Crop Profile for Beans (Dry) in Michigan

Prepared: October, 1999

General Production Information

- Top states in dry bean production are North Dakota and Michigan.
- Michigan ranks 2nd in overall dry bean production .
- Michigan leads the country in Navy bean production accounting for 48% of the national total.
- Michigan also leads the nation in Black and Cranberry bean production.

 (17)

	Dry Beans
Michigan Ranking	2
Percent U.S. Production	17 %
Area Planted (5 year average)	372,000 acres
Area Harvested (5 year average)	355,000 acres
Value ofProduction(5 year average)	$ 118,451,000
Production (5 year average)	5,324,000

(17)

	District	Counties	Acres Planted	Acres Harvested
Dry beans in Michigan, MASS 1996-97	Upper Pennisula	Delta (1995) Other counties (1995)	900 200	800 200
	Northwest	Kalkaska (1995) Manistee (1995) Other counties 1995 1996	700 1100 300 1400	700 1050 250 1300

The Crop Profile/PMSP database, including this document, is supported by USDA NIFA.

Northeast	Alcona 1995 1996 Alpena 1995 1996 Iosco 1995 Montmorency 1995 Ogemaw 1995 Otsego1995 Presque Isles 1995 1996 Other counties1996	1200 1000 4200 3400 300 600 250 400 2950 2900 1100	1150 950 3980 2900 290 590 250 390 2750 2800 950
West Central	Muskegon 1995 Newaygo 1995 Oceana 1995 other counties 1995	200 200 200 100	200 200 200 100
Central	Gladwin 1995 1996 Gratiot 1995 1996 Isabella 1995 1996 Mecosta 1995 1996 Midland 1995 1996 Montcalm 1995 1996 Other counties 1995	2300 1800 34300 25800 6500 4400 2950 2800 7200 5300 19600 17900 150	2300 1600 33700 23800 6350 4200 2950 2600 7050 4900 19300 17400 150

East Central	Arenac 1995 1996 Bay 1995 1996 Huron 1995 1996 Saginaw 1995 1996 Sanilac 1995 1996 Tuscola 1995 1996	13700 12000 39000 37000 108000 102000 22300 16200 29000 26800 63000 61000	13600 10600 38400 34000 106900 98000 22100 15600 28800 23300 62700 59500
Southwest	Cass 1995 Kalamazoo 1995 Kent 1995 1996 Other counties 1995 1996	900 1000 1800 2300 400 800	900 1000 1800 2200 400 800
South Central	Barry 1995 Branch 1995 Calhoun 1995 Clinton 1995 1996 Eaton 1995 1996 Ionia 1995 1996 St. Joseph 1995 Shiawasee 1995 Other counties 1995 1996	300 1550 700 2100 1000 3300 1600 2500 1100 2500 500 250 1900	300 1500 700 2000 700 3100 1400 2450 850 2500 500 250 1900

	Southeast	Genesee 1995 Lapeer 1995 1996 Lenawee 1995 Monroe 1995 St. Clair 1995 Other counties 1995 1996	1000 7000 3350 450 300 1350 300 3550	1000 6850 3350 450 300 1300 300 3350

(17)

Cultural Practices

In Michigan, 40% of total yearly precipitation falls during June through September. Evaporation during the growing season is almost double the precipitation. The growing season for dry beans ends with the first killing frost (32F or 0C). This time falls between 9/20 and 10/5. Plowing occurs in the fall between Sep.-Nov. Some fields require deep tillage and leveling. Cultivation (tillage after seeds are replanted) is used to to break crusts, control weeds, increase water infiltration and facilitate harvesting by ridging bean rows. Of all the different operations in bean production, fuel and time requirements for tillage are highest. Weeds are controlled by cultivation and herbicides. Herbicides are first applied before planting the bean crop. Farmers incorporate herbicides into the upper 2 or 3 inches of top soil by using harrow (PPT- pre plant incorporated method). Growers also apply herbicides after planting (preemergence and postemergence).

Very few of the beans grown in Michigan are irrigated, because high quality irrigation well water is not generally available where they are grown. Too much or too little water are problems that interfere almost every year in MI dry bean fields. Disposing of excess water is mainly an emerging problem. MI bean producers are in need of ways to improve surface drainage because water infiltration is slow in many fields.

The best soils for growing dry beans are loam with relatively high organic matter. An ideal system for cropping of dry beans includes improvments in soil productivity through better management tactics. Fields composed of rotation of several crops, each well suited to soil conditions and to availability of both labor and machinery, improve dry bean productivity. There are 16 Major elements necessary for dry beans production, including (N), (P), and (K), which is most likely to be deficient in Michigan soils. The Secondary elements include (Ca), (Mg) and (S), which are rarely lacking in Michigan soils with pH greater than 6.5. The others are (Zn), (Mn), (B), (Fe), (Cu), (Cl) and (Mo). The sources for these elements are soil, fertilizer, manure, air (source of nitrogen, dry beans fix nitrogen), rain and

irrigation water.

Insect Pests

Biology
Adult seedcorn maggots are grayish brown and resemble small houseflies. Adults emerge from in early April and begin host finding and egg laying.. The damaging stage is the maggot or larva, which is a pale, yellow- white, legless, and a maximum length of ¼ inch long. Usually the first of three larvae generations damages to crops (2). These larva feed for 2-4 weeks before pupating (1).

The maggots attack the young plants by boring into the seeds or developing cotyledons (2). They may also feed on developing roots , resulting in seeds that do not germinate, damaged primary leaves, stunted plants, or an affliction called "snakehead" beans.(1) Wet, cool weather, as well as high levels of organic matter (such as fresh green manure) increase the chance for seedcorn maggot injury. The severity of the damage increases with slower germination and earlier infestation. Turing over fresh green manure before planting will increase the likelihood of infestation as well (2).

Cultural Controls
Limiting the amount of organic matter can reduce the attractiveness of the field to the egg-laying flies. Some growers have found that delaying planting for several days can greatly reduce the amount of damage to plants (2)

Chemical Controls
Phorate
dyphonate

Potato Leafhopper

Biology
Potato leafhopper is the major dry bean pest in Michigan.(12) PLH do not overwinter in the Midwest but are carried in each spring by southerly winds. The adult leafhopper is yellowish green and about 1/8 inch long with a row of six white spots just behind the head. Nymphs are smaller versions of the adult, lacking wings and ability to fly (2). The development time between the egg and adult stage is usually 25 to 30 days, depending on the weather. (1).

Both the adult and nymph stages cause damage to dry beans. Leafhoppers feed by sucking water and nutrients from the leaves. The first signs of leafhopper feeding are pale leaf veins and curled leaves. "Hopperburn" can result from continued feeding. This is a condition resulting in triangular yellowing or

browning of the leaf tip.

Cultural Controls
Rotation

Chemical Controls
All growers dust for leaf hoppers. One method is a pre-emergence (Thimet) and one spray postemergencee. Thimet will not last season long unless PLH presence is very low. A second method is postemergence with sprays generally at cultication or until row closure (dimethoate, dimate).(19)

Alternative Controls
No information available.

Bean Leaf Beetle

Biology
Bean leaf beetles overwinter as adults in wooded areas, leaf litter, weeds, set-aside acres, and pastures. They become active and move into bean fields as the temperature rises in the spring. The adult is about ¼ inch long and varies from pale yellow to dull red. Bean leaf beetles may or may not have black spots on each wing. The key characteristic is a small black triangle immediately behind the head of the beetle. There are usually two generations per year. Although the larvae feed on roots of beans they are not a threatening pest stage.

Bean leaf beetles chew small round holes in the leaves of bean plants. This damage causes stress by itself or in combination with other defoliators like Japanese beetles or grasshoppers. First generation damage is more of a threat south of Interstate 80. Adults feed on primary leaves and directly on the pods. Damage results in reduction of plant vigor, plant size, and yield.

Cultural Controls
Bean leaf beetles should only be controlled if 1/4 or more of the foliage is damaged by leaf feeding insects, primarily bean leaf beetle.(19) Scouting for damage is important with bean leaf beetles . (2)

Chemical Controls
dimethoate
esfenvalerate
acephate

Alternative Controls
No information available.

Mexican Bean Beetle

Biology
Adults are ¼ to 1/3 inch long, oval, and yellow to copper in color. They have eight black spots in three rows across each wing cover. Mexican bean beetles overwinter as adult beetles in grass and litter in fence and tree rows. (2). They begin feeding as soon as they emerge (1). After feeding for 1 to 2 weeks, the adults lay their eggs on the underside of bean leaves. The yellow-orange egg masses hatch into larvae that are bright yellow and have six rows of branching spines. (2) Larvae then mature into adults in 25 days. (1)

Mexican bean beetles feed on all types of beans. Both larvae and adults feed on the underside of leaves, removing the leaf tissue but leaving the epidermis. Severely injured leaves may have a lace-like appearance, also known as "window-paning " of the afflicted leaf . (1) (2)

Cultural Controls
Early planting is avoided to reduce damage (VIM 50).

Chemical Controls
Treat when 1/4 or more of foliage has been damaged primarily by Mexican bean beetle, or if there is 1+ adults per plant.(19)
carbaryl
acephate
esfenvalerate

Alternative Controls
No information available

Tarnished plant bugs *(Lyqus lineolaris)*

Biology
The tarnished plant bug is found throughout North America but is primarily a pest in temperate areas. It has two to five generations per year, depending on location. It is a true bug with piercing-sucking mouthparts.

Adults are 6-6.5 mm long, oval and somewhat flattened. They are greenish-brown in color with reddish brown markings on the wings. A distinguishing characteristic is a small but distinct yellow-tipped triangle in the center of the back. They overwinter as adults under leaf litter, stones, and tree bark and in other protected places. They become active at the end of April and begin laying eggs in crop and weed

hosts. The eggs are about 1 mm (0.04 in.) long, cream colored and flask shaped. They are laid in plant tissues so only the small anterior end is visible. Eggs can be laid on fruit crops but are generally deposited on weeds and grasses. The eggs hatch into nymphs about 7 days after being laid. Young nymphs are pale green and resemble aphids, except for their legs are more robust, their movements are more rapid and they have no abdominal cornicles. The nymphs resemble the adults without wings.

Cultural Controls
Plants are monitored visually or by sweep net sampling, especially during flowering and pod formation.

Chemical Controls
Products sprayed, usually at cultivation for potato leafhopper, also controls tarnished plant bug.
dimethoate
esfenvalerate
carbaryl

Alternative Controls
No information available

Insecticide Profiles

Registered Insecticides used by Michigan Growers(12)

dimethoate (organophosphate) (10)(14)

- Formulations: dimethoate, dimate (19)
- Pests Controlled: Aphids, grasshoppers, leaf beetles, leafhoppers, mites and plant bugs (10)
- Percent of Crop Treated:
- Application Rates: 4 EC--0.5-1 pt lb/acre. 5lb--6.4 oz/acre (10)
- Types of Applications: banded broadcast (12)
- Number of Applications:1-3 (14)
- Timing: usually at cultivation
- Pre-Harvest Interval: 7 days (10)`
- REI: 4 days(10)
- Use in IPM Programs: NA
- Use in Resistance
- Management Programs: NA
- Efficacy Issues: no information available
- Advantages: Systemic insecticide therefore full coverage is not required. (10) Less expensinve than comparable products.(19)

- Disadvantages: no information available.
- Critical Use Issue: Highly toxic to bees. Do not feed treated vines to livestock. (10)

esfenvalerate (pyrethroid) (10)

- Formulations:Asana XL 0.66 EC (10)
- Pests Controlled:aphids, cutworms,grasshoppers, green cloverworm, leaf beetles, leafhoppers and Mexican bean beetles.(10)
- Percent of Crop Treated:
- Application Rates: 5.8-9.5fluid ozs/acre for all pests except Mexican bean beetle, which is 2.9-5.8 fluid ozs/acre (10)
- Types of Applications: banded and broadcast. (12)
- Number of Applications: no information available
- Timing: no information available
- Pre-Harvest Interval: 21 days(10)
- REI:12 hours (10)
- Use in IPM Programs: no information available
- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages: no information available
- Disadvantages: no information available.
- Critical Use Issue: High toxicity to bees.Max 2lbs active ingredient per acre per season. Do not graze or feed forage to livestock. (10) Restricted Use Pesticide- A pesticide applicator certificate is required from the MDA for the purchase and use of these pesticides.

phorate (organophosphate) (10)

- Formulations: Thimet 20 G, Phorate (10)
- Pests Controlled:seedcorn maggot (10)
- Percent of Crop Treated: no information available
- Application Rates:4.5-7oz formulation/acre (10)
- Types of Applications: banded (12)
- Number of Applications: no information available
- Timing:no information availalbe
- Pre-Harvest Interval: 60 days (10)
- REI: 48 hours (10)
- Use in IPM Programs: no information available
- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages: no information available
- Disadvantages: no information available
- Critical Use Issue: Restricted Use Pesticide- A pesticide applicator certificate is required from

the MDA forthe purchase and use of these pesticides. (10)Thimet can not contact seed.(10)

acephate (organophosphate)(10)

- Formulations: Orthene 75 S, 75 WSP(10)
- Pests Controlled:aphids, armyworms, cutworms, grasshoppers, green cloverworms, leaf beetles, leafhoppers, leafrollers,Mexican bean beetles, plant bugs and thrips.(10)
- Percent of Crop Treated: no information available
- Application Rates: 0.67-1.33 lb formulation/acre(10)
- Types of Applications:banded (10)
- Number of Applications: no information available
- Timing: no information available
- Pre-Harvest Interval: 14 days (10)
- REI: 24 hours (10)
- Use in IPM Programs: no information available
- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages:Systemic Insecticide, full coverage not required (10)
- Disadvantages: no information available
- Critical Use Issue: High toxocity to bees, do not feed treated vines to livestock.(10)

Other registered insecticides in Michigan

carbaryl (carbamate) (10)
Methoxychlor (diphenyl chloride) (10)
Malathion (organic phosphate)(10)
Malathion (organophosphate) (10)
Naled (organophosphate) (10)
Methomyl (carbamate) (10)
Penncap-M
Methyl parathion (organic phosphate) (10)
Bacillus thuringiensis (biological) (10)

Diseases

White Mold (*Sclerotinia sclerotiorum*)

Biology

White mold is a key pest of dry beans in Michigan (5). White mold infections initiate at the flowers and enter the stem. Stem infection causes that part above the point of infection to wilt and die. Affected stems appear bleached and dry which differs from the tan color characteristic of mature, dry plant tissue. Hard, black, irregulary-shaped resting structures (sclerotia) of the fungus form on and within the infected plant parts. Sclerotia which fall to the soil during harvest, germinate the following season as small (1/4 inch or 6 mm diameter) beige-colored mushroom-like structures (apothecia) which release spores that are spread to dead blossoms or leaves. These spores germinate on and utilize this dead tissue as an energy source before the fungus invades healthy tissue (DBPP 22).

Cultural Controls

Certified seed of recommended bush or upright type varieties is planted if land has a history of white mold. Rotation for at least three years to non-host crops such as sugarbeets, corn, sorghum, barley, and other small grains is recommended to reduce the number of white mold sclerotia. Growers use recommended plant populations and row widths to promote rapid drying of the plants and soil surface after rain or irrigation, especially immediately before and during the flowering period. Apply only the recommended amount of fertilizer where needed to avoid excess canopy development. Irrigation is scheduled only as required by the crop for satisfactory growth since disease development depends on a moist soil surface beneath the plant. **Late in the season the only way to slow down a white mold epidemic is to extend irrigation intervals or cease irrigating**. (1)

Chemical Controls

Because white mold is not a problem every year, but only when there is abundant rainfall and an extensive canopy cover, chemical control may not be advisable as a normal management practice. However, chemical control can be effective when the chemical is applied before the infection has occurred or if the chemical adheres to the plant for a considerable period of time. Chemical applications can also be effective if the chemical penetrates the canopy and reaches the flowers, which are the most important sites of initial infection. These conditions require that the 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. Spraying is done between the onset of flowering and peak bloom. The timing of chemical applications is critical. (3)

Alternative Controls

No information available

Anthracnose

Biology
Anthracnose is a seed-transmitted disease caused by the fungus *Colletotrichum lindemuthianum.* Although once a severe problem for Michigan bean growers, development of resistant, improved seed production and certification programs has reduced the treatment of Anthracnose. However, the disease is still found in a few fields every year and occasionally causes severe losses. Black beans are especially susceptible. In 1981and 1994 the use of contaminated seed caused severe disease problems. (4) (5)

There are numerous strains or races of the bean anthracnose fungus which are distinguished by their ability to attack certain bean varieties. The alpha, beta and gamma strains are found in Michigan. Disease symptoms produced by all strains are identical. The initial symptom of an infection is a dark brown to black lesion along the leaf veins on the underside of the leaves. Leaf petioles and even stems may also show this symptom. The plants may appear fairly normal until the disease is well advanced because infections are initially restricted to the lower leaf surface. Symptoms of pod infection appear as circular, reddish-brown to near-black lesions on the pods. The spots develop a sunken center as the lesions enlarge. The center first shows brown, dead tissues which are quickly replaced by pink fruiting structures which contain the spores of the fungus. The fungus may then penetrate seeds. Such infected seeds, when planted, serve as the source of infection for succeeding crops. **Because anthracnose infrequently overwinters in Michigan, infected seeds serve as the primary source of inoculum**. (4)

Anthracnose development is favored by cool to moderate temperatures and prolonged periods of high humidity or free water on foliage and young pods. The pathogen can be easily transmitted to healthy plants by storms, people, and machinery moving through the field when plants are wet. Anthracnose is usually not a problem in semi-arid regions. (1)

Cultural Controls
It is important to plant treated, disease-free seed to minimize the risk of infection. (4) Some Michigan growers use western grown seeds to control possible outbreaks of anthracnose. (5) A one year rotation out of beans is recommended because studies indicate the fungus may overwinter. (4) It is recommended that fields remain clear of walking and scouting when plants are wet. (1)

Chemical Controls
If anthracnose is found in a field, spread of the disease can be limited by the use of fungicides. A single application of benlate when disease first appears is important. However, chemical control is dependent on identifying the disease early and will be ineffective once the disease is well established. **Chemical control is often erratic and satisfactory control may not be achieved**.

Alternative Controls
No information available

Common blight(*Xanthomonas campestris* pv. *phaseoli*) Fuscous and Halo Bacterial Blight

(*Pseudomonas syringae* pv. *phaseolicola*) *X. phaseoli* var. *fuscans*

Biology

Bacterial blight is a key pest of dry beans in Michigan. (5) Bacterial blight is a collective term used to describe the symptoms on beans caused by one or more species of bacteria. The species of concern to Michigan farmers are those listed above (*Xanthomonas campestris* pv. *phaseoli*, *X. phaseoli* var. *fuscans* and *Pseudomonas syringae* pv. *phaseolicola)* which cause common blight, fuscous blight, and halo blight respectively. All are seed transmitted and spread from plant to plant by rain, hail and wind. All are believed to survive in plant debris in the soil for at least one year. Plant infection occurs through natural leaf openings, or through wounds created by hail, blowing soil particles, sucking insects, or mechanical injury. Pod infection occurs rapidly, after which immature seeds are invaded by the bacteria. The seeds will usually transmit the disease to the resulting bean crop. All Michigan bean varieties are susceptible to common and fuscous bacterial blights. (6) Most navy beans are resistant to halo blight.(15)

Symptoms of Common and Fuscous blight include small water-soaked spots on the underside of leaflets are the first symptoms. These spots enlarge and merge, becoming dried and brown. A narrow, bright lemon-yellow border of tissue often encircles the lesion. Infected pods develop circular water-soaked spots, and yellow masses of bacteria may be seen in their centers. Later, the spots dry and become reddish-brown sunken lesions. Early pod infection may cause shriveled seeds.. The bacteria may cause yellowing under the seed coat of infected seeds. A stem girdling or joint rot can occur above the cotyledonary node of plants grown from infected seeds. (1) The disease ordinarily begin early in the development of the plant, but symptoms are not obvious until blossom. Spread from plant to plant is very rapid. (6) Warm weather favors infection. The bacteria survive in the field from one year to the next in infected seed and bean debris. The pathogen can be transmitted from the surfaces of infected leaves and stems to healthy plants by storms, people and machinery moving through the field. Rain and hail also spread the pathogen. (1)

Halo bacterial blight develops more rapidly during the cooler temperatures in early growing season. (6) Symptoms of Halo blight include small water-soaked spots on the leaflets. In a dry climate, these spots soon become dad and tan-colored. A broad yellow-green halo develops around the spots. This broad halo helps distinguish this disease from common and fuscous blights which exhibit a narrow, lemon-yellow boarder mentioned above. However, presence of the halo is temperature dependent, and it may cause leaflets to become curved and induce considerable yellowing of younger leaves without the appearance of halos or dead spots. Halo blight symptoms on pods begin as water-soaked circular spots or water-soaked streaks on the pod suture. The bacteria in the center of the spots may appear cream or silver colored. Early pod infection may cause shriveled seeds. Stem girdling and joint rot may occur above the cotyledonary node of plants grown from infected seed. Planting infected seed enhances early infection. Cool weather favors the disease and production of the toxin that forms halos and systemic yellowing. Wet weather and violent hail and rainstorms enable the pathogen to be spread more rapidly. Movement of people or machinery through the fields enhances spread of halo blight bacteria. Continuous cropping favors survival of the pathogen. (1)

Cultural Controls
Certified seed of blight resitant/tolerant varieties and knowledge of seed history are important controlling this disease. (6) (1) Infected bean debris is incorporated into the soil after harvest and beans are rotated with other crops for at least two years. Old bean straw on fields, reuse of infected irrigation water, and walking on fields when plants are we are sources for spreading this disease. (1) Prevention of field infection by isolation: Beans grown for seed should not be planted adjacent to neighboring commercial bean fields because blight may spread to adjacent fields by man, wind, animal or rain. **Because westerly winds prevail in Michigan, greater separation should be made to the west side of fields**. The more isolated the crop, the greater the chances of avoiding infection. (6)

Chemical Controls
Seed treated with S*treptomycin* to helps reduce seed coat surface contamination. (1) Seed treatment does not eliminate internal bacterial infections. A water solution containing a bactericideis used to prepare a standard seed slurry containing a fungicide and insecticide. (6) Bactericides such as copper sprays generally provide poor to moderate control depending upon disease pressure and climatic conditions. (1) A chemical spray program should not be necessary if the preceding recommendations are followed. Only in the case of halo bacterial blight is there evidence that copper spray will help prevent the spread of blight, but effects in yield are limited.(15) There is not sufficient evidence to recommend spraying for control of common and fuscous blight on beans. (6)

Alternative Controls
No information available

Common Mosaic Virus (BCMV)

Biology
BCMV can cause a systemic mosaic or darkening (necrosis) in infected plants, depending on the variety and its genetic background. The systemic mosaic symptom occurs in susceptible plants infected by the virus. Symptoms appear as green to bluish-green mottled or mosaic pattern on leaves which usually exhibit a downward curling or cupping. This mosaic symptom is often associated with and follows the network of leaf veins which become slightly darker than the areas between the veins. This symptom can sometimes be more easily observed by shading the leaf from direct sunlight. Severe, early infection can greatly reduce plant vigor and productivity, and increase seed transmission. (1) Plants infected early in the growing season or grown from infected seed may have fewer pods and fewer seeds per pod than healthy plants. Plants infected through secondary means later in the season usually produce near normal yields, but a high percentage of the seed may be infected. (7)

The systemic necrosis symptom (black root reaction) occurs in varieties with a specific gene which is being used frequently in the development of new bean varieties with more stable forms of resistance to BCMV. These varieties are resistant to all strains of BCMV under most conditions. However, when plants growing at high temperatures are inoculated with BCMV, the black root reaction may develop.

The systemic necrosis begins with a slight wilting of young leaflets at any stage of plant growth, followed by a browning or blackening of the vascular tissue and various plant parts, wilting of leaves, and eventually plant death. Discoloration of the water conducting tissue of stem and pods can be observed by making a cross sectional cut through them. (1) The rapid wilting and death of plants prevents them from serving as sources of infection for healthy plants. However, when large numbers of plants are affected by black root, yield losses are substantial. (7)

BCMV may be severe when susceptible varieties are grown near a virus source (i.e. infected plants in the field or nearby field) and are subjected to aphid infestations. BCMV generally does not cause serious problems east of the Rockies, unless seed stocks of susceptible varieties are badly contaminated and unusually high populations of aphids exist. Yield losses from BCMV are generally more severe when infection occurs earlier in the growing season. (1)

Cultural Controls
Certified seed of BCMV resistant varieties is available in areas where this disease is a problem. (1) Even a low percentage of infected seed (1-5%) can result in the introduction and buildup of new strains of BCMV in Michigan that could induce the black root reaction in resistant cultivators. Crop rotation, early planting, and deep plowing of infected fields are NOT effective in controlling BCMV, but are recommend practices for other diseases of dry beans. (7) Adjustment of cultivation equipment and timing is important to minimize mechanical rubbing and injury of plants, especially if BCMV or any bacterial is present in the field. (1)

Chemical Controls
None registered in Michigan

Alternative Controls
No information available

Angular Leaf Spot of Dry Beans (*Isariopsis griseola*)

Biology
Angular leaf spot is caused by the fungus *Isariopsis griseola,* which overwinters in crop debris in tropical and subtropical climates. It is not know, however, whether this fungus overwinters on crop debris in Michigan. ALS attacks kidney beans and the dark red kidney bean variety, Montcalm, in particular. It does not attack other bean market classes or varieties. Symptoms are generally evident at late flowering or early pod fill. Leaf lesions, initially gray or brown, become necrotic and well defined with the typical angular shape occurring by 9 days after infection. Plant stems, petioles and branches may also be infected. Pod lesions are oval to circular with reddish-brown centers surrounded by darker colored boarders. Infected pods may contain poorly developed or entirely shriveled seeds, and the fungus can be carried on or in the seed. These symptoms should not be confused with bacterial blight. Angular leaf spot is characterized by fluffy growth of the fungus (synnemata which bear spores) in the

lesions on the underside of the leaf. (8)
Although generally rare in Michigan, angular leaf spot was a serious problem on the Montcalm red kidney bean variety in the northern production areas, chiefly Presque Isle County. The Montcalm red kidney bean is the dominant variety in northeast Michigan and, therefore, the most severely infected. It was a concern in the mid to late 1980's and was found on kidney beans in Presque Isle county this year, but the incidence was low and not considered epidemic.

Cultural Controls
Severely infected fields should be rotated out of susceptible bean crops for at least one year. Of the various commercial classes of dry beans, red kidney and cranberry are most susceptible. Until more is know about this disease, rotation to another crop is recommended. (8)

Chemical Controls
The fungus has been identified on seed used for planting. Therefore, seed treatment with the standard combination of fungicide, antibiotic, and insecticide is recommended. Application of a fungicide to the foliage of bean plants may be beneficial if applied early. **Once infections are well advanced, fungicides will be of little benefit**. Fungicide spray trials have not been done in Michigan, but benomyl and thiophanate methyl reportedly control angular leaf spot. **Fungicides are used only when the disease is positively identified and detected early.** (8)

Alternative Controls
No information available

Bacterial Brown Spot *(Pseudomonas syringae* syn. *P s.* pv. *syringae*)

Biology
Size varies, but usually small, brown lesions form on leaves and may be surrounded by a narrow yellow zone. Water-soaked tissue may not be noticeable, but if present may appear as small circular spots on the lower leaf surface. The centers of old lesions commonly fall out, leaving a tattered strip or hole on the affect leaves. Plant lesions can occur along the stem and pods may become bent or twisted. Older plants are generally more resistant to infection. (1)

Planting infected seed may enhance early infection and spread of the disease, especially if tissue is damaged. Survival of the bacterium in infected bean debris may also cause early infection where continuos bean production is practiced. Survival on susceptible weeds such as hairy vetch may also provide the initial source of bacteria. Rainstorms and sprinkler irrigation can promote spread of brown spot. (1)

Cultural Controls
Certified seed of recommended varieties. Incorporation of infected bean debris into the soil after harvest and rotation of beans with non host crops for at least two years. Walking through fields when

plants are wet can spread this disease.

Chemical Control
Seed treated with streptomycin to helps reduce seed coat surface contamination. Bactericides such as copper reduces spread of the pathogen to leaves and pods depending upon disease pressure and climatic conditions. (1) Some Michigan farmers have found spraying to be ineffective. (5)

Alternative Controls
No information available

Fusarium *(Fusarium solani* f. sp. *phaseoli*)

Biology
Root rot is a key problem for Michigan growers.(5) Fusarium root rot initially appears as red to reddish brown streaks (lesion) on the hypocotyl and primary root (tap root) 2-3 weeks after planting. These affected areas enlarge with age, may merge and gradually become brown. These symptoms may extend up the main root and hypocotyl to the soil surface, and longitudinal cracks can develop in older lesions. Severely infected primary and secondary roots are commonly killed but can persist on the plant as dried remnants. Lateral roots can develop from the hypocotyl above the initial infection site if sufficient soil moisture is available. Plants are seldom killed by the fungus, but may be stunted with yellow leaves.(1)

The Fusarium rot rot fungus occurs in most cultivated soils of the region where beans have been grown previously, and most plants grown in these soils will become infected to some degree before they mature. Root rot severity depends on factors such as cropping history, plant spacing, moisture and temperature stresses, and soil compaction. In general, any factor which contributes to a reduced rate of root growth increases the plant's susceptibility to Fusarium root rot. Early planting in cool, moist soil favor the disease, as does soil compaction in the form of tillage or hardpan layers.

In dry land production areas the disease can be more serious, especially in years of drought. High plant populations also increase plant stress and favor infection. Improper cultivation, other soil-borne pathogens, and various herbicides are also know to induce injury of young roots and aggravate Fusarium root rot damage. The effect of Fusarium root rot is usually more apparent during blossming and early pod set when the plant and its productivity are most sensitive to stress. (1)

Cultural Controls
Certified seed of Fusarium root rot tolerant or resistant varities is recommended. Most snap beans varieties are more susceptible to Fusarium root rot than dry bean types. Rotation of beans with non-host crops such as corn, wheat, barley, or alfalfa will usually reduce root rot severity. Planting is done when surface 6 inches (15 cm) soil temperature is at least 60 degrees F (16 degrees C) Chiseling (subsoiling) 20 inches (50 cm) deep between bean rows or 11 inches (28 cm) deep immediately in front of the planter

and 1.5 inches (4 cm) to the side of the row promotes root penetration. Where chiseling is practiced, irrigation intervals are extended. Irrigation is managed to provide enough water to the developing plant without causing moisture stress or excess. Plants may be predisposed to infection after being stressed by moisture of temperature extremes. Plants are spaced within the row to reduce plant compition for water. Soil is tilled around the base of infected plants to enhance lateral root development above infected portions of the hypocotyl. (1)

Chemical Controls
No recommendations. (15)

Alternative Controls
No information available

Pythium (*Pythium* species)

Biology
Pythium species may infect planted seeds, germinating seedlings, young plants, or even older plants during blossoming and pod formation. It is one of the pathogens capable of causing seed decay and seedling death. Initial root rot symptoms, elongated water soaked areas on the hypocotyl and roots, usually appear within 1-3 weeks after planting. Root rot is a major pest for Michigan farmers. (5) The can extensively prune roots, reduce overall plant growth, and destroy much of the hypocotyl and main root system. The water soaked region may extend several inches above the soil line, with little, if any, visible evidence of the fungus. THe water-soaked area eventually dries out, becomes somewhat sunken, and tan to brown in color. Plants may then wilt and die. Pods in contact with the soil may become infected and exhibit a watery soft rot, or a mass of white fungal growth (but without forming black sclerotia as with white mold). (1)

Pythium root rot and wilt is favored by high soil temperature, depending upon the species of Pythium involved. Varietal susceptibility may also influence disease development. Pathogen survival and inoculum buildup are favored by soils with high organic matter and poor drainage. Susceptibly can be increased if roots are damaged during cultivation or by other soil borne problems, such as nematode feeding. The fungus can be transported within and between fields by contaminated irrigation water. (1)

Cultural Controls
Rotation of crops reduces residual populations of the pathogen. Warm, moist soil (60 degrees F or 16 degrees C) are recommended for rapid germination and emergence. Management of irrigation tail water is needed to restrict the spread of the fungus between and within fields. Where pod root rot is a problem, irrigation intervals are extended near the end of the season to allow the soil surface to dry, thus inhibiting active fungus development. (1)

Chemical Controls

Treatment of seed with recommend fungicides eliminates seed coat contamination and protects germinating seedlings. (1)

Alternative Controls
No information available

Rhizoctonia (*Rhizoctonia solani*)

Biology
Rhizoctonia solani can cause seedling death, root and hypocotyl rot, stem cankers and pot rot. Initial symptoms appear on roots or hypocotyls as linear or circular reddish-brown sunken lesion delimited by a brown to reddish-brown margin. These cankers enlarge, become darker, rough textured, underrated plant growth. The fungus can invade the central part of the lower stem and produce a brick-red discoloration. Disease symptoms often occur on scattered plants in a somewhat circular field patter. Severe seedling infection may cause plant death. Lesions may also develop on pods that are in contact with the moist soil surface and cause pod rotting or seed discoloration. Mixed infection with Fusarium and Pythium root rot organisms are common. (1)

The fungus survives in infected plant debris, and inoculum concentrations in the soil can be increased by continually cropping fields to susceptible crops such as beans and sugarbeets. Rhizoctonia can be spread within fields by irrigation water and soil movement. Rhizoctonia root rot of germinating seedlings is favored by moderate to high soil moisture and low soil temperatures. Damage is generally restricted to young seedlings, but can affect older plants, especially when the plants are stressed by extremes in temperatures between warm soil and cool water from deep irrigation wells. (1)

Cultural Controls
Rotation of crops reduces residual populations of the pathogen. Previous crop residue is incorporated deeply and early enough to promote complete decomposition before planting. Warm soil (60 degrees F or 16 degrees C) with adequate moisture for rapid germination and emergence is recommended. Shallow planting (1-1.5 inches or 2.5-4 cm) is recommended for fields with anticipated Rhizoctonia problems. (1)

Chemical Controls
Seed treatment with recommended fungicides to protect the seedling during its early growth. (1)

Alternative Controls
No information available

Rust (*Uromyces phaseoli*)

Biology
Rust symptoms first appear as small yellow or white slightly raised spots on the upper and/or lower surfaces of leaves. Those spots enlarge and raise further to form reddish-brown or rust colored pustules which are about 1/8 inch (1-3 mm) in diameter and contain thousands of microscopic spores called summer spores (urediospores). Pustules may be surrounded by a yellow boarder. Spores are released from the pustule readily giving a rusty appearance to anything they contact; they fell like talcum powder when rubbed between the fingers. Severe infection results in premature leaf drop. Pod set, and especially pod fill, can be reduced if infection is sever during early reproductive development of the bean plant. Green pods, and occasionally stems, may also become infected and develop typical rust pustules. Near the end of the season, pustules undergo a subtle change and form dark brown to black winter spores (teliospores)), which signify the end of the currnt infection cycles. (1)

Rust development is favored by cool to moderate temperatures with moisture conditions that result in prolonged periods of free water on the leaf surface. Multiple disease cycles may occur at 10-14 day intervals under favorable conditions. The earlier the plant becomes infected during its development, the greater the chance for yield loss. Anything that delays plant maturity, such as hail damage, excess nitrogen, or late planting may increase the potential for significant yield losses in the event that a rust epidemic occurs. (1)

Cultural Controls
Certified seed of varieties resistant to the prevalent races of rust in the area is used. When late planting is necessary, susceptiblr varieties are avoided. Incorporation of infected bean debris into the soil after harvest and rotation with non-host crops for a least two years is recommended. (1)

Chemical Controls
Various fungicides are available that can prevent or reduce rust infection if applied early in the epidemic and coverage is thorough. Fields aremonitored frequently during blossom and early pod development for the initial signs of rust. Effectiveness of fungicides will also depend on environmental conditions and irrigation methods. Center pivot systems and frequent rains may wash protectant fungicides off leaves before they can affect the rust spores. (1)

Alternative Controls
No information available

Bean Yellow Mosaic Virus

Biology
Initial symptoms of bean yellow mosaic virus (BYMV) are small yellow spots less than 1/8 inch (1-3 millimeters) in diameter, which may be surrounded by a halo. These spots gradually enlarge and merge to produce a general yellowing of affected leaves. young leaves become brittle, glossy, and curl downward. Yellow and green mottling becomes more intense as leaves mature. Infection can also

shorten internodes, excess branching, plant stunting, and delayed maturity.

Systemic darkening (necrosis) symptoms can also occur from certain BYMV strains. Symptoms appear as purplish discoloration at the base of lower leaves which may be accompanied by vain, stem and petiole darkienng, necrosis of terminal growing point, or even plant death. The symptoms can resemble those of the black root reaction of BYMV.

BYMV is transmitted by aphids and mechanical damage, but is not seedborne. Its occurrence is largely correlated with the growth of white sweet clover which is one of its principle hots, as well as red clover, crimson clover, and gladiolus. Disease development depends on proximity to a virus host reservoir and on aphid movement within and between fields. (1)

Cultural Controls
Cultivation equipment and timing is adjusted to minimize rubbing and injury of plants,especially if BYMV or any bacterial disease is present in the field. The control of other hosts, such as white or yellow sweet clover growing wild along fence rows or ditch banks, is also important. (1)

Chemical Controls
No information available

Alternative Controls
No information available

Curly Top Virus

Biology
Curly top virus (CTV) infection causes a downward curling or cupping of leaves which are often greatly distorted and puckered. Primary leaves of infected plants may be thicker and more brittle than those of healthy plants. Leaves often become yellowed, and the entire plant may be stunted and even killed. Symptoms of mid season infection might be confused with BYMV. With curly top, the youngest leaves are usually the most curled and cupped; whereas with BYMV infection, older leaves are most affected. (1)

Many newer varieties of beans are resistant to CTV, but even in resistant varieties, the plants seedling stage may be susceptible. Curly top virus is not seedborne or mechanically transmissible, and is only transmitted by the sugarbeet leafhopper. New infections depend on the movement of leafhoppers which may overwinter on Russian thistle, mustards, and other weed species. Yield losses are usually more sever when infection occurs in the early *growing season.* (1)

Cultural Controls

The use of certified seed of curly top resistant varieties in areas where CTV is a problem. (1)

Chemical Controls
No information available

Alternative Controls
No information available

Red Node

Biology
The cause of red node is the Tobacco streak virus. This infection causes a reddish discoloration of nodes at the point of attachment of leaf petioles to stems. In severe cases, infected plants will bend over or break at a discolored node. Veins and veinlets of leaves may exhibit a red to reddish-brown streaking. Red to reddish-brown concentric rings may form on pods which may become shriveled or puffy and not produce seeds. Plants can be severely stunted and killed by the virus. (1)

Tobacco streak virus has recently been shown to be vectored by two species of thrips. Other hosts include white sweet clover, yellow sweet clover, asparagus and cowpeas. There are reports of resistant varieties and seed borne virus transmission, but their validity has not been tested by researchers. The disease is generally of rare occurrence and seldom causes economic loses. (1)

Cultural Controls
Control measures have not been developed, but destroying the known inoculum reservoir adjacent to bean fields is beneficial. (1)

Chemical Controls
No information available

Alternative Controls
No information available

Fungicide Profiles

- Formulations: benlate (15)
- Pests Controlled: white mold, anthracnose (15)
- Percent of Crop Treated: no information available
- Types of Applications: no information available

- Number of Applications:1 (15)
- Timing: initiation of flowering and before peak bloom, optimal is at 100% bloom. (15)
- Pre-Harvest Interval: 21 days (16)
- REI: 48 hours (16)
- Use in IPM Programs: no information available
- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages: no information available
- Disadvantages: no information available
- Critical Use Issue: Anthracnose control is based on scouting but would coincide with white mold timing. (15)

- Formulations:Topsin M (15)
- Pests Controlled: anthracnose, white mold (15)
- Percent of Crop Treated: no information available
- Types of Applications: no information available
- Number of Applications: 1(15)
- Timing: coincide pretty closely with white mold control. Dependent on scouting. (15)
- Pre-Harvest Interval 21 days (16)
- REI: 48 hours (16)
- Use in IPM Programs: no information available
- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages: no information available
- Disadvantages: no information available
- Critical Use Issue: anthracnose control is based on scouting.(15)

Nematodes

Root Feeding Nematodes: Root-knot (*Meloidogyne spp.*) & Root-lesion (*Pratylenchus spp.*)

Biology

Symptoms of severe nematode damage may appear on the plant structure as stunted growth and yellowing. These symptoms can be similar to those induced by nutrient deficiencies. Frequently, however, above ground symptoms are not readily noticeable. Root symptoms of nematode infection

vary with the kind of nematode. *Root-knot* nematodes cause a swelling or gall formation at the point of root infection. Nematode-induced galls are solid swollen root tissue and, when numerous, may resemble beads on a string. Root galls caused by nitrogen fixing bacteria differ from nematode induced galls by being attached to the side of the root. These are spongy when squeezes, and can be rubbed off easily. *Root-lesion* nematodes feed internally and cause the root to exhibit a brown to black color in infected areas without gall formation. the discolored tissue may become infected by various fungi, thereby causing further injury from root pathogens. (1)

Population levels of nematodes at the beginning of the season affect the degree of infection and subsequent plant injury and yield loss. Plants already stressed by other factors can be affected more adversely by a given population of nematodes. Continuos cropping to beans or rotation with other crops that are also susceptible to nematodes will increase population levels. (1)

Cultural Controls
Rotate beans with non-host crop to reduce nematode populations. This may be impractical with nematode species that have a wide host range. Practice weed management, since weed species also serve as hosts for nematodes and can increase population levels in the soil

Chemical Controls
Nematicides used on a previous crop in the rotation, i.e., sugarbeets, may exhibit some beneficial effects on the following bean crop.

Nematicides

aldicarb (carbamate)(10)

- Formulations: Temik 15 G (10)
- Pests Controlled: Sugarbeet Cyst Nematode and leafminer (10)
- Percent of Crop Treated: no information available
- Types of Applications: Nematode-18-22 oz/1000 row ft at planting time in a furrow to the side and below the seed or in a 4-6 in band centered over the row and incorporated into the soil. Leafminer-drill granules 1-3 in below seed line. Postemergence, apply granules on both sides of row and work into soil. (10)
- Application Rates: Nematode-27-33 lb/acre, 4-5 lb/acre active ingredient. Leafminer-14-20 lb (or 9.5-13.5 oz/1000 row ft), 2.1-3 lb/acre active ingredient (10)
- Number of Applications: no information available
- Timing: no information available
- Pre-Harvest Interval: Nematode- 120 days. Leafminer- 90 beets, 120 tops (10)
- REI: no information available
- Use in IPM Programs: no information available

- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages: no information available
- Disadvantages: no information available
- Critical Use Issue: Restricted Use Pesticide- A pesticide application certificate is required from the MDA for the purchase and use of these pesticides. (10)

Weeds

Biology
Michigan farmers report a variety of weeds in their dry bean fields. Those that are most problematic are broad leaf weeds. Specified weeds include black nightshade, common ragweed, common lambsquarters, velvetleaf, redroot pigweed, annual grasses and jimson weed. Of these, common ragweed, common lambsquarters and black nightshade seem to be most problematic. (5)

Cultural Controls
Weed control is important for the control of diseases and pests. Organic growers use a rotary hoe and field cultivator as well as hand labor to remove weeds. Non-organic growers use herbicides in conjunction with these other practices to control weeds. These herbicides can be banded over the row or applied broadcast. Crop rotation and cultivation help to control weeds.

Chemical Controls
Herbicides can be preplant icorporated before planting or immediately to the soil preemergence, immediately after planting. Other herbicides can be applied after the crop has emerged. Michigan growers use the following chemical controls most frequently: Eptam, Dual and Treflan. Reflex has been applied for the past three of four years under a special use exemtion Section 18. (18) Most growers that have had success with Reflex hope it will be registered for use on the crop. One farmer reports he has to be careful what kind of herbicides he uses because some herbicides have a 40 month carry over which is unacceptable for the pickle and sugar beet portion of the rotation, mainly Pursuit. (5)

Alternative Controls
None available

Herbicide Profiles

Registered Herbicides used by Michigan Growers (12)

bentazon (benzothialdiazin compound) (13)(11)

- Formulations: Basagran (13)
- Pests Controlled: cocklebur, velvetleaf, jimsonweed, nutsedge and canada thistle. (13)
- Percent of Crop Treated: 15% (18)
- Application Rates: 4 lb/gal L. (13) 2 pr/ac so application is 1.0 lb/ai broadcast. (18)
- Types of Applications: banded and broadcast. (12) 1/2 of acres treated are band-applied (18)
- Number of Applications: usually 1 (18)
- Timing: postemergence (13)
- Pre-Harvest Interval: NA
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: Weed spectrum is limited to those listed. (18)
- Advantages: crop tolerance is very good. (18)
- Disadvantages: Doesn't control common lambsquarter or common ragweed if they exceed 2 in. tall. Does not control at any growth stag redroot pigweed or black nightshade.(18)
- Critical Use Issue: Very important for the pests control of weeds listed above. (18)

metolachlor (acetamide compound) (13)(11)

- Formulations: Dual (13)
- Pests Controlled: annual grasses, yellow nutsedge, redroot pigweed and black nightshade.(13)
- Percent of Crop Treated: 35% (18)
- Application Rates: 8 lb/gal L (5) 2 pt/ac so 2.0 lb ai/ac broadcast. (18)
- Types of Applications: banded and broadcast (12) 1/2 of acres treated are band-applied (18)
- Number of Applications: 1
- Timing:preplant and preemergence, (13)
- Pre-Harvest Interval: NA
- REI: 12-24 hours. (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: black nightshade control is marginal, poor control of common lambsquarter. (18)
- Advantages: provides better nutsedge suppression than Frontier. (13)
- Disadvantages: crop tolerance from PRE application is poor on sandy soils or on all soils in a cool, wet year at planting time. (18)
- Critical Use Issue: Requires rainfall for activation. (18)

EPTC (thiocarbamate) (13)(11)

- Formulations: Eptam (13)
- Pests Controlled:annual grasses and annual broadleaves. (13)
- Percent of Crop Treated: 70 % (18)
- Application Rates: 7 lb/gal L; 2 1/4 pt/ac (18)
- Types of Applications: must be broadcast and incorporated. (18)
- Number of Applications: 1 (18)
- Timing:preplant, incorporate immediately after application(13)
- Pre-Harvest Interval: NA
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: suppresses wild mustard and common ragweed.(13)
- Disadvantages: short residual in the soil. Always applied with Treflan or Sonalan or Dual. (18)
- Critical Use Issue: Very important to suppressing common lambsquarter, redroot pigweed and common ragweed early in the season. (18)

trifluralin (dinitroanaline compound) (13)(11)

- Formulations:Treflan (13)
- Pests Controlled: annual grasses and annual broadleaves except nightshade, cocklebur and jimsonweed.(13)
- Percent of Crop Treated: 50 % (18)
- Application Rates: 4 lb/gal L; (13) 1 pt/ac (18)
- Types of Applications: broadcast, must be incorporated. (12)
- Number of Applications: 1
- Timing:preplant and preplant incorporated before planting. (13) (18)
- Pre-Harvest Interval: NA
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: Excellent on common lambsquarter and redroot pigweed. (18)
- Disadvantages: No effect on common ragweed and black nightshade. (18)
- Critical Use Issue: no information available

ethalfluralin (dinitroanaline)(13)(11)

- Formulations: Sonalan (13)
- Pests Controlled: annual grasses and annual broadleaves except nightshade, cocklebur and jimsonweed. (13)
- Percent of Crop Treated: 30 % (18)
- Application Rates: 3 lb/gal L (13) 3 pt/ac (18)

- Types of Applications:must be broadcast and incorporated.(18)
- Number of Applications: 1
- Timing: preplant incorporated before planting. (18)
- Pre-Harvest Interval: NA
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: better than Treflan (10%-20%) on all small-seeded broadleaf weeds. (18)
- Advantages: no information available
- Disadvantages: not effective on common ragweed. (18)
- Critical Use Issue: no information available

dimethenamid (acetamide compound) (13)(11)

- Formulations: Frontier (13)
- Pests Controlled: annual grasses, yellow nutsedge, redroot pigweed and black nightshade. (13)
- Percent of Crop Treated: 10% (18)
- Application Rates: 6 lb/ gal L (13) 25 oz./ac (18)
- Types of Applications:banded or broadcast. (12) About 1/3 of acres treated are banded. (18)
- Number of Applications: 1
- Timing: preplant and preemergence. Apply before June 20th.(13)
- Pre-Harvest Interval: no information available
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: better nightshade control than Dual. (13)
- Disadvantages: Dual better for yellow nutsedge control (13) Black bean and navy bean classes have less tolerance to Frontier compared to Dual. (18)
- Critical Use Issue:requires rainfall for activation. (13)

Imazethapyr (imidazole compound) (13)(11)

- Formulations: Pursuit (13)
- Pests Controlled: annual broadleaves and annual grasses(13)
- Percent of Crop Treated: 10%(18)
- Application Rates: 2 lb/gal L; 70 % DG, ECO-PAK(13) 2oz/ac of 2 L or 0.72 oz of DG. (18)
- Types of Applications:banded or broadcast (12)
- Number of Applications: 1
- Timing: preplant, preplant followed by preemergence, preemergence and postemergence. (13)
- Pre-Harvest Interval: no information available
- REI: 4-12 hours (13)
- Use in IPM Programs: NA

- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: Excellent on black nightshade. (18)
- Disadvantages: Does not control common ragweed. Crop rotation restrictions-40 months to sugar beets. (18)
- Critical Use Issue: Do not apply if cold and/or wet conditions are present or predicted to occur within one week of application. Do not use on sands or loamy soils. (13) Crop tolerance is reduced under these conditions. (18)

pendimethalin (dinitroaniline) (13)(11)

- Formulations: Prowl (13)
- Pests Controlled: annual broadleaves and annual grasses. (13)
- Percent of Crop Treated: 10% (18)
- Application Rates:3.3 EC (13) 1.8 pt/ac (18)
- Types of Applications: broadcast and incorporate. (12)
- Number of Applications:1
- Timing: preplant and preplant followed by preemergence (13)
- Pre-Harvest Interval: NA
- REI: 12 hours (13)
- Use in IPM Programs: no information available
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: A prepackaged mix of Prowl and Pursuit is registered for use in dry beans. (13) Excellent on common lambsquarter. (18)
- Disadvantages: Not as good on redroot pigweed as Treflan or Sonalan. Doesn't control commmon ragweed or black nightshade. (18)
- Critical Use Issue: no information available

alachlor (acetamide compound) (13)(11)

- Formulations: Lasso (13)
- Pests Controlled:annual grasses, annual broadleafs, yellow nutsedge, redroot pigweed and black nightshade.(13)
- Percent of Crop Treated: 5% (18)
- Application Rates: 4 lb/gal L; 15% G(13) 2qt/ac, 3lb/ac 65% DG (18)
- Types of Applications:broadcast (12)
- Number of Applications: 1
- Timing:incorporated before planting. (18)
- Pre-Harvest Interval: NA
- REI: 12 hours (13)
- Use in IPM Programs: no information available

- Use in Resistance Management Programs: no information available
- Efficacy Issues: no information available
- Advantages: better on black nightshade than Dual. (18)
- Disadvantages: crop tolerance less than Dual. Must preplant incorporate. Can't use on sandy soils. (18)
- Critical Use Issue: Restricted Use Pesticide- A pesticide applicator certificate is required from the MDA for the purchase and use of these pesticides. (13)

quizalofop-P-ethyl (organic compound) (13)(11)

- Formulations:Assure II (13)
- Pests Controlled:annual grasses, quackgrass, volunteer corn.
- Percent of Crop Treated:5 % (18)
- Application Rates: 0.88 lb/gal L (13) 7 oz/ac. (18)
- Types of Applications: banded and broadcast (12)
- Number of Applications: 1
- Timing: postemergence, apply to annual grasses up to 4 in. (13)
- Pre-Harvest Interval: Do not cultivate within five days prior to and 7 days following application. 30 days between application and dry bean harvest. (13)
- REI: 12 hours
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: controls emerged grasses. (18)
- Disadvantages:poor weed control will result if applied to grasses under stress. (13) No soil residue. (18)
- Critical Use Issue: no information available

fomesafen (diphenyl compound) (13)(11)

- Formulations: Reflex (13)
- Pests Controlled: common ragweed, redroot pigweed and black nightshade. (18)
- Percent of Crop Treated: 15 % (18)
- Application Rates: 2 lb/gal L (13) 1 pt/ac. (18)
- Types of Applications: postemergence (18)
- Number of Applications: 1
- Timing: 1
- Pre-Harvest Interval: no information available
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: Excellent control on common ragweed, good control on black nightshade, fair to

good control on redroot pigweed. Bean tolerance is good. (18)
- Disadvantages: Need special exemption Section 18 each year. (18)
- Critical Use Issue: Would like federal label. (18)

Other registered herbicides in Michigan

sethoxydim (oxime compound) (13)(11)

- Formulations: Poast (13)
- Pests Controlled: annual grasses, quackgrass. (18)
- Percent of Crop Treated: 5% (18)
- Application Rates: 1.53 lb/gal L (13) 1 pt/ac (18)
- Types of Applications: postemergence
- Number of Applications: 1
- Timing: Postemergence, annual grasses up to 8 in, crabgrass up to 6 in. (13)
- Pre-Harvest Interval: 30 days. Do not cultivate 5 days prior to and 7 days following application. (13)
- REI: 12 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA
- Efficacy Issues: no information available
- Advantages: no information available
- Disadvantages: no soil residual to stop later emerging grasses. (18)
- Critical Use Issue: Do not apply to grasses under stress or poor weed control will result. (13)

clethodim (oxime compound) (13)(11)

- Formulations: Select (13)
- Pests Controlled: annual grasses, quackgrass, volunteer corn. (18)
- Percent of Crop Treated: 2 % (18)
- Application Rates: 2 lb/gal L (13) 6 oz/ac (18)
- Types of Applications: postemergence (18)
- Number of Applications: 1
- Timing: Postemergence, annual grasses up to 6 in.(13)
- Pre-Harvest Interval:30 days. Do not cultivate 7 days prior or 7 days after treatment. (13)
- REI: 24 hours (13)
- Use in IPM Programs: NA
- Use in Resistance Management Programs: NA

- Efficacy Issues: NA
- Advantages: controls emerged grasses (18)
- Disadvantages: no soil residual (18)
- Critical Use Issue: no information available

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