3.8 Harvest Management

3.8.1 Harvest timing (B. Geisel)

Conducting harvest in a timely manner is critical in the production of high quality potatoes that are in demand by the market. A timely harvest will not improve the quality of the potatoes, but a crop can be lost if harvest is not timed appropriately. The majority of the cost of producing a potato crop has accrued by the time of harvest and growers should not risk that expenditure and effort by an untimely harvest. The factors that should be considered when planning a timely harvest are:

- Target yield
- Crop maturity
- Soil and tuber temperatures
- Harvest capacity

Conducting harvest in a timely manner is critical in the production of high quality potatoes that are in demand by the market. A crop can be lost if harvest is not timed appropriately.

Ideally, harvest would not begin until the crop has attained the producer's target yield goals, but that is not always achievable for late maturing varieties. The growing season in Western Canada is highly variable and there are not always enough heat units to achieve target yield goals. Delaying harvest will allow for additional growth and yield, but any gains in yield may be offset by losses, if not all of the crop can be harvested and stored because of adverse weather (rain or frost).

Chemical maturity (see section 3.8.2 *Chemical Maturity*) contributes to storability, marketability and processabilty of the tubers. Delaying harvest will usually improve maturity, but any gains may be offset by losses, if not all of the crop can be harvested and stored because of adverse weather (rain or frost). Crop maturity monitoring does not affect the onset of harvest, just the order which fields are harvested. The grower should harvest the most mature fields first leaving the immature fields to the end of harvest, allowing for more growth.

Harvest temperatures have the greatest influence on harvest timing. The ideal harvest temperature is between 45 and 60°F (7°and 15°C). Tubers warmer than 64-68°F (18-20°C) and under drought stress are susceptible to black spot bruising. Harvesting when tuber pulp temperature exceeds 68°F (20°C) increases the risk of leak and pink rot, which can result in storage decay. Harvesting when the tuber temperature is less than 45°F (7°C) will contribute to the incidence of shatter bruising. If the tubers are repeatedly chilled below 40 °F (5°C) the concentration of sucrose will be high resulting in poor fry colour. Depending upon hill shape, variety, soil moisture and vine cover; temperatures below 32°F (0°C) will freeze some or all of the tubers, causing the crop to break down in storage. Rarely can a crop with more than five percent frozen tubers be stored successfully.

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To bring a good quality crop into storage, the harvest must take place when soil and tuber temperatures are ideal (see above). The number of days that these temperatures exist in September and early October are limited. The grower must have the capacity to complete harvest before chilling temperatures or frost damage will render the crop unmarketable. In early October, the risk of crop damage is very high and producers should plan to complete harvest before then. When evaluating harvest capacity, the grower must account for some down time due to inclement weather, wet soils and mechanical breakdowns.

3.8.2 Chemical Maturity (M. Pritchard)

The 'chemical' maturity of potato tubers provides a measure of their suitability for long-term storage and processing quality. As potato tubers develop and the crop matures, the amount of free sugars (sucrose, glucose, and fructose) in the tuber decrease. When the sugars drop to a minimum level, the tubers are considered "chemically mature". This stage normally coincides with maximum dry matter accumulation and indicates that the crop is ready for harvest.

Late planting that shortens the growing season, cool weather that delays plant growth, excess nitrogen, and heat stress can cause elevated sugars at harvest. Chemically immature potatoes contain a high concentration of sucrose, which breaks down to produce the reducing sugars glucose and fructose after the tubers are harvested. High reducing sugars in turn result in unacceptable darkening during frying. Storage stresses such as improper handling, cold temperatures, high carbon dioxide, improper sprout inhibitor application, and tuber aging can also increase sugars, especially in tubers, which were chemically immature at harvest.

Chemical maturity is determined by the sugar concentration in the tuber. Analysis of the sucrose and glucose concentrations along with a standard frying test provides useful information in assessing the chemical maturity of the crop and the effect of various management practices on crop quality. Sucrose concentration gives a good estimate of potential processing quality before harvest while glucose concentration, when measured during storage, gives the best estimate of processing quality of French fry cultivars, specifically Russet Burbank and Shepody. Sucrose monitoring can be used to determine which fields are nearing maturity and glucose monitoring can be used to determine when they have reached a stage of chemical maturity that will ensure optimum processing quality out of long term storage. Different varieties vary in the amount of sugar that is acceptable for processing. For example, chipping potato varieties must have a lower reducing sugar content than those used for French fries.

Determination of sugar concentrations can be accomplished by various technologies. Most processors use some method of sugar analysis. Equipment for this purpose can be expensive although less expensive technologies are available though may be less reliable.

For further information on the relationships between sugars and colour of processed potatoes and on storage of immature potatoes, refer to the following bulletins on the Department of Plant Science, University of Manitoba webpage:
Relationships of Sugars to Colour of Processed Potatoes (http://www.umanitoba.ca/afs/plant_science/extension/potatoessugars.pdf)

3.8.3 Vine Killing (B. Geisel, D. Waterer, M. Dyck)

Timely vine killing is essential in the production of table, chipping and seed potatoes. Vine killing is not always employed in the production of late season maturing French fry processing potatoes. The growing season in Manitoba is short and late season tuber growth is required to achieve an economic yield of processing potatoes, so vine killing is rarely used. The growing season in Alberta is longer, economic yields are achieved early in the season, so vine killing is a more common practice. Vine killing achieves the following:

- Termination of growth to control tuber size
- Termination of growth to set skin, which reduces skinning and bruising during harvest and shrinkage in storage. A requirement for table production.
- Prevents the spread of viral diseases by aphids. See *aphid* section 3.6.2 *Insect Management*
- Reduction in the spread of late blight spores from infected vines to tubers at harvest
- The time between vine killing and harvest allows diseased tubers to rot in the hill before harvest.
- Stabilization of chemical maturity in chipping potatoes
- Reduction in harvest losses by facilitating separation of the tubers from the stolon
- Removal of vine growth that interferes with harvest

If potatoes are not fully mature, vine killing can reduce the yield and specific gravity. Manitoba studies report that vigorous Russet Burbank potatoes develop 5.5 to 8.6 cwt/ac/day (620 - 970 kg/ha/day) in early September. Vine kill during this stage of growth can significantly reduce yield. The extent of yield and specific gravity losses depend upon the following factors:

- Stage of growth at the time of vine killing. The more immature the crop at the time of vine killing, the greater the loss of yield and specific gravity.
- Condition of the crop at the time of vine killing. Yield losses are greatest if the crop is vigorous and capable of further tuber bulking.
- The interval between vine killing and harvest or a killing frost. The longer the interval between vine killing and harvest or frost, the greater the yield and specific gravity losses.
- The effectiveness of the vine killing operation. Mechanical vine killing will terminate growth much more rapidly than chemical desiccation and result in a greater yield loss if carried out too early.

The 'chemical' maturity of potato tubers provides a measure of their suitability for long-term storage and processing quality.

Under rare circumstances, discolouration of the vascular ring can occur after vine killing. Discolouration is confined to the stem end of the tuber, causing problems in processing (French fries and chips) and table markets. Stem end discoloration (SED) has no effect on seed quality. SED is more likely to occur when vine killing is rapid, the soil moisture is low and the weather is hot. To reduce the risk of SED, avoid rapid vine killing methods during hot weather, especially if the soil is dry.

Vine killing is accomplished by chemical desiccation and mechanical methods. Chemical desiccation is the most common method of vine killing. Apply the desiccant 2-3 weeks before harvest to allow for complete vine kill. Plants may continue to bulk after desiccation, so apply in advance of achieving the desired tuber size for seed and table production. Variety, plant vigour and environmental conditions will effect the rate of desiccation. Two chemical desiccants are registered for use in Western Canada. Check the manufacturer's product label for detailed application procedures and rates.

Chemical Desiccation

Reglone produces a moderate rate of vine kill. Two or 3 applications may be required if growth is vigorous. Reglone performs best if applied at dusk with high volumes of water. This allows the product to penetrate the leaves and stems before being activated by the sunlight the following day. As well, best results are obtained after the onset of senescence and adequate skin set has been established.

Liberty produces a slow to moderate rate of vine kill. A single application will usually achieve complete vine kill. Liberty works best when applied during daylight hours, when photosynthesis is taking place. Efficacy is also enhanced when application is delayed until after the onset of plant senescence. Liberty works best when warm and humid. Conditions that impede plant growth will reduce the effectiveness of Liberty. Liberty is not registered for use on seed potatoes.

Mechanical Methods

Two methods of mechanical vine killing are employed on the Prairies. Both are used in conjunction with a chemical desiccant. Rolling vines with rubber tires or crowfoot packer wheels followed by a Reglone or Liberty application produces a moderate to fast rate of vine kill (Figure 3.8-1). Rolling damages the foliage resulting in partial vine kill, but it also exposes more of the foliage to Reglone or Liberty, enhancing the effect of the desiccant. This results in fewer desiccant applications to achieve complete kill and a faster rate of vine kill. The vine roller also seals cracks in the hills, preventing sunlight from contacting the tubers and causing greening.

Figure 3.8-1 Vine roller with crowfoot packer wheels (Courtesy of Gaia Consulting Limited)

The flail vine shredder, which consists of varying knife lengths to accommodate the contours of the hill and furrow, produces a very rapid vine kill. Flailing removes all but 6 inches (15 cm) of the vine. Flailing closer to the hill can uncover and injure the tubers. The debris from flailing can interfere with the performance of Reglone. A short waiting period may be required for the debris to fall off of the remaining vine before applying Reglone. Do not use the vine shredder in conjunction with Liberty.

Some flail implements are equipped with drum rollers, which seal cracks in the hills, preventing sunlight from contacting the tubers and causing greening. Flailing reduces the desiccant applications required to achieve complete vine kill and provides a significantly faster rate of vine kill. Flailing causes rapid death, so the vine kill procedure can be timed closer to the harvest date than slower vine kill methods. This extends the length of time for tuber bulking and chemical maturation, thus maximizing yield and specific gravity.

3.8.4 Bruise prevention (L. Delanoy)

An excellent crop in the field prior to harvest does not ensure a high profit out-of-storage. A severe frost or excessive precipitation during harvest, which is beyond the control of the grower, can devastate a crop and eliminate any profit. Harvest timing and management, which can be controlled by the grower, also has a significant effect on quality, net yield and profit out-of-storage. Mechanical damage and bruises caused by rough handling during harvest, trucking and piling into storage, will increase the incidence of storage rots, reduce quality, increase grade-out and reduce the value of the crop.

There are two types of potato bruising that occur at harvest. Both types are caused when the potato strikes an object (machinery, soil clods, stones, other potatoes, etc.), however, each type of bruise occurs under contrasting environmental conditions.

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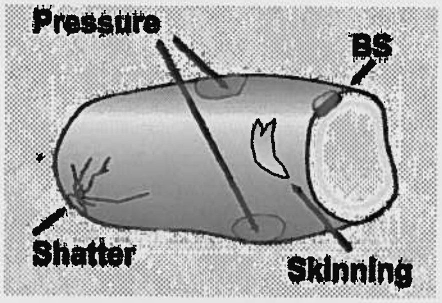
Blackspot Bruising (Figure 3.8-2)

Blackspot bruising occurs under warm dry soil conditions. Susceptibility increases with increasing tuber temperature and decreasing soil moisture and water content in the tuber. The impact ruptures individual cells below the skin of the tuber without breaking the skin. These bruises are not immediately visible. After two days the damaged tissue will turn dark grey or black and can be seen only after the skin is peeled. Varieties vary greatly in their susceptibility.

Shatter Bruising (Figure 3.8-2)
Shatter bruises are thin cracks or splits in the tuber flesh. This is more common on larger tubers. Susceptibility increases with decreasing temperatures below 45°F (7°C) and increasing soil moisture and water content in the tuber. Thumbnail cracks are a form of shatter bruise, which can occur when cold tubers are roughly handled out of storage or on packing lines.

Figure 3.8-2 Blackspot and Shatter bruise (Courtesy of C. Schaupmeyer)



Other forms of mechanical damage include skinning, cutting and scraping. All types of bruises and mechanical damage adversely affect the appearance of potatoes and can result in rot in storage.

The amount of bruising and mechanical damage at harvest is influenced by soil conditions, cultivar, tuber maturity, tuber temperature, and equipment condition and operation at harvest. For detailed harvester adjustments, please contact your local machinery dealer. The following describes how each of the above factors affects bruising potential at harvest:

Soil Clods
Field preparation or in-row tillage performed under wet soil conditions can produce soil clods. Soil clods will persist until harvest and contribute to blackspot bruising. Under dry soil conditions, the clods are hard and cause injury when contacting the tubers during harvesting, trucking and storing operations (Figure 3.4-5). Irrigation prior to harvest can soften clods and reduce damage.

Temperature and Moisture
Western Canada potato producers encounter a wide range of temperatures during harvest in September and early October. As indicated above, extremes in temperature cause different types of bruising. Hot and dry soils produce ideal conditions for blackspot bruising. Irrigating before harvest will increase the water content of the tuber decreasing susceptibility to blackspot bruising.

The risk of shatter bruise increases later in the season (late September and October) as soil temperature decreases. Growers should complete harvest early to avoid conditions, which cause this type of bruising. Harvest date is influenced by factors such as cultivar selection, planting date, fertility, irrigation, and vine killing.

Fertility
Excess nitrogen delays maturity and promotes skinning and blackspot bruising.

Harvester Operation and Adjustment
The harvest operation accounts for the majority of mechanical damage to potatoes. Trucking, piling into storage and handling for market also contribute to bruising. The following points should be considered when preparing and operating the harvester and other handling equipment:

- All chain or conveyor links and flights should be properly padded with the exception of the primary bed.
- Use ample padding on deflectors, sharp edges and any other locations where bruising can occur.
- Adjust the digger blade depth so that potatoes are not be bruised or cut. Operate the blade deep enough to maintain some soil on the primary and secondary bed to cushion the potatoes.
- Adjust the digger blade height on harvesters and windrowers so potatoes do not bump into the front of the primary chain.
- Maintain a proper forward speed to chain ratio to ensure good soil separation and, at the same time, keeping the conveyors as full of potatoes as possible.
- Keep chain agitation to a minimum. Consider installing hydrostatic agitators (shakers) on the primary bed to improved control.
- Keep beds and conveyors sufficiently tight to avoid sagging and whipping.
- Reduce the distance that tubers drop to 15 cm or less including the loading boom. Consider installing deflector lip on the end of the boom to reduce bruising.
- Check frequently for bruising at various points on both harvester and equipment.

Make your employees aware of the causes and consequences of bruising. Train them to operate equipment in a manner to prevent damage to the tubers. Encourage operators to inspect all handling equipment regularly and to inform you of any situations that have the potential to cause bruising. Encourage employees to act as a team to prevent bruising. Since harvest operators cannot see the entire digging operation they must rely on the knowledge and experience of others for feedback. For more information about bruising obtain the fact sheet Preventing *Potato Bruise Damage*, Bulletin 725 from the University of Idaho, Cooperative Extension System.