Crop Profile for Beans (Dry Edible) in North Dakota

Prepared: October, 2000

General Production Information

Dry edible bean (*Phaseolus vulgaris*) is a relatively new crop to the North Dakota-Minnesota region (Berglund 1997). They have been grown on a large scale since the 1970s. North Dakota produced approximately 8,265,000 cwt. of dry beans in 1999 (Table 1). A total of 630,000 acres were planted and 570,000 acres were harvested, with an average of 1,450 lbs yield per acre. Two classes of dry bean (navy and pinto) encompass the major commercial acreage. In addition, black turtle, dark and light red kidney, great northern, cranberry, pinks, and small red bean classes are also grown on limited acres.

Twenty-five percent of the dry edible beans (DEB) are grown under contract annually; the remainder of the crop is sold on the open market, or delivered to a processing firm after harvest. Firms are located throughout the eastern half of North Dakota and west central Minnesota counties. The industry is anchored regionally by Northarvest Bean Growers Association which provides a full range of services and funding assistance to facilitate the greater utilization of North Dakota and Minnesota grown DEB. Bounded by the green fields of America's cornbelt on the south and the golden Canadian wheat fields on the north, Northarvest spans 112,000 square miles of fertile soil. The Northarvest region includes all of North Dakota and Minnesota.

DEB are grown in all regions of North Dakota, but the majority of the acres are in the eastern counties of the state (83 %).

Table 1. Dry edible bean production for all classes in North Dakota from 1991 to 1999 (NDASS 2000).

Year	Acres Planted	Acres Harvested	Yield Per Acre	Production	Marketing Year Avg. Price	Value of Production	Value Per Harvested Acre	U.S. Production	
	(000 Acres)		*(Lbs.)*	*(000 Cwt.)*	*($/Cwt)*	*(000 Dols)*	*(Dols)*	*%*	*Rank*
1991	520	510	1,480	7,548	12.20	92,086	180.56	23	1
1992	440	390	1,200	4,680	16.80	78,624	201.60	21	1
1993	510	380	780	2,964	23.00	68,172	179.40	14	2
1994	570	470	1,300	6,110	17.90	109,369	232.70	21	1

1995	600	540	1,330	7,182	16.90	121,376	224.77	23	1
1996	580	570	1,320	7,524	20.30	152,737	267.96	28	1
1997	620	565	1,260	7,119	16.80	119,599	211.68	24	1
1998	750	710	1,380	9,798	15.50	151,869	213.90	32	1
1999	630	570	1,450	8,265	-----	-----	-----	25	1

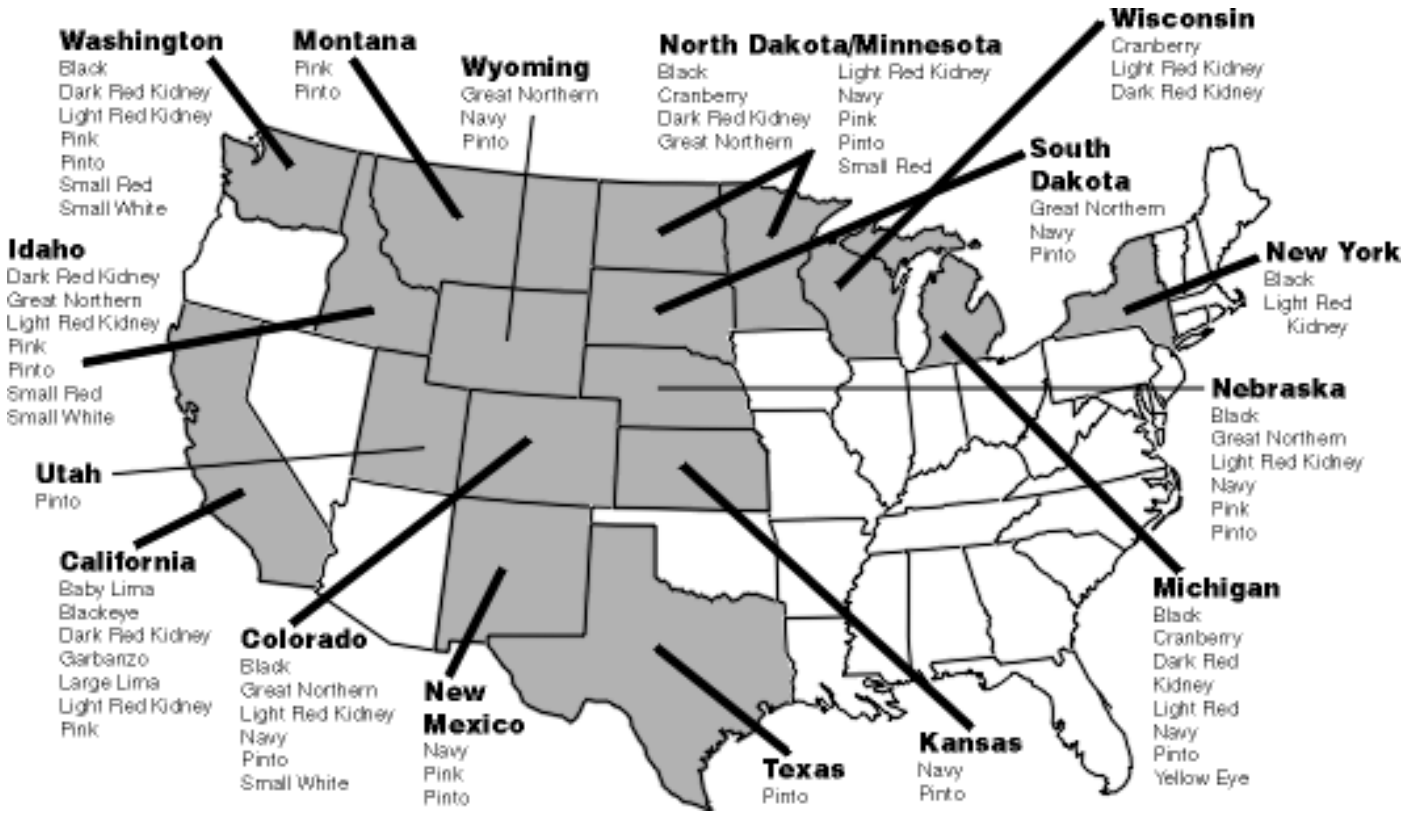

Figure 1. Dry edible bean production areas and classes grown in the U.S.

DEB are warm season crops and usually are not affected by high temperatures if adequate soil moisture is present. Cool, humid or rainy weather is unfavorable to DEB, but they are adapted to a fairly wide range of temperature. The optimum average growing temperature for field beans is 65 to 75°F. DEB are not tolerant to frost or to prolonged exposure to near-freezing temperatures at any stage of plant growth. DEB production is more successful in areas where rainfall is light during the latter part of the growing season. It is essential that the crop be grown on a well-drained soil since beans are extremely sensitive to standing water or waterlogged conditions.

Planting rates vary from 35 to 65 pounds of live seed per acre for Navy beans with a target population of 90,000 plants per acre. Pinto bean planting rates are 50 to 65 pounds of live seed per acre for a population of 70,000 plants per acre. Rates are adjusted for low germination or cool, wet planting conditions. Seeding typically begins in mid-May; harvest begins in mid-August and should be completed before frost.

Crop rotation is an important cultural practice for improving DEB yield. Rotating DEB with other crops can prevent pests from overpopulating a field. A three or four year crop rotation with small grains (wheat and barley) is the most common. Alfalfa, corn, oats, and sugarbeets are also used in rotation in North Dakota.

Other cultural practices include irrigation, cultivation and chemical application. Irrigation was used on 8% of North Dakota DEB fields in 1999 (NDASS 2000). Cultivation of soil when plants are dry and 30 inch row spacings are common practice with DEB. Triple seed treatment of streptomycin, fungicide and insecticide greatly enhance the potential for high value and yield.

Production problems reported by growers vary from year to year. In 1996, disease was the worst overall production problem for DEB in North Dakota; delayed planting ranked second (Lamey et al. 1998). In the 1998 survey of grower production concerns, weeds were ranked as the number one problem and weather was second (Lamey et al. 1999).

Insect Pests

In North Dakota, populations of potential insect pests of DEB are usually small and require only infrequent management with insecticides (Glogoza 2000). Insects causing moderate defoliation early in the season have little effect on DEB. Insect feeding during the reproductive stages are more likely to cause yield and quality losses.

Grasshoppers and potato leaf hoppers are the two primary insect problems in the region. The seed corn maggot can be a serious pest of DEB when temperatures are unfavorable for germination and emergence of DEB. Spring hatching cutworms can cause problems during stand establishment. Aphids, bean leaf beetles, armyworms, green cloverworm, cabbage looper, velvetbean caterpillar, and thistle caterpillar are all potential pests in the region but seldom require management. European corn borer, can be found in dry bean fields, but information on field scouting and possible treatment guidelines have not been determined for the region.

Grasshoppers

Clearwinged grasshopper (*Camnula pellucida*), Two-striped grasshopper (*Melanoplus bivittatus*), Migratory grasshopper (*Melanoplus sanguinipes*), differential grasshopper (*Melanoplus differentialis*), and Redlegged grasshopper (*Melanoplus femurrubrum*)

In the northern plains, eggs of crop pest grasshoppers hatch from late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground. Bean growers expect to find grasshoppers feeding first along bean field margins adjacent to these sites. Later, infestations can develop when grasshopper adults migrate from ripening small grain fields. In DEB, grasshoppers will feed on leaves and pods. Along with the damage potential from migrating grasshopper in August, bean fields become sites for significant egg laying. These conditions put the next crop at risk to early season feeding when nymphs hatch throughout the field site. Grasshopper control is advised whenever 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop.

Potato Leafhoppers *Empoasca fabae*

Potato leafhoppers do not overwinter in North Dakota. Migrations of potato leafhoppers can occur from May through August, moving with weather fronts originating over southern states. The extent of seasonal problems is influenced by the time of migration and the numbers of leafhoppers that are transported into the region. Leafhopper adults are wedge shaped and pale green. Adults are very active and jump or fly when disturbed. Adults are very mobile and move readily within and between fields. Nymphs are wingless, run backwards or sideways, feed on the underside of the leaf, and complete their growth on the leaves near their hatching site. Hopper-burn is the term used to describe leafhopper damage. Leaves become dwarfed and curled, and small triangular brown areas appear on leaf tips. Feeding damage reduces plant vigor and yield. The recommended treatment threshold is one leafhopper per trifoliate leaf. Insecticides used to manage leafhoppers are very effective. It is not uncommon for growers to use reduced rates of certain insecticides to control early leafhopper migrants while DEB are still small and before the plant canopy has closed.

Seedcorn maggot *Delia platura*

Seedcorn maggot attack DEB seed, preventing sprouting or weakening the seedlings. The yellowish white maggot is found burrowing in the seed or emerging stem. The adult flies emerge in spring when soil temperatures reach 50E F. They deposit eggs in soil where there is abundant organic matter and decaying crop residue, or on the seed or seedling. Losses due to seed corn maggots are most severe when wet, cool conditions are present during DEB seeding. Seed treatments that contain an approved insecticide provide the best defense against injury. The statewide pesticide use survey did not report seed treatments for DEB (Zollinger et al. 1998). In 1998 and 1999 regional DEB surveys, 12% and 27% of the respondents reported using an insecticide seed treatment (lindane or chlorpyrifos) on 29% of the their acres, respectively (Lamey et al. 1999, 2000).

Cutworms

Most damage by cutworms occurs when bean plants are in the early stage of development. Damage consists of young plants being chewed off slightly below or at ground level. Some cutworm feeding injury may occur on foliage. Because cutworms primarily feed at night, feeding damage often is overlooked until stand loss occurs. Scouting for cutworms requires digging in the soil to a depth of one to two inches at the base of recently damaged plants. Treatment is warranted when one cutworm or more is found per 3 feet of

row and the larvae are still small (<3/4 inch long). Post-emerge insecticide applications to manage cutworms are effective, but timing is critical to minimize plant loss.

Bean Leaf Beetle *Cerotoma trifurcata*

This beetle occurs at a low incidence in North Dakota. Adults emerge from overwintering, moving into bean fields as the seedlings emerge. The white larvae develop in the soil, feeding on the roots and nodules. New adults emerging in July feed on foliage and pods. The injury to pods results in secondary infections by fungi and bacteria, causing rotting and discoloration. Due to the low incidence of this insect in North Dakota, no local control guidelines have been developed.

Table 2. Registered insecticides and their usage in North Dakota to manage Dry edible bean insect pests.

Insecticide	Tradename	Acres treated [1]		Dosage in Lb AI/ Acre	Product per Acre	Insect Controlled [2]	Preharvest interval (days)
		x 1000	%				
Esfenvalerate	Asana XL	1.4	0.2	0.03 - 0.05	5.8 - 9.6 fl oz	LH, A, CW, GCW, GH	21
Carbaryl	Sevin	NR	NR	1 - 2	6 - 12 oz/ 1,000 ft of row	AW, BLB, CW, GH	0
Diazinon	Diazinon	NR	NR	NR	see specific label	SCM	NR
Disulfoton	Di-Syston G	NR	NR	1 - 2	6- 12oz/ 1,000 ft of row	LH, A	60
Dimethoate	Cygon	NR	NR	0.25 - 0.5	0.5 - 1 pt	LH, A	0
Endosulfan 3EC	Thiodan	NR	NR	0 .5 - 1.0	0.66 - 1.33 qts	A	NR
Methomyl	Lannate LV	NR	NR	0.225 - 0.9	2 - 2.5 pts	A	NR
Lindane	Lindane 30 C	NR	NR	NR	0.7 fl oz/ 100 lbs seed	SCM	NR
Chlorpyrifos	Lorsban 30 F	NR	NR	NR	2.5 fl oz/ 100 lbs seed	SCM	NR
Malathion	Malathion	NR	NR	0.9 - 1.25	1.5 - 2 pts	LH, A, GCW	1

Methoxychlor	Marlate	NR	NR	1	2 qts	BLB	7
Acephate	Orthene 75S	NR	NR	0.25 - 0.5	0.33 - 0.66 lb	GH	14
				0.5 - 1	0.66 - 1.33 lbs	LH, A, BLB, CW, GCW	14
				0.75 - 1	1 - 1.33 lbs	AW	14
Methyl parathion	Penncap-M	NR	NR	0.5	2 pts	LH, A, GCW	15
Phorate	Thimet 20 G	NR	NR	0.9 - 1.4 oz / 1,000 ft of row	4.5 - 7.0 oz/ 1,000 ft of row	LH, A, ASCM	60

[1] Zollinger et al. 1998.
[2] LH - Leafhopper, A - Aphid, AW - Armyworm, BLB - Bean Leaf Beetle, CW - Cutworm, GCW - Green Cloverworm, GH - Grasshopper, SCM - Seed Corn Maggot.
NR - not reported in 1996.

Diseases

Dry edible beans are susceptible to many diseases that can cause significant reduction in quality and yield. The four most serious diseases in North Dakota are bacterial blights, white mold, rust and root rot.

Bacterial Blights:

- Common blight (*Xanthomonas campestris* pv. *phaseoli*)
- Fuscous blight (a variant of *Xanthomonas campestris* pv. *phaseoli*)
- Halo blight (*Pseudomonas syringae* pv. *phaseolicola*)
- Brown spot (*Pseudomonas syringae* pv. *syringae*)

Blight bacteria cause plant defoliation with discoloration and are highly contagious. Blight bacteria are seed-borne, entering the seed through natural openings (Venette and Lamey 1998). North Dakota has four types of bacterial blight: Common blight (*Xanthomonas campestris* pv. *phaseoli*), Fuscous blight (a variant of *Xanthomonas campestris* pv. *phaseoli*), Halo blight (*Pseudomonas syringae* pv. *phaseolicola*), and Brown spot (*Pseudomonas syringae* pv. *syringae*). Common and fuscous blight occur during warm, wet weather; halo blight is prevalent during cool, rainy weather. Brown spot occurs in areas where plants dry slowly. Disease usually spreads from infected seed or bacteria from previous crops. Rainstorms or

hailstorms are ideal conditions for infections, because the bacteria enter wounds. Symptoms include a small, greasy green spot on leaves, stems, or pods.

To manage blight bacteria, it is recommended to plant high quality, certified seed tested for blight bacteria; treat seed with streptomycin to eliminate surface bacterial contaminants; use a granular, in_furrow inoculant rather than a seed_applied inoculant; practice crop rotation of three to four years to allow decomposition of debris; use pinto and navy beans which have some field resistance to halo blight and tolerance to common blight; and, clean equipment.

White Mold *Sclerotinia sclerotiorun*

White mold is a fungal disease that is difficult to eliminate. The fungus produces tough, black to grayish bodies called sclerotia that can survive more than 10 years in the soil (Venette and Lamey 1998). The sclerotia germinate and produce small fruiting structures, 1/8 to 3/8 inch in diameter and shaped like funnels. As many as 40 fruiting structures can arise from a single sclerotium. The fruiting bodies can be produced throughout the growing season, releasing spores that are dispersed by the wind. The spores do not infect healthy plant tissue, but germinate on dead tissue and then infect the whole plant. The fungus may be spread by contaminated seed or through flood and irrigation water. Symptoms include a soft water-soaked spot which enlarges to form masses of rotted tissue. White mold develops under moderate temperature conditions, about 75^{o}F.

A high level of resistance to white mold has not been incorporated into commercially acceptable pinto and navy beans. Fungicides can help suppress the disease. Benomyl (Benlate) and thiophanate methyl (Topsin M) are registered for this use. These materials are locally systemic and do not move downward into older plant tissue. Since the disease usually begins on the dead blossoms and lower parts of the plant, control relies on thorough coverage of the lower plant. It is doubtful that effective coverage can be obtained after bean rows have closed. Low volume fungicide application, less than 5 gallons/A, by aircraft generally gives poor coverage of the lower plant parts; high volume, 7 to 10 gallons/A, by aircraft has provided better control in university trials. The most economic application of fungicide is a banded or directed spray applied by ground applicator at early bloom. Higher fungicide rates provide better control.

Rust *Uromyces appendiculatus*

Rust is caused by a fungus and is found mainly on bean leaves. Rust prefers cool temperatures (60-75^{o}F) and moist growing conditions (Venette and Lamey 1998). Rust affects late planted beans or heavily fertilized beans. Symptoms of rust include a pustule with rust-colored spores or severely defoliated leaves. Most older pinto cultivars, as well as some light red and all pink and small red cultivars, are susceptible to rust. Many new pinto cultivars, as well as many cultivars of navy, cranberry, black, dark red kidney, white kidney and great northern, are resistant to current races of rust.

Deep plowing soon after harvest and a three year rotation reduces the chances of rust damage. Early detection and fungicide application is the best control method to prevent yield loss. Chlorothalonil, trade

name Bravo, and maneb are registered for rust control. Propiconazole, trade name Tilt, is awaiting registration on DEB and has been available for several years under a section 18 emergency registration. Treatment guidelines based on plant maturity and rust severity are available (Venette and Lamey 1998).

Seedling Blights and Root Rots Rhizoctonia, Pythium, *Fusarium* spp. *Fusarium* spp.

Seedling blights and root rot are increasingly serious problems in North Dakota. Rhizoctonia and Pythium can cause root rot, but *Fusarium* spp. has been the most troublesome. Root rot is soil borne and attacks the roots, causing reddish lesions (Venette and Lamey 1994). Fusarium produces a dry rot in drought years. Long crop rotations can help control the fungus, and planting tolerant varieties can reduce yield loss.

To protect seedlings from these pathogens, seed treatments are regularly used. The 1996 pesticide use survey estimates that 84.3% of the seed was treated (Zollinger et al. 1998). The survey does not identify which seed treatment products were used. Products are most likely to contain a three way pesticide mix which includes the one of the fungicides captan, carboxin, metalaxyl, mefenoxam or combinations, plus streptomycin for bacterial blight, and possibly lindane or chlorpyrifos for seedcorn maggot.

Alternaria Blight, **Anthracnose**, **and others**

Alternaria Blight, damping off, anthrancnose, and bean common mosaic are other diseases effecting DEB.

Alternaria blight is a sporadic disease that may cause serious damage, but has no effective control. Irregular, brown, spreading lesions develop with light centers. Black spores cover the undersides of lesions after moist periods.

Anthracnose has not been observed in North Dakota, for some years, but could be introduced on seed from infested areas which may cause fatal infections. Currently anthracnose is known to occur in Manitoba, Michigan and Ontario. but may cause fatal infections. Linear or angular dark, brick-red to purplish-brown to black lesions appear on the veins on the lower leaf surface. Resistant varieties and "pathogen free" seed should be used. Western grown seed should be free of the anthracnose pathogen.

Bean common mosaic virus is a seedborne virus transmitted by aphids and mechanically by plant sap. Infected plants are often stunted and spindly, leaves are irregular with yellowish areas, and pods are usually small and have an off-color. The use of high quality, virus-tested seed aids in management.

Table 3. Registered foliar fungicides and their usage in North Dakota to manage Dry edible bean diseases.

				Disease Control [1]	**Acres treated [2]**	

Fungicide	Tradename	ApplicationMethod	Rate/ A	Rust	Halo Blight	White mold	x 1000	%	Application Timing
Benlate	Benlate	Spray or fungigation	2 lb	P-F	No	G-E	35.3	6.1	At least 14 day before harvest
Chlorothalonil	Bravo 500	Spray or fungigation	2 - 3 pt	E	No	No	8.9	1.5	At least 14 days before harvest
	Bravo 720		1.38 - 2 pt						
Copper	Basicop	Spray	4 lb	F	P	No	NR	NR	NR
	Champ	Spray or fungigation	0.66 - 2 pt	F	P	No	NR	NR	NR
	Champion	Spray or fungigation	1-3 lb	F	P	No	NR	NR	NR
Iprodione	Rovral	Ground spray / fungigation	1.5 - 2 lb	F	No	G-E	NR	NR	Before full bloom
Maneb+zinc	Maneb Plus Zinc F4	Spray or fungigation	1.5 - 2 lb	E	No	-	4.8	0.8	30days PHI
Propiconazole	Tilt (Section 18)	Spray	4 fl oz	E	NR	NR	45.7	7.9	28days PHI
Thiophanate methyl	Topsin	Spray or fungigation	1.5 - 2 lb	P-F	No	G-E	35.7	6.2	At least 14 days before harvest

[1] P - Poor, F - Fair, G - Good, E - Excellent, No - No control, NR - not reported.
[2] Zollinger et al. 1998.

New Advancements in Disease Management

Registration of tebuconazole, trade name Folicur, is pending, and may occur by the cropping season of 2001. This product will provide excellent rust control. Propiconazole, trade name Tilt, also provides excellent rust control. Propiconazole has been available under a section 18 for some time and registration is pending, but will not be registered prior to the completion of the reregistration process. A section 18 for propiconazole will be requested until either tebuconazole or propiconazole are registered.

Several experimental fungicides have shown promise for white mold management. However, it is too soon to determine if any of them will be registered or if they will provide superior control compared to currently registered products.

Weeds

A wide variety of annual and perennial weeds are present in dry bean fields. Eastern black nightshade, Canada thistle, cocklebur, and kochia are the worst weed problems in North Dakota (Lamey et al 1998, 1999, 2000). Other common weed problems include ragweed, redroot pigweed, lambsquarters, foxtail, biennial wormwood, and volunteer grain.

An estimated 93% of the DEB acres in North Dakota were treated with herbicides in 1996 (Zollinger et al. 1998). Bentazon, ethalfluralin, trifluralin, imazethapyr, and sethoxydim were applied to 60%, 50%, 18%, 16%, and 14% of the dry bean acreage, respectively, in 1996 (Table 4). DEB growers reported the same herbicides used at 46%, 44%, 22%, 22%, and 24% of the dry bean acreage, respectively, in 1999 (Lamey et al. 2000). The herbicide, imazamox (Raptor) was used on 13% of the DEB acres in 1999 under a Section 18, Emergency exemption, to address problems with Eastern black nightshade (Lamey et al. 2000).

The North Dakota Dry Bean Production Guide (Berglund 1997) discusses the most common herbicide uses and the target weed pests. These discussions regarding specific active ingredients are summarized for reference.

EPTC plus either **pendimethalin**, **trifluralin**, or **ethalfluralin** controls a broader spectrum of weeds than either herbicide used separately, especially wild oat, common lambsquarters, and eastern black nightshade. EPTC plus pendimethalin must be incorporated thoroughly, immediately after application. The mixture permits lower rates and reduces the chance of carryover from any dinitroaniline herbicide.

Alachlor or **metolachlor** applied preplant incorporated (PPI) or pre-emergent (PRE), controls annual grasses and some broadleaf weeds, including nightshade. Metolachlor may be tank_mixed with EPTC for wild oat control. **Trifluralin**, **pendimethalin** and **ethalfluralin** applied PPI controls annual grasses and certain broadleaf weeds except wild mustard, common cocklebur, and sunflower. The low labeled rates are used on coarse_textured, sandy soils. The higher rates are used for control of eastern black nightshade.

Ethalfluralin applied in the fall or spring suppresses foxtail in DEB grown in reduced tillage systems. Apply in the fall between October 10 and December 31, or in the spring PPI before planting. There are specific directions for incorporation that must be followed to assure effective weed management. The higher label rate is recommended for fields with high crop residues and heavy weed populations.

Split Applications of **bentazon** can be applied in DEB as successive sequential treatments for broadleaf weed control in navy, pinto, kidney and great northern types of DEB. The first bentazon application should be made before the weeds are 0.5 to 4 inches tall, depending on the weed species. The second application follows 7 to 10 days later. Bentazon applied as a planned split application program offers

improved broadleaf weed control compared to a single application. Split applications control common cocklebur, common lambsquarters, annual smartweed, Venice mallow, and wild mustard.

Imazethapyr applied post-emerge controls wild mustard and only provides suppression of nightshade in pinto, navy, great northern, kidney, black turtle, cranberry type dry beans. Reduced crop growth, yield, and/or delayed maturity may result from application. Imazethapyr is not recommended if planting is delayed, or cold and/or wet weather are present or predicted to occur within one week of application. Imazethapyr may control several grass and broadleaf weeds not listed on the label. Imazethapyr has controlled mustard, nightshade, foxtail, pigweed, kochia, marshelder, Russian thistle, common cocklebur, sunflower, smartweed, wild buckwheat, lanceleaf sage, common lambsquarters, and common ragweed less than 1 inch tall in NDSU field trials. Soil residual from POST applications may provide erratic control of subsequent flushes of weeds.

Nightshades *Solanum* spp.

Nightshade is identified as the worst weed problem in North Dakota DEB. Management requires a concerted effort directed at preventing seed production (Berglund 1997). Three kinds of nightshade are found in North Dakota: eastern black, hairy, and cutleaf. Nightshade plants are frost tolerant, can remain green through the harvest season, and can cause serious harvest problems. The berries produced by nightshades are poisonous. The juice from ruptured berries can stain crop seed and glue nightshade seed and dirt to bean seed. Nightshade problems are increased by human activity. Seed is spread by tillage and harvesting equipment or planting crop seed contaminated with nightshade. Nightshade germination occurs from June to September, depending on moisture levels. Seeds can remain viable up to ten years and are frost tolerant.

Nightshade is tolerant to many herbicides, including sulfonylureas. Herbicides remove other broadleaf weeds, allowing nightshade to increase its population through the elimination of competition. Residual herbicides help control continuous nightshade flushes, but few effective herbicides used in DEB have effective residual activity against nightshade. Of the available herbicides, only imazethapyr, has residual activity which can aid in suppressing continuous flushes of germinating nightshade. Defoliation with sodium chlorate or paraquat kills the above-ground portion, speeds harvest, and improves quality and marketability by protecting the bean color and reducing seed contamination.

Table 4. Registered herbicides and their usage in North Dakota to manage weeds in Dry edible beans.

Herbicide	Tradename	Acres treated[1]		Dosage in Lb AI/ Acre	Product per Acre	Weeds controlled	Application Timing
		x 1000	%				

Alachlor	Lasso	2.0	0.4	2 - 3	2 - 3 qt	Grass, eastern nightshade, some broadleaf	PPI
Alachlor +Trifluralin	Freedom	2.4	0.4	NR	NR	NR	NR
Bentazon	Basagran	347.3	59.9	0.5 - 1	1 - 2 pt	Wild mustard, cocklebur, Canada thistle	POST: cotyledon or later
Clethodim	Select Prism	NR	NR	1.5 - 2 oz	6 - 8 fl oz 12.8 - 17 fl oz	annual grasses, quackgrass	Crop: 30 days prior to harvest; Grass 2 to 6 inches
Dimethenamid	Frontier	1.4	0.2	0.75 - 1.5	16 - 32 fl oz	Grass, eastern nightshade, some broadleaf	PPI, PRE, or POST to third trifoliate
EPTC	Eptam/ Eradicane	13.4	2.3	3 - 4	3.5 - 4.5 pt	Grass, eastern nightshade, some broadleaf	PPI or after October 15
Ethalfluralin	Sonalan	291.8	50.3	0.55 - 1.7	1.5 - 4.5 pt	Grass, some broadleaf	PPI: After October 15 or Spring
Glyphosate	Roundup	6	1.0	0.19 - 0.75	0.5 - 2 pt	Emerged grass and some broadleaf	Preplant or prior to emergence
Imazethapyr	Pursuit	95	16.4	0.5 oz	2 fl oz	Wild mustard, eastern nightshade	POST: after first trifoliate, but before flowering
Sodium chlorate	Leafex-3, Defol	NR	NR	6	2 gal	Desiccant	7-10 days before harvest

Metolachlor	Dual II	10.8	1.9	2 - 3	2 - 3 pt	Grass, eastern nightshade, some broadleaf	PPI or PRE
Paraquat	Gramoxone Extra	1.2	0.2	0.31 - 0.47	1 - 1.5 pt	Dessiccant	7 days before harvest
Pendimethalin	Prowl, Pendimax	2.2	0.4	0.75 - 1.5	2.4 - 3.6 pt	Grass, some broadleaf	PPI
Quizalofop-P	Assure II	33.2	5.7	0.6 - 1 oz	6 - 10 fl oz	Annual grass, quackgrass	Crop: 30 days before harvest Grass: 2 -6 in
Sethoxydim	Poast	81.6	14.1	0.1 - .3	0.5 - 1.5 pt	Annual grass	30 days PHI
Trifluralin	Trifluralin	103.4	17.8	0.5 - 1	1 - 2 pt	Grass, some broadleaf	PPI: Fall or Spring

[1]Zollinger et al. 1998.
NR - not reported.

New advancements in Weed Management

Imazamox, trade name Raptor, was made available through ND Section 18 emergency labeling in 2000 for control of nightshade in DEB. An advantage of imazamox includes fewer crop rotation restrictions when compared to imazethapyr. Imazamox, when applied with a postemergence grass herbicide or preceded by a soil applied grass herbicide registered in DEB, controls most annual grass and broadleaf weeds. DEB crop injury concerns are the same for imazamox and imazethapyr. Section 3 registration of imazamox is expected by use season 2001.

Fomesafen, trade name Reflex, was made available through ND Section 18 emergency labeling in 2000 for control of nightshade and kochia. Fomesafen, when applied with a postemergence grass herbicide or preceded by a soil applied grass herbicide registered in DEB, controls most annual grass and broadleaf weeds. Fomesafen controls many other broadleaf weeds, including common cocklebur, mustard species, lanceleaf sage, Venice mallow, marshelder, pigweed species, ragweed species, annual smartweed, and sunflower. Section 3 registration of fomesafen is expected by use season 2003.

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