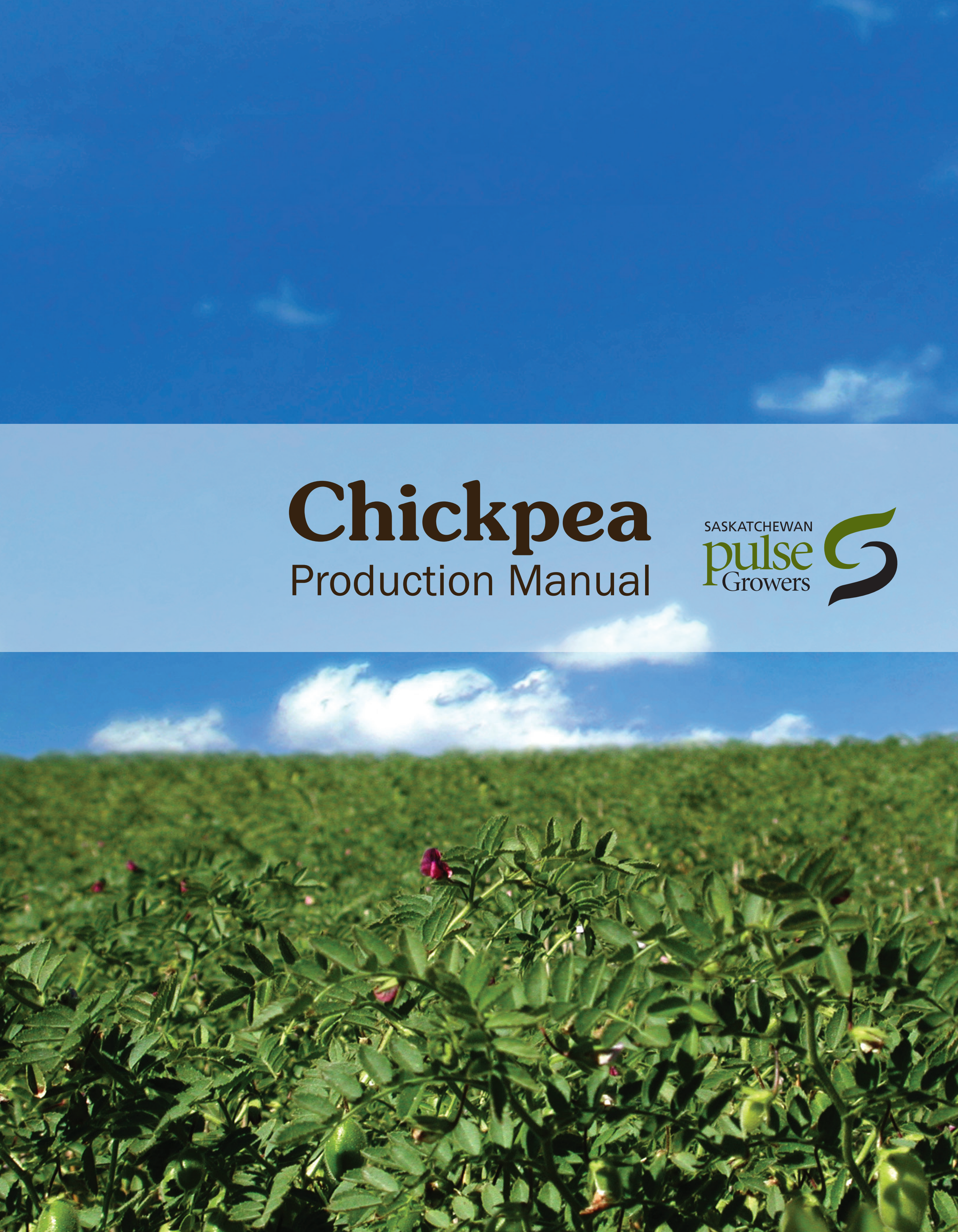


Chickpea

Production Manual

SASKATCHEWAN pulse Growers

Index

Quick Facts

- Desi type chickpeas have smaller, angular seeds with yellow to brown seed coats. Kabuli type chickpeas have a more rounded seed with a cream-coloured coat.

- Depending on moisture available, plants range in height from 30 cm to 70 cm.

- Plants continue to flower until they encounter some form of stress, such as drought, heat, frost, nitrogen deficiency, mechanical damage, or chemical desiccation.

- The main stem of the chickpea plant will produce up to seven primary branches originating near ground level.

- Plants are expected to reach maturity in 110 to 130 days.

Plant Description

Two major seed types or classes of chickpea are grown; desi and kabuli. Desi types have smaller, angular seeds with yellow to brown seed coats. Kabuli types have more a rounded seed with a cream-coloured coat.

Chickpea scale nodes are typically short. Depending on moisture available, plants range in height from 30 centimetres (cm) to 70 cm. The plants are naturally resistant to lodging and the inflated pods, each containing one to two seeds, form several inches from the ground and are relatively shatter resistant. Even though the plants are small, the tap root extends to rooting depths similar to wheat.

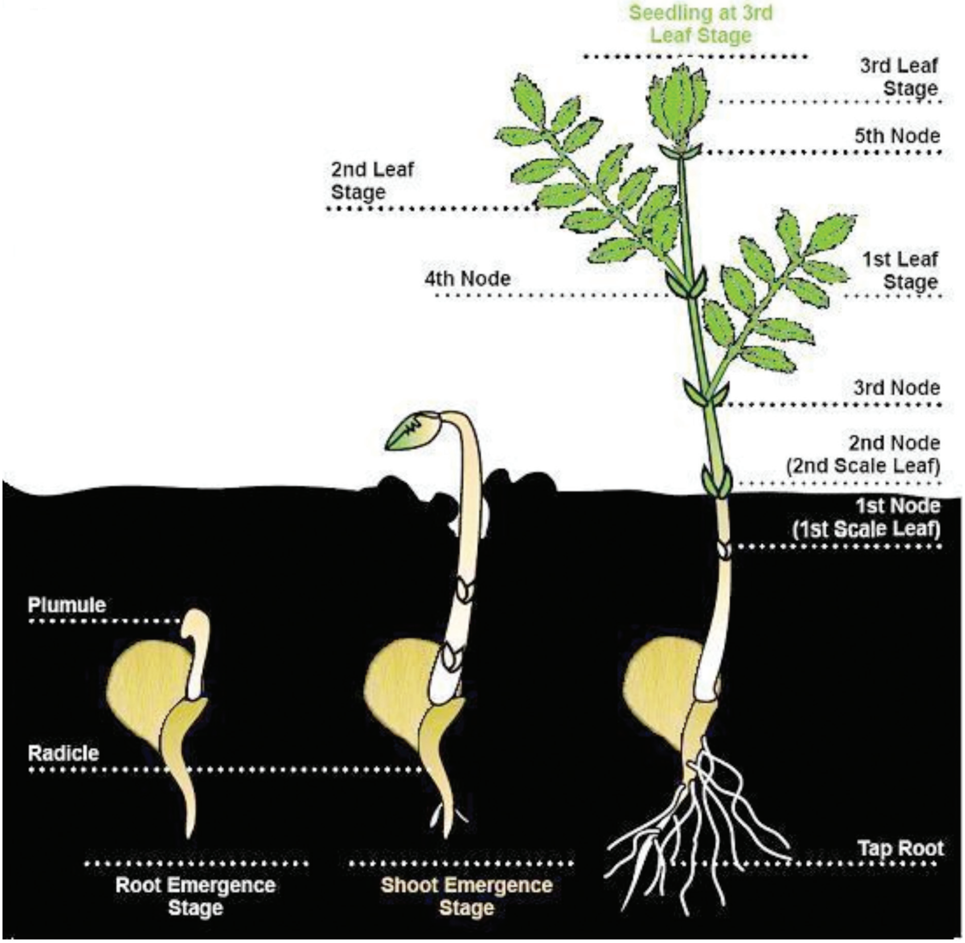
Chickpea scale nodes remain below the ground during germination, offering the plant some late spring frost tolerance and opportunity for regrowth if the top growth is damaged in the seedling stage.

The first two nodes of the chickpea plant produce scale leaves. The first scale leaf may be below the ground, but the first true leaf is produced at the third node position. On average, a new node is produced every three to four days.

Chickpea scale nodes 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. This indeterminate growth habit is usually expressed in late maturity group varieties, but all current chickpea varieties are classified as indeterminate in growth habit.

The main stem of the chickpea plant will produce up to seven primary branches originating near ground level, usually leading to an erect growth habit. A large number of secondary branches are produced on the main stem and primary branches. Desi chickpea and newer kabuli varieties have leaves about five cm long with nine to 15 leaflets, and are described as having a fern-leaf structure. Some older kabuli varieties, such as CDC Xena, have a single (unifoliate) leaf structure instead of leaflets. Flowers, which are highly self pollinating, start to be produced at about the 13 or 14 node stage (usually 50 to 55 days after seeding) in axillary racemes. Depending on the type and variety of chickpea, seed size and colour can range considerably. However, all seeds have the distinctive "beak" formed at the radical tip. In most years the plant would be expected to reach maturity in 110 to 130 days.

Figure 1. Chickpea seedling
Source: Pulse Production Manual 2000



Quick Facts

- If not limited by other production factors, chickpea does best with 15 to 25 cm of growing season rainfall.
- Two serious production limitations in Saskatchewan are the long growing season requirement for current varieties and the high risk of ascochyta blight, an extremely aggressive disease.
- Due to the indeterminate growth habit of chickpea, plants can re-grow late in the season after rain showers or in the absence of a killing frost.
- Temperatures of 35°C and higher cause stress during early flowering and pod development.
- Soil zone/crop insurance coverage areas reflect the adaptation of this crop. Due to maturity issues, coverage is available only if chickpea is planted on either summerfallow or stubble in the Brown soil zone or on stubble in the Dark Brown soil zone. Contact your local office for insurance coverage details.

Adaptation

Chickpea is a cool season crop that grows best when daytime temperatures are between 21°C and 29°C, and nighttime temperatures are between 18°C and 21°C. It is relatively drought tolerant as its long taproot (often greater than a meter in depth) can access water from a greater depth than other pulse crops. Chickpea grows best on well drained soils with neutral pH. If not limited by other production factors, chickpea seems to do best with about 15 to 25 cm of growing season rainfall. In drier areas of the province, or in dry years, planting chickpea on fallow may produce a higher yield than on stubble. However, if the growing season has ample rainfall, combined with higher soil moisture reserves on fallow, excess vegetative growth may result and maturity will be extended.

Chickpea is best adapted to the Brown and Dark Brown soil zones in Saskatchewan. Soil zones with more moisture and a shorter growing season will have increased problems with seedling blight, late maturity, and severe ascochyta. Chickpea is not well-adapted to saline soils or to high-moisture areas. It is also not well suited to soils with high clay content or areas where soils are slow to warm in the spring. Chickpea does not tolerate wet or waterlogged soils.

Two serious production limitations in Saskatchewan are the long growing season requirement for current varieties and the high risk of ascochyta blight, an extremely aggressive disease. Planting chickpea outside the areas of best adaptation has proven to be very risky due to delayed maturity, high green seed content, and destructive disease infections. To prevent delayed or uneven maturity, avoid planting chickpea in low lying areas in the field, around sloughs, or in areas with high soil organic matter.

Fallow is often not the best choice for chickpea if soil moisture reserves and growing season precipitation combine to provide excess moisture. Planting on stubble fields tends to reduce vegetative growth and results in moisture stress to hasten maturity. Due to the indeterminate growth habit of chickpea, plants can re-grow late in the season after rain showers or in the absence of a killing frost. There are no management practices to overcome the problem of late vegetative regrowth.

In the Brown and Dark Brown soil zones, stubble retention is critical for capturing and holding snow. Maximizing the amount of standing stubble that remains after seeding will assist in reducing wind speed at the soil surface, minimize evaporation and increase water use efficiency. Increased soil moisture at seeding will also be of benefit to the rhizobia in the inoculant and improve seedling.

Chickpeas adapt root depth to water availability with 88 and 67 per cent of root area in the top 23 cm under irrigation and dryland, respectively. Chickpea has double the root area of pea, and as such, may be better adapted to dryland production in semi-arid areas than pea, based on water availability.

Chickpea has a deep rooting system, better suited to lighter textured sandy soils and is very tolerant to drought. Chickpea will mature earlier and with better quality on sandier soils.

Chickpea often leaves the soil drier at harvest compared to other crops due to its late maturity and utilization of late-season rainfall.

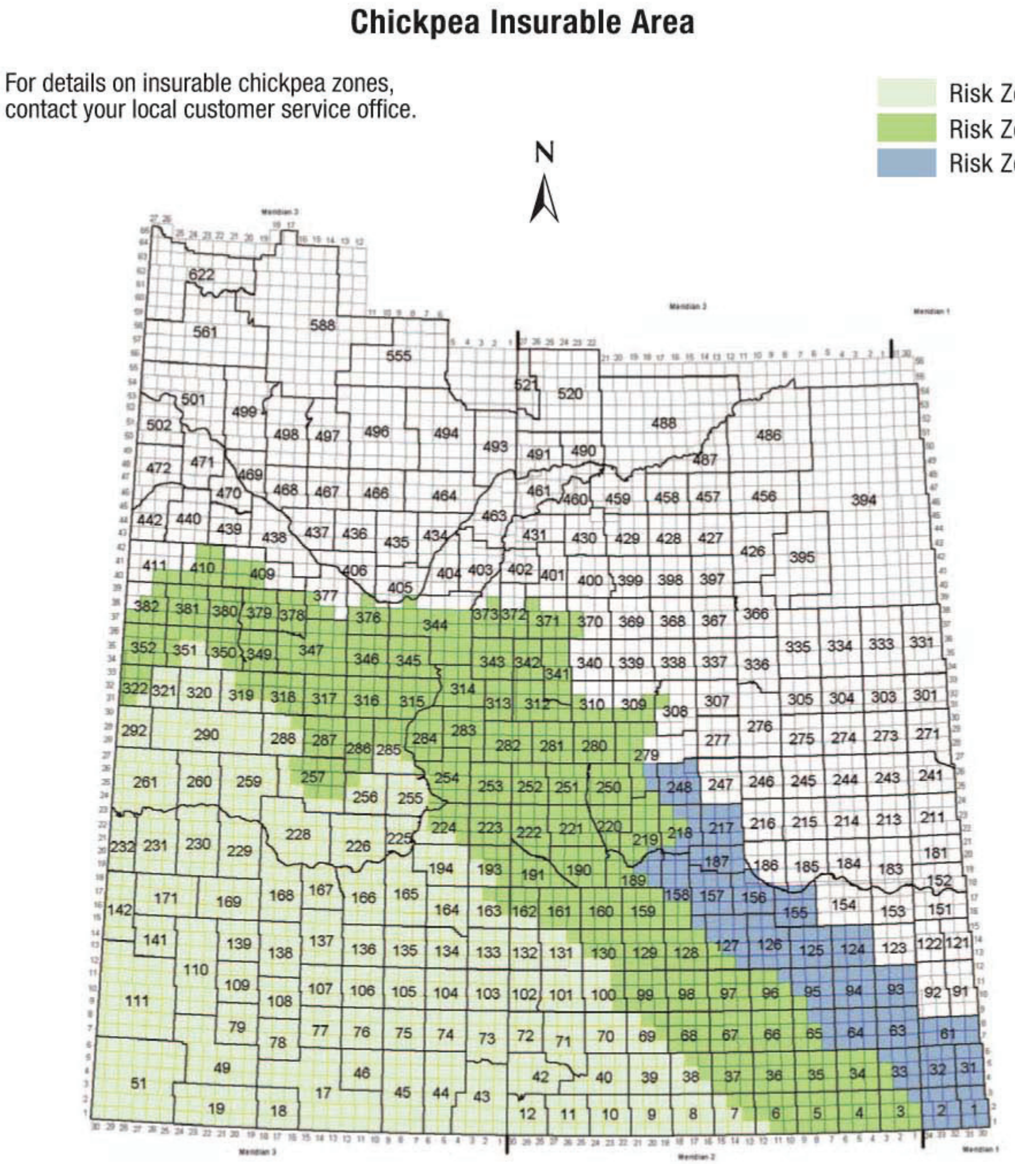
Temperatures of 35°C and higher cause stress during early flowering and pod development. Yield reductions are greatest, over 50 per cent, when stress occurrs during pod development as compared to early pod development where yields are reduced by approximately 30 per cent. Crop management to reduce heat stress at these periods will increase pod fertility, seed set, and yield.

Desi chickpea varieties are short and early in maturity. They are higher yielding and more resistant to mechanical, frost, and insect damage than kabuli varieties. The area of adaptation can extend into the moist Dark Brown soil zone if grown on stubble or on lighter textured soils.

Kabuli chickpea varieties are strongly indeterminate, usually maturing in 110 to 120 days. In a cool, wet season, the maturity of kabulis can easily extend past 120 days. The Brown soil zone provides the conditions most likely to encourage maturity in a reasonable time. Frost in the fall usually causes more damage to kabuli varieties and can prevent the green seed from turning golden in colour.

Soil zone/crop insurance coverage areas reflect the adaptation of this crop. Due to maturity issues, coverage is available only if chickpea is planted on either summerfallow or stubble in the Brown soil zone or on stubble in the Dark Brown soil zone. Contact your local office for insurance coverage details.

Figure 2. Saskatchewan Crop Insurance chickpea coverage zones
Source: Saskatchewan Crop Insurance



Quick Facts

- *Market demand for a particular class or variety can change over time.*

- *Smaller, niche markets may exist for certain varieties.*

- *Characteristics such as disease tolerance, maturity, or harvestability can quickly overshadow potential yield gains.*

- *Ascochyta blight easily overcomes the typical chickpea disease response/ defense mechanisms.*

- *Continued breeding efforts are underway to increase the levels of resistance to ascochyta blight, decrease days to maturity, and improve seed quality.*

Variety Selection

There are many agronomic and market factors to consider when choosing a variety. Market demand for a particular class or variety can change over time. Check with buyers to determine their needs. Smaller, niche markets may exist for certain varieties, but not all buyers are interested in handling all chickpea varieties.

Yield is an obvious consideration within a market class. However, other characteristics such as disease tolerance, maturity, or harvestability can quickly overshadow potential yield gains if the plant is limited in reaching its full potential.

Disease resistance, specifically resistance to ascochyta blight, is an extremely important factor in variety selection. Ascochyta blight easily overcomes the typical chickpea disease response/ defense mechanisms. As a result, complete resistance to blight has not been identified in chickpea to date.

Most of the current varieties have improved resistance to ascochyta blight. Continued breeding efforts are underway to increase the levels of resistance to ascochyta blight, decrease days to maturity, and improve seed quality. Chickpea varieties have been evaluated in the Saskatchewan regional testing program since 1995. Please visit the SPG website at www.saskpulse.com for an updated variety listing.

Figure 3. Desi chickpea
Photo: David Stobbe

Figure 4. Kabuli chickpea
Photo: David Stobbe

Quick Facts

- *Well-drained soils are best suited for chickpea production.*
- *Water logging can result in a poorly developed root system. When dry conditions are encountered later in the season, the plant may not be able to obtain adequate moisture and nutrients to meet its needs.*
- *If a certain weed is likely to be present in high numbers and cannot be controlled, field selection may have to change.*
- *It is very important to control perennial weeds in the years prior to seeding chickpea.*
- *It is important to maintain herbicide records with the active ingredient, common name, and rate for each crop year.*
- *Bioassay results from laboratories are only as good as the sampling protocol used to collect the soil samples.*
- *Spores of ascochyta can be found four years after the initial crop, even with burial of crop residues.*
- *Chickpea production is often successful in rotation with cereal grains such as durum wheat, because chickpea does not leave significant amounts of crop residue.*

Field Selection and Preparation

In areas where chickpea is adapted, the physical properties of the field should be considered. Well-drained soils are best suited for chickpea production. The short stature of the plant will result in the crop being cut fairly low, although most pods will be formed a few inches above the soil surface. Chickpea plants do not lodge, so the cutter bar will not have to travel as close to the ground as it does for lentil or pea, therefore, rolling is also not necessary, but it may still offer some advantages. With stones pushed into the ground and a more level surface, rolling will still improve cutterbar operation, increase speed of cutting and reduce earth tag. Rolling, if done, should be completed before the chickpea plant emerges. Straw and residue from the previous crop should be finely chopped and evenly spread to ensure uniform emergence.

Land that has rolling topography will usually lead to differences in maturity across the field due to variance in soil moisture. Since chickpea is shatter resistant, this may not lead to any problems unless the later maturing areas are considerably behind. However, the lower areas of the fields may need to be harvested separately. If lower areas of the field are subject to water logging or standing surface water, the chickpea in those areas can drown or have severely reduced yield. Water logging can also result in a poorly developed root system and when dry conditions are encountered later in the season, the plant may not be able to obtain adequate moisture and nutrients to meet its needs.

Weeds must be considered when selecting a field. Chickpea plants are poor competitors. The short, open canopy is ideal for weed growth. Ensure herbicides are available to control weeds expected to be competing with the chickpea crop. This requires knowledge of the field's weed history including herbicide resistant weeds if they are present. Few herbicides are registered for broadleaf weed control in chickpea and in-crop control options may not exist for certain weeds. Remember to also consider volunteer crop as weeds. Volunteer canola, mustard, and flax are difficult to control and it is advisable to not seed chickpea following these crops. If a certain weed is likely to be present in high numbers and cannot be controlled, field selection may have to change.

Perennial weeds such as Canada thistle, dandelion, perennial sow thistle and quackgrass are very competitive in any crop and even more so in non-competitive crops like chickpea. Herbicides currently registered in chickpea have little to no effect on most of these weeds. It is very important to control perennial weeds in the years prior to seeding chickpea. Good weed control requires a long-term strategy involving the entire crop rotation. A pre-harvest glyphosate application, in years when the crop and timing allows, is key to long-term perennial weed control.

Fall weed control options, in addition to pre and post-harvest glyphosate for perennial weed control, should be reviewed to determine if they offer any advantages. A late fall application of a phenoxy herbicide such as 2,4-D or MCPA will control winter annual weeds. However, the maximum rate applied should be 280g ai/ha or 113g ai/ac (8 active ounces). Since spring glyphosate application is so common, application of a phenoxy in the fall, prior to seeding chickpea, is not a common practice. In years of higher priced glyphosate, 2,4-D may be cheaper to apply compared to glyphosate and offers a way of diversifying the herbicide mix on a particular field over time. This practice may have more of a fit in fields where seeding may be delayed in the spring, or in fields where very early spring weed growth is expected.

Soil residues of many herbicides commonly used in Saskatchewan can cause injury to a chickpea crop. Many of the herbicide labels do not list chickpea when disclosing re-cropping considerations. As a result, information on susceptibility to the various soil residual herbicides is difficult to find. If re-cropping information is not available, many manufacturers will suggest re-cropping guidelines in excess of what is actually necessary.

It is important to maintain herbicide records with active ingredient, common name, and rate for each crop year.

If the possibility exists that a soil residual product might affect chickpea growth, a test plot should be planted the year before chickpea is grown in that field. The plot should be grown to maturity to ensure that there are no late season herbicide effects on yield or crop quality. Another option is to submit soil samples to a lab for a bioassay. Bioassay results from laboratories are only as good as the sampling protocol used to collect the soil samples and 100 per cent accuracy cannot be guaranteed. False positive results are of no harm, but a false negative could mean crop damage or failure.

Disruption of disease cycles is also an important consideration in field selection. Chickpea is extremely susceptible to ascochyta blight and careful consideration must be given to crop rotation to reduce the risk of this disease. Ascochyta blight can cause devastating losses of chickpea in all soil zones, therefore varieties with good ascochyta resistance should be grown.

Spores of ascochyta can be found four years after the initial crop, even with burial of crop residues. Saskatchewan research concluded that at least two non-host crops needed to be grown between successive chickpea crops to reduce disease risk if blight was present in the initial crop. Chickpea grown next to chickpea stubble from the previous year is also at high risk of ascochyta infection.

Crop rotation goes beyond disease considerations and weed control (including volunteer crop). Chickpea production is often successful in rotation with cereal grains such as durum wheat, because chickpea does not leave significant amounts of crop residue. Growing cereal crops with tall stubble before and after chickpea provides much needed residue to protect the soil from erosion.

Research has shown that chickpea can root to a depth similar to wheat or canola, and can extract moisture from that depth. Although this characteristic helps chickpea tolerate drought, it also depletes the soil profile of moisture for subsequent crops. This may explain why cereal yields tend to be lower following a chickpea crop, compared to a lentil or pea crop.

Quick Facts

- *Chickpea production can be successful under both minimum and no-till soil management.*
- *Seed quality includes genetic and mechanical purity, germination and vigour, and levels of seed-borne disease.*
- *Seed size selection for chickpea can be more of a consideration compared to other pulse crops because the value of the seed increases with the size.*
- *In the Brown and Dark Brown soil zones, seed testing zero to 0.2 per cent ascochyta infection is suitable for planting, but all seed should be treated with fungicide controlling ascochyta as even a zero per cent result may contain some infected seeds at a lower frequency than what was detectable by the lab.*
- *Chickpea has the ability to fix 60 to 80 per cent of its nitrogen requirement through nitrogen fixation.*
- *Inoculant is economical relative to its potential benefits and nitrogen fertilizer replacement. The risk of poor nodulation is too great to not inoculate each time the crop is seeded.*
- *If nitrogen fixation is active, the nodules will be pink or red on the inside. Lack of nodules indicates rhizobia did not infect the pulse plant. Lack of a pink colour (usually green or cream coloured) indicates the rhizobia are not fixing nitrogen.*
- *Chickpea is slower to emerge, especially the larger seeded kabuli types, so a wider window between seeding and emergence allows more time if a post-seed/pre-emergent glyphosate application is planned.*
- *Sufficient soil phosphorus is required for nitrogen fixation and promotes earlier maturity.*
- *The maximum safe rate of actual phosphate applied with chickpea seed is 22 kg P_2O_5/ha (20 lb P_2O_5/ac) in a 2.5 cm spread and 22.5 cm row spacing under good to excellent moisture conditions.*
- *Chickpea requires planting equipment with a seed-feeding mechanism capable of handling medium to large seeds.*
- *The desired plant population for chickpea is 44/m^2 (4/ft^2).*
- *Row spacing on most seeding equipment presently on Saskatchewan farms is in the range of 22.5 cm to 30 cm.*
- *Desi chickpea will germinate in soil as cold as 5°C, but seedling vigor will be greater if soil temperature is at least 7°C.*

Production

Method of Seeding

Chickpea fits well into a direct seeding crop system with no problems noted for crop emergence and establishment. Chickpea production can be successful under both minimum and no-till soil management. Minimum till offers producers a way to provide additional mechanical weed control while no-till appears to have both economic and environmental benefits across all of Saskatchewan.

Taller standing stubble can increase the height of the lowest pods (normally at about 10 cm as has been the case in lentil and pea).

Equipment that seeds between rows of standing stubble will reduce water loss to evaporation and benefit the chickpea crop, especially in dry conditions. Standing stubble will reflect sunlight and may result in colder soils which are slower to warm in the spring and this may be detrimental in a cool, wet spring.

Research at Swift Current from 1996 to 1998 and 2000 determined that seeding into tall (25 to 36 cm) standing stubble increased chickpea yields by nine per cent as compared to short (15 to 18 cm) standing stubble.

Seed Quality

Selection and use of high quality seed is the first step in establishing a rapidly emerging, vigorous stand, and producing a high quality and profitable crop. Inoculation, fertilization, and pest control will be of limited value if planted seeds do not produce a healthy, vigorous stand.

Planting high quality, pure seed should:

- Increase tolerance to seedling diseases.
- Promote rapid and uniform stand establishment.
- Enhance tolerance to early season stresses such as adverse temperature and moisture conditions.
- Promote rapid root development leading to improved nutrient, and water use efficiencies.
- Result in enhanced disease, weed, and insect tolerance.
- Provide a more uniform stand with more uniform maturity, allowing for improved harvest efficiencies and a more uniform product.
- Produce higher yields and superior seed quality.

Seed quality includes genetic and mechanical purity, germination and vigour, and levels of seed-borne disease.

Seed purity is determined by the nature and amount of unwanted contaminants in the pure seed. Impurities include unwanted crop seed, weed seeds, and inert material. They can adversely impact crop yield and quality, as well as increase production costs.

Seed germination tests assess the ability of the seed to produce a healthy plant under favourable growing conditions. These tests are generally conducted under controlled conditions that provide ideal moisture, temperature, and light for a prescribed period of time. Unfortunately, these tests may over-estimate actual field emergence. Seed lots with low germination often lack the ability to produce strong, healthy seedlings.

Seed vigour tests, conducted by some seed testing labs, are conducted under more adverse conditions than a germination test. Vigour tests are not standardized and conditions imposed upon the seed may vary from lab to lab. Vigour tests are an attempt to more realistically predict field seedling emergence. Seed vigour can decrease due to mechanical damage, immaturity at harvest, seed age, pathogen (disease) infection, wet harvest conditions, and seed handling during cleaning and seeding operations. Although not standardized, vigour tests can provide useful seed quality information.

Seed from fields treated with pre-harvest glyphosate should be avoided. The seed may contain residue which can reduce germination, vigour, normal root development and inoculant efficacy. Any chickpea crop having a pre-harvest herbicide applied, whether it is for weed control or crop desiccation, has the potential for reduced germination.

Contamination from seed-borne diseases should be as low as possible. Seed borne ascochyta easily transmits to seedlings in the field and only seed with close to zero percent seed-borne ascochyta should be used. The seed level of this disease is very important from a disease management standpoint and also has to be considered for crop insurance reasons. Saskatchewan Crop Insurance Corporation (SCIC) has set maximum seed-borne ascochyta infection levels in chickpea seed at 0.3 per cent to qualify for a crop insurance claim where the cause of loss was ascochyta blight.

Other chickpea diseases can be spread by infected seed and are summarized in Table 1. These are guidelines only as other factors must also be taken into account. These factors include such things as the cost and availability of disease-free seed with good germination, availability of registered seed treatments to control the disease(s), and typical weather conditions.

Seed Size

Seed size selection for chickpea can be more of a consideration compared to other pulse crops because the value of the seed increases with the size.

Large kabuli chickpea seed can be screened and sized before planting. The 9 and 10 millimetre (mm) seeds can be removed from the seed lot and sold into the commercial market, and the eight mm seeds are used for planting. There are no yield penalties for two years as long as the smaller seeds do not have an increased percentage of seed-borne diseases. However, there will be a decrease in the percentage of large seeds harvested.

The use of small seeded fractions (7.1 to nine mm) from kabuli seed lots has resulted in minimal effects on yield, unless the small seed is planted too deep (100 mm), compared to 50 mm. However, small seed resulted in four per cent lower plant height, and five per cent lower height to first pod as compared to unselected kabuli seed lots.

Seed Treatment

Seed to seedling transmission of ascochyta blight is high in chickpea and seed treatment is usually recommended.

In the Brown and Dark Brown soil zones, seed testing zero to 0.2 per cent ascochyta infection is suitable for planting, but all seed should be treated with fungicide controlling ascochyta as even a zero per cent result may contain some

Table 1. Guidelines for Tolerances of Seed-borne Diseases in Chickpea Planted Seed

(These are guidelines only and should be considered along with farming practices and level of disease risk for the situation)

Disease (Pathogen)	Tolerance and Factors Affecting the Level
Ascochyta *(Ascochyta rabiei)*	Use with Seed less than 0.3% ascochyta infection 3. Even though a seed test may indicate 0% infection, the seed lot may still contain infected seed and seed treatment is recommended. Seed-to-seed transmission of ascochyta blight is high in chickpea. The disease is very aggressive and can spread quickly in a field once established if weather conditions are favourable. Guidelines for ascochyta blight control in chickpea are available at: http://www.agr.gov.sk.ca/docs/production/ascochytaonChickpeas.asp.
Seed Rots and Damping-off	These are soil-borne diseases and are not tested for at seed testing labs. The use of seed treatment is strongly recommended for kabuli varieties since they are very susceptible to these diseases.
Seed Rots and Seedling Blights	*Sclerotinia, Rhizoctonia* and *Fusarium* are primarily soil-borne. *Botrytis* and *Fusarium* are also often seed-borne and can be tested for at seed testing labs. Up to 10% infection *(Sclerotinia + Botrytis)* may be tolerable, but will result in significant seedling blight if a seed treatment is not used. The importance of seed-borne *Fusarium* in seed rot and seedling blight in pulses is not known. Some labs will notify growers if >5% *Fusarium* infection occurs. If present, add the *Fusarium* value to the *Sclerotinia* + *Botrytis* value above (not to exceed 10%).

[1] New seed treatments are continually being registered. Contact the Ag Knowledge Centre at 1-866-457-2377, your local agri-retailer or industry rep for updated information on seed treatments registered in pulses. SMA's *Guide to Crop Protection* is available online http://www.agr.gov.sk.ca/docs/production/cropguide00.asp. Always refer for the product label before applying product to the seed.

[2] The level of seed-borne infection is not the only factor to consider on whether or not to apply a seed treatment as most seed treatments are also effective against soil-borne pathogens. Refer to product label for details.

[3] Saskatchewan Crop Insurance Corp (SCIC) will not support claims for ascochyta loss that are made on chickpea fields that had over 0.3% seed infection and no seed treatment was used. Refer to SCIC website at: http://www.saskcropinsurance.com/programs/2006/Specialized/NewCrops/chickpeas.shtml#.

Source: Saskatchewan Ministry of Agriculture (SMA)

infected seeds at a lower frequency than what was detectable by the lab. Kabuli varieties, with their thinner seed coats, should always be treated for seed rot diseases and seed-borne ascochyta blight. Desi chickpea, which has a thick, dark-coloured seed coat, does not usually require a seed treatment to protect it from pythium, although it too is susceptible to other rots and blights.

One or more of the following trends may increase the value of seed treatment compared to past recommendations:

- Shortened crop rotations.
- Earlier seeding due to increased farm size (cooler soil temperatures).
- More crop residue with minimum-till and no-till practices results in slower soil warming.
- Improved efficacy and handling of newer seed treatment products.

Different fungicides control different species of fungal organisms so it important to know what organism is infecting your seed.

Seed treatment for control of insect pests in chickpea is much more limited compared to treatments available for disease. Currently only one insecticidal seed treatment (Cruiser Maxx Pulses®) is registered for use on chickpea for non-commercial seed treatment for wireworm control.

Certain fungicides and insecticides may be harmful to inoculants. Check the label of both the inoculant and the seed treatment to ensure compatibility. Review treatment procedures to ensure maximum bacteria survival. If no reference is made to compatibility, check with both the seed treatment and inoculant manufacturer for advice.

Seed treated with a fungicide should be dried prior to applying nitrogen fixing inoculant. Once inoculated, plant as soon as possible, as delays can reduce the seed efficacy of the inoculant.

The use of granular inoculant will avoid any problems with direct contact between seed treatment and inoculant.

Inoculation for Nitrogen Fixation

Chickpea has the ability to fix 60 to 80 per cent of its nitrogen requirement through nitrogen fixation.

Nitrogen fixation is a symbiotic relationship and both the rhizobia and the plant benefit from the relationship. Nitrogen fertilizer can be used in chickpea to manage maturity. If used, inoculant should not be applied. Either method should result in the same yield. The use of nitrogen to manage maturity is detailed in the fertility section.

Kabuli chickpea is an excellent nodulator and nitrogen fixer. Desi chickpea is a good nitrogen fixer under ideal conditions, but may be a little sensitive to adverse environmental conditions.

Chickpea requires a specific rhizobium species for nitrogen fixation. Chickpea rhizobium species are not the same as the rhizobium species for peas and lentil. Examine the label of any inoculant to make sure that it is appropriate for chickpea. Some chickpea inoculants will be labelled as "garbanzo bean" and are appropriate for use in chickpea. Note that many different strains of this rhizobium species occur and vary in terms of their effectiveness. The manufacturer may have one or more strains in the inoculant.

The rhizobia enter the root hairs of the plant and induces nodule formation. The plant provides energy and nutrients for the rhizobium bacteria living inside the nodules. The rhizobia, in return, converts atmospheric nitrogen from the soil air surrounding the roots into a form that can be used by the plant. Rhizobium bacteria are not very mobile so the inoculant must be placed close to the seed for maximum nodulation. The maximum benefit from nitrogen fixation is derived if the supply of available soil nitrogen is low and the soil moisture and temperature levels are good at the time of seeding. If the soil plus fertilizer nitrogen exceeds 40 kg/ha (35 lbs/ac), nodulation can start to be reduced. If the level reaches 55 kg/ha (50 lbs/ac) or higher, nodulation can be dramatically delayed and fixation greatly reduced or eliminated.

If the rhizobia are actively fixing nitrogen, the nodules will appear visibly red or pink inside if sliced open. Nitrogen fixation is synchronized with plant growth, supplying the crop requirements during rapid vegetative growth.

Once the proper inoculant is chosen, steps should be taken to ensure maximum rhizobia survivability.

Rhizobium bacteria (either on the seed or in the package) die if they are exposed to stress such as high temperature, drying winds or direct sunlight.

Inoculant must be stored in a cool place prior to use and must be used before the expiry date. Following application of the inoculant, plant the inoculated seed into moist soil as soon as possible. Rhizobium bacteria on inoculated seed will die quickly if the seed is placed into a dry seedbed. Inoculants are sensitive to granular fertilizer. If applying higher rates of fertilizer, banding fertilizer to the side and/or below the seed is preferred. Never mix inoculant with granular fertilizer. Inoculants are also sensitive to some seed-applied fungicides. Check the label of both the inoculant and seed treatment for compatibility. When using a combination of fungicide and inoculant, apply the fungicide to the seed first, allow it to dry, and apply the inoculant immediately prior to seeding.

Inoculants Formulations

Liquid based products offer convenience and better control of application rate compared to other forms of innoculants. However, they are also more susceptible to environmental damage prior to seeding than other inoculant forms. Recommended time from application to seeding is as little as six hours for some liquid products. Air velocity settings in air seeders need to be at minimum settings to reduce desiccation of the bacteria. If seeding into dry soils or virgin legume land, double rates should be used. If treated seed is planted immediately into a moist seedbed, liquid formulations perform well.

Extenders can help reduce desiccation damage. Inoculant extenders, defined as products represented to improve inoculant on-seed survival, are any product represented as a “bio-stimulant” (e.g. vitamins, enzymes).

Powdered formulations are more durable and less prone to desiccation and seed treatment damage compared to liquid formulations. The bacteria can still be killed by desiccation so the same precautions should be taken as with liquid inoculant.

Peat based powder inoculants require the use of a sticker. Application method is to apply a slurry to slightly damp seed. These products are not very convenient to use and are not used in any significant amounts. Ensure stickers are not detrimental to the rhizobia if using this method.

Self-sticking powdered peat inoculants are peat based powder inoculants with a sticker incorporated into the formulation. These inoculants are far more convenient than peat based powder formulations and application rates are easier to control. Adhesion to the seed can be enhanced if the seed is slightly damp during inoculation. This can be accomplished with a small backpack type pressure sprayer emitting a very fine mist to the seed during auguring and inoculant application. Alternatively, wet the seed in the truck overnight with the deck tilted to facilitate drainage. This allows the seeds to swell and stay slightly moist, assisting in inoculant adhesion. This procedure may also prevent seed splitting and chipping, which may be a problem if the seed moisture content is low (less than 13.5 per cent). Some growers use a liquid inoculant to dampen the seed when applying the peat based self stick inoculants.

Granular formulations are more costly but offer the advantage of ease of use. They help save the time needed to apply the inoculant directly to the seed and are the least likely to desiccate. They are available with peat or clay carriers and can be soil applied by side-banding or placed in-row with no yield differences. Granular inoculants are less sensitive to seed applied fungicides than other formulations because the granular product does not have direct contact with the seed treatment. Although granular products offer a number of advantages, they do have to be handled carefully.

An additional tank is required for their use, which should not be filled more than half full to avoid compaction. It is recommended to avoid auguring peat based granular products. Seed tanks must be emptied each night to avoid compaction and bridging, and flow rates must be carefully monitored on humid days. During application check the meter rollers occasionally for good flowability. Granular inoculant rates can be adjusted with row spacing (Table 2).

Table 2. Granular Inoculant Rates with Different Seed Row

Row Spacing	7	9	1	1	2	3
Rate	6	5	3	3	2	1

Source: Gary Hnatowich

All inoculant formulations will perform well if conditions are ideal. Under less than ideal conditions (toxic seed treatments, low pH soils, cold soil, dry soil, extended treated storage), expectations would be that the best performing formulation would be granular, followed by peat, and then liquid.

Research completed at the University of Saskatchewan evaluated the performance of inoculant formulations in chickpea. Peat-based and liquid inoculants were applied directly to the seed, and granular inoculants were applied either in the seed row, or placed in a side-band, 2.5 cm to the side, and at depths of either 2.5 or eight cm below the seed. Results indicated that inoculation using granular formulations was as good as, or better than other formulations. The peat-based powder and liquid formulations performed as well as the granular formulation in some instances, especially when soil moisture was not limited. Studies carried out in drier soil conditions favoured granular products. Granules placed below and to the side of the seed in moist soil may result in better Rhizobium survival and enhanced fixation relative to seed-placed inoculants.

Strain antagonism results from competition for infection sites between the rhizobium strains capable of infecting the root hairs of chickpea. If the inferior strains of Rhizobium infect first, they block the best crop specific strain from infecting. No native strains of Rhizobium are present in Saskatchewan soils, but previous inoculations of chickpea may have left some residual Rhizobium in the soil. Over time, these bacteria may have changed and become weaker at fixation. This reinforces the recommendation to inoculate each time chickpea is seeded.

Chickpea crops should be inoculated each time they are grown. This ensures sufficient numbers of the correct strain of highly effective rhizobia are available where they are needed. Inoculant is economical relative to its potential benefits and nitrogen fertilizer replacement. The risk of poor nodulation is too great to not inoculate each time the crop is seeded.

The effectiveness of inoculation can be checked by examining the pulse crop in early summer. It may take three to four weeks after seed germination before nodulation reaches a point where it can be evaluated. Although kabuli chickpea is an excellent nitrogen fixer and the nodules can easily be seen when a plant is pulled from the ground. The best way (especially for desi types) to check for nodulation is to dig a plant and gently remove the soil from the roots by washing it in a bucket of water. Nodules are fragile and readily pull off if the roots are pulled out of the soil. Nodules should show as swollen bumps that develop near the stem close to the soil surface.

Seed applied inoculant should result in nodules forming on the primary root near the crown. If the inoculant was soil applied (granular), nodules should be found on primary and secondary roots. If nitrogen fixation is active, the nodules will be pink or red on the inside. Lack of nodules indicates rhizobia did not infect the pulse plant. Lack of a pink colour (usually green or cream coloured) indicates the rhizobia are not fixing nitrogen. Nitrogen fixation declines once plants begin pod formation and seed development.

Handling and application is critical to ensure maximum survivability of the rhizobia.

When applying an inoculant during auguring, operate the auger at half capacity to allow adequate mixing and seed coverage. If using a liquid inoculant, shake the inoculant bag aggressively to evenly disperse the rhizobia before adding the inoculant to the seed in the auger.

If seeding is delayed more than one day for peat based inoculants, check manufacturer's recommendation for re-inoculating. Some liquid inoculant manufacturers suggest re-inoculation if the delays from the time of application, to when the seed is planted exceeds six hours.

Inoculated seed flows through seeding equipment slowly, so calibration of the seeder is more accurate if it is done using inoculated seed.

Anything that negatively impacts plant growth will also restrict nitrogen fixation. If the crop is harmed by such things as herbicide residue, inappropriate herbicide application or poor timing of post-emergent herbicide applications, nitrogen fixation will decline. If the legume crop is not supplied with adequate plant nutrients, especially phosphorus, fixation will be reduced. If seed contains residual traces of glyphosate, root development (particularly root hair development) will be abnormal and nodules are unlikely to develop. Cool, cloudy weather early in the growing season will delay nodulation. Rhizobia do not tolerate saline soils, contact with damaging fertilizers (primarily due to the fertilizer salt effect,) or extremes in soil pH.

Fixation of some pulses can be dramatically reduced in soils where soil pH levels are near 5.5. On low pH soils, increasing the inoculation application rate or using a granular inoculant is recommended.

Pulse inoculants and pre-inoculated seed products are supplements, as defined by the Fertilizers Act, and are subject to registration and monitoring for quality control.

Inoculation for Phosphorus Solubility

JumpStart® contains the fungus Penicillium bilaii and is also available in the dual inoculant TagTeam®. This fungal inoculant enhances phosphorus solubility and uptake by plants. The fungus colonizes along the root system of the plant, and through the production of organic acids, increases the solubility of soil or fertilizer phosphorus. Keep in mind that JumpStart® will normally replace approximately 11 kg/ha (10 lb/ac) of P_2O_5 fertilizer; therefore, JumpStart® should be used in conjunction with phosphorus fertilizer, particularly in cool spring conditions. JumpStart® has no residual effect. Your long-term fertilizer plan must ensure you are replacing phosphorus removed by the grain you sell from your farm.

Not all research has shown an advantage to using phosphate solubilizing inoculants. Penicillium bilaii inoculation, either alone as Jumpstart® or as TagTeam® (P. bilaii and rhizobium), in a four year field study from 1999 to 2002 had no effect on chickpea (desi and kabuli) at two locations in the Brown soil zone except in one of the 18 crop site-years where yield was increased. No improvements were observed in plant establishment, yield or harvestability (plant height, lowest pod height, maturity).

Spring Pre-Plant/ Pre-emergent Weed Control

Pre-plant and pre-emergent herbicide options are used extensively by experienced chickpea growers. A spring glyphosate application, either pre-seed or pre-emergent, is recommended. This provides early season weed control and may provide control of weeds for which no in-crop control is available. Chickpea is slower to emerge, especially the larger seeded kabuli types, so a wider window between seeding and emergence allows more time if a post-seed/pre-emergent glyphosate application is planned. However, with good growing conditions and shallower seeding, emergence can be quicker than expected so timing must be watched closely. Seedlings can be damaged as early as soil cracking as they are emerging and many come into contact with glyphosate.

Sulfentrazone (Authority®), can be applied either pre-plant incorporated or surface applied pre-emergent. On most acres, it is mixed with glyphosate in a pre-seed or pre-emergent application. If applied post-seeding prior to emergence, apply within three days of seeding to prevent crop injury when emerging. Authority® works through root uptake in the soil, meaning precipitation must follow application for proper activation and good weed control. Ten to 20 mm of precipitation within 10 to 14 days is needed for optimum efficacy. If weeds start to grow prior to activation, the result will be poor weed control. Chickpea has shown excellent tolerance to this chemistry.

The Authority® label lists control of wild buckwheat, kochia (including Group 2 resistant types), red root pigweed and lamb's quarters. Its major weakness is lack of control of cruciferous weeds, such as wild mustard. Its main limitation of use is its soil residual properties and subsequent re-cropping restrictions. One major concern is the recommendation to not grow lentil for three years following Authority® application. In most chickpea producing areas of Saskatchewan, lentil is also a popular crop option and application of Authority® will limit lentil production. If fields are very weedy, Authority® may be used as a clean-up herbicide and lentil production is held off for three years. Although Authority® offers control of weeds that can be a real problem in chickpea. The label should be reviewed thoroughly prior to use to ensure it fits with current rotations and land characteristics.

Authority® (sulfentrazone) absorption by plant roots increases as soil pH decreases. At soil pH of 6.5 or less, which can occur even in localized areas of the root zone, greater sulfentrazone uptake can occur and explain unpredictable patterns of injury to crops.

A listing of current registered herbicide products available for use on chickpea before or after seeding can be found in the Saskatchewan Ministry of Agriculture's annual *Guide to Crop Protection.*

Non-herbicide options may be considered as well. Tillage can have a beneficial effect for control of some weeds, while having the opposite effect on others. For example:

- Tillage may be a tool to reduce kochia populations. Kochia appears well adapted to no-till with germination beginning at 50 cumulative growing degree days (well before other common weed species). Burial of kochia seed at least one cm or deeper can result in reduced germination or death of the germinated seed prior to emergence. Tillage to bury kochia seed should not be overlooked as a part of an integrated weed strategy of control for kochia. However, this has limited value where minimum or no-till is practiced.
- Spring tillage, even minor, significantly increases the burial and resulting germination of false cleavers and catchweed bedstraw. Farmers should consider limiting spring tillage as part of an integrated weed management program for cleavers.

Fertility

As with other crops, a soil test should be used to plan a fertility program for chickpea.

If soil nitrogen levels are unusually high, nodulation and nitrogen fixation may be adversely affected. Nodule formation and subsequent nitrogen fixation are very sensitive to external nitrogen sources, including fertilizers and available soil nitrogen. As the supply of nitrogen from soil and fertilizer increases, the amount of nitrogen fixed by the plant decreases.

High moisture, coupled with high soil nitrogen in fallow will produce excessive vegetative growth at the expense of pod set and seed production. Maturity will also be delayed, especially for late maturing varieties.

Chickpea does not tolerate saline soils and should only be grown on non-saline soil.

Low pH can inhibit nodulation, reducing nitrogen fixation and plant growth. Most Saskatchewan soils have a pH range suitable for chickpea growth.

Sufficient soil phosphorus is required for nitrogen fixation and promotes earlier maturity.

If using nitrogen for maturity management, it is critical to know the starting soil nitrogen levels to increase success rates.

Other macronutrients such as potassium and sulphur may be limiting for optimal yields. Fertility requirements for chickpea are not well-defined. Micronutrients are not likely to limit chickpea yield but should be measured periodically. Any abnormal growth should be noted and if symptoms point to a possible micronutrient deficiency, it should be investigated thoroughly.

Generally, nitrogen fertilizer is not required if nitrogen fixation is optimized. Well nodulated chickpea plants can derive 50 to 80 per cent of their nitrogen requirement through fixation under favorable growing conditions. The remainder comes from soil nitrogen available in the soil at seeding, plus nitrogen released from the soil during the growing season.

If nitrogen fixation is not optimized due to unfavourable growing conditions (e.g. relatively dry seed bed), chickpea may benefit from low rates of starter-nitrogen in some years. But, Saskatchewan research conducted with four chickpea varieties from 2004 to 2006 showed no differences in seed yield when sown with or without starter-nitrogen when granular inoculant was utilized. Starter-nitrogen in the phosphate source is rarely added if the crop is inoculated.

Most chickpea varieties are late maturing. Management of maturity is critical to optimize crop quality. In addition to field selection and seeding practices to encourage early crop development, nitrogen fertilization management can be used to manage maturity. Research conducted in Saskatchewan concluded that cropping strategies and practices that produce vigorous early growth allow for earlier pod set. This early pod set ties up plant resources and minimizes the production of new podding sites. A strong early pod setup provides a strong reproductive sink and helps slow the production of new vegetative tissue. The results showed that nitrogen fertilizer supplied to uninoculated chickpea accomplished many of these strategies.

Starter-nitrogen of 28 to 56 kg N/ha (25 to 50 lb N/ac) without inoculant resulted in earlier maturity by an average of 13 days in normal to cooler/wet seasons. In dry years, only marginal differences were noted as drought conditions accelerated crop maturity. Research at Swift Current and Shaunavon, SK suggests the best practice may be to apply starter-nitrogen instead of inoculating the seed.

Figure 5. Starter-nitrogen on right side without inoculant, Swift Current 2004
Source: Saskatchewan Ministry of Agriculture

Earlier research using starter-nitrogen for maturity management utilized higher starter-nitrogen rates of 56 to 67 kg N/ha (50 to 60 lb N/ac), applied away from the seed, without inoculants. Figure 5 shows varying maturity of chickpea in research trials at Agriculture and Agri-Food Canada (AAFC), Swift Current, in 2004.

The following should be considered when deciding if nitrogen should be used for maturity management compared to inoculation:

If adding nitrogen for maturity management, keep it away from the seed. Chickpea is sensitive to seed placed fertilizer. This method of maturity management appears most effective on fields where chickpea is grown for the first time. If soils contain residual Rhizobium from previous chickpea crop(s), this will not work as effectively.

Nitrogen may increase vegetative growth. This may be a concern in more moist areas of the province compared to those with expected drier environments. With a relatively short growing season, there is not enough time for extra vegetative growth to be converted to yield.

If poor nodulating conditions are expected or occur (eg: cold soil temperature, dry soil conditions, excess moisture, crop injury from herbicide residue or application), nitrogen fertilizer should increase yield if nodulation is reduced. Under good growing conditions with proper inoculation, chickpea would be expected to be well nodulated with no yield penalty compared to fertilization.

If a nodulation failure is noted by early summer, nitrogen can be applied as a rescue treatment. Check closely seven to 10 days prior to flowering. Nodulation and nitrogen fixation should be well developed by the 12 node stage. Although application rates have not been established, an immediate top-dressed application of 44 to 55 kg N/ha (40 to 50 lb actual N/ac) should be appropriate. This nitrogen is best applied as broadcast urea or dribble banded liquid 28-0-0. The use of Agrotain®, which protects the urea-nitrogen for up to two weeks while waiting for a rain to move the nitrogen into the soil, should be considered with this later application of nitrogen. Supplemental nitrogen should not be applied later than approximately six weeks after seeding (approximately 10 to 13 node stage) since it may cause excessive vegetative growth, poor pod set, and delayed maturity. The rescue treatment would not be expected to result in the same yield compared to a well nodulated crop. The yield capacity of the crop will be limited due to the advanced crop development stage when the rescue treatment is applied.

Phosphorus is an important plant nutrient for chickpea because it has a relatively high requirement for the nutrient. Phosphorus promotes the development of extensive root systems and vigorous seedlings. Encouraging vigorous root growth is an important step in promoting good nodule development. Phosphorus also plays an important role in the nitrogen fixation process and in promoting earlier, more uniform maturity. Chickpea removes approximately 0.36 lb P205 per bushel produced. This is significant and must be taken into account in the rotation.

Chickpea grown on soils testing low in available phosphorus may respond to phosphate fertilizer even though dramatic yield responses are not always achieved. Even though seed yield may not be increased every year in response to phosphorus fertilizer, the crop may still benefit from earlier maturity. Adding some phosphorus fertilizer will leave the soil with a higher level of residual phosphorus for future years.

The maximum safe rate of actual phosphate applied with chickpea seed is 22 kg P_2O_5/ha (20 lb P_2O_5/ac) in a 2.5 cm spread and 22.5 cm row spacing under good to excellent moisture conditions. This assumes use of monoammonium phosphate, the most common source of phosphate fertilizer used in Saskatchewan. Diammonium phosphate is much more toxic to seedlings and caution is needed if used. Rates of seed-placed fertilizer must be reduced if the seedbed has less than ideal moisture conditions. Higher rates of P_2O_5 fertilizer placed with the seed can damage the emerging seedlings and reduce the stand. If higher P_2O_5 rates are required, banding the fertilizer away from the seed (side-band or mid-row band) is recommended.

To minimize the chance of seed injury, some growers apply extra phosphorus with the crop seeded the year before chickpea. They will then either not apply phosphorus the year seeding chickpea, or reduce the amount of phosphorus the year seeding chickpea to reduce the chance of seedling injury. If soil levels of phosphorus are higher due to previous years applications, Jumpstart® may be able to solubilize enough early season phosphorus to provide the "starter" effect in the absence of phosphorus fertilizer.

Potassium is usually not required as a fertilizer supplement in most soils where chickpea is grown. When soil test levels are very low, at least a small amount should be seed-placed. However, seed-placing potassium may cause seedling damage. As with phosphate, a wider opener may allow for slightly higher safe seed-placed rates.

The maximum safe rate of potassium and phosphorus is 20lb/ac.

Sulphur is deficient in some Saskatchewan soils. If identified as deficient through a soil test, sulphur can be added by side-banding, mid-row banding, or broadcasting ammonium sulphate, which contains sulphur in a plant available form.

Micronutrient deficiencies for chickpea production have not been identified as a problem through chickpea growing areas of Western Canada, although no research has been conducted to access micronutrient requirements of chickpea. If a micronutrient deficiency is suspected, it is advisable to analyze soil and plant samples within the suspect area and compare the analysis to soil and plant samples collected from a non-affected area of the same field. If the analysis confirms a micronutrient deficiency at a relatively early growth stage, a foliar application of the appropriate micronutrient fertilizer may correct the problem.

Seeder Setup

Chickpea seed, especially kabuli, is susceptible to mechanical damage. Physical injury, either through handling or the seeding operation, can easily lead to 30 per cent seed damage. Chickpea seed should not be below 13 per cent moisture. It can easily break, chip, or crack, leading to reduced germination. Moisturizing the seed prior to seeding may be beneficial. The Prairie Agricultural Machinery Institute (PAMI) fact sheet, *Moisturizing Pulses to Reduce Damage,* provides a good review of this subject. Chickpea requires planting equipment with a seed-feeding mechanism capable of handling medium to large seeds.

As outlined in the fertility discussion, chickpea is susceptible to injury from seed placed fertilizer in excess of rates considered safe. If higher rates of fertilizer are applied it should be kept away from the seed.

It is important to minimize seed bounce. Use the lowest possible air speed setting for fans, while still allowing movement of seed through the hoses. It may be of benefit to have air release opener designs to reduce damage to your chickpea seed.

On row packing to ensure good soil contact with the seed is recommended (as long as soils are not water logged). Harrowing and further packing after seeding is not needed if on row packing is available on the seeding equipment.

Seeding Rate

The desired plant population for chickpea is 44/m^2 (4/ft.2), but can be further defined by market class as follows:

- Desi chickpea: 30 to 45 seedlings/m^2 (2.8 to 4.3 seedlings/ft^2).
- Medium to small chickpea: 40 seedlings/m^2 (3.8 seedlings/ft^2).
- Large kabuli chickpea: 38 seedlings/m^2 (3.6 seedlings/ft^2).

Brown soil zone research conducted from 1998 to 2000 in Swift Current determined that the optimum planting density for maximum yield of chickpea were as follows:

Summerfallow

Kabuli	40 to 45 plants/m^2 (3.8 to 4.3 seedlings/ft^2)
Desi	45 to 50 plants/m^2 (4.3 to 4.7 seedlings/ft^2)

Wheat stubble

Kabuli	35 to 40 plants/m^2 (3.3 to 3.8 seedlings/ft^2)
Desi	40 to 45 plants/m^2 (3.8 to 4.3 seedlings/ft^2)

Increasing plant density from 20 to 50 plants/m^2 (1.9 to 4.7 seedlings/ft^2) decreased the days to maturity by 1.5 to three days, and increased the height of the lowest pod by five to 10 per cent.

Chickpea yields increased as plant densities were increased from 20 to 50 plants/m^2 (1.9 to 4.7 seedlings/ft^2) in desi, small kabuli, and kabuli by 20, 27, and 17 per cent, respectively in 2003 research conducted in southwest Saskatchewan.

Southern Alberta research from 2000 to 2004 with desi chickpea found that maximum yield was achieved with seeding dates prior to May 15th and plant stands of 30 to 40 plants/m^2 (2.8 to 3.8 seedlings/ft^2). Crop stands of this density provide better competition against weeds and will result in more uniform maturity and higher yields.

The optimum seeding rate for each seed lot varies depending on its seed size. Larger seeded chickpea will require a higher seeding rate to achieve placement of the same number of seeds per unit area compared to a smaller seeded variety. For example, CDC Luna, with a weight of 377 grams per 1000 seeds will have approximately 1204 seeds per pound. Compare this to CDC Vanguard with a weight of 219 grams per 1000 seeds, and it will have approximately 2073 seeds per pound.

The average 1000 seed weight for a specific chickpea variety can be found in the Saskatchewan Ministry of Agriculture's *Varieties of Grain Crops* publication. Seed lots of the same variety can differ in seed size depending on growing conditions. To determine the 1000 seed weight of a chickpea seed lot, count out 1000 seeds and weigh them using a gram scale.

Survival percentage is expected germination, subtract expected field mortality. Germination per cent levels should be obtained through a germination test at an accredited lab. Field mortality is commonly 15 to 30 per cent, depending on the harshness of spring seedbed conditions. A seed lot with 95 per cent germination and an expected field mortality of 15 per cent would have an expected emergence or survival of 80 per cent.

Row Spacing

Choice of row spacing when purchasing or retrofitting seeding equipment is based on more than chickpea crop response. Factors such as soil type, horsepower, soil zone, type of opener, and amount of residue all influence row spacing decisions. Response to row spacing can change from year to year and farm to farm depending on a variety of factors including weather, disease pressure, moisture etc. Row spacing on most seeding equipment presently on Saskatchewan farms is in the range of 22.5 cm to 30 cm. This range works well for chickpea, while still maintaining good residue clearance.

Seeding rate recommendations are not influenced by row spacing. Chickpea is a poor competitor with weeds and narrower row spacing may be an advantage in competing with weeds. Narrower row spacing will result in faster canopy closure and reduced soil moisture loss through evaporation between the rows. Narrower row spacing also encourages quicker rooting exploitation of the soil between the rows and subsequent use of mid-row soil moisture. Narrower rows leave less standing stubble and residue clearance is more of an issue while wider rows disturb less soil and preserve more standing stubble. Wider row spacing can be used in high moisture regions to reduce the risk of a thick crop canopy, leading to poor pod set and lodging. Wider row spacing may also reduce disease pressure if the micro-climate within the crop is kept drier due to the wider spacing.

Table 3. Chickpea Seeding Rate (lb/ac) for a Target Population of 4 Plants/Square Foot

Seed Weight (g/1000 seeds)	Survival (%)						
	60	65	70	75	80	85	90
220	147	135	126	117	110	104	98
240	160	148	137	128	120	113	107
260	173	160	149	139	130	122	116
280	187	172	160	149	140	132	124
300	200	185	171	160	150	141	133
320	213	197	183	171	160	151	142
340	227	209	194	181	170	160	151
360	240	222	206	192	180	169	160
380	253	234	217	203	190	179	169
400	267	246	229	213	200	188	178
420	280	258	240	224	210	198	187
440	293	271	251	235	220	207	196

Source: Saskatchewan Pulse Growers

Seeding Time and Depth of Seeding

The recommended minimum average soil temperature at depth of seeding for desi chickpea is 7ºC. Desi chickpea will germinate in soil as cold as 5ºC, but seedling vigor will be greater if soil temperature is at least 7ºC. The minimum average soil temperature at depth of seeding for kabuli chickpea should be 10ºC. Warmer soil increases rapid germination and emergence of seedlings. Planting should take place as soon as the soil reaches these temperatures to provide maximum time for the crop to mature before the first fall frost. In Saskatchewan, chickpea should not be planted later than May 24th due to the crop's long growing season requirement, and the risk of fall frost damage. Kabuli chickpea should also not be seeded into excessively wet soils.

Chickpea grows best when daytime temperatures are between 21ºC and 29ºC, and nighttime temperatures between 18ºC and 21ºC. Later seeding reduces plant growth, duration of flowering and seed set, leading to reduced yield. However, crop developmental stages can become more compressed with later seeding and little effect on yield unless maturity is delayed enough that immature seeds are killed by frost.

Chickpea is tolerant of spring frost. Frost survival depends on how low the temperature drops, how long the freezing conditions last, how much cold conditioning the crop receives, moisture content, and the growth stage of the crop when frost hits. Even if the frost is severe enough to kill the main shoot, the chickpea plant can re-grow from one of the scale nodes at or below the soil surface.

The recommended seeding depth for chickpea is 3.5 to 6 cm. Chickpea should be seeded into moist soil to provide the necessary moisture for proper germination and inoculant survival.

Seeding into a dry soil increases imbibitional injury (swelling damage as the seed absorbs water too quickly when exposed to a rainfall after lying in a dry soil) and is not good for kabuli chickpea. Try to seed after a rainfall into a warm soil for best results.

If Sencor® herbicide is to be used, do not seed less than 5 cm deep or in soils with less than four per cent organic matter. The herbicide, if leached due to high moisture infiltration, can cause significant damage if seeding depth is less than 5 cm.

Rolling

Benefits from land rolling for chickpea are lower compared to pea and lentil because chickpea plants rarely lodge, and pods are produced higher off the ground. If the objective for rolling is to push rocks into the soil and level the ground to facilitate cutterbar operation, it should be done prior to emergence. Post emergent rolling damages chickpea plants through mechanical injury because of their stiff stems. It can also spread ascochyta blight, while leaving the plant weaker and more susceptible to disease attack. Do not roll if the soil surface is wet, or if the operation results in an over packed soil.

Quick Facts

- *Chickpea is a poor competitor against weeds.*

- *During periods of crop stress (eg: heat, drought, frost), the ability of the chickpea crop to tolerate herbicide application may be reduced.*

- *Ensure the herbicide hits the target, water volume is adequate, nozzles provide good coverage, and travel speed is reasonable enough to ensure a good spray pattern.*

- *The major weeds of concern in chickpea include kochia (the vast majority of which are Group 2 resistant), Russian thistle, wild mustard, stinkweed, and perennial weeds Canada thistle, and quackgrass.*

Disease and Pest Control

In-Crop Weed Control

Chickpea is a poor competitor against weeds. Weed control in chickpea must be considered throughout the rotation, not just in the year of growing. Herbicide options in the fall, prior to seeding and pre-seed/pre-emergent spring herbicide options must be considered. In-crop weed management is the final step. Perennial weed management, knowing your field's weed history and anticipating in-crop weeds are key to a successful weed control program.

Crop scouting is a key component of a successful weed control program. This includes scouting every year so an inventory of weeds is recorded. One to two weeks after applying a herbicide, scout for both weed control symptoms and crop injury symptoms. If the weeds are not completely dead, look for symptoms of herbicide activity such as yellowing, purpling, twisting, cupping, or bleaching. Timely post-spray audits may leave enough time to perform a rescue treatment if necessary.

Crop choice the year prior to growing chickpea may allow the use of a herbicide to control a troublesome weed that has no herbicide available for in-crop control in the chickpea crop. Herbicide options in chickpea are much more limited than most other crops.

For weed control in chickpea please consult the Saskatchewan Ministry of Agriculture's *Guide to Crop Protection.*

A few key points regarding in-crop herbicide choice and application are worth noting.

Although not considered an in-crop herbicide, Authority® can act in-crop through its soil residual properties.

In-crop herbicides registered for grassy weed control all are Group 1 herbicides.

Sencor® should be applied early post-emergence. Best performance is achieved when chickpea plants are at the one to three above ground node stage, and the weeds are small. Chickpea injury is more severe at advanced growth stages. Some leaf scorch will almost always be evident after application, but plants recover quickly if they are small. Sencor® can move in the soil after heavy rainfall, so if the use of this product is anticipated, chickpea must be planted at least five cm deep to prevent injury to seedlings. Do not use Sencor® in soils with less than four per cent organic matter.

If weeds are present, control them early. Chickpea is not a competitive crop, especially when weed competition can severely reduce yield. If weeds have emerged, apply herbicides at early crop stages. This will improve weed control, reduce competition from the weeds, and usually reduces herbicide injury.

Research conducted in 2008 and 2009 by the University of Saskatchewan's Crop Development Centre (CDC) showed that when applied, post-emergence, the non-registered herbicides imazethapyr (Pursuit®), imazamox (Solo®) and the registered herbicide metribuzin (Sencor®), all caused increases in ascochyta disease in chickpea, as well as crop damage and associated delays in maturity and reduced yield. Sulfentrazone (Authority®), also utilized in the study, was a safer choice for broadleaf weed control across all locations and years. Sulfentrazone can be applied either pre-plant or pre-emergent.

Post-emergent harrowing is not recommended. It can spread disease and cause severe mechanical crop injury.

During periods of crop stress (eg: heat, drought, frost), the ability of the chickpea crop to tolerate herbicide application may be reduced. Crop injury can be reduced by waiting approximately four days after the crop stress occurs before applying a herbicide, by maintaining water volumes at label recommendations, and applying the product during the evening.

Because weeds left behind can cause significant yield loss and interfere with harvest, maximizing sprayer efficiency can pay big dividends. Ensure the herbicide hits the target, water volume is adequate, nozzles provide good coverage, and travel speed is reasonable enough to ensure a good spray pattern.

The major weeds of concern in chickpea include kochia (the vast majority of which are Group 2 resistant), Russian thistle, wild mustard, stinkweed, and perennial weeds Canada thistle, and quackgrass. Once the competitive weeds have been removed, non-competitive weeds such as cow cockle, round-leaved mallow, bluebur, and wild tomato can also become a problem.

Management to delay or reduce the occurrence of herbicide resistant weeds is important for all crops in rotation. It is of particular importance to chickpea growers due to the limited in-crop herbicide choices and the non-competitive nature of the chickpea plant. Herbicide resistant weeds already influence herbicide choice in chickpea. For example, all in-crop herbicides for control of wild oat and green foxtail control are limited to Group 1 products.

Herbicide selection in non-chickpea years should take into account herbicide rotation to reduce or slow the development of resistant weeds. Resistant weeds can have a bigger impact in chickpea crops simply because it is less competitive. A review of herbicide resistance and strategies to prevent or slow its development is important in any crop rotation, but is magnified when crops in rotation are less competitive and are limited in choice of in-crop herbicides.

A few examples of herbicide resistant weeds that are particularly troublesome for chickpea growers include Group 2 resistant kochia (unless Authority® is applied), Group 1 resistant wild oat and Group 2 resistant wild mustard.

Resistance can build with each application and applications do not have to be consecutive year after year. Therefore, with high risk herbicides in Groups 1 and 2, the longer you can rotate away from these chemistries, the better the resistance. On average, if a grower has applied Group 1 or Group 2 herbicides more than 10 times in a field, there is a high risk of resistance developing among one or more weed species.

Research indicates that alternating between two modes of action for wild oat control will double the number of years for resistance build-up. Alternating with a third mode of action will increase the time of resistance build-up to four times compared to using a single mode of action for wild oat control each year.

Use integrated control methods through the rotation, such as higher seeding rates, promoting quick crop emergence, and using herbicides only when economic thresholds are reached. Preventing kochia from setting viable seed for one or two years greatly reduces kochia populations in a field because the seed is short lived in the soil.

Disease Management

There are only a few diseases that significantly affect chickpea. Ascochyta blight is the most powerful disease, and can devastate a chickpea crop through yield and quality reductions. Ascochyta blight in chickpea is much more aggressive than ascochyta blight in lentil or pea, and is caused by a different ascochyta species.

Ascochyta blight is a foliar disease that can completely destroy a chickpea crop with up to 90 per cent yield loss in kabuli, and up to 50 per cent yield loss in desi chickpea (pesticide risk reduction program 2008).

Additional Ascochyta Blight Reference Tool:

- *Scouting and Management of Ascochyta Blight in Chickpea* (March 2010), a publication funded by the Pesticide Risk Reduction Program of Agriculture and Agri-Food Canada's (AAFC) Pest Management Centre (www.agr.gc.ca/prrmup). (PRRP 2010).
- Saskatchewan Ministry of Agriculture CD ROM *Management of Ascochyta Blight of Chickpea in Saskatchewan.*

Information presented on ascochyta blight and its management is taken from the publication Scouting and Management of Ascochyta Blight in Chickpea, a publication funded by the Pesticide Risk Reduction Program of Agriculture and Agri-Food Canada's Pest Management Centre.

The pathogen overwinters on chickpea residue and seed. Both asexual spores and sexual spores can be produced on the residue. The sexual stage produces ascospores, which can spread several miles in the wind and are believed to be responsible for early season lesions. These ascospores are produced by genetic recombination, meaning the population can become genetically diverse. Research carried out at AAFC, Saskatoon, has identified 15 races of *Ascochyta rabiei* in Western Canada. This not only makes breeding for resistance more of a challenge, it increases the likelihood of fungicide-resistant strains developing.

Sentinel plant research using potted chickpea plants has shown that disease inoculum is airborne, traveling over several kilometres, and is present in the field prior to the emergence of the crop.

Early symptoms are often only the size of a pinhead and can occur on leaflets or stems. They can range in colour from light tan to dark brown, and have a distinct margin. They can be very difficult to identify, but early detection and control is critical to controlling disease progression. A magnifying glass may be needed at this stage to identify the lesions.

Lesions will expand rapidly under humid conditions. Lesions on leaflets are usually tan in colour and have a dark brown margin. Dark fruiting bodies, called pycnidia, are formed in the lesions. The pycnidia ooze spores in wet and humid conditions. These spores are spread by rain to other plants and through the field, thus infection is aided by weather with frequent showers.

Anything that moves though an infected field will spread spores, especially if the canopy is moist.

Stem lesions are more elongated, but similar in colour and also contain pycnidia. The lesions can girdle the stem and this can lead to stem break-age and plant death within three to four weeks of infection if it is not treated.

Figure 6. Early pinpoint lesions of ascochyta in chickpea
Source: Saskatchewan Ministry of Agriculture

Figure 7. Ascochyta blight; early lesions, leaf symptoms
Source: Saskatchewan Ministry of Agriculture

Pod infections limit pod development and can cause seed size reduction and discoloured seed, resulting in a grade loss.

Figure 8. Ascochyta blight; pod lesion
Source: Saskatchewan Ministry of Agriculture

The environment (rain and humidity) plays a critical role in the development of ascochyta blight. Rain plays a role in determining the severity of ascochyta blight in two ways:

- Rain-splashed droplets physically spread the disease within the crop canopy by transferring spores from diseased plant tissue to healthy plant tissue.
- Rain provides the moisture required for spore germination and penetration of the fungus into the plant. The high humidity common in chickpea crops, even in the absence of rain, is also sufficient for spore germination and penetration. But the humidity itself will not transport spores from one plant to another like rain-splash does.

Dew and humidity promote pycnidia development and the "oozing" of the spores which can cause new infections.

An important part of the infection process is known as the incubation period or latent period. It is the period of time between penetration of the fungus into the plant, and the first visible disease symptoms. The incubation period for ascochyta blight in chickpea is only four to six days. This means symptoms that appear within a few days of a fungicide application were likely the result of a spore that had already successfully invaded the plant.

Figure 9. Ascochyta blight; healthy (top), infested seed (bottom); desi (left) and kabuli (right)
Source: Courtesy of the Canadian Phytopathological Society

If weather turns warm and dry, infected plants may survive, but will be delayed in maturity and produce lower yields.

Management strategies must be implemented to control the disease through the crop rotation and in-crop. Producers should not rely exclusively on a single management practice, but rather integrate a combination of practices to develop a consistent long-term strategy for disease management that is suited to their production system and location.

Fungicides work to control disease by creating a barrier on the plant's surface to prevent the spores from germinating and infecting the tissue. All fungicides registered for control of ascochyta blight in chickpea have this protectant activity and are most efficacious if they are applied preventatively, or before the fungus penetrates the plant. In addition to protectant activity, some of the fungicides registered for control of ascochyta blight have a slight curative activity. The curative activity is limited to the early part of the incubation period, and only for the first 24 to 36 hours after spore germination and infection. These fungicides have limited systemic movement within the plant tissue and will not be translocated throughout the plant or into new growth. Application must be made within the first 36 hours after a rainfall to provide curative effects. These curative products do not repair tissue that has already been damaged or killed by the fungus.

No fungicide will protect against disease already established in the plant or once lesions form. All fungicides will protect against spores entering the plant (protectant activity). Curative fungicides will also protect against early stages of the incubation period.

The key to managing ascochyta progression is to prevent or slow early development. Fungicide application at the seedling stage is critical for our short growing season, spraying before the occurrence of infection to provide a disease-free canopy as long as possible, combined with follow up field scouting and additional fungicide applications is necessary.

Fungicides that are currently available will provide protection against disease for no longer than two weeks. This protection period is shorter when a highly susceptible chickpea variety is grown, when frequent rainfall is received, and/or when the plant has developed new growth. When nearing the end of this protective period, watch the weather forecast and be prepared to spray again before a rain event.

Research carried out in Saskatchewan has shown that fungicide application at the seedling stage is critical to reduce ascochyta blight severity and maintain yield for susceptible cultivars. The timing of follow up fungicide application is not as critical; however, three well timed applications per season are as effective as four to five applications in partially resistant cultivars. Fungicide choice is less important, but usually using two strobilurin products gives better control and often higher yield. Under high disease pressure, higher water volumes of at least 200 litres per hectare are more important than spray droplet size. Increasing water volume has shown better disease control on fern leaf types, but not on unifoliate leaf types.

Saskatchewan research conducted on ascochyta in chickpea with varied leaf structures examined the effectiveness of fungicide control. The research concluded that nozzle type (flat fan, twin nozzle or air induced), and resulting spray quality had no significant effect on spray retention or disease control, with all producing the same degree of control when used properly.

Research has shown ground and air application of fungicides will both be effective and provide similar yields. Ground applications use higher water volumes and provide greater overall coverage, but wheel tracks may reduce yield and can spread disease. Conversely, aerial applications use lower water volumes, but do not damage the crop and can cover more area in a timely fashion.

Calendar spraying refers to applying fungicides when the previous fungicide's effectiveness has reached a minimum (usually about two weeks). However, the importance of combining scouting and using weather forecasts cannot be overlooked. Applying fungicides at regular intervals, even if it is not necessary, not only adds to the cost of production, but can limit further fungicide choice when considering the need for fungicide group rotation. As the crop advances and weather conditions become hot and dry, the spray interval could be increased to three or more weeks. Alternatively, if disease risk is high and moist weather conditions are occurring, the spray interval may need to be decreased to five to seven days. Disease risk can change daily depending on weather conditions, development of new symptoms, varietal resistance and yield potential. The only spray that should be considered "routine" is the first spray of the season, about two to three weeks after the crop has emerged.

There are situations when it becomes advisable to stop fungicide application. Experience has shown it is not beneficial to apply fungicides after the first week of August in commercial crops unless the goal is to preserve seed quality. It takes about one month for a flower to develop into a full-sized seed. If a mid-September frost is expected, as it is most years, new flowers produced in mid-August are not likely to form viable seed. Pedigreed seed fields might be considered exempt from this rule of thumb in order to reduce the level of seed-borne ascochyta.

Applying foliar fungicides later in the season to protect new growth may in fact delay crop maturity and increase green seed count without improving yield. Fungicides applied after August 7th to August 10th generally do not improve chickpea yields in Saskatchewan.

If disease has not been effectively controlled during the season (variety with poor resistance, wet growing season, fungicides not applied when needed) and pod lesions are already widespread, it is usually too late to apply a fungicide.

If you are considering discontinuing fungicide application due to the advancement of ascochyta blight, talk to your local Saskatchewan Crop Insurance Corporation (SCIC) Customer Service Office regarding your decision. Choosing not to follow disease control strategies may impact your claim.

An integrated management strategy is needed to manage ascochyta. Fungicides alone will not be sufficient.

In Saskatchewan, under our cool and dry conditions, a three to four year crop rotation to non-host crops is necessary to reduce spores from previous crop stubble.

Avoid planting chickpea adjacent to previous year's chickpea fields to reduce spread of residue and wind-borne spores and use non-host strips at field edges. Field selection should be at least 500 metres away from fields that had a chickpea crop the previous season.

Choose available varieties that are as disease resistant as possible. Currently the best resistance level available is fair, and therefore, select varieties with a "fair" instead of "poor" or "very poor" rating for ascochyta.

Kabuli chickpea is much more susceptible to ascochyta blight compared to desi chickpea. Unifoliate kabuli varieties appear to be much more susceptible to severe ascochyta blight, compared to fern leaf kabuli.

Keep plant density within the recommended range of 30 to 45 plants/m^2 (2.8 to 4.3 plants/ft^2). Plant stand density within that range does not appear to have an association with the severity of ascochyta blight in less susceptible varieties. Do not increase planting density above the recommended range, as ascochyta blight risk increases with increasing plant density.

Follow sound agronomic practices. A healthy plant is able to battle disease invasion. Plant seed that has been tested at an accredited lab and has zero levels of ascochyta, or levels as low as possible (not more than 0.3 per cent). Seed at the optimum date, depth, and rate. Use seed treatments if needed.

A disease decision support checklist for ascochyta has been developed to aid in determining risk rating to ascochyta, and to determine appropriate management strategies. (See Table 4 on next page).

Table 4. Determining Your Disease Risk

1) Review the following six considerations and assign a risk value to each.
2) Add up the risk values to create a total risk value.
3) Use the total value to compare to the risk rating below.

1. Field History and Crop Rotation	**Risk Value**
a. Crop is being grown in a region that has never had chickpea production	0
b. Crop is planted on land that has not had chickpea for at least three years	5
c. Crop is planted on land that has had chickpea in the last two years; or is located adjacent to chickpea stubble from the year before	10
2. Chickpea Variety	**Risk Value**
a. Desi variety or kabuli variety rated as "fair" resistance to ascochyta blight	5
b. Kabuli variety that is rated as "poor" resistance to ascochyta blight	10
c. Kabuli variety that is rated as "very poor" resistance to ascochyta blight	20
3. Level of Seed-born Disease and Use of Seed Treatment	**Risk Value**
a. Seed test indicated no seed-borne ascochyta AND used registered seed treatment for ascochyta blight control	0
b. Seed test indicated low levels of ascochyta (<1%) AND used registered seed treatment for ascochyta blight control	5
c. Seed test indicated significant levels of ascochyta blight (5-10%) AND used a registered seed treatment for ascochyta blight control	10
d. The seed quality is unknown, or I am not using a seed treatment	20
4. Presence of Disease Symptoms since last Fungicide Application	**Risk Value**
a. No new disease lesions have developed since last fungicide application	0
b. Disease lesions have developed on a new crop growth since last fungicide application	10
c. Leaf and/or stem lesion have developed and no fungicide has been applied this season	20
5. Weather Conditions	**Risk Value**
a. No rainfall in the past week and short-term forecast is for continued dry weather	5
b. Weather conditions are unknown	10
c. Rainfall or heavy dew has occurred during past week	20
d. Weather is unsettled, thunderstorms are likely	20
6. Other Crop Health Considerations	**Risk Value**
a. Crop emerged well in the spring and there has been no significant weather/injury to crop	0
b. Crop was seeded very early and was slow to emerge	5
c. Crop was damaged by early herbicide application or soil-residue	10
d. The crop has received a light to moderate hail shower in the past 24 hours	20

TOTAL RISK VALUE 1+2+3+4+5+6= ___________

Source: Saskatchewan Ministry of Agriculture's *Scouting and Management of Ascochyta Blight in Chickpea*

Total Risk Value is < 15:

Your risk is low and ascochyta blight should not have a negative impact on your crop if you remain diligent about scouting and applying fungicides when necessary.

Consider the following recommendations:

- Apply fungicide if the crop is at the seedling stage and a fungicide has not yet been applied.
- Delay fungicide application if there has been no new lesion development and there is no rain in the forecast.

Total Risk Value is 20 to 45:

Your risk is low to moderate. Continue to scout for new lesion development as your crop matures.

Consider the following recommendations:

- Apply fungicide if it has been close to 14 days since the last application.
- Delay fungicide if less than 14 days since last application and there is no rain in the forecast.

Total Risk Value is 50 to 75:

Your risk is moderate and disease is either increasing in your crop due to favourable weather conditions, or because ascochyta blight was established before a fungicide was applied. Some yield loss due to disease will occur.

Consider the following recommendations:

- Apply fungicide if it has been close to 14 days since the last application.

Total Risk Value is > 80:

Your risk is high and ascochyta blight will impact your yield and seed quality.

Consider the following recommendations:

- Apply fungicide if crop is in the flowering to early pod stages and there is a potential for suitable yield.
- Do not apply fungicide if disease is severe and there is little chance for economic return.

Management of fungicide resistance is extremely important for all crops and diseases but even more so for ascochyta in chickpea due to the genetic diversity of the fungus, and the fact that isolates with resistance to strobilurin fungicides have been confirmed in Saskatchewan. If a pathogen develops resistance to one fungicide in the strobilurin group, it will be resistant to other fungicides in that group.

The following guidelines, adopted from the North American Fungicide Resistance Action Committee, are recommended to prevent the increase of fungicide resistant fungi:

- Do not use a fungicide that contains only a strobilurin active unless it is tank mixed with a non-strobilurin fungicide.
- Rotate the use of a fungicide with a strobilurin product in the mix (or tank mixed) with a non-strobilurin product.
- Do not use more than two applications per year of any fungicide containing a strobilurin on the same field.
- Do not apply more than two applications of the same group in a single growing season (except for chlorothalonil, which can be applied three times).

Seed rot, seedling blight and root rot of chickpea are caused by a complex of pathogens including species of Pythium, Fusarium, Rhizoctonia and Botrytis. These pathogens are present in all Saskatchewan agricultural soils and can infect and kill individual seedlings from germination to the early flowering stage. Seed rots and seedling blights are most severe when soil is cool or saturated, and seedling emergence is delayed. Infected seed may fail to germinate. Infected seedlings will usually turn yellow, wilt and then die. Stems may be girdled and discoloured at or just below the soil surface and roots may be rotten, allowing the plants to be pulled easily from the soil. Kabuli chickpea is especially susceptible to rots due to its thin, zero-tannin seed coat.

Figure 10. Chickpea: Root rot
Source: Saskatchewan Ministry of Agriculture

Crop rotations that include cereal and oilseed crops can reduce the build-up of soil-borne pathogens specific to chickpea. However, many of these pathogens can survive as saprophytes in the absence of a susceptible host. Therefore, crop rotation may have a limited effect in managing seedling blight and root rot.

Review the section on seed treatment for control of these pathogens.

Botrytis grey mold attacks chickpea, both at the seedling stage, and in advanced stages. Botrytis grey mold of seedlings may spread down a seed row, resulting in a series of yellow or dead seedlings. Botrytis grey mold is also favoured later in the growing season by dense canopies and moist conditions. Botrytis is usually most evident after flowering and is common on pods, resulting in shrunken, discoloured seed. The infected area is often covered by a dark grey, fuzzy, fungal growth.

Figure 11. Chickpea: Botrytis stem and pod rot; grey mold symptoms
Source: Courtesy of the Canadian Phytopathological Society

Figure 12. Chickpea: Botrytis stem and pod rot; grey discolouration on seed
Source: Saskatchewan Ministry of Agriculture

Botrytis pathogens can survive in the absence of host crops so rotation has limited effect on disease level. Fungicides are available for the control of late season development of botrytis grey mold on chickpea, but need to be applied prior to symptoms showing to be effective.

Sclerotinia white mold attacks chickpea grown in conditions of high rainfall, which produces dense crop canopies. This disease is more common in crop rotations that include other susceptible broadleaf crops such as canola, mustard, lentil or pea. Symptoms usually occur in patches, typically in heavier crop areas. Infected plants are initially paler green and the diseased tissue may be covered by a white, cottony, fungal growth. The plant later becomes bleached in colour and the infected area will easily shred apart, revealing small black fungal resting structures. Sclerotinia becomes evident later in the growing season and if found, may have minimal impact on the crop. In most years it is not common through a lot of the chickpea growing area.

Fungicides are available to control sclerotinia. However, they must be applied prior to the onset of symptoms.

There are no bacterial or viral diseases of significance in Saskatchewan chickpea crops at the present time.

Scouting in chickpea should begin at the seedling stage, two to three weeks after seeding. Ascochyta is very aggressive and can infect a crop early. Scout every three to seven days during the seedling stage. Rain and/or high humidity means scouting frequency should be increased. If conditions are drier and the chickpea plant gets past the seedling stage, scouting frequency can be decreased to every seven to 10 days. It may be useful to use flags to mark specific areas in the field for regular monitoring to watch for disease spread to new tissues and/or to determine the effectiveness of previous fungicide applications.

It is very important that you keep the field as sanitary as possible. Before entering fields, put on clean footwear and do not transfer disease organisms from one field to another. This problem becomes worse following a rain, or when dew is still present. Ensure that these same guidelines apply to all other persons entering the field.

Figure 13. Chickpea: White mold; early symptoms
Source: R. Morrall

Figure 14. Chickpea: Sclerotinia stem rot; bleached stems and pods
Source: Courtesy of the Canadian Phytopathological Society

Check a minimum of five sites in a field. If fields are large, that number should be increased. Walk an "M" pattern through the crop to cover a large area. Early symptoms are usually first noticed in the lower canopy so look closely at the lower leaves and stems (a magnifying glass will help).

Early identification of infection sites is critical. This gives you time to make a decision regarding fungicide application before the disease gets a foothold in the crop. Remember that tiny microscopic organisms cause disease. By the time large-scale symptoms can be seen, it may be too late to take action. Some well-planned scouting can determine how to get the most efficient use of a fungicide application.

Resistance (insensitivity) to fungicides is increasing in Western Canada. A southern Alberta study in 2004 and 2005 examined resistance to fungicides in ascochyta spores collected from chickpea fields in southern Alberta in 2003 and 2004 from four locations. Only one of the locations, Carmangay, did not have resistance (insensitivity) to fungicides. These farms used four or five fungicide applications with the first two being azoxystrobin (i.e. Quadris®) or pyraclostrobin (Headline®), followed by two applications of boscalid (Lance®) and finally chlorothalonil (Bravo 500®). Resistance to the fungicides were examined and over 70 per cent of the isolates were resistant to one or more fungicide. Further examination showed 70 per cent were resistant (insensitive) to either pyraclostrobin or chlorothalonil. Six per cent of the isolates were resistant (insensitive) to all three fungicides tested (pyraclostrobin, chlorothalonil, mancozeb).

Insect Management

Chickpea leaves, stems, and pods are hairy and secrete malic acid. This makes the plant much less attractive to insects when compared to other pulse crop plants.

Cutworms can cause damage to newly emerged chickpea seedlings, and at times may require insecticide application. Below ground feeding cutworms cut plants off at or near the soil surface. The pale western and red-backed cutworms are two of the species most frequently found in Saskatchewan soils.

Damaged seedlings can dry up and disappear quickly, so frequent field scouting is critical in determining the cause of the damage. Cutworm feeding is usually limited to portions of the field (often less than five per cent), although in some cases, it has been much more significant.

Foliar feeding cutworms have also been found occasionally in Saskatchewan in the last few years. Dingy cutworms have been found in eastern regions and army cutworms have been reported in western regions. Dingy and army cutworms feed above ground, consuming the plant foliage. Typically, these cutworms are more likely to cause damage on hilltops, south facing slopes, and in drier areas of a field.

No economic threshold has been established for cutworm damage in chickpea. The economic threshold for cutworm damage in dry bean could be used as a guideline because dry bean and chickpea are sown at the same plant densities. The economic threshold for cutworms in dry bean, and assuming it is similar for chickpea, is one cutworm per metre of row in the top 7.5 cm of soil, when the larvae are still small (less than two cm long).

Important Note: This economic threshold is lower than that for pea or lentil.

Figure 15. Below ground feeding cutworms
Source: J. Gavloski, Manitoba Ag Food & Rural Initiative

Figure 16. Cutworm damage
Source: Saskatchewan Ministry of Agriculture

Grasshoppers rarely cause damage to chickpea and tend to feed on chickpea only when other food sources are low or absent. Only in years with heavy infestations is enough damage caused to warrant an insecticide application. If damage does occur it is usually only at the very early crop stage, and most likely along ditches and road allowances. Weeds within the crop are often the more preferred food source.

Figure 17. Foliar feeding cutworm
Source: J. Gavloski, Manitoba Ag Food & Rural Initiative

Wireworms are the immature stage or larvae of "click" beetles. Wireworms tend to be more abundant in moist soils and in the lower, damper areas of a field. Although wireworms prefer grassy plants (cereal crops), wireworm damage has been noted in other crops including canola, chickpea, lentil and potato. Wireworms tend to shred the plant tissue below the soil surface. Initially, symptoms may show up as wilting in the main central leaves, but can eventually cause death to the plant.

Damage may not be noticed early enough in the season to reseed. There is no established economic threshold for wireworm in chickpea and there is no in-crop insecticide available to control wireworm. Controlling wireworm requires the use of an insecticidal seed treatment. When wireworm is present it is unusual for it to affect more than a few acres within a field.

Figure 18. Wireworm damaged seedling
Source: Saskatchewan Ministry of Agriculture

Alfalfa looper is a rare pest in chickpea. Occasionally, the pest has been noted to cause damage, especially if a chickpea field is grown near alfalfa. Moths are blown in from the United States in the early summer, but can also stay over the winter in the soil as pupae, or in crop residue near the base of host plants such as wild mustard or chickpea plants. The adult moths are present through the growing season because generations overlap. There are two to three generations per year with the larvae of the second generation causing the most severe damage. Damage to chickpea fields is sporadic. When significant damage occurs, yield losses can be up to 20 per cent. Vigorous growing older plants are better able to withstand damage. No insecticide treatment is registered for use on chickpea. Other insecticides registered in chickpea may control alfalfa looper.

Figure 19. Wireworm larvae
Source: J. Gavloski, Manitoba Ag Food & Rural Initiative

To scout for alfalfa looper, beat plants in an area of 50 x 50 cm and record the number of larvae on the ground. Repeat this procedure several times in different locations to obtain an average number of larvae per square metre for the field.

The economic threshold for alfalfa loopers in chickpea is when damage occurs through defoliation and clipping of flowers and immature seed pods. No economic threshold has been established for chickpea. However, in other crops, more than 15 larvae/m^2 (1.4 larvae/ft^2), combined with heavy defoliation or flower and pod clipping, may warrant control.

Pea leaf weevil will feed on chickpea but is not considered a pest of concern since it does not maximize reproduction on chickpea. However, occasional monitoring to look for the characteristic U shaped notches on seedlings in early spring is advised.

Environmental and Herbicide Stress Symptoms

Environmental stress symptoms may also be noted. Purpling on maturing desi chickpea is caused by heat or drought stress. It can result in the plant exhibiting red to purple leaves, stems, and pods. This purpling is a result of an accumulation of naturally occurring plant pigments called anthocyanins. This colour change often occurs on the side of the plant facing the sun, and has not been found to negatively affect yield or quality of the grain beyond that caused by heat and drought stress.

Figure 20. Chickpea: desi variety red pigmentation
Source: AAFC SPARC - GAN

Other environmental stresses include frost, hail, salinity, and drought.

Herbicide injury is not unusual as chickpea is sensitive to low doses of several herbicides. Chickpea may be damaged as a result of improper sprayer clean-out, soil herbicide residues, untimely herbicide application, non-label use or spray drift. Products like 2,4-D (growth regulators) can cause malformed roots and foliage of emerging chickpea seedlings.

Metribuzin (ie. Sencor®) is registered for use on chickpea, but crop injury can occur if heavy rains move the herbicide into the rooting zone, the herbicide is applied at advanced growth stages, or the crop is stressed either before or after application. Seeding depth should be at least five cm to reduce the chance of the herbicide leaching into the rooting zone. Application should be made at a young growth stage, but even at a young stage, symptoms of some degree of injury is usually evident. Symptoms may include leaf burn, leaf spotting, leaf margin burn, and plant stunting. These symptoms are especially evident when application is followed by hot weather or soil is low in organic matter. Leaf spotting can be confused with ascochyta blight.

Figure 21. Drought stress; stunted plants
Source: AAFC SPARC - GAN

Imazethapyr (i.e. Pursuit®) damage is characterized by severe cupping and yellowing of the leaves. New growth can be yellow or red, with malformation of the upper leaves and delayed growth.

Metsulfuron, flucarbazone (Everest®) can cause severe malformation when recropping restrictions are not followed.

Seed abnormalities and discolouration that may occasionally be noted include brown to yellow discolouration due to ascochyta infection, pink to red discolouration due to fusarium, and pink seed caused by *Erwinia rhapontici.*

Figure 22. Chickpea: Frosted Pod
Source: AAFC SPARC - GAN

Figure 23. Metribuzin damage, plant stunting and leaf margin burn
Source: Saskatchewan Ministry of Agriculture

Figure 24. Imazethapyr damage, malformation of upper leaves, yellow new growth
Source: Saskatchewan Ministry of Agriculture

Figure 25. Pink seed caused by Erwinia rhapontici
Courtesy of the Canadian Phytopathological Society

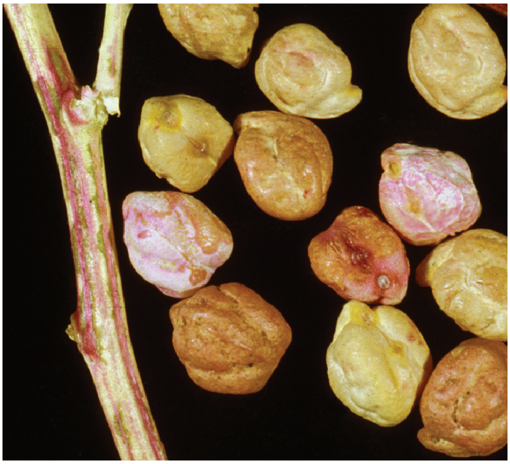


Figure 25. Chickpea: stressed (Left) vs. diseased (Right)
Source: AAFC SPARC - GAN

Quick Facts

- *Chickpea is considered ready to harvest when the majority of the plants are yellow and most pods are mature.*
- *In chickpea, the use of stripper headers was found to reduce weed seed dockage and shriveled chickpea seeds as opposed to samples from straight cut or pick up headers.*
- *Threshing can start when seed reaches about 18 per cent moisture.*
- *Deductions are implemented if immature green seeds comprise more than 0.5 per cent in kabuli, and one per cent in desi chickpea.*
- *Factors that negatively affect quality are botrytis or sclerotinia in the seed, admixtures, small seed size, and a lack of seed uniformity.*

Harvest Management

Chickpea is considered ready to harvest when the majority of the plants are yellow and most pods are mature. At this stage, the top of the plant may still be green. If chickpea is swathed it can be done as early as 30 per cent seed moisture, but is usually left until the majority of pods are straw yellow. If swathed too early, green immature seeds will not lose their green colour. Chickpea can also be swathed ahead of the combine if straight cutting equipment is not available. Swathing the crop when plants are slightly damp should result in the formation of an intact swath less susceptible to wind movement. The dampness should also reduce pod loss while swathing. Swathing can be used to put an end to late season growth if moisture is still readily available to the plant.

Glyphosate can be applied for pre-harvest weed control when seed grain moisture is less than 30 per cent. At this stage, chickpea stems are green to brown in colour, pods are mature (yellow to brown in colour) and 80 to 90 per cent leaf drop (original leaves) has occurred. Certain formulations of glyphosate are registered for pre-harvest weed control in chickpea under the User Requested Minor Use Label Expansion (URMULE) program. This means the responsibility of using these products lies with the grower. The main advantage of using pre-harvest glyphosate is for perennial weed control. It can also be used to stop late season chickpea re-growth, but drydown time will still be governed by the weather.

Note: Do not apply glyphosate products to any crops that will be harvested for seed.

Reglone® desiccant is registered for crop drydown in chickpea. It will not speed maturity of green crops. It should be applied when plants have yellowed, the pods have matured, and seeds have changed colour and detached themselves from the pods (pod rattle stage). This is a very mature stage of the crop so the reduction in days to threshing following a Reglone® application compared to lentil or pea is less. As well, with the later maturity of chickpea, cooler conditions and shorter days later in the growing season will reduce the speed of desiccation with Reglone®, compared to applications made earlier in the growing season. However, Reglone® can still be expected to dry down green plant material and result in threshing of the crop sooner than if no desiccant is used.

Research has shown that direct cutting without desiccation (natural maturity) results in the highest yields and largest seed size. Desiccation with Reglone® or application of pre-harvest glyphosate applied prior to pod rattle stage, when 80 per cent of pods were tan coloured, preserved yield. However, these treatments did not speed the time to maturity and seed size was reduced. Although desiccation is not as common on chickpea compared to pea and lentil, it can still be a valuable tool in some situations. Most chickpea acres are straight cut without the aid of a desiccant. Chickpea has stiff stems and a relatively upright growth habit, with pods developing several inches above the ground. Pods are quite shatter resistant (although under the drought conditions in 2001, some chickpea growers reported shattering of maturing pods). Pods and seeds often mature before the stems and leaves. These characteristics result in chickpea plants being well suited to straight cutting. However, if the plants are left standing too long following maturity there is a risk of pod drop. This can occur if the small stem attaching the pod to the plant breaks. If left in the field too long following maturity, seed weathering can reduce quality. If a field is variable in maturity, harvesting the field in stages may be needed to minimize loss and maintain quality. Also if seed quality is variable in different areas of the field, bin separately.

In chickpea, the use of stripper headers was found to reduce weed seed dockage and shriveled chickpea seeds as opposed to samples from straight cut or pick up headers. Stripper headers in chickpea are able to strip off ripened pods and leave green leaves on the plants. Very little green material goes into the combine.

Threshing can start when seed reaches about 18 per cent moisture. Avoid combining chickpea that is wet or immature. When straight cutting, air or pick-up reels should reduce harvest loss compared to bat reels. Initial combine settings should be similar to those used for dry pea, however, a wider concave setting for larger seeds and an increased cylinder or rotor speed may be required to remove the seed from the pod. Care must be taken not to damage the seed, especially with the large kabuli types.

Chickpea seed colour is an important grading factor. The stage of the crop should be closely monitored, as harvesting too early increases the chance of green seed in the crop, which lowers the grade and value of the grain. Deductions are implemented if immature green seeds comprise more than 0.5 per cent in kabuli, and one per cent in desi chickpea. Early frost, as little as 2°C or 3°C, during pod filling and ripening can result in immature green seed in the harvested crop. This is common in regions outside the areas best adapted for chickpeas. This will significantly reduce the grade and value. Other factors that negatively affect quality are botrytis or sclerotinia in the seed, admixtures, small seed size, and a lack of seed uniformity.

Quick Facts

- *In chickpea, particularly kabuli type, the seed begins to pull away from the seed coat at moisture contents of 12 per cent or below, resulting in the seed becoming increasingly fragile.*

- *Growers are advised that the percentage of each seed size class determined in the pre-cleaning sample may not be the same as net off the cleaner, and the grower and processor should agree beforehand how payment will be based.*

Post-Harvest Storage and Handling

Chickpea should be handled in a manner similar to other pulse crops. The irregular seed shape with the exposed beak can lead to increased mechanical damage when handling. The use of conveyors instead of augers can reduce damage. Aeration can improve storage by reducing seed moisture and temperature. Seed should be stored at 14 per cent moisture or less. Stored chickpea should be checked at intervals for moisture and temperature levels to avoid spoilage loss. Large seed can often test dry, but still be moist in the centre.

In chickpea, particularly kabuli type, the seed begins to pull away from the seed coat at moisture contents of 12 per cent or below, resulting in the seed becoming increasingly fragile. Therefore it is recommended that the moisture content does not get lower than 13 per cent. Reducing bin storage temperatures should be used to extend viability (preserve the germination level) of chickpea seed, as opposed to reducing moisture content lower than 13 per cent.

Chickpea can go through a "sweat," whereby moisture migrates toward the seed coat and potentially into the surrounding atmosphere. In the case of stored chickpeas the atmosphere is confined to the airspace between chickpeas within the bin. This release of moisture accumulates in these air spaces and are subject to further migration influences based on temperature differences between the atmosphere in the stored grain and the temperature outside the bin. The movement of moisture moves with the consequent airflow that results from these differences and because the air spaces are confined within the bin, they accumulate in various places within the grain mass.

Table 5. Suggested Number of Weeks for Safe Storage of Chickpea at the Specified Grain Moisture Content and Storage Temperature

	Storage Moisture Content (%)					
Temp (°C)	**12****	**13**	**14**	**16**	**18**	**21**
25	31	16	13	7	4	2
20	55	28	23	13	7	4
15	100	50	40	20	12	6
10	200	95	80	38	20	21
5	370	175	150	70	39	20

= Safe Long Term

= Safe Storage

= Safe Short Term

= High Risk - Unsafe or quality at risk

Source: Extrapolated from Pea data (Sokhansanj 1995).

**As moisture levels decline especially in kabuli types, chickpea seed begins to shrink from the seed coat and are more susceptible to damage in handling at less than 13 per cent.

If needed, supplemental heat drying of chickpea should be limited to temperatures below 45ºC.

The Canadian Grain Commission has developed grading standards and a moisture conversion table for chickpea. Grading is done on the basis of seed colour, damaged seed, cracked seed coats, green seed and foreign material. However, kabuli chickpea prices are often determined by the percentage of seed in each size class (for example: 10mm, 9mm, 8mm, 7mm). The percentage of each size class is often determined as it exits the cleaning equipment in the processing plant (described as "net off the cleaner"). Growers are advised that the percentage of each seed size class determined in the pre-cleaning sample may not be the same as net off the cleaner, and the grower and processor should agree beforehand how payment will be based.

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