5. Dry Edible Beans

Dry edible beans (*Phaseolus vulgaris*) belong to a class of legumes (Fabaceae family). Production of dry edible beans occurs primarily in western Ontario, and the crop is typically grown under contract. Over 80% of production is exported. The main types of beans grown in Ontario include white (navy), kidney, cranberry, black, otebo, and adzuki (or azuki) beans. Adzuki beans (*Vigna angularis*) are only distantly related and are unique in their growth habit, production and susceptibility to diseases and insects. Dry edible beans require special cultural management practices for optimum quality and profitability.

Tillage Options

Dry edible beans grow best in soils with excellent soil structure and good drainage. The seedbed requirements are similar to those for soybeans, including a firm seedbed to enhance a uniform planting depth and good seed-to-soil contact to promote rapid and uniform emergence. The best, highest-yielding stands come from beans that emerge within a week of planting and remain stress free for the first 3 weeks. This is accomplished with:

- uniform soil moisture
- good soil-to-seed contact
- secondary tillage limited to the minimum required for seedbed preparation
- surface conditions that minimize risk for soil crusting

The choice of tillage system must consider the harvest method. White and black beans are direct harvested and can be successfully grown using conventional, strip, reduced or no-till systems. Large seeded bean types, including kidney and cranberry, are typically harvested by pulling and windrowing prior to combining. Some producers have had success with direct harvest when done at the ideal bean moisture content. Conventional tillage is the traditional and most common method of preparing seedbeds for larger-seeded bean types that are pulled at harvest, but an increasing number of producers are successfully employing other tillage systems. Large-seeded coloured beans are more prone to damage by crusting because of their large cotyledons.

In no-till systems, dry edible beans respond to some form of tillage in the seed zone at planting. This is largely because of their inherently small and poorly developed root system. Tillage coulters on the planting unit will provide the necessary seed-zone tillage to optimize emergence, stand establishment, early growth and plant height. Beans are shorter when grown in a no-till system and are therefore better suited to narrow row production.

Packing following planting is usually necessary where direct harvesting is planned and for dry edible beans planted no-till into corn stubble. Packing will level the field for clipping beans close to ground and reduce stones, cornstalks and contamination from dirt when combining.

Site Selection and Crop Rotation

The most important factors in field selection include:

- disease history
- previous crop
- weed control and potential herbicide carry-over
- soil structure, slope and drainage

Soil Type and Structure

Fields planted to dry edible beans are susceptible to soil erosion due to late planting, slow growth and the relatively poor root systems of the crop. The crop canopy and crop residue only protect the soil for a relatively short period of the season. For beans in wide rows, the crop canopy may only fully cover the soil in August.

Dry edible beans are one of the most responsive crops to good soil structure and grow best on loamy, uncompacted soils. Heavy soils that are poorly drained, prone to crusting or hard to till risk uneven emergence and poor stands. Soil that remains saturated for 24 hours will cause severe seedling damage. Beans have relatively inefficient and poorly developed root systems that are susceptible to stress. Uneven emergence results in uneven ripening, delayed harvest and immature beans that increase the “pick” and result in lower grade and price when marketed.

Avoid growing dry edible beans in fields where compaction is a concern. Soil compaction is a serious dry bean production issue that restricts root growth, promotes root disease and increases risk of herbicide injury. Yield reductions from compaction and poor soil structure can be as high as 30%–50%. Compaction takes time to overcome and cannot be alleviated with tillage alone.

Disease History

A rotation where beans are grown only once in 3 years (or longer) is essential to avoid the build-up of diseases. The most common diseases encouraged by short rotations are root rots and white mould (*Sclerotinia*). Soybean, canola, potato and sunflower are poor rotation choices with beans since they are all susceptible to white mould. Root rots are challenging to control through rotation, because they have a wide crop-host range. The organisms that cause root rots are often invasive, infecting plants that are under stress. Soil compaction, poor drainage, frequent cropping to beans, and other factors cause plant stress that favours root rot. Dry edible beans are also hosts for soybean cyst nematode (SCN). Adzuki beans are particularly susceptible to SCN. For additional information about SCN and other dry edible bean diseases, see Chapter 16, *Diseases of Field Crops*.

Bean dealers and buyers may stipulate the crop protection products that are permitted to be used, based on the maximum residue limit (MRL) approval of importing countries. Producers need to check their production contract or guidelines and speak with their dealer for a list of approved products.

Weed Control

Options for controlling annual broadleaf and perennial weeds with herbicides are limited in dry edible beans, so weeds must be controlled in the previous crop. Weeds present at harvest may also create quality problems (i.e., seed staining) and reduce harvest efficiency. Nightshade and perennial pokeweed cause severe staining of beans at harvest. Corn is often favoured as a previous crop due to the number of options for controlling problem weeds. Cultivation between the rows can be used to control weeds. Refer to Chapter 7 of Publication 75, *Guide to Weed Control,* for more information on cultural and chemical control options in dry edible beans. Note that not all dry edible bean classes are tested in herbicide-tolerance evaluations, and the classes may vary in their tolerance to certain herbicides.

Dry edible beans are very sensitive to certain herbicides that may be in the soil. To reduce carry-over injury from previous crops, select herbicides carefully the year prior to bean production. Refer to Table 4–4, *Herbicide Crop Rotations,* and *pH Restrictions–Field Crops* in OMAFRA Publication 75, *Guide to Weed Control.*

Considering all the factors, the ultimate rotation crops for dry edible beans include corn, forages and cereals. A previous crop of corn or cereals provides a good opportunity to control weeds, and an effective break in edible bean diseases. The earlier harvest date of dry edible beans allows for timely planting of winter wheat. A cereal crop in which weed control was good would be preferred over a corn field where compaction following a wet harvest might be an issue. Forages promote the best soil structure, but soil insects and weed pressure can be an issue. For more information on appropriate crop rotations for dry edible beans and precautions under different tillage systems, see Table Intro–1. *Management considerations for various crop rotations*, found in the Introduction.

Variety Selection

Before deciding on a market class, carefully consider the unique production requirements and risks for each class. There are differing seed sizes and plant architectures that may dictate the required equipment and harvest method, and for some classes there are distinct challenges in meeting quality standards. Most dry edible beans in Ontario are grown under contract; consider the various marketing opportunities and contract options.

In choosing a dry edible bean variety, consider:

- growth habit (e.g., upright or vining)
- days to maturity
- yield potential
- suitability for intended harvest method
- disease resistance/tolerance (e.g., anthracnose, bean common mosaic virus (BCMV), common bacterial blight (CBB))

Annual variety performance information is published by the Ontario Pulse Crop Committee at www.gobeans.ca.

Choosing varieties of an appropriate maturity is of primary importance. The variety information from seed dealers and the Ontario Pulse Crop Committee indicates the number of days to maturity for each variety. Select varieties that will mature within the first 3 weeks of September, when the weather is generally more favourable for harvest and the opportunity for timely winter wheat planting exists. Harvesting in dry weather will help maintain high bean quality.

Varieties are rated for resistance to two important diseases: bean common mosaic virus (BCMV) and anthracnose. Currently all bean types are susceptible to white mould, however adzuki beans have higher tolerance.

Kidney beans are more susceptible to root rot than other types and for this reason grow best on loam soils. Black and adzuki beans have a stronger root system than other bean types and can be grown on a wider range of soil types; however, adzuki beans take longer to emerge than other beans because of their hard seed coat and are therefore more susceptible to emergence problems on crusting soils. White bean varieties are rated for their suitability for direct harvest. When dry edible beans are grown in narrow rows, select varieties with an upright plant type since direct harvest is the only option.

Planting

Seed Quality

Using high-quality, pedigreed seed from inspected fields is important to promote early season vigour and reduce the risk of seed-borne disease. Bacterial blights, anthracnose and BCMV are seed-borne diseases that cause serious issues in some years.

Most coloured bean seed (except black bean seed) is imported from arid growing regions in the U.S. where there is a low incidence of bacterial blight and anthracnose. Some seed, particularly white and black bean seed, may originate from pedigreed seed production in Ontario. Test all seed for germination. See Appendix F, *Ontario Laboratories Offering Custom Seed Germination Testing*.

Ensure that seed is free from mechanical injury and weather damage, and be sure to handle seed gently. Bean seeds are fragile and sensitive to rough handling, which can damage the growing point within the seed and result in slow or reduced emergence, distorted growth and missing cotyledons. Seed harvested at less than 16% moisture is more prone to mechanical damage. To reduce damage, minimize the distance seed falls, ideally less than 0.5 m (2 ft), and use brush augers and conveyors rather than regular augers. Poor-quality seed, including mechanically damaged seed, can result in reduced germination and vigour, uneven emergence, stunting or even "bald-headed" plants (plants without true leaves).

Planting Date

The ideal germination temperature for dry edible beans is 15°C or above. Optimum plant growth occurs between 18°C–23°C. The minimum temperature for growth is 10°C and maximum temperature is 32°C. Table 5–1, *Planting date guidelines,* displays the ideal planting dates according to geographic region. The highest yields are obtained by planting within these dates. Refer to Chapter 1, *Corn* Figure 1–1, *Crop heat units (CHU-M1) available for corn production,* to determine the heat unit rating for your area. Check with the seed distributor for variety-specific planting recommendations.

Table 5–1. Planting date guidelines

Legend: CHU = crop heat units

CHU Geographic Area	Planting Date Guidelines
Less than 3,000 CHUs	May 26–June 6
3,000–3,200 CHUs	May 30–June 10
More than 3,100 CHUs	June 7–June 20

Dry edible beans are less vigorous than soybeans and must be planted when soil conditions are warm and moist, ensuring quick, uniform emergence. Low temperatures at planting increase the risk of slow emergence, and damage from herbicide injury, soil crusting and root rot. When determining the planting date, temperatures at flowering must also be considered. Planting within the appropriate dates will avoid hot, dry weather during flowering and ensure a timely harvest. Temperatures greater than 32°C can cause "flower blasting" (dropping of buds and flowers). Regardless of planned planting date, it is most important that the soil is fit for planting before proceeding. Under late planting conditions, carefully

consider when dry edible beans will mature before continuing to plant. Dry edible beans are less able than soybeans to adapt to a shorter growing season from late planting.

Seeding Rates

Dry edible bean seed size varies greatly. Check to ensure the planter is calibrated properly to plant the correct number of seeds per metre of row. Adjust seeding rates for seed quality and expected germination rate, field conditions and field history. In conditions where reduced emergence is a risk, increase seeding rates by up to 10%. High-risk conditions include seeding into heavy soil, late or very early planting, deeper plantings or expected seedling loss from wireworm or seed corn maggot injury, and planting into soils susceptible to soil crusting.

Table 5–2, *Seeding rates for white and black beans* displays the seeding rates for white and black beans according to row width. General seeding rate guidelines for coloured beans are shown in Table 5–3, *Coloured bean seeding rate*. The average desired plant stand for adzuki beans is 210,000 – 222,500 plants/ha (85,000–90,000 plants/acre), and for otebo is 173,000 plants/ha (70,000 plants/acre). Consult the seed supplier for more specific information on seeding rates for the various classes. Seeding rates may also depend on the type of equipment used for planting.

Table 5–2. Seeding rates for white and black beans

Seeding rates are based on 90% germination and 90% emergence. Adjust seeding rates for germination percent and expected percent emergence.

	Parameters		
Number of Seeds	**36-cm (14.5-in.) row** 10–13 seeds/m of row (3–4 seeds/ft of row) **Seeding rate:** 369,000 viable seeds/ha (150,000 seeds/acre)	**53-cm (21-in.) row** 11.5–15 seeds/m of row (3.5–4.5 seeds/ft of row) **Seeding rate:** 272,000 viable seeds/ha (110,000 seeds/acre)	**76-cm (30-in.) row** 15–16 seeds/m of row (4.5–5.0 seeds/ft of row) **Seeding rate:** 222,000 viable seeds/ha (90,000 seeds/acre)
4,500–5,000 seeds/kg (2,000–2,300 seeds/lb)	72–83 kg/ha	54–62 kg/ha	42–48 kg/ha
5,000–5,500 seeds/kg (2,300–2,500 seeds/lb)	66–72 kg/ha	50–54 kg/ha	38–42 kg/ha
5,500–6,000 seeds/kg (2,500–2,700 seeds/lb)	61–66 kg/ha	46–50 kg/ha	36–38 kg/ha
6,000–6,500 seeds/kg (2,700–3,000 seeds/lb)	55–61 kg/ha	42–46 kg/ha	32–36 kg/ha
100 kg/ha = 90 lb/acre			

Table 5–3. Coloured bean seeding rate

Suggested seeding rates vary significantly between market classes. Check with seed distributor for recommended rates. Seed sizes can vary between lots; check the seed tag for seeds/kg (seeds/lb).

Row Width	Seeding rate	Final Plant Stand[1]
53 cm (21 in.)	9.5–11.5 seeds/m of row (3.5–4.0 seeds/ft of row)	173,000–205,000 plants/ha (70,000–80,000 plants/acre)
76 cm (30 in.)	11.5–15.1 seeds/m of row (4.3—6.0 seeds/ft of row)	148,000–198,000 plants/ha (60,000–80,000 plants/acre)

[1] Based on 90% germination and 90% emergence.

Seeding rate can be calculated using seeds/kg found on seed tag with the following formula:

Seeding rate (kg/ha or lb/acre)
= desired final plant population ÷ seedling survival rate ÷ seeds/kg (seeds/lb)

Example: Cranberry beans
148,000 plants/ha desired population
85% seedling survival
1760 seeds/kg

Seeding rate
= 148,000 ÷ 0.85 ÷ 1760
= 99 kg/ha

Seeding Depth

The seeding depth for dry edible beans is critical for uniform emergence. Frequently, poor stands are the result of not planting into moisture. Planting depth should be at least 1.2 cm (0.5 in.) into soil moisture. Uneven emergence results in uneven maturity. A seeding depth of 4–6 cm (1.5–2.5 in.) is normal, but deeper plantings of up to 9 cm (3.5 in.) may be necessary to seed into moisture. Beans planted deeper are more susceptible to poor emergence and crusting. Some older drills cannot provide accurate depth control. In these situations, a planter may be a better option. Seed drills should have gentle seed distribution devices, depth bands — or depth gauge wheels — and press wheels to ensure uniform seed placement and coverage. High quality, accurate and calibrated seeding equipment is critical to dry edible bean production success. Rolling or packing a field prior to planting helps firm the seedbed and conserve moisture, and can help control planting depth when seeding with a drill. Packing after planting helps level out ridges, pushes down small stones and conserves moisture, but it also makes the soil more susceptible to crusting.

Row Width

Row widths of 70–75 cm (28–30 in.) are standard for both white and coloured beans when the crop will be pulled and windrowed. In fields with a high risk of white mould, wide row widths are preferred to allow more air circulation in the canopy. Narrow row widths of 36–56 cm (14–22 in.) are most suitable if the bean crop will be direct harvested. Ontario row width trials with no-till white beans produced yields 14% higher in narrow row widths, i.e., less than 56 cm (22 in.), compared to wide rows. White and black bean row width trials, done in Michigan (2011–12), compared 15 in. and 20 in. row widths to 30 in. rows. Yields were improved between 4.5%–14% with narrower row width, and with no increase in plant height. In narrow rows, it is important to select white bean varieties with an upright plant type and good tolerance to white mould.

Emergence may be better in wide rows seeded with a conventional corn planter than narrow rows seeded with a grain drill or air seeder. Consider that:

- Drills and air seeders can damage fragile seed.
- Planters are designed to provide more uniform and accurate seed depth placement and better seed coverage.
- Wide rows have more seeds per linear measure to push up through surface crust. For example, 16 seeds/m (5 seeds/ft) of row in wide rows, compared to 10 seeds/m (3 seeds/ft) of 36 cm (14 in.) rows.
- Planting seeds into tire tracks can result in emergence problems.

In narrow rows, emergence can be a problem for beans planted into tractor tire tracks. Some producers adapt equipment to harrow or cultivate between the tractor tires and the planter. The advent of rod pullers has enabled beans planted in 50–56 cm (20–22 in.) rows to be pulled and windrowed.

Inoculation

The species of rhizobia for dry edible beans is *Rhizobium leguminosarum biovar phaseoli.* Dry edible beans are less efficient at fixing nitrogen through rhizobia than soybeans or other legumes. Inoculation trials and routine use of an inoculant have not shown an economic advantage in Ontario, even though other regions do suggest inoculant use for virgin dry edible bean fields.

Dealing with Soil Crusting

Pounding rains from thunderstorms can result in severe crusting on heavy soil types, or soils with poor aggregate stability, and can inhibit bean emergence, particularly if hot, dry conditions bake the soil surface. Soil loosening and aeration may be required. There is no advantage to waiting once a crust has been identified. Waiting may increase the lack of uniformity of the stand. It may be better to have a lower, more uniform stand, than an uneven stand with a higher

population. Rotary hoes, culti-packers, coulter-carts, no-till drills, planters and harrows have all been used successfully (and unsuccessfully) in breaking crusted soils.

Typically the rotary hoe can reduce bean stands by 5%–10%, but the extra beans that emerge more than compensate for this reduction. Rotary hoeing during the "hook" stage of bean emergence will result in significant plant losses. Rotary hoeing during mid-day, when bean plants are more flaccid, or limp, will reduce plant damage. Target speed is 10–20 km/h. Adjust the equipment over a short distance and check that the percentage of bean plants buried or uprooted is less than 10%. It is normal for the crop to look a little "tough" following rotary hoeing. Weed control will also be enhanced when uprooted weeds dry out in mid-day heat.

Stand Assessment and Replant Decisions

The decision to replant can be one of the most difficult decisions for a producer to make. Stresses on the crop are additive and typically have a greater impact on dry edible beans than soybeans. An adequate stand of dry edible beans is a minimum of two-thirds to three-quarters of a full stand. Dry edible beans have a limited ability to branch and compensate for stand losses.

Beans which germinate, but are slow to emerge, will often develop a thickened hypocotyl (stem), leaf out underground, or develop seedling blight. When injury has been identified, flag a few areas in a field to monitor and reassess. Check the root system for new growth and for discolouration caused by root disease; the roots should be bright white. Compare the growth in injured areas to growth in unaffected areas. Consider that additional weed control and/or desiccants may be needed where plant stands are uneven.

Before replanting, consider the cause of the poor stand, the remaining population of healthy plants, plant uniformity, weed control needs and the date of replanting. Cranberry beans generally perform better under late planning scenarios than white beans or other coloured beans.

Minimum number of healthy plants in the row should be:

6.5–8 plants/m of row in 38–56 cm rows
(or 2–2.5 plants/ft of row in 15–22 in. rows)

10–13 plants/m of row in 76 cm rows
(or 3–4 plants/ft of row in 30 in. rows)

5–6.5 plants/m of row in 18 cm rows
(or 1.5–2 plants/ft of row in 7 in. rows)

These numbers are based on good growing conditions, the good health of the remaining plants, a uniform stand and uncompacted soil.

Plant Development

Bean varieties are characterized by their growth habit. Indeterminate plants continuously grow and exhibit long vines. Most of the commonly grown bean types have a semi-determinate growth habit, meaning they continue to grow after flowering begins and develop short to long vines. Determinate types tend to flower and ripen over a short period. Determinate types (also called "bush") can be more susceptible to moisture and heat stress than indeterminate or "vining" types, which flower and fill seed over a longer period.

In addition to determinate and indeterminate plant types, the growth of beans is also identified as:

Type I — determinate bush growth habit, for example, most cranberry beans and very early white bean varieties.

Type II — upright short vine, narrow plant with 3–5 branches for example, most white, black, kidney, otebo varieties.

Type III — plants with weak main stem that produces a vine that is prostrate along the soil surface.

The vegetative and reproductive stages of dry edible bean growth are indicated in Table 5–4, *Vegetative and reproductive growth stages of dry edible beans*. Vegetative stages are described by the number of trifoliates on the main stem. Trifoliates are counted when the edges of unfolding leaves no longer touch. Dry edible beans are normally self-pollinated.

Table 5–4. Vegetative and reproductive growth stages of dry edible beans

Stage Abbreviated	Stage Title	Description	Days from Planting[1]
VE	hypocotyl emergence	seedlings emerge from the soil (crook stage)	7–8
VC	cotyledon & (unrolled unifoliate)	hypocotyl straightens, cotyledons (seed leaves) unfold, and unifoliate visible	8–9
V1	first trifoliate	first fully developed trifoliate leaf at third node	10
V2	second trifoliate	second trifoliate (leaf edges no longer touching)	19
V3	third trifoliate	third trifoliate unfolds. Secondary branching begins in leaf axil.	29
V4	fourth trifoliate	fourth trifoliate	33
V5	fifth trifoliate	bush — Type I plants (determinate types) begin to display blossom and become stage R1	50
V8	eighth trifoliate	vine — Type II plants (indeterminate types) begin to display blossom and become R2	40
Vn	trifoliate n	nth trifoliate develops at node N-2 new node every 3–5 days	40 + n
R1	first flower	one open flower per plant	50
	30% flower	open and dying blossoms are present, but no evidence of pods 30% of total blossoms that will appear are open	53
R2	50% flower	appearance of first pods (pin beans)	53
R3	early pod set	one pod has reached maximum length	56
R4	mid-pod	50% of pods have reached maximum length (seed not discernible)	60
R5	early seed fill	one pod per plant with fully developed seeds	64
R6	mid seed fill	50% of pods with fully developed seeds	66
R8	maturing	50% of leaves yellowing, point of maximum production	90
R9	physiological maturity	80% of pods have changed colour from green to mature colour, only 40% of leaves still green	105

[1] Approximate days from planting will vary with season and cultivar.

Fertility Management

Nitrogen

Although dry edible beans are legumes, they obtain less than half their nitrogen requirement through nitrogen fixation. Studies have not shown a benefit to inoculation with rhizobia. Ontario nitrogen research has demonstrated yield increases in some years, but has not shown an economic response to pre-plant incorporated or banded nitrogen. Nitrogen applied pre-flower does not increase yield. Other jurisdictions (Manitoba, Michigan, Wyoming, North Dakota) have shown an economic yield response to pre-plant nitrogen and suggest between 18–36 kg N/ha (40–80 lb N/acre). Where phosphate fertilizers are banded, a small amount of nitrogen (10 kg/ha or 9 lb/acre) may improve the availability of the phosphate.

It is important to consider cropping history, soil organic matter levels, and manure application history in making a decision on applying additional nitrogen fertilizer. Nitrogen may not be required where beans follow a crop that received a high amount of nitrogen, where manure is applied or where the previous crop was a legume.

Nitrogen stimulates plant and root growth. This can be helpful when bean growth is slow due to environmental stresses or root rot. Where edible bean yields have traditionally been low due to bronzing or root rots, apply up to 100 kg/ha (90 lb/acre) of nitrogen before planting. Under these conditions, nitrogen will increase yield but will not cure bronzing or root rots. Applying nitrogen can increase plant height, which is helpful in narrow-row bean harvest or for beans grown on heavy clay soils. Nitrogen can increase the risk and severity of white mould because of increased vegetation, but does not significantly delay maturity.

Phosphate and Potash

Phosphate and potash recommendations for dry edible beans are presented in Table 5–5, *Phosphate guidelines for dry edible beans* and Table 5–6, *Potash guidelines for dry edible beans*. For information on the use of this table, or if an OMAFRA-accredited soil test is unavailable, see *Fertilizer Guidelines* in Chapter 9, *Soil fertility and nutrient use*.

Where manure is applied, reduce the fertilizer application according to the amount and quality of manure according to Table 9–10, *Typical amounts of available nitrogen, phosphate and potash from various types of organic nutrient sources.*

Where soil fertility levels are adequate, dry edible beans show minimal response to starter phosphorous. Where potassium fertility is low, deficiency symptoms appear in white beans as yellowing of the lower leaves and necrosis on leaf margins, as seen in Photo 5–1. Dry edible bean seedlings are very sensitive to ammonia toxicity and salt damage from starter fertilizer. No fertilizer should be placed in direct contact with the seed. Band starter fertilizer 5 cm (2 in.) to the side and 5 cm (2 in.) below the seed. Banding is a more efficient method of applying phosphorus or zinc when they are required. Fertilizer may be broadcast and plowed down, worked in before planting or applied through a planter that has a separate attachment for fertilizer.

Photo 5–1. Potash deficiency in white beans as seen by yellowing of lower leaves and necrosis of leaf margins.

Table 5–5. Phosphate (P_2O_5) guidelines for dry edible beans

Based on OMAFRA-accredited Soil Tests.

Profitable response to applied nutrients occurs when the increase in crop value, from increased yield or quality, is greater than the cost of the applied nutrient.

Where manure is applied, reduce the fertilizer application according to the amount and quality of manure (Chapter 9, Manure section).

Legend: HR = high response; MR = medium response; LR = low response; RR = rare response; NR = no response

Sodium Bicarbonate Phosphorus Soil Test	Phosphate Required
0–3 ppm	80 kg/ha (HR)
4–5 ppm	60 kg/ha (HR)
6–7 ppm	50 kg/ha (HR)
8–9 ppm	40 kg/ha (HR)
10–12 ppm	30 kg/ha (MR)
13–15 ppm	20 kg/ha (MR)
16–30 ppm	0 (LR)
31–60 ppm	0 (RR)
61 ppm +	0 (NR)[1]

100 kg/ha = 90 lb/acre

[1] When the response rating for a nutrient is "NR," application of phosphorus in fertilizer or manure may reduce crop yield or quality. For example, phosphorus applications may induce zinc deficiency on soils low in zinc and may increase the risk of water pollution.

Table 5–6. Potash (K_2O) guidelines for dry edible beans

Based on OMAFRA-accredited Soil Tests.

Profitable response to applied nutrients occurs when the increase in crop value, from increased yield or quality, is greater than the cost of the applied nutrient.

Where manure is applied, reduce the fertilizer application according to the amount and quality of manure (Chapter 9, Manure section).

Legend: HR = high response; MR = medium response; LR = low response; RR = rare response; NR = no response

Ammonium Acetate Potassium Soil Test	Potash Required
0–15 ppm	120 kg/ha (HR)
16–30 ppm	110 kg/ha (HR)
31–45 ppm	90 kg/ha (HR)
46–60 ppm	80 kg/ha (HR)
61–80 ppm	60 kg/ha (MR)
81–100 ppm	40 kg/ha (MR)
101–120 ppm	30 kg/ha (MR)
121–150 ppm	0 (LR)
151–250 ppm	0 (RR)
251 ppm +	0 (NR)[1]

100 kg/ha = 90 lb/acre

[1] When the response rating for a nutrient is "NR," application of potash in fertilizer or manure may reduce crop yield or quality. For example, potash application on soils low in magnesium may induce magnesium deficiency.

Plant Analysis

For dry edible beans, sampling the top fully developed leaf (three leaflets plus stem) at first flowering is preferred for plant nutrient analyses. Refer to Table 5–7, *Interpretation of plant analysis for dry edible beans*. Sample plants suspected of nutrient deficiency as soon as the problem appears. If sampling occurs at times outside of the recommended timing, collect samples from both healthy and injured areas so comparisons can be made. Take a soil sample from the same area and at the same time as the plant sample. Values in Table 5–7 apply to the top fully developed leaf (three leaflets plus stem) at first flowering.

Micronutrients

Manganese

Manganese deficiency in dry edible beans has been diagnosed occasionally in Ontario. This problem is more likely to occur on muck soils or very sandy soils. Plants with manganese deficiency have pale green-to-white upper leaves. The veins of affected leaves will remain green. The pattern can appear similar to iron deficiency, but manganese deficiency occurs more generally over the entire plant whereas iron deficiency appears on new growth. Correct the deficiency as soon as it is detected by spraying the foliage with 2 kg/ha (1.8 lb/acre) of actual manganese from manganese sulphate (8 kg/ha (7.1 lb/acre) of manganese sulphate) in 200 L (44 gal) of water. Use of a "spreader-sticker" is recommended. Use a spray grade manganese product to prevent nozzle plugging.

In good growing conditions, the affected leaves should green up in 4–5 days. Chelated manganese products are equally effective if applying the same amount of manganese, but the cost is significantly higher than manganese sulphate. Low rates of chelated manganese are not effective in correcting a deficiency.

In general, beans will give a profitable response to manganese in the parts of the field where manganese deficiency is obvious. There is no benefit to applying manganese to beans that are not showing deficiency symptoms.

Table 5–7. Interpretation of plant analysis for dry edible beans

Legend: — = no data available

Nutrient	Critical Concentration[1]	Maximum Normal Concentration[2]
Nitrogen (N)	4.00%	5.5%
Phosphorus (P)	0.15%	0.5%
Potassium (K)	1.20%	2.5%
Calcium (Ca)	–	5.0%
Magnesium (Mg)	0.10%	1.0%
Boron (B)	10.0 ppm	55.0 ppm
Copper (Cu)	4.0 ppm	30.0 ppm
Manganese (Mn)	14.0 ppm	100.0 ppm
Zinc (Zn)	14.0 ppm	50.0 ppm

[1] Yield loss due to nutrient deficiency is expected with nutrient concentrations at or below the "critical" concentration.
[2] Maximum normal concentrations are more than adequate but do not necessarily cause toxicities.

Zinc

Low zinc conditions may occur on low organic matter, compacted, sandy, very high pH and/or eroded soils. Deficiency symptoms may also appear when early growing season conditions are cool and wet.

Zinc is not very mobile in plants so deficiency generally appears on new growth. Leaves will appear pale green between veins with yellowing of the leaf tips and outer margin. In the early stages of deficiency, leaves can be crumpled or dwarfed. Later in the season the leaf tissue may look like sunscald with bronzing or browning of leaves, and deficiency can cause terminal pods to drop during flowering leading to a delay in maturity.

Dry edible beans do not often respond to zinc fertilizer until zinc levels in the soil are low (zinc index below 15). For zinc soil and foliar application options, refer to Chapter 9, *Soil Fertility and Nutrient Use.*

Boron

Beans are very sensitive to boron and should not be grown in a field where boron was applied to rutabagas, sugar beets or forages in the previous year.

Harvest and Storage

Dry edible beans are sensitive to damage at harvest. Beans are sold based on eye appeal so seed coat quality and colour are important. Producing beans that are clean, bright and whole is the ultimate goal and timely harvest is paramount to maintaining quality. Know the quality standards for the crop's market class. The ideal moisture range for harvest is 16%–20%. Harvesting outside this range will reduce quality. Low moisture content at harvest will increase the amount of split seeds and cracked seed coats.

Weather conditions in the fall can cause some bean types to deteriorate in quality much more quickly than others. Some differences in classes are as follows:

- Kidney, Dutch brown and black beans tend to withstand more adverse weather at maturity than the white navy, cranberry, otebo and white kidney types.
- Cranberry beans are susceptible to darkening of seed coat following maturity, lowering their value, so prompt harvest is important.
- Larger seeded coloured beans tend to absorb more moisture after a rain, requiring more time to dry down.
- Adzuki beans are strongly upright, quite resistant to weathering and their hard seed coat resists absorption of moisture after maturity.

Each bean type has unique quality standards that buyers look for. It is important to know these prior to harvest. White beans must be clean and free of dirt tag (smearing) and staining. Seed size and colour are important in cranberry and adzuki beans, while a low level of cracked seed coats in kidney beans is an important quality factor.

Dockage and Pick

Dockage is anything foreign that is removed from the beans through a screening process. Some items can only be partly removed through screening, such as weed seed, corn, soybeans or other crop types. Severe bean staining from weeds or green material can cause a load to be refused, and quality will be reduced if there is dirt on the beans. Other items that can cause a load to be rejected include metal and glass. It is critical that bean deliveries are free of soybeans, corn or other bean classes. Soybeans or corn in a sample can result in the rejection of a load because it will be assumed they are genetically modified, which is not tolerated by some importing countries. Allergens such as wheat and soybean can also be a concern, and processing may not be able to remove all contaminants. Before harvesting, clean the combine of any residual seed from previously harvested crops.

Pick refers to the percentage by weight of defective beans, including cracked seed coats and discoloured and misshapen beans that remain after dockage is removed. The dollar charge for pick is double; equal to the weight loss from picked beans plus the cost of removal.

There are two common methods of harvesting dry edible beans: pulling followed by windrowing and direct-combining.

Pulling, Windrowing, Combining

Larger-seeded beans and beans planted in wide rows are usually pulled and placed in windrows at harvest. Pulling refers to cutting the plants 3-5 cm (1.2-2.0 in.) below the soil surface and merging several of the planted rows into a single swath or windrow. Beans are pulled when 90% of pods have matured and turned "buckskin brown." To prevent pod drop and shattering losses, pull beans early in the morning when the plants are tough and damp with dew. Beans are harvested later the same day with an edible bean or conventional combine equipped with a windrow pick-up attachment. Since prolonged exposure of the mature crop to moisture will result in reduced quality, harvest the crop as soon as possible after pulling. This specialized harvesting is required to meet quality standards set by the market for larger-seeded bean types. Under good conditions, seed losses of 3%–5% are normal during harvest (e.g., 1% loss pulling and windrowing, 1% at combine pick-up, and 1%–2% cleaning and threshing).

Direct Combining

Bean types most suited to direct harvest include white beans with upright plant type, adzuki beans, black beans and pinto beans. Some larger-seeded types can be successfully direct harvested when grown in narrow row widths and harvested at appropriate seed moisture to reduce seed damage.

Combine enhancements help reduce harvest losses and minimize dirt, splits and damage to the beans. The cleaning and threshing characteristics of the crop will change throughout the day as moisture content changes, meaning that adjustments to the combine should be conducted throughout the day.

Combine set-up considerations are:

- Keep knives sharp to minimize shatter losses.
- Run cylinders only fast enough to thresh the crop. Run as much plant material as possible through the cylinder to minimize seed damage. Cylinder speeds on many combines do not go below 250 rpm, which can be too fast for easily threshed beans. Cylinder slow-down kits, which include a smaller diameter drive pulley and a belt, are available.
- Run unloading augers slow and full to minimize seed damage. The short vertical auger on the combine (turret auger), which takes seed from the bottom of the tank to the main unloading auger, is a point of high potential seed damage. Some bean producers have changed unloading augers to conveyer belt systems.
- Set combine ground speed to about two-thirds the speed used for harvesting soybeans.
- Use vine crop lifters which raise low hanging pods before the plant is cut. This can be one of the greatest benefits when harvesting varieties without a strong upright plant type. Direct harvesting at an angle to the row distributes the flow of bean plants across the knife.
- Adjust the flexible floating cutter bar to clip the bean plants as close to the ground as possible. This will help minimize the cutting of low-hanging pods and associated seed loss. The knife must cut cleanly and quickly to avoid shaking the plants, splitting pods and shattering beans. Most losses that occur are shatter loss. Ontario studies have shown that a flexible floating cutter bar can reduce losses by 25% compared to a conventional floating header. In addition, a "quick-cut" sickle bar can reduce loss by up to 40% compared to a standard sickle bar.
- Use an air reel to significantly improve intake of plants into the combine and reduce losses at the knife. The air blast keeps weeds and bean plants off the knife, offering better cutter bar visibility without shoving stones into the header. The biggest benefit of the air reel is demonstrated under difficult harvest conditions, when the crop is lodged or the volume of crop is reduced. Under good conditions, harvest losses may be as low as 3%, regardless of whether an air reel is used. As pods dry late in the day, header losses can reach more than 20% with a standard pick-up reel, while losses with an air reel are only 10%.
- Follow a modified harvest pattern to improve yield and quality. Travelling against the direction of lodging allows the harvest of leaning branches and low-hanging pods and can reduce stubble losses. In an unevenly maturing field, delay harvest in the affected areas until they are mature.

Quality Preservation at Harvest

Occasionally, the crop may be ready to harvest but the field, or part of the field, may still be green or weedy. Harvesting when green stems or green weeds are present may result in stained beans. Similarly, weeds with purple berries, such as Eastern black nightshade and American pokeweed, can cause severe staining. Also, secondary growth of beans can occur as plants begin to mature, particularly when rainfall follows an extended dry period. Where direct harvest is intended, apply a desiccant to dry the remaining green tissue. Harvest aid products are available to burn down weeds and desiccate the crop. For more information see OMAFRA Publication 75, *Guide to Weed Control.* There may be different application timings for different products, so refer to and follow all product labels. There may also be restrictions on use of certain products for dry edible beans exported to specific markets. Check with the bean dealer on restrictions.

If on-farm storage is necessary, store individual varieties of dry edible beans in separate bins that are free from other grains and oilseeds. Keep harvested beans free of stones, glass and other seed-size contaminants. Failure to maintain the purity of the crop can result in lost value.

Other Crop Problems

Insects and Diseases

Figure 5–1, *Dry edible bean scouting calendar* shows insects, pests and diseases that could be causing injury symptoms in the field. Individual descriptions of insects, pests and diseases, as well as scouting and management strategies can be found in Chapter 15, *Insects and Pests of Field Crops* and Chapter 16, *Diseases of Field Crops.* Recommended treatments to control insects, pests and diseases can be found in OMAFRA Publication 812, *Field Crop Protection Guide.*

Frost and Hail Damage

Both frost and hail can be devastating to a bean crop. The extent of early-season frost damage will depend upon where the plants were damaged. If the plant is damaged below the cotyledons, it will not recover. If the growing point is damaged, but the lower stem remains intact, the plant will send out new shoots from the base of the leaves or cotyledons. Wait a few days before replanting to see if these shoots appear.

Dry edible beans have a much more limited ability to recover from hail than soybeans. Determinate plant varieties are less likely to recover than Type II indeterminate types. When evaluating hail damage, check for bruising on the plant stem. Stems damaged during the vegetative stage may not be able to support the weight of pods. In addition, wounds from hail damage serve as entry point for bacterial blight pathogens to infect plants. When the pods are damaged by hail, the seeds or entire pods will often rot.

If frost occurs close to maturity, pods that are yellow to brown in colour are often sufficiently mature to escape damage. Green beans will shrivel, retain their off-green colour and result in increased "pick." Delaying harvest until the beans dry down sufficiently will help prevent staining and improve separation.

Bald Heads

Bald heads refer to seedlings that emerge with damaged or no growing point. Cotyledons (seed leaves) may or may not be present as seen in Photo 5–2. Plants may develop auxiliary buds at the base of cotyledons but they fail to develop. Without a growing point, plants eventually die. The most common cause of bald heads is mechanical damage to seed or harsh handling. Damage is characterized by cracks in the seed coat. This injury should not be confused with symptoms of seed corn maggots, which will leave the seedlings ragged in appearance. Poor quality seed can also cause seedlings to have broken or cracked cotyledons. Seed with moisture content below 16% is more prone to mechanical damage. Use only high-quality certified seed for planting. Treat seed with a fungicide at planting to protect against seedling disease and handle gently to minimize mechanical damage.

Photo 5–2. Baldheaded beans lack seed leaves.

Soil Compaction and Soil Structure

Dry edible beans are one of the crops most sensitive to compaction, tillage hard pans or poor soil structure. Often plants become stunted, as seen in Photo 5–3, because diminished root growth cannot sustain top growth. Restricted or stressed root systems often develop root rot disease. Options to alleviate compaction or improve soil structure during the growing season are limited to inter-row cultivation. This can loosen and aerate the soil, and throw loose dirt around the base of the plant to encourage new roots to develop. Foliar fertilization is effective for correcting micronutrient deficiencies, but plants cannot absorb sufficient nitrogen, phosphorous or potassium through foliar application.

Photo 5–3. Soil compaction in white beans results in shallow root systems as seen in the plant on the bottom.

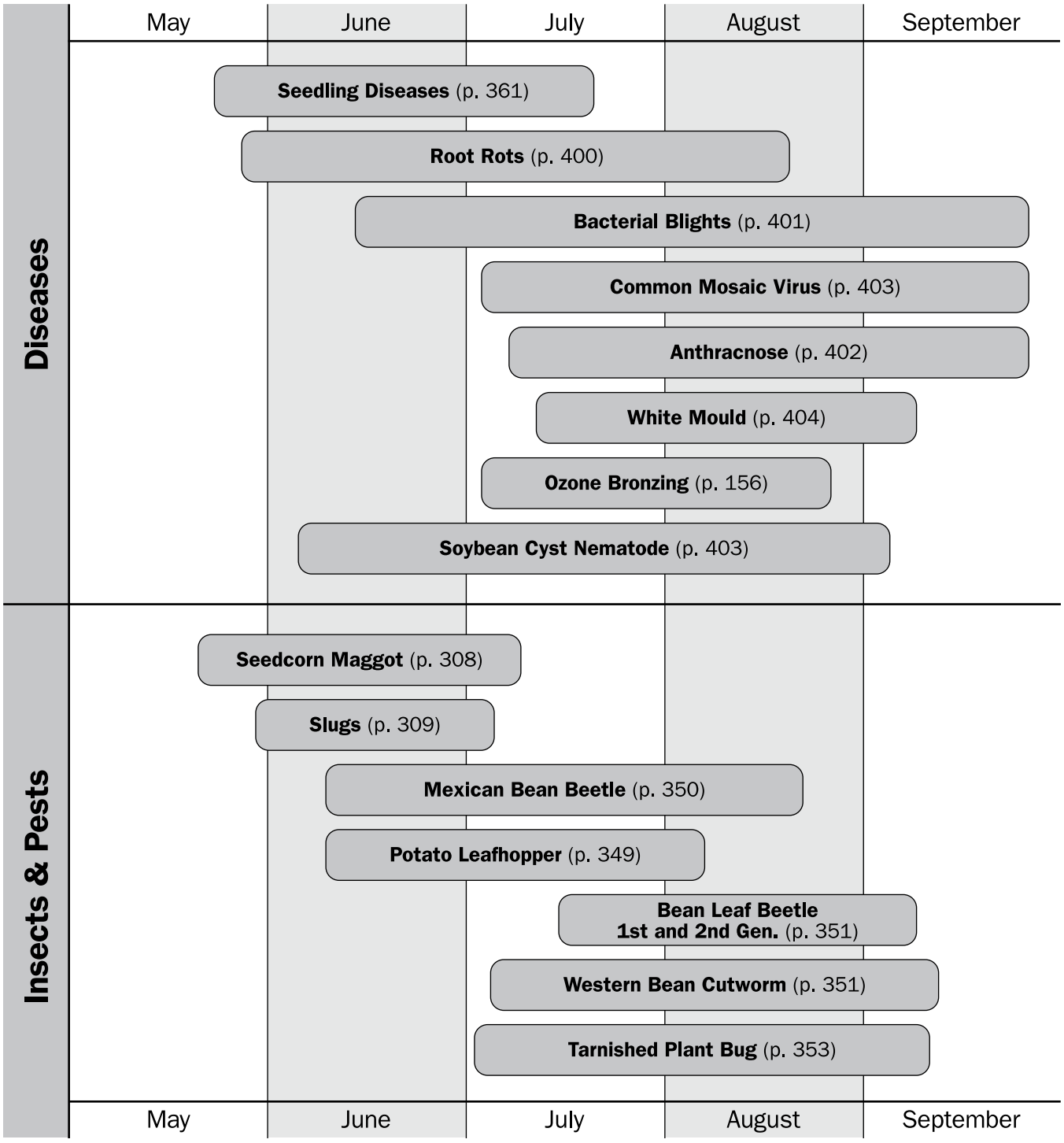

Figure 5–1. Dry edible bean scouting calendar.

Sunscald and Bronzing

Sunscald is caused by intense concentration of the sun's heat on plant tissue (Photo 5–4). Sunscald can occur on leaves, stems or pods and most often affects new succulent leaf tissue. Affected leaves can exhibit brown scorched leaf tissue or white discolouration of upper exposed leaves. Leaf tissue becomes necrotic and crumbles easily, resulting in a ragged leaf appearance. Injury often occurs when bright sunny days follow cloudy, warm and humid conditions. Sunscald is not considered to affect yields.

Photo 5–4. High temperatures can burn top leaves causing wilting or brown necrosis similar to frost injury.

Photo 5–5. Bronzing damage affects the upper leaves of dry bean plants and is caused by ozone.

Bronzing is caused by exposure to ozone (O_3). Ozone is caused by air pollution and lightning produced during storms. Conditions of intense sunlight or high temperature favour ozone damage. Under dry conditions plants are more tolerant to ozone, therefore symptoms may be more severe under moist conditions. The amount of damage found on the plant, or in an area, often corresponds to air pollution alerts or heavy thunderstorms. Damage appears as reddish-brown flecking or "bronzing" on the upper surface of leaves (Photo 5–5). Pods may also be affected, but damage is usually superficial and seeds are typically not affected. Bean cultivars vary in their susceptibility to ozone. Black beans appear to be particularly susceptible.