

7/Lentil



Lentil QuickTips



Seeding Rate	Target 12 plants/ft ² (130 plants/m ²). (40 lb/ac or 45 kg/ha, Eston) (53 lb/ac or 60 kg/ha, CDC Richlea) (80 lb/ac or 90 kg/ha, Laird).
Seeding Depth	1.5 to 3 inches (3.8 to 7.6 cm).
Seeding Date	Mid-April to early May.
Recommended Varieties	Laird is standard, but being replaced. CDC Richlea, CDC Vantage and CDC Milestone are highest yielding. CDC Milestone for irrigation. Indianhead for green manure.
	Ascochyta Resistant CDC Glamis, CDC Grandora, CDC Sovereign, CDC Vantage, CDC Milestone, CDC Robin, CDC Redcap, CDC Redwing.
	Best Resistance to Anthracnose CDC Robin
Best Performance	On cereal stubble in the Dark Brown soil zone.
Rolling	Up to 5-node stage.
Registered Herbicides & Registered Fungicides	Refer to Table 5.6 (Weed Control), Table 7.6 or the Saskatchewan Agriculture and Food Guide to Crop Protection.
Rotational Frequency of Lentil Production For Disease Control	4 to 5 years for anthracnose; 3 to 4 years for ascochyta.
Swathing or Desiccation	1/3 of bottom pods turn yellow to brown and seeds rattle when pods are shaken.
Direct Harvesting	16 to 22% seed moisture.
Storage Moisture	14%

7/Lentil Production

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Lentil

Introduction

Lentil was one of the earliest cultivated crops in the world with archeological evidence from the early Stone Age. India leads the world in lentil production, and most of the lentils are consumed by India and its neighbours. The Palouse area of Washington and Idaho was the main area of lentil production in North America after WW II, but Canada began production in 1969 and soon surpassed these areas. Currently, Canada and Turkey are the world's largest lentil exporters. Saskatchewan produces about 97% of the Canadian lentil crop and the rest is produced in Alberta and Manitoba.

Historically, lentil was widely used in India, Southwest Asia, and the Mediterranean areas in the form of split lentil (dhal) and it is still an important source of dietary protein in these areas. Lentil contains approximately 22% protein, and is high in fibre, Vitamin A, calcium, starch, iron, phosphorus, copper and manganese. While the lentil seed is used mainly as food, the straw can also be used as a high quality animal feed or as a source of organic material for soil improvement. The chemical composition of lentil is shown in Table 7.1.

Lentil production provides a number of advantages to producers.

- **It can be used to diversify and lengthen the crop rotation, which reduces disease pressure in other crops and has weed control advantages.**

- **Lentil also improves soil tilth and reduces the requirement for nitrogen fertilizer.**

Lentil prices vary, but net returns are often higher than those obtained from wheat. On the prairies, lentil yields range between 450 and 2500 lb/ac (500 and 2800 kg/ha), with an average yield of about 1200 lb/ac (1345 kg/ha).

Table 7.1 Average concentration of major nutritional components in lentil seed and straw for livestock rations.

Lentil	Seed	Straw
Protein (%)	22	6.4
TDN (%)		44 – 46
D.E. (swine) (Kcal/kg)	3250	
Calcium (%)	0.10	0.65
Phosphorus (%)	0.39	0.20
Crude fibre (%)	4.80	
Fat (E.E.) (%)	1.50	
Lysine (%)	1.60	
Methionine + cystine (%)	0.48	

Individual samples are required for more accurate analysis.

The Lentil Plant

Lentil is classified into two groups by seed size. The large-seeded Chilean type has a seed size that averages 50 grams or more per 1000 seeds. The small-seeded Persian type has a seed size which averages 40 grams or less per 1000 seeds. For both types of lentils, the seeds are lens-shaped which is the source of the name lentil. Seed coat colours range from clear to green, brown, grey, blotched purple or black. The cotyledons can be yellow, red, or green (Figures 7.1.1 - 7.1.7).

The lentil seeds remain under the ground after germination. This offers some protection to the young seedling. If the main shoot is damaged above ground by a late spring frost, heat canker, or Sencor/Lexone (metribuzin) burnoff, the plant can regrow from buds (at the second scale node) below ground. The first two very small nodes are known as scale nodes (Figure 7.2). The first scale node is typically below the soil surface. The first leaf usually develops at the third node position, and new leaves are produced on succeeding nodes on the stem every 4 - 5 days under good growing conditions. The number of leaflets per leaf will vary from 9 - 15.

Lentil plants are typically short, but with variations in crop conditions

Figure 7.1.1 CDC Glamis Lentil

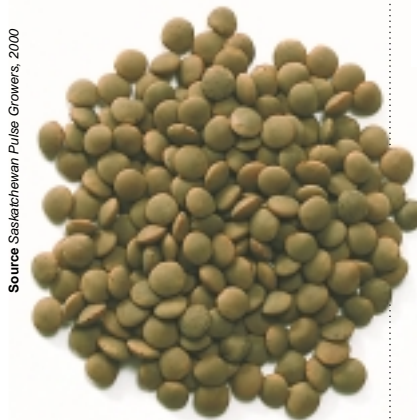


Figure 7.1.2 CDC Milestone Lentil



7.4 Lentil

Figure 7.1.3 CDC Robin Lentil



Source: Saskatchewan Pulse Growers, 2000

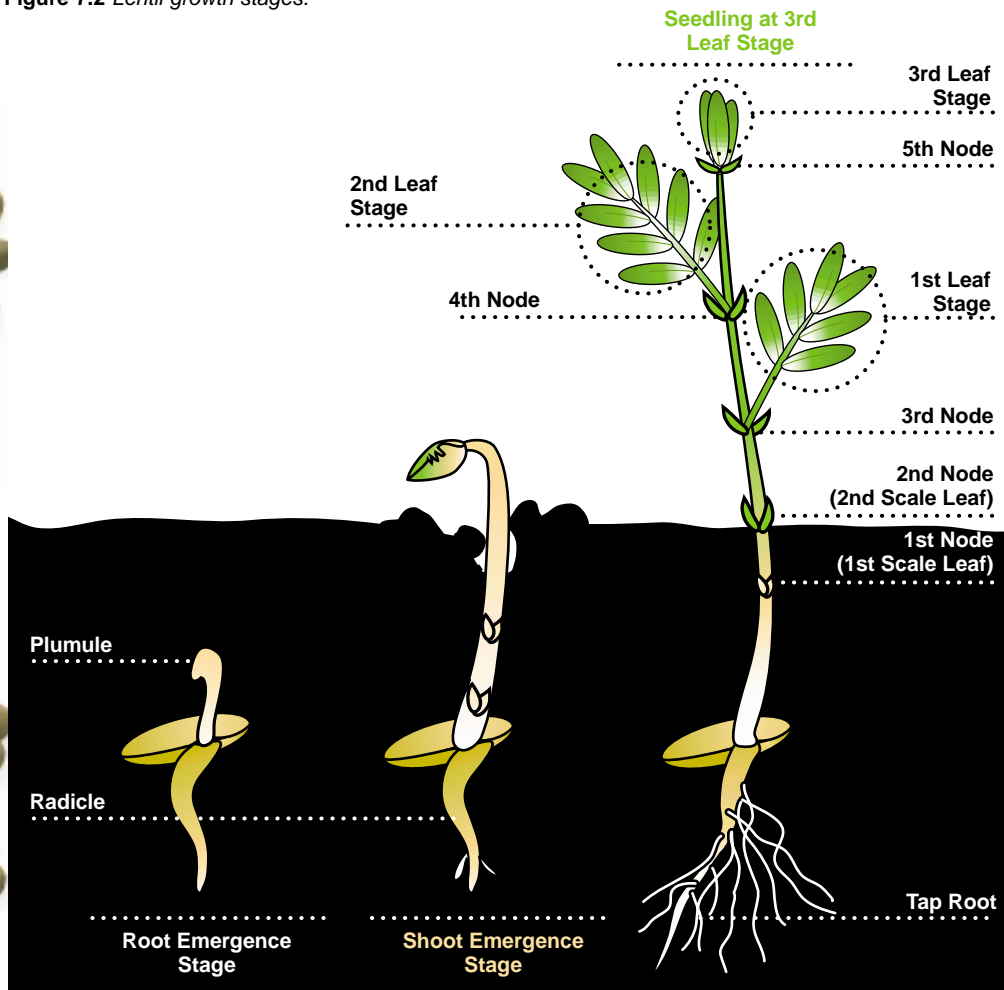
Figure 7.1.4 Crimson Lentil



Figure 7.1.5 Laird Lentil



Figure 7.2 Lentil growth stages.



and variety, height can range from 8 to 30 inches (20 to 75 cm).

Just before flowering, leaves start to produce a tendril at the leaf tip. Early maturing varieties such as Eston, flower at about the 11th or 12th node stage. Later maturing types, such as Laird, flower at the 13th or 14th node stage. Flowers are self-pollinated so they do not require insects for pollination or seed formation. The flowers are borne on short flower stalks at the base of the upper leaves in clusters of 2 to 3 flowers per flower stalk. The first few flower clusters on the main stem often shrivel without seed formation (flower abortion). This is especially likely to occur if

conditions favour vegetative growth over seed production such as occurs with good moisture and high nitrogen fertility.

- **Lentil plants have an indeterminate growth habit. Plants continue to flower until they encounter some form of stress, such as drought, heat, frost, nitrogen deficiency, mechanical damage, or chemical desiccation.**

Seedpods are small, usually less than 1 inch long (2.5 cm), and generally contain 1 or 2 seeds. Vigorously growing lentil plants with adequate space will produce two or more primary shoots from the base of the stem. However, the main contribution to seed yield is made by

secondary (aerial) branches that arise from the uppermost nodes of the main stem just below the first flowering node. Up to five aerial branches may develop on the main stem. When growing conditions are suitable for an extremely high yield, the secondary branches also produce additional seed-bearing branches.

Adaptation

Lentil is a cool season crop with moderate resistance to drought and high temperature. The crop performs best on level or slightly rolling land with a soil pH of 6.0 to 8.0.

- **Lentil plants do not do well on waterlogged soils and will not tolerate flooding or salinity.**

- **Although lentil plants are somewhat drought tolerant, they do require at least moderate moisture (6 to 10 inches, or 15 to 25 cm) during the growing season to produce a full seed set.**

Excess moisture before the plant is in full bloom can delay and reduce seed set, and excess moisture near the time of harvest encourages the spread of fungal diseases. Lentil plants are short and must be cut near the soil surface, so fields should be free of surface stones and dirt lumps. To obtain the best surface possible, a land roller is used to smooth the soil surface after planting.

- **Lentil seedlings are tolerant of light frost (-4°C), and can regrow from the scale nodes below the soil surface if early frost damage is severe.**

- **Frost in late summer or early fall will damage young pods and immature seeds.**

In the **Brown** soil zone:

- **Lentil performance is best on fallow on medium to fine textured soils, or when grown under irrigation.**

Table 7.2. Crop yields obtained on stubble and fallow cropping systems in the Brown soil zone over six years.

Crop	Fallow	Stubble	Stubble/Fallow
	lb/ac (kg/ha)		%
CWRS Wheat	2580 (2892)	1700 (1906)	66
Lentil	1380 (1547)	1090 (1222)	79

Results from Swift Current indicate that lentil can be successfully grown on stubble in the Brown soil zone, however yields will be lower than when grown on fallow (Table 7.2). Growers planting lentil on stubble fields in this soil zone should consider a direct seeding system or agronomic practices that minimize spring soil disturbance.

In the **Dark Brown, moist Dark Brown, and Thin Black** soils:

- **Lentil generally can be grown successfully on stubble with good soil moisture reserves.**

- **Lentil yield on stubble in the Dark Brown and moist Dark Brown soil zone averages about 90% of the yield of lentil on fallow. In contrast, stubble-seeded wheat may yield only about 75 – 80% of fallow-seeded wheat. The indeterminate growth habit of lentil and its ability to respond to a mid to late season rain makes it very suitable as a stubble crop in the Dark Brown and moist Dark Brown soil zones.**

In the **moist Black and Grey** soil zones:

- **Soils are often too wet for consistent production of high quality lentil as excess moisture aggravates disease problems and greatly delays maturity.**

- **The growing season is often not long enough for production of later maturing and strongly indeterminate varieties, such as Laird, especially if seeded late.**

Figure 7.1.6 Redcap Lentil

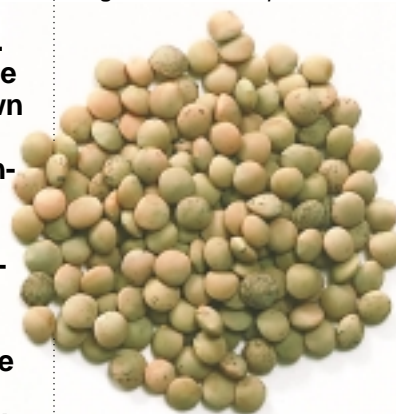


Figure 7.1.7 CDC Vantage Lentil



Equipment and Modifications

Most existing farm equipment can be used or modified to successfully produce lentil. One exception is the need for a roller, which is used to smooth the soil surface and make it easier to harvest pods close to the soil surface. The roller substantially reduces cutterbar damage and 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. Vine lifter guards, pick-up reels, flex headers and air reels improve the cutting of plants with pods close to or in contact with the soil surface. Generally, lentil production results in higher wear on swathers and combines than cereals, which increases the cost of repairs and leads to more frequent machine replacement.

Lentil requires gentle handling to prevent splitting and chipping of the seed. Even non-visible minute damage to the seed can result in a substantial loss in germination. Seed with low moisture content is particularly susceptible to damage when handled in cold temperatures. To reduce damage during extensive handling of lentil, special conveying equipment should be considered. Refer to PAMI Research Update #660, Conveying Equipment For Pulse Crops, for detailed information on handling pulse crops.

Field Selection and History

Field history is an important consideration in field selection for lentil. Lentil is sensitive to residues of herbicides such as Accord, Ally, Amber, Assert, Curtail, Lontrel,

Muster, Odyssey, Poast FlaxMax, Prestige and Unity. Cropping restrictions apply with the usage of Express Pack and Poast Ultra. Short-term residual herbicides, such as Banvel and 2,4-D/MCPA can, under certain conditions, have a deleterious effect on lentil 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 is a potential problem, a test plot should be planted the year before lentils are planted. The plot should be grown to maturity to ensure that no late-season herbicide effects occur on yield or crop quality.

• In rotation, lentil should not follow lentil, even for resistant varieties, as this can result in a severe infection of ascochyta blight and anthracnose and hasten the breakdown of resistance.

Sclerotinia and volunteer crops may be a problem, if lentil follows pea, faba bean, sunflower, canola, or mustard. Fields free of Canada thistle or perennial sow thistle offer the best probability of success as lentil competes poorly with these weeds and effective herbicide control methods in the lentil crop are not available.

Lentil fits well into a direct-seeding crop production system. Lentil seedlings can emerge through cereal crop residue because of their strong seedling vigour.

• If lentil is direct seeded into stubble, it is important to match the lentil with the previous crop.

Volunteer canola or mustard may be difficult to control in some years. Volunteer cereals, such as barley or durum, are difficult to separate from large-seeded lentil during the cleaning process and must be

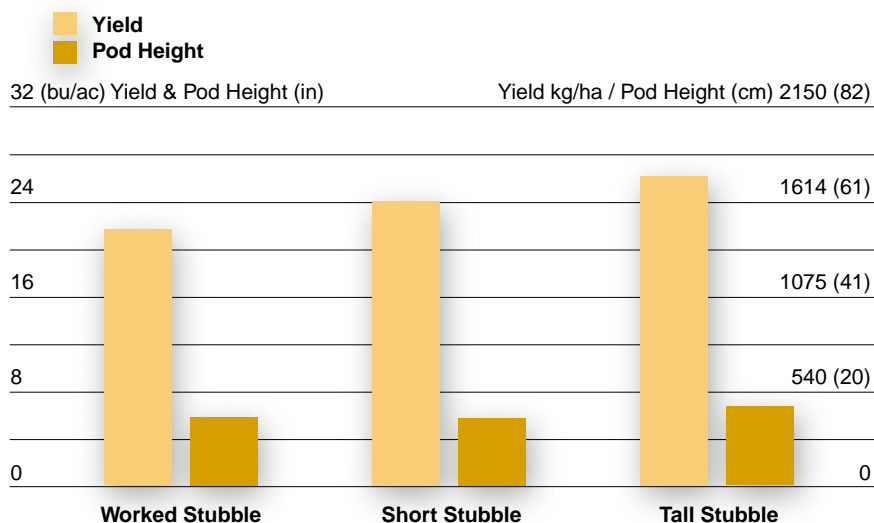


controlled in the field. Likewise, small-seeded lentil is difficult to separate from red spring wheat. If the two crops cannot be separated, lentil grade can be severely reduced. In areas where anthracnose is widespread, avoid seeding lentil next to other lentil fields or lentil stubble to avoid the possibility of disease transfer in wind-blown dust. In areas where ascochyta is the main risk, avoid lentil fields and lentil stubble. A buffer strip of cereal at least 50 feet (15 m) wide between a lentil stubble field and a new lentil planting will delay the rate and onset of ascochyta spread from the lentil stubble.

Studies conducted at Swift Current demonstrated the benefit of producing lentil on untilled stubble and the influence of the previous crop stubble height (Figure 7.3).

Lentil yield increased significantly as the stubble height of the previous crop increased. Fields that were pre-worked produced the lowest yields. The influence of seeding into tall standing stubble helped reduce soil moisture evaporation, particularly during the period prior to flowering. This results in greater water use efficiency (amount of grain produced per unit of water used) by the crop, an extremely important factor in dryland production in drier regions. As stubble height increased, the height of the lowest pod also increased, which can make swathing or combining easier and possibly reduce shattering losses. Lentil sown into standing stubble or heavy crop residue is prone to greater late spring frost injury than lentil grown under conventional tillage. This is because bare soil absorbs more heat from the sun during the day and releases it at night relative to a stubble field. Straw residue must be spread evenly, to assist in minimizing potential frost injury.

Figure 7.3 Influence of stubble height on lentil at Swift Current.



Source: Miller et al. 1998.

Varieties

The first lentil grown commercially in Canada was common Chilean, an unregistered type from the United States. Small quantities of other unregistered types are still grown in Canada, primarily common Chilean, Spanish brown and French green or dark speckled.

Most registered varieties in Canada were introduced or developed by the Crop Development Centre in Saskatoon (refer to Chapter 3./Variety Selection, Lentil).

• **More than 60% of the lentil grown in Canada, up to 1999, is the variety "Laird", which has extra large seeds that suit the quality preferences of many international markets.**

Laird has a strongly indeterminate growth habit and in cool moist areas, it may continue to grow late into the season. This thick vegetative growth and late maturity provides an excellent environment for the development of disease, particularly in moist weather.

• **As a result, Laird is better suited to drier production areas that have longer growing seasons.**



A series of ascochyta-resistant, large-seeded varieties such as CDC Glamis, CDC Sovereign and CDC Grandora are being introduced as replacements for Laird.

Eston is a small-seeded ascochyta-susceptible variety that is being replaced by CDC Milestone, a higher-yielding, ascochyta-resistant variety. These varieties are less indeterminate and earlier maturing than Laird, and perform better in moist conditions. When affected by drought conditions, however, the plants may be so short that they present difficulties in harvesting. Eston and CDC Milestone lentil are especially suited to markets where a firm cooked seed is important as they remain intact after cooking.

CDC Richlea is a medium-seed-size variety with a greenish yellow seed coat and yellow cotyledons. It is produced on approximately 10% of the lentil production area. CDC Vantage resembles CDC Richlea, but has ascochyta resistance.

CDC Redwing is an ascochyta resistant lentil with red cotyledons and a greenish yellow seed coat. It is sold into markets where lentil is split before consumption. Crimson is a U.S. variety with red cotyledons and a brown seed coat. It is sold into both splitting and whole consumption markets. It is susceptible to both ascochyta and anthracnose. Other red cotyledon varieties becoming available in 2001 - 2002 are CDC Redcap and CDC Robin. CDC Redcap has a greenish yellow seed coat, but is plumper than CDC Redwing. It is resistant to ascochyta. CDC Robin resembles Crimson except the seed is smaller than Eston.

• At present no anthracnose resistant lentil varieties are available. However, CDC Robin, a red-seeded variety with an intermediate level of anthracnose resis-

tance plus ascochyta resistance is being increased and will be available for commercial production in 2002.

Indianhead is a black-seeded lentil used as a green manure or plow down crop. It is seeded at 30 to 35 lb/ac (34 to 39 kg/ha) and will produce seed, if seeded early and if drought stress occurs in July and August. To use it as a green manure, it is generally planted in mid to late May to avoid seed production, and the plants are killed with 2,4-D herbicide or by cultivation when flowering begins. Either herbicides or a high residue retention method of cultivation helps to protect the soil from erosion and provides for greater snow-trap capability. Indianhead lentil does not add as much nitrogen to the soil as a plow down of pea or faba bean, but it can be a cost-effective alternative as it's small seed size makes it relatively inexpensive to grow.

Crop Management

Seeding Considerations

Lentil production success is highly dependent on the quality of the seed used.

• Lentil seeds are susceptible to mechanical damage during harvesting, handling, storage, and seeding.

Mechanical damage and herbicide misuse in the parent crop can reduce both germination and seedling vigour. Lentil diseases can also be spread by infected seed. To avoid potential problems, it is best to have seed tested for germination, seedling vigour, weed seed contamination and seed-borne ascochyta blight infection. A list of accredited seed testing laboratories is provided in Chapter 3./Variety Selection, Table 3.1.

• Dry lentil seed (14% or less seed moisture) is very brittle and



difficult to handle without chipping and splitting the seed so all handling should be done as gently as possible (see Chapter 2./ General Production). Even nearly invisible seed cracks can result in a reduction in germination.

- If seed testing reveals ascochyta infection levels in excess of 10%, an alternative seed source should be used.

- In the Brown and Dark Brown soil zones seed testing 0 - 5% ascochyta infection is suitable for planting, levels of 5 - 10% infection levels should be treated with Crown fungicide, and infection levels greater than 10% should not be used.

- In the Black soil zone, plant 0% ascochyta infected seed if possible.

- Seed from fields treated with pre-harvest glyphosate should be avoided, as seed may contain residue, which can reduce germination, vigour, normal root development and inoculant efficacy.

Seed treatment of lentil for fungal diseases is generally not recommended. However, Crown (carbathiin and thiabendazole) is registered for control of seedling blight, seed rot, and seed-borne ascochyta infection in lentil. Crown should be considered if seed-borne ascochyta infection levels exceed approximately 5%. Crown is safe to use with inoculants but should always be applied, and allowed to dry, prior to adding a rhizobium inoculant.

Inoculation

For detailed information on inoculation refer to Chapter 4./Plant Nutrition, Inoculation. The legume-Rhizobium combination has the potential to fix up to 80% of the nitrogen needed by the lentil crop so it is important to ensure proper inoculation. The inoculant must be

stored in a cool place prior to use and must be used before the expiry date. Seedcoat-treated inoculant (peat-based or liquid) should be thoroughly mixed with the seed just prior to seeding and after any fungicidal seed treatment.

Fertilization

Fertilizer requirements of lentil are discussed in Chapter 4./Plant Nutrition, Fertilization.

Time of Seeding

Lentil seedlings tolerate light frosts and can even regrow from the uppermost scale node after a severe frost. This allows for early seeding which usually results in the best yields and quality.

- Seeding can begin when the average soil temperature at the depth of seeding reaches 5°C, providing it is not excessively wet.

Early seeding generally occurs in late April to early May. Early seeding increases plant height and the height of the lowest pods. Higher pods are desirable as they are easier to swath and they stay cleaner which helps to maintain a higher grade. In most years seeding may be delayed in southern areas to as late as May 25 for Laird or June 10 for Eston, though late seedings rarely yield as well as early seedings. Early seeding may help reduce flower abortion caused by high temperatures during flowering.

Plant development may be more rapid for plants that are seeded later because of warmer growing conditions and longer days during early growth. Early maturing varieties may be able to nearly "catch up" with plants seeded at an earlier date, but late maturing varieties generally will not. The rate of plant growth and development generally increases with daily maximum tem-



Table 7.3 Lentil seeding rates.

Source: Hhstowich/Slinkard Personal Communications

Variety	Seed size	Seeding rate	
		lb/ac	(kg/ha)
Laird	Large	80-90	(90-100)
CDC Glamis	Large	80-90	(90-100)
CDC Grandora	Large	80-90	(90-100)
CDC Sovereign	Large	80-90	(90-100)
CDC Richlea	Medium	53-62	(60-70)
CDC Vantage	Medium	53-62	(60-70)
Eston	Small	40-45	(45-50)
CDC Milestone	Small	40-45	(45-50)
CDC Redwing	Small	40-45	(45-50)
CDC Redcap	Small	40-45	(45-50)
Crimson	Small	50-55	(55-60)
CDC Robin	Very small	35-40	(40-45)

peratures up to about 27°C after which heat stress starts reducing growth rate.

Seeding Rate

Recommended seeding rates are based on 12 plants/ft² (132 plants/m²). The actual seeding rate by weight of lentil will depend upon seed size and germination. Typical seeding rates of registered varieties in Saskatchewan are shown in Table 7.3.

• Seeding equipment should be calibrated using inoculated seed as the inoculant may reduce the flow rate through the metering system.

Seeding rates should be adjusted for germination as lower than recommended plant numbers will severely reduce the already weak competitive ability of the lentil seedlings. Lentil yields are often lower at lower seeding rates or wider row spacing (Figure 7.4).

Overall lentil yields were greater in the Brown soil zone on tilled summerfallow as opposed to direct-seeded stubble. Within each cropping system yields were reduced with lower than recommended seeding rates and with wider row spacing. Narrower row

spacing will result in faster canopy closure and reduced soil moisture loss through evaporation from between the rows. Narrower row spacing also encouraged quicker rooting exploitation of the soil between the rows and the use of mid-row soil moisture. Differences due to row spacing would be less dramatic in higher moisture regions.

Higher than recommended seeding rates are often used as a hedge against expected losses. For instance, if harrowing is planned as an early season weed control measure and plant losses of 15% are anticipated, then a 15% boost in seeding rate will help offset these losses.

Established plant stands higher than the target recommendation may facilitate more rapid infection and spread of foliar diseases, particularly in wet years.

Seeding

Seeding can be done with any type of seeder, including hoe drills, disc drills, discers and air seeders.

• When using air seeders, caution is advised as seed damage may occur if the seed is too dry (below 14%) or if the air velocity in the distribution system is too great.

• Studies with Laird lentil showed that up to 30% damage (cracking plus germination reduction) occurred with excessive air-flow settings.

The lowest possible air speed that avoids line plugging should be used. To obtain low enough airflow rates to reduce seed damage in some machines, it may be necessary to reduce the travel speed. Since a lower speed requires lower seed flow rates, a lower air velocity will carry the lesser quantity of seed without plugging. Refer to the manufacturer's recommendations for optimum fan speeds and machine configuration.

Laird is more prone to seed damage than Eston. Adding water to the seed in an auger can reduce lentil seed damage during handling and seeding due to dry seed. Refer to PAMI Research Update #704 for more information on lentil moisturizing.

Ascochyta and botrytis are serious seedborne diseases of lentil in Saskatchewan that can result in significant yield losses.

- **Have your seed tested and sow disease-free seed whenever possible.**

- **In the Brown and Dark Brown soil zones if seed has higher than 5% ascochyta infection, treatment with the fungicide Crown should be considered. Fungicide application should occur prior to application of a rhizobia inoculant. In the Black soil zone, ascochyta seed levels should be as close to 0% as possible.**

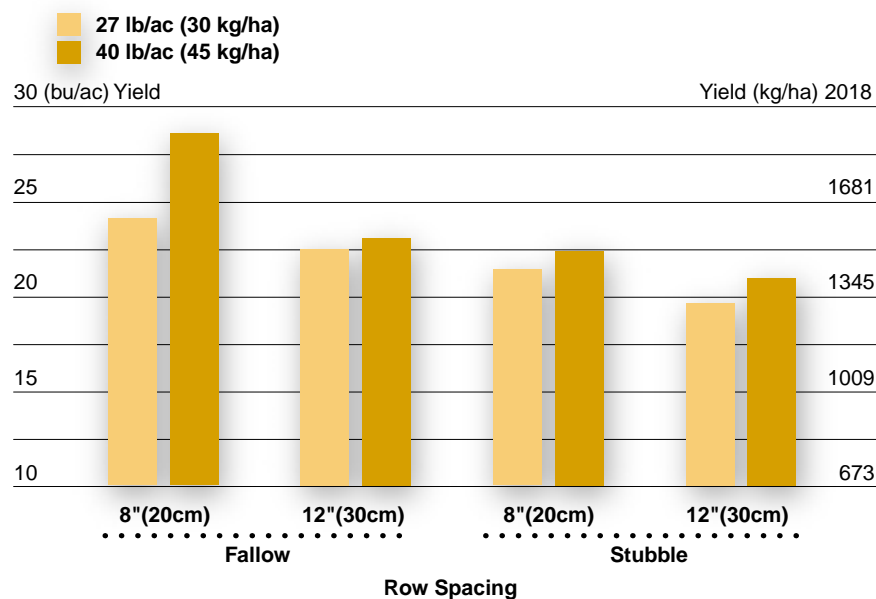
- **Another source of seed should be obtained for planting if ascochyta infection levels exceed 10%.**

Lentil seedlings can emerge from relatively deep seeding because the seeds are large, but large seeds are also prone to drying out. Deep seeding is not required providing the seed is placed in moist, firm soil. In direct-seeding systems, the seed can be placed at a shallow depth compared to pre-tilled soils as soil moisture is usually much higher in un-tilled soil.

- **A seeding depth for lentil of between 1.5 to 3 inches (3.8 to 7.6 cm) is advised. Ideally seed should be covered with 1.5 inches (3.8 cm) of moist packed soil.**

If Sencor or Lexone DF (metribuzin) is used, the crop should be seeded more than 2 inches (5 cm) deep to minimize possible herbicide injury to the

Figure 7.4 Influence of seeding rate and row spacing on yield of Eston lentil. Average 1995-98.



Source: Adapted from McConkey and Miller, 1999

seedlings that may occur following a heavy rain within 3 weeks of planting. If planting on fields treated with fall application of Edge a shallow seeding depth of no more than 1.5 inches (3.8 cm) is recommended to minimize any stunting effect.

If the soil is not waterlogged, it should be firmly packed to ensure good soil contact with the seed. Avoid over packing in wet soils. If the seedbed is very wet, delaying packing and rolling for a day allows the seed to absorb water in the presence of the oxygen it requires. Letting a wet clay soil dry slightly will also help prevent surface crusting. Harrowing or further packing after seeding is not needed if seeders with on-row packing are used, but rolling will be required to smooth the surface. Seeding with discers or air seeders without packer wheels should be followed by harrowing and packing to level and firm the soil, and this should then be followed by rolling. Lentil seeds germinate quickly, so harrow packing and rolling should be completed very soon after seeding.

7.12 Lentil

Table 7.4 Effect of post-emergent land rolling on Laird lentil seed yield.

Node stage	% of check
5 to 7	100
8 to 10	95
11 to 13	85

Intercropping

Researchers in North Dakota have found that intercropping flax and lentil (growing both together in the same field) can increase the harvestability of lentil. It increases the height of the pods above the ground and reduces lodging. Lentil yield will be reduced by the flax, but the yield of lentil plus flax is usually about the same as for either crop grown alone.

• **However, the results of intercropping flax and lentil are too variable for the practice to be recommended to Saskatchewan growers.**

In-Crop Considerations

Rolling

Lentil plants are harvested close to the ground, so a smooth and level ground surface is desirable. Rolling will level out soil ridges caused by seeding. Rolling allows for higher speeds when swathing or direct combining, and reduces guard and sickle section breakage. Lentil can be rolled after harrowing or harrow packing, if conventional tillage is used, or after seeding, if direct seeded.

• **A light to medium land roller can be used successfully between seeding and up to the 5th node stage of the lentil plant.**

A study conducted by Whatley with Laird lentil in Saskatchewan showed yield reductions from rolling after the 5 to 7 node stage (Table 7.4). Late rolling resulted in yield losses of 15% due to breakage of main stems and crimping of aerial branches.

Rolling a wet clay soil before plant emergence can cause crusting and may delay or reduce emergence. The pulverizing effect of rolling can result in soil erosion and consequently, plant injury from relat-

ed wind-driven soil particles, especially under low residue conditions such as summerfallow or on light textured, sandy soils. Therefore, when soil erosion is a potential problem, rolling should be delayed until some canopy protection is established.

• **Rolling should take place on hot days as the plants are more flexible when partially wilted and will incur less stem breakage as compared to when they are rolled on a cooler day.**

• **Some growers caution that rolling in temperatures exceeding 30°C may result in setting back lentil due to stress.**

• **Rolling when the crop is damp from rain or heavy dew can spread ascochyta blight and anthracnose over the entire field.**

• **Rolling may damage and weaken the lentil seedlings, so rolling and herbicide application should not follow each other too closely. A minimum of 2 days between operations will allow the crop to recover.**

• **Likewise, rolling should not follow immediately after a frost.**

Weeds

For further information on weed control see Chapter 5./Weed Control. Lentil is a short crop with a sparse crop canopy, which makes it a poor competitor with most weeds. Yield losses due to weeds can be severe, and lentil is susceptible to weed problems that may not be important in other crops (Table 7.5). For instance, a low growing weed, such as wild tomato or round-leaf mallow, in a wheat or barley crop may not be cause for concern. In a lentil crop, the competitive effect of these types of weeds can be severe, and no herbicides are available to control them. These low growing weeds can dramatically interfere with harvest. Wild tomato

Table 7.5 The effect of weeds on lentil yield.

Weed	Weed-free lentil yield	Lentil yield with weed competition	Yield loss
Wild Oat (125/m ²) ^A	2000 lb/ac (2242 kg/ha)	520 lb/ac (583 kg/ha)	74%
Green Foxtail (250/m ²) ^B	2640 lb/ac (2959 kg/ha)	1850 lb/ac (2074 kg/ha)	30%
Wild Tomato (418/m ²) ^C	1280 lb/ac (1435 kg/ha)	490 lb/ac (549 kg/ha)	62%

produces an abundance of juicy fruit that can be crushed during threshing and may stick dirt to the combine and to the lentil seed.

• **Good weed management depends on a strategy that considers all of the interrelated conditions of the crop production system and the entire crop rotation in the field rather than simply the lentil crop.**

Techniques for effective weed control (Chapter 5./Weed Control) are applicable to lentil.

Post-emergent harrowing with a tine harrow can be used for weed control in lentil crops when the crop is in the seedling stage (no more than 4 inches or 10 cm tall), providing the foliage is dry and the work is done on a hot sunny day. Some plant losses will occur, but these can be offset by using higher seeding rates.

The number of herbicides available for use in lentil is quite limited, compared to those available for many other field crops. Although herbicides registered for use in lentil control a number of common weeds, not all broadleaf weeds can be controlled. Controlling only some of the weeds in a field may not be economical. In all cases, the producer must decide, if a weed problem is of economic concern or only a cosmetic problem before choosing a control method.

Chapter 5./Weed Control includes a listing of the herbicides registered for use in lentil. Some specific cautions with respect to herbicide use in lentil follow. The general cautions provided in Chapter 5 and all label instructions, cautions,

and recommendations should also be followed.

Lentil plants are tolerant of Hoe-Grass 284 (diclofop methyl) at all stages of growth except during hot, humid weather when leaf cupping and some leaf burn may occur after application.

Poast (sethoxydim) can be expected to suppress quackgrass for 6 to 8 weeks, but in a weakly competitive crop like lentil, some regrowth may occur prior to harvest.

Caution must be used in applying Sencor or Lexone DF (metribuzin) to lentil. They should not be used if the lentil seeds are planted less than 2 inches (5 cm) deep or on soil that has less than 4% organic matter. Sencor/Lexone DF can cause significant crop injury if the lentil seedlings have fewer than 2 nodes or more than 5 nodes at the time of application, but a split application of Sencor/Lexone DF at reduced rates (the second application to follow 7 to 10 days later the first) reduces the risk of crop damage and increases the effectiveness of the herbicide application.

• **A full rate of Sencor/Lexone DF applied on a hot day to lentil plants at the 5 to 6-node stage or later will burn the leaves off.**

Only fall application of trifluralin products (Advance, Rival, Treflan, Bonanza) is recommended for lentil as spring application can result in crop injury, delayed seeding, and because of incorporation tillage, a dried-out seed bed. These herbicides should not be used on land where risk of soil erosion is severe as the extra tillage for incorporation and low levels of residue from lentil





production can aggravate the problem. Deep seeding or environmental factors which delay seedling emergence increase the risk of crop injury from these products and may result in stand thinning, delayed maturity, and reduced yield.

• **Although not registered for this use, studies at Scott and Indian Head using surface-applied granular herbicides under no-till conditions have shown weed control and crop safety comparable with incorporated Edge and Trifuralin in some years. This method of application would provide important advantages for control of erosion.**

Some winter annual weeds in the mustard family, such as flixweed and shepherd's purse, are not controlled by the herbicides registered for lentil. Pre-seeding glyphosate application or pre-seeding tillage can be effective. Some growers have experimented with late fall or very early spring applications of 2,4-D or MCPA to control weeds prior to seeding lentil. These treatments are very effective as a control measure and have the added benefit of low cost.

• **However, they are not recommended because of a high risk of crop injury from soil residues, particularly under dry, cool conditions. Early fall treatment of winter annuals with 2,4-D is much safer in terms of crop injury compared to late fall or spring treatment.**

Use of salt or amine formulations of 2,4-D or MCPA reduces the risk of chemical residual relative to the ester formulations. MCPA is also less likely to cause injury than 2,4-D. Either fall or spring application of Banvel (dicamba) will cause lentil injury. If glyphosate is used as a pre-seeding spring burnoff, care should be taken in selecting the formulation. Roundup, Renegade,

Touchdown, Victor and Glyphos, are safe for use, but Rustler, which contains dicamba, can cause crop injury.

A number of glyphosate products are registered for pre-harvest weed control in lentil. Applications of these products do not desiccate the crop and their benefit in drying down the crop has been inconsistent.

• **Do not use these products if the seed will be retained for planting. Glyphosate carryover in seed can result in poor germination, irregular plant development and poor nodulation.**

Insects

Crop loss from insects in lentil 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 knowledge of the biology of the insects that might cause problems, field scouting for insects, knowledge of insect survey projections, sound agronomy, and the use of insecticides when necessary.

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

Appendix Table 7.6 outlines those insecticides available for use in Saskatchewan lentil production. Knowledge about application of each insecticide will enhance activity and optimize use. Insecticides should be used with caution.

Several insects can cause damage to lentil, including lygus bug, aphids, cutworms, and grasshoppers. However, the only insect likely to cause economic levels of crop injury in lentil in

Saskatchewan is the grasshopper. 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 inspection 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 speed up 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 leaf area is not quickly replaced.

Grasshoppers chew through young shoots, even if they do not eat the plant. Damage can occur at both the seedling and flowering stages. Grasshopper nymphs can attack lentil seedlings on the edge of the field as they emerge in spring, but lentil plants will generally regrow from buds below or near the soil surface. If the damage is not repeated, maturity will be delayed, but the plant will not be permanently harmed. If lentil is planted early, the plants may outgrow the susceptible stage before the grasshoppers emerge. Grasshoppers cause greater damage if they attack flower

buds, flowers or young pods. This damage does not hurt the lentil plant, but the yield can be reduced up to 90% and maturity can be delayed due to delayed pod set. Contamination of the lentil seed lot with grasshopper parts can also reduce lentil quality.

- **At the flowering and early podding stages of lentil, the threshold population level is 2/m².**

- **Early planting is recommended if the Saskatchewan Grasshopper Forecast predicts a severe to very severe grasshopper risk.**

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 summerfallowing 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.

- **During combining, grasshoppers enter the combine; the heads are broken off, and due to size similarity, are generally not easily separated from the lentil seeds. Additional cleaning may be required to remove them.**





Cutworms occasionally cause problems. The risk is low, unless more than 2 to 3 cutworms/m² 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. Crops, such as lentil where the cotyledons (seeds) 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. 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.

Lygus bugs are small pale green to reddish-brown insects that feed on the sap of a number of crops and weeds. In western Canada they have caused considerable damage on canola and alfalfa, and have caused damage to lentil in the U.S. At present lygus has not been a problem in Saskatchewan.

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

Diseases

Disease management is important in reducing the likelihood and severity of lentil diseases (see the suggestions given in Chapter 2./General Production, Diseases).

Ascochyta blight and anthracnose are two diseases that are of significant concern. A third disease, botrytis stem and pod blight (sometimes called grey mold), can be a significant problem under wet conditions. All three of these diseases become most problematic during

the period of flowering to maturity.

• **Ascochyta blight is a fungal disease caused by a specific strain of the fungus that only infects lentil. This fungal strain will not cause ascochyta blight in pea or chickpea.**

Ascochyta is widespread in Western Canada, and common in other lentil-growing areas of the world. Yield loss in Eston, common Chilean and Laird may be as high as 30 to 50%.

• **New aggressive strains of ascochyta have developed, and Laird has little resistance to the new strains.**

• **The newer varieties CDC Glamis, CDC Grandora, CDC Sovereign, CDC Vantage and CDC Milestone are ascochyta resistant.**

• **The newer red cotyledon varieties CDC Redwing, CDC Robin and CDC Redcap have ascochyta resistance, Crimson does not have ascochyta resistance.**

The yield loss due to ascochyta is caused by flower and pod abortion, but heavy infection may delay maturity as well. The reductions in lentil quality and grade may cause larger economic losses than the reduction in yield. The disease is spread by rain splash transferring spores from plant residue on the soil surface to the developing lentil plant and from plant to plant. Ascochyta can also be seedborne so planting infected seed can spread the disease. Infection can occur throughout the growing season. Symptoms of the disease include the occurrence of grey to tan spots or lesions on the leaflets, stems, flowers and pods, with dark margins and often with tiny black fruiting bodies (pycnidia) in the centers (Figure 7.5). Lesions first occur on lower leaflets close to the soil surface. Lesions on stems can gir-

dle the plant and result in wilting. Under severe conditions, leaves turn completely brown and may be lost and the seeds discoloured. Seeds may become partly or wholly brownish-purple, and may be shriveled (Figure 7.6). In extreme cases, they may have fluffy white patches or bumps. Disease symptoms are most severe under cool (15°C), wet conditions. A late seed-borne infection may occur with little or no seed discoloration in the harvested lentil seeds. This can be detected by a seedborne ascochyta test.

The fungus can overwinter in the field on lentil stubble. Movement of wind-blown spores from field to field is limited, but can occur from adjacent fields. Where lentil is planted adjacent to a lentil stubble field, it may be beneficial to treat approximately 50 m along the field edge with a fungicide application. Alternatively, this buffer area may have higher levels of seedborne infection and should be combined and binned separately from seed from the remainder of the field to prevent downgrading. Another option would be to seed a 50 m buffer strip of wheat or other non-host crop.

The likelihood of disease can be reduced by allowing several years (at least 3) between lentil crops, and by planting only seed that is ascochyta-free. Agar plate tests of seed that indicate "none detected" are recommended for pedigreed seed growers or for growers in Black soil zone where cool, moist conditions are most likely. Even 1% seedborne ascochyta can result in epidemics in cool, moist seasons, but up to 4-5% seed infection will not normally cause a problem in dry areas. If seed with 5 - 10% seedborne infection is planted, seed treatment with Crown fungicide or delayed seeding is recommended to reduce transmission

from infected seed to seedlings. Seed lots with greater than 10% seedborne infection should not be planted.

• **Under high ascochyta disease pressure, yield and quality losses can occur, even with varieties designated as resistant. It might be advisable for growers to substitute the term "tolerance" for "resistance" in areas or in production systems where disease pressure is extreme.**

Yield is not likely to be reduced with low levels of ascochyta infection on the bottom half of the crop canopy. However, if infection spreads to the top of the canopy, yield potential can be lost. Should this situation occur, a fungicide application may be warranted. Bravo 500 is registered for controlling the spread of ascochyta blight in lentil. Application should be applied at early flowering; a second application may be applied 10 -14 days later, if cool, wet weather persists.

Anthrachnose is a fungal disease that is severe in southern Manitoba and is widespread in Saskatchewan. The fungus spreads readily, and low levels are able to initiate epidemics, especially in southern Manitoba. The incidence and severity of anthracnose in Saskatchewan is generally less than in Manitoba, probably because of the cooler, drier summers. Anthracnose can be carried by stubble, wind-blown dust, and by seed. Although seed-borne infection does not significantly contribute to seedling disease, seed from highly infected fields should not be used for planting. Anthracnose-infested debris from previous lentil crops is the most important source of the fungal inoculum. The fungus can readily move from field to field, and can remain viable in the soil on buried plant material for more than

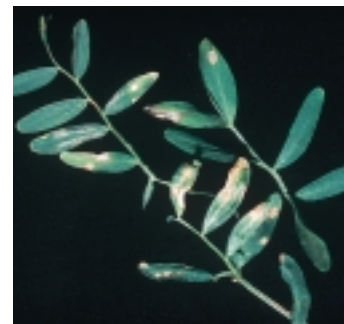


Figure 7.5 Leaf symptoms of ascochyta blight in lentil.

Source: Department of Biology, U of S

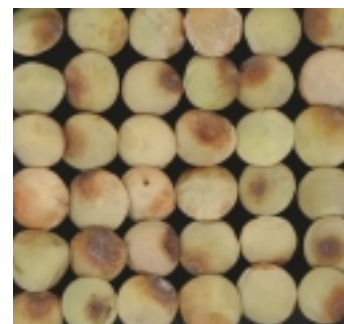


Figure 7.6 Ascochyta-infected lentil seed.

Source: Bert Vandenberg

7.18 Lentil



Source Lone Buchwaldt



Figure 7.7.1 Anthracnose in lentil.

Source Lone Buchwaldt

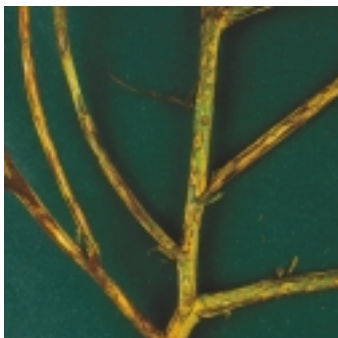


Figure 7.7.2

Source Lone Buchwaldt



Figure 7.7.3

Source Lone Buchwaldt

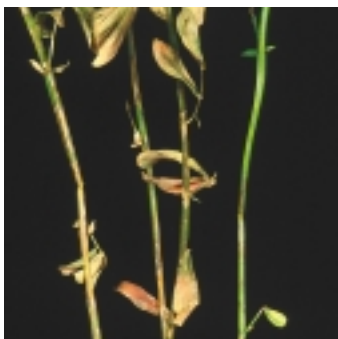


Figure 7.7.4

2 years. Risk factors for anthracnose include the previous presence of the disease in the field, or even the district, and frequent rainfall. Rain splash assists in disease transfer and aerial spores are carried by raindrops during thunderstorm activity. Disease incidence is promoted with warm temperatures (20 – 24°C) and humid conditions. Swathing and combining a heavily infected crop will create spore clouds, further spreading the disease by wind.

Disease symptoms include grey to cream patches on leaves, and spreading tan to golden brown lesions on the lower stems (Figures 7.7.2-7.7.5). Leaves, and entire plants may die back and the stems of mature and dead plants often blacken. This is especially evident after swathing. Leaflets littering the soil surface are another sign of anthracnose infection. Warm moist weather, frequent showers and a dense lentil canopy favour the disease. Severe stem infection will kill the stem before any seed becomes infected. Leaf symptoms usually appear between the 8 - 12 node stages, approximately one week prior to flowering. Stem lesions begin at the base of the plant soon after the appearance of leaf lesions. Stem lesions progress along the entire stem and infection can result in stem girdling. Consequently, large areas of the field will exhibit wilting and begin to die-off. Most damage from this disease occurs when the stem is infected.

- **It is recommended that growers avoid infected seed and use crop rotations that include at least 4 or 5 years between susceptible crops such as lentil, pea, or faba bean.**

- **Lentil crops should be planted as far as possible from previous anthracnose-infected fields.**

- **The fungal inoculum declines quicker, if infected residue is left exposed on the soil surface. Therefore, zero-tillage systems are advantageous. Residue incorporation and burial extends fungal survival.**

- **As anthracnose is not highly seed-borne, fungicide seed treatments for prevention is not recommended.**

- **CDC Robin, a small-seeded, red-cotyledon lentil with an intermediate level of resistance to anthracnose plus good resistance to ascochyta, was registered in 1999 and some commercial seed will become available in 2002.**

Bravo 500 (chlorothalonil) is registered for ascochyta and anthracnose control in lentil. The fungicide protects the sprayed plant from infection until new non-sprayed growth develops. Therefore, under moist conditions or in areas where anthracnose is present, a repeat application may be required. The first application should occur just prior to flowering when bud formation is evident, followed by a second application 10 – 14 days later at early to mid-flowering. In areas where the risk of anthracnose is low or conditions are not favourable for its development, growers may wish to protect their crop with a single fungicide application at early flowering. Bravo 500 must be handled carefully as it can cause severe eye damage and label recommendations should be followed. The secret to in-crop fungicide application is early detection of disease symptoms. This requires that producers monitor their fields carefully and looking for visual indications of the disease. Effective field scouting can't be done from the truck - footwork is necessary.

Crown (carbathiin and thiabendazole) is registered as a seed treatment for control of seedling

blight caused by pathogens such as *Botrytis*, seed rot and seedborne ascochyta. The chemical is sold as a liquid (water base) that can be used as a sticker for inoculant. Crown can be applied simultaneously or sequentially with *Rhizobium* inoculants. Treated seed is toxic. Vitaflo 280 is registered for control of seed rot and seedling blight in lentil.

It is difficult to distinguish between ascochyta blight and anthracnose on the basis of early symptoms on the leaves and stems, particularly as both diseases can be present within the field. Anthracnose is usually responsible for premature leaf drop, and severe stem lesions and girdling, whereas flower and pod abortion are associated with ascochyta blight.

Most fungicide dealers in Saskatchewan have anthracnose diagnostic kits available from Discovery Seeds Lab in Saskatoon. Sampling involves collecting 15 - 20 leaflets exhibiting lesions and placing them in a plastic container with wet paper. The samples are mailed to Discovery Seeds and the company will make a diagnosis and inform the grower within 48 hours. This procedure will confirm the presence of anthracnose, but cannot predict the severity or likely losses associated with its presence.

A set of guidelines for identifying situations where fungicide application is most cost-effective is being developed at Agriculture and Agri-Food Canada, Saskatoon Research Centre through partial



Figure 7.7.5

Table 7.7 Disease risk assessment to evaluate the need for application of Bravo to control ascochyta and anthracnose on lentil.

This assessment summarizes the relative risk associated with factors that control disease development. However, the decision to apply a fungicide is the responsibility of the producer and AAFC does not assume any liability.

Inspect at least 10 locations in the lentil crop at 10% flowering.

	Risk factor
A. Plant stand	
1. Thin (high weed pressure, low yield expectation)	0
2. Moderate (some weeds, possibly low yield)	5
3. Normal (about 12 lentil plants/ft ² or 135/m ²)	10
4. Dense (more plants than normal, lush growth)	15
B. Number of days with rain in the last 14 days	
0 days	0
1-2 days	5
3-4 days	10
5-6 days	15
7 or more days	20
C. The 5-day weather forecast	
1. Dry	0
2. Unpredictable	10
3. Light showers	15
4. Rain	20
D. Symptoms of anthracnose and ascochyta blight on lentil plants	
1. No visible symptoms	0
2. Few lesions on lower ½ of the foliage (up to 10% of the leaflets infected)	5
3. Lesions on lower ½ of the foliage (up to 25% of the leaflets infected)	15
4. Lesions on lower (up to 25%), as well as upper, foliage (up to 10%)	25
5. Lesions on lower foliage and premature leaf drop characteristic of anthracnose	25
6. Flowers and/or peduncles infected, characteristic of ascochyta blight	25



Figure 7.8 *Botrytis* in lentil.

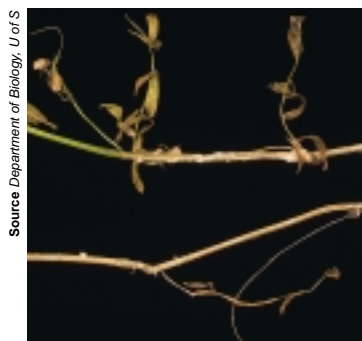


Figure 7.9 *Sclerotinia* symptoms on lentil stems.

funding by the Agri-Food Innovation Fund. Growers using it will be choose the risk factors that best describe:

- A/** plant stand,
- B/** number of days with rain in the last 14 days,
- C/** 5-day weather forecast, and
- D/** disease development stage.

The guideline summarizing the relative risk associated with factors that control development of ascochyta and anthracnose in lentil are shown in Table 7.7.

- **Growers are advised that the guidelines are presently in the development stage and further refinements are ongoing.**

- **USE OF THE DECISION SUPPORT SYSTEM IS THE RESPONSIBILITY OF THE PRODUCER. AGRICULTURE AND AGRIFOOD CANADA DOES NOT ASSUME ANY LIABILITY REGARDING ITS USE.**

Inspect the lentil crop no later than the 10-node stage. Choose the risk values that most closely describe the plant stand, number of days with rain in the past 14 days, and the 5-day weather forecast. Average the disease symptoms over at least 10 sites in the field.

A risk value is then calculated as **A+B+C+D**.

- **If the risk value is less than 50, a fungicide application is not recommended, but a new assessment should be made at 3-5 day intervals until the crop is no longer flowering.**

- **When the risk value is 50 or above, a fungicide application is recommended.**

- **The optimal time for control of anthracnose is at the 10 – 12 node stage or early flowering when premature leaf drop first occurs. An application may be warranted at low levels of stem infection to protect those plants that are still healthy.**

- **It is too late to control anthracnose when severe lesions can be found at the stem base, and when the crop is no longer flowering.**

- **Control of ascochyta blight may be achieved from early to late flowering, whenever the first symptoms appear. An application at early pod set may prevent reduction of seed grade.**

Botrytis (grey mold) stem and pod rot can cause severe crop losses (Figure 7.8).

- **It is most destructive under irrigation, or in cool wet years.**

Botrytis-infected seeds usually produce infected seedlings which die soon after emergence and result in a reduced plant stand. Symptoms of the disease usually occur later in the season and include wilting, premature ripening, failure of pods to fill, and dead, infected crop areas. Grey moldy growth can be found throughout the canopy on stems and pods. During harvest, clouds of spores are dispersed from the lower canopy and are clearly visible. In such cases, protective dust masks should be used. No control is available at this stage of disease development. The fungus causing this disease can overwinter at the soil surface or in debris, and can occasionally be seed-borne. Inoculum is widespread and needs only prolonged cool, wet periods and a dense canopy to become serious.

- **No resistant varieties are available.**

Sclerotinia (white mold) can cause rotting of stems and pods (Figure 7.9).

- **Although Sclerotinia is widespread in lentil, it is usually not of economic concern, except in areas with early lodging in wet years.**

The risk to other susceptible crops in the rotation, especially canola, is increased if it follows lentil

in the rotation because of the multiplication of the fungus in the lentil crop.

Seedling blights and root rots can be widespread, but usually they only occur on scattered plants and they are rarely of economic importance (Figure 7.10). Individual diseased plants turn yellow, die and dry up. The root system and the base of the stem are brown and rotten, and may have white or pink mold growing on them. The disease affects only scattered plants and does not spread far. Crop rotations that include cereals can delay the build up of these soilborne diseases.

Viral diseases are not severe in lentil in Saskatchewan, but several viruses attack lentil in other areas of the world. Pea seedborne mosaic virus is a potential threat to lentil as it may be introduced with infected pea seed. The virus usually is spread by pea aphids, which are more common in Manitoba.

Heat canker can easily be confused with seedling blight (Figure 7.11). The base of the stem looks pinched, leaves wilt and turn yellow, and the stem dies. With heat canker, the stem remains plump below the canker. Heat canker occurs when the young seedlings are exposed to high soil surface temperatures before they have enough leaves to shade their own stems. Heat canker was a major problem in 1987 and 1988. Seedlings can regrow from buds below the soil surface, if the soil surface cools down and the soil moisture supply is adequate for good growth. Heat canker is less serious if the crop is seeded in a north-south direction, or if the soil surface is well covered with crop residue.

Herbicide injury symptoms sometimes can be mistaken for disease symptoms (Figure 7.12).

Herbicide injury can be avoided or at least reduced by applying herbicides according to label instructions, carefully cleaning sprayers, and avoiding spray drift.

Irrigation

Irrigated lentil production requires a thorough knowledge of dryland lentil production, as well as specific knowledge of irrigation requirements. Laird, CDC Glamis and common Chilean lentil are late maturing and have a strongly indeterminate growth habit that often results in excess vegetative growth and low seed yields. Lentil plants do not tolerate waterlogged soils and will die if flooded. Dense lentil canopies favour the spread of disease and increase the severity of disease.

• **Early maturing CDC Milestone lentil, or the intermediate types such as CDC Richlea, CDC Vantage and CDC Redwing, are not strongly determinate and late maturing and are more suited to irrigated production.**

Highest yields are obtained with an application of 6 to 10 inches (15 to 25 cm) of total water, the exact amount depending on rainfall and the rate of evaporation. It is important to avoid water accumulation on the surface and water logging of the soil, especially at seeding time. Irrigation of 0.8 to 1.2 inches (2 to 3 cm) in early June may be used to prevent the stunting (short plants) and lowered yield from drought stress. Irrigation is usually avoided in mid to late June as a slight moisture stress for a brief period after the onset of flowering encourages seed set.

• **Irrigation should be avoided for at least 2 weeks after spraying with Lexone or Sencor (metribuzin) to avoid leaching it into the lentil rooting zone where**

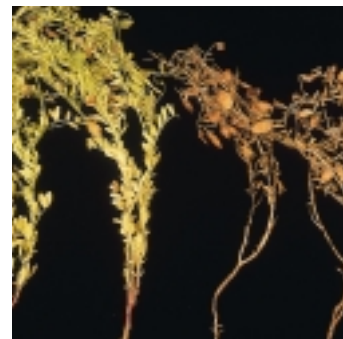


Figure 7.10 Lentil plants infected with root rot.



Figure 7.11 Heat canker on lentil seedlings.



Figure 7.12 Growth regulator herbicide injury on lentil plants.

it can cause damage.

Supplemental moisture may be beneficial during flowering and early pod-filling stages. Approximately 4 inches (10 cm) of total water are recommended during the first 3 to 4 weeks of pod set. After this critical period, irrigation should be shut down to allow enough moisture stress to ensure that the crop matures. Research conducted at the Saskatchewan Irrigation Development Centre has demonstrated that over-irrigation in wet years at or before flowering can dramatically reduce yields.

• **During a wet season, irrigation at the flowering stage reduced yield by 22% compared to non-irrigated plots.**

Yield reductions are usually associated with excessive vegetative growth and delayed maturity.

When grown under irrigation, lentil should be seeded early, at a depth of 1 to 2 inches (2.5 to 5 cm). Seeding rate and row-spacing recommendations for dryland production are suitable for irrigated production. Higher seeding rates increase the risk of disease. To reduce the risk of sclerotinia, lentil should not be planted on land that has produced mustard, canola, lentil, pea, sunflower, or faba bean in the previous 4 years.

Diseases, such as ascochyta, anthracnose and sclerotinia stem rot, can cause severe damage to lentil under high moisture conditions. Irrigation increases disease pressure.

Harvest

Lentil plants have an indeterminate growth habit and will continue to flower until stopped by some stress, such as heat, frost or drought. Large-seeded lentil varieties are more indeterminate than small-seeded varieties and in many years, crop maturity will not occur in

a timely manner. Because of this, many farmers hasten the drying of their crop by either chemical desiccants or by swathing. Lentil pods shatter easily when dry. Early swathing or desiccation is used to hasten dry down and to make it more uniform, which reduces shattering losses.

• **The best time to swath or desiccate cannot be determined by the colour of the crop as seen from the road.**

Straight combining without desiccation can be done with some early maturing varieties in a hot dry harvest season. Some varieties may be more prone to lodging. This may increase shattering losses due to dry pods and will increase crop losses due to unthreshed green pods.

The fields should be walked and the plants should be examined. Swathing or desiccation provide the best results when the bottom pods of the lentil plants turn yellow to brown, and the seeds rattle within them when shaken. At this time, the upper pods will still be green, but further delay will increase the risk of harvest loss due to shattering of the bottom pods.

Desiccation

Reglone (diquat) is registered as a desiccant for use in lentils. Desiccation can assist in ease and timeliness of harvest, reduce shattering losses and seed quality deterioration. Reglone application is recommended when one-third of the pods have turned colour and rattle when shaken. If the crop is chemically desiccated, it can still be either swathed and combined or straight-cut. With Reglone, about 7 to 10 days are required between application and threshing. Straw from lentil plants desiccated with Reglone or sprayed with a glyphosate herbicide for perennial weed control can be used as livestock feed.



• **Glyphosate is not an effective desiccant and is not registered as a desiccant, but can be used to control perennial weed growth before harvest. Seed germination and seedling vigour can be reduced if glyphosate is applied pre-harvest. Do not use glyphosate on crops reserved for planting. Roundup Fast Forward can enhance drydown, if weather conditions are warm and dry.**

Swathing

If the crop has not been desiccated, it can be swathed when about 1/3 of the lower pods turn yellow and the seeds in them rattle. Cutting under conditions of high humidity can reduce shattering losses.

Swathing the crop may be the most difficult part of lentil production. The bottom pods are close to the soil surface, so the cutterbar must travel close to the ground. The cutterbar should preferably be about 2 inches (5 cm) from the ground, at an angle of 20 to 30° to the ground. Cutting will be easier if the surface is level, firm and dry. Fields that were rolled after seeding are easier to swath since rolling helps to level the soil surface.

A properly equipped forage or grain swather can be used to cut lentil. However, pull-type swathers are a poor choice because of the severe side draught and frequent dragging that occurs when cutting lentil plants near the soil surface.

• **Ideally, a swather should be equipped with a pickup reel and vine lifter guards for a good job of cutting, especially if the crop is lodged.**

A good quality pickup reel without lifter guards may do an adequate job and is preferred over a swather having only lifter guards and a standard bat reel. Proper adjustment of the pickup reel is

important to obtain the maximum possible lifting action. The reel should be positioned as far ahead of the cutterbar as possible.

The direction traveled while cutting the crop can also make a difference in the effectiveness of the pickup reel and lifters, especially if the crop has a prevailing lean to it. The cutterbar lifter guards will have a greater effect if the cutting direction is perpendicular to the direction of crop lean.

Since the cutterbar will be operating close to the ground, an alteration to the header flotation system may be required. Adjusting existing header flotation springs or adding additional springs to increase flotation will help keep cutterbar damage to a minimum. On uneven terrain, use a narrow swather or swather equipped with a floating or flexible cutterbar and/or adjustable gauge wheels. Lentil and weed residues can be gummy and may stick to the cutterbar. An excessive buildup will cause poor cutting and increase wear on the cutterbar.

• **The cutterbar may need to be cleaned periodically with soapy water and a scraper to maintain cutting efficiency.**

Lentil swaths can be light and fluffy, especially if cut a bit on the dry side. Because the crop is cut very close to the ground, little stubble remains after harvest. This makes the swath very prone to wind damage. Using a swath roller will reduce the risk of wind damage, but can greatly increase shattering losses. Partially green swaths will settle after a day or two and are then less likely to be moved by the wind. Swaths are also less prone to damage if they are laid in the same direction as the prevailing wind. Swathed lentil plants may dry more rapidly than standing lentil plants, but rain on the swath is a serious concern as it can result in sprouting,

wrinkling of the seed coat, disease spread to pods and seeds, and reduced quality. Wet swaths flatten out and are harder to pick up. To speed the drying process, they can be turned with a swath turner or a side-delivery rake, but shattering losses may be high.

• **A slower ground speed will assist in reducing shattering losses. Swathing lentil is a difficult task, "Slow and easy" is the operative term to keep in-mind.**

Straight Cutting

Straight cutting, like swathing, is best done with a properly equipped header.

• **In desiccated lentil, flex headers, automatic header height control, and air reels work well, provided the crop is relatively weed-free.**

• **In non-desiccated lentil, a pickup reel and vine lifters work well, especially if the crop is lodged.**

The improvement in lentil grade obtained by reducing the amount of debris harvested with the seed may pay for the additional cost of a header, if harvesting conditions are difficult. As a guideline, operators who produce 300 acres or more of lentil and/or pea each year can usually justify the expense of a direct-cut attachment for their combine.

Threshing

If the weather is warm and windy, the lentil crop can dry very rapidly. The crop should be monitored to determine when it should be threshed. Correct timing can make a large difference in the ease and success of the combining operation.

Lentil seed can be safely stored at 14% moisture. If no drying equipment is available, it may be necessary to wait until the seed reaches this moisture content

before threshing. This is not the best solution because shattering losses and seed damage are likely to result.

Experiments conducted to investigate the effect of moisture content on breakage showed that the percentage breakage increases with decrease in moisture content below 14%. It has also been observed from field experiments that when moisture content of seeds were greater than 20%, the crop was extremely hard to combine without smashing the seeds. Therefore, 20% and 14% are the recommended upper and low boundaries for the grain moisture content in a harvest operation.

• **Ideally, the seed should be threshed at about 16% moisture. This will result in a cleaner crop sample and a reduction in shattering losses and seed damage.**

Lentil plants thresh easily, and the seed is easily damaged. Rotor and cylinder speeds between 250 and 500 rpm are often used. However, determining the proper cylinder speed involves a compromise between a slow enough speed to avoid damage and a fast enough speed to avoid cylinder plugging. Cylinder speeds can be increased if the lentil plants are moist, but samples should be monitored for chipping, cracking and splitting, and the cylinder speed should be reduced if a problem develops. Concaves should be set to allow good threshing and separation. If the lentil plants and seeds are very dry, settings must be adjusted accordingly. Chaffers should be initially set at 3/4 inch (2 cm) and cleaning sieves at 3/8 inch (0.9 cm) and adjusted as necessary. Tailings should be kept to a minimum to reduce cracking and splitting. Clean grain and return elevator chains should be kept properly adjusted as too loose an adjustment increases the chance of crack-

ing seed. Fan speeds should be high enough to ensure a clean sample, but no higher.

Post Harvest

Drying

Lentil seeds can be safely stored at up to 14% moisture content and at temperatures below 15°C. Higher temperatures and moisture contents result in a more rapid degradation due to discoloration. Higher moisture contents will also cause the air in the bin to be more humid which can lead to mold growth. Lentil seeds should also be cleaned before drying to reduce the content of green weedy material that holds moisture and to eliminate finer dockage that interferes with airflow. Lower moisture content increases the risk of damage during handling. If high moisture lentil seeds are dried too rapidly, tiny cracks may develop on the seed.

• **Lentil seeds should not be dried by more than 4 or 5 percentage points per pass through the dryer, and they should be tempered up to 8 hours between passes to allow adequate time for moisture migration and cooling.**

All drying should be done at temperatures below 45°C if high germination is required. If lentils are to be sold for commercial purposes, higher drying temperatures may be possible. Recent research suggests drying air temperatures as high as 70°C may be possible, but tiny cracks must be minimized. This will speed up drying. However, operators are cautioned to have their buyers test samples of grain dried at different temperatures as safe drying temperature can vary between dryers and with grain condition.

Lentil seed is easily damaged in conveyors or in the dryer, espe-

cially when hot. One way to minimize passes through conveyors is to use a natural air-drying system. Aeration bins should be able to provide at least 2 cfm/bu or more airflow with partial or fully perforated floors. Table 7.8 presents computer simulation results of aeration drying of lentil.

Drying time is calculated from the initial moisture contents given in Table 7.8 to a safe storage moisture content of 14%. The simulation results indicated that 1 cfm/bu would dry lentil at 20% moisture in about a month. Airflow rates above 1 cfm/bu are beneficial, if drying must be completed in a shorter period. The starting date (harvest date) used in the simulation had some effect on drying time. Generally, earlier harvest resulted in shorter drying time, but this was dependent on the airflow rate, ambient air temperature and specific dates of drying. The amount of energy used to achieve drying increased with the airflow rate, ranging from 20 to 80 kWh/t of grain dried. Assuming 5 cents per kWh of electricity, the operating cost of natural drying of lentil amounts to \$1 to \$4 per ton of dried grain.

Generally, aeration bins that have good performance when drying cereal grains will have adequate airflow performance with lentil. Laird lentil seeds have 25% less resistance to airflow than wheat has per unit of depth, so aeration bins will generally have an equal or faster drying rate with lentil than when drying an equal amount of wheat. An

Table 7.8. Days required for natural drying of lentils with unheated ambient air.

Start date	Moisture content %	Airflow rate (cfm/bu)		
		1.0	2.0	3.0
August 15	20	36	21	6
August 15	17	26	20	17
September 15	20	38	12	10
September 15	17	35	10	9

increase in moisture content of Laird lentil seeds from 10.5 to 20% results in a 22% decrease in resistance to airflow. The resistance of Laird lentil seeds to horizontal airflow is one-half of the resistance to vertical airflow. The resistance to airflow of Eston lentil seeds is up to 27% higher than that of Laird lentil seeds. The drying rate or drying performance is influenced by the type of seed and bin parameters, fan performance curve, and the weather, so drying conditions must always be carefully monitored.

Storing and Handling

Lentil seed coats turn brown with age, resulting in a reduction in grade. The browning is a result of the oxidation of tannin precursors in the seed coat, and occurs faster at high temperature, high humidity and in sunlight. For this reason, it is advisable to store lentil seeds in light-tight bins, and to aerate them to cool them to below 15°C immediately after binning. The effect of storing undried lentils at 13.4% w.b. for a period of 6 months was investigated. Storage increased breakage by 2 to 5%, decreased germination by 2%, and the shear force of a cooked sample was slightly higher. Each of these effects is a small, but significant quality deterioration.

• Lentil seeds from successive years should not be mixed as all the lentil seeds may be downgraded by the colour changes in the oldest seed.

Oxidized lentil seeds may be used for seed if germination and viability are high. All lentil seeds should be sold within two years of harvest.

Lentil seeds are very susceptible to peeling and cracking of the seed coat and to splitting if they are handled when it is colder than -20°C or the seeds are drier than 14% seed moisture content.

Grading

The Canadian Grain

Commission under recommendation of the Producer Trade Advisory Committee sets the standards for the lentil grades. Lentil grading is based on colour; presence of earth tag or dirt and other material attached to the seed; damage, such as cracking, splitting, wrinkling, and smell; and the content of foreign material, such as stones, insect parts, other plant material, sclerotinia and ergot (Figures 7.13 to 7.21 and Tables 7.9, 7.10 and 7.11).

Fall Land Preparation

Harvested lentil plants leave very little stubble or residue, and can leave land prone to erosion. In erosion-prone areas, it is advisable to take steps to reduce the problem. Spring cereals, seeded after September 15 as a cover crop, can be used to help stabilize the soil in a wet year. The cereals are seeded at a rate of about 1 bu/ac (67 kg/ha).

Lentil stubble is too short to use in snow trapping. Strip seeding one row of flax or durum per seeder width (30 to 40 feet, 9 to 12 m) when lentil is planted may help with snow trapping, if the row is left standing at harvest time. Seeding perpendicular to the prevailing wind may also help.

Shelterbelts, direct seeding, and strip cropping can also be very effective. Planning the rotation is very important as it can help eliminate or reduce the need for fall incorporated herbicides on land where the risk of soil erosion is severe.



Table 7.9 Primary grade determinants for Lentils other than red, Canada.

Grade name	*Degree of soundness	Contrasting colours (%)	Damaged (%)				
			*Stained (%)	*Heated	*Peeled, split, broken	*Other damage	*Total
No. 1 Canada	Uniform in size, of good natural colour	0.2	1.0	About 0.2	2.0	1.0	2.0
No. 2 Canada	Uniform in size, of reasonably good natural colour	0.5	4.0	About 0.5	3.5	2.0	3.5
Extra No. 3 Canada	Uniform in size, of fair colour	2.0	7.0	About 0.5	5.0	5.0	5.0
No. 3 Canada	Poor colour	3.0	No limit	1.0	10.0	10.0	10.0
Grade, if No. 3 specs not met		Lentils, Sample Canada, Account Contrasting Colours		Lentils, Sample Canada, Account Heated	Lentils, Sample Canada, Account Damaged	Lentils, Sample Canada, Account Damaged	Lentils, Sample Canada, Account Damaged

Source: Canadian Grain Commission Official Grain Grading Guide, August 1999

Grade name	Foreign Material (%)					*Total
	Ergot	Excreta	Sclerotinia	*Stones	Other foreign material	
No. 1 Canada	0.05	0.01	0.05	About 0.1	About 0.2	About 0.2
No. 2 Canada	0.05	0.01	0.05	About 0.2	About 0.5	About 0.5
Extra No. 3 Canada	0.05	0.01	0.05	About 0.2	About 0.5	About 0.5
No. 3 Canada	0.05	0.01	0.05	About 0.2	1.0	1.0
Grade, if No. 3 specs not met	Lentils, Sample Canada, Account Ergot	Lentils, Sample Canada, Account Excreta	Lentils, Sample Canada, Account Admixture	2.5% or less – Lentils, Rejected (grade) Account Stones, or Lentils, Sample CE, Account Stones Over 2.5% - Lentils, Sample Salvage	Lentils, Sample Canada, Account Admixture	Lentils, Sample Canada, Account Admixture

*Defined in Canada Grain Regulations



7.28 Lentil

Table 7.10 Primary grade determinants tables for Lentils, Canada Red

Source: Canadian Grain Commission Official Grain Grading Guide, August 1999

Grade name	*Degree of soundness	Damage (%)				
		Contrasting Colours (%)	*Heated	*Peeled, split and broken	*Other damage	*Total
No. 1 Canada	Uniform in size, of good natural colour	0.2	About 0.2	2.0	1.0	2.0
No. 2 Canada	Uniform in size, of reasonably good natural colour	0.5	About 0.5	3.5	2.0	3.5
Extra No. 3 Canada	Uniform in size, of fair colour	2.0	About 0.5	5.0	5.0	5.0
No. 3 Canada	Poor colour	3.0	1.0	10.0	10.0	10.0
Grade, if No. 3 specs not met		Lentils, Sample Canada, Account Contrasting Colours	Lentils, Sample Canada, Account Heated	Lentils, Sample Canada, Account Damaged	Lentils, Sample Canada, Account Damaged	Lentils, Sample Canada, Account Damaged

Grade name	Ergot	Foreign material (%)				
		Excreta	Sclerotinia	*Stones	Other foreign material	*Total
No. 1 Canada	0.05	0.01	0.05	About 0.1	About 0.2	About 0.2
No. 2 Canada	0.05	0.01	0.05	About 0.2	About 0.5	About 0.5
Extra No. 3 Canada	0.05	0.01	0.05	About 0.2	About 0.5	About 0.5
No. 3 Canada	0.05	0.01	0.05	About 0.2	1.0	1.0
Grade, if No. 3 specs not met	Lentils, Sample Canada, Account Ergot	Lentils, Sample Canada, Account Excreta	Lentils, Sample Canada, Account Admixture	2.5% or less Rejected (CW grade) Account Stones, or Lentils Sample Canada, Account Stones Over 2.5% - Lentils, Sample Salvage	Lentils, Sample Canada, Account Admixture	Lentils, Sample Canada, Account Admixture

*Defined in the Canada Grain Regulations



Table 7.11 Export grade determinants tables for Lentils, Canada

Grade name	Degree of soundness	Damage (%)					*Total
		Contrasting Colours	*Stained	*Heated	*Peeled, split and broken	*Other damage	
No. 1 Canada	Uniform in size, of good natural colour	0.2	1.0	About 0.2	2.0	1.0	2.0
No. 2 Canada	Uniform in size, of reasonably good natural colour	0.5	4.0	About 0.5	3.5	2.0	3.5
Extra No. 3 Canada	Uniform in size, of fair colour	2.0	7.0	About 0.5	5.0	5.0	5.0
No. 3 Canada	Poor colour	3.0	No limit	1.0	10.0	10.0	10.0

Source: Canadian Grain Commission Official Grain Grading Guide, August 1999

Grade name	Ergot	Foreign material (%)			Total
		Sclerotinia	Stones	Other foreign material	
No. 1 Canada	0.05	0.05	About 0.1	About 0.2	About 0.2
No. 2 Canada	0.05	0.05	About 0.2	About 0.5	About 0.5
Extra No. 3 Canada	0.05	0.05	About 0.2	About 0.5	About 0.5
No. 3 Canada	0.05	0.05	About 0.2	1.0	1.0

*Defined in the Canada Grain Regulations

7.30 Lentil

Source: Canadian Grain Commission



Figure 7.13 Good natural colour lentil sample.

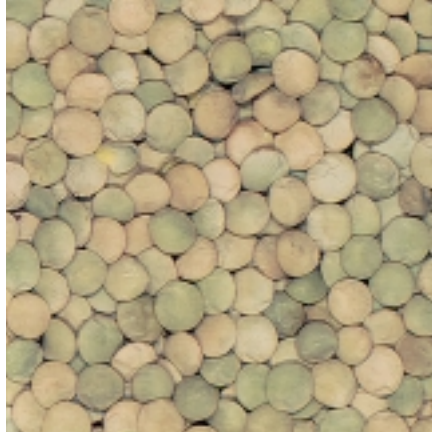


Figure 7.14 Reasonably good natural colour lentil sample.

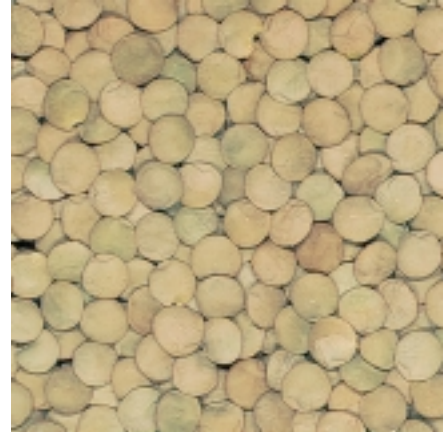


Figure 7.15 Fair colour lentil sample.

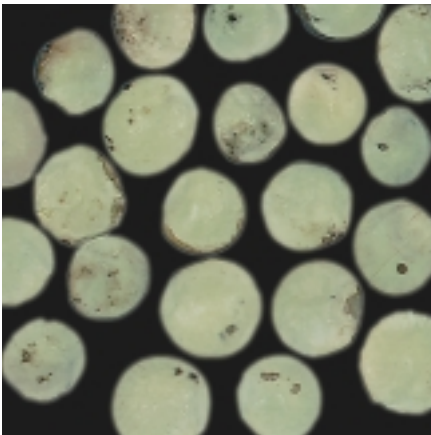


Figure 7.16 Not stained lentil sample.

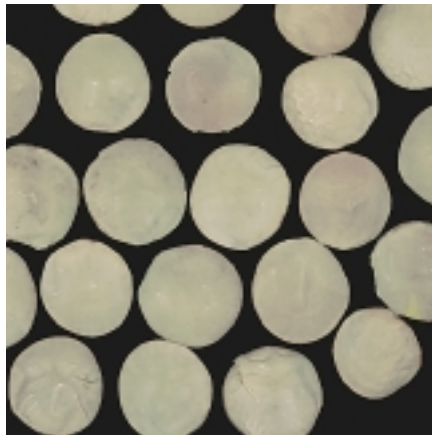


Figure 7.17 Not considered as stained lentil sample – evaluated on colour.

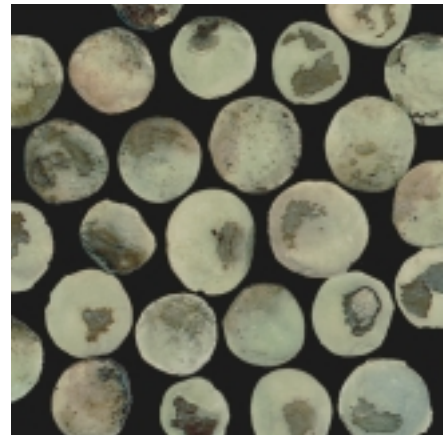


Figure 7.18 Stained lentil sample.

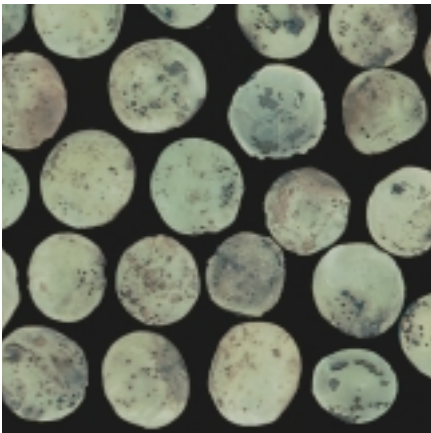


Figure 7.19 Mottled lentil sample – considered as stained.

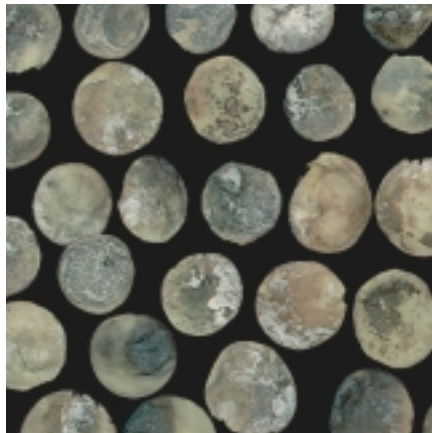


Figure 7.20 Damaged lentil sample – ascochyta also considered as stained.

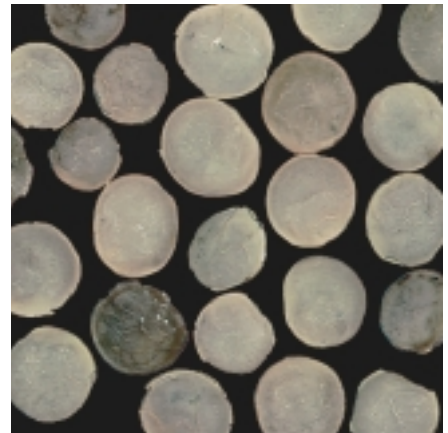


Figure 7.21 Damaged lentil sample – frost.