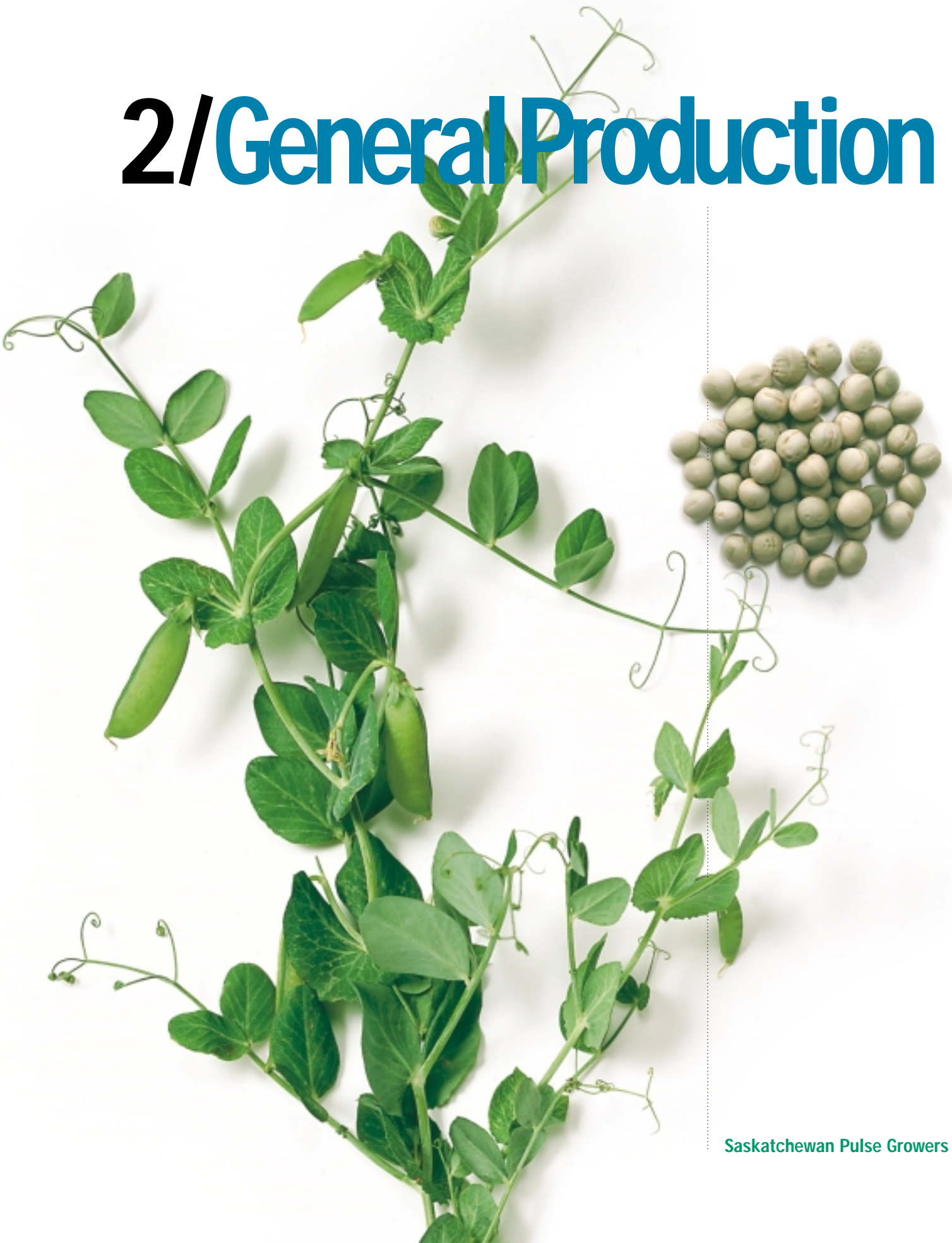


# 2/General Production



# 2/General Production

## General Production Contents

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*continued...*

## 2.2 General Production

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# General Production

## Crop Adaptation

The climate of Saskatchewan offers many opportunities for quality pulse production. Cold winters and dry summers limit disease and insect problems, and help to keep production costs down. The cereal crops grown on the Prairies are relatively low in value, so pulse crop production provides a promising alternative in spite of higher production costs.

In the **Brown soil zone**, inadequate moisture is the major limitation to agricultural production. Suitable crops must have good drought and heat tolerance.

- **Chickpea production can be successful with a limited supply of available water.**

- **Lentil has slightly less drought tolerance (drought escaping), and can be grown effectively in the Brown soil zone on fallow, or on stubble in years with good moisture.**

- **Recent research has indicated that pea may be more adaptable to stress conditions than once thought and it has been successfully grown in the Brown soil zone with early seeding.**

In the **Dark Brown soil zone** stress conditions are less than in the Brown soil zone as precipitation normally is higher and evaporation demands lower.

- **Lentil and chickpea are especially suited to production on cereal stubble in the Dark Brown and moist Dark Brown soil zones of Saskatchewan.**

- **Dry bean is a drought-sensitive, warm-season crop well suited to irrigated production in the long season areas of the Dark Brown soil zone. Late July rainfall is essential for profitable dry bean production on dryland in the moist Dark Brown and thin Black soil zones.**

- **Pea yields can be limited due to moisture limitations in dryland production in the Brown and Dark Brown soil zones, but pea yields well when rainfall is above average, if seeded early, or under irrigation.**

**Black and Grey soils** are generalized as having favourable moisture levels, but are limited by a shorter growing season than other soil zones.

- **Pea yields usually are greatest with production in the Black soil zone.**

- **Consistent production of quality lentil is restricted by excess moisture and a limited growing season.**

- **In this area, the growing season is generally too short for chickpea and dry bean.**

Table 2.1 gives some agronomic characteristics that may help growers select a pulse crop suitable for their area. This table is a generalization only. For instance, the table indicates that the Black soil zone is too wet for lentil production. This is not intended to imply that lentil cannot be grown successfully in the Black soil zone; only that in typical years lentil will be at risk from excess moisture (e.g., it will be less likely to produce seeds and more likely to suffer from disease).

## Rotations

The advantages of pulse crops in the rotation are many and not limited to the years in which they are grown. They extend and diversify crop rotations, increase available nitrogen, improve soil tilth, and contribute to soil organic matter. They also reduce dependence on summerfallow, break cereal disease cycles, offer unique opportunities for grassy weed control and broaden market opportunities.

## 2.4 General Production

**Table 2.1** Agronomic characteristics of some pulse crops.

	Lentil	Pea	Chickpea	Dry Bean
Optimal temperature	Cool	Cool	Cool to warm	Warm
Spring frost tolerance	Tolerant	Tolerant	Tolerant	None
Drought response	Tolerant	Less tolerant	Very tolerant	Less tolerant
Maturity	Some early varieties	Some early varieties	Very late	Late
Potential on Brown Soil	Fallow	Fair on fallow, irrigated	Excellent on fallow	Irrigated
Potential on Dark Brown soil	Excellent on stubble	Fair to good on moist stubble, irrigated	Excellent on stubble	Fair on fallow & moist stubble, irrigated
Potential on moist Dark Brown soil	Good on stubble	Good	Fair on stubble & light soil	Fair to good on fallow & moist stubble
Potential on Black soil	Too wet	Excellent	Season too short, wet	Fair to good in longer season areas with early varieties
Potential on moist Black soil	Too wet	Excellent	Season too short, wet	Season too short
Potential on Gray soil	Too wet	Excellent	Season too short, wet	Season too short
Annual yield (lb/ac)	900 - 1400	1250 –2600 dryland, 3000 irrigated	1000 - 2000	700 – 1200 dryland, 1500 – 2000 irrigated

Source: Various sources including SAF 1994, A. E. Stirland, personal communication

**Table 2.2** Average grain yield and protein content for uniformly managed wheat grown on various pulse stubbles.

Crop stubble	Wheat Yield		Wheat Protein
	lb/ac	kg/ha	%
Field pea	2260	2535	13.0
Lentil	2190	2455	12.9
Desi chickpea	2166	2428	12.9
Wheat	1896	2125	12.1

Source: Miller, P. et al., 1999

Cereal yields, following pulse crops, are often higher than following cereals. At Swift Current, wheat, following three pulse crops, averaged 16% higher yield and 7% higher protein compared to wheat following wheat (Table 2.2). At Melfort, Scott and Saskatoon, cereals (barley or wheat) following lentil or pea crops, yielded substantially more on average than those following cereals. The amount of advantage gained from a pulse crop over that of a cereal as the preceding crop in the rotation may depend on available moisture. At Swift Current (Brown soil zone), cereal yields on lentil stubble were approximately 70% of cereal yields on fallow; in the moister sites (Dark Brown and

Black soil zones), cereal yields on lentil or pea stubble were approximately 90% of yields on fallow.

• **When moisture limits production, pulses provide less yield benefit, and may even reduce yield, possibly because they leave very little stubble for snow trapping.**

In a separate study at Swift Current, with a long-term lentil-wheat rotation, nitrate nitrogen in the rooting zone was higher in a wheat-lentil rotation than in any other continuous cropping rotation. This increase in soil nitrogen resulted in a reduction in the fertilizer nitrogen requirements and a consistent 1% boost in the grain protein of wheat. Consequently, the fertilizer nitrogen savings on wheat following lentil averaged 7 lb/ac (8 kg/ha) and ranged from 0 to 22 lb/ac (0 to 25 kg/ha) in any one year. The protein boost was attributed to an improved synchrony between the breakdown of pulse crop residues, and release of available nitrogen, with nitrogen demand

and uptake by the wheat crop.

At Melfort, pulses had a beneficial effect that continued in the third year of the rotation. Barley yielded more when it followed a pulse than when following barley, even though fertilizer nitrogen was applied to the required level. In the third year, wheat yields were still substantially higher in the pulse rotation than in the cereal rotation. Different pulses produced their maximum effect at different times. The effect of pea was strongest in the third year.

In another crop sequence study at Melfort, the yield of a number of crops was higher following a pulse than following a cereal (Table 2.3). However, pea did not yield higher when following a pea crop. Pea yields were highest following a cereal in rotation, and higher following an oilseed in rotation than when following pea or peaola.

A recent study at Indian Head has shown that nitrogen fixation is greater in zero tillage systems than with conventional tillage. Nitrogen

Crop	Yield after pea as % of yield after wheat
Flax	126
Barley	140
Wheat	147
Canola	126

Source From Townley-Smith, 1995.

Preceding Crop	Pea yield as % of yield after pea
Flax	115
Barley	130
Wheat	119
Canola	113
Peaola	103
(Pea-canola Intercrop)	

**Table 2.3** Pulse rotation effect in several different crops at Melfort.

**Table 2.4** Crop rotations (the rotations move from left to right, e.g., in R5 spring wheat is grown after sunola).

Rotation	Phase in rotation			
	Cereal	Oilseed	Cereal	Pulse
R1: Post-emergent herbicide	Spring wheat	Canola	Spring wheat	Lentil
R2: Pre- & post-emergence herbicide <sup>a</sup>	Spring wheat	Canola	Spring wheat	Lentil
R3: Low-input herbicides <sup>b</sup>	Spring wheat	Canola	Spring wheat	Lentil
R4: Low-input herbicides & fertilizers <sup>c</sup>	Spring wheat	Pea (Pulse)	Spring wheat	Lentil
R5: Highly diversified I	Canary seed	Sunola	Spring wheat	Lentil
R6: Highly diversified II	Spring wheat	Mustard	Canary seed	Lentil

Source Derksen et al., 1996.

<sup>a</sup> Post-emergence herbicides used in the spring wheat phases and pre-emergence (trifluralin) used in canola and lentil.

<sup>b</sup> In this rotation grassy weeds were not controlled in the spring wheat phases and reduced herbicide levels were used for broadleaf weed control. Wheat seeding was delayed 10 to 14 days compared to other rotations.

<sup>c</sup> This rotation used the same herbicide approach as R3 and the rates of fertilizer used for all crops were half that applied in the other rotations (i.e., one-half soil test recommendations).

## 2.6 General Production

**Table 2.5** Net returns (\$/ac) of specialty crop rotations by tillage method and year.

Tillage	Rotation	1992	1993	1994	1995	Mean
		\$/ac				
<b>Conventional</b>						
	R1: Post-emergence herbicide	424	158	78	227	221
	R2: Pre-emergence herbicide	465	150	119	261	249
	R3: Low-input herbicides	434	195	187	188	251
	R4: Low-input herbicides & fertilizers	231	185	156	190	191
	R5: Highly diversified I	492	131	24	132	195
	R6: Highly diversified II	338	57	49	108	138
<b>Mean</b>		<b>397</b>	<b>146</b>	<b>102</b>	<b>184</b>	<b>207</b>
<b>Zero</b>						
	R1: Post-emergence herbicide	505	174	70	191	235
	R2: Pre-emergence herbicide	514	153	139	185	248
	R3: Low-input herbicides	492	200	155	194	260
	R4: Low-input herbicides & fertilizers	309	246	195	234	246
	R5: Highly diversified I	493	126	54	129	201
	R6: Highly diversified II	475	79	86	124	191
<b>Mean</b>		<b>465</b>	<b>163</b>	<b>117</b>	<b>176</b>	<b>230</b>
<b>Overall Mean</b>		<b>431</b>	<b>154</b>	<b>109</b>	<b>180</b>	<b>219</b>

**Table 2.6** Fertilizer nitrogen credits associated with pea production in different soil zones.

Soil zone	N credit (lb) (for every 1000 lbs pea seed produced/ac)
Black	15 lb
Dark Brown	5 lb

Soil zone	N credit (kg) (for every 1000 kg pea seed produced/ha)
Black	15 kg
Dark Brown	5 kg

fixation was 10% higher in lentil crops and 31% higher in pea crops, when the zero tillage system was used compared to conventional tillage. In addition nitrogen fixation was improved in lentil grown in diversified rotations in both zero till and conventional tillage (Tables 2.4 and 2.5). The cause of this improved nitrogen fixation has not been determined, but the less stressful crop establishment environment with zero tillage may be beneficial to nitrogen fixation.

**• Nitrogen fixation by the pulse crop is an important part of the total benefit of growing a pulse in rotation.**

Pulse crops fix nitrogen (in association with rhizobia) and release it in an available form when their residues decompose. The amount of nitrogen fixed can be substantial and is largely a function of the dry matter yield (about 40 lb of nitrogen/tonne of dry matter). The "pulse effect" can be the equivalent

to the boost that the crop would receive if given 50 lb/ac (56 kg/ha) or more of fertilizer nitrogen. Most of the fixed nitrogen is removed as protein in the harvested seed. The pulse residues usually contain only about 1% nitrogen (slightly more than cereal residues), but pulse crop residues break down very rapidly, releasing this nitrogen and making it available to the succeeding one or two crops. In spite of this, less than 50% of the nitrogen in the pulse crop residue is available to the following grain crop. Trials conducted by Agriculture and Agri-Food Canada indicated the nitrogen fertilizer replacement value of field pea averaged 25 lb/ac (28 kg/ha) in the Black soil zone and 11 lb/ac (12 kg/ha) in the Dark Brown soil zone. Based on seed yield results, the nitrogen fertilizer credit from pea in rotation to the succeeding non-legume crop is shown in Table 2.6

**• The boost in productivity that is not due to nitrogen is**

**termed the "non-nitrogen benefit". Many factors contribute to this benefit, and these factors work in combination, so the effect of individual factors is difficult to determine.**

Pulse crops improve soil tilth. Soil organic matter may actually be reduced following pulses, relative to cereals, because less dry matter residue remains, but relative to fallow, organic matter can be greater following pulses. Crop rotations that include pulses can substantially increase soil microbial activity and this may increase nutrient availability (including phosphorus).

A real benefit may be realized in cereal crops that follow a pulse because the pulse year interrupts pest cycles. Most cereal diseases do not affect pulse crops. Soil-borne root rots in continuous wheat (or wheat-fallow) or continuous barley rotations can cause average yield losses of 5 to 10%. These yield losses may be reduced by inserting a pulse crop into the rotation. Insects, such as grasshoppers, may find pea much less palatable than wheat. Weeds may have different abilities to survive in pulse and cereal crops. For example, a wide range of grassy weeds can be controlled over a wide window of growth stages with herbicides, which are registered for use in pulse crops, but not in cereal crops.

### **Equipment Purchases and Modifications**

Most existing farm equipment can be used or modified to successfully produce pulse crops. One exception is the need for a roller, which is used to smooth the soil surface to make it easier to harvest pulses such as pea, lentil, and dry bean that have pods close to the soil surface. The roller substantially reduces cutterbar damage, may

improve seed quality by reducing earth tag (earth sticking to seeds) and speeds up swathing or direct harvesting.

Swather and combine modifications can also significantly reduce seed loss, increase harvest efficiency, and improve seed quality in some of the pulses. Vine lifter guards, pickup reels and flex headers improve the cutting of plants with pods close to or in contact with the soil surface. Generally, pulse crop production results in higher wear on swathers and combines which increases the cost of repairs and leads to more frequent machine replacement.

An undercutter may be used to harvest dry bean grown under wide-row systems. The plants are cut below the surface with a knife, a rod cutter or a knife followed by a rod cutter. Following undercutting the beans are windrowed. The pods of some dry bean market classes, such as pinto, often touch the soil, and the undercutter reduces losses during swathing.

Most pulses require gentle handling to prevent seed splitting and reduced germination. Even non-visible minute damage to the seed can result in a substantial loss in germination. Seed with low moisture content (< 13.5%) is particularly susceptible to damage when handled in low temperatures (< 20°C). To reduce damage during extensive handling of pulses, special conveying equipment should be considered. Refer to PAMI Research Update #660, Conveying Equipment For Pulse Crops, for detailed information on handling pulse crops.

Equipment requirements, notes on use, or modifications of equipment for specific pulse crops have been included in the individual pulse crop chapters as many requirements are specific to a particular crop.

### Field History

Field history is an important consideration in all pulse production. The decision to grow pulses in a given field is best made one or two years in advance so that the site can be prepared.

Pulses generally cannot tolerate residues of herbicides such as Ally, Amber, Assert, Banvel, Curtail, Lontrel, Muster, Poast FlaxMax, Prestige, or Unity. Only pea can tolerate residues of Pursuit. The recommended period following chemical application before pulses can be grown safely varies with the type of chemical, the rate applied, the soil characteristics, such as pH and organic matter, and the type of pulse.

**• Follow label recommendations and, if in doubt, grow a test plot of the desired pulse in the field in the year before the pulse is to be planted.**

The plot should be grown to maturity to ensure that no late season effects occur on yield or crop quality. A chemical assay can also be conducted to determine soil residue levels. Accurate spray application records are essential for a grower to evaluate the risk of chemical residues.

Pulse crops are susceptible to diseases that can overwinter in the soil and in stubble. It is best to grow pulses following a cereal, rather than following another crop that may carry pulse diseases.

Pulse crops are not very effective competitors with weeds, and not all weeds can be controlled in pulse fields, so it is best to have a weed management strategy in mind before seeding pulses (see Chapter 5./Weed Control). In particular, it is a good idea not to seed pulses on land that has a number of broadleaf perennial weeds. Sowing pulses into clean fields offers the best prob-

ability of success, but pulses are frequently seeded on stubble and potential weed competition is often high and can often be complicated by volunteer crop growth.

If pulse crops are zero-till seeded into stubble, the previous crop is very important. Volunteer canola or tame mustard may be especially difficult to control, and may smother a pulse crop. Volunteer cereal control is expensive, and the seeds from any wheat plants that escape can be difficult to separate from small-seeded pulses, such as Eston lentil. If pulse and cereal can be separated easily, some level of yield loss in the pulse can be offset by sale of the cereal and ease of harvesting. The cereal yield is unlikely to fully compensate for the pulse yield loss, as even a sparse cereal stand will substantially reduce pulse yield, and pulses generally have higher value than cereals.

Pulses are susceptible to damage from drift and off-target movement of phenoxy herbicides, such as 2,4-D or MCPA formulations, particularly esters. This should be considered when choosing a field for pulse crop production.

### Production

#### Seed Quality

With pulse crops, the quality of the crop is dependent on the quality of the seed. Seed testing at accredited seed test labs (see list given in Table 3.1, Chapter 3./Variety Selection) can include tests of germination, seedling vigour and disease contamination with *Ascochyta*, Anthracnose, and *Botrytis*.

Pulse crop seeds are easily damaged by rough handling. Equipment used to harvest, clean, move, inoculate and plant the seed in the soil can all cause damage. Seeds are especially prone to dam-

age when they are dry or cold. The tiniest cracks in the seed coat indicate seed damage and reduced germination, and make the seedling more prone to infection by soil-borne diseases such as Pythium seed rot.

Seed that has been frozen, especially when it was damp or tough, may have low germination, or may result in a high proportion of abnormal seedlings.

• **The seed produced in immature pods that were treated with a desiccant, or with a pre-harvest weed control product (notably glyphosate or glufosinate ammonium), may have reduced germination or seedling vigour.**

This effect can be reduced by strict adherence to herbicide label guidelines. Even seed that germinates well may produce seedlings that do not develop normally. Professional seed testing can assist in detecting this sort of problem. Sizing to remove small seeds during seed cleaning helps produce quality seed for planting.

### Time of Seeding

Lentil, pea, and desi chickpea are cool season crops that can be seeded early. All are tolerant of light frosts (-4 to -6°C). Best yields and quality usually result from early seeding as soon as the top inch (2.5 cm) of the soil reaches 5°C, providing the soil is not excessively wet. This soil condition generally occurs in late April to early May. Kabuli chickpea should usually be seeded in the second week of May, and soil temperature should be 10°C (at 2 inches or 5 cm) to promote rapid emergence and reduce seed rot. Dry bean is a warm season crop and has no frost tolerance. Best yields of dry bean usually arise from seeding later than for the other pulse crops, usually the fourth week

of May, when frost risk is low and the soil temperature at seeding depth has reached a minimum of 12°C.

### Seeding Rate

Determining the best seeding rate involves careful consideration and calculation. Seed size varies widely among varieties, and even within a single variety, the size can easily vary 10 to 20%. A 20% difference in seed cost can be important.

Seeds can be sized during cleaning to produce a more uniform lot. If the desired plant population (plants/ft<sup>2</sup>), the likely seed survival (in percentage from the seedling vigour and germination tests expressed as a decimal), and the 1000-seed weight (weight of 1000 seeds) are known, the calculation of seeding rate is straightforward:

Seeding Rate (lb/ac)=  
(Population/sq.ft. x 1000 Seed Wt in Grams ÷ % Survival) x 10

For example, for Laird lentil, with a population of 12 plants/ft<sup>2</sup>, a 1000-seed wt of 70 g, and 80% of seed producing vigorous seedlings, the seeding rate =  
[(12 x 70) ÷ 80] x 10 = 105 lb/ac (118 kg/ha).

The seeder calibration (done after inoculation) involves some of the same information, plus the row spacing:

Plants per foot of row = plant/ ft<sup>2</sup> x [row spacing (in.) ÷ 12 (in./ft)] ÷ % germination expressed as a decimal.

For the above example, with a 6-inch row spacing, number of seeds/ft of row = (12 x [6 ÷ 12] ÷ 0.8) = 7.5 seeds/ft of row (25 seeds/m of row).

The adjustment for seed survival should include an adjustment

for the rate of germination and the rate of production of healthy vigorous plants.

The best plant populations for a crop are somewhat flexible.

**Recommended numbers for plants/ft<sup>2</sup> are:**

- **12 plants for lentil (130/m<sup>2</sup>),**
- **8 plants for pea (88/m<sup>2</sup>),**
- **3 plants for irrigated or 4 plants for dryland dry bean (33 or 44/m<sup>2</sup>, respectively),**
- **and 4 plants for chickpea (44/m<sup>2</sup>).**

The grower may use higher or lower rates, based on the moisture conditions in the field, date of seeding, weed pressure, and experience in the management of the crop. However, stand density does not increase in direct proportion to the increase in seeding rate because of reduced percent emergence resulting from increased competition among adjacent seedlings in a denser stand.

The best seeding rate is a compromise. Seeding rates above those recommended are used to compensate for expected losses. For instance, if harrowing losses of 10% are probable, a 10% boost in seeding rate could offset losses, and result in achieving the recommended plant number after harrowing. Higher seeding rates often result in higher yields because higher than recommended rates reduce competition from weeds by allowing the crop to close off the canopy earlier. Higher plant numbers also stress lentil plants earlier, causing earlier maturity, which plays a role in higher yield. However, higher plant numbers also increase the rate of spread of disease, particularly under cool moist conditions. The selected benefits from weed suppression and beneficial stress on the one hand and the increased risk of disease and higher seed costs on the other, must be weighed for each field each year.

### **Inoculation and Fertilization**

For details on inoculation and pulse crop fertilizer requirements please refer to Chapter 4./Plant Nutrition.

### **Seeding**

Pulse crops can be planted under conventional, minimum till or zero till production systems with a wide range of seeding equipment including: double disc press drills, hoe drills, discers, air drills and air seeders.

Pea, lentil, and desi chickpea crops can be seeded into cool soils (5°C). Dry bean and kabuli chickpea crops require warmer soil (>10°C) for good germination and emergence.

Direct seeding techniques are very effective for pulse production. At Indian Head (Black soil zone), net returns for field pea or lentil on stubble, using zero-till or minimum till were higher than those from conventional tillage systems. Grain yields were higher in most years, possibly because of improved soil-moisture conservation, and a good, firm seedbed. Work in Alberta suggests that nodulation may be more effective in direct-seeded fields, again as a result of improved moisture conditions.

**• Extended rotations are especially important in direct seeding to reduce the spread of disease from intact residues on the soil surface and to allow for a slower breakdown of residual herbicides.**

With any seeding equipment, the seed metering system and the metering device must be able to handle high flow rates of large seed.

**• The seed cups or meter clearance must be large enough to allow accurate metering of large-seeded pulses without damage to the seed.**

A trial run with a sample of the

pulse will show if the system is capable of handling large seeded pulses without damaging the seed. If in doubt, a germination test should be conducted, as only slight visible damage may indicate a severe reduction in germination.

Air seeders can be successfully used to seed pulse crops, provided the pneumatic system is adjusted to handle the easily damaged seed.

- **Excessive fan speed and a high airstream velocity may result in substantial physical damage and a major reduction in germination.**

- **Never exceed the manufacturers recommended airflow settings.**

Studies with Laird lentil showed that up to 30% damage (cracking plus reduced germination) occurred with excessive airflow settings. By reducing the fan speed to the minimum required to convey the seed without plugging, damage can be reduced to low levels. Since ground speed is a factor in airflow requirements for a given seeding rate, reduced ground speed allows for slower fan speeds and results in reduced damage. Refer to the manufacturer's recommendations for optimum fan speeds for each crop and machine configuration.

Inoculation can affect the flow and metering of seed, so equipment should be calibrated with inoculated seed. As the cost per ac/ha of pulse seed is often quite high, accurate calibration of seeding equipment can minimize seed costs.

- **Pulse seeds are sensitive to handling and seeding damage when seeds have a low moisture content. If the moisture content of the seed is below the maximum level required for safe storage (refer to - Table 2.9), consideration should be given to moisturizing the seed prior to handling and seeding.**

Refer to PAMI report #704, Research Update: Moisturizing Pulses to Reduce Damage, for information on raising the moisture content of pulse seeds.

Most pulse seeds can emerge from deep seeding depths due to their large size. However, deep seeding is not required, provided the seed is accurately placed in firm, moist soil. In direct seeding systems, the seed can be placed at a shallower depth compared to pre-tilled soils as soil moisture is usually much higher in untilled soils. Large seeds require large amounts of water to germinate and, therefore, the moisture available at seeding depth must be higher than required for a small-seeded cereal or oilseed crop.

- **Lentil should be seeded more than 2 inches (5 cm) deep to minimize herbicide-leaching damage to seedlings from Sencor or Lexone DF application.**

Seeding into soil conditions that promote rapid emergence is important for crops that are sensitive to soil-applied herbicides such as Edge and the trifluralins as longer exposure prior to germination and emergence increases the risk of seedling damage or death.

### Weeds

For information on weeds and weed control refer to Chapter 5./Weed Control.

### Insects

Crop loss from insects in pulse crops is sporadic, but the potential for yield and quality loss is high for specific insects, if their population is high. Insects are most effectively controlled, if the grower maintains an integrated management system that includes a knowledge of the biology of the insects that might cause problems, field scouting, knowledge of insect survey projec-

tions, sound agronomy, and the use of insecticides when necessary.

The number of insects in any given field is dependent on a multitude of factors, including weather, the farm management system, the number of insects in previous years, and the buildup of various predators, diseases, and parasites.

### Grasshoppers

Saskatchewan Agriculture and Food publishes an annual grasshopper forecast each year that indicates the likelihood of a grasshopper outbreak. It is based on surveys of egg numbers in each crop district. Regular field inspections should be used to verify that insects are at damaging levels.

Grasshoppers usually lay their eggs in areas with green growth in the fall. Good fall weed management discourages egg laying. When grasshoppers hatch in the spring, they are only 1/10 inch (0.25 cm) long. They can be spotted in uncultivated areas, such as ditches, stubble, pasture, and field edges, by looking carefully, or by using a cloth net swept near the soil surface. Grasshopper survival and crop damage will be the greatest in hot, dry springs, and in field areas that accentuate those conditions such as south slopes and sandy soils. These conditions accelerate the grasshopper hatch, bringing more hungry insects to the crop at one time. A heat-stressed crop is less tolerant of insect damage than one with adequate moisture because when stressed, growth is slowed and the damaged area is not quickly replaced.

Grasshoppers chew through young shoots, even if they do not eat the plant. Pulse crops are not strongly preferred by grasshoppers, but damage to seedlings bordering ditches and roads can occur. During the early flowering stage, grasshop-

pers can eat the first buds and flowers of lentil, delaying seed set and reducing yields.

**• As few as two grasshoppers/m<sup>2</sup> at the first flowering stage of lentil can cause serious yield losses.**

Grasshopper problems are more likely in the warmer, drier southwest region of Saskatchewan. In these areas, summerfallowing is more common, and these tilled areas can be incorporated into the grasshopper management system. Clean summerfallow will starve newly emerged grasshoppers. If grasshoppers have already begun to feed when summerfallow is started, they will be more likely to move to neighbouring fields. In this case, trap strips of green growth can be left to concentrate the grasshoppers before applying a registered insecticide. The effectiveness of the trap strip will be increased, if it is planted early in the year.

Stubble cropping increases the risk of grasshopper problems because the previous crop provides a habitat that encourages egg-laying. This risk is greatest in years when a warm spring occurs and severe or very severe grasshopper outbreaks are forecast.

If insecticidal sprays are used in areas where bees are kept, they should be applied in the evening or early morning, when bees are not foraging. Bee keepers in the area should be notified at least 48 hours in advance of any insecticide treatment.

### Cutworms

Cutworms occasionally cause problems. The risk is low, unless more than 2 to 3 cutworms/m<sup>2</sup> occur in the top 3 inches (7.5 cm) of soil. Cutworms overwinter as eggs or young larvae that feed on newly emerged shoots in spring. The shoots may be cut off below the soil

surface. Pulse crops, such as dry bean, with cotyledons (seed) that emerge from the soil, are generally killed if attacked by cutworms. Crops, such as lentil, pea, and chickpea, with cotyledons (seed) that remain below the soil surface, can often recover from cutworm damage, if cool, moist growing conditions occur. However, recovered plants are generally set back 4 to 7 days by the damage and may not be competitive.

Red-backed cutworm moths (more common in the Black and Dark Grey soil zones) lay their eggs in weedy areas. Good weed management in late summer can discourage them. Pale western cutworm moths (more common in Brown and Dark Brown soil zones) lay their eggs in loose soil. Fall tillage encourages them to lay eggs in an area.

### Aphids

Aphids rarely overwinter in Saskatchewan. If the wind direction is right, aphids can blow in from the south or the east. If this occurs early in the season, damage can result.

Aphids are the mosquitoes of the plant world; they suck the sap from plants, and they transmit viral diseases. Under warm moist conditions, aphids reproduce at astonishing rates. Early seeding, or later arrival of the aphids, reduces damage as aphids are less attracted to older plants.

### Insecticides

Several insecticides are registered for use in Saskatchewan pulse crops (see specific pulse crop sections for further details). Knowledge about application of each insecticide will enhance activity and optimize use. Insecticides should be used with caution.

### Diseases

Diseases, like weeds, present a challenge to the pulse grower. They can result in substantial yield losses and reduction in seed quality.

• **Control of diseases is most effective if the grower uses an integrated disease management system that includes a good knowledge base of the diseases**

Disease	Field pea	Lentil	Chickpea	Dry bean
<b>Fungal</b>				
Ascochyta/Mycosphaerella Blights	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■	
Ascochyta foot rot	■ ■ ■ ■			
Anthracnose		■ ■ ■ ■		■
Seedling blight	■ ■	■ ■	■ ■ ■ ■	■
Botrytis stem and pod rot	■	■ ■ ■ ■	■ ■ ■ ■	
Sclerotinia stem rot	■ ■	■ ■	■	■ ■ ■ ■
Powdery mildew	■ ■			
Septoria leaf blotch	■			
<b>Bacterial blights</b>	■			■ ■ ■ ■
<b>Viruses</b>	■	■		■

Table 2.7 Diseases that threaten pulse crops in Saskatchewan.

Source from Mantens et al., 1984 and R.A.A. Morrall and A.E. Slinkard, personal communication.

- ■ ■ ■ often causes major economic losses
- ■ ■ widespread and causes significant economic losses when present
- ■ widespread but usually not of economic importance
- infrequent and usually not of economic importance

**and the life cycles of the organisms that cause them, use of disease-free seed, sound agronomy in growing the crop, and the use of fungicides when necessary.**

### **Knowledge of the Diseases**

Good disease management begins with knowing which diseases have spread into an area and how serious each is in a given year. Table 2.7 lists pulse diseases that occur in Saskatchewan. Details of each disease are found in the chapter relating to the specific crop.

**Fungi** are the most common cause of plant diseases. Fungal diseases are spread by microscopic spores (the fungal equivalent of seeds) or mycelia (infection threads). Spores may be dispersed by wind, water, insects and by direct contact. Spores usually require moisture to germinate. Upon germination, spores produce infection threads that enter the plant through small openings on the surface, or by directly penetrating through the plant tissue. Inside the plant, the fungus forms thread-like structures that grow throughout the tissue. These structures absorb nutrients from the plant and cause blockage or tissue breakdown. When the food supply is nearly used up, the fungus often produces more spores and reproductive or survival structures that allow identification of the disease. When conditions are right, spores are produced and released again, followed by germination and infection, and the disease can spread rapidly. Some fungi also produce larger structures as resting stages, such as hard sclerotia bodies formed in the disease sclerotinia, that can remain dormant for a time and then resume growth and infect plants.

Some fungi, such as those which cause powdery mildew in pea, can use only a particular living plant as a source of food and for reproduc-

tion. Removing the host crop can control these fungi. Other fungi, such as *Botrytis*, can cause considerable crop damage, but they are not limited to the crop. These fungi survive and grow on the remains of a variety of plants, and for this reason they cannot be easily eliminated.

**Bacteria** are one-celled organisms, some of which cause plant diseases. They can be spread by infected seed, rain splash, by plant-to-plant contact and by insects. They enter the plant through stomata (pores in the plant surface) or through wounds caused by hail, insects, sand blasting, machinery, etc. **Phytoplasmas** are a special class of disease that can be problematic. They are spread from plant to plant by insects, especially leafhoppers. The leafhopper sucks in the phytoplasmas with the sap as it feeds. The phytoplasmas multiply within the leafhopper, and then infect healthy plants when the insect feeds on them.

**Viruses** also cause plant diseases. Although some viral diseases spread by plant-to-plant contact, many are spread by insects, especially aphids, and a few are transmitted through the seed.

Many **environmental factors** cause unhealthy plant growth. Among these are mineral deficiencies or excesses (including problems from salinity or extreme pH), seed damage, herbicide injuries, ozone damage (from air pollutants), heat canker, sun scald, wind damage, sand blasting, waterlogging, and frost damage.

**Crop monitoring** for early symptoms of disease is important. Disease management may be impossible, if the disease is already widespread in the crop. As with weed management, nothing replaces inspecting the fields. Avoid spreading diseases from field to field. Diseases are much more likely to develop

where free moisture occurs. Places to check are where crop canopies are thick or in low-lying areas of the field where water accumulates. Of course, any dead or weakened patches should also be examined. Environmental factors determine the likelihood and the rate of spread of most diseases. In general, all factors which increase humidity increase the risk of disease. Monitoring is especially important during periods of cool moist weather, if crop residues are retained, or when crop growth is dense.

Diseases evolve in response to **farming practices**. For instance, when Laird lentil was introduced, it was rated as moderately resistant to ascochyta blight, but it is now rated as susceptible because a more aggressive form of ascochyta has developed. The expansion of Laird lentil acreage over the province has provided a large host crop area for successful multiplication of fungi which can successfully infect it.

### Disease Prevention

The most effective way to manage diseases is to prevent or avoid them. A method of choice is the use of resistant varieties. Disease resistance is often a major goal of plant breeding. Ascochyta-resistant lentil and chickpea varieties are excellent examples. Resistance is not available for all diseases in all crops, and each type of resistance can eventually be overcome by evolution of the organisms that cause the disease. Diseases evolve greater aggressiveness, if the disease and crop occur together over a long time. Continued breeding is always required to develop improved disease-resistant varieties.

- **The use of clean seed avoids the introduction of seed-borne diseases into fields.**

Seed testing laboratories can determine the level of infection in a

seed lot. The test is usually run on a sample of 400 seeds. If none of those 400 seeds carries the disease, the result is reported as "none detected". This is not an absolute guarantee of disease-free seed. If only 1 in 1000 seeds were infected at recommended seeding rates for Laird lentil, more than 500 infected seeds would be planted per acre. This is still less of a risk than planting 50,000 infected seeds per acre.

Many diseases overwinter and survive on crop residues. The sooner the residues are removed, or broken down, the sooner the disease source is eliminated. Plowing residues under, or burning them, speeds their breakdown. However, both methods substantially increase the risk of soil erosion. With no-till farming methods, a higher and more prolonged risk of disease spread may occur unless attention is paid to crop rotation.

- **For diseases that persist either in crop residue or in soil, crop rotations are the key to reducing risk.**

Each additional year between susceptible crops in the rotation reduces the likelihood of diseases being carried over from one crop to the next. For diseases that require the living crop for growth and reproduction, extended rotations can eliminate the source of disease. For diseases able to grow on either living or dead plant parts, rotations can reduce the level of disease. The length of rotation needed to break the disease cycle depends on both the disease organism and the management system. If the disease is dependent on crop residues, the tillage system, moisture and temperature determine the rate of residue decay, and, thus, the infective period. If the disease can live in the soil, longer rotations are required to

reduce the level of inoculum in the soil.

Some diseases are unique to a given crop, for instance, ascochyta blight of lentil. Each pulse crop has a unique ascochyta fungus disease. Other diseases, such as sclerotinia stem rot, infect a range of broad-leaved crops.

Expansion of pulse crop acreage increases the likelihood of disease development by increasing the number of fields where diseases can become established. For instance, spores of anthracnose from infected lentil fields can be wind-blown for at least half a mile. Because of this, producers in a lentil-rich area are more at risk from this disease than those who are relatively isolated from other lentil fields.

### **Sound Agronomy**

Crops may be more susceptible to disease when they are weakened by unfavorable weather, physical injury, pesticide treatment, or nutrient deficiency. A vigorous crop is a good defense against disease. All management decisions that influence crop vigour have an effect on the likelihood that the crop can withstand disease.

Whether a disease is severe or insignificant is often determined by the weather. It is possible to change the microclimate within the crop. Some practices reduce the persistence of moisture available within the crop canopy and, thus, reduce spread of the disease. Spring tillage reduces surface residues, and dries out the tilled layer of soil. It also dries and warms the soil and makes it more prone to erosion. Crops seeded at lower rates develop thinner canopies, or develop thick canopies later than those seeded at higher rates. The timing of planting can be important in the spread of disease. For instance, if the only lentil seed available has a high level

of ascochyta, some reduction of seed-to-seedling transmission may be obtained by planting late as the seeds germinate and emerge quicker in warmer soils. This may create additional problems, if late rains promote diseases at a later stage in the life cycle of the crop.

Weeds in a field can harbour diseases and create a thick canopy that favours disease spread. Insects in fields can cause damage that promotes invasion by disease organisms. Good weed and insect management reduces the risk of disease.

Some management practices can increase disease spread. All creatures and vehicles that move through the field, or from field to field, have the potential to spread disease. Activities, such as post-emergent harrowing, rolling, herbicide application, and field scouting, increase the risk of disease spread, if they are carried out when leaves are damp. If disease is suspected, vehicles and clothing should be washed before moving from an infected field to a healthy field. Overhead irrigation, or rain, at vulnerable stages can also increase the risk of disease.

### **Disease Control**

Good disease prevention practices should reduce the need for treating disease. Suppression techniques are needed when other methods have not provided adequate control. Allowing diseases to proceed unchecked is risky. If weather cooperates, most diseases may be substantially reduced. However, with weather favourable to the disease, the disease can reduce yield, produce infected seeds and plant residues, and build up sources of infection, which may cause problems for years. In extreme cases, aggressive disease control is necessary to reduce the spread of disease (e.g. seed growers with a newly introduced crop).

### Biological Control

No biological controls are registered for pulse diseases in western Canada. Viral diseases that are dependent on aphids for spread can be countered by control of the aphids. Ladybird beetles (ladybugs) are voracious aphid-eaters. Often, ladybug populations do not build up in time to provide adequate control of aphids.

### Chemical Disease Control

Several fungicides are registered for use in Saskatchewan pulse crops. Comments on each product are given here, but the user should always read and follow label instructions, whenever fungicides are applied. Current information on the use of fungicides and the recommended rates is contained in the "Crop Protection Guide" published annually by Saskatchewan Agriculture and Food. Similar guides are available in Alberta and Manitoba.

Agrox, Apron FL, Captan, Thiram, and Vitaflo-280/Anchor are registered seed treatments for pea and dry bean to control seed rots, seedling blights, or damping-off. Apron FL is also registered for use in chickpea and DCT for dry bean. Vitaflo-280/Anchor is registered for lentil. Studies in Alberta and Saskatchewan have failed to show consistent advantages to treating pea seed with these products. An advantage may occur when the seed is planted into cool, wet soil or if poor quality seed is used. Crown is a registered lentil seed treatment for control of seed-borne ascochyta, as well as seedling blight and seed rot. It is also effective on seed-borne botrytis.

Bravo is a foliar fungicide registered for control of anthracnose in lentil and ascochyta blight in lentil, pea and chickpea. Bravo does not cure infected plants, but protects

plants from infection. It is effective only if used as the crop comes into flower, when symptoms are few and scattered or even before the detection of symptoms. Many producers apply Bravo too late to get maximum benefit. Once the disease is widespread, fungicide application provides little benefit. A producer can determine the relative risk of disease by considering previous crops, the results obtained from seed test labs, and the relative risk in the geographic area. The cost/benefit ratio is greatest for pedigreed seed fields in years with a rainy period during the start of flowering. For instance, in southern Manitoba, anthracnose of lentil is very likely to develop, whereas in Saskatchewan, at present, it is not. However, nothing can replace careful inspection of a young crop on a frequent and regular basis.

Kumulus is registered for powdery mildew control in pea. Like Bravo, it is a protectant chemical rather than a cure for the disease. Benlate, Ronilan EG and Senator 70WP are registered for sclerotinia control in dry bean. Application at an early stage of the disease and good foliage coverage are necessary for disease control. Bacterial blight in dry bean can be controlled by Champion WP, Clean Crop Copper 53W, and Kocide DF, Clean Crop Copper 53W is also registered for control of anthracnose and downy mildew in dry bean.

### Irrigation

Not all pulse crops are suited to irrigated production. Pea and dry bean can be successfully produced under irrigation. Some lentil varieties can be produced with extreme care. Chickpea is unsuitable for irrigation. In general, pulse crops are not tolerant of flooding. Most pulse crops have an indeterminate growth habit, and under irrigation, plant

## 2.18 General Production

**Table 2.8** Recommendations for irrigated pulse production.

	Pea	Lentil	Dry bean
Seeding rate - lb/ac (kg/ha)	Variable-depends on seed size	30 – 40 Eston (34 – 45)	67 (75)
Target plants/m <sup>2</sup>	72	80	35
Earliest seeding date	April 20	April 20	May 20
Moisture use - inches (cm)	28 (70)	15 (38)	18 (46)
Critical stage	Flowering to mid-pod fill	Flowering to mid-pod fill	First 2 weeks, flowering to early pod fill
Discontinue irrigation	mid to late pod fill	3rd to 4th week of July	August 10
Rotation to pulse	Minimum 4 years	Minimum 4 years	Minimum 3 years
Rotation to broadleaf crop	Minimum 4 years	Minimum 4 years	Minimum 3 years
Average yield – lb/ac (kg/ha)	3000 (3365)	1500 (1680)	1750 (1960)

Source From SWC 1992, A.E. Sillikard, personal communication.

growth will be promoted rather than seed production. Continuing vegetative growth assures that the crops will not mature within the limited growing season in Saskatchewan. Lush vegetative growth provides an environment that fosters the development and spread of disease. Growers with experience in irrigation and in pulse production can succeed, if care is taken to select appropriate varieties and to avoid over-watering.

Refer to Chapter 3./Variety Selection for pea varieties recommended for irrigation.

In general, production recommendations follow those for dryland production, except that fertilizer requirements may be higher, crop maturity may be delayed, and disease management, especially for sclerotinia, is much more important. Table 2.8 gives a summary of irrigation recommendations. Risk is reduced by the use of disease-free seed and longer rotations to avoid disease carry-over. Seeding rates are generally lower, again, to reduce the spread of disease.

Irrigation before seeding is recommended if the seedbed is dry. Large-seeded pulses require adequate moisture for germination, but are sensitive to waterlogging, cold soils, and seed rot. Irrigation

between seeding and seedling emergence is not recommended. Over-irrigation during the vegetative stages can delay or prevent flowering in pulses with strongly indeterminate growth. The additional vegetative growth increases disease potential and lodging, and results in decreased yield. Irrigation to reduce moisture stress during flowering and early pod fill is necessary for maximum yield. In pulses, extended irrigation will delay maturity. In general, irrigation should be discontinued at mid to late pod fill, often in late July or early August.

### Harvest

Many pulse crops have an indeterminate growth habit, which means that they will continue to flower and produce pods until they are stopped by some stress. Plants may still be actively growing and flowering when the first pods are ripe, and ready to shatter. Harvest timing is a compromise between increased yield from the younger pods and increased losses from shattering of the older pods. The optimal time for harvest is usually before shattering losses occur, because young pods are at greater risk than the mature pods for weather, disease, and insect damage. If the weather is warm, windy or dry,

the crop can mature very rapidly. Walking the field daily will improve the chances of the grower selecting the right time to harvest.

Complete crop dry-down is unlikely before the optimal harvest time for most pulse crops in most years. Crops often do not dry down uniformly in the field. Uniform, quick dry-down is generally accomplished by either swathing or the use of a desiccant.

### Desiccation

Desiccation reduces the risks associated with swathing, such as wind movement of the swath and disease and sprouting of the crop in the swath. Desiccated crops remain standing and dry more quickly after a rain than do swaths and generally retain better seed quality.

Chemical products registered for pre-harvest application include Reglone and glyphosate (Roundup, Renegade, Victor, Glyfos).

**• Glyphosate formulations are recommended for pre-harvest management of perennial weeds (see Chapter 5./Weed Control). This will reduce the amount of green material going into the combine, but glyphosate is not an effective desiccant.**

The drying of the crop following glyphosate application is slow and inconsistent, and may not occur at all. In addition, early application can cause crop loss or residues that interfere with seed germination and seedling vigour.

Desiccants speed the drying of the crop, but do not speed maturation. If the desiccant is applied before the crop is mature, it will dry the foliage, but will not mature the seed. Desiccation is often used in dry green food peas to facilitate harvest at 20% seed moisture with minimal loss of the desired green colour.

Lentil crops are mature when the bottom 10 to 30% of the pods are brown and dry, but not split. Seeds in the bottom pods are hard and rattle in the pods. Pea crops are mature when seeds in the bottom pods are detached and loose in the pods, and when the upper pods are turning yellow. Bean crops are mature when 80 to 90% of the leaves have dropped off. In Saskatchewan, light frost often acts as a natural desiccant.

Reglone is registered for desiccation of lentil, pea, and dry bean crops. The optimal timing for use of Reglone is at 25 to 35% seed moisture. The crop usually can be harvested in 4 to 7 warm, dry days after application. Seed and seedling quality are not affected. Both ground and aerial application are registered.

Losses from wheel tracks can look substantial, but studies at Scott have indicated that high-clearance, narrow-tired, 60 ft (18 m) sprayers cause on average 1% yield loss per wheel track.

### Swathing and Straight Cutting

To avoid excessive shattering losses, pulse crops must be swathed or straight cut at the correct stage and seed moisture content. In general, pulse crops should be cut when the straw is "tough" to reduce crop losses (Table 2.9).

Rolling after seeding makes swathing or straight cutting easier since rolling levels the soil surface and pushes small stones into the ground, reducing damage to the cutterbar. Rolling later than 14 days after emergence is not recommended for chickpea because of excessive crop damage.

Conventional swathers and straight-cut headers are not

## 2.20 General Production

**Table 2.9** *Timing of swathing and combining pulse crops.*

Crop kind	Moisture content	Colour of crop seed &/or seed at cutting stage	Quick test for proper moisture content at combining	Registered desiccant	Other important notes
Yellow pea	16% dry and safe for storage	Swath when pods and vines are yellow coloured. Vines are prostrate.	Thresh when seeds are firm and can no longer be penetrated with thumbnail. 20% moisture content or lower.	Reglone	Some shatter loss usually occurs. Mixing soil and juicy weeds with pea seeds can cause earth-tagging – a down-grading factor.
Green pea	Same as yellow	Swath when pea plant mature and the seed has a good green colour. Pea vines are yellow coloured. If desiccating, apply when vein pattern of upper-most pods is easily recognized and 75 – 90% of the pods have turned to yellow tan.	Seeds are firm, but no longer penetrable with thumbnail. Pea vines may or may not be prostrate depending on variety and conditions. Combine at 18 – 21% moisture and aerate for food grade, unbleached dry green seed.	Reglone	2% bleached pea seeds is maximum. Bleached seeds are caused by high humidity, bright sunshine, and warm temperatures during final maturation stage.
Feed pea	Same as yellow. Some companies accept 17% moisture content.	Swath when pea vines are yellow coloured. Vines are often prostrate.	Seeds are firm, but no longer penetrable with thumbnail. Combine settings and operation not as critical for feed pea as for human food pea. Admixtures of various pea kinds allowed.	Reglone	Any amount of bleached, cracked, or split pea seeds, and earth-tagged pea seeds is accepted for feed pea.
Lentil	14 – 16% for short term storage, 14% is dry for long term.	Swath when lower-most pods are tan coloured and rattle when shaken.	Thresh when seeds test 18% moisture content or lower. Over dry lentil (9 – 13%) are hard and difficult to bite.	Reglone	Plants may still be green when pods are ripe. Crop typically matures in patches. Some shatter loss usually occurs.
Chickpea	15% or less for safe storage	Swath when all pods are yellow coloured. Direct-cut harvest preferred.	Thresh when seeds test 18% moisture content or lower.	None	Severe cracking can occur with over dry seed (<13%). Rough handling can significantly reduce germination of kabuli.
Dry bean	16% for safe storage	For straight cutting of pinto bean with flex header and air reel; pods and vines should be dry and yellow. For under-cutting, start at 50% buckskin stage.	Difficult to penetrate seed with thumbnail.	Reglone	Weed control critical for straight cutting. Shattering losses are within acceptable limits if proper equipment is used

designed to cut low-growing pulse crops as the headers are unable to cut closer than about 3 inches (7.5 cm) from the soil surface and, therefore, miss the pods on the lower parts of the crop. Swather or straight-cut header modifications can substantially improve the efficiency of the cutting operation and reduce seed losses. Suggested modifications to the system include header adjustments, use of a pickup reel, addition of vine-lifter guards, and the use of a floating cutterbar or flex header.

Adjusting existing header floatation springs by adding additional springs to increase floatation, using a floating or flexible cutterbar, or addition of adjustable gauge wheels and poly skid plates will keep cutterbar damage to a minimum. Use a narrow swather or header on uneven terrain. The pickup reel substantially improves harvesting of pulses and should be used in combination with vine-lifter guards. Proper adjustment of the pickup reel is important to obtain the maximum possible lifting action. This setting will differ considerably from the setting used for cereal crops. The cam action of the pickup reel should be adjusted so it has a positive lifting action and the reel should be positioned as far ahead of the cutterbar as possible.

Vine-lifter guards greatly improve the swathing of lentil and pea by lifting the vines and pods up to the cutterbar (Figure 2.1).

The addition of rigid lifters can reduce lentil swathing loss from 5% to less than 1% compared to a swather without lifters and allows faster travel speeds. Rigid lifters (attached rigidly to the cutterbar) perform better over a wide range of operating conditions as they penetrate the soil to lift completely flattened vines. In contrast, skid lifters are hinged and allowed to float.

When needed, growers modify them to ensure they do not float over the lowest vines and cause losses. In taller crops, longer and taller lifters perform better, whereas shorter lifters perform better in short and medium-height crops.

Vine lifters should be spaced between 9 and 12 inches (23 and 30 cm) apart on the cutterbar. Wider spacing results in missed vines and spacing less than 9 inches (23 cm) causes plugging between the lifters. Lifters must be adjusted (shimmed) to match the angle of the guards so the tip of the lifter just touches the ground with the swather header fully lowered.

Pea and lentil plants often cause gumming due to the juice associated with cutting green plants and weeds and the presence of soil from cutting close to the ground (Figure 2.2). The buildup of gum on the cutterbar results in a decrease in clearance between the cutting surfaces of the knives and adds resistance to knife movement. In most pea and lentil fields, the knife must be cleaned about every 10 hours to maintain cutting effectiveness and to avoid knife damage. A thorough brushing with soapy water every few hours may be adequate.

The direction traveled while cutting the crop can also make a difference to the effectiveness of the pickup reel and lifters, especially if the crop has a prevailing lean. Often, it is advisable to cut the fields so that the cutting direction is perpendicular to the direction of crop lean as the lifters will then be more effective.

### Threshing

Pulse crops are highly susceptible to mechanical damage from harvesting. This damage can be in the form of cracking, splitting, and germination damage.

Pulse crops should be handled gently to reduce seed damage.



Figure 2.1 Vine lifters.



Figure 2.2 Knife gumming.

Source Pulse Manual 1997, 2-36

Source Pulse Manual 1997, 2-36

## 2.22 General Production

**Table 2.10** Number of weeks for safe storage of pea at the specified grain moisture content and storage temperature.

Storage Temp. (°C)	Moisture content (%)				
	12	14	16	18	21
25	31	16	7	4	2
20	55	28	13	7	4
15	100	50	20	12	6
10	200	95	38	20	21
5	370	175	70	39	20

Source: Sokhansanj, 1995

Cylinder or rotor speeds should be kept to a minimum with maximum concave clearance, especially with larger seeds.

Chaffer and cleaning sieves should be adjusted to the specifications required for each pulse crop. However, with all pulses the sieves should be adjusted to minimize tailings as re-threshing will increase cracking, splitting and germination damage.

High chaffer air flow can be used with all pulses, except lentil, as heavy seeds will not blow out of the back of the combine and this will result in a cleaner sample. Lentil seeds are flat (oval) and are easily blown out, so wind speed should be adjusted to allow maximum cleaning without seed loss.

Elevators should be properly adjusted as too loose an adjustment increases the chance of cracking seed. Combine unloading augers should be run full at a slow speed to minimize seed damage.

### Post Harvest

#### Drying and Storing

To reduce harvesting losses and maintain optimum quality, pulse crops are often harvested at moisture contents above the safe level for storage. As a result, pulse crops must be dried to preserve the quality of the product. Pulse seeds often undergo a "sweat" when first placed in the bin. The bin should be aerated for several days unless the seed

was dry (< 14% moisture) and cool (< 20°C).

Research conducted by Dr. Sokhansanj showed that for safe storage pulses must be dried to less than 14% moisture content and cooled to less than 15°C for prolonged storage (Table 2.10).

Pea seeds at 18% moisture content can be stored for 20 weeks at 10°C, but only for 4 weeks at 25°C. Warm grain must be cooled immediately following binning, even when the moisture content is low. Cooling with an aeration system usually takes less than one day. However, in-bin drying with unheated air may take 3 or 4 weeks. The recommended airflow volume for bins is about 1 to 2 cubic feet of air per bushel per minute, or about 2000 to 4000 cubic feet per minute for a 2000-bushel bin.

The fan must be able to provide the required air flow by overcoming the resistance of the grain to airflow. The resistance of grain to air flow depends on grain size, with lower resistance for large seeds such as pea and bean, and higher resistance for smaller seeds such as lentil. At typical airflow rates, lentil seeds have about 18% less resistance to airflow compared to wheat seeds while pea seeds have about 75% less resistance to airflow than wheat seeds. Though airflow will be higher, the rate of drying depends on other factors including air temperature, humidity, and the rate of movement of moisture out of the seeds. As such, drying must be carefully monitored to prevent over drying.

The aeration floor or perforated tube layout will affect the distribution of air through the bin. A fully perforated floor will provide more even air distribution compared to systems that only cover part of the floor area. Partial perforation systems may result in drying of the seed in one

part of the bin and damp seed in other parts, which can lead to storage problems. In addition, when pulses with high dockage are binned, the dockage concentrates in the centre of the bin and air flow is reduced in that area. This leads to a high localized concentration of moisture and problems with storage. Cleaning the seed prior to storage or using a distributor in the bin will help to reduce local high moisture concentrations.

Storing pulses under high humidity can result in the crop absorbing moisture. Conversely, under dry conditions pulse crop seeds lose moisture more readily than wheat or canola seeds. As the climate in western Canada is primarily dry, stored pulses may dry to a percentage moisture that is likely to result in cracking or splitting in any subsequent handling process. The seed moisture should be checked prior to handling stored pulses and, if too low, moisture can be added to the seed to reduce handling damage. Refer to PAMI report #704 Research Update: Moisturizing Pulses to Reduce Damage for information on raising the moisture content of pulses.

Mould growth can be a problem in the storage of pulses. Some micro-organisms will grow at relative humidities as low as 70% and at temperatures as low as -2°C. Using aeration in the winter should allow pulses to be cooled and reduce the relative humidity in the bin to safe levels.

Drying pulses with heated air must be done with caution. Hot pulses are extremely susceptible to breakage in recirculating drying systems and while augering out of the dryer. The damage can be reduced by using low drying temperatures and cooling the seed prior to augering from the dryer.

**• Drying temperature should be limited to a maximum of 45°C and at moisture contents above 24% the maximum drying temperature should be 38 to 40°C.**

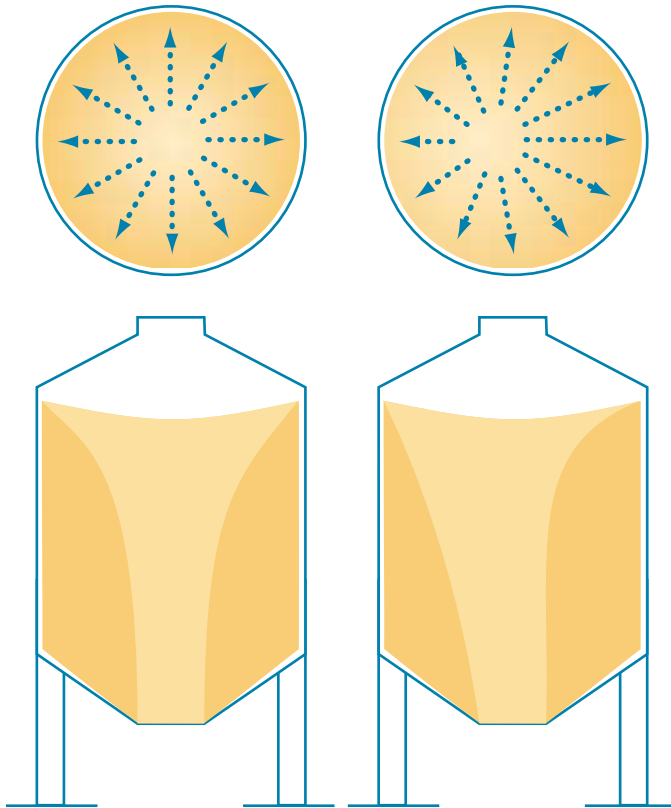
Due to the slow drying process in the large seeds of pulses, drying high moisture seed may require two or more separate drying operations to prevent cracking of the seed. If the pulse requires a reduction in moisture of 10%, the drying should take place in two or three passes through the dryer with a minimum of 8 hours between passes to allow the moisture in the seed to equalize. Larger seeds, such as chickpea and bean, require 24 hours between drying operations.

If pulses are stored for extended periods, the seed should be cooled in the fall in stages until the entire bin is cooled to 0°C. In spring the pulse should be aerated in stages until the temperature is raised to about 10°C. In summer, the seed carried over should be periodically aerated during fair weather when the outside temperature is lower than the grain temperature. These measures prevent air currents and wet spots caused by the natural circulation of air and condensation within the bin.

Grain storage structures are designed for center loading and unloading. Off center loading and eccentric unloading cause large non-symmetric pressures on the bin wall. These pressures induce bending forces on the bin wall that often lead to bin wall denting and collapse. Figure 2.3 shows two cases of unloading. In Case A, grain is unloaded uniformly from the center and the pressures are distributed evenly around the circumference of the bin. In Case B, the bin is being unloaded off-center. The result is a non-uniform circumference load on the bin wall.

## 2.24 General Production

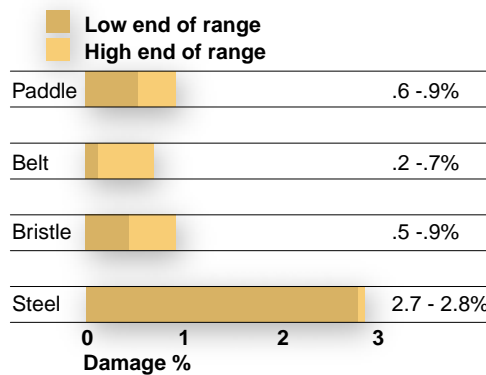
Figure 2.3 Bin unloading and loads on the bin wall.



Source Pulse Production Manual, 1997, 2-38

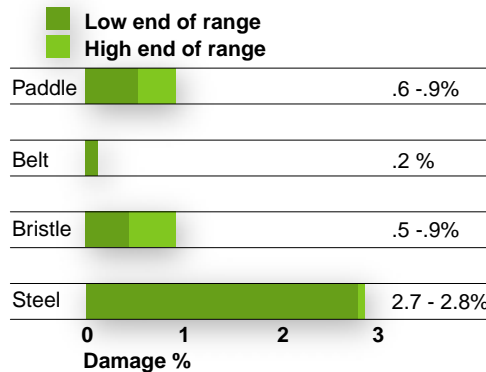
Eccentric unloading can be caused by improper design of the unloading gate, caking and crusting of stored grain, or non-uniform flow within the bin caused by bean ladders or other obstructions. The use of bean ladders must be done in close consultation with the bin manufacturer. The following are a few points that must be considered to prevent bin failure due to eccentric unloading: (a) the bean ladder should not impede the free flow of grain; (b) provide stiffeners for the bin wall, especially at the cone-cylinder junction and where the ladder is connected to the floor; (c) provide air vents to prevent moisture accumulation and possible crust development; (d) provide adequate support for the bean ladder; (e) minimize grain impurities; (f) check the bin periodically for moisture, temperature, and any grain shrinkage and possible consolidation; (g) seek professional engineering services for planning and installation of grain handling systems.

Figure 2.4 Damage to lentil seeds from various types of conveyors.



Source PAMI Research Update 660

Figure 2.5 Damage to pea seeds from various types of conveyors.



Source PAMI Research Update 660

### Handling

Damage to pulses during handling and processing can significantly reduce the grade and value of the crop. In addition, non-visible damage can occur with pulses that can significantly affect germination of the seed.

Pulse crops are very fragile and are extremely susceptible to injury at low moisture levels. However, mechanical injury can also occur at moisture levels normally considered safe.

As a general principle, pulse crops should be handled as little as possible and with great care to reduce damage. Mechanical damage is much higher with dry seed. Raising the moisture content of the seed, combined with the proper operation of equipment and/or using specialized conveying equipment, can be used to minimize damage.

**Table 2.11** Physical characteristics of pulse seeds in western Canada.

Pulse	1000-seed mass (g)	Specific gravity	Bulk density (lb/bu)	Porosity fraction (mm)	Length (mm)	Thickness (mm)	Spherical equivalent diam. (mm)	Sphericity fraction
Field pea	219	1.27	65.6	0.37	7.6	6.8	6.5 – 7.9	0.99
Laird lentil	70	1.43	60.7	0.47	7.0	2.8	6.3 – 7.4	0.73
Eston lentil	33	1.40	61.0	0.45	4.8	2.5	4.1 – 4.9	0.78
Desi chickpea	248	1.25	61.9	0.38	8.7	7.0	6.3 – 9.7	0.88

The type of conveyor can substantially reduce seed damage. With both lentil and pea crops, damage was at least double with a typical steel flighting auger compared to paddle, bristle flighting and belt conveyors (Figures 2.4 and 2.5).

Dropping of the seed from conveyors is another source of pulse damage. Augers should be adjusted to minimize drop height of the seed. When the pulse seed must drop long distances, such as in processing plants, bean ladders should be used to slow down and soften the impact of the seed. Bean ladders are devices attached to the end of conveying systems, which direct the seed in a zigzag direction to reduce velocity and reduce impact damage to the seed. The bottom of the bean ladder must be far enough above the bin clean-out that the bin contents empty in a symmetrical and unimpeded manner. Any asymmetrical flow of seed during bin emptying may result in warping and bursting of the bin.

### Seed Cleaning and Grading

Seed cleaning involves removal of undesirable particles from a grain lot. Grading, on the other hand, involves classifying the grain into different grades, usually based on seed quality. Pulse grading follows the cleaning operation, usually in one cycle.

Conventional cleaning equipment is based on physical characteristics of the seed. Air classification is used to separate the components of a mixture of seed and its undesirable contents based on density (specific gravity based on density relative to water).

Seed cleaning is also done based on the length, width, and thickness of the seed. Length is the longest dimension, width is the intermediate dimension, and thickness is the shortest dimension. Wheat seed has a clear dimension to it, whereas pea seed is recognized by one dimension (diameter), or lentil can be recognized by two dimensions (diameter and thickness). In practice, sieves with round holes are used to separate seeds for their width, slotted holes are used to separate seeds based on their thickness and indents are used to separate seeds based upon their length.

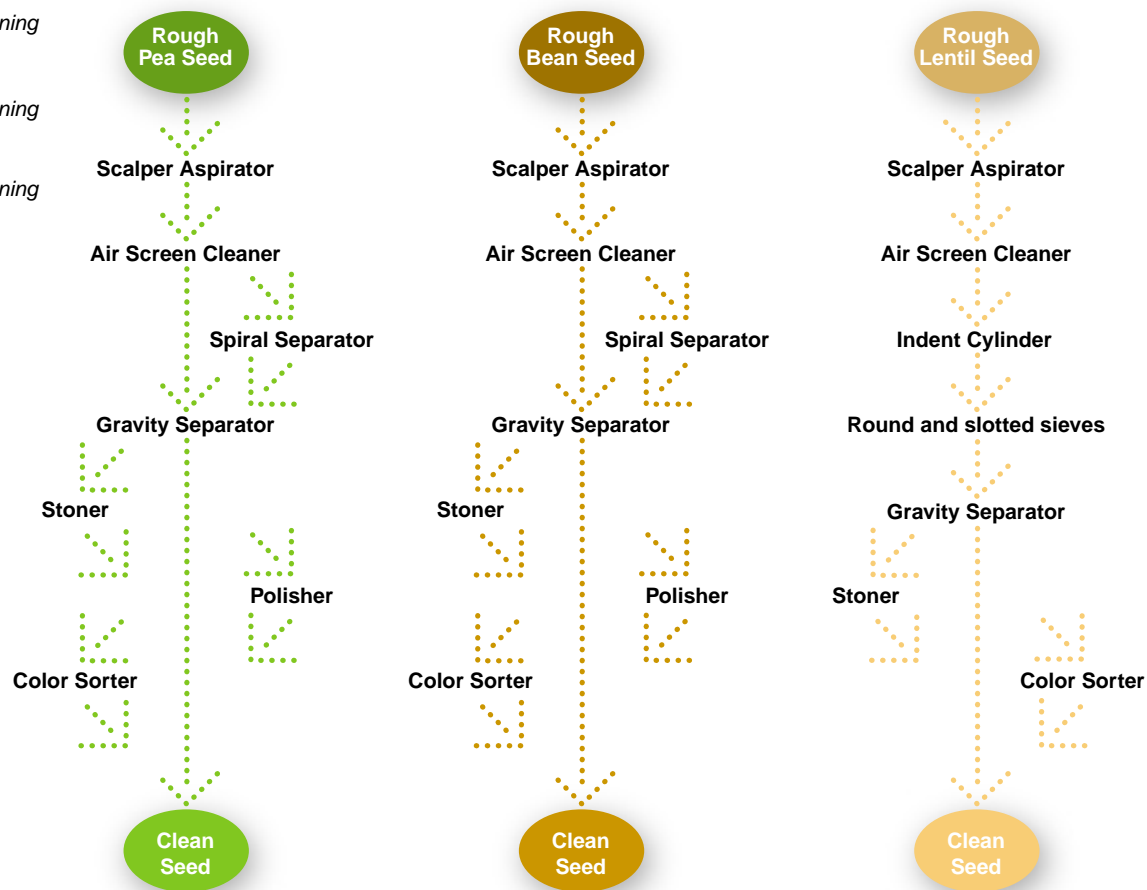
Other devices are used to separate seeds, based on a combination of properties or more unconventional properties. For example, gravity tables are used to clean and grade seeds, based on their shape, density, size, and surface characteristics. Color sorters are used to separate the seeds, based on their color-reflecting property. Velvet rolls or belts are used to sort seeds based on surface texture of the par-

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**Figure 2.6** Sequence for cleaning and sorting pea seeds.

**Figure 2.7** Sequence for cleaning and sorting bean seeds.

**Figure 2.8** Sequence for cleaning and sorting lentil seeds.



ticles and spirals sort seeds based on their friction and rolling characteristics. Table 2.11 lists some physical properties that are important in the selection of equipment for seed cleaning and grading.

Figures 2.6, 2.7 and 2.8 show sequences, which are used to clean pea, bean and lentil seeds. All sequences start with a scalper aspirator to remove large, unwanted trash and fines. The scalper is based on the overall size of the seed and airflow. This pre-cleaning makes the workings of the subsequent machines easier.

Air screen machines are based upon seed size and airflow, but the motion of the mix through the machine is more precisely controlled. Several sieves may be required for a complete clean out of

the seed. Pea seeds might be completely cleaned on these machines. Disc separators and indent cylinders are more precise machines than the previous one. They separate and grade seeds based on their length. Disk separators and indent cylinders can be adjusted in many ways and with a proper adjustment, a high degree of cleaning can be expected.

Contaminants in a lot that have a size similar to the seed, but are of different specific gravity, can be separated on a gravity table. The seed mixture is fed onto a perforated table, the air blowing through perforations keeps the mixture fluidized, while an oscillating/vibrating motion stratifies the material and separates the heavy seeds from light ones. The material is divided into several fractions and, each individually col-

lected at the other end or at the side of table. Gravity tables are quite versatile machines, but require experienced operators to run at their peak efficiency. At least nine variables can be adjusted in a well-designed gravity table. The most important variables are degree of oscillation; rate of vibration; airflow; slope and direction of the deck; decking configuration and decking material; number of output spouts, loading rate on the deck, and the location of the unloading dividers.

Color sorters are sometimes used as final equipment to separate seeds based on their reflective (color) characteristics. In these devices the seed is fed into the machine in single file (or channel). One or a series of light diodes emits a filtered light onto the seed as the seed passes through the detector ring. The reflected light from the seed is compared electronically to the reflected light from a reference plate. The seed is ejected from the stream by a mechanical means, if its reflected light is different from the reference. The mechanical ejector is usually a pressurized air nozzle and may pulsate at a maximum rate of 70 ejections per second. The amount of air per ejector may be as much as 0.75 cubic feet per minute.

Factors that affect the operation of a color sorter are: loading rate, i.e., the rate seed flows against the sensor light; electronic settings; ambient light (or background light); dust accumulation on lights and reflector plates; vibrations, and type and degree of discoloration on the seed. The capacity of color sorters can be increased by adding channels and the size of a channel controls the grain size. For larger seeds, such as Laird lentil, rollers are used to guide the seed through the detector ring. Slider channels are used for small seeds.

### Land Management

Pea, dry bean, lentil, and chick-pea plants are cut close to the ground and leave very little standing plant residue. After harvest, fields without plant cover are at higher risk from erosion. Responsible soil management includes some provision for reducing the erosion risk on susceptible land. If moisture is adequate and the season sufficiently long, fall-seeded cover crops may be beneficial. Cover crops of wheat, barley, or oat can be seeded at reduced rates (e.g., 1 bu/ac, 67.25 kg/ha) and achieve sufficient growth to provide cover before being killed by fall frosts.

Wind barriers can reduce wind erosion. Field shelterbelts effectively reduce wind speeds for approximately 700 ft (215 m) down wind. Annual strips (taller crops, seeded in rows 50 to 60 ft, or 15 to 18 m, apart) can be used to reduce wind speeds in the crop, and to trap snow over winter (Figure 2.9). Strip cropping can be effective in reducing field size and, therefore, the exposed land area.



**Figure 2.9** Use of annual barriers to reduce erosion and trap snow.

Source: Pulse Production Manual 1997