Crop Profile for Soybean in Michigan

Prepared March, 2002

General Production Information

- The total acreage planted in Michigan was 2.1 million in 2000 (1).
- The total acreage harvested was 2.03 million in 2000 (1).
- Soybean production was 74.9 million bushels valued at $335.6 million dollars in 2000 (1).
- The average bushels/acre was 36 in 2000 (1).
- The price/bushel of soybeans in 2000 was $4.75 (1).
- Michigan was ranked 10th in soybean production in the US in 1999 (1).
- Michigan contributed 2.7% to the total US production of soybean in 2000 (1).

Production Regions:
The top counties in soybean production in 2000 were Lenawee, Sanilac, Monroe, Saginaw and Tuscola and in 1999 Lenawee, Saginaw, Sanilac were the top three counties with Monroe, Shiawassee and Gratiot completing the top six counties (1).

Production Practices:
Soybeans are adapted to a wide range of climatic and soil conditions. The recommended planting depth for no-till soybeans is 0.75-1.0 inch. For conventional till, the recommended depth is 1.5 to 2.0 inches. Under dry conditions growers plant a little deeper but no deeper than 2.0 inches. On sandy soils seeds are planted about 2.0 inches deep. Planting deeper than 2.0 inches may be necessary to get to soil moisture, but delays emergence and reduces stands of some varieties. On loam and clay loam soils, where resistance to no-till planting is great and crusting more likely than on sandy soils, soybeans are planted 1.0 to 1.5 inches deep. Planting generally takes place in May and June (28).

Growers sometimes use minimum till or no-till methods to prevent excessive soil drying. However, seeds must be covered adequately with soil or they will not germinate. Inadequately covered seed is also subject to herbicide injury. Adding weight to the planter may be necessary to obtain the proper depth. Planting into dry soil may be a gamble but so is waiting for rain and expecting conditions to be prefect

after the rain. Most of the moisture for soybean germination comes from the soil beneath the seed. Soybeans in Michigan are generally harvested around October (28).

Insect Pests

Armyworms
Pseudaletia unipuncta

Armyworms are a rare pest in Michigan (3). The larvae damage soybean plants by chewing on the leaves. They prefer to feed on the succulent leaves in the whorl first. Feeding is usually confined to leaf margins, but occasionally they may strip the entire plant leaving only the midrib of the leaves (4).

Biology: Armyworms migrate to Michigan in the spring and produce 2-3 generations per year. The larvae (caterpillars) vary in color from black to brown to a greenish color. They have a narrow light stripe across their back and broad stripes running down the sides of the their body (3).

General Control Information: The likelihood of infestation by armyworm is minimal, therefore preventative treatments are not justified. Infestation is usually associated with no-till and grassy cover crops (4). Controls are warranted when defoliation by armyworms averages 20% (5).

Cultural Controls: Disking large areas, thereby exposing armyworms to natural predators and hot weather is a useful cultural control. Weed control along with disking takes away any refuge they may have besides alternative crops, once again exposing them to natural predators and hot weather (5).

Biological Controls: Parasites, various diseases, insect predators and birds often keep armyworms under control except after cold, wet springs (5).

Chemical Controls: Cyhalothrin, methomyl, carbaryl, chlorpyrifos, thiodicarb, Bt (3).

Alternative Controls: No information available.

Bean Leaf Beetles
Certoma trifurcata

Bean leaf beetles can be a problem in Michigan, depending on the previous winter and the survival rate of the adult beetles. They prefer to feed on the youngest plant tissue available. Adult feeding reduces pod set and seed quality (2).

Biology: Bean leaf beetles are about 1/4-inch long and vary greatly in color from reddish brown to yellow. Usually they have black wing margins and two black spots on each wing cover. All have a black, triangular spot on the forward margin of the wings (2).

Bean leaf beetles overwinter as adults in leaf litter and other vegetation, although primarily in wooded areas, and emerge in early spring. Emerging bean leaf beetle adults feed on the cotyledons, unifoliate and trifoliate leaves of small soybean plants, sometimes completely defoliating the plant. They feed on soybean seedlings and a variety of other legumes, mate and lay eggs. Each female may lay 175-250 orange eggs in clusters of 10-30 in the soil at the base of soybean plants. Larvae feed on below ground plant parts and eventually pupate in earthen cells. Adult beetles emerge to feed on bean pods and foliage until they hibernate in the fall (2).

General Control Information: The threshold for bean leaf beetle is 25% or more defoliation throughout the field; 50% defoliation of the seedlings, or 25% defoliation during pod setting/filling or if pod damage is more than 10% (36).

Cultural Controls: Practices that promote healthy, vigorous soybean plants are effective in reducing the impact of all soybean defoliators. Soybeans grown under good conditions are remarkably tolerant to defoliation damage (2). Timely application of rescue treatments will reduce losses in yield and seed quality. Late plantings of soybeans will escape defoliation by overwintering bean leaf beetles and limit establishment of the first generation (6). Planting beans so that germination occurs between the 2 generations of adult beetles is helpful (7).

Biological Controls: A tachinid fly that parasitizes adult beetles aids in controlling the bean leaf beetle in some states, however, little is known about natural enemies of the bean leaf beetle in Michigan (2).

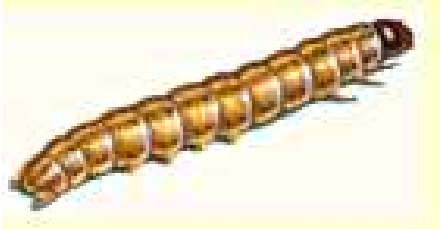
Chemical Controls: None needed for early season bean leaf beetles (2). Full coverage is not required when using systemic insecticides, although complete coverage is necessary for maximum efficiency when non-systemic insecticides are used. Drop nozzles may be needed for complete coverage if the canopy is large (35).

Permethrin, esfenvalerate, dimethoate, methomyl, thiodicarb, chlorpyrifos, methyl parathion, carbaryl and cyhalothrin.

Alternative Controls: No information available.

Cutworms

Lepidoptera: Noctuidae



Cutworms are a sporadic pest on soybeans in Michigan in the early season (36). Cutworms are more likely to be found in fields with a history of cutworm damage, those planted under reduced or no-tillage practices, fair to poorly drained fields and/or 'overflow' land or fields covered with winter annual weeds prior to planting (8). The larvae cut seedlings thereby reducing stand development (3).

Biology: The larvae (caterpillar) can be up to 2 inches in length. Their coloring is variable from black, to tan and greenish-yellow, with a row of light yellow stripes down their back. The adults migrate into Michigan in early spring and lay eggs on weeds or crop debris (3). Egg laying coincides with the planting of the crop and is often associated with the availability of weeds in the field. Larvae of the cutworm have 7 instars of which the 5^{th} through the 7^{th} are most easily detected. The mature larvae pupate in the soil and a second and sometimes third generation occurs by fall. Late planted soybean may be affected by the 2^{nd} generation (9).

General Control Information: Soybeans can tolerate considerable stand reduction without loss of yield. Control measures can be justified if 5% or more of small plants show cutworm damage and larvae are less than 1.5 inches in length (36). Early detection is essential (10).

Cultural Controls: Since weeds lead to additional pest activity, control of weeds is very important (9).

Black light traps and sex pheromone baited sticky traps are used to monitor adult cutworm activity and enable general prediction of forthcoming field infestations (9).

Action thresholds have been developed for counts of larvae found per 100 feet of row. However, detection of larvae is very dependent on soil and cultivation conditions (9).

Biological Controls: No information available.

Chemical Controls: Soybeans tolerate considerable stand reduction without loss of yield; chemical rescue (post plant) option is preferred (36).

Permethrin, esfenvalerate, chlorpyrifos, cyhalothrin, carbaryl (3).

Alternative Controls: No information available.

Grasshoppers

Melanopus spp.

Grasshopper outbreaks in Michigan are occasional in soybean fields. The adults and nymphs damage the plants by chewing them thereby defoliating the plants (3).

Biology: Eggs overwinter in the soil and nymphs hatch in mid-June as soil temperatures rise and spring rains begin. The first nymph to leave the egg pod makes a tunnel from the pod to the soil surface through which the succeeding nymphs emerge. Nymphs feed and grow for 35-50 days, molting five or six times during this period. Development proceeds most rapidly when the weather is warm and not too wet (11).

Mature grasshoppers mate and continue feeding on crop plants. About 2 weeks later, females begin to deposit clusters of eggs in the soil. During this process, a glue-like secretion cements soil particles around the egg mass, forming a protective "pod." Each pod may contain 25 to 150 eggs, depending on the species of grasshopper. Grasshoppers that deposit masses containing fewer eggs usually lay more pods to compensate. Each female may produce 300 eggs. Swarms of grasshoppers usually adopt a specific area as their breeding ground and lay all eggs in that vicinity. Most economically important grasshopper species complete only one generation each year. Red-legged grasshoppers, however, have at least two annual generations (11).

General Control Information: If 2 or more years of dry weather precedes the growing season, conditions will likely favor infestation and damage. Other conditions favoring damage include undisturbed grassy sites next to fields, which is preferred for egg laying, and dry, warm weather often enhances survival of nymphs. The threshold for grasshoppers in soybean fields is 25% or more defoliation (3).

Cultural Controls: Practices that promote healthy, vigorous soybean plants are effective in

reducing the impact of all soybean defoliators. Soybeans grown under good conditions are remarkably tolerant to defoliation damage (2).

Biological Controls: A fungal pathogen can kill many eggs and nymphs under wet spring conditions. There are also many animals such as birds, rodents and amphibians that eat grasshoppers (3).

Chemical Controls: Carbaryl, chlorpyrifos, dimethoate, esfenvalerate, carbofuran, methyl parathion, cyhalothrin (3).

Alternative Controls: No information available.

Green Cloverworm

Plathypena scabra

Green cloverworm larva

The green cloverworm can be found at subeconomic levels in most soybean fields. Occasionally, however, conditions produce a population explosion of this pest, which results in heavy defoliation of soybean plants (13). Green cloverworms feed on the foliage, giving plants a ragged look. They may also attack the pods when infestations are heavy (2).

Biology: Green cloverworms are green caterpillars with two narrow stripes down each side of the body. They have 3 pairs of legs near the head and four pairs of pro-legs near the rear. Quite active, they thrash violently at the slightest disturbance. Adults are dark-brown, black-spotted or mottled moths with a wing span of about 1-1/4 inches (2).

Green cloverworms overwinter in either the pupal or adult stage. In the spring, moths become active about the time clover becomes abundant. After mating, females lay single eggs on the undersides of soybean leaves. The eggs usually hatch in less than a week. Eggs produce green worms that feed on these leaves for about 4 weeks before dropping to the ground to burrow into the leaf litter or soil where they pupate (2). The pupal stage lasts about 10 days. Three to four generations per year can occur. Larvae appear on soybeans during early July, peak in mid-August, and decline by late September (12).

General Control Information: Thresholds for soybeans are set when defoliation exceeds the economic threshold, which is 25% foliage loss (36).

Cultural Controls: Practices that promote healthy, vigorous soybean plants are effective in reducing the impact of all soybean defoliators. Soybeans grown under good conditions are remarkably tolerant to defoliation damage (2).

Biological Controls: Beneficial insects and diseases usually regulate green cloverworm populations in most soybean growing areas (1).

Chemical Controls: Esfenvalerate, Bt, methomyl, chlorpyrifos, methyl parathion, permethrin, carbaryl, diflubenzuron, cyhalothrin, and thiodicarb.

Alternative Controls: No information available.

Japanese Beetles

Popillia japonica

Japanese beetle adult on soybean leaf.

Japanese beetles are common, but seldom an economic problem in soybean production in Michigan. Although, Japanese beetle larvae are increasingly becoming a problem in Michigan crops. Large numbers of Japanese beetles frequently gather in soybean fields during late July and August (13). The adults feed on leaf tissue between veins giving a 'skeletonized' appearance (3).

Biology: Japanese beetle grubs overwinter as third instars within 5 inches of the soil surface. As the soil warms in the spring, the grubs move closer to the surface and feed on fine rootlets. Shortly thereafter, they remain inactive for a 10-day period prior to pupation. After a pupal stage of 8 to 20 days, adults emerge. Emergence usually begins in mid-June and may begin as late as July. On warm days the beetles fly and often congregate on host plants to feed and mate. In the afternoon, females burrow into loose, moist soil (usually sod) and deposit one to four eggs. Over her 1.0 to 1.5-month life span, each female produces 40 to 60 eggs. Grubs emerge 2 weeks after egg deposition, feed on rootlets, and remain active until cold weather arrives (14).

General Control Information: Feeding by Japanese beetle adults alone is usually not sufficient to warrant treatment. The general threshold is 25% defoliation due to combined feeding from Japanese beetles and others such as bean leaf beetles, grasshoppers, etc. (3)

Cultural Controls: Practices that promote healthy, vigorous soybean plants are effective in reducing the impact of all soybean defoliators. Soybeans grown under good conditions are remarkably tolerant to defoliation damage (2).

Biological Controls: No information available.

Chemical Controls: Permethrin, esfenvalerate, methyl parathion, cyhalothrin, carbaryl diflubenzuron (3).

Alternative Controls: No information available.

Mexican Bean Beetle

Epilachna varivestis

Mexican bean beetles are found throughout the South and in parts of the Midwest and is an occasional pest in Michigan. Both adults and larvae feed by stripping away the surface tissue primarily on the underside of leaves. Remaining tissue dies and turns brown to give the foliage a burned, lacy appearance. As soybean foliage matures, the beetles may feed on stems and green pods leaving superficial scars (15).

In some areas this beetle is a very serious pest of snapbean, lima beans and soybeans and during years of high infestation, total defoliation can be quite common. Soybeans are especially vulnerable to insect defoliation during the latter period, when plants are in the podset-podfill stages (15).

Biology: Mexican bean beetles are round, copper-colored insects with 16 black spots on the wing covers. The adult beetles come out of hibernation, where they have spent the winter months under collections of brush or leaves, as soon as warm weather arrives. Some may, however, delay their appearance until mid summer. In mid-May adults tend to search out snap and lima beans, although since there are rarely snap or lima beans in Michigan they go directly for soybeans. After feeding on the tender young bean plants for one to two weeks, the females start to lay their eggs, each depositing 500 to 600 of them in batches of 40 to 75 on the underside of the foliage. The eggs are carefully attached at the end so that they all stand vertically. They hatch in a week during warm weather but may require at least two weeks under more unfavorable conditions (15).

The larvae feed voraciously for two to five weeks, depending upon the temperature. When first hatched, they all feed together. If the leaf is somewhat dry, the first hatched may devour the remaining unhatched eggs. As they grow older, they still retain their gregarious habits but tend to split up into small scattered groups. When pupating, the larva fastens the tip of the abdomen to a part of the plant and starts to wiggle out of the larval skin, not entirely shedding it but pushing it back until only the tip of the abdomen remains in the skin. The pupal stage lasts for five to ten days, but may drag out much longer in the cool

weather of autumn. The adults are strong fliers and travel long distances hunting for new bean fields. The beetles overwinter in moist, protected places, remaining dormant until spring (15).

General Control Information: Practices that promote healthy, vigorous soybean plants are effective in reducing the impact of all soybean defoliators. Soybeans grown under good conditions are remarkably tolerant to defoliation damage (2). The threshold is 25% or more defoliation throughout the field or one or more adults per plant in established plants (36).

Cultural Controls: Cultural control efforts include destruction of overwintering locations and late planting of the soybean crop. The destruction of overwintering locations increases exposure to inclement weather conditions and can greatly reduce adult numbers the following spring. Under certain conditions, a combination of a trap crop with delayed planting of a portion of the field might be used to advantage. Since overwintering beetles actively forage upon emergence in the spring, beans planted early will attract a disproportionate number of beetles feeding during their preoviposition period (15).

Biological Controls: Natural control organisms include at least 17 species of predators. They feed on bean beetle eggs, larvae and pupae. The adult beetles are protected by hard wing covers and by an offensive, yellow liquid, which is secreted in small drops from the leg joints when the insects are disturbed (15).

Ten species of parasitoids are prevalent in soybeans during the vegetative stages, but only the tachinid fly *Paradexodes epilachnae* and the eulophid wasp *Pediobius foveolatus* seem to be promising in reducing the number of bean beetles. Since the eulophid wasp is not a native parasite it is necessary to import it when the Mexican beetle is an important pest. The tachinid fly parasitizes Mexican bean beetle larvae during the growing season, but fails to overwinter for lack of a diapause capability and/or available host material. The annual inoculative releases of this insect, if conducted early enough and in conjunction with establishment of nurse plot areas of snap beans in a widespread manner, are capable of suppression of the Mexican bean beetle on soybeans (15).

Chemical Controls: The threshold is 25% or more defoliation throughout the field or one or more adults per plant in established plants (36).

Chlorpyrifos, dimethoate, esfenvalerate, cyhalothrin, methomyl, methyl parathion, permethrin, thiodicarb, diflubenzuron or carbaryl.

Alternative Controls: No information available.

Potato leafhoppers

Empoasca fabae

While leafhoppers can and do feed on soybeans, economic damage is relatively uncommon. This is due to the hairiness of the leaf surface of most soybean varieties (2).

When soybeans are subjected to leafhopper feeding, they are readily attacked and the damage is similar to what occurs on dry beans. While hairy soybeans can also be attacked, significant damage is deterred under most circumstances. However, when populations of potato leafhopper are high, economic damage has been observed, even on hairy varieties (2).

Biology: Potato leafhoppers are dispersed by northward winds from the South where they breed on various legumes. They have not been found to overwinter north of the Gulf states. Females deposit their eggs within the stems, petioles and major veins of leaves. Hatching normally occurs in about 10 days, after which the newly hatched nymphs begin to feed. Leafhopper nymphs molt five times before they are fully grown. The life cycle takes approximately three weeks to complete and there may be several generations during a single season. Leafhoppers can increase sufficiently by late June or early July to damage crops and are present in the field until the first killing frost. High populations can quickly develop when there is abundant food and warm, damp nights (16).

General Control Information: The guideline for treating potato leafhoppers on soybeans in Michigan is 1 or more potato leafhoppers per trifoliate leaf and when leaves show first signs of cupping (36).

Cultural Controls: Practices that promote healthy, vigorous soybean plants are effective in reducing the impact of all soybean defoliators. Soybeans grown under good conditions are remarkably tolerant to defoliation damage (2).

Biological Controls: No information available.

Chemical Controls: Carbaryl, dimethoate, esfenvalerate, cyhalothrin, permethrin.

Alternative Controls: No information available.

Seedcorn Maggots

Delia platura

Seedcorn maggots occur occasionally in Michigan affecting green cover crops of the soybean acreage (3). The flies are attracted to fields where relatively fresh manure and other organic material is present. The larvae are maggots that seek out germinating soybean seeds and eat the germ, killing the plant (2).

Biology: Seedcorn maggot is the larva of a small gray fly (2). They overwinter as pupae in the soil and the adults emerge as flies in early spring. The adults lay their eggs in disturbed soil with decaying organic matter. There are generally multiple generations every year (3).

General Control Information: There are no rescue treatments available for control of seedcorn maggot, so most treatments are made in replant situations (2).

Cultural Controls: There is decreased potential for injury in reduced tillage fields. Because the weather and seed corn maggot populations are variable, precautions are taken every year to keep damage from this insect to a minimum. Otherwise the seed corn maggot will probably not be detected until seeds and seedlings are lost. Then it is too late for effective control on the planting and the field must be either replanted or left as a poorly developed stand (17).

To prevent seed corn damage the following steps are taken: planting after the ground is warm enough for rapid germination and growth; planting in a well-prepared seedbed only deep enough for adequate soil moisture; plowing heavily manured or over-cropped land early the previous fall so it will be less attractive to the egg laying flies the following spring; delaying planting until the first generation is pupating; and reducing use of organic fertilizer in the seeded row whenever possible (17).

Biological Controls: No information available.

Chemical Controls: Seed treatment before planting is the easiest control method and can be used in air blast planters. Planter box treatments are also effective in conventional planters, but cannot be used with air blast planters. Seed and planter box treatments often come mixed with fungicides. Be sure that the insecticide is applied at the amount recommended when a prepared mixture is used. Soil insecticides are more expensive, but offer an alternative if seed or planter box treatments cannot be used (17).

Lindane and Phorate.

Alternative Controls: No information available.

Slugs

Agriolimax reticulatus

Slugs occur occasionally on Michigan soybeans. They may damage the seedlings by feeding on stems, cotyledons, and leaves (3).

Biology: Most field slugs pass through a single generation per year and generally overwinter in the egg stage. However, if the winter is mild, adults may survive the winter. Since field slugs may live 12 to 15 months and eggs are laid both in the early spring and fall, overlapping generations of adult and juvenile stages may be observed. In the winter, adult slugs may enter a state of hibernation, and in the dry and hot summer conditions they enter a similar inactive state of aestivation. Peak slug activity generally occurs in late spring and early summer when the spring hatch attains adult growth and again in the early fall when cooler temperatures resume (18).

Slugs are hermaphrodites (both male and female). As a result, when they copulate, there is a reciprocal exchange of spermatozoa. Self-fertilization is possible in some species such as the marsh slug but in general, pairs of slugs are needed to reproduce (18).

General Control Information: A soybean stand can tolerate up to 40% defoliation during pre-bloom, but if the growing point is killed the stand can be significantly reduced. Planting into wheat stubble or other heavy crop residue or into a field with recent history of slug damage may favor conditions for damage. Cool, wet conditions also favor damage. At this time there are no developed thresholds although a treatment is sometimes necessary if slug damage threatens to reduce stand density below an acceptable level (3).

Cultural Controls: Occasional use of reduced tillage decreases the development of slug problems in the fields that were maintained under long term no-tillage practices. Slug problems in minimum tillage systems such as ridge tillage are rare. Mechanical devices on planters that remove residue over the seed furrow may reduce slug damage to seeds and emerging seedlings. In the case of no-tillage soybean fields, growers learn to tolerate sub-economic levels of slug injury. Reduction of slug populations, once they have become established, is difficult to achieve since the bait treatment only reduces the slug activity buying time to enable the crop to outgrow the problem (18).

Biological Controls: No information available.

Chemical Controls: Metaldehyde (3).

Alternative Controls: None available.

Thrips

Sericothrips variabilis


Thrips are common in Michigan, however economic damage caused by thrips is rare. The most obvious damage occurs early in the season. Adult and nymph rasping/sucking mouthparts scrape cells on leaf underside, leaving silvery scratches that may turn leaves brown. The younger leaves may appear crinkled if attacked by thrips (3).

Biology: The adults are small and slender. They are brown and white banded on the abdomen and have narrow fringed wings. The larva are wingless and yellow/orange. Adults are carried into Michigan in spring on airstreams (3).

General Control Information: Conditions that favor damage include hot, dry weather coupled with large thrips populations. Young plants can generally outgrow feeding injury. Damage may also be confused with some types of herbicide injury. A rough guideline for the threshold of thrips is to treat when 30% of the plants have thrips and some drying of leaves is seen (3).

Cultural Controls: No information available.

Biological Controls: Thrips have many natural enemies including minute pirate bugs, predacious thrips and mites (3).

Chemical Controls: Methyl parathion, methomyl, carbaryl, cyhalothrin (3).

Alternative Controls: No information available.

Wireworms

Wireworms occur occasionally on Michigan soybean fields. They feed on germinating seeds reducing stand development (3).

Biology: Wireworms are slender, shiny brown caterpillars with a wiry segmented body. They are generally up to 1.5 inches long. The adult form is a click beetle, which is found in grasslands, sod or fallow fields (3). The larval stage of wireworms requires from two to six years or more to complete. In contrast to the long period of larval development, the pupae and adult stage require only a few months before eggs are laid near grassy weeds and the cycle repeats itself (20).

General Control Information: Wireworms are scouted for with a bait trap at least one week before planting (3). The threshold for wireworms is one or more per bait trap (36).

Cultural Controls: Since grasses are the primary host plant of various wireworm species, the greatest potential for wireworm problems occurs where there are significant grass weed problems or in crops following pasture or sod (20). Spring and fall plowing is recommended to establish sod before the crop is planted (36).

Biological Controls: No information available.

Chemical Controls: Seed treatment; Lindane.

Alternative Controls: No information available.

Soybean Aphid

Aphis glycines

This species is native to Asia, where soybean originated. It feeds on soybean and in Asia alternates between another plant called buckthorn. Previously, the soybean aphid had not been found in the U.S., but in the summer of 2000 it was simultaneously found in Wisconsin, Michigan, northern Illinois and southeastern Minnesota. More states are now looking in soybean fields for this species. Soybean aphids

have been found in fields in Allegan, Berrien, Calhoun, Cass, Ingham, Kent, Montcalm, Muskegon, Newaygo, Oceana, Ottawa, St. Joseph, Saginaw, Van Buren, and Washtenaw counties (37).

Soybean aphids suck plant juices and in heavy infestations, leaves covered by aphids are wilted or curled. The aphids also feed along the stems. Upper leaves tend to have the most aphids, while lower leaves may be sticky and black with sooty mold. As aphids feed, they secrete a sweet substance called honeydew. The honeydew drops onto lower leaves, and provides an excellent place for the mold to grow. On the ground and lower leaves, there are also numerous shed skins and dead aphids -- it may appear that the plant has "dandruff." The soybean aphid merely removes plant sap, and thus water and nutrients from the plant. It does not inject toxins that cause hopperburn or growth regulator type injury on leaves (37).

Recommendations are not leaning towards insecticide use to control the soybean aphid. First, the fields are often loaded with biocontrol agents -- predators, parasitoid wasps, and pathogenic fungi that infect and kill aphids. The pathogens are doing a particularly good job of killing aphids, and populations crash in a matter of days. Second, it is difficult to spray fields and get adequate coverage without physically damaging beans. And finally, the price of soybeans probably does not warrant spending the money to spray, unless the infestation is tremendous (37).

INSECTICIDE PROFILES

Bacillus thuringiensis:(Biological)

Formulations (lb formulated/A): Javelin WG, Dipel 2X; Dipel ES; Dipel 48F; Dipel DF; Biobit FC; Biobit HP; Biobit XL; Condor; MVP; and Lepinox WDG.
Pests Controlled: Green cloverworm and armyworm.
Application Rates:
Javelin WG; 0.25 to 1.5 lb/A (36)
Dipel 2X; 0.5 to 2 lb/A (36)
Dipel ES; 2.0 to 4.0 pt/A (36)
Dipel 48A; 1.5 to 5.5 pt/A (36)
Dipel DF; 1.0 to 2.0 lb/A (36)
Biobit FC; 2.0 to 7.0 pt/A (36)
Biobit HP; 0.5 to 2.0 lb/A (36)
Biobit XL;1.5 to 5.5 pt/A (36)
Condor; 0.67 to 1.67 qt/A (36)
MVP;1.0 to 4.0 qt/A (36)
Lepinox WDG; 1.0 to 2.0 lb/A (36)
Types of Application: Ground and aerial. (38)
Timing: Works best on small larvae (36).

PHI: 0 days (36).
REI: 4-12 hours (38).

Carbaryl (Carbamate)

Formulations: Sevin XLR+, 4F, 50W or 80WSP (36).
Pests Controlled: Green cloverworm, bean leaf beetle, Mexican bean beetle, potato leafhopper, Japanese beetle, armyworm, grasshoppers, thrips, cutworm (36).
Application Rate: 0.5 to 1.5 lb ai/A (36).
Types of Application: Ground, aerial, and chemigation (38).
Timing: When pests are present.
PHI: 21 days (36).
REI: 12 hours (38).
IPM Concerns: Toxic to beneficial insects and mites and disruptive to established IPM programs.
Efficacy Issues: Do not mix with 2, 4-DB (36).

Chlorpyrifos (Organophosphate)

Formulations: Lorsban 4E and 15G.
Pests Controlled: Green cloverworm, bean leaf beetle, mites, Mexican bean beetle, armyworm, grasshoppers, and cutworm (36).
Application Rate: 0.25 to 1.3 lb ai/A (36).
Types of Application: Airblast sprayer (38).
Timing: When pests are present.
PHI: 28 days.
REI: 24 hours.
Efficacy Issues: Maximum of 6 pt/A per season (36).
Restricted Use Pesticide.

Diflubenzuron (IGR)

Formulations: Dimilin 25W or 2L.
Pests Controlled: Green cloverworm, and Mexican bean beetle (36).
Application Rates: Dimilin 25W; 0.125 to 0.25 lb ai/A (36).
Dimilin 2L; 0.03 to 0.06 lb ai/A (36).
Timing: When pests are present.
PHI: 21 days (36).
REI: 12 hours.
Efficacy Issues: Dimilin inhibits the molting process of larvae and does not provide immediate kill. Three to seven days may be required before populations are reduced. There is a minimum reapplication interval of 30 days (36).
Restricted Use Pesticide.

Dimethoate (Organophosphate)

Formulations: Dimethoate 400 or 4EC or 5 lb (36).
Pests Controlled: Bean leaf beetle, Mexican bean beetle, potato leafhopper, grasshoppers and mites (3).
Application Rates: 0.45 to 0.5 lb ai/A (36).
Timing: June and July.
PHI: 5 days for forage and 21 days for beans (36).
REI: 48 hours (38).
Efficacy Issues: Full coverage is not required when using dimethoate (36).

Esfenvalerate (Pyrethroid)

Formulations: Asana XL.
Pests Controlled: Green cloverworm, bean leaf beetle, Mexican bean beetle, potato leafhopper, Japanese beetles, grasshoppers, cutworm (36).
Application Rate: 0.015 to 0.03 lb ai/A (green cloverworm, Mexican bean beetle, and potato leafhopper) and 0.03 to 0.05 lb ai/A (all other listed insects) (36).
Types of Application: Ground, aerial, and chemigation (38).
PHI: 21 days (36).
REI: 12 hours (38).
IPM Concerns: Highly disruptive to mite populations (38).
Efficacy Issues: Not to exceed 0.2 lb ai/A/season (36).
Restricted Use Pesticide.

Lambda – Cyhalothrin (Pyrethroid)

Formulations: Warrior.
Pests Controlled: Thrips, mites, Mexican bean beetle, potato leafhopper, Japanese beetle, bean leaf beetle, green cloverworm, armyworm, grasshoppers, cutworm (36).
Application Rate: 0.015 to 0.025 lb ai/A and 0.025 to 0.05 lb ai/A (for armyworm, grasshopper, Japanese beetle and mites) (36).
Types of Application: Aerial or ground (38).
PHI: 45 days (36).
REI: 24 hours.
Efficacy Issues: Vines are not fed to livestock. Used for suppression of mites, not control (36).
Restricted Use Pesticide.

Lindane (Chlorinated hydrocarbon)

Formulations: Lindane (various formulations) (36).
Pests Controlled: Seedcorn maggot and wireworm (36).

Application Rate: 0.5 oz ai/100 lb seed (36).
Types of Application: Seed or planter box treatment (36).
Timing: At planting.
REI: 12 hours.

Metaldehyde (Molluscicide)

Formulations: Deadline MP 4% Bait.
Pests Controlled: Slugs (36).
Application Rate: 0.4 to 1.6 lb ai/A (36).
Types of Application: Ground or aerial (36).
Timing: Pellets are broadcast and irrigated before and after application every 3 to 4 weeks as needed during the season. Pellets are not allowed to come into contact with the edible portion of the plant (36).
PHI: 0 days (3).
REI: 12 hours.
Efficacy Issues: For best results, applications are made in the evening, after a rain or after irrigation (36).

Methomyl (Carbamate)

Formulations: Lannate 2.4LV and 90SP.
Pests Controlled: Green cloverworm, bean leaf beetle, Mexican bean beetle, armyworm, thrips (38).
Application Rate: 0.12 to 0.34 lb ai/A (36)
Types of Application: Ground and aerial (38).
Timing: When pests are present.
PHI: 14 days for beans, 12 days for hay and 3 days for forage (36).
REI: 48 hours (38).
IPM Concerns: Highly toxic to mite predators and can cause mite population buildup (38).
Efficacy Issues: Maximum of 3 applications per crop per season (36).
Restricted Use Pesticide.

Methyl Parathion (Organophosphate)

Formulations: Penncap-M.
Pests Controlled: Green cloverworm, bean leaf beetle, Mexican bean beetle, Japanese beetle, grasshoppers and thrips (38).
Application Rate: 0.75 to 1.0 lb ai/A for Japanese beetle and 0.5 to 0.75 lb ai/A for all others (36).
Timing: When pests are present.
PHI: 20 days (36).

REI: 4 days.
Efficacy Issues: Maximum of 2 applications per crop per season (36).
Restricted Use Pesticide.

Permethrin (Pyrethroid)

Formulations: Pounce 3.2EC or 25WP or 25WSB; and Ambush 2E, 25W, 25WP (3).
Pests Controlled: Green cloverworm, bean leaf beetle, Mexican bean beetle, potato leafhopper, Japanese beetle and cutworm (36).
Application Rate: 0.05 to 0.1 lb ai/A (36).
Types of Application: Ground, aerial and chemigation (38).
Timing: When pests are present.
PHI: 60 days (36).
REI: 12 hours (38).
Efficacy Issues: Maximum of 0.4 lb ai/A per season (36).
Restricted Use Pesticide.

Phorate (Organophosphate)

Formulations: Thimet 20G.
Pests Controlled: Seedcorn maggots (36).
Application Rate: 6 oz per 1000 ft row (36).
Types of Application: Ground (36).
Timing: At planting in 7 inch band centered over the row or at planting granules are distributed evenly in the row to the sides of the seeds (38).
REI: 48 hours.
Efficacy Issues: Must not come into contact with the seed. Treated foliage is not fed as forage. Phorate is not applied if metribuzin herbicides have already been applied (36).
Restricted Use Pesticide.

Thiodicarb (Carbamate)

Formulations: Larvin 3.2F.
Pests Controlled: Mexican bean beetle, bean leaf beetle, green cloverworm and armyworm (36).
Application Rate: 0.25 to 0.75 lb ai/A (36).
Timing: When pests are present.
PHI: 28 days (36).
REI: 12 - 48 hours.
Efficacy Issues: Vines are not fed to livestock. Not to exceed 3 lb ai/A per season (36).

Carbofuran (Carbamate)

Formulations: Furadan 4F
Pests Controlled: Grasshoppers (36).
Application Rate: 0.11 to 0.25 lb ai/A (36).
Timing: When pests are present.
PHI: 21 days (36).
REI: 14 days.
Efficacy Issues: Vines are not fed to livestock. Maximum of 2 applications per season (36).
Restricted Use Pesticide.

MITES

Two spotted Spider Mites

Spider mites are common in both Michigan and are an occasional economic pest. Heavy infestations kill the leaves and result in "scorched" areas in the field. Mite outbreaks are often associated with drought conditions (2).

Biology: Spider mites overwinter as adults in fencerows and woodlots. They move to the edges of the field in the summer, developing small colonies on the undersides of leaves. Spider mites are very small and are frequently blown from plant to plant. Eggs, nymphs and adults may all be found on the undersides of leaves at the same time. They withdraw plant juices with their sucking mouthparts and are particularly abundant during hot, dry conditions (2).

Mites are sucking pests that insert mouth parts into individual plant cells, resulting in small speckled yellow spots (stippling) (3).

General Control Information: If a problem with mites is identified early, treatment of hot spots may suffice. If mites have spread across the field then thresholds are: pre-bloom- 40% damage; bloom to podfill - 15% damage; and podfill to early maturity - 25% damage (3). When scouting for mites, look for leaves that show yellowing near the petiole, especially during hot, dry periods of the season. Examine the leaf undersides for silky webbing. Estimate the percent of the leaf surface damaged (2).

Cultural Controls: No information available.

Biological Controls: There is a fungal pathogen that kills mites under warm, humid conditions (3).

Chemical Controls: Chlorpyrifos, dimethoate and *lambda*-cyhalothrin.

Alternative Controls: No information available.

MITICIDE PROFILES

Dimethoate: see insecticide profile.

Chlorpyrifos: see insecticide profile.

lambda-cyhalothrin: see insecticide profile.

Nematodes

Soybean Cyst Nematode

The soybean cyst nematode is a major limiting factor in Michigan soybean production. This pest was first detected in Michigan in 1987 and is now known to be present in 27 counties. Soybeans infested with soybean cyst nematode result in poor stands, stunted plants, yellow foliage and low bean yields (2).

Biology: Soybean cyst nematode is a microscopic roundworm that is infective at the second-stage. The egg hatches shortly after it molts from the first stage. Second stage juveniles are invisible to the naked eye. They penetrate soybean roots, causing the formation of specialized feeding cells in the root's vascular system. After initiating feeding, soybean cyst nematode juveniles swell and no longer move, however, the male is the exception. Soybean cyst nematode males leave the root system and move throughout the soil to mate with females and they do not contribute any further to soybean damage (21).

The majority of plant damage is caused by the female soybean cyst nematodes. Females are white to begin with, become yellow with age and turn brown when they die. They can be seen with the naked eye on soybean roots (see photo). The cysts contain eggs, usually around two or three hundred. The role of the cyst is to protect the eggs from adverse conditions. Soybean cyst nematode can complete many generations in one season depending on planting date, soil temperature, soil moisture, host suitability, etc. (21).

General Control Information: It is currently estimated that roughly 25-30% of Michigan's soybeans are infested with soybean cyst nematode. Losses can range from 5-90% of the yield potential. Therefore it is imperative for all Michigan soybean growers to have a well-developed strategy to avoid soybean cyst nematode problems or to minimize impacts if soybean cyst nematode is already present (2).

Cultural Controls: Rotations with dry beans, green beans and peas is avoided, since they act as hosts to the soybean cyst nematode. Two years of nonhost crops such as corn, potatoes, alfalfa, red clover, small grains, sugar beets and most vegetables lowers soybean cyst nematode numbers and reduces yield losses. Population densities of soybean cyst nematode will decline in the presence of nonhost crops and it is essential that soybean cyst nematode-infested fields be re-sampled before soybeans are grown. The duration that nonhost crops are grown before the next soybean crop is planted is dependent on the number of soybean cyst nematode eggs and second-stage juveniles recovered from 100cm^3 of soil (2).

A nine-year cropping scheme is recommended for growers to avoid soybean cyst nematode or to minimize its impact in infested fields. This scheme integrates much of the information already provided (2).

Reduced tillage systems can result in reductions in soybean cyst nematode population densities compared to conventional tillage. These results, however, are not always reproducible. Reduced tillage will also retard spread of soybean cyst nematode within a field. There are no reports where reduced tillage resulted in increased soybean cyst nematode damage. Personal communication with selected Michigan growers indicates that symptoms due to soybean cyst nematode feeding are not as severe or widespread in no-till or fields under reduced tillage (2).

Monitoring for soybean cyst nematode is an essential part of nematode management. All soybean fields in Michigan should be routinely sampled for nematodes, preferably every fall before soybeans are planted. At a minimum, soybean fields should be sampled at least once every three years. Soybean cyst nematode management strategies must be based on the population densities of nematodes detected in these samples. Early detection is critical to avoid drastic yield losses and high population densities of soybean cyst nematode (2).

Weed problems are much greater in soybean cyst nematode-infested fields than in non-infested fields. Good management of weeds, water and soil fertility increases the tolerance to soybean cyst nematode infection. Some weeds are hosts of soybean cyst nematode. For example,

chickweed is one fairly common weed known to host soybean cyst nematode in Michigan soybean fields, and some winter annual weeds, such as purple deadnettle, are also reported to be excellent hosts for soybean cyst nematode (2).

Biological Controls: No information available.

Chemical Controls: Temik 15G is registered for use on soybean cyst nematode in Michigan, however the economics of nematicide use for control of soybean cyst nematode under Michigan conditions has not consistently justified its use (2).

Alternative Controls: Soybean cyst nematode-resistant varieties generally have one of two sources of resistance; Peking or PI 88788. In general, public varieties with the PI 88788 source of resistance have yielded best in variety trials in Michigan and throughout North Central States. Jack is a public variety with PI 88788 resistance in maturity group III. Although Jack is a late maturing variety, it has yielded very well in maturity group I growing zones. Both private and public varieties are available that are reported to have soybean cyst nematode resistance (2).

Because most commercial lines only have two sources of resistance, it is important to rotate the sources of resistance as well as rotating crops. Resistance to soybean cyst nematode may break down if one source of resistance is grown frequently in one site. Research indicates that soybean cyst nematode will adapt in 2-4 years in the presence of resistant varieties with the same source of resistance. It is also important to occasionally include a soybean cyst nematode-susceptible variety in the rotation when the population density of soybean cyst nematode is low enough to allow profitable production of these cultivars (2).

NEMATACIDE PROFILES

Aldicarb (Carbamate)

Formulations: Temik 15G.
Pests Controlled: Soybean cyst nematode (3).
Application Rate: 1.5 to 2.1 lb ai/A (36).
Types of Application: Apply in 8 to 12 inch band and work into the soil or cover with soil to a depth of 2 to 4 inch. Center treated band over the row and plant in treated zone. Granules should be at a depth of 2 inch (3).
Timing: At planting.
PHI: 90 days.
REI: 48 hours.
Restricted Use Pesticide

Diseases

Seedling Blights

Phythium spp.

Symptoms: These diseases may occur on soybeans from the time a seed is sown to the end of flowering. However, these are usually associated either with seeds rotting in the soil or young seedlings being killed. Such plants are said to 'damp off.' Infected seeds may not germinate and may be soft and overgrown with other fungi and bacteria, giving the seed a fuzzy appearance and mushy feel. Seedling rot or blight results from infection by these fungi after the seed has germinated but before or just after the seedling has emerged through the soil. Infected roots have a brown color and a wet appearance. If plants are infected after emergence the plant will wilt and if leaves are present, they will first have a gray-green color and then turn brown after a day or so. Such infected plants are easily pulled from the soil. As the soil dries up, so does the infected root, which then resembles a shoestring attached to the cotyledon. Diseased plants may stand singly or in small circular groups, particularly in low spots in the field, or they may occur uniformly over an entire field if there has been a period of rain (20).

Methods of Transmission: *Pythium* is found in most cultivated soils and survives in soil or crop refuse as oospores and mycelium (20).

Conditions Favoring Infection: Soybean seed planted in cold, wet soil is most subject to infection by these fungi (20).

Management: Soybean diseases are usually managed through rotation, residue management, and variety selection. Fungicide seed protectant is used in fields where problems have occurred. Carryover seed or seed that has a high percentage of broken seed coats is not used for planting. Only high germinating seed is used. (Crop rotation is not a control for *Pythium*) (20).

Fusarium spp.

Symptoms: Seeds may have poor germination, resulting in either pre- or postemergence damping off or late emergence and stunted plants. The fungus causes dark brown lesions that are confined to roots and the lower portions of stems. This symptom may be confused with other root rots. Root systems of severely infected plants may be completely destroyed. Wilting is most frequently observed on seedlings or young plants when roots are rotted and soil moisture is low. Older plants are seldom killed, but they wilt when soil moisture is low and recover turgidity at night or when moisture becomes adequate (20).

Methods of Transmission: *Fusarium* spp. survives in the soil as chlamydospores and as mycelium or chlamydospores in crop refuse (20).

Conditions Favoring Infection: Poor stands caused by *Fusarium* are usually associated with poor seed quality, heavy rains, soil compaction, or soil flooding after planting (20).

Management: Seedlings infected with *Fusarium* spp. and showing signs of wilting or death of lower leaves are not cultivated until adequate soil moisture is available. When cultivating, the soil is ridged around the base of the plants. This promotes root development from the stem base above the diseased area. There, roots are not as easily infected by the fungus and help the plants to recover rapidly. All varieties are susceptible, and crop rotation is of little value in disease control (20).

Rhizoctonia spp.

Symptoms: The disease is first noticed by the presence of wilted and dead plants. Typical symptoms are decay of lateral roots and localized brown to reddish brown lesions on the hypocotyl and lower stem that do not extend above the soil line. The reddish brown color is a good symptom to aid in diagnosing the disease. However, it is best observed immediately after removing the plant from the soil because the color fades upon exposure to the air. The discoloration is usually limited to the cortical layer of the main root and hypocotyl and does not extend into the root or stem. Infected stems remain firm and dry. The disease pattern may occur as a single plant or a group of dead plants in a row or in circular areas where soil moisture may be higher than in other areas of the field. Although the disease is associated with young plants, older plants may die if there is moisture stress and the hypocotyl is sufficiently decomposed to limit uptake of water (20).

Methods of Transmission: *Rhizoctonia* is a common soil fungus. It produces no spores and survives in the soil as sclerotia and may grow as a saprophyte on dead plant material in the absence of soybeans (20).

Conditions Favoring Infection: The fungus infects young plants when the soil is wet. The first symptoms of the disease ordinarily appear as the weather becomes warm (20).

Management: Ridging soil around the base of plants when cultivating and having good drainage and soil aeration is important (20).

Phytophthora Root Rot

Phytophthora sojae

Phytophthora root rot is caused by the fungus *Phytophthora sojae*. It is one of the most destructive diseases of soybean in the United States (25). Yield loss in Michigan varies from year to year, but severe

losses are not widely occurring. Losses in individual fields can range from 10 to 50% (29).

Symptoms: Soybeans may be infected at any stage of development. There is a yellowing followed by a wilting of the leaves that remain attached to the plant. The best diagnostic symptom is a brown discoloration of the stem and lower branches that extends from below the soil line upward to several inches above the soil line. The taproot is dark brown and the entire root system may be rotted. Sometimes there may be no obvious symptoms but plants will be reduced in vigor and stunted. This symptom is often difficult to tell unless there is a side-by-side comparison with a resistant variety. Infection of lateral branches may also occur. In such cases the fungus eventually grows into the stems, and since the roots may not be rotted, the disease may be confused with stem canker. The disease pattern varies within a field. It may be roughly circular, corresponding to the poorly drained areas, or it may occur as a dead or dying individual plant or groups of plants in a row (29).

Methods of Transmission: *P. sojae* is a common soil fungus that survives from season to season as spores or mycelium in soil or in crop refuse buried in soil (29).

Conditions Favoring Disease: The disease is most common in low, poorly drained areas, headlands where soil is compacted, and heavy clay soils. It may also appear on higher ground during a wet season. Plants may become infected later in the growing season even under 'dry' soil conditions (29).

Management: Plant resistant varieties (29).

Brown Stem Rot

Cephalosporium gregatum

Brown stem rot is widespread in Midwestern and some southeastern states of the United States and Canada, and can cause yield reductions in individual fields of 17-25% (6).

Symptoms: Infection of soybeans by *C. gregata* occurs through the roots and lower stem early in the growing season. The only positive way to tell if plants are infected is to split the lower 6 inches of the stem 10 to 30 days before the soybeans mature. Healthy stems have white tissue in the center, while infected stems have brown tissue in the center. Often there may be an internal browning only at the nodes, while internodal tissue may be white. The browning (indicative of fungal growth) progresses upward in the stem during the growing season, moving most rapidly during cool weather, whereas warm weather suppresses the disease. Severely diseased plants may lodge. Leaf symptoms are not ordinarily a reliable diagnostic tool, and may be confused with other leaf disorders especially sudden death syndrome. Leaf symptoms develop when infected plants are subjected to high temperatures or drought stress following a period of cool weather. Tissues between the veins turn brown and dry rapidly, usually about three or four weeks before maturity, while tissue adjacent to the veins remains green a few days longer. Eventually, the whole leaf dies. An infected field of soybeans turns yellow then brown in contrast to the yellow-green color of a normally maturing field, suggesting early frost. Since the disease is usually difficult to identify by visible outward symptoms, most growers blame a low yield on other

causes (29).

Methods of Transmission: *C. gregata* is a seedborne fungus that exists as mycelium within the seed coat. It overwinters in soybean debris and in soil (26).

Conditions Favoring Disease: Cool weather in July-Aug. followed by hot, dry weather favors brown stem rot, as well as temperatures between 59-81° F. Little or no disease develops above 90° F (26).

Management: Crop rotation is used to control brown stem rot in soybeans in Michigan. An infested field is not planted to soybeans, alfalfa, or red clover for three years, since *G. gregatum* is also pathogenic to alfalfa and red clover. Infected residue should decompose within this time and *C. gregatum* cannot survive in soil outside of the infected area (29).

Downy Mildew

Peronospora manshurica

Symptoms: The initial symptoms of downy mildew on the leaves are pale green to yellow spots on the leaf's upper surface. These may enlarge and change to a yellow lesion, followed eventually by death of the infected tissue. On the bottom of the leaf immediately opposite the upper surface lesion, a gray to pale cottony growth can be observed. These are areas of sporulation that will produce spores for new infection if a favorable environment persists. Pod infections may occur without external symptoms. The interior of pods and the seed coat may be encrusted with a whitish mass of mycelia and oospores. Seeds partly or completely encrusted with oospores often appear dull white and have cracks in the seed coat. They may be smaller or lighter in weight than normal seeds (32).

Methods of Transmission: The causal fungus overwinters in infested crop debris or seed. Spores are spread to and infect soybeans during periods of high humidity/moisture and relatively cool temperatures. Excessive soil moisture may also encourage disease development (25).

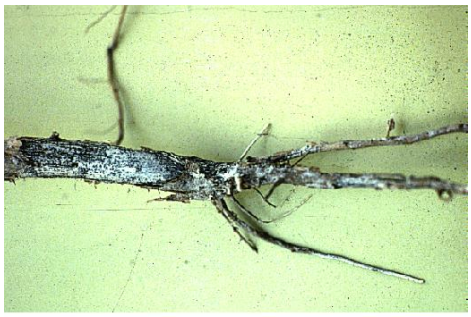
Conditions Favoring Disease: Downy mildew is favored by high humidity and temperatures of 68 to 72° F. Sporulation occurs between 50° F and 77° F and no sporulation occurs above 86° F or below 50° F (32).

Management: Several formulations of Bravo are registered for use on soybeans to control downy mildew, although no information is available on how effective Bravo is at controlling downy mildew on soybeans. Planting oospore-encrusted seeds will produce a few systemically infected seedlings under

cool conditions, and seed treatment with Apron is recommended if downy mildew is evident on the seed. To reduce the amount of inoculum available for infection in subsequent years, growers plow under soybean residue and rotate soybeans out for one year or more. Generally, downy mildew is a serious economic problem only with the soybean variety Vintron 87. These specialty soybeans are grown for the Japanese market and oospore encrusted seed affects buying decisions. (32).

Charcoal Rot

Macrophomina phaseolina



Charcoal rot (Macrophomina phaseolina) on soybean.
Courtesy Joseph Krausz, TAES - 1996.

Symptoms: Infected seedlings can show reddish-brown discoloration at the emerging portion of the hypocotyl. If infection occurs through the roots, discoloration is evident at the soil line and above. The discolored area turns dark-brown to black and infected seedlings may die under hot, dry conditions. Later, a light-brown discoloration of the subepidermal tissues in the taproot and lower part of the stem develops. At first infected plants do not show aboveground symptoms, however, in a more advanced stage, leaves turn yellow, wilt and remain attached. Superficial stem lesions may extend from the soil line upwards. When the epidermis is removed, small black bodies may be so numerous as to give a grayish-black color to the tissues. The sclerotia resemble a sprinkling of finely powdered charcoal. When split open, the taproot and base have black streaks in the woody portion and frequently sclerotia are formed in the pithy area of the stem (30).

Methods of Transmission: Sclerotia may survive free in the soil or embedded in host residue in dry soils for long periods. In wet soils, sclerotia cannot survive more than seven to eight weeks and the mycelium can survive no more than seven days. *M. phaseolina* is a poor competitor in soil, but readily colonizes plant debris. Sclerotia germinate on the surface of roots and produce numerous germ tubes (30).

Conditions Favoring Disease: If wet, cool weather persists, infected seedlings survive, but carry a latent infection. Disease symptoms may appear later with hot, dry weather (30).

Management: Excessive seeding rates are avoided. Weakened seedlings produced by crowding are more vulnerable to fungal attack. Soybeans are fertilized to encourage vigorous growth. Long rotations between soybean crops reduces incidence and severity. Although resistant lines are available for breeding, no highly resistant cultivars have been developed (30).

White Mold

Sclerotinia sclerotiorum

White mold is caused by a soil borne fungus *Sclerotinia sclerotiorum*. The disease has emerged as a major production problem in the north central region with outbreaks occurring in areas where maturity groups I to III are grown (33).

Symptoms: The first symptoms are wilted and yellow plants scattered throughout the field. In most years these symptoms become evident about the middle of August. Eventually, these plants die and by harvest the stems will have a bleached appearance, which is a characteristic symptom of white mold infected plants. Before the foliage symptoms become visible it is often possible to observe white mycelium growing on the stem at nodes where blossoms were first colonized. If adjacent plants come into contact with the infected area, they may also become infected. However, plant to plant spread is minimal and not as important as blossom infections (33).

Methods of Transmission: The white mold fungus survives in the soil as hard, black structures called sclerotia (33).

Conditions Favoring Disease: Soils continuously wet for 10 to 14 days favor the germination of the sclerotia to form apothecia, small mushroom like structures that eject spores into the air (33).

Management: Chemical control with fungicides may be economical in seed production fields, but is probably not economical in commercial fields. Benlate and Topsin M have provided some control, but yield increases have been limited to 20 to 25%, and economic yield increases have not always been consistent. The herbicide Cobra has been shown to reduce white mold infections in soybeans. As with Benlate and Topsin M, application timing is critical and must coincide with the first appearance of flowering (33).

Planting into a ground cover such as grass or clover, or into surface residues of corn, may reduce white mold if enough of the soil surface is covered so that spores are trapped on the lower surface of the ground cover or residue. A late cultivation in early July could be an effective management tool to reduce white mold by disrupting sclerotia as they germinate, if the soil is not too wet to accommodate cultivation (33).

Although there are no completely resistance varieties, some varieties differ in their response to this disease (33).

Sudden Death Syndrome

Fusarium solani

Sudden death syndrome is a soil borne disease caused by *Fusarium solani*. This disease has recently become prevalent in soybean production regions in the North Central United States (6).

Symptoms: Sudden death syndrome symptoms are fairly easy to identify. Leaves on infected plants first have scattered yellow or white spots between leaf veins. These spots start to die and enlarge to form brown streaks between the veins (interveinal necrosis). Only mid-vein and major lateral veins remain green. Eventually, infected leaves drop but petioles remain on the stem. Diseased plants with sudden death syndrome are easily pulled out of the ground because the taproots and lateral roots have deteriorated due to root rot. The root cortex will be a light gray-brown and the discoloration may extend up into the stem, but does not discolor the pith or central tissues of the stem. If infections are severe during the early reproductive stage, flower and pod abortion may occur. Foliar symptoms can be confused with brown stem rot foliar symptoms, but roots on brown stem rot infected plants are not rotted, and the pith of the main stem is usually discolored brown (31).

Methods of Transmission: Sudden death syndrome is a root rot disease and the causal fungus is confined to soil and crop residue in soil. Root infection occurs in the early vegetative stages when soil moisture is high. The fungus in rotting roots is thought to produce a plant toxin that causes above ground symptoms. Above ground symptoms can occur in the late vegetative stages, but usually appear at mid-pod fill or later through wounds caused by insects, nematodes or mechanical injury. Saturated soil favors infection and disease development (25).

Conditions Favoring Disease: Sudden death syndrome is prevalent during cool, wet growing conditions throughout the early flowering season (25).

Management: Well-adapted, high-yielding varieties are grown in warm, well-drained, fertile soil. Balanced soil fertility is maintained based on soil tests. Drainage is improved in the field and soil compaction is reduced (26).

Other diseases, weeds, and insects need to be kept in check. Seed from sudden death syndrome-infected

areas is not saved to eliminate passing the disease on to other fields. Planting times are extended so that all beans are not planted at the same growth stage at the same time. Sanitation guidelines are followed (i. e. clean tires, combines and other equipment of soil and crop debris) (26).

FUNGICIDE PROFILES

Benomyl (carbamate)

Formulation: Benlate.
Pests Controlled: White mold (2).
Application rates: 0.5 lb ai/A (2).
Types of Application: Ground.
Timing: Postemergence, at initiation of flowers. Make only one application (2).
Pre-harvest interval: 35 days. Do not graze or feed treated vines to livestock (2).
REI: 24 hours (2).
Efficacy Issues: Limited to seed production fields (2).

Lactofen (nitrophenyl herbicide)

Formulation: Cobra.
Pests Controlled: White mold (2).
Application rates: 6 to 8 fl oz/A (38).
Types of Application: Ground (38).
Timing: At or just before 1st bloom. Generally this occurs after the 4th trifoliate is fully expanded (28).
Pre-harvest interval: 45 days.
REI: 12 hours (38).
Efficacy Issues: The effects of Cobra on white mold is not a fungicidal response but one that may involve Systemic Acquired Resistance (SAR) (38).

Thiophanate-methyl (carbamate)

Formulation: Topsin-M.
Pests Controlled: White mold (2).
Application rates: 0.35 - 0.7 lb ai/A per application - one application per season (2).
Types of Application: Ground.
Timing: Applications are made at first sign of flowers (2).
REI: 12 hours (2).
Efficacy Issues: Treated vines and hay are not grazed by or fed to livestock. Generally used only for white mold control in seed production (2).

Weeds

Annual weed species comprise a majority of the weed control problems in Michigan soybean production since they tend to follow a life cycle similar to the soybean plant. Weeds that are able to germinate in the spring following primary tillage, compete with the crop, and produce seed before frost or harvest. In addition to annual weeds, perennial weeds and winter annual weeds are problematic in Michigan no-till fields (more than in conventional fields). Grasses can be as competitive as broadleaf weeds. (Side note: one grass plant is probably less competitive than one common ragweed, but there tend to be much higher populations of grasses than ragweed in a given area. Therefore, as a population, the grasses can be just as or even more competitive than the broadleaves) (2).

No-till soybean acreage in Michigan is approximately 50% each year. Therefore 50% of the fields have winter annuals and perennials in addition to summer annuals, which require multiple applications of herbicides for season-long weed control (2).

Annual grasses: There are several annual grasses of concern in Michigan: barnyard grass, giant foxtail, green foxtail, yellow foxtail, fall panicum, witchgrass and field sandbur. Many annual grasses are controlled with preemergence herbicide applications and tillage (2).

Annual summer and winter broadleaves: Annual broadleaf species that are of concern in Michigan include: common lambsquarters, redroot pigweed, smooth pigweed, and common cocklebur. Others that are of concern include: the smartweeds, velevetleaf, wild mustard, cocklebur, Eastern black nightshade and jimsonweed. Winter annuals can be a problem in no-till in Michigan. A few of the winter annual broadleaf species include: henbit, purple deadnettle, common chickweed, and white campion (2).

Control

Roundup ready soybeans, a soybean genetically engineered to be resistant to postemergence applications of Roundup Ultra, has changed weed control in soybeans. Roundup Ready Soybean acreage is approximately 60 to 70% of the total soybean acreage in Michigan, glyphosate (Roundup Ultra) is the primary herbicide used in these areas (35).

Weed resistance: Weed resistance to herbicides is now recognized as a major threat to soybean production. Herbicide resistant weeds in the Midwest include triazine-resistant common lambsquarters, ALS-inhibitor-resistant common ragweed, ALS-inhibitor-resistant giant ragweed, etc. (35).

Crop Rotation: Michigan has a diverse array of crops and a wider array of crop rotations than most other states in the Midwest. Crops included in some rotations with soybeans include: corn, dry beans, sugar beets, potatoes, wheat, alfalfa, and cucumbers. (Other vegetables may also be used in rotation with soybean but at a much smaller acreage) (35).

Crop Competition: Planting soybeans in narrow rows rather than wide rows results in quicker closure of the soybean canopy. A closed canopy suppresses later emerging weeds and results in better season long control. Soybeans planted in narrow rows can efficiently utilize sunlight, water and nutrients because the plants are spaced equidistantly. This can increase soybean yield. These advantages can increase the effectiveness of reduced rate postemergence herbicide programs, which in turn may increase soybean production profitability. However these same practices also promote the development of white mold disease in soybean (34).

Cultivation: Use of inter-row cultivation requires more labor and field scouting than using herbicides, and is more suitable to smaller or mid-size farming operations (35).

Chemical: Herbicide choices depend on many factors including crop, crop stage, weeds, weed stages, environmental conditions, crop rotation for the following year, soil moisture, and distance to waterways (35).

HERBICIDE PROFILES

Ammino Acid Synthesis Inhibitors

Glyphosate (Organophosphate)

Formulation: Roundup Ultra 4SL, Roundup Original, Touchdown, Credit, Glyfos, Glyphomax, Glyphomax Plus, Silhouette, Rattler, Extreme, and Backdraft.
Pests Controlled: Grasses and broadleaves (39).
Acres Crop Treated: 1,596,000 acres treated (1).
Application rates: 0.77 lb ai/A (1).
Types of Application: Ropewick applicator, wipe-on applicator or recirculating sprayer (39).
Timing: Emergence to 30 inches or V8 growth stage. For applications after 24 inches drop nozzles are used (39).
Pre-harvest interval: 7 days (39).
REI: 4 to 12 hours (38).
Efficacy Issues: Ammonium sulfate is always included (39).

ALS-inhibitors and amino acid derivatives

Cloransulam-methyl (triazolopyrimidine)

Formulation: FirstRate 84WDG.
Pests Controlled: Annual broadleaves (except nightshade) (39).
Acres Crop Treated: 21,000 acres treated (1).
Application rates: 0.031 lb ai/A (1).
Types of Application: Ground (35).

Timing: Preplant incorporated (PPI), preemergence (PRE) and postemergence (POST) (39).
Pre-harvest interval: 65 days (39).
REI: 12 hours (38).
Efficacy Issues: Application rate is adjusted according to soil type and percent organic matter (39).
Comment: This product has a groundwater advisory statement (39).

Chlorimuron (sulfonylurea)

Formulation: Classic 25DF.
Pests Controlled: Annual broadleaves (except nightshade and lambsquarters) and yellow nutsedge (39).
Application rates: 0.0106 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI), or preemergence (PRE) (Canopy formulations) and postemergence (POST) (applied after 1st trifoliate has fully expanded) (Classic, Synchrony) (39).
Pre-harvest interval: 60 days (39).
REI: 12 hours (38).
Efficacy Issues: Most effective on small weeds. Cultivation 14 days after treatment improves weed control for postemergence applications (39).
Component in these compounds: Canopy 75DF, Canopy XL 56.3DF, Concert 25DF, and Synchrony STS 42DF.

Flumetsulam (triazolopyrimide)

Formulation: Python 80WDG.
Pests Controlled: Broadleaves.
Application rates: 0.057 to 0.062 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI), preemergence (PRE) (apply 30 days prior to planting until before the soybean cracking stage) (39).
Pre-harvest interval: 85 days.
REI: 12 hours (38).
Efficacy Issues: Not used on peat or muck soils. Not used if soil pH exceeds 7.8 because increased crop injury will occur (39).
Comment: This product has a groundwater advisory statement (39).
Component of these compounds: Broadstrike+Dual, Broadstrike+Trelan, Hornet, Scorpion

Imazamox (imidazolinone)

Formulation: Raptor 1AS.
Pests Controlled: Annual broadleaves (except common ragweed) and annual grasses (39).

Acres Crop Treated: 21,000 acres treated (1).
Application rates: 0.03 lb ai/A (1).
Types of Application: Ground (35).
Timing: Postemergence (POST) applied after 1st trifoliate is expanded fully but before soybean bloom (39).
Pre-harvest interval: 85 days.
REI: 4 hours (38).
Efficacy Issues: Applied with a surfactant and a fertilizer (28% liquid nitrogen) (39).

Imazaquin (imidazolinone)

Formulation: Scepter 70DG, Scepter 1.5AS, Scepter OT.
Pests Controlled: Several broadleaves (suppresses yellow nutsedge) (39).
Acres Crop Treated: 63,000 acres treated (1).
Application rates: 0.05 lb ai/A (1).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI), preemergence (PRE) (up to 45 days before planting), postemergence (POST) (39).
Pre-harvest interval: 90 days.
REI: 12 hours (38).
Efficacy Issues: PPI may cause stunting of soybeans in sandy soils (39).
Component of these products: Squadron, Detail

Imazethapyr (imidazolinone)

Formulation: Pursuit 2AS, Pursuit 70DG, Pursuit Plus.
Pests Controlled: Annual broadleaves (39).
Acres Crop Treated: 273,000 acres treated (1).
Application rates: 0.05 lb ai/A (1).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI) – two pass incorporation is suggested for weed control and postemergence (POST) - apply to weeds less than 3 inches in height (39).
Pre-harvest interval: 85 days.
REI: 4 - 24 hours (38).
Efficacy Issues: Caution is used to avoid misapplication or spray overlap or carryover may occur to labeled rotation crops (39).

Thifensulfuron (sulfonylurea)

Formulation: Pinnacle 25DF.
Pests Controlled: Annual broadleaves (only lambsquarters, smartweed, pigweed, wild mustard and velvetleaf) (39).

Application rates: 0.0004 oz ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) after 1st trifoliolate has expanded (39).
Pre-harvest interval: 60 days (38).
REI: 12 hours (38).
Component of these products: Harmony Extra, Synchrony STS

ACC-ase inhibitors

Clethodim (Cyclohexene oxime)

Formulation: Select 2EC.
Pests Controlled: Annual grasses, perennial grasses.
Application rates: 0.094 to 0.25 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) - to actively growing grasses (39).
Pre-harvest interval: 60 days (39).
REI: 24 hours (38).
Efficacy Issues: No soil activity. Not cultivated 7 days before or after treatment (39).

Fluazifop-butyl (aryloxyphenoxyproprionic)

Formulation: Fusilade DX 2EC.
Pests Controlled: Annual and perennial grasses and volunteer corn (39).
Application rates: 0.094 to 0.188 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) – to actively growing grasses up until soybean bloom (39).
REI: 12 hours (38).
Component of these products: Fusion

Quizalofop-p-ethyl (aryloxyphenoxyproprionic)

Formulation: Assure II 0.8EC.
Pests Controlled: Annual and perennial grasses and volunteer corn (39).
Application rates: 0.031 to 0.0625 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) – to actively growing weeds up until pod set (39).
Pre-harvest interval: 80 days (39).
REI: 12 hours (38).
Efficacy Issues: No soil activity. Controls only grasses present when sprayed. Not cultivated for 7 days before or after treatment (39).

Sethoxydim (cyclohexandione)

Formulation: Poast Plus 1EC, Poast 1.5EC.
Pests Controlled: Annual and perennial grasses and volunteer corn (39).
Application rates: 0.19 to 0.29 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) - to actively growing grasses (39).
Pre-harvest interval: 75 days.
REI: 12 hours (38).
Efficacy Issues: No soil activity. Controls only grasses present when sprayed (39).
Component of these products: Rezult G

PSII inhibitors (non-mobile)

Bentazon (benzothiadiozole)

Formulation: Basagran 4S.
Pests Controlled: Annual broadleaves (except pigweed and nightshade) and yellow nutsedge (39).
Application rates: 0.75 to 1.0 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) (39).
REI: 48 hours (38).
Efficacy Issues: Most effective on small weeds. Not applied if plants are under stress from herbicide injury, cold or dry weather (39).
Component of these products: Galaxy, Result B and Storm

PSII inhibitors (mobile)

Linuron (phenylurea)

Formulation: Lorox 50DF, Lorox 4L and Linex .
Pests Controlled: Broadleaves (39).
Application rates: 0.75 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preemergence (PRE) (after planting, before emergence) (39).
REI: 24 hours (38).
Efficacy Issues: Soybeans are planted at least 1 ¾ inch deep. If heavy rainfall occurs soon after application, injury to crop may occur (39).

Metribuzin (triazine)

Formulation: Sencor 75DF, Sencor 4F.
Pests Controlled: Annual broadleaves (except nightshade) and grasses (39).
Application rates: 0.1 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI), preemergence (PRE) (prior to soybean emergence) (39).
REI: 12 hours (38).
Efficacy Issues: Some soybean varieties have low tolerance to metribuzin (39).
Component of these products: Canopy, Boundary, Axiom, Domain and Turbo.

Shoot inhibitors

Alachlor (acetanilide)

Formulation: Lasso 4EC, Lasso II 15G, Partner 65DF, and Micro-Tech.
Pests Controlled: Annual grasses and a few broadleaves (39).
Application rates: 2.0 to2.5 lbs ai/A (39).
Types of Application: Ground (35).
Timing: Early preplant (up to 30 days prior to planting) (EPP), preplant incorporated (PPI), preemergence (PRE) (39).
REI: 12 hours (38).
Efficacy Issues: PPI application of Alachlor is increased to 3 qt/A (4.5 lb ai/A) for effective nutsedge control. PRE application is increased to 2.5 qt/A (3.8 lb ai/A) for effective nutsedge control (39).

Dimethenamid (amide)

Formulation: Frontier 6EC, Outlook.
Pests Controlled: Grasses and a few broadleaves (39).
Acres Crop Treated: No information available.
Application rates: 1.31 lb ai/A (Frontier) and 0.75 lb ai/A (Outlook) (39).
Types of Application: Ground (35).
Timing: Early preplant (EPP), preplant incorporated (PPI), preemergence (PRE), early postemergence (E.POST) (up to 3rd trifoliolate stage of soybeans) (39).
REI: 12 hours (38).
Efficacy Issues: PPI application is increased to 30 oz/A for effective nutsedge control. Outlook is increased to 21 oz/A for effective nutsedge control (39).
Component of these products: Detail

Flufenacet (anilide)

Formulation: Axiom 68DF (a premix with metribuzin.
Pests Controlled: Fair control of annual grasses.

Acres Crop Treated: No information available.
Application rates: 0.44 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant (PP), preplant incorporated (PPI), preemergence (PRE) (39).
REI: 12 hours (38).

Metolachlor and S-metolachlor (chloroacetanilide)

Formulation: Dual II 7.8 EC, Dual II Magnum 7.64EC.
Pests Controlled: Most annual grasses and yellow nutsedge (39).
Application rates: 1.27 lb ai/A (39).
Types of Application: Ground (35).
Timing: Fall applied: early preplant (EPP) (up to 30 days prior to planting), preplant incorporated (PPI), preemergence (PRE) (39).
REI: 24 hours (38).
Efficacy Issues: PPI and PRE applications of Dual II Magnum are increased to 1.66 pt/A for effective nutsege control (39).
Component of these products: Broadstrike+Dual, Turbo, Boundary and Bicep.

Root inhibitors

Ethalfluralin (dinitroaniline)

Formulation: Sonalan 3HFP.
Pests Controlled: Most annual grasses and common lambsquarters and redroot pigweed (39).
Application rates: 0.9 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI) (within 2 days after applications) (39).
REI: 24 hours (38).
Efficacy Issues: Incorporated within 2 days after application (39).

Pendimethalin (dinitroaniline)

Formulation: Prowl 3.3EC.
Pests Controlled: Most annual grasses and common lambsquarters and redroot pigweed (39).
Crop Acres Treated: 273,000 acres treated (1).
Application rates: 0.71 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI), preplant surface (PP), preemergence (PRE) (39).
REI: 24 hours (38).
Efficacy Issues: Incorporated within 7 days of application unless rainfall comes first (39).
Component of these products: Pursuit Plus EC, Squadron.

Trifluralin (dinitroaniline)

Formulation: Treflan 4EC.
Pests Controlled: Most annual grasses and common lambsquarters and redroot pigweed (39).
Application rates: 0.75 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preplant incorporated (PPI) (incorporation required within 24 hours) (39).

REI: 12 hours (38).
Efficacy Issues: Most effective control if application is made 10 days to 2 weeks ahead of planting and field is reworked just prior to planting (39).
Component of these products: Broadstrike+Treflan.

Growth regulator

2,4-D (phenoxy acetic acid)

Formulation: 2,4-D LV ester 4EC (several products).
Pests Controlled: Marestail (horseweed) (39).
Application rates: 0.5 lb ai/A (39).
Types of Application: Ground (35).
Timing: Applications are made 10 to 14 days before planting, followed by a sequential application preemergence (39).
REI: 12hours (38).
Efficacy Issues: Plants are not treated when stressed. Applications are made when temperatures are at least 60 degrees F (39).

Pigment synthesis inhibitor

Clomazone (isoxazolidinone)

Formulation: Command 4EC, Command 3ME.
Pests Controlled: Most annual broadleaves and grasses (except nightshade) (39).
Application rates: 0.75 lb ai/A (39).
Types of Application: Ground (35).
Timing: Preemergence (PRE) (39).
REI: 12 hours (35).
Efficacy Issues: Clomazone is not applied within 1200 feet of housing, greenhouses, fruit, and vegetable production (39).
Component of these products: Command Extra.

(PPO Inhibitor)

Aciflurofen (nitrophenylether)

Formulation: Blazer 2L, Ultra Blazer.
Pests Controlled: Annual broadleaves (except velvetleaf and lambsquarters) (39).
Application rates: 0.38 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) (39).
Pre-harvest interval: 50 days (39).
REI: 48 hours (38).
Efficacy Issues: Most effective on small weeds (39).
Component of these products: Galaxy, Storm.

Flumiclorac (N-phylphthalimide)

Formulation: Resource 0.
Pests Controlled: Velvetleaf (39).
Application rates: 0.041 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) (39).
Pre-harvest interval: 60 days (39).
REI: 12 hours (38).
Efficacy Issues: There are no crop rotation restrictions (39).

Fomesafen (nitrophenylether)

Formulation: Flexstar 1.88ME, Reflex 2LC.
Pests Controlled: Annual broadleaf weeds (except velvetleaf, smartweed, lambsquarters, and cocklebur) (39).
Application rates: 0.25 lb ai/A (39).
Types of Application: Ground (35).
Timing: Postemergence (POST) (before soybean blooming) (39).
REI: 24 hours (38).
Efficacy Issues: Not applied to the same field for 2 years in a row (39).

Lactofen (nitrophenylether)

Formulation: Cobra 2EC.
Pests Controlled: Annual broadleaves (except velvetleaf, smartweed and lambsquarters) and white mold (39).
Application rates: 0.195 lb ai/A (39).

Types of Application: Ground (35).
Timing: Postemergence (POST) – not during cotyledon stage (39).
Pre-harvest interval: 45 days (39).
REI: 12 hours (38).
Efficacy Issues: Effective on small weeds. A timely cultivation one week following application assists in weed control (39).

Sulfentrazone (triazolone)

Formulation: Authority 75DG.
Pests Controlled: Some annual broadleaves (including nightshade) (39).
Application rates: 0.188 to 0.25 lb ai/A (39).
Types of Application: Ground (35).
Timing: Early preplant (EPP)(up to 30 days), preplant incorporated (PPI), preemergence (PRE) (39).
REI: 12 hours (38).
Efficacy Issues: Used on soils with organic matter from ½% to 4% (39).
Component of these products: Canopy, Gauntlet and Command Extra.

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