed bed, preemergence only

Photosynthetic Inhibitors:

Paraquat (Gramoxone MAX)

- Stale seed bed, preemergence only
- Used on replant acres or second plantings
- Level of control = fair
- Works better for tank mixing than Roundup
- REI = 12hrs PHI =

ALS Inhibitors

Imazimox (Raptor)

- Peas only in Midwest states
- Level of control = poor
- 4 oz.
- High potential for crop injury

- Use in sandy soil
- REI =   PHI =

Bentazon (Basagran)

- Level of control = fair suppression of Canada thistle
- Applied at a rate of 1.5-2.0 pt/A
- REI = 12hrs PHI = 10d on peas, 30d on snap beans
- Can't use crop oil in peas
- Under stressed conditions, run risk of crop injury

Growth Regulators

MCPA (MCPA) Peas only

- Level of control = fair
- Applied at a rate of 0.25-0.75 pt/A
- It is important not to use MCPA when temperatures exceed 80 F to prevent burning of plants
- Applied post emergence
- PHI =   REI =

MCPB (Thistrol) PEAS ONLY

- Applied post emergence
- Level of Control = fair Canada thistle bud suppression
- Applied at a rate of 2-3 pt/A, and should not be applied if soils are waterlogged or during drought
- PHI =   REI =

Pipeline Products:

Fomesafen (Reflex) - snap beans only

- Puncture vine control
- Bindweeds and big root morning glory
- Tank mix with Basagran for improved control

"To Do" List (Summary for all weeds)

- Need to keep 2,4-D registered for broadleaf weeds in crops in the year prior to planting edible legumes as a means of reducing seed bank populations.
- More information is needed on the possible role of 2,4-D type herbicides used in a rotation or systems approach. (Where does it work/not work?)
- Basagran's 30 day PHI for snap beans needs to be shortened to 10 days to permit its use.
- A full registration for Reflex is needed to expand broadleaf weed control options.
- Research is necessary to screen products and develop a systems approach for weed control. This system should look at nightshade control, crop injury, herbicide carryover, and other factors.
- More research is needed on a systems approach for weed control that includes various tillage regimes. Currently there are problems with harvesting some no-tilled fields.
- More research is needed on basic weed biology and ecology. This information needs to be provided to growers.
- Research is necessary to measure the negative impact of Farm Programs (Conservation payment programs) on pest management in minor crops (non-base commodities).
- More information is also necessary on the impact of GMO crops on minor crops.

Table 4. Herbicide Use on Edible Legumes (Estimated for 2003)

Herbicide	Percent crop treated			Number of appl.			Avg lbs a.i. per A		
	Snap	Lima	Pea	Snap	Lima	Pea	Snap	Lima	Pea
Alachlor (Micro-tech)	10	5	5	1	1				
Bentazon (Basagran)	55	60	30	1	1		1		.75
Clomazone (Command)	1	X	3	1	X			X	.25

DCPA	-	X	-	-	X	-	-	X	-
EPTC	22	-	X	1	-	X			X
Glyphosate (Roundup)	5	5	15	1	1		1		
Halosulfuron (Sandea)	1	X	X	1	X	X		X	X
Imazethapyr (Pursuit)	20	85	65	1	1				
Imazimox (Raptor)	3	-	5	1	-				
Metolachlor (Dual)	50	60	35	1	1		1.9		
Paraquat (Gramoxone)	1	-	-	1	-	-			
Pendimethalin (Prowl)	30	85	40	1	1		.5		
Trifluralin (Treflan)	30	50	35	1	1		.5		
Sethoxydim (Poast)	40	-	X	1	-	X	.156		X
MCPA	X	X	5	1	X	1	X	X	.65
MCPB	X	X	5	1	X	1	X	X	.5

Appendix A Field events and worker exposure.

The following tables show the field events in peas and beans that are expected to affect the exposure level of agricultural workers. Although it is possible to estimate the total time in the field by various workers it is not possible to determine from these numbers the exact level of exposure. For example, during many pest scouting events the scouts simply walk a (somewhat) random path among the plants in the field with little or no actual contact with pesticide residues on the soil or plants. It is possible though that during some insect or disease scouting events that the scouts may have to handle many plants and come in close contact with many others.

Peas	Figures are relative to a 100 acre field		
In-field event	Number of people involved in event	Hours per event X number of events	Total event hours per season
Planting	1	10 X 1	10
Irrigation	1	.25 X 4	1
Scouting	1	1 X 3	3
Pre-grading 5 days to harvest	1	.2 X 5	1
chemical app: weeds (ground)	1	2 X 1.5	3
chemical app: diseases	0	0	0
chemical app: insects (aerial)	1	1 X 1	1
harvest-mechanical	6	10 X 1	10

Lima & Snap Beans	Figures are relative to a 100 acre field		
In-field event	Number of people involved in event	Hours per event X number of events	Total event hours per season
Planting	1	10 X 1	10
Irrigation	1	.25 X 8	2
Scouting	1	.5 X 6	3
Cultivation	1	1.5 X 10	15
Pre-grading 5 days to harvest	1	.5 X 4	2
chemical app: weeds (ground)	1	2 X 2	4
chemical app: diseases (aerial)	1	1 X 1	1
chemical app: insects (aerial)	1	1 X 3	3
harvest-mechanical	5	8 X 1	8

Appendix B Herbicide Modes of Action

ALS-inhibitors and amino acid derivatives (HRAC code B)
inhibits amino acid synthesis (ALS acetolactate synthetase), which is first step in amino acid synthesis (proteins not replenished & growth ceases): flumetsulam, halosulfuron, imazapyr, imazethapyr, nicosulfuron, primisulfuron, rimsulfuron

PSII inhibitors (non-mobile) (HRAC code C3)
prevent electron transfer, excess electrons develop and results in formation of singlet oxygen O2- and HO- which destroys lipid membranes: bentazon, bromoxynil

PSII inhibitors (mobile) (HRAC code C1)
blocks electron flow in PSII (Hill) reaction, preventing electron transfer, excess electrons develop and breakdown cells: atrazine, cyanazine, metribuzin, simazine

Root-mitosis- inhibitors (HRAC code K1)
disrupt mitosis by inhibiting tubulin-spindle apparatus formation during cell splitting: pendimethalin

Shoot inhibitors (HRAC code K3)
inhibition of lipid synthesis but other processes also active: acetochlor, alachlor, dimethenamid, EPTC, flufenacet, metolachlor

Growth-hormone- regulator (HRAC code O)
stimulates irregular cell growth and may loosen connections between cell walls, other processes also active: 2,4-D, clopyralid, dicamba

Pigment synthesis inhibitor (HRAC code F2)
affect enzymes of carotenoid synthesis which prevents chlorophyll formation (unknown target enzyme): impinging light develops free radicals for further destruction: isoxaflutole, mesotrione

Protein synthesis inhibitors (HRAC code G)
inhibits amino acid synthesis EPSP synthase (amino acids are not replaced): glufosinate, glyphosate

ACCase inhibitors (HRAC code A)
inhibits acetyl CoA carboxylase with lipid synthesis in meristem primarily affected, lipids not replenished: sethoxydim, quizalofop, fluazifop, clethodim

PPO inhibitors (HRAC code E)
inhibition of protoporphyrinogen oxidase (PPO) results in development of free radical and lipid: peroxidation (breakdown of chloroplasts ect)

Appendix C Fungicide Modes of Action

Information abstracted from:
http://www.ndsu.nodak.edu/instruct/gudmesta/lateblight/Modified/PDFdocuments/fungicides.PDF
Not all products listed may be registered for field corn.

Protectants
Dithiocarbamates: ferbam, thiram, ziram:
Interfere with oxygen uptake and inhibition of sulfur containing enzymes
Ethylenebisdithio-carbamates EBDCs: mancozeb (Manzate, Dithane M-45, Penncozeb, Fore), maneb (Dithane M-22), zineb (Zineb)
Breaks down to cyanide, which reacts with thiol compounds in the cell and interferes with sulfhydryl groups
Phenylpyroles: fludioxonil (Maxim), fenpiclonil:
Affects membrane transport
Phenylthalimides: captan (Captan 50WP, Captan 80WP, Captec 4L):
Degrades to thiophosgene which inhibits fungal enzymes
Substituted Benzenes Pentachloronitrobenzene or PCNB (Terraclor, Turfcide, Blocker), Chlorothalonil (Bravo, Daconil, Echo, Evade, Equus)
PCNB induces lysis of mitrochondrial membranes
Chlorothalonil inhibits sulfur-containing enzymes

Curatives
Benzimidazoles: benomyl (benlate), Thiabendazole (Mertect), thiphanate-methyl (Topsin-M) Inhibition of mitosis by preventing polymerisation of beta-tubulin
Dicarboximides: iprodione (Rovral, Chipco 26019), vinclozolin (Ronilan)
Unknown mode of action
Phenylamides (Acylalanines) metalaxyl (Ridomil, Subdue, Apron) mefenoxam (Ridomil Gold, Subdue Gold, Apron XL) fluoronil (Ultraflourish)
RNA synthesis inhibition

Sterol inhibitors
Triazoles: triadimefon (Bayleton), triadimenol (Baytan), propiconazole (Tilt, Orbit, Break, Banner), myclobutanil (Rally, Nova, Eagle), cyproconazole (Sentinel, Alto), tebuconazole (Folicur, Elite, Raxil), fenbuconazole (Indar, Enalbe, Govern), difenconazole (Dividend), hexaconazole (Anvil), tetraconazole (Emminant), flusilazone, epoxiconazole, flutriafol (Impact)
Inhibition of sterol biosynthesis (demethylation inhibitors DMI)

Strobilurins
Beta-methoxyacrylates: azoxystrobin (ICIA5504, Abound, Quadris, Heritage) trifloxystrobin (Flint)
Disruption of electron transport in cytochrome bc1 complex

Appendix D Insecticide Modes of Action

Growth Regulators

These compounds are either hormone mimics or enzyme inhibitors. Some (like methoprene), are analogs to insect juvenile hormones. Their presence causes the larvae of target insects to remain in a juvenile state. Unable to molt, the larvae eventually die. Since they act like hormones, they are effective at very low concentrations, and can be applied at very low rates. Since most vertebrates (all mammals) do not have receptors for such hormones, they are unaffected by these compounds. The low effective rate and low mammalian toxicity make them very safe. Aquatic crustaceans and some fish, though, seem to have analogous hormones and are quite sensitive to these compounds.

Benzimidazoles

These pesticides are also enzyme inhibitors. They inhibit enzymes involved in assembly of glucose transport structures in the intestines of target pests (roundworms and flatworms). Not being able to absorb glucose, the worms eventually die. Mammals do not have these enzymes and are thus relatively insensitive to these compounds. (Some, such as fenbendazole, also have anti-fungal activity.)

Avermectins

Avermectins are a group of compounds obtained from a common soil fungus (actinomycete). They act on GABA (gamma-aminobutyric acid) receptor sites. GABA is an inhibitory neurotransmitter and acts to limit the transmission of nerve impulses. The avermectins act to keep open a chloride ion channel that controls the GABA receptor. Thus, when avermectin molecules are present, the neuron continues to fire at a high rate, which paralyzes the muscles involved. The only place in mammals where GABA and GABA receptors are found is in the brain (where it is the major inhibitory neurotransmitter). Since avermectins cannot cross the blood-brain barrier except at levels much higher than normal therapeutic levels, these compounds are relatively non-toxic to mammals. In insects and roundworms, GABA receptors are found distributed throughout their nervous systems, particularly in skeletal or body muscles.

Organophosphates

Organophosphate compounds cause an irreversible modification of acetylcholinesterase. When this enzyme is deactivated, acetylcholine in synapses is not broken down after its use and continues to cause the receiving neuron to fire. This leads to convulsions and paralysis of the muscle cells involved. Since acetylcholine is the main neurotransmitter between nerve cells in all type of mammalian tissues, these compounds are usually quite toxic to mammals as well as to other vertebrates and insects. In some cases, mammals have enzymes that can degrade certain organophosphate compounds (such as malathion), and these particular compounds are not quite as toxic as the others.

Pyrethroids

Pyrethrum, the original pyrethroid, was obtained from flowers of a tropical chrysanthemum species. However, most pyrethroids currently in use are synthetic, though their basic structure is patterned after natural pyrethrins. They act on the axon of the neuron on the transmitting side of a synapse. They either cause a sodium ion channel on that axon to stay open too long or they prevent it from closing. This causes the neuron to either transmit a very weak pulse or to fire repetitively. The muscle cells involved thus do not receive the nerve impulse or they are overexcited. In either case, the muscles are paralyzed. Mammalian sensitivity is much lower than that of insects because of fewer binding sites and because the pyrethroids can be broken down by esterases in mammalian cells.

Imidothiazoles

The imidothiazoles bind to acetylcholine receptors on the receiving side of a synapse. This, of course, causes the receiving neuron to fire just as if acetylcholine had bound to the site. However, the imidothiazole molecule cannot be broken down and inactivated by cholinesterase so the nerve cell continues to fire. This results in spastic paralysis of the muscle cells involved.

Pyrimidines

These have the same mode of action as the imidothiazoles (acetylcholine mimic).

Organochlorines

Work by overstimulating the nervous system causing convulsions and uncontrolled muscle movements. These products are not cholinesterase inhibitors. Lindane is an example of an organochlorine.

Carbamates

These have essentially the same mode of action as organophosphate insecticides. Carbofuran is an example of a carbamate insecticide.

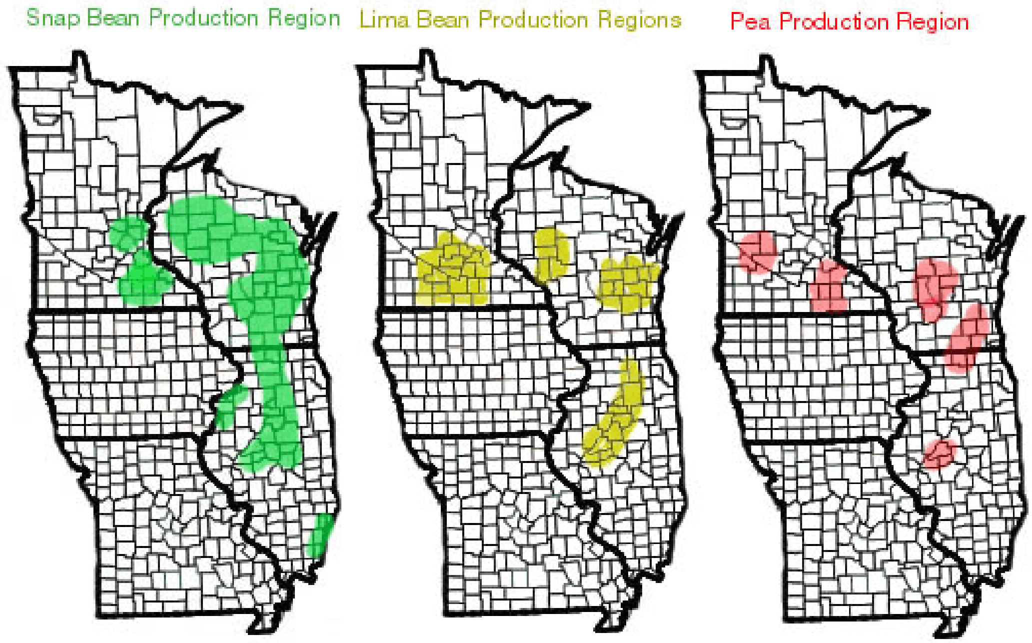
Appendix E Active Ingredient and Mode of Action for List

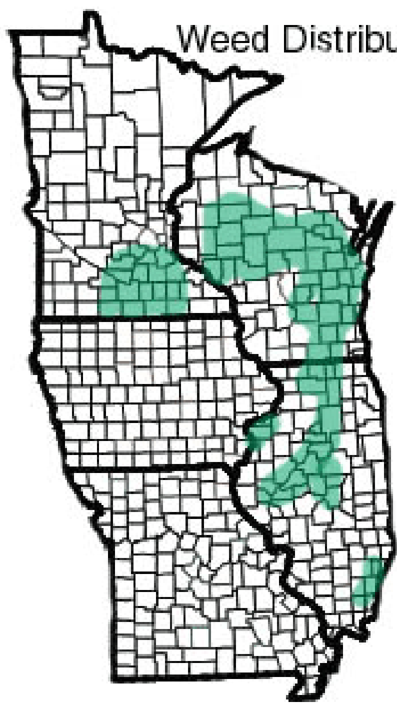
	Active Ingrediant (ai)	Trade name	Class
Insecticides	*Bacillus thuringiensis*	Dipel, MVP, Javelin	Biological
	Bifenthrin	Brigade, Capture	Pyrethroid
	Carbaryl	Sevin	Carbamate
	Carbofuran	Furadan	Carbamate
	Chlorethoxyfos	Fortress	Organophosphate
	Chlorpyrifos	Lorsban	Organophosphate
	Cyfluthrin(+Tebupirimphos)	Aztec, Baythroid	Pyrethroid + Organophosphate
	Diazinon (+Lindane)	Kernel Guard	Organophosphate + Organochlorine
	Dimethoate	Cygon	Organophosphate
	Esfenvalerate	Asana	Pyrethroid
	Fipronil	Regent	Phenylpyrazole
	Imidacloprid	Gaucho, Gaucho Xtra, Prescribe	Chloronicotinyl
	Lambda-cyhalothrin	Warrior	Pyrethroid
	Lindane (+Diazinon)	Kernel Guard	Organochlorine + Organophosphate
	Methyl Parathion	Penncap-M	Organophosphate
	Methomyl	Lannate	Carbamate
	Permethrin	Ambush, Pounce	Pyrethroid
	Permethrin	Kernel Guard Supreme	Pyrethroid
	Phorate	Thimet	Organophosphate
	Tebupirimphos + Cyfluthrin	Aztec, Baythroid	Organophosphate + Pyrethroid
	Spinosad	Tracer	Biological (Naturalyte)
	Tefluthrin	Force, Force ST, Proshield	Pyrethroid
	Terbufos	Counter	Organophosphate
Fungicides	Azoxystrobin	Quadris	Triazole
	Captan	Captan	Phenylthalimide
	Chlorothalonil	Bravo	Substituted Benzene
	Fludioxonil	Maxim	Phenylpyrole
	Mancozeb	Dithane, Mancozeb	Ethylenebisdithiocarbamates
	Metalaxyl	Apron	Phenylamide
	Propiconazole	Tilt	Triazole
			Class fb HRAC Mode of Action
Herbicides	2,4-D	Many on the market	Chlorinated phenoxy O
	Acetochlor	Doubleplay, Harness, Surpass, (in FulTime)	Acetamide K3
	Alachlor	Lasso, Micro-tech	Acetamide K3
	Atrazine	Atrazine, Extrazine, (in Laddok, Marksman)	Triazine C1
	Bentazon	Basagran, (in Laddok)	Other C3
	Bromoxynil	Buctril, Contour, (in Buctril+Atrazine)	Other C3
	Butylate	Sutan Plus	Thiocarbamate N
	Carfentrazone	Aim	Aryl triazolinone E
	Clethodim	Select	Cyclohexanediones A
	Clopyralid	Hornet, Scorpion, Stinger	Picolinic acid O
	Clomazone	Command	Isoxazolidinone F3
	Dicamba	Clarity, (in Celebrity, Distinct, Marksman, NorthStar)	Benzoic acid O
	Diflufenzopyr	Distinct,	Semicarbazone P
	Dimethenamid	Frontier, Outlook	Acetamide K3
	EPTC	Doubleplay, Eradicane	Thiocarbamate N
	Fluazifop	Fusilade	Aryloxyphenoxyproprionates A
	Flumetsulam	Accent Gold, Hornet, Python	Sulfonanilides B
	Flumiclorac	Resource	N-Pheylphthalimide E
	Flufenacet	Axiom	Oxyacetamides K3
	Glufosinate	Liberty	Phospinic acid H
	Glyphosate	Roundup	Glycines G
	Halosulfuron	Permit	Sulfonylurea B
	Imazapyr	Lightning	Imidazolinone B
	Imazethapyr	Contour, Lightning, Resolve	Imidazolinone B
	Isoxaflutole	Balance	Isoxazoles F2
	Mesotrione	Callisto	Triketones F2
	Metolachlor	Dual II Magnum	Acetamide K3
	Metribuzin	Sencor, Lexone	Triazinone C1
	Nicosulfuron	Accent, Accent Gold, Basis Gold	Sulfonylurea B
	Paraquat	Paraquat	Bipyridylium, Dipyridylium D
	Pendimethalin	Pentagon, Prowl	Dinitroaniline K1
	Primisulfuron	Beacon, (in Exceed, NorthStar, Spirit)	Sulfonylurea B
	Prosulfuron	Exceed, Spirit	Sulfonylurea B
	Pyridate	Tough	Phenylpyridazine C3
	Quizalofop	Assure	Aryloxyphenoxyproprionates A
	Rimsulfuron	Basis, Basis Gold	Sulfonylurea B
	Sethoxydim	Poast	Cyclohexanediones A
	Simazine	Princep	Triazine C1

Appendix F Glossary of Terms Used

A.I. Abbreviation for active ingredient: the amount of pesticidal compound in a formulated product.
Adventitious: The secondary root system of corn which forms above the ground level. Also known as brace roots.
Air-assist: An application method which uses channelized air to assist the delivery of spray droplets.
Annuals: Plants which germinate, flower, and produce seed within a one year period.
Anti-drift: Chemicals added to liquid sprays to reduce the number of fine droplets which have a high potential for drift.
Application: The placement of a pesticide in the field by means of a liquid spray or granular form.
Applicator: A farmer or independent agent for hire who applies a pesticide.
At-planting: The time the crop is planted.
Beneficials: Insects which are considered to be generally advantageous to the crop.
Biochemical: A chemical process that occurs within a living organism.
Biodegradation: Breakdown of a pesticide by living organisms.
Biotechnology: The technology which involves insertion of genetic material into one organism from another organism not closely related.
Biotype: Groups of individuals within a species that bear genetic traits that vary in minute, but identifiable ways from the larger population.
Booms: The extensible arms of a mechanical sprayer.
Broadleaf: Dicotyledonous plants that are typically characterized by netted veins and non-linear formed leaves.
Burn-down: Herbicides used to kill vegetation that is present and actively growing at the time of application.
Carryover: A pesticide that when applied to one crop, persists in the soil to negatively affect crops in succeeding plantings.
Chemigation: Pesticide application directly to a crop by injection directly into an irrigation system.
Commodity Profiles: Documents describing the general pest/pesticide situation faced by producers of a crop.
Conidia : An asexual fungal spore.
Cross-resistance: Development of a resistance mechanism to one pesticide that confers resistance to another pesticide.
Diapause: A period of physiological inactivity occurring at one stage in the life cycle of an insect.
Dormancy: A period of quiescence, enforced or voluntary, where active development ceases.
Edaphic: Of or relating to the soil.
Inbreds: Breeding stock intentionally crossed with parent lines to amplify desirable traits.
Meristematic: Tissue in plants from which new growth originates.
Mycelium: Threadlike, vegetative tubes of a fungal body.
Mycotoxins: Toxins developed from fungal organisms.
Oviposit: Deposition of insect eggs directly to a surface or region.
Perennials: Plants which live for three or more years.
Pheromone: Chemical compounds which convey behavioral signals.
PHI: Pre Harvest Interval: The required time between a pesticide application to a commodity and the harvest of that commodity.
Post-emergence: Pesticide applied after the crop has emerged.
Pre-emergence: Pesticides applied before the crop has emerged.
Pupae: Pre-adult insect developmental stage.
REI: Restricted Entry Interval: Required time between an application and worker entry into a treated field.
Restricted Use Pesticide: Pesticides which must only be applied by a licenced applicator.
Rhizomes: Underground rooting structures of perennial plants from which new shoots may emerge.
Silking: Corn stage where the silks are fresh and emerging from the corn ear.
Smartbox: Enclosed pesticide containers attached directly to corn planters, reducing exposure of operators to the pesticide.
Stacked Traits: The inclusion of more than one genetic trait in one plant from organisms not closely related.
Strip till: Tilling a small strip of soil within which the crop row is planted. This permits the greater portion of the field to remain untilled.
Systemic: Having an action or effect transmitted throughout the entire plant.
Systems-based: Involving the use of multiple approaches to solving a single problem.
T-banded: Application of an insecticide in a narrow band directly over the row and down into the seed furrow.
Tassel: The corn stage where the tassels begin to emerge from at the top of the plant.
Teliospore: Rust spore resting stage that germinates at the end of winter.
TMDL: Total Maximum Daily Load: The maximum permissible exposure limit to environmental contaminants.
Tolerant: An organism which tolerates to some degree, but is not totally resistant to, a non-benign agent.
Transgenic: Insertion of genetic material into one organism from another organism not closely related.
Whorl: Funnel shaped leaf formation found at the top of the corn plant and many other grasses.

Appendix G. Distribution Maps of the Production and Pests of Edible Legumes



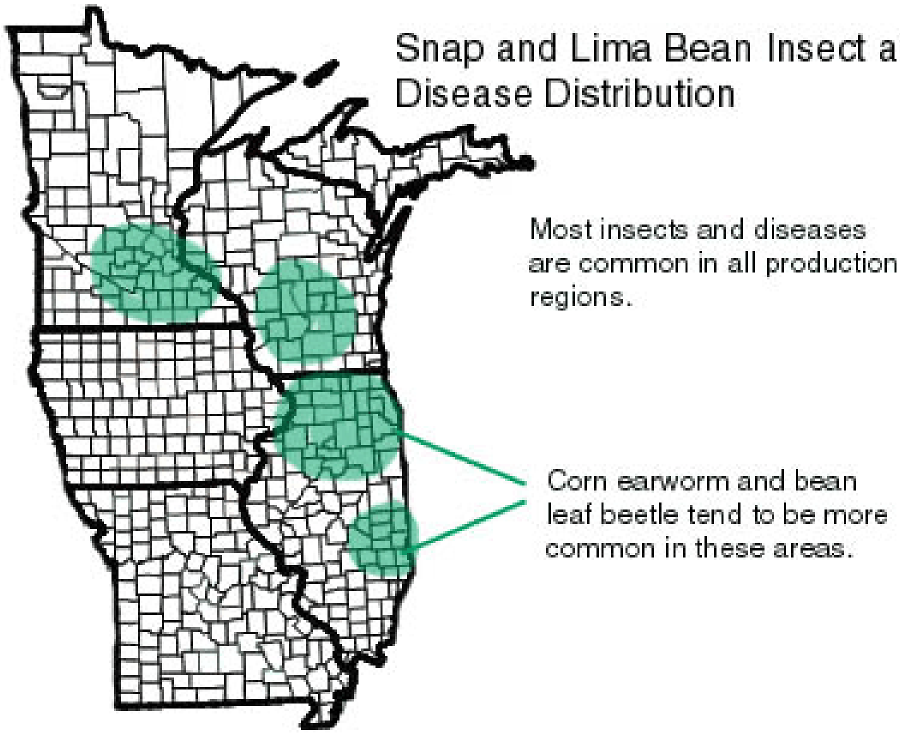


Weed Distribution in Legume Growing Regions

Many of the same weeds are found throughout all the suculent legume growing areas and are a problem to all growers. These weeds include the foxtails, nutsedge, common milkweed, Canada thistle, dandelion, eastern black nightshade, and hairy nightshade, common cocklebur, common lambs quarters, common and giant ragweed, smartweeds, pigweeds, velvetleaf, and mustards.

Some weeds, however, are far more troublesome in some areas. Puncturevine is a problem only in Illinois, and fall panicum, wirestem muhly, bluegrass, morningglories, pokeweed, and horseweed and field bindweed tend to be more of a problem in the mid to south legume production area.

Snap and Lima Bean Insect and Disease Distribution



Pea Insects and Diseases