

Crop Profile for Beans (Dry) in Minnesota

Prepared August: 2001

Minnesota ranked fourth nationally in the production of dry edible beans during the 2000 growing season, with 150,000 acres harvested. Dry edible beans (mostly navy and pinto) provide a relatively consistent source of income, and an excellent fit within the crop rotation systems of this area, typically small grains and corn. In 2000, total value of production was estimated at \$42.7 million. In addition to the direct value of this crop to growers in the central and northwest regions of our state, the crop provides to the processing industry, snap bean contracts between processors and growers assist in adding economic diversification for traditional corn and soybean growers in southern and west-central Minnesota.

The high value of this crop, along with the potential for economic losses from insect, disease and weed pests, continue to create demand for effective integrated pest management (IPM) programs. In response to new IPM information needs generated by the Food Quality Protection Act (FQPA), this profile was developed to a) summarize current IPM practices for insect, disease and weed pests, b) highlight pesticides under review by US-EPA, c) estimate the impact of the loss of selected pesticides, and d) assess alternatives for such losses.

Insect Pests: Insect pests are usually the most damaging and difficult pests to control in dry edible beans, affecting either bean quality or yield. The most important insect pests include seed corn maggot and the potato leafhopper. Seed corn maggot (SCM), and other soil-borne insect pests such as white grubs and wireworms, can do considerable damage, resulting in uneven plant stands, and/or by causing delayed maturity. Potato leafhopper (PLH), if left unchecked will also cause damage by stunting the plants and reducing yield. Both SCM and PLH have caused considerable damage during the past 5 years. New seed treatments have recently shown good efficacy against PLH in snap beans, and these may become feasible for edible beans. PLH, although damaging, is still relatively easy to control with currently labeled insecticides. Seed treatments, when registered, may be able replace some foliar sprays for PLH. Currently, three insecticides under close review by EPA include Diazinon, Sevin and Orthene. The potential loss of Diazinon and Sevin would likely be most problematic for growers.

Diseases: Numerous pathogens affect dry edible bean production in Minnesota. The most common disease problems include: root rots (*Fusarium*, and *Rhizoctonia*), white mold, gray mold, and several bacterial blights (brown spot, common blight and halo blight). In some years, under favorable environmental conditions (cool weather at planting, followed by hot, dry conditions), up to 100% of fields can be infected. Rust can still be a concern in warm, humid years. Selected fungicides are available for most diseases, however their efficacy is variable, and strict cultural practices such as 2-3 year rotations out of beans should be maintained. For rust, only Bravo and Nova are available. For white and gray mold, Benlate and Topsin are available. For seedling diseases and root rots, a seed treatment, Apron can be used, or Ridomil at planting. Nova has been an excellent, relatively recent addition for growers. However, if and when any of these products come under review, with respect to FQPA, there will be a renewed need to assess risks/benefits. Growers will continue to need to take a whole-farm, systems approach to disease management, including maintaining enough land to be able to maintain a 3-4 year rotation out of beans.

Weeds: Many broadleaf and grass weed species are potentially very damaging to dry edible beans. Because of the "minor use" status of this crop, few registrants are interested in pursuing labels for herbicides (as with other pesticides). Pre-emergence herbicides include: Dacthal, Eptam, Dual Magnum, Gramoxone, and Prowl. Post-emergence materials are limited to Poast, Assure, and Basagran. Thus, growers currently have few options for weed control, but current products, in tandem with timely cultivation, seem to be working well in Minnesota. Again, part of this success, may be due to current overall crop rotation schemes with corn and small grains, which also affects differential weed species pressure. If these products come under review, there will be a renewed need to assess risks and benefits of each.

General Production Information

Minnesota ranked fourth nationally for the production of dry edible beans during the 2000 growing season with 150,000 acres harvested (165,000 acres planted) (14). The state produced Navy (60,000 acres harvested), Pinto (34,000 acres harvested), Light Red Kidney (9,600 acres harvested), Dark Red Kidney (30,000 acres harvested), and others (16,400 acres harvested)(16). The main dry edible bean production region in Minnesota is the northwest portion of the state, led by Polk (59,500 acres) and Marshall (23,400 acres) counties (16). In 2000, the crop had a total production value of \$42.7 million (16). Dry edible beans are grown primarily for human consumption as they are a rich source of protein. Roughly half of the dry edible beans produced in America are exported to other countries (16).

Cultural Practices

Dry edible beans are planted from May through July. Seeds are typically planted 1.5 inches deep either in rows or drilled and plants are seeded at 8-12 plants/foot. Rows are typically spaced 18-36 inches apart. The recommended density for planting is 70-100 pounds of seed/acre or approximately 174,000 plants/acre. Seeds will germinate 6-12 days after planting with temperatures of 65-85F (3, 10). Dry edible beans take 80-90 days to mature and are harvested in September when plants senesce and leaves drop. Plants are cut at or below the soil and allowed to dry for 4-5 days after which the beans are removed from the pods by combine and processed by cleaning and sorting by size (10).

Dry edible beans thrive in well-drained soils that receive adequate moisture throughout the growing season. Fields that are crusted over and have a high salt concentration are less than ideal for bean production. Dry edible beans grow quickly with adequate moisture and nutrients. The crop will require 1-1.5 inches of water every 4-5 days for ideal growth (9). Dry edible beans have the ability to fix their own nitrogen with the aid of rhizobia although they require a seed treatment to protect them from insect and disease damage. Seed treatments kill rhizobia, however, and nitrogen is applied to compensate for the lack of nitrogen fixation by the plant. In addition to applying nitrogen, phosphorus, and potash are also recommended which are applied at or prior to planting. During cool wet periods, plants may develop iron deficiencies that appear as yellow, chlorotic areas between veins on leaves. There are numerous treatment options available for insect, disease and weed management in dry edible beans.

Insect Pests

There are numerous insect pests of dry edible beans that damage plants at all stages of development and retard growth. The following insects vary in the damage they inflict and in the frequency of their presence.

Seed Corn Maggot (*Hylemya platura*)

Seed corn maggots are the larval form of small flies. The maggots feed on germinating seeds and are more prevalent during cool, wet summers. The insect overwinters in the ground as a maggot (12). Seed corn maggots are attracted to rotting plant debris and newly plowed fields. It is good practice to plow under winter cover early in the springtime and do a good job of recovering fields (9). Removing plant rubbish also decreases egg-laying sites. Later planting dates and shallow seeding depths encourage fast and early germination, which also shortens the time seed is susceptible to corn seed maggot feeding and damage. Additionally, seeds should be handled carefully so they do not develop cracks as they encourage seed corn maggot damage (12).

Also see factsheet: <http://www.vegedge.umn.edu/vegpest/seedmag.htm>

Potato leafhoppers (*Empoasca fabae* Harris)

Leafhoppers are approximately 1/8 inch in length and can be green, light brown or grayish in color. They inflict damage with their piercing-sucking mouth parts which, in extreme cases, cause foliage to discolor and die. Eggs are deposited inside plant tissue as opposed to on the surface. It can take from a few weeks to over a year for eggs to hatch and for larvae to begin feeding on plant sap. The larvae go through a total of five nymph stages, and all of the stages including the adults, feed on the sap. Examples of damage include: stripping the plant of its nutrients, transmitting viruses and the feeding damage itself (7). Controlling weeds is an important way to decrease the leafhopper population. Chemical control includes use of pyrethroids and insecticidal soaps (8, 9).

Also see factsheet: <http://www.vegedge.umn.edu/vegpest/plh.htm>

European corn borer (*Ostrinia nubilalis* Hübner)

European corn borer (ECB) is generally found in corn, but when dry edible beans are planted next to corn with heavy infestations, ECB can move into bean fields. Larvae feed on the interior of plant stems and bean pods which makes scouting for the insect difficult, but not impossible. As ECB larvae feed, their presence can be determined via the presence of frass (excrement), protruding from small holes in stems and pods. European corn borer overwinter as larvae and emerge as adults starting in June and continuing through August, as two distinct generations are typically observed. Adults have wingspans of 1 inch; females are pale-yellow in color while the males are a darker brown. Adults are active at night. In fall, winter, or early spring, it is beneficial to destroy crop residue that may harbor overwintering larvae. Burning or deep plowing all crop debris and weeds is one way to achieve this. Later planting dates are also useful in managing European corn borer as is the use of resistant varieties. Additionally, rotating with legumes, controlling weeds, and avoiding planting beans next to corn all aid in management (12). The insects can be monitored through the use

of blacklight or pheromone traps. The threshold is >25 moths caught in a black light trap/night with 7-10 days left prior to harvest (9). In fall, winter, or early spring, it is beneficial to destroy all crop residues to reduce ECB number.

Also see factsheet: <http://www.ent.iastate.edu/pest/cornborer/htm>

Corn Earworm (*Helicoverpa zea* Boddie)

Corn earworm, similar to European corn borer, is generally found on corn, however, the insect can be found on dry edible beans, as well, in Minnesota. Adults originate from the southern U.S. because they are unable to overwinter in northern climates. Adults are 0.75-1 inch long with a wingspan of 1.5-2.0 inches and are tan/buff colored with characteristic green eyes. Adult females lay eggs on foliage, eggs hatch in 5-7 days, and larvae pass through six instars before pupating. Larvae can possess green, tan, pink, dark brown or black coloration and inhabit stems and/or pods. Proper timing of insecticide application is critical as there are no control options once larvae enter the protective covering of the stem or pod. Damage can be severe in August and September as larvae feed upon stems and/or pods.

Also see factsheet: <http://www.vegedge.umn.edu/vegpest/cewbean.htm>

Bean leaf beetle (*Cerotoma trifurcata*)

Bean leaf beetles are red, orange, tan, or gray with dots or strips on their backs. The adults overwinter in leaf debris in wooded areas next to fields and have a characteristic black triangle behind their thorax. Adults emerge in the spring and lay eggs in the soil. Upon hatching, larvae feed on the parts of the plant that are under the soil for 3-6 weeks. They will pupate and emerge as adults one week later in mid July. These adults will mate and lay eggs and a second generation will occur in September. The second generation will overwinter (2). Adults inflict the most severe damage by feeding on the underside of leaves and pods making small round holes. Beetles can clip off entire pods if feeding occurs at the base of the pod and other tissue damage on pods allows moisture to enter which allows disease to enter which causes mold, discoloration, and shrunken pods. The bean leaf beetle serves as a vector for these pathogens (2).

Mexican bean beetle (*Epilachna varivestis*)

Although the Mexican bean beetle occurs only rarely in Minnesota, it can cause considerable damage. These beetles are ¼ inch long and copper brown in color. They possess black spots which number eight on each wing (8). Mexican bean beetle adults overwinter in plant debris and as such, it is very important to manage crop debris to minimize infestations. Upon plant emergence, beetles will move from their winter shelters and begin feeding on the underside of the leaves only, leaving the top-side intact. Larvae also feed on foliage, but the damage creates a lace-like appearance on the leaves. With a heavy infestation, beetles will also feed on stems and pods, sometimes killing the host plant (12). Plowing crop debris after harvest helps minimize attractive sites for beetles. Chemical treatments and altered planting dates can be effective means of controlling beetles. Use of early or late maturing varieties can be very effective as most damage is done during July and August (12).

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

Aphids are not usually a serious problem of edible beans in Minnesota. The adult bean aphid, *Aphis fabae*, is dark green to black, and can be either winged or wingless (12). They reproduce both sexually and asexually. During the summer months, reproduction occurs asexually by females who produce live offspring. At the end of the season, as fall approaches, females and males will reproduce sexually. Eggs produced by male/female mating will overwinter in the host crop (1). Aphids inflict damage with their piercing-sucking mouthparts making leaves curl and appear wilted due to the honeydew (waste) substance they excrete.

Bean Weevil (*Sitona lineatus*)

Bean weevil adults are approximately 4-5 mm long with a light sandy to darker brown color and faint stripes running longitudinally along their backs. Larvae are wrinkled and fleshy with a creamy white color. Adults overwinter in debris or near streams and hedges and emerge once the weather begins to warm in the spring. Upon emerging, adults mate and females lay their eggs on leaves or in the soil. Rain water or irrigation will push the eggs deeper into the soil. Within three weeks, larvae hatch and begin to feed upon plants' root systems. After several weeks of root feeding, larvae mature into adults; these adults will emerge from the ground and begin feeding on foliage before they find a site for overwintering. Damage caused by weevils is most severe when plants are in early vegetative stages. Adult feeding is exhibited by u-shaped notches in the foliage, although it is usually not enough to cause yield loss, root feeding damage by larvae can cause significant damage, however (12).

Spider Mites (*Tetranychid urticae*)

Spider mites only reach damaging levels in very dry, hot years. For example, during the drought of 1998, mite infestations resulted in yield losses exceeding 50%, but this is a rare event. Spider mites are 0.4-0.5 mm long; males are slightly smaller than females. White colored eggs are often covered by webs to protect them from predators and to regulate the surrounding microclimate. Spider mite larvae are pink with six legs, but turn green or red with eight legs as they grow in maturity. Larvae pass through three instars in a lifecycle that spans 6-8 days. Spider mites reproduce both sexually and asexually. When offspring are created asexually, only male spider mites are created. The mites disperse

by either walking or with the aid of the wind. Damage caused by mites includes yellow spots on the underside of leaves with webbing nearby. Heavy infestations cause leaves to curl, cup or turn completely yellow and die. The mites' saliva interferes with the plant's growth and as a result, the plants' height, flowering, pod number and pod length are affected. Damage is more severe during vegetative versus reproductive growth stages (12).

Chemical Control:

Control options for dry edible beans insect pests (type of control/insecticide class) (4, 5, 9):

Alternative:

Spinosad (SpinTor 2SC) This product is biologically derived from the fermentation of the soil organism *Saccharopolyspora spinosa* and can be used to control lepidoptera larvae on a variety of crops, including snap beans. The product is applied at a rate of 0.05-0.10 lbs/AI/Ac. Treatment should begin prior to egg hatch for best control. There is a 28 day pre-harvest interval for this product.

Insecticidal control options:

Carbamates

Carbaryl (Sevin XLR Plus) Sevin can be used to control corn earworm, Mexican bean beetle, bean leaf beetle and potato leafhopper. There is a 12-hour REI for Sevin and ears can not be harvested for 21 days following the last application. The labeled rate for Sevin in snap beans is 0.5-1.5 qts/A with total field-applied product not to exceed 6 quarts/A in a single growing season.

Methomyl (Lannate LV) *Lannate is a restricted use product (RUP) that is labeled for use in controlling European corn borer larvae and eggs, corn earworm larvae, Mexican bean beetle, leafhopper and aphid. The labeled rate is variable depending on pest to be controlled but the product is applied at a rate of 0.75-3 pts./A. There is a field REI of 48 hours for this product and pre-harvest interval of 14 days.

Pyrethroids

Esfenvalerate (Asana XL) *Asana is a restricted use product that is labeled for use on snap bean to control European corn borer and corn earworm larvae, pea aphid, potato leafhopper, and Mexican bean beetle. The labeled rate is 0.02-0.05 lb. AI/A with total annual applied product not to exceed 0.2 lb AI/A EXCEPT for Mexican bean beetle: 0.015-0.03 lb AI/A. Asana can be applied up to 21 days before harvest.

Bifenthrin (Capture 2 EC) *Capture is a restricted use product that is labeled to control European corn borer and corn earworm larvae, aphids, sap beetles and leafhoppers. Application rate is 1.6-6.4 fl. oz/A depending on the insect being treated for, see label for specific information. There is a three day pre-harvest interval and total applied product must not exceed 0.2 lb AI/A/year.

Organophosphates

Acephate (Orthene 75S) *Orthene is a restricted use product that can be used to control European corn borer and corn earworm larvae, beetles, grasshoppers, and leafhopper. It is applied at rates of 0.33-1.50 lbs/A. There is a 14 day PHI for Orthene. Treatments should start once eggs or adults are observed on foliage and continue every 7-10 days.

New products/registrations

A new product, marketed by Eden Bioscience Corporation, called 'Messenger' is touted as enhancing plants' natural suppression systems, thereby minimizing insect feeding damage. The AI in Messenger is a byproduct of bacteria, thus it is considered a biological or biochemical product. An additional claim made by the manufacturer is added disease suppression.

Table 1. Insect control options: chemical products

Foliar Products	Field Rate	A.I. Rate	PHI/REI	Application Schedule	Remarks
<i>Spinosad</i>					
SpinTor 2SC	3-6 oz/A	0.05-0.10 lb/A	28 d 4 h	Prior to egg hatch, 3 day intervals	ECB, CEW, looper, leafminer; total <12 oz/A/year
<i>Carbamates</i>					
Lannate LV	0.75-3 pts/A	0.23-0.92 lb/A	14 d 48 h	5-7 d	ECB, CEW, beetles, mites; total <4.5 lb/AI/A/year AND <10 applications

Sevin XLR Plus	0.5-1.5 qts/A	0.5-1.5 lb/A	21 d 12 h	7+ d	ECB, CEW, beetles, leafhopper, aphids; total <6 qt/A/year
Pyrethroids					
Asana XL	2.9-9.6 oz/A	0.02-0.05 lb/A	21 d 24 h	3+ d	ECB, CEW, beetles, leafhopper, mites, aphids; total <0.2 lb/AI/A/year
Capture 2EC	1.6-6.4 oz/A	0.025-0.10 lb/A	3 d 24 h	As needed	ECB, CEW, beetles, leafhopper, mites, aphids; total <0.2 lbAI/A/year
Organophosphates					
Orthene 75S	0.33-1.3 lbs/A	0.25-1.00 lb/A	14 d 24 h	7-10 d	ECB, CEW, beetles, leafhopper; grasshopper; <2 lb/AI/A/year

Biological Control:

There are several biological control agents available for control/suppression of pests in dry edible beans. These range from other insects to fungi and protozoans. Some of these are commercially available for release by growers:

Pest	Biological Control Agent
European corn borer	<i>Lydella thompsoni</i>
	<i>Macrocentrus grandii</i>
	<i>Beauveria bassiana</i> (Fungi)
	<i>Perezia pyraustae</i> (Protozoan)
	<i>Nosema pyrausta</i> (Micro sporidan)
Mexican bean beetle	Spined soldier bug
Bean leaf beetle	Tachinid fly, <i>Calatoria diabroticae</i>

Diseases

Anthracnose (*Colletotrichum lindemuthianum*)

Anthracnose is transferred onto plants through rain, dew, contaminated seeds or air and produces rust-colored specks that enlarge to 5-7mm in length. Red to purple lesions develop on the leaf petioles and affected plants will possess dry, shriveled pods. Anthracnose survives in crop debris and can be transmitted among a number of crops. Damage can result in as much as 100% yield loss (10). Because anthracnose persists in soil debris, specifically infected plant matter at or below the soil surface, managing this layer with proper field sanitation will provide some control. Two cultural practices that reduce plant debris are deep plowing and modifying tillage practices by reducing conservation tillage. Rotating crops on a 2-3 year schedule and the use of resistant varieties provide control against anthracnose (9).

Rust (*Uromyces appendiculatus*)

Rust can appear on and damage any above ground part of beans but most often occur on the leaves. Warm, humid climates favor rust development (10). The symptoms signaling its presence includes initially small whitish raised pustules found under leaves (8). These spots turn into reddish-brown circular fruiting bodies that will rupture the leaf making powdery vegetative spores ranging 1-2 mm in diameter (10). Rust management includes using resistant varieties and treating affected fields with appropriate fungicides (8).

Common Bacterial Blight (*Xanthomonas phaseoli* Smith)

This disease produces small water-soaked lesions that increase in size as the disease progresses. Lesions become reddish-brown in color and can affect both stems and pods, eventually causing necrosis of the affected plant tissue (8). Rotating crops on a 2-3 year schedule and the use of resistant varieties reduces the occurrence of the blights. Seed treatments and foliar-applied fungicides also minimize the impact of bacterial blight (9).

White Mold (*Sclerotinia sclerotiorum*)

White mold is spread by tissue contact and is capable of surviving in a field for more than five years being a continuous problem if not dealt with. Initial symptoms include the presence of white cottony flowers. Small, round, dark green and water soaked lesions will also appear on pods, leaves, branches, and stems of the affected plants. Lesions increase in size and become slimy, ultimately becoming cottony in texture. Infected tissue has a lighter color that ranges from pale brown to white. Severe white mold can result in yield losses up to 100%. Disease severity increases in fields where plants form a dense canopy and there has been a history of white mold. Cool damp weather during and after flowering also aid the development of the disease (10).

Gray Mold (*Botryotinia fuckeliana*)

Similar to white mold, gray mold is more frequent in fields that have dense canopies during cool, humid weather. Flowers that remain on the pod after senescence also are a cause of this mold. Rain and wind are what spread the mold to plants. Plants that have tissue damage are at a higher risk of becoming infected, as the damaged tissue serves as an entry point for disease development. Initial symptoms include the appearance of dark, water soaked lesions which eventually become slimy. The lesions may take on different appearances depending on their location on the plant (10). Treatment options for Gray mold are identical to those for White mold (9).

Seedling Diseases: Rhizoctonia Root Rot, Pythium diseases, Fusarium Root Rot, Black Root Rot (*Rhizoctonia solani*, *Pythium spp.*, *Fusarium solani*, *Thielaviopsis basicola*)

Seedling diseases (root rots) persist in the soil and infect both seed and root structures. The soil born fungi can persist for extended periods of time in the soil, several years in some cases (10). Cold, wet weather after planting followed by hot, dry conditions can lead to severe yield losses. Seeds affected by these fungi will become soft and fail to germinate while seedlings affected by will have dark, water soaked lesions on their stems. Seedlings will most likely die soon after infection. Infection by root rot in mature plants is usually isolated in the roots and causes the plants to become stunted, wilt, and die (12). The use of certified seed can minimize effects of root rot as can the application of fungicides containing metalaxyl (Ridomil) (9).

Also see factsheet: <http://www.ag.ohio-state.edu/~ohioline/hyg-fact/3000/3110.html>

Mosaic Virus

Aphids and leafhoppers can vector alfalfa mosaic virus from plant to plant. Leaves can become yellow, dark or light green mosaic colored, and may become deformed. Plant stunting and blossom drop may also be observed. Control can be achieved by using resistant varieties and by controlling insect vectors (9).

Table 2. Disease control options: chemical products

Foliar Products	Field Rate	A.I. Rate	PHI/REI	Application Schedule	Remarks
Bravo Ultrex	1.25-2.7 lb/A	1-2.25 lb/A	7 d 48 h	Weekly (as needed)	Rate varies for gray mold/rust; <11 lb/A/year
Nova 40W	4-5 oz/A	1.6-2 oz/A	0 d 24 h	7-10 d (as needed)	Controls rust; <0.5 lb/AI/A/year
Topsin M WSB	1.5-2 lb/A	1-1.4 lb/A	14 d 12 h	1-2 applications depending on % of crop in bloom	Controls white/gray mold, Anthracnose, 28 day PHI for lima beans
Ridomil Gold EC	0.5-1 pt/A	1-2 lb/A	-- 48 h	Applied at planting	Incorporated into soil at planting; controls seedling diseases
Apron XL	0.32-1.28 oz/100 lb seed	0.10-0.42 oz/100 lb seed	-- 48 h	Seed treatment	Rate varies for Pythium, Phytophthora and downy mildew (see label)
Benlate SP	8-32 oz/A	4-16 oz/A	14 d 48 h	7-10 d (as needed)	Apply at 10% bloom and 7 d post 10% bloom; for control of Fusarium, Anthracnose, white/gray mold

Nematodes

The two most common nematodes to infect dry edible beans are the root-knot nematode, *Meloidogyne spp.*, and the lesion nematode, *Pratylenchus spp.* Stand loss for each can be severe ranging from 10-80% for the lesion nematode and 45-90% for the root-knot nematode. Nematodes overwinter as both adults and larvae in the soil or within root tissue (11, 18). Damage by the root-knot nematode is more detrimental in light-textured soils and well-drained fields. Infested plants will appear chlorotic, stunted, necrotic, or wilted. Knots or galls are also commonly associated with nematodes. When the nematodes take up a permanent feeding locations on roots, the surrounding area will produce enlarged cells that increase in number and produce knots. Knots are generally 1-10 mm in diameter and can cause wilting, defoliation, and/or death.

The root-knot nematode population decreases in both very dry and very wet field conditions. Control options include flooding fields with water, rotating with non-host crops, weed control, deep plowing and long fallow periods. Although available, nematicides are quite expensive and may not prove economically viable. Damage caused by the feeding of lesion nematodes includes underdeveloped roots with lesions, stunting, chlorosis, and wilting. The lesion nematode prefers cool (10-15°C), moist soils. Crop rotation is not a control option for lesion nematodes as once a field becomes infested, the population can persist several years. Field flooding and summer fallow are two control options. Fumigant and non-fumigant nematicides also provide control but are very expensive and in most cases, not financially advantageous (11).

Weeds

There are numerous weed pests that affect dry edible bean fields. Dry edible beans do not compete well with weeds, thus weed management plays a crucial role in an IPM program. Weeds compete with beans for available resources including soil nutrients, moisture, and light. The weeds can be divided into either annual broadleaf weeds or annual and perennial grasses (4, 5, 8, 19). Field cultivation is one tactic used to control or suppress weeds, however, weeds within the rows are most often unaffected by field cultivation--thus the need for chemical input. A number of herbicides are labeled for and used to manage weeds in dry edible beans in Minnesota. Selected herbicides are listed in Table 4 with their effectiveness on select weeds listed in Table 5.

Broadleaf Weeds

Many broadleaf weeds adversely affect dry edible beans in Minnesota. Examples are: velvetleaf (*Abutilon theophrasti*), common lambsquarters (*Chenopodium album*), giant and common ragweed (*Ambrosia trifida* and *Ambrosia artemisiifolia*, respectively), and pigweed (*Amaranthus retroflexus*). These weeds can reach heights comparable to snap beans and compete with the beans for available light and soil nutrients. In absence of control, weeds can and do reduce snap bean yield (8, 14).

Grasses

Annual grasses cause significant problems with dry edible bean production because of their fast growth and ability to compete for resources. Additionally, they are tolerant to extreme moisture and temperature variation once established. They can be very difficult to eliminate from production areas and given their reproductive potential, they require management/control prior to seed-set. Examples are: foxtail (*Setaria spp.*), wild proso millet (*Panicum miliaceum*), and crabgrass (*Digitaria spp.*)(8, 14).

Table 3. Weed control option: chemicals (4, 5, 9)

Pre-emergence Products	Field Rate	A.I. Rate	REI	Remarks*
Dacthal 75WP	6-14 lb/A	4.5-10.5 lb/A	12 h	G, BL**; applied at planting
Eptam 7E	3.5-4.5 pt/A	3-4 lb/A	12 h	G, BL; <9.75 pt/A/year; apply before/immediately after planting
Dual II Magnum (Metolachlor)	1.3-2 pt/A	1.25-2 lb/A	24 h	G, BL**; applied fall or spring and can be tank mixed with other products--see label
Gramoxone Extra (Paraquat)	1.5-3 pt/A	0.5-1 lb/A	12 h	G, BL
Lasso	1.5-3 qt/A	1.5-3 lb/A	12 h	G, BL**; Not for use on Aduzki beans; *Restricted use
Prowl 3.3EC (Pendimethalin)	1.2-3.6 pt/A	0.5-1.5 lb/A	24 h	G, BL**; rate varies by soil type; can be applied with Dual, Lasso, Eptam
Pursuit	2-3 oz/A	0.03-0.05 lb/A	4 h	BL**
Treflan	1-2 pt/A	0.5-1 lb/A	12 h	G, BL**; Apply in fall prior to planting

Post-emergence Products				
Poast 1.5E	0.5-2.5 pt/A	0.06-0.3 lb/A	12 h	G; Not to exceed 4 pt/A/year; 15 d PHI
Assure II 0.88E	5-12 oz/A	0.03-0.08 lb/A	12 h	G; not to exceed 14 oz/A/year; 15 day PHI
Basagran (Bentazon)	1.2 pt/A	0.6 lb/A	48 h	BL**; 4 pt/A/year MAX, second application 10-14 days post first treatment; 30 day PHI

*G: grass, BL: broadleaf

**Certain broadleaf weeds, see label

Table 4. Effectiveness of selected herbicides against selected weeds affecting dry edible beans (9, 19)

Herbicide	Application Type	Bean Tolerance	Foxtail	Thistle	Cocklebur	Lambsquarters	Ragweed	E. Black Nightshade	Hairy Nightshade	Pigweed	Smartweed	Wild Mustard
Assure II	post	G	G	N	N	N	N	N	N	N	N	N
Basagran	post	G	N	G	G	P	G	P	F	P	G	G
Dual II	pre/ppi	G	G	N	P	F	P	G	F	G	P	P
Eptam	ppi	G	G	N	P	F	F	P	P	F	F	P
Lasso	ppi	G	G	N	P	P	F	G	G	G	P	P
Poast	post	G	G	N	N	N	N	N	N	N	N	N
Prowl	ppi	G	G	N	N	N	F	P	P	G	F	N
Pursuit	pre/post/ppi	F	P	N	N	P/F	P/F	F	G	G	P	G
Treflan	ppi	G	G	N	N	F	N	P	P	G	G	N

G=Good, F=Fair, P=Poor, N=None

pre=preemergence, ppi=preplant incorporate, post=post emergence

Contacts

Mr. Patrick O'Rourke
 MN Pesticide Survey & Impact (PSI) Group
 Dept. of Entomology
 219 Hodson Hall
 1980 Folwell Avenue
 St. Paul, MN 55108
 Phone: 612-624-9292
 Email: orour010@tc.umn.edu

Insects:

Dr. William D. Hutchison
 University of Minnesota
 Pesticide Survey & Impact Group
 Department of Entomology
 219 Hodson Hall
 1980 Folwell Avenue
 St Paul, MN 55108
 Phone: 612-624-1767
 Email: hutch002@maroon.tc.umn.edu

Mr. Eric Burkness
 University of Minnesota
 Department of Entomology
 219 Hodson Hall
 1980 Folwell Avenue

St Paul, MN 55108
Phone: 612-624-3670

Plant Diseases:

Dr. James Percich
University of Minnesota
Department of Plant Pathology
316 Stakman Hall
1519 Gortner Ave
St Paul, MN 55108
Phone: 612-625-6240

Weeds:

Dr. Roger Becker
University of Minnesota
Department of Agronomy/Plant Genetics
Agronomy and Plant Genetics
A 203A Hayes Hall
1509 Gortner Ave
St Paul, MN 55108
Phone: 612-625-5753

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