POTATO HARVEST: WHERE YIELD GETS REAL

Harvest is where all the effort and expense that has gone into growing the crop finally comes to 'tuberition.' It is where money can be made or lost, and where the grower finally, conclusively, finds out what has been happening under their feet.

GROWING A GOOD CROP

A good harvest starts even before the potatoes are planted. This particularly means minimising the clods and rocks that can physically damage potatoes during harvesting, as well as acting as contaminants in the finished product.

Once the potatoes are growing, ensuring adequate nutrition and irrigation is an important part of preparing tubers for harvest day. For example, production factors that reduce the risk of bruising include:

- Moderate nitrogen fertiliser application (excessive nitrogen increases susceptibility to bruising, especially if applied late in the cropping cycle)
- Optimised levels of potassium
- High calcium – with a target of 250ppm tuber concentration
- Accurate irrigation, avoiding excessively wet or dry conditions

TERMINATING THE CROP

Vine kill is the first step in preparing the crop for harvest. It may occur when the crop is mature, or in response to market demand for a particular range of tuber sizes. Vine kill promotes tuber maturation and separation from the stolons, as well as removing plant material that would otherwise clog the harvester.

If vine kill is timed to meet market demand, growers may be tempted to allow the largest tubers to become oversize in the hope that more small tubers will reach the marketable range. However, larger tubers tend to be expanding faster than smaller ones, so this does not always work. Moreover, tubers can continue to expand slightly even after vine kill has occurred:

- If soil is dry, tubers are likely to only increase 1mm at most, regardless of kill method
- If soil is damp and vines are killed mechanically, tubers may increase by 1-2mm
- If soil is damp and vines are killed chemically, tubers may increase 2-3mm

Vine kill is usually conducted when the largest tubers from at least two-thirds of test digs have reached the maximum marketable size. Delaying further should only be considered if there is a good market for oversize tubers. To conduct test digs:

- Choose at least three locations within the crop, avoiding areas that look unusual or are growing poorly
- Conduct digs every 3–4 days once the largest tubers are within 10mm of maximum desired size
- Each dig should lift between 1-2m of the row (minimum three plants)
- Divide the tubers into appropriate size fractions and weigh each group to calculate percentage yield by size grade

Figure 1. Test digs should include at least three plants per location, and be repeated across the paddock.

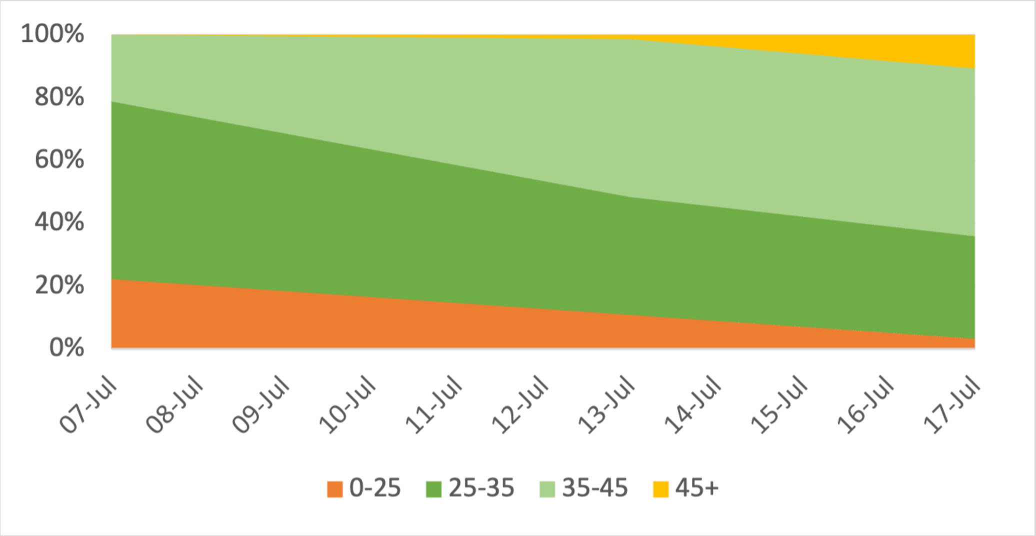

Figure 2. Example result from test digs for salad potatoes with a maximum marketable size of 45mm and optimum size grades of 25-35mm and 35-45mm. By 17 July, the crop was already passing optimum size. Data derived from summary by S. Wale, Teagasc.

Defoliation can be achieved using chemical, electrical or mechanical means.

Chemical

Chemical defoliants can provide a fast and efficient way to defoliate plants. Whatever product is used, it is essential to follow the label directions to avoid contaminating the tubers, soil or surrounding environment.

Diquat is commonly used for this purpose. Diquat acts by inhibiting photosynthesis. However, it is usually recommended to apply it under cloudy conditions, preferably later in the day. This is because the product works so fast when it is sunny that the plant tissue dies before the chemical can diffuse throughout the leaf.

One potential downside of rapid desiccation is the potential for vascular browning. To minimise risk, avoid applying defoliant when the soil is dry and plants are stressed.

For example, Syngenta recommends conducting a basic soil moisture test before application of diquat:

- Take a soil sample from the centre of the ridge (5cm below the deepest tuber)
- Gently squeeze into a ball
    - If it stays in a ball the soil is sufficiently moist
    - If it collapses the soil is too dry
- Repeat at several points across the paddock, particularly sampling in drier areas
- If the soil is too dry, delay application of diquat until after rain or irrigation

As diquat is a contact herbicide, it is essential to use nozzles that provide good penetration into the crop canopy. Achieving good contact also means avoiding application if plants are dusty, as this forms a barrier on the leaves.

Although diquat is deactivated when bound to clay particles, it is highly residual in both soil and water. Regulation of diquat is increasing; it is no longer approved for use within the European Union, but is still registered in other countries including the USA and Australia.

Note that the herbicides Pyraflufen-ethyl and Carfentrazone-ethyl are used for crop-termination in Europe but are NOT registered for pre-harvest application to potatoes in Australia.

Whichever product is used, it is important to follow label rates. In some cases, a lower rate may be used first to remove the leaves. The second application then directly contacts the plant stems, optimising vine kill.

Electrical

The loss of chemicals in Europe has encouraged exploration of alternative crop termination methods. The CROP.ZONE system uses a combination of a conductive liquid and electrical current.

Figure 3. Terminated vines at the PotatoLink Ballarat demonstration site. April 2023.

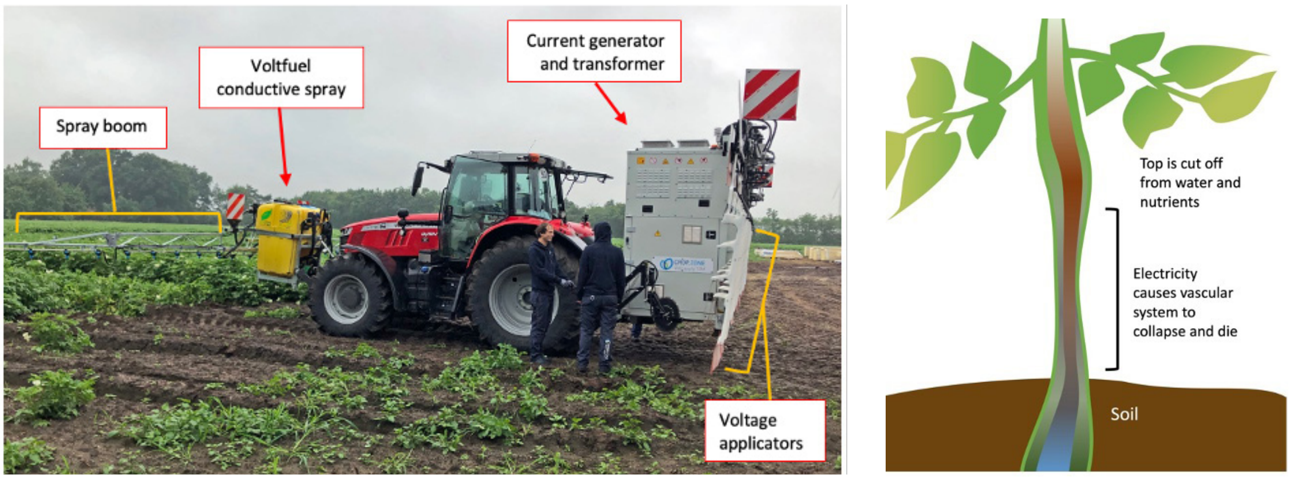

Figure 4. The CROP.ZONE system for vine termination combines an electrically conductive spray with voltage applicators, electrocuting the potato plants. This collapses the plant vascular system, starving the leaves of water and nutrients.

A 12m wide boom spray attached to the front of the tractor is used to apply "Volt.fuel" conductive liquid. This contains a spreader and dissolved solutes. The solution maximises electric conductivity between the applicator electrodes and the waxy, hairy, uneven surfaces of the plant leaves. Decreasing electrical resistance significantly reduces the voltage required.

Electricity is delivered using applicators attached to the rear of the tractor. This is most effective if the soil is relatively dry, as electricity will pass preferentially through the wet tissues of the plant vascular system. The current collapses the plant vascular bundles, stopping supply of water and nutrients to the plant leaves.

The system works best when applied to the crop twice in opposing directions. Unfortunately, the energy cost is estimated to be 5x higher than herbicides, and the 12m maximum boom width is likely to be limiting for larger growers. However, by reducing reliance on herbicides and avoiding impacts on soil biology, the system may meet sustainability objectives.

Mechanical

Mechanical methods of terminating the crop involve flailing and chopping. This may be combined with rolling to flatten the stems. Potential advantages of mechanical vine kill include speed and – possibly – a reduction in sprouting by remaining volunteer potatoes.

Speed can be important if growing seed or salad potatoes, where size specifications are relatively strict. Minimising the period between vine kill and harvest may also reduce incidence of black dot (*Colletotrichum coccodes*).

While chemical free, one key downside is the potential to spread disease. Mechanical methods break vines into tiny pieces. They then spread them around the paddock, along with any spores/oospores/bacteria that they might contain.

It is sometimes recommended to follow mechanical termination with application of a combined desiccant (e.g. diquat) plus a fungicide to prevent spread of diseases such as late blight. In this case, the cut stems should be left around 20cm long and the chemicals only applied once the leaf tissue has dried and exposed the cut stems (Wale, 2018).

Figure 5. This Grimme mechanical topper crushes and chops the plant haulm and deposits the trash in the interrow, leaving the plant stems exposed for further treatment. Image: R Halleron, Agriland.

SKIN SET

While tubers are still growing, their skins need to stay soft and flexible. Such soft skins are easily rubbed off (skinning) or wounded when handled.

Once tuber growth stops – whether naturally or at vine kill – the skin starts to harden and thicken. It also becomes more tightly attached to the flesh, protecting the underlying tissue. Good skin set is essential to reduce vulnerability to wounding and bruising, increasing storability of the tubers.

Complete skin set can take anywhere from one to four weeks, depending on variety and soil conditions. Skin set will take longer in cool, moist soil, yet still not achieve as good a result as that in warmer conditions. Also, if the crop is allowed to naturally senesce, the start (and finish) of skin set will vary between plants.

Potatoes that are to be processed immediately, or which are accessing a new market window, may sometimes be harvested before the skins set (green harvesting). Shelf life of such potatoes will be relatively short. For most end uses, it is important that harvest does not commence until the skins have properly set.

HARVEST

Once the skins have set, potatoes can be harvested. Avoiding damage during harvest is key to producing high quality potatoes with excellent potential storage life. Wounds and bruises inflicted during harvest detract from appearance, accelerate respiration and provide entry points for disease.

Factors that help reduce damage during harvest include:

Figure 6. Potato skins remain soft while growing, and are easily rubbed off if the tubers are harvested before the skins have hardened and set. Image: Arvalis JM Gravouille

Figure 7. Preparing the site well, and ensuring weather and soil conditions are right, will reduce the risk of damage occurring at harvest.

- The field is free of clods and rocks
- The crop has grown evenly throughout the paddock
- The soil is moist and tubers are normally hydrated
- Soil temperature is 12 – 18°C; soil temperatures below 5°C or above 25°C increase risk of bruising
- Tubers have lower dry matter, with small starch granules

The way the harvesting machine is operated will also have a major impact. The speed at which the harvester moves through the paddock needs to be adjusted according to crop yield and soil type.

Driving the harvester too slowly allows tubers to pile up, be caught by the haulm roller and pushed against the sides. Conversely, driving the harvester too fast means tubers roll and bounce around.

- Ensure the digging blade is angled correctly, so that tubers travel smoothly from the blade onto the primary conveyor
- Adjust drive speed so that the web is around 85% full
- Adjust web speed so that soil goes right to the top
- Use the minimum shaking and agitation needed to separate tubers from clods and soil
- Minimise drops and/or provide padding to reduce damage; potatoes should not drop more than 30cm when transferring between conveyors or from the boom conveyor to the bin, trailer or truck

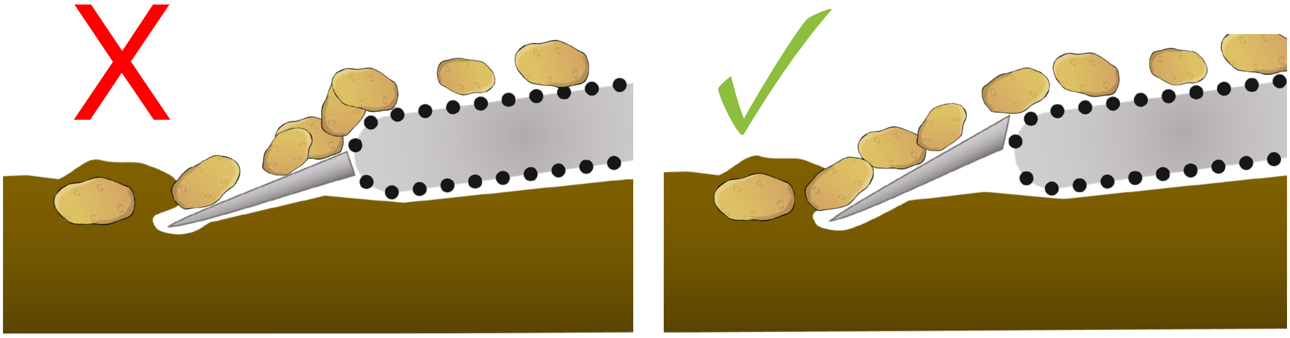

Figure 8. Ensure that the digger blade does not jam tubers into the primary conveyor, but delivers them smoothly onto the top of the chain.

BRUISING

Bruising can be roughly divided into two types - shatter bruises and blackspot. Shatter bruises are obvious. Damage is visible as cracks that can extend to the core of the tuber. These provide an easy entry point for rots and are visually unattractive. In contrast, blackspot bruises are internal, so more difficult to detect.

Potato skin is constructed from relatively small, corky cells that are good at resisting damage, so long as the skin has properly hardened off before harvest. However, the swollen, starch-laden cells that make up the underlying flesh are more fragile. Impacts can fracture the internal membranes of these cells, allowing the polyphenols (tyrosine) and enzymes (polyphenol oxidases) that are normally held separately inside the cells to mix.

The reaction between these compounds leads to the formation of melanin, the brown to black compound that makes bruises visible. The intensity of the colour that develops is directly related to the amount of substrate that is present. As the reaction is not instantaneous, bruises or 'blackspots' develop over at least 24 to 48 hours.

Bruise development is strongly variety dependant, with some varieties bruising more easily than others. Bruising is also more severe at low temperatures than warmer ones.

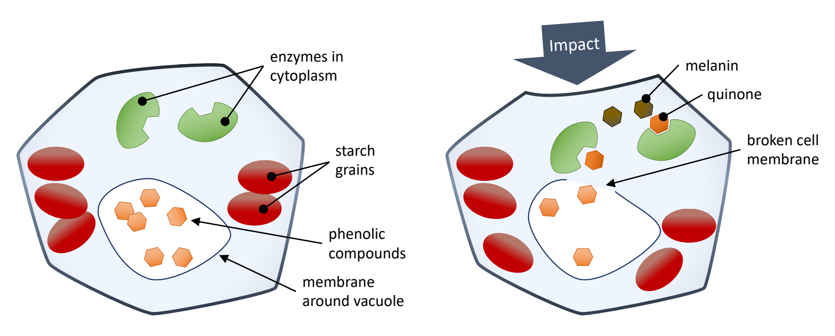

Figure 6. Intact potato cells (left) contain phenolic compounds and oxidising enzymes, kept separate by internal cell membranes. Impacts (right) can rupture this internal membrane, allowing mixing. Oxidation eventually gives rise to the dark compound melanin, visible as 'blackspot'.

For example, Dawson and Johnstone (2016) found that >50% of Nadine potatoes were bruised by a 50cm drop at 10°C, whereas drops less than 60cm did not cause any damage when the temperature was increased to 15°C. Moreover, while a drop of 80cm damaged virtually all Nadine potatoes (regardless of temperature), Ruby Lou was less susceptible. Approximately 20%/40% of Ruby Lou at 15°C/10°C were damaged by the same impact.

Impact recorders, such as the 'Smart Spud' or Techmark IRD (Impact Recording Device), can be used to identify points during harvesting with consistently high impacts. The device can be run again, after making changes, to confirm that impact intensity has been reduced. In the case of the IRD, the software includes a potato "damage boundary"; forces greater than this can potentially cause blackspot.

Figure 10. Impact recorders can be used to identify points on the harvester where consistently high impacts occur, then test ways to reduce these impacts.
Image: P. Morris, Techmark

EXPLORE THE TOPIC FURTHER BY CLICKING THE TITLE BELOW

FACTSHEET: Potato bruising and management

WEBINAR: Harvesting: Bruise prevention and grading

STORING SPUDS

Once the stress of harvest is over, potatoes need to be cured and cooled, especially if they are to be stored for any length of time.

WOUND HEALING (CURING)

While it is clearly better to avoid wounding potatoes in the first place, to some extent potatoes can heal or 'cure' themselves postharvest. Facilitating this natural process is critical if they are to be stored for any length of time.

The rate of curing is affected by temperature and relative humidity. Wounds heal faster above 15°C. However, warm temperatures increase the risk of storage rots, as well as increasing respiration rate and, therefore, internal temperatures.

Conversely, wound healing is very slow at temperatures below 10°C. While such low temperatures reduce the risk from diseases such as pink rot (*Phytophthora erythroseptica*) and watery leak rot (*Pythium* spp.), the slow rate of healing that results can allow other, opportunistic pathogens to take hold.

The optimal conditions for curing are therefore 5 to 10 days at 10 to 15°C.

Ideally, relative humidity (RH) should be kept at 85 to 90% during curing. If RH is over 90%, even small temperature changes are likely to result in condensation. Condensation restricts respiration by the healing tissues and increases infection risk. Maintaining good air movement is the best way of reducing the risk of condensation, especially if cool air is actively pulled through bins of potatoes; as air warms as it flows through the bins, rather than cools, no condensation will occur.

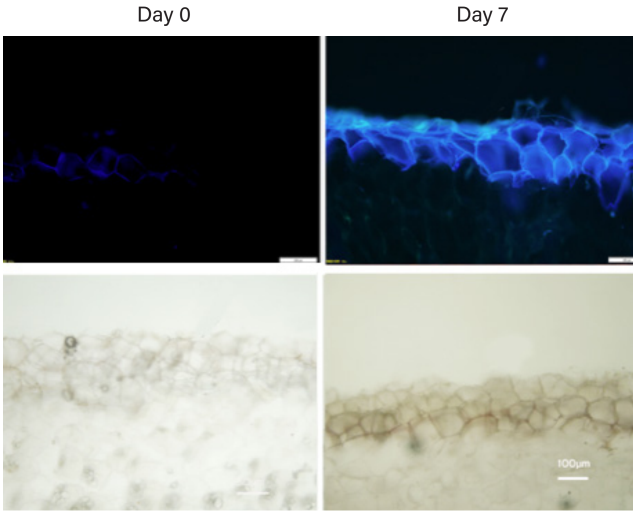

Figure 11. Cross section of freshly cut potato (left) and after 7 days curing (right). Top images use fluorescence to detect suberin; bottom images show lignification of cell walls. Image: Zhu et al., 2023.

Table 1.
Effect of temperature on wound healing. From Cunnington, 2019, ADHB Store Managers guide

Tuber temperature °C)	Initial suberisation (Days)	Suberisation complete (Days)
<5°C	7 to 14	21 to 42
10°C	4	7 to 14
20°C	1 to 2	3 to 6

The curing strategy will need to be adjusted if freshly harvested potatoes are wet. To reduce risk of rots, ventilation should be increased and relative humidity reduced, at least until the potatoes are dry.

While curing is an important step towards maintaining potato quality in storage, it should not be extended past what is needed. Curing is conducted at relatively high temperatures, so will accelerate ageing processes.

RESPIRATION

Stored potato tubers are **alive!** They can develop sprouts, produce chlorophyll, lose or absorb moisture, and continue to mature. All of this metabolic activity is fuelled by respiration.

Respiration breaks down stored carbohydrate reserves, consuming oxygen and releasing carbon dioxide, water and energy. While most energy is used by the cells, some is also lost as heat.

High respiration rates are associated with shortened storage life for many products. Moreover, as respiration produces heat and heat promotes respiration, a 'heat snowball' can develop, especially in poorly ventilated areas of the store.

Perhaps most importantly, high respiration increases the risk of high CO_2 building up in the storage environment. Ventilation rates need to match CO_2 production to avoid this occurring.

Effects of temperature

Respiration rates of potatoes are generally minimised between 3 and 8°C, and may show limited variation within this range. However,

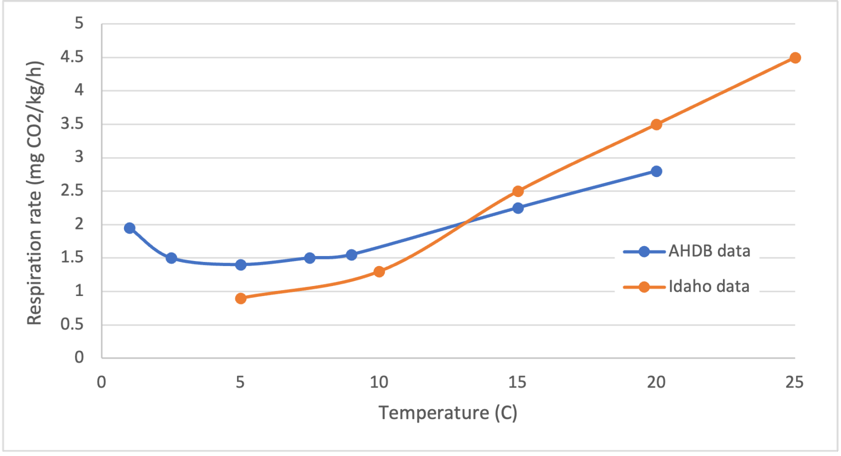

Figure 12. Effect of temperature on respiration rate of potatoes. Data derived from AHDB 2017 (average of five varieties including Russet Burbank and Maris Piper) and University of Idaho Extension 2024 (cv. Clearwater Russet).

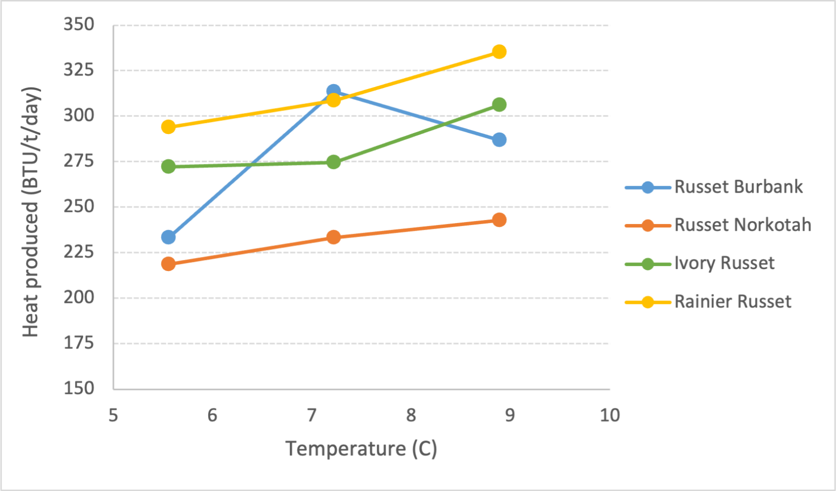

Figure 13. Average vital heat (BTU/t/day) generated by Russet potato cultivars treated with CIPC and stored for eight months at 5.6 to 8.9°C. Data derived from University of Idaho Extension (2024).

Figure 14. Blackheart can occur if internal tissues are starved of oxygen. Image: E. Banks, Ontario Potato Board.

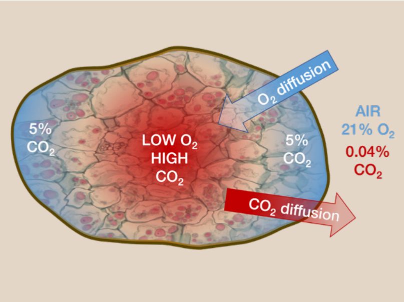

Figure 15. Limited gas diffusion between the external air and internal spaces inside potato tuber flesh means that significant gradients in CO_2 and O_2 are likely to occur, especially if respiration rate is high. For example, at 20°C the flesh immediately under the skin can contain 4 to 6% CO_2. The core may be even higher.

temperatures below 3°C can actually increase respiration rate – an indication that the potato is under stress (Figure 11). Temperatures higher than 10°C are associated with much higher respiration rates, doubling then tripling as potatoes approach ambient temperatures (20 to 25°C).

Respiration rate can vary between cultivars, by maturity at harvest, and with time in storage. After an initial decline, respiration generally remains fairly stable over several months of storage. They then tend to trend upwards as potatoes start to deteriorate. Rising respiration rates can sometimes be the first sign that stored products are starting to break down. For example, marked increases were commonly observed as potatoes kept at 15 or 20°C approached the end of storage life (AHDB, 2017). Damage (e.g. bruising) and sprouting also stimulate respiration.

Energy use in storage

The importance of respiration lies not just on its effects on ageing, but also its impact on the energy required to keep the storage room cool. According to the University of Idaho, a respiration rate of 1mg CO_2/kg/hour produces approximately 61.2 kcal/t/day energy, or 243 BTU/t/day heat.

This suggests that an increase in respiration rate from 1.0 to 1.5mg CO_2/kg/hour will increase the heat load on the cooling system to 364 BTU/t/day. This research also indicates that differences in respiration rates between varieties can change energy costs by 35% or more (Figure 13).

Cooling is essentially value adding with electricity. Although it may require more energy initially to cool potatoes below 7°C, this may be offset against lower energy costs once potatoes are cold. If potatoes warm back up, the value added is lost.

Ventilation

Preventing build-up of CO_2 is essential, especially during early storage.

One reason is that high CO_2 can stimulate production of ethylene. Both ethylene and CO_2 increase breakdown of starch into sugar thereby causing fry darkening and off flavours. High CO_2 can also result in 'blackheart', where the internal tissues blacken and die due to oxygen starvation

Potatoes are extremely susceptible to CO_2 damage because their dense structure limits gas diffusion into the internal flesh. This means there can be significant gradients between the inside and outside of tubers. For example, at 20°C, the outer tuber flesh of 'King Edward' potatoes contained 4 to 6% CO_2, compared to 0.04% in the ambient air (Banks and Kays, 1988). Accumulation of CO_2 is likely to be even greater at the tuber core, where the cells are most tightly packed (Gancarz and Konstankiewicz, 2007).

The threshold external CO_2 level that can cause damage varies between 1,200 to 5,000ppm (0.12 to 0.5%), and is likely to be affected by both respiration rate and tuber flesh density.

Increasing ventilation rates not only increases energy costs, but also, potentially, moisture loss and risk of condensation.

To minimise negative impacts of respiration:

- Harvest potatoes when mature; immature potatoes tend to have higher respiration rates
- Harvest when soil is cool to reduce cooling requirements
- Minimise harvest injuries
- Stimulate curing by keeping potatoes at 10 to 15°C after harvest
- Adjust ventilation rates so as to remove CO_2 generated by respiration;
  - ventilation rates may be reduced as the potatoes cool to holding levels
  - ventilation needs to increase if seed potatoes are warmed before unloading from storage

TEMPERATURE AND COOLING

Temperature is an extremely important factor in quality and storage life of potatoes. It is critical to ageing of stored seed, affects disease progression, and is key to sugar accumulation, sprouting and weight loss in ware and processing potatoes.

Once curing is complete, potatoes should be cooled as soon as possible. However, the ideal cooling method and storage temperature will vary with both cultivar and end purpose. It is critically important to avoid condensation on stored potatoes. This is very likely if bins of warm potatoes are simply placed directly into a cold room.

Cooling methods

One option to prevent condensation is to use positive pressure (forced air) to cool potatoes. Such systems use a powerful suction fan mounted into a plenum to pull cold room air through loaded bins or crates. Air is forced past individual potatoes, cooling the tubers much faster than passive room cooling. The air warms slightly as it moves through the product, so no condensation occurs.

Forced air systems are widely used for other horticultural products. Faster cooling rates mean that both total energy use and moisture lost by the product may be reduced.

Although not generally used for potatoes, forced air cooling should be considered if potatoes are harvested warm (>18°C) and/or wet. In this case, rapid removal of field heat is priority. Loading warm potatoes directly into trucks or shipping containers can easily end in disaster, with self-heating and disease rapidly destroying product quality.

The alternative to pressure cooling is to cool potatoes slowly, dropping the temperature gradually. The cold room air is set only 1°C to 4°C below the flesh temperature of the tubers, ensuring that dewpoint is not exceeded. This has long been standard practice for seed, processing and ware potatoes, with temperature reduced by 2 to 3°C weekly (approx. 0.5°C/day) until the potatoes reach the target temperature.

Effective storage

Maintaining good air movement around the bins or through a bulk load is essential during cooling, but remains important even once products have reached their ideal storage temperature. Well-designed stores have uniform airflow under normal operating conditions, preventing warm or cold spots developing. This may be achieved by adding air ducts or lateral outlets across the store.

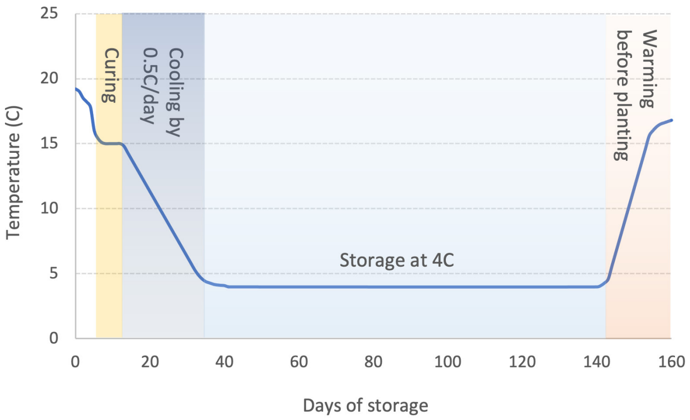

Figure 16. Recommended temperatures for seed potato curing, cooling and storage

A good store also needs to keep temperature stable, RH high, and include monitoring systems that can alert the grower if anything goes wrong.

In Australia's climate, getting the best possible insulation is a wise investment. Insulation works by trapping air in between layers of waterproof outer skin. Air is a poor conductor of heat – that's why puffer jackets are so warm! In contrast, water conducts heat very well. If insulation materials become wet, they will be ineffective.

Keeping floors, doors and walls properly sealed against moisture is an investment in infrastructure that will save energy costs and reduce internal temperature gradients.

- Always repair damage from forklifts or bins
- Check that door rubbers seal thoroughly
- Ensure seals between cold room panels are intact
- Keep the floor dry and sealed against moisture

Commercial systems are available which are designed specifically for storing potatoes. The Tolsma system (p17) is one example. A key benefit of using this technology is the timed ventilation that takes advantage of cool overnight air, providing energy efficiencies. Air refreshment can also be made through the 'Fresh Box', which pre-cools air in a heat recovery unit before using it to vent the room. This reduces CO_2 concentration without increasing room temperature. Automated temperature, atmosphere and humidity controls can be checked remotely, while a check-weigh system can be added to monitor weight loss in stored tubers.

All well designed rooms will provide good air movement, whether delivered above stacks of bins or through ducting on the floor of bulk stores. Air movement can be further improved by:

- Leaving gaps that allow the cool room air to circulate between stacks of bins
- Leaving gaps between bins and the cool room walls and ceiling
- Aligning pallet skids to airflow
- Ensuring the air intakes and cold air delivery system have clear space around them

Airflow can be checked using a hand-held anemometer. This is also a useful way to check that cold air is reaching all parts of the cold room. Adding flexible ducting or diffusers can help if airflow is limited.

Air temperature should be monitored at both the coldest and warmest parts of the room. However, it is the temperature of the potatoes, not the air, which is most important. Periodically checking the potato flesh temperature is an excellent way to double check the room is running well. Even simple, inexpensive temperature probes (such as those sold as kitchenware) can provide a reasonable result, especially if their calibration is checked (see breakout box below).

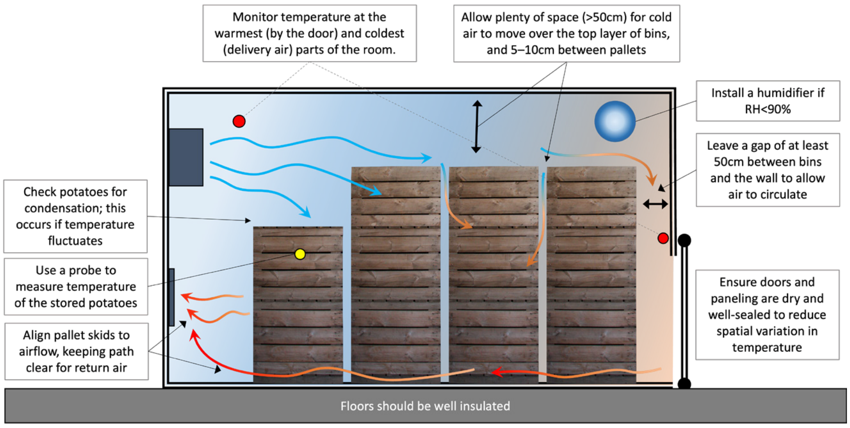

Figure 17. Cold storage rooms should be designed to allow cold air to circulate freely around the bins. For example, lleave gaps between stacks and around walls and consider how much air is reaching the far corners of the room. Monitor air temperature and humidity as well as checking flesh temperature of stored tubers.

PROBE CALIBRATION

The calibration of temperature probes can be readily checked using melting ice.

- Obtain some crushed ice or place ice cubes inside a double ziplock bag and smash with a hammer
- Place crushed ice in an insulated flask (e.g. a thermos, or double insulated container) with just enough water to cover
- Stir the water-ice slurry and allow to equilibrate for a few minutes
- Insert the probe into the slurry and stir gently
- Wait until the reading stabilises;
    - If it is 0°C, your probe is correctly calibrated
    - If it varies from 0°C then this figure needs to be added/subtracted
    - Record the correction (if any) and calibration date and sticker onto the probe for future reference

Typical temperatures used for long term storage are:

Use	Optimum storage temperature
Seed	3.5 – 4.5
Fresh market	3.5 – 7
Processed – Frying	7 – 10
Processed – Crisping	7 – 13

Cold temperatures and undesirable sweetening

Optimum storage temperatures vary between varieties. However, most varieties can suffer chilling injury if stored below 3°C.

Chilling damage does not cause obvious external symptoms, but the flesh can develop grey, discoloured areas that become more noticeable after cooking. Exposure to low temperatures can also reduce sprouting, making it particularly important to avoid temperatures below 3°C when storing seed.

Perhaps the most important impact of chilling temperatures is low temperature sweetening. This occurs due to conversion of starch into sucrose. As little as three days at 2°C can trigger significant accumulation of sucrose in some varieties. Some of this is further converted into the sugars glucose and fructose.

High levels of sugars result in undesirable browning when potatoes are roasted or fried. Not only do these compounds look unappealing and have a bitter taste, they include the probable carcinogen acrylamide.

Low temperature sweetening is due to a combination of both time and temperature. Risk differs greatly between varieties. For example, Figure 16, shows the difference in crisp colour of a variety highly sensitive to low temperature sweetening (Karaka) and one that is resistant (1021/1) after different storage periods.

In general, potatoes are most susceptible during the first two

Figure 18. Colour of crisps prepared from cold sensitive (Karaka) and resistant (1021/1) potato varieties processed immediately after harvest, following storage at 6°C for 1 or 4 months and following storage plus reconditioning for 10 days at 18°C. Image: Datir, 2011.

COOLING POTATOES

Some industry members have suggested that seed potatoes should be cooled slowly so as to avoid cold 'shock'. However, there is little evidence for this in published literature.

The PotatoLink team is therefore conducting a small trial growing seed potatoes (cvs Crop 77 and SIFRA) which were cooled fast or slow then stored for over six months in facilities with different levels of environmental control:

1. **Cooled rapidly** (approx. 1 hour) one week after harvest, minimal temperature fluctuations during storage at 4°C
2. **Cooled slowly** four weeks after harvest, with temperature reduced to 3.5°C over a two-week period, occasional temperature fluctuations during storage to maximum 5°C
3. **Cooled rapidly** (approx. 1 hour) three weeks after harvest, stored in a cool room fluctuating daily between 2°C and 5°C

An initial assessment of stem number and plant height was conducted four weeks after planting. While extremely preliminary, there was a trend to slightly taller plants with more stems when grown from Treatment 1 seed. Crop 77 plants grown from Treatment 3 seed were smaller and had fewer stems than those from other treatments, but the same difference was not found for SIFRA.

Full results and description of this trial will be included in PotatoLink winter edition.

Figure 19. Crop 77 (left) and SIFRA (right) plants grown from seed stored under three different protocols (1 to 3, as described above), pictured four weeks after planting

months after harvest. Sensitivity can be reduced by harvesting potatoes at correct maturity (not immature or overmature) and through stepped cooling – where the temperature is gradually reduced.

Sweetening can be reversed to some extent through post-storage conditioning at 16 to 20°C. By increasing respiration rate, easily accessed sugars are metabolised and reconverted into starch. The process generally takes around three to four weeks.

It is important to monitor sugar levels and processing colour frequently during this time, so as not to over-condition and reduce quality. For example, reconditioning can promote sprouting and disease development. Moreover, post-storage conditioning does not always work. Reversing low temperature sweetening is most difficult if tubers have been stressed in the field.

Long term storage at temperatures above 10°C can also trigger sweetening. In this case, accumulation of sugars is due to ageing. This type of sweetening cannot be reversed.

Irreversible sweetening was also thought to occur in response to high levels of CO_2. However, recent research has found no relationship between storage atmosphere and fry colour.

In ground storage

In Australia, particularly South Australia, ground storage is a common practice for managing year-round supply for the fresh market and extending the supply period for processors.

If storage time is less than four months, and temperatures are cool, ground storage can achieve similar, or even better, outcomes than harvesting then storing in cold rooms. Ground stored potatoes have undergone skin set without the skin damage and wounding that is virtually inevitable during harvest. In the case of fresh market potatoes, skin finish may actually be better when potatoes

COOLING AND VENTILATION SYSTEMS

Sophisticated and specialised systems can help take the guess work out of potato storage. Tolsma sells a number of systems designed to cure, cool and store potatoes. The drying wall shown below (Figure 20, left) is designed to dry and control the temperature of freshly harvested/cut seed potatoes. Once cured, potatoes are stored in the open space ventilation and cooling system (Figure 20, right). The unit blows cool air over stored potatoes, sucking it back through the bins in the air return. An inlet hatch within the unit opens to draw in outside air for cooling, drying and to vent CO_2 as needed. Outlet hatches equalise pressure when outside air is drawn in.

Sensors measure potato pulp temperature and weight loss as well as temperature and relative humidity inside and outside the store. The temperature and absolute moisture differential between outside and inside air is calculated to determine whether outside air is suitable for cooling and/or drying.

Figure 20. The Tolsma drying wall for curing freshly harvested/cut seed potatoes (left) and the Tolsma open space ventilation and cooling system (right). Images supplied by Tolsma.

have been ground stored instead of harvested and cold stored.

Depending on the dormancy characteristics of the variety, an in-crop application of a registered plant growth regulator (e.g. maleic hydrazide) may be needed to control sprouting. Timing is important, as early application can reduce yield whereas late spraying can be ineffective. Such products should always be applied according to label directions.

To be effective, ground storage also needs the right paddock conditions. Soil needs to be kept moist, but not wet, to stop tubers dehydrating. Regular, light irrigation can help reduce soil temperature during hot periods, maintaining more even conditions. This is because dry soils heat and cool easily, whereas moist soil is more stable.

Keeping soil moist also reduces the risk of wind eroding the hills. Erosion is more likely to become a problem as the vines die off and degrade. However, keeping the hills intact is essential to prevent tubers being exposed to the sun and, therefore, greening. Erosion and soil cracking also increase the risk from potato tuber moth. Caterpillars from eggs laid on dead haulms will crawl through soil cracks and burrow into the tubers below.

Once the vines are dead, weed seeds can germinate and grow in the moist soil. This can pose problems at harvest if not controlled early or managed. However, weeds do help protect the hills from erosion.

While it is important soil does not dry out, it is also important that soil does not stay wet. Wet or waterlogged conditions interfere with skin set, even if it has already occurred. Lenticels become swollen and risks from soil-borne diseases such as pink rot and bacterial rots massively increase.

Even under ideal conditions, ground storage can increase the risk of soil-borne diseases such as black dot, silver scurf and black scurf. Fresh market potatoes should not be ground stored in paddocks where there is high risk from these diseases.

Look out for more on anti-sprout agents in future editions of PotatoLink.

ACKNOWLEDGEMENTS

Much of the information presented here was sourced from the 2022 Australian Potato Growers Manual, specifically:

Chapter 4 – Harvest, by N Crump and N Malseed) and

Chapter 5 – Storage, by M Rettke and J Ekman

Hort Innovation project PT19003.

REFERENCES

Banks NH, Kays SJ. 1988. Measuring internal gases and lenticel resistance to gas diffusion in potato tubers. J. Amer. Soc. Hort. Sci. 113:577-580.

Cunnington A. 2019. Potato store managers guide, 3rd edition. Sutton Bridge crop storage research. AHDB. https://potatoes.ahdb.org.uk/knowledge-library/potato-store-managers-guide

Datir S. 2011. Cold induced sweetening in potato (Solanum tuberosum L): genetic analysis of the apoplastic invertase inhibitor gene. PhD thesis submitted to Lincoln University, NZ.

Dawson P, Johnstone R. 2016. https://www.agric.wa.gov.au/potatoes/improve-potato-quality-minimising-mechanical-damage

Gancarz M, Konstankiewicz K. 2007. Changes in cellular structure of potato tuber parenchyma tissues during storage. Res. Agr. Eng. 53:75-78.

Wale, S. 2018. Harvest. https://www.teagasc.ie/crops/crops/potatoes/salad-potatoes-agronomy-/harvesting/

Zhu Y et al. 2023. Foliar Application of Chitosan AcceleratesWound Periderm Formation with an Intensified Deposition of Suberin Polyphenolic and Lignin in theWounds of Potato Tubers. Horticulturae 9:663.

Figure 20. Harvesting ground stored potatoes