9/Dry Bean

Dry Bean QuickTips

Seeding Rate	Target 3 plants/ft^2 (33 plants/m^2) under irrigation, 4 plants/ ft^2 (44/m^2) dryland.
Seeding Depth	2.5 inches (6 cm).
Seeding Date	4th week in May (soil temperature 12˚C at 2 inches). Bean is extremely susceptible to frost after emergence.
Recommended Varieties	Direct harvest or swathing – CDC Nordic, CDC Nighthawk, CDC Expresso, AC Skipper, CDC Pintium, CDC Camino, CDC Bianca, UI906 Undercutting – Othello, Fargo, CDC Bianca, US 1140, CDC Pinnacle
Best Performance	Dryland – summerfallow on Moist Dark Brown and Black soil zones. Avoid heavy clay soils. Irrigated – long growing season.
Rolling	Within 3 days of seeding.
Registered Herbicides & Registered Fungicides	Refer to Table 5.6 (Weed Control) or the Saskatchewan Agriculture and Food Guide to Crop Protection.
Rotational Frequency of Dry Bean Production For Disease Control	5 years for sclerotinia, 2 years for bacterial blight.
Undercutting or Swathing	50 to 70% buckskin.
Direct Harvesting	75% pods hard and dry and the rest at buckskin.
Storage Moisture	15%

9/Dry Bean Production

Dry Bean Production Contents

continued...

Dry Bean

Table 9.1 *Market classes of dry bean.*

Class	Seed colour	g / 1000 seeds	Main Canadian production	Main consumption
Pea = navy = white	White	170 – 210	Ontario, Manitoba	United Kingdom, North America
Kidney	Light red, dark red, white	550 – 630	Ontario, Manitoba	North America, Europe, South Asia
Black	Black	170 – 210	Alberta, Manitoba, Ontario	South America, Mexico, Caribbean
Cranberry = romano	Pink-red on buff	500 – 570	Manitoba, Ontario	North America, Europe
Pinto	Brown on cream	330 – 370	Alberta, Manitoba	USA, Mexico
Red	Red	320 – 350	Alberta	North and Central America
Pink	Pink	330 – 360	Alberta	North America
Yellow eye	White with yellow eye	400 – 500	Eastern Canada, Ontario	Eastern North America
Great northern	White	340 – 380	Alberta	Mediterranean, Middle East

Source *Ag Canada 1985; Dr. Bert Vandenberg, Personal communication.*

Introduction

Common bean, called dry bean in western North America and field bean in eastern North America, is an ancient crop native to South and Central America. Today, dry bean production and trade volumes exceed that of any other pulse crop. It is grown in subtropical or temperate areas throughout the world, and during the cool, dry season in tropical areas. Major production areas are the Americas, east Africa, east Asia, and west and southeast Europe. Brazil is the leading producer of dry beans, followed by Mexico. In North America, approximately 2.5 million acres (1 million ha) of dry beans are grown annually. North Americans consume more of them per capita than any other pulse.

By 1997 Canada produced approximately 1% of the dry bean in the world, but had become the world's fifth largest exporter of dry bean. Export markets account for approximately 80% of our total production. The majority of Canadian dry bean exports are in the unprocessed form.

Dry bean is used almost exclusively as food. Only a minimal amount of weather-damaged low-grade bean seeds are used in livestock feed. The seeds have a protein content of 22 to 24%. Like all pulses, bean seeds are high in some amino acids and low in others, but are an excellent source of balanced protein when served along with cereal products. Bean seeds are also high in dietary fibre and complex carbohydrates. They are low in sodium and gluten-free, making them suitable for low salt and gluten-free diets. The straw that remains after harvest is a valuable source of organic nitrogen.

Dry bean has been grown in Canada since the mid-1800s, with most production historically in Ontario. Production has been shifting west and in 1998 Manitoba became the largest dry bean producing province. Saskatchewan was a dry bean producer in the 1920s and 1930s, but since the 1970s, most of the bean on the Prairies is grown under irrigation in Alberta and on dryland in southern Manitoba. Dry bean has made a comeback in Saskatchewan since the mid-1980s with the help of the Saskatchewan Irrigation Diversification Centre, and currently, approximately 8000 acres (3238 ha) of dry bean are grown under irrigation. Most dry bean in Saskatchewan is in the pinto class, but it is possible to grow other market classes as well (Table 9.1). Production on dryland in Saskatchewan has increased slowly, but a growing number of pulse

Figure 9.1.1 *AC Skipper Navy Bean*

Source *Saskatchewan Pulse Growers, 2000*

Figure 9.1.2 *CDC Camino Pinto Bean*

Figure 9.1.3 *CDC Crocus Great Northern Bean*

growers are experimenting with the crop, mostly with pinto, great northern and black bean.

The average yield of pinto bean is 1500 lb/ac (1682 kg/ha) under irrigation. Dryland yield levels are not yet established, but at least 1000 lb/ac (1121 kg/ha) should be possible in suitable production areas.

The Dry Bean Plant

Dry bean belongs to the group that includes vegetable, snap, or green bean. The word dry refers to the dry edible seeds that are the commercial end product. Several classes of dry bean include: pinto; great northern; navy, pea or white; small white; small red; pink; kidney; black; cranberry; white marrow; flat small white; and yellow eye (Figures 9.1.1 - 9.1.6). Lima and scarlet runner beans are different species. Adzuki and mung beans are only distantly related. The most common bean class in North America is the pinto bean which accounts for 40% of annual production in the USA and 65% of annual production in Alberta. Some 70% of the pinto bean seeds produced in North America are consumed domestically.

Unlike lentil, pea, and chickpea, the dry bean seeds do not remain below ground during germination. Instead, the cotyledons push up through the soil and are exposed. This type of germination makes the seedling more vulnerable to damage.

- **If the seed is buried too deep, the plant may die if the seed separates from the shoot before it emerges.**
- **If frost, cutworms, or mechanical damage destroy the seedling shoot, the growing point is lost and the plant will die (Figure 9.2).**

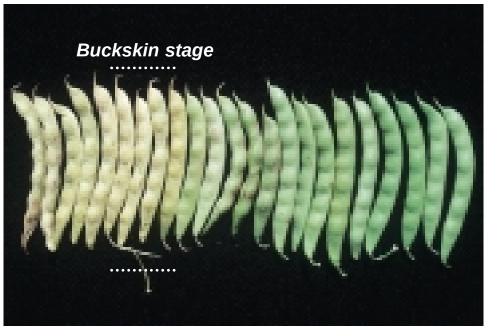
Figure 9.2 *Emerging bean seedlings.*

Source *Pulse Production Manual 1997, 6-2*

The first pair of true leaves are single leaves opposite each other on the stem (unifoliolate). Subsequent leaves have 3 leaflets (trifoliolate) and are arranged on alternate sides of the stem. On average, a new leaf is produced every 4 to 6 days. The growing point of the plant is located in the leaf axil of the newest emerging leaf. Varieties with determinate growth habits (bush types) generally have 5 to 9 nodes on the main stem, and 2 to several branches. Varieties with an indeterminate growth habit (vine types) may have 12 to 15 nodes on the main stem. Vines are usually produced just before flowering is about to begin.

Flowers are carried on short (vine types) or long (bush type) flower stems in clusters emerging from the upper leaf axils. Flowers range in colour from white to purple, and typically self-pollinate before they open. Flowering lasts about 2 weeks and each flower can produce a single pod. Under heat and moisture stress, many of the pods abort, but under ideal conditions, pods produce up to 8 seeds. Pods grow longer as they develop and this elongation can carry the pod tips to ground level or below, which contributes to high harvest losses. Development of varieties with pods higher off the ground is a major goal of bean breeding for Saskatchewan.

Figure 9.3 *Buckskin stage of bean pod maturity.*



Source *Pulse Production Manual 1997, 6-3*

• When the seeds have filled, the pods are fleshy and brittle, but as the seeds begin to mature, the pods change colour (usually yellow) and become soft-textured. This stage is referred to as the "buckskin" stage.

At maturity, the pods turn tan coloured and dry and harden (Figure 9.3).

Adaptation

Dry bean is a warm-season plant and is very sensitive to frost.

• Since the seeds emerge from the ground at germination, even a short exposure to frost will kill the plant.

• Frost late in the season will also kill plants and cause quality losses in any seed containing more than about 30% moisture.

Due to its extreme sensitivity to frost, a major limitation to bean production is the length of the frost-free season. Most varieties require 90 to 120 days to mature.

Seed germination is best at soil temperatures above 12˚C at planting depth. Prolonged cool weather in the spring results in weak and disease-prone plants, as growth slows at temperatures below 15˚C. If temperatures drop below 8˚C, or rise above 35˚C during flowering, flowers and pods are likely to abort. Cool weather in the fall tends to delay maturity. The optimal daytime temperature for dry bean is approximately 24˚C.

Dry bean plants respond to good moisture throughout the growth period. Moisture stress during flowering and early pod-fill can reduce yields. The plants cannot tolerate flooding. Even 24 hours in standing water severely reduces plant growth. If drainage is poor, or soil is compacted, bean roots suffer from oxygen deficiency.

Soils with even slight salinity should be avoided. If soil pH is higher than 7.5, bean plants are susceptible to micronutrient deficiency. Heavy clay soils have poor internal drainage, remain cool in the spring and are more prone to waterlogging. Heavy clay soils should be avoided for bean production.

• Dry beans are best adapted to dryland production on summerfallow in the moist Dark Brown soil zone and to irrigated production in areas with a relatively long growing season.

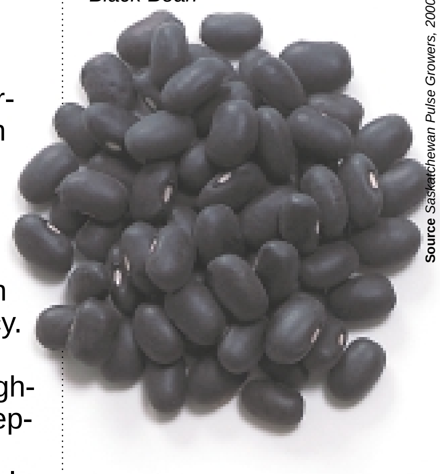
• Early varieties can be grown in the thin Black soil zone.

Maturity becomes an issue in the northern areas of the Black soil zone. Dryland production in the Dark Brown zone usually results in reduced yield, but offers the advantage that it should be possible to grow disease-free seed in our relatively dry climate. Such seed sells at a premium because bacterial blight is a common and potentially devastating disease in other areas of production. Saskatchewan growers are advised to obtain certified seed that is disease-free.

Equipment and Modifications

Most existing farm equipment can be used or modified to successfully produce dry bean. Seeders should be checked and calibrated to ensure seed can be successfully

Figure 9.1.4 *CDC Nighthawk Black Bean*



Source *Saskatchewan Pulse Growers, 2000*

Figure 9.1.5 *CDC Rosalee Pink Bean*

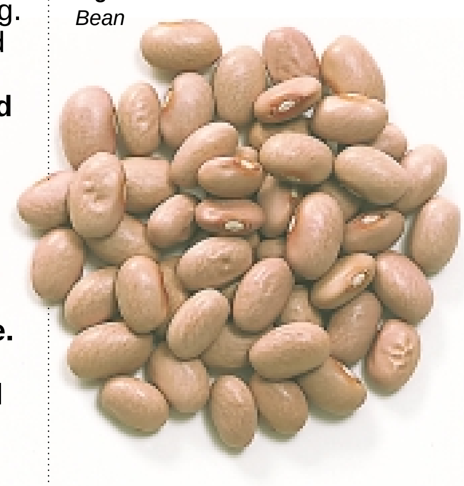
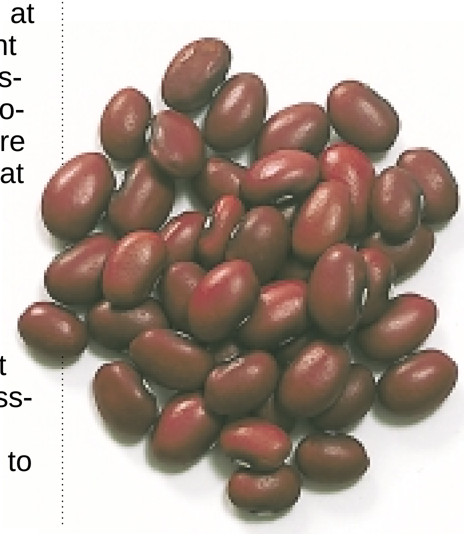


Figure 9.1.6 *US Coop Red Bean*



distributed without damage. A condition in dry bean termed baldhead results from mechanical damage during handling. Using seed with moisture content above 14%, and reduced fan speeds, can minimize damage from distributor manifolds on airseeders.

Field Selection and History

As with all pulses, field history is important for dry bean production. Dry bean plants are sensitive to residues of herbicides such as Accord, Ally, Amber, Assert, Attain, Curtail, Lontrel, Muster, Poast FlaxMax, Prestige and Unity. Cropping restrictions apply with the usage of Poast Ultra. Short Term residual herbicides, such as Banvel and 2,4-D/MCPA can, under certain conditions, have a deleterious effect on dry bean growth. Refer to the Saskatchewan Agriculture and Food "Guide to Crop Protection" regarding residual herbicide carryover.

- **Always follow label recommendations and check product labels carefully.**

If active residual herbicide could be present in the field, a test plot should be sown the year before dry bean is planted. The plot should be grown to maturity to ensure the absence of late season herbicide effects on yield or crop quality.

- **Dry bean plants are very poor competitors with weeds.**

Steps should be taken to minimize weed problems before the crop is planted (see Chapter 5./Weed Control). Fields with large populations of perennial weeds should be avoided.

Sclerotinia in dry bean fields can be serious. To reduce the incidence of sclerotinia in areas where the disease is well established, dry bean should not be grown in rotation after dry bean, lentil, pea, faba bean, sunflower, mustard, or canola. The risk of sclerotinia decreases, if these susceptible crops are separated by 3 to 5 years.

An ideal bean field has soil that warms up quickly, is not a frost risk, and has 2 feet (60 cm) of moisture reserves (this is more commonly available in summerfallow fields or under irrigation). The field should also be free of salinity, perennial weeds, stones and low lying areas prone to frost. While dry bean can be successfully grown on heavy clay soils, they are not the most desirable soil for dry bean production in Saskatchewan. Clay soils are slow to warm, delaying germination and enhancing potential seed rot infection, and are prone to compaction and crusting. Surface crusting can result in uneven emergence, growth and development. Seedlings will die if cotyledons are lost attempting to push through crusted soil. Indeterminate growth habit, vine-type field bean varieties grown on heavy clay soils often experience delayed maturity and consequent poor pod filling. Determinate types may become stunted when grown on heavy clay soils. If soil crusting occurs after planting, the field can be lightly harrowed to break up the surface. Poorly drained soils, prone to waterlogging, can result in drowned plants or stunting, delayed maturity and low yield of poor quality seed. Field bean is well suited to light-to medium-textured soils under irrigation and medium-textured soils under dryland production in areas that receive adequate moisture in late July and August.

Varieties

For a list of varieties currently recommended for production in Saskatchewan refer to Chapter 3./Variety Selection, Dry Bean.

Dry bean production in western Canada is still almost entirely dependent on varieties bred in the USA or eastern Canada. Plant breeding objectives at the Crop Development Centre include the development of early maturing, high yield, and acceptable seed quality varieties with better canopy structure for direct harvesting. The development of new varieties is an essential component in the improvement of dry bean production in Saskatchewan (Figure 9.4).

Comparative data for many varieties are limited because regional testing is only just beginning. As both temperature and day length may influence the rate of dry bean development, variety performance is very erratic from location to location. Producers are encouraged to check with their local Saskatchewan Agriculture and Food office for regional trial results, when choosing a variety for their area.

Varieties have distinct growth habits.

• Type I varieties have a determinate upright bush growth habit.

• Type II varieties have an upright and indeterminate growth habit.

• Type III varieties are indeterminate but have a spreading canopy which may cause problems with low hanging pods at maturity.

Many available pinto bean varieties (especially Othello) develop canopies with low-hanging pods. With swathing or direct harvest systems, this results in high harvest losses. Tall determinate varieties of several market classes will become available beginning in 2000. Early maturity is an absolute requirement in Saskatchewan, except in the very warmest parts of the province.

Crop Management

Seeding Considerations

Seed selection is extremely important to crop quality. It may be necessary to order early to get quality seed. Only very early varieties mature reliably under our growing conditions. Seed imported from Idaho, Washington or other desert climates is less likely to carry bacterial blight. This disease is seed-borne, can destroy the crop, and should be avoided by purchasing certified blight-free seed.

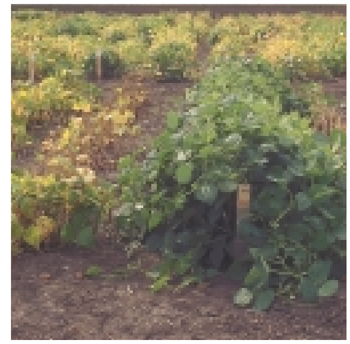
• Use the earliest maturing varieties available to minimize the risk of damage from fall frost.

• Obtain high quality seed with acceptable germination early; suitable variety availability is often limited.

Seed from Idaho is often below 12% moisture, and such seed is very susceptible to handling injury. Handling injury increases as the seed moisture decreases, and the damage is worse in cold weather. Damaged seeds may not germinate, produce less vigourous seedlings, and are more susceptible to seed rot and seedling diseases.

• Seed is less sensitive to handling damage, if the moisture content is increased to the 14 to 16% moisture range. Several methods of adding moisture are available.

If seed is obtained several weeks in advance of seeding, it can be stored in a warm and humid area. Alternatively, water can be added directly to seed bags at least a week before seeding. For this treatment, the bags and the water should be kept at room temperature, and the bags should be rotated regularly to distribute the moisture evenly. For most rapid hydration, wet sawdust can be added to the seed a few days before planting. Alternatively, water can be added to



Source *Bert Vandenberg*

Figure 9.4 *Dry bean breeding plots at the Crop Development Centre.*

bulk seed in a truck box and the excess water allowed to drain off. Repeat after 8 hours and plant with an air seeder after 24 hours.

Inoculation

Dry bean seeds require inoculation with the correct inoculant in order for the plants to fix nitrogen. To be effective, inoculant should be used prior to the expiry date and applied with a sticker. The inoculated seed should be protected from sunlight, and should be planted immediately (see Chapter 4./Plant Nutrition, Inoculation).

Dry bean has the lowest nitrogen-fixing ability of any annual pulse crop grown in Saskatchewan.

• Dry bean rarely fixes more than 50%, and typically only 25 – 30%, of its nitrogen requirement.

Part of the reason is possibly due to the germination growth habit of dry bean. Upon germination the cotyledons are pushed upward, carrying the seed coat and depositing it at the soil surface. Therefore, the seed coat and, consequently, any rhizobia attached to it are positioned above the rooting system, resulting in less than desirable inoculation. Granular formulations of dry bean inoculants may be a preferred inoculant, as the rhizobia bacteria remain in position near the developing root system.

It is also possible that dry bean varieties develop a unique Rhizobium specificity. If this is true, one dry bean variety may respond well to a specific inoculant product whereas use of the same inoculant may prove disappointing when applied to a different variety.

A further consideration is that dry bean is simply a poor nitrogen fixer, and we cannot do much about it. Research conducted in 1998-1999 showed that some varieties fix nitrogen better than others.

On-going research is being conducted by the University of Saskatchewan to evaluate the response of dry bean varieties to inoculation.

• At present, it is recommended that producers augment inoculant treatment with supplemental nitrogen fertilization or add 50 lb/ac (56 kg/ha) of nitrogen fertilizer prior to planting.

Seed treatment to control wireworms and seed and seedling diseases may be beneficial.

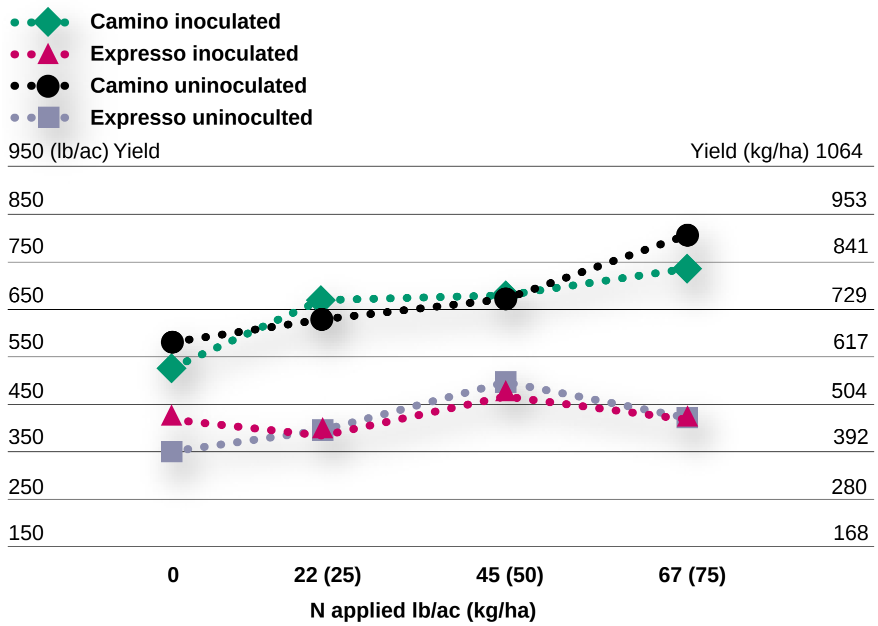
• Treat seed with a recommended fungicide/insecticide combination.

Fungicidal seed treatments, especially Captan, can be toxic to the Rhizobium. Apron FL is effective for controlling seed rot. If a fungicidal seed treatment is used, it is especially important to seed immediately after inoculation. Any delay will increase contact between the fungicide and inoculant which can harm the Rhizobium. If fungicidal seed treatments are used, it is recommended to increase the amount of inoculant applied. A list of registered seed treatment products in Saskatchewan is shown in Appendix Table 9.2.

Fertilization

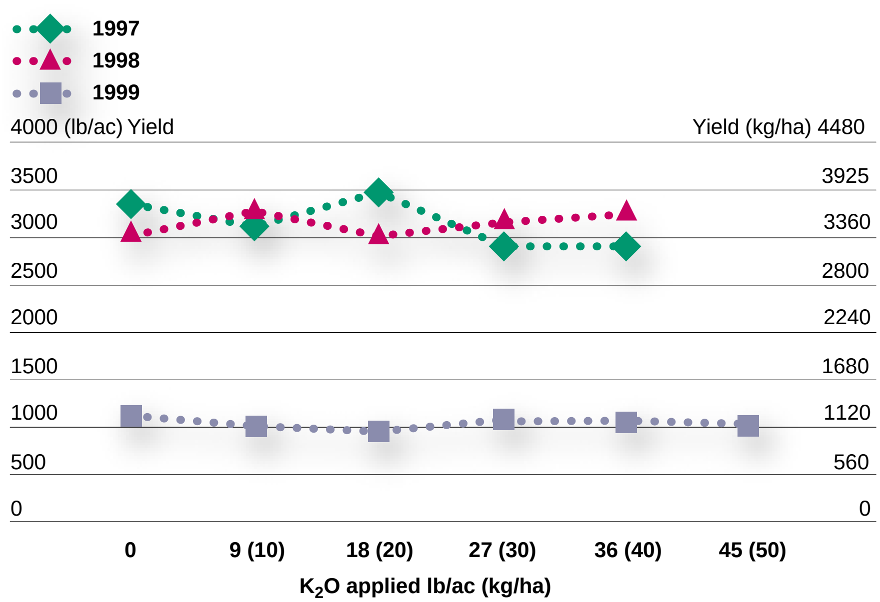
The probability of fully effective inoculation and high rates of nitrogen fixation is rather low. Accordingly, many growers apply nitrogen to reduce the risk of inoculation failure. Soil tests are recommended to determine whether other nutrients are at appropriate levels. Preliminary research was conducted by the Department of Plant Sciences at the University of Saskatchewan on nitrogen fertilization. Results from two sites in 1999 indicate that inoculation of either variety had little effect on plant yield (Figure 9.5). Additions of fertilizer nitrogen increased

Figure 9.5 *Effect of nitrogen fertilization on dry bean yield.*



Source *S. Shirtliffe, U of S, 1999 unpublished data, preliminary findings. Average of two sites*

Figure 9.6 *Effect of potassium fertilizer additions on dry bean yield.*



Source *Hogg, T. 1999, unpublished data, Agri-Food Innovation Fund, Specialized Crops, SIDC Spoke site*

yield in both varieties at both locations. These results support Manitoba research where in 15 separate field trials inoculation produced increased yields in only 2 cases, whereas the application of fertilizer nitrogen resulted in positive yield responses in 12. Excess nitrogen can delay bean maturity, make plants more susceptible to disease and insects, and may give weeds a competitive advantage.

• On irrigated land, if soil tests indicate nitrogen levels below 50 lb/ac (56 kg/ha), up to 50 lb (56 kg/ha) of nitrogen can be added, but not with the seed.

• In dryland bean production, consider applying nitrogen at 40 lb/ac (45 kg/ha).

Dry bean apparently is very effective in sourcing residual soil phosphorus for plant growth. Research from traditional dry bean areas of the Northern Great Plains has produced mixed responses to phosphorus fertilizer additions. However, phosphorus is extremely important in advancing plant maturity and should not be ignored for dry bean production.

• If phosphorus levels fall below 25 lb/ac (28 kg/ha), an additional 15 - 25 lb/ac (17 - 28 kg/ha) may be added.

• Seed placement of phosphorus or nitrogen in excess of 15 lb/ac (17 kg/ha) may reduce plant stand and yield.

An alternative is to use JumpStart, a fungal inoculant that enhances phosphate uptake by plants. JumpStart contains the naturally occurring fungus Penicillium balaji. Use may increase the availability of fertilizer and soil phosphorus to the crop during the growing season. It can be seed placed either alone or along with phosphate, up to the maximum allowable amount, in order to arrive at an adequate phosphorus level, JumpStart can make available the equivalent of 10 lb/ac (11 kg/ha) P_2O_5. Refer to manufacturer's label for compatibility with seed treatments.

Potassium fertilization is probably not required in areas of dry bean adaptability. In trials conducted over a three-year period by the Saskatchewan Irrigation Diversification Centre, irrigation failed to demonstrate any benefit from potassium fertilization (Figure 9.6).

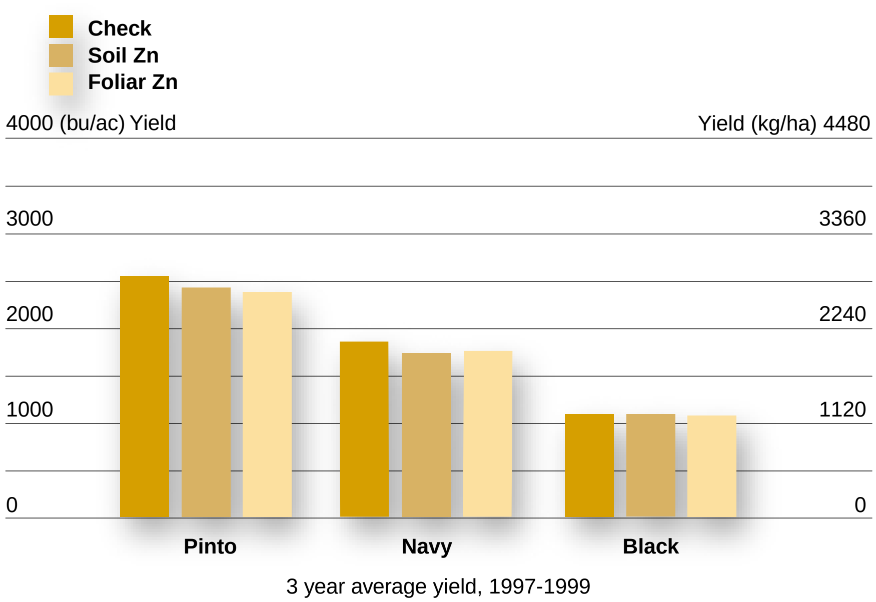
Source *Pulse Production Manual 1997, 6-6*

Figure 9.7 *Bean plot with zinc deficiency.*

Source *Pulse Production Manual 1997, 6-6*

Figure 9.8 *Bean plant with zinc deficiency*

Figure 9.9 *Effect of zinc fertilizer application on dry bean yield.*



Dry bean is the pulse crop most sensitive to zinc deficiency (Figures 9.7 and 9.8). While all bean classes require adequate zinc levels, navy bean is more susceptible to zinc deficiency than the coloured beans. Excess phosphorus may make zinc less available to the plant. Zinc deficiency is more likely, if soil pH is higher than 7.0 and if early season weather is cool and wet.

Zinc deficiencies are expected to occur first in the irrigated, sandy soil production areas surrounding Lake Diefenbaker. However, research by the Saskatchewan Irrigation Diversification Centre at Outlook over a three-year period did not show any response to zinc fertilization (Figure 9.9).

Zinc deficiency symptoms are unlikely to occur throughout an entire field; actual deficiencies are generally confined to isolated portions within the field. Zinc deficiency symptoms include chlorosis of inter-veinal areas of the leaf; leaf veins remain green. Tissue sampling can assist in confirming zinc deficiency problems; producers should sample plants from both affected and unaffected areas for comparison. Both soil and tissue sampling should be utilized to confirm a possible zinc deficiency. Iron and manganese deficiencies exhibit similar chlorotic symptoms and can be mistaken for a zinc deficiency. Zinc can be applied to the soil as a granule or can be sprayed on the leaves. Zinc sulphate and zinc chelates are the most commonly applied sources of zinc fertilizer.

Time of Seeding

Bean plants are sensitive to spring frost at planting time, and seeds germinate slowly when soil temperature is below 10˚C. This increases the risk from early seeding. Ideally, beans should be planted when soil temperatures reach 12˚C at 2 inches (5 cm) depth. Using a soil thermometer, measure the soil temperature at the depth of seeding in the morning and in the afternoon. Average the two measurements to obtain the soil temperature. Only the earliest varieties will mature in our growing season. Delayed seeding increases the risk of delayed maturity and frost damage in the fall.

- **In most years, the ideal time for seeding is the 4th week of May.**
- **Seed should be placed in moist soil at a depth of 2.5 inches (6 cm).**
- **White-seeded beans are most susceptible to cold soil injury.**

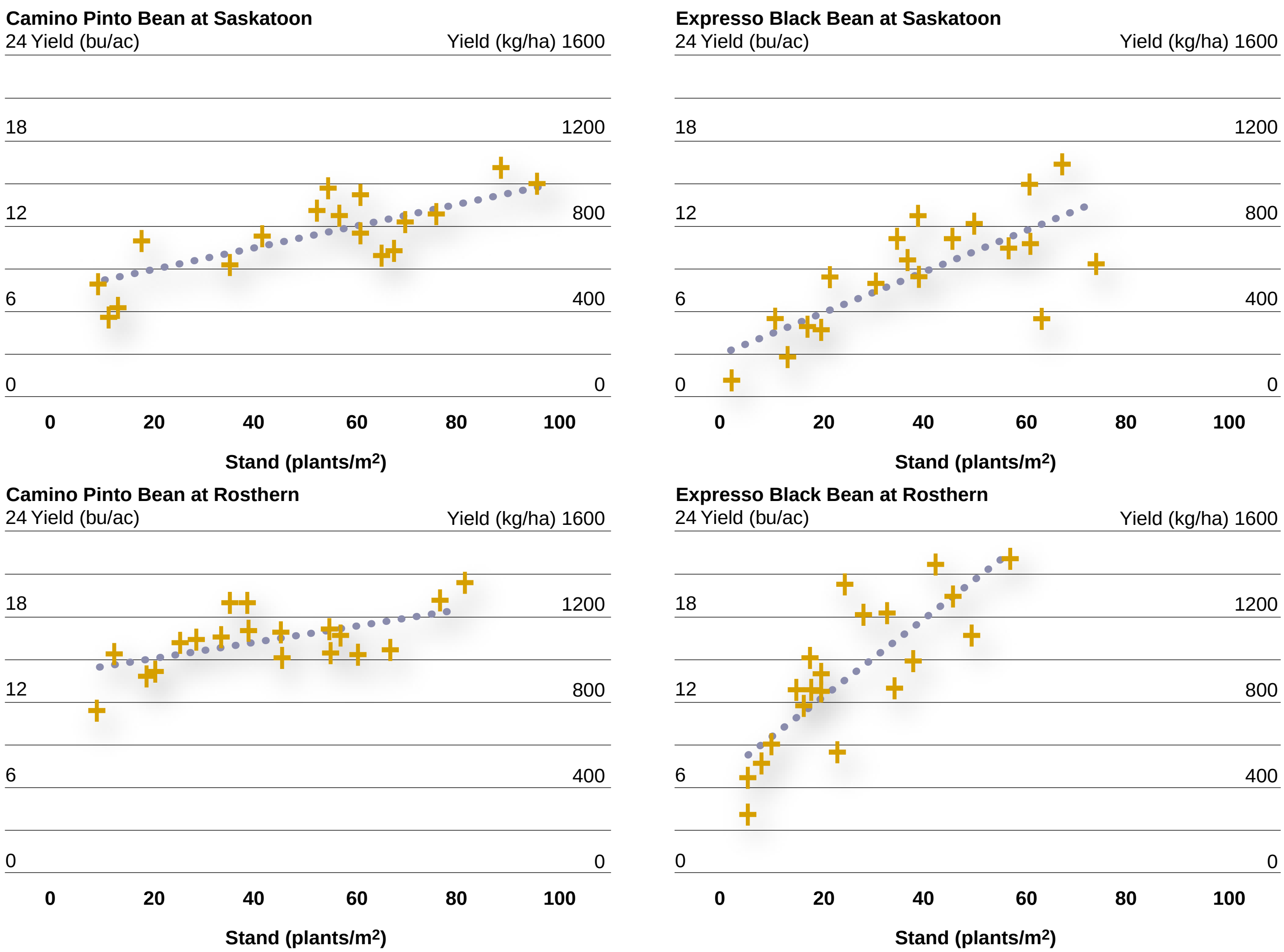
Bean seeds are large, and take up their own volume in water as they germinate. A moist seedbed is required for rapid germination. Seeding closer to the soil surface may allow the seed to dry out before it absorbs enough water to germinate. Shallow seeding also increases the risk of lodging. Seeding too deeply increases the chance that the seedling will not be able to emerge intact.

- **Emergence will take 6 to 15 days, depending on soil temperature.**

Seeding Rate

Seeding rates depend on seed size, which varies with variety and from year to year. A target plant density is 3 plants/ft² (33 plants/m²) under irrigation and 4 plants/ft² (45 plants/m²) on dryland. For Othello pinto bean, this requires an average of 65 to 85 lb/ac (73 to 95 kg/ha) of seed under irrigation and 80 to 100 lb/ac (90 to 112 kg/ha) of seed on dryland. Higher seeding rates are associated with solid seeding compared to row cropped bean production. Results of two seeding-rate trials conducted in 1999 are shown in Figure 9.10. Increased seeding rates resulted in increased seed yields in general, but the black bean variety, CDC Expresso, responded to increasing seeding rates to a greater extent than the pinto bean variety, CDC Camino. Pinto bean plants are larger and may close the crop canopy earlier at the same plant stand. For some types, a lower seeding rate is undesirable as it encourages more vegetative growth and delays maturity. Higher seeding rates can increase the severity of some diseases under irrigation. A recent study conducted by the Lethbridge Research Station indicated that narrow rows with higher seeding densities increased yield by 15 - 20%, if white mold was controlled. Tables 9.3 and 9.4 outline the target seeding rates for various seed weights and row spacings.

Figure 9.10 *Effect of stand density on yield of two dry bean varieties.*



Source *S. Shirtcliffe, U of S, 1999 unpublished data, preliminary findings*

Table 9.3 *Planting rate of dry bean of various seed weights and target plant populations.*

Seed weight		Target plant population							
		Plants/m²				Plants/m²			
(g/1000 seed)	(seeds /lb)	25	30	40	45	25	30	40	45
		lb/ac				kg/ha			
220	2000	49	59	78	88	55	66	88	99
240	1850	53	64	86	96	60	72	96	108
260	1700	58	69	92	104	65	78	104	117
280	1600	62	75	100	112	70	84	112	126
300	1500	67	80	106	120	75	90	120	135
320	1400	71	85	114	128	80	96	128	144
340	1300	76	91	122	137	85	102	136	153
360	1250	80	96	128	144	90	108	144	162
380	1175	85	101	136	153	95	114	152	171
400	1100	89	107	142	160	100	120	160	180

Approximate target seeding.

Table 9.4 *Number of seeds per linear foot of drill run for various planting rates and row spacings.*

Target planting rate	Row spacing in inches					
	9	12	18	20	21	24
seeds/m²	Seeds per linear foot of drill run					
25	1.9	2.5	3.8	4.2	4.4	5.0
30	2.3	3.0	4.5	5.0	5.3	6.0
40	3.0	4.0	6.0	6.6	7.0	8.0
45	3.4	4.5	6.8	7.5	7.9	9.0

Approximate seeds per linear foot.

Seeding

Successful dry bean production can be obtained by two different production systems. The first is traditional row cropping commonly used in established production regions, often under irrigation. For vine type varieties (Type III), 22 or 30-inch (56 or 76 cm) rows often produce the highest yields and this spacing reduces the risk of sclerotinia under irrigation. The second system involves production in narrow rows (solid seeding), as is used in cereal production and is more common in the recently developed dry bean production areas on dryland. With this dryland production system, more upright bush varieties (Type I and upright indeterminate Type II) can be used in solid-seeded plantings for traditional swathing or direct combine harvesting.

- **With an upright growth habit, the newer bush-type bean varieties generally have pods higher off the ground, and the cutter bar can be positioned underneath to minimize harvest losses.**

Solid seeding can be used on dryland because sclerotinia is not usually a serious problem in bean fields in the moist Dark Brown soil zone. In areas where canola has been grown frequently, such as in the Black soil zone, sclerotinia will be a definite problem in years when cool, wet weather occurs during flowering and early pod fill. Upright growth habit with pods higher off the ground eliminates the need for undercutting and, therefore, facilitates planting of narrow rows and higher seeding densities. In future, new technology for direct harvesting in combination with upright dry bean varieties will improve the harvestability of the crop by reducing shattering losses before and during harvesting.

• Bean seeds must be handled very carefully to avoid damaging them.

Even hairline cracks in the seed coat can reduce germination. Hoe drills or double disc drills can be used for seeding, providing the seed cup openings are large enough to accommodate the seed. Careful adjustment of the seeder and the use of a seeder with externally fluted seed cups can reduce seed damage. Air seeders can be especially damaging to the seed if they are not adjusted carefully.

• Moisturizing the seed to above 15% moisture and setting airflow rates to the minimum required to prevent plugging can reduce air seeder damage.

• Reduced seed flow rates arrived at by slower ground speeds can also assist in this as they allow for correspondingly lower air speeds.

• Since uniform plant stands are more productive, ensure seeding equipment delivers seed uniformly at an even seeding depth.

Reduced ground speed during seeding reduces the amount of injury to the seeds with all seeding equipment, and helps to assure accurate depth control. In row crop systems, plate planters or vacuum planters may be used for more precise seed placement.

In-Crop Considerations

Rolling

For dryland narrow-row systems, rolling, harrowing, or harrow-packing may be used to level the field. A level field, free of projecting stones or soil ridges, is important for harvesting which must take place right at the soil surface. Field leveling must immediately follow the seeding operation, or be done within 3 days of seeding to avoid breaking the seedlings off as they emerge from the soil.

Weeds

Dry bean plants are short, slow growing (especially in cool springs), and rarely produce a solid canopy. They are also very sensitive to weed competition.

• Weed control is critical, especially if plant stands are thin.

At Morden, 2 wild mustard plants/ft^2 (22/m^2) reduced navy bean yields by 46 to 57%. At Lethbridge, less than 2 hairy nightshade per yard (m) of row resulted in pinto bean losses of 13%, and 90 hairy nightshade per yard of row caused losses of 77%. Nightshade caused pinto bean losses, even if competing for only 3 weeks in the spring. A full 9 weeks of weed-free conditions after dry bean emergence was necessary before yield losses were avoided. This illustrates that a strong weed management strategy must be developed as part of any successful dry bean production plan.

Like chickpea, the availability of in-crop herbicides in dry bean production is limited, particularly for perennial weeds (refer to Chapter 5./Weed Control for further information).

• Dry bean is the pulse crop least capable of competing with weeds.

• Plant dry bean in fields free

Table 9.5 *Typical weed management strategy for dry bean planned for production in year 2.*

Timing	Management strategy
June, year 1	Grow a cereal. Control annual grassy and broadleaf weeds. Scout thoroughly to understand which weeds are present.
August, year 1	If required, apply a pre-harvest herbicide for perennial weed control.
September, year 1	Evaluate the intended bean field. What and how many weeds are present, are chemical or cultural control practices available? Decide whether dry bean should be sown.
October, year 1	Consider applying a pre-emergent herbicide (Edge or trifluralin). Application could also be spring applied; ensure thorough incorporation for best results.
May, year 2	If using conventional tillage, control existing weeds with a tillage operation about May 21. Plant immediately after. If additional weeds emerge before bean plants, consider harrowing.
June, year 2	Scout fields for grassy and broadleaf weeds. Apply Basagran or Pursuit (pinto, pink and red varieties only) for broadleaf weed control. Poast can be applied for grassy and volunteer cereal control, Poast can be tank mixed with Pursuit.
June-August, year 2	If row-cropping conduct inter-row cultivation. Cultivation should be first done at the 2 – 3 leaf stage. Later operations should be conducted with caution to prevent root pruning. Conduct when plants are slightly wilted.
August, year 2	Consider desiccation to improve harvestability, if significant green weeds are present.

Source *Adapted from Entz, P. et al. 1997.*

of perennial weeds such as quackgrass, Canada thistle, perennial sow thistle and dandelion.

• Ensure that annual weeds, that are likely to be present, can be controlled with available herbicide options.

Interrow cultivation is a common practice in row-cropped bean production. The first cultivation is usually done when bean plants are at the 2- to 3-leaf stage. A second cultivation follows, if necessary, 3 weeks later.

• Cultivation should be conducted during warm weather when plants are slightly wilted and flexible.

• Tillage can facilitate disease spread, if conducted while plants are wet from rain or dew.

• Interrow cultivation should be discontinued once the bean plants start flowering.

In solid-seeded systems the elimination of interrow cultivation means that producers must rely on herbicide application for weed control. However, a recent study by the Lethbridge Research Station concluded that total herbicide use did not increase with this type of production system.

Table 9.5 outlines a typical weed management program for field bean production.

Insects

Insect damage has not yet been a problem for dry bean production in Saskatchewan. However, wireworms and seedcorn root maggots are seed predators that cause problems in other areas. Seed is often treated with an insecticide-fungicide combination, such as DLC, that provides control of these insects. Insecticides used alone can reduce seed germination. The fungicide, in combination with the insecticide, reduces the toxic effect on the seed.

Grasshopper damage may be a problem in years of severe grasshopper infestation.

Saskatchewan government forecasts indicate the risk each year. In the moist Dark Brown soil zone, risk is cyclical and rarely severe.

Insecticides registered for use on dry bean in Saskatchewan are indicated in Appendix Table 9.6. Knowledge about application of each insecticide will enhance activity and optimize use. Insecticides should be handled and applied with extreme caution.

Disease

Dry bean plants are susceptible to a number of diseases, the most important are sclerotinia or white mold, and bacterial blight.

Sclerotinia, a major fungal disease of bean, can cause severe crop loss.

• Be prepared to apply a fungicide to control sclerotinia in irrigated bean fields.

The disease is most serious in crops with a dense canopy, in fields with a history of sclerotinia, in cool (10 to 20˚C), moist conditions. Crop losses will be highest when these conditions exist during or after flowering. Under irrigation, the disease is almost always a problem. Bean plants become infected only after flowering has started. The spores of this fungus need dead tissue to start growing and the fallen flower petals provide a ready food source. Symptoms of the disease include lesions on pods, leaves, branches, and stems. Typically lesions first appear at the junction of plant branches and the main stem. The lesions are small, round, and initially green, but soon become larger, water soaked and slimy, and the affected plant parts dry and turn pale brown or white. Infected leaves often turn yellow, wilt and are shed. A white, cottony growth may cover the affected parts under humid conditions. Whole plants can be killed, if infection girdles the main stem. Infected pods produce smaller, discoloured seed. About a week after infection, hard black bodies called sclerotia are formed (Figure 9.11). The sclerotia can survive in soil for up to 5 years. Control of sclerotinia is difficult, if plants are lush and viny as disease spread from plant to plant readily occurs. For currently available viney varieties under irrigation, sclerotinia is less problematic in row crop systems than in solid-seeded field plantings as moisture retention within the canopy is reduced. Thus, solid seeding is not a normal practice under irrigation.

• A rotation with several years between susceptible crops (especially other pulses, canola, mustard, sunflower, safflower) will reduce the likelihood of sclerotinia.

• Infection can be carried over in some broadleaf weeds.

• Avoid planting dry bean adjacent to fields that were cropped to dry bean or other susceptible crops the previous year.

• Field scouting should begin prior to, and during, the early blossom stage of the bean crop.

• Growers should be looking for the presence of small mushroom-like structures on the soil surface or plant debris and for lesion development on leaves and stems.

• Sclerotinia can sometimes be controlled by application of foliar fungicide during the flower period (refer to Appendix Table 9.7).

• Flower petals and the canopy must be thoroughly covered for effective control.

• Under irrigation, avoid excessive and late season water application; allow the soil to dry prior to further additions.

Bacterial blights (common blight, halo blight, and bacterial brown spot) can also be severe.

Source Pulse Production Manual 1997, 6-8

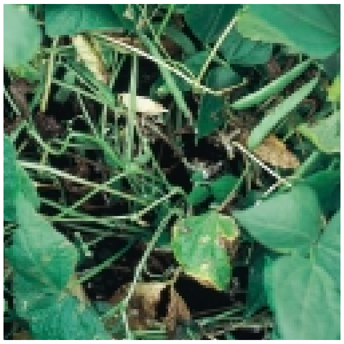


Figure 9.11 *Sclerotinia – white cottony growth on stem bases and pods of bean.*

Source Department of Biology, U of S

Figure 9.12 *Bacterial blight on bean pods.*

Although the bacterial blight diseases can overwinter in the soil, the main source of infection is contaminated seed. Initial symptoms include water-soaked (greasy green) spots that gradually enlarge and leaves that wilt and die. Often leaves will appear burned, but will remain attached to the stems. Pods can develop lesions that ooze (Figure 9.12). Seeds develop yellow or brown spots and shrivel, and many are not viable. Seed contamination can take place both inside and outside of the seed. The disease develops most rapidly at warmer temperatures (28 to 32˚C) and under sprinkler irrigation. Hailstorms accelerate spread of the bacteria by providing injured sites for infection and widespread dissemination of the bacteria. Seedlings from contaminated seed carry large numbers of bacteria and generally die early.

• Effective disease control includes the use of seed that is grown in bacterial blight-free regions or seed that is certified bacterial blight free.

• A rotation with at least 2 years between bean crops will minimize bacterial blight inoculum in the field.

• Bacteria is spread mechanically through the field, so growers should avoid field operations when the foliage is wet.

Anthracnose is a major bean disease worldwide, but has not yet been a serious problem in western Canada. It is widespread only in areas of frequent rainfall during the growing season. Anthracnose is a fungal disease that is spread by seed, but can survive and be spread by crop residues and can, as well, be carried by wind-blown residues. Lesions appear as water-soaked spots that gradually darken, those on the lower leaf area, leaf-veins and petioles are dark red and elongated, becoming dark brown to black in colour. Pod lesions are sunken and are tan to rust in colour.

• A rotation with 2 to 3 years of cereals reduces the risk of disease by reducing the quantity of infected debris.

• The use of disease-free seed is also important. Seed treatment may be beneficial, if seed is not severely infected.

Seedling blights, caused by three different fungi (Fusarium, Pythium, Rhizoctonia), cause the death of young seedlings. Symptoms include narrow red to brown streaks on young stems; leaf drop, mushy, discoloured, wilted seedlings with water-soaked lesions on the roots and up the young stem; sunken lesions that grow to completely girdle the stem, and cankers that become rough and dry. Each fungus is most active at a distinctly different temperature.

• The use of high quality seed reduces the risk of seedling blight infection by favouring a rapid, uniform emergence.

Seed may be treated with Agrox B-3, Captan, Apron FL, or Thiram to reduce the risk of stand thinning (Appendix Table 9.2). Irrigation between seeding and emergence increases the risk of seedling blight because it cools the soil and increases seed rot. A rotation that includes sugar beet increases the risk, and cereals in the rotation reduce the risk. The fungi are common in the soil and survive for many years, but their numbers are reduced in years when no susceptible crop is grown.

Bean is susceptible to numerous **viral diseases**, including bean common mosaic. These diseases have not been problematic in western Canada yet, but may develop as acreage increases. Symptoms of bean common mosaic virus include the presence of dark and light patches on the leaves, leaf rolling, leaf malformation, slow growth, and in severe cases, stunting and failure to pod. This virus is spread from other legumes by aphid transmission.

Dry bean can also be affected by **non-parasitic diseases**. Baldhead is a condition that results from seed damage, resulting in a broken shoot with a dead growing point. The young seedlings do not have a growing tip and, therefore, do not develop. Dry bean plants are also very sensitive to herbicide injury, especially from the drifting of phenoxy herbicides, such as 2,4-D, MCPA, or dicamba. Sun scald can be caused by intense sun after a rain or irrigation, and the entire plant may collapse without discolouring. Sun scald generally does not affect yield. Heat injury is also possible from high temperature on sandy soil.

Irrigation

About 35% of North American dry bean production is under irrigation. In terms of water use, dry bean is intermediate between lentil and pea, using up to 14.5 inches (37 cm) per season. When the seedbed is dry, irrigation may be used before planting. However, irrigation between planting and emergence cools the soil, delays germination, causes soil crusting, and generally increases the chance of seedling diseases. Between emergence and flowering, bean plants are small and use little water. One to two irrigations may be necessary, if rainfall is below average. Just before flowering when vines begin to form, the water level should be brought up to near field capacity. Flooding should be avoided, as even short periods of standing water can delay growth and may even kill plants.

- **Yields are highest when no drought stress occurs during the entire period, from flowering through pod fill. Longer than 5 days of moisture stress at flowering reduces pod number and seeds per pod.**
- **Irrigation should be shut down, if widespread sclerotinia develops, or when the seeds have formed.**
- **Since irrigation usually extends maturity by approximately one week, careful attention should be paid to maturity ratings when choosing a variety.**

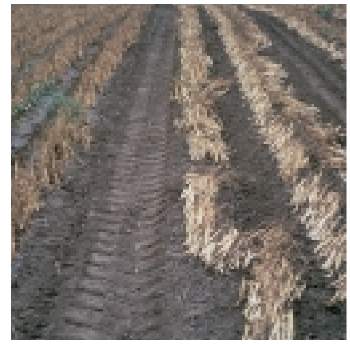
Irrigation during crop ripening may delay maturity and increase the chance of disease.

Harvest

Two basic harvesting systems are used for dry bean: undercutting or swathing in row-cropped bean, and direct harvesting in solid-seeded bean. Undercutting is effective, but requires specialized equipment. In contrast, direct harvesting results in significant harvest losses, but does not require specialized equipment. Growers must pay close attention to the crop development stage as harvest approaches because the timing of harvest operations is extremely important to minimize damage and losses, and to maximize quality. Dry bean plants, seeds and pods can dry down very quickly. In years with warm, dry weather and drought conditions near harvest, seeds can lose moisture at more than 5% per day after the seed moisture reaches 40%.

Undercutting

The traditional harvesting method for row crop bean production is to cut the bean plants below the soil surface with a knife, or a rod cutter, or a knife followed by a rod cutter (Figure 9.13). Once undercut, two or more bean rows are gathered together with a windrower or side delivery rake. If the beans are pulled, usually 6 to 8 rows are



Source *Pulse Production Manual 1997,* 6-10

Figure 9.13 *Undercut plants in row crop bean production.*

Source *Keho Alta Products*

Figure 9.14 *A prototype bean harvester.*

Source *Keho Alta Products*

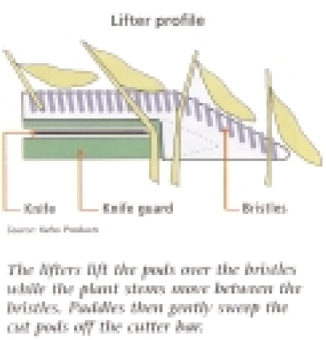


Figure 9.15 *Diagram of Pod Lifter*

Source *Pulse Production Manual 1997, 6-11*

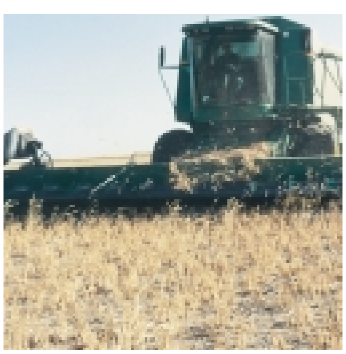


Figure 9.16 *Straight combining bean.*

pulled and windrowed together. The crop is usually cut or pulled when 50 to 75% of the pods are in the buckskin stage. Cutting or pulling when pods are damp and tough, such as in the morning, reduces shattering losses. When the crop is dry, it is threshed with a combine equipped with a pickup.

Although the undercutting method is much less prone to shattering losses, it has several disadvantages. The need to purchase new equipment has caused grower resistance to trying dry bean production in Saskatchewan, particularly on dryland. In addition, bean seeds may rot in the swath, if the weather is wet. The swath is vulnerable to wind damage due to the lack of stubble to anchor it in place. Separating the soil from the crop can be costly and difficult and can result in earth tag when the soil contaminates the seed surface. This harvesting method also exposes the soil to an increased risk of soil erosion.

Swathing is a feasible alternative to undercutting only if most of the pods clear the cutterbar.

• The usual stage for swathing is at 50% buckskin.

Upright varieties, which have been grown in narrow rows to encourage podding higher on the stem, can be swathed with little difficulty. If stems are moist, knives may gum up and must be cleaned periodically. Swathing creates little soil disturbance, results in less earthtag and soil particles in the seed, and improves marketability.

Direct Harvesting

Straight combining has only recently been considered feasible. The pods of many indeterminate pinto bean varieties hang down to the ground and even push into the soil surface.

• A typical combine can only cut to within 1.5 inches (4 cm) of the ground. As a result, cutterbar losses can be 40 to 50% of yield.

Even with specialized lentil harvesting equipment, such as flexible headers and air reels, the losses usually exceed 30%.

Cutterbar losses are high in dry bean because of the shape and characteristics of the plant. Dry bean stems and pods are generally positioned vertically making vine lifters largely ineffective. Although vine lifters may show some advantage, particularly if the crop is lodged, too many plants and pods are missed. Assuming 330 mg/seed, a loss of 3 seeds per sq/ft^2 (33 seeds/ m^2) amounts to a loss of 90 lb/ac (100 kg/ha).

• New pinto bean varieties with improved direct-harvesting characteristics and a crop lifter designed specifically for dry bean will address the harvesting loss problem (Figure 9.15).

Some bean growers are still choosing to direct harvest rather than to invest in undercutting equipment. Not only is the additional outlay of capital avoided, but gathering losses can be less than the weathering losses that sometimes occur when beans are exposed in the swath (Figure 9.16).

Monitoring Crop Maturity

Direct-harvesting can begin after the bean leaves fall off. The leaves of bean plants turn yellow and drop off naturally as the crop matures. Desiccation may be used to dry down the crop and weed top growth, but it will not hasten crop maturity. The crop can be left standing until it is killed by frost which acts as a free desiccant. When weed problems are severe, tall weeds can be lopped off above the bean crop by high level swathing before harvest. Delaying harvest until after frost occurs generally has little negative effect on yield or quality, unless the seed is threshed too dry (<13% moisture).

• The crop is ready for direct harvesting when roughly 75% of the pods are hard and dry and the remainder are yellow and flexible (the buckskin stage).

• At this stage, the pods are generally 12% moisture and the seeds are near 18%.

Monitoring Crop Moisture Content

Pod and seed moisture content are two important factors that will determine the success of the direct-harvest operation. Once the crop matures past the buckskin stage, it becomes subject to daily fluctuations in moisture content. At this stage, bean pods will take on or release moisture as quickly as ambient conditions change. The bean seed with its thick seed coat takes on and releases moisture much more slowly. A good pod moisture content range for harvesting is between 6 and 14%. Furthermore, the pod moisture content should always be at least 4% less than the seed moisture content for effective separation of the seed from the pod.

In early morning and late evening, bean pod moisture content may be high increasing the possibility of threshing and separating losses from the rotor or cylinder/straw walker. The problem is compounded further because cylinders and rotors are turning slow to avoid seed damage. In extremely moist situations, feeding of the crop material into the combine will be uneven, causing clumps of material to pass through the combine.

As a typical harvest day progresses, pod moisture content will decrease improving threshing and separation. Appropriate combine settings should be made as necessary (see the equipment section). On an extremely hot and dry day, pod moisture content may decrease rapidly, causing an increase in shatter loss. Furthermore, seed moisture content may drop below 13%, increasing the risk of cracking or splitting the sample. A quick indication of low pod moisture content is obtained by watching for open pods at the cutterbar. Open pods are readily seen, as the inside of a bean pod is lighter in colour than the outside. In these situations, harvesting may best be postponed until the evening or morning when crop moisture content is higher. Alternatively, a light irrigation can be used to moisturize the pods and reduce shattering losses. New harvest equipment technology, such as the Bean Sweep, the Un-Reel and ultrasonic header height sensors, and new varieties, with reduced shattering, will allow improved harvesting under drier conditions.

Equipment Considerations

The timing of the harvesting operation, combine adjustments, and condition of the combine components can be more important than the choice of which combine to use for harvesting dry bean. A floating cutterbar (flex header) is recommended because of the low nature of the crop. Air reels may help reduce losses in relatively weed-free fields by keeping the cutterbar clear of seed and loose plant material. Some pods may also be lifted, if it is adjusted close to the ground. A parallel-state pickup reel may reduce losses by more gently entering the crop canopy than a bat reel. However, it will be largely unsuccessful at lifting pods above the cutterbar and is best positioned over the cutterbar and used only to keep the cutterbar clean. Modified sickle guards with "teeth" that lift up the pods in front of the sickle are also available.

Combine components should be checked carefully to ensure that they will not be contributing to seed damage. New rub bars and concaves should be used in cereal crops before harvesting bean to wear sharp edges down. Removal of concave blanks and wires may help in some situations by allowing the larger bean seed to fall through the concave more readily. Auger flightings should be checked for clearances that are too close and for sharp edges that can cause damage. Aftermarket belt conveyors and bucket elevators are available for some combines, which help to reduce seed damage.

Combine adjustments include running the cylinder or rotor as slow as possible for effective threshing and separation without damaging the seed. Typical cylinder speeds are approximately 150 to 300 rpm, depending upon crop moisture content. Follow the recommendations of the operator's manual and then adjust accordingly. Keep the combine as near to capacity as possible. A soak test can be used to determine the level of damaged seed since it often cannot be seen visually. Soak 100 randomly chosen seeds in water for 5 minutes. Damaged bean seeds absorb water more quickly and will swell in size. Combine adjustments are required if more than 5 damaged bean seeds are present. Keep in mind that it is the peripheral speed of the cylinder or rotor that determines the potential for crop damage and generally plays a larger part in crop quality than concave clearance. Cylinder slow-down kits are available for some combines, if required. The concave should be adjusted to its largest opening. Other important adjustments for minimizing seed damage include proper tensioning of the clean and return elevator chains.

Post Harvest

Care should be taken to prevent seed damage after it leaves the combine. Some growers dump directly into mini-bulk bags. Belt conveyors and auger flighting with brushes are often used to transfer the bean seeds to the bin.

- **Steel flighting augers are not recommended for bean.**

When augering, slow the auger speed as much as possible and operate only when full. Bean ladders within the bin are also used to reduce the distance the bean seed must drop.

Storage in mini-bulk bags reduces the need for handling. Storage for more than a year reduces quality of some market classes (such as pinto, pink, and red) because the seed coats will start to discolour due to oxidation of tannin precursors.

Weed seeds and other dockage should be removed early to minimize heating and to increase the market appearance of the sample. Bean seeds should not be handled in low temperatures (below –20˚C) or when very dry (below 14%) due to increased mechanical damage. Beans can be stored for a short period at 16 to 18% moisture, but for long-term storage a level below 15% moisture is recommended. Drying temperatures above 38˚C can reduce the germination of seed beans.

Grading

The Canadian Grain Commission under recommendation of the Producer Trade Advisory Committee sets the standards for the bean grades (see Tables 9.8 and 9.9).

Table 9.8 *Pea Beans (Canada) - Primary and export grade determinants.*

			Total damage including splits, foreign material & contrasting classes of beans (%) Damage, foreign material and contrasting classes Foreign material				Damage including splits, foreign material & contrasting classes of beans (%) Damage, foreign material and contrasting classes			
Grade name	*** Standard of quality**	***Other classes of beans that blend (%)**	**Ergot**	**Sclerotinia**	***Stones, shale or similar material**	***Total foreign material**	***Contrast-ing classes of beans**	**Heated, rotted, mouldy**	***Total**	***Total**
Extra No. 1 Canada	Uniform in size, of good natural colour	1.0	0.05	0.05	About 0.01	About 0.05	About 0.1	Nil	1.0	1.0
No. 1 Canada Select	Fairly good colour	1.0	0.05	0.05	About 0.01	About 0.05	About 0.1	0.2	1.5	2.0
No. 1 Canada	Reasonably good colour	1.0	0.05	0.05	About 0.05	About 0.1	About 0.1	0.1	1.5	2.0
No. 2 Canada	Fairly good colour	5.0	0.05	0.05	About 0.1	About 0.2	1.0	0.2	3.0	4.0
No. 3 Canada	Fairly good colour	5.0	0.05	0.05	About 0.2	About 0.5	1.0	0.3	5.0	6.0
No. 4 Canada	Off colour	5.0	0.05	0.05	About 0.2	About 0.5	1.0	1.0	8.5	10.0
Grade if No. 4 specs not met		Pea beans, Sample Canada, Account other Classes that Blend	Pea beans, Sample Canada, Account Ergot	Pea beans, Sample Canada, (class), Account Admixture	2.5% or less, - Pea beans, Rejected (CW grade) (class), Account Stones, or Pea beans, Sample CE (class) Account Stones Over 2.5% - Pea beans Sample Salvage	Pea beans, Sample Canada, Account Admixture	Pea beans, Sample Canada (class), Account Contrasting Classes	Pea beans, Sample Canada, Account Heated or Account Mouldy Kernals	Pea beans, Sample Canada, Account (reason)	

* Defined in the Canada Grain Regulations

Source *Canadian Grain Commission Official Grading Guide 1999*

9.22 Dry Bean

Table 9.9 *Beans (Canada) other than Cranberry, Blackeye, Yelloweye or Pea Beans - Primary and export grade determinants.*

			Total damage including splits, foreign material & contrasting classes of beans (%) Damage, foreign material and contrasting classes Foreign material				Damage including splits, foreign material & contrasting classes of beans (%) Damage, foreign material and contrasting classes			
Grade name	* Standard of quality	*Other classes of beans that blend (%)	Ergot	Sclerotinia	*Stones, shale or similar material	*Total	*Contrast-ing classes of beans	Heated, rotted, mouldy	*Total	*Total
Extra No. 1 Canada	Uniform in size, of good natural colour	1.0	0.05	0.05	Nil	About 0.05	1.0	Nil	1.0	1.0
No. 1 Canada	Reasonably good colour	3.0	0.05	0.05	About 0.05	About 0.1	1.5	0.1	1.5	2.0
No. 1 Canada Select	Fairly good colour	3.0	0.05	0.05	About 0.05	About 0.1	1.5	0.1	1.5	2.0
No. 2 Canada	Reasonably good colour	5.0	0.05	0.05	About 0.1	About 0.2	3.0	0.2	3.0	4.0
No. 3 Canada	Fairly good colour	10.0	0.05	0.05	About 0.2	About 0.5	5.0	0.3	5.0	6.0
No. 4 Canada	Off colour	15.0	0.05	0.05	About 0.5	1.0	8.5	1.0	8.5	10.0
Grade if No. 4 specs not met		Beans, Sample Canada, (class) Account other Classes that Blend	Beans, Sample Canada, (class) Account Ergot	Beans, Sample Canada, (class), Account Admixture	2.5% or less, - Beans, Rejected (CW grade) (class), Account Stones, or Beans, Sample CE (class) Account Stones Over 2.5% - Beans Sample Salvage	Beans, Sample Canada, (class) Account Admixture	Beans, Sample Canada (class), Account Contrasting Classes	Beans, Sample Canada, (class) Account Heated or Account Mouldy Kernals	Beans, Sample Canada, (class) Account (reason)	

* Defined in the Canada Grain Regulations

Source *Canadian Grain Commission Official Grading Guide 1999*

Table 9.7 *Foliar fungicides registered for dry bean in Saskatchewan*

Product	Disease	Rate	Water volume	Crop stage
Benlate (white bean)	Botrytis Sclerotinia	0.71 – 0.91 kg/ac	10-20 gallons/ac (40-80 L/ac)	Apply between the stage when 50% of all plants have 1 open flower and full bloom.
Champion WP	Bacterial blight	0.9 – 1.3 kg/ac		First application when plants 6 inches (15 cm) tall. Repeat every 7-14 days depending on conditions.
Clean Crop Copper 53W,	Bacterial blight, downy mildew, anthracnose, early blight	2.2 kg/ac	88 gallons/ac (400 L/ac)	First application when plants 6 inches (15 cm) tall. Repeat every 7-10 days depending on conditions.
Kocide 101,	Bacterial blight, (bacterial & halo)	0.9 - 1.3 kg/ac	Enough to ensure thorough coverage	Apply when plants 6 inches (15 cm) tall. Refer to label for repeat applications.
Ronilan EG	Sclerotinia	0.6 kg/ac if using 1 application/year. 0.4 kg/ac if using 2 applications/year.	Enough to ensure thorough coverage. Check label.	Apply at early to mid bloom (30-50%), repeat 7-14 days later if disease persists, or weather conditions are favourable for disease development.
Senator 70 WP (white bean)	Sclerotinia	0.7-0.9 kg/ac	15-20 gallons/ac (70-90 L/ac)	When conditions favour disease development, usually during early bloom. Refer to label for repeat applications.

Source *Saskatchewan Agriculture and Food Guide to Crop Production 1999.*