CUPGRA

Cambridge University Potato Growers Research Association

Research Update

Potato Storage 2022/23

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POTATO STORAGE UPDATE 2022/23

for Cambridge University Potato Growers Research Association

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1. INTRODUCTION

The current season will be a challenge from a storage perspective as multiple factors amass to work against the industry and, in particular, producers.

The hot growing climate we have experienced in 2022 was expected to produce crops with a larger degree of accumulated temperature and high dry matter that are more prone to premature dormancy break and have a greater chance of bruising. Reports suggest these are not as severe as first thought but these factors remain at higher-than-average risk.

Generally, with warm temperatures persisting, curing has not been an issue, although cooler night-time temperatures as we have progressed through quite a rapid harvest have meant some later-maturing varieties have been on the cusp of acceptability for skin set going into store.

Curing remains an important phase of storage as it is likely there will be an increased risk of infection from diseases such as dry rot (*Fusarium* spp.) or bacterial soft rot (*Pectobacterium* spp.), especially if there is any moisture around to encourage infection through wounds and disease spread. Warm, wet conditions can also encourage other diseases such as watery wound rot (*Pythium* spp.) and pink rot (*Phytophthora erythroseptica*). Both have been reported this autumn. There is some excellent guidance on disease identification still available in the AHDB archive at https://archive.ahdb.org.uk/knowledge-library/potato-disease-identification or contact PSI.

It has been imperative to bring crops under control as soon as store loading began. This meant getting the fans on and removing field heat where appropriate. Fridges have been beneficial for cooling crops on intake to remove excess heat and dry out any pockets of moisture within boxes although it is important to take care not to reduce temperatures too vigorously. Matching temperature to incoming crop helps avoid big differentials between stocks in the store which can cause condensation on the cooler crops (especially if temperature differences exceed 4C).

Loading as quickly as practical, ensuring doors are not left open for a long time, reduces the risk of condensation if warm external air is blown into the store and comes into contact with cooler potatoes.

Dry, ambient air is good for cooling if there is sufficient temperature differential (2°C or more) but try to ensure this is *controlled* ventilation. Manual use of fans may seem the right thing to do but can often lead to re-wetting when conditions change, or the fans get turned off.

Storage efficiency

Optimising storage efficiency is a hot topic right now. With SERIOUS changes in energy costs imminent for many, it is imperative to do everything possible to make sure that stores are running as efficiently as possible to keep running costs down – *see 'On-farm generation', page 8.* And, with just two years' experience in the bank since CIPC was banned, the industry remains on a steep learning curve to tackle the new challenges in sprout suppression with its toolbox of more expensive sprout control products.

2. STORAGE SYSTEMS

Storage systems can impact how well a store performs. Although most store owners are obviously obliged to use the system they have, there are different measures that can be taken to get the best out of the store.

BULK STORAGE

Bulk storage offers a major bonus over many box stores in that it almost always allows the use of positive ventilation. Positive ventilation is where all the air delivered to the crop from the fan has to pass through the potatoes. From an efficiency perspective, this is great as, providing the delivery of that air is uniformly distributed, it allows all the air to be used for drying and/or cooling.

The downside can come if there isn't close enough control of the ventilation process. Automated control of fans is always recommended as, if the fans are left on unnecessarily, this will increase the chance of dehydration (i.e. higher weight loss) and, in more severe cases, even compression damage/bruising.

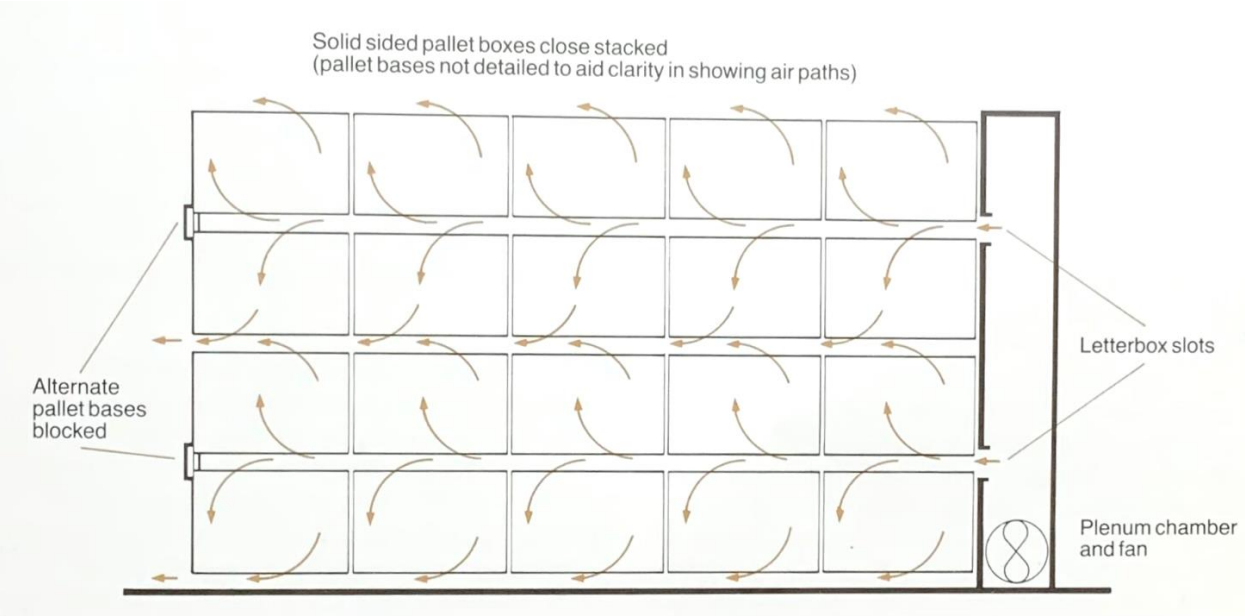
BOX STORAGE

In contrast to the advantages of bulk storage outlined above, many box stores can be quite problematic and this can quickly impact their efficiency.

Before considering those issues, it should be stressed that some boxes fitted with positive ventilation systems can perform well. These broadly distil down to two types of box store:

1. *Letterbox positive ventilation*

   These are stores where foam bungs are used to block pallet slots to force air to pass through the crop, as shown below:



reproduced from [1]: Farm Energy Handbook 1983

2. *Lateral flow suction systems (eg 'Aspire')*

These specially-constructed stores use sheets to cover and seal longitudinal suction voids between the boxes to allow the air to flow laterally through the boxes, as shown:

Other box storage systems (unless they are stacked on a ventilated floor) pretty much all fall into the category of passively ventilated systems. This means air does not have to pass through the potatoes; it usually just passes down the pallet slots and temperature control is achieved indirectly. This indirect cooling and drying can still be effective but all to often it is compromised by poor store management. Examples include:

Box stacking: It is imperative to stack the crop in the store to allow air to *circulate* unimpeded through all of the boxes. As soon as airflow is restricted by poor stacking or overloading, then hot spots are created which will only keep fans running and increase the energy bill.

Short-circuiting: Air always takes the path of least resistance. If this is allowed to happen at the expense of ensuring it goes through the crop, cold air will return to the fridge and only serve to ice up the coils, resulting in more need to defrost. It will cost money to run the fan but it will not remove heat. Consider the use of curtains, plenums or even empty boxes to close off short circuits.

Defrost settings: Refrigerated stores need to have some defrost time – the cooler they run, the more this is necessary. But many stores run unnecessary defrosts that just put heat back into the store, especially if they are controlled by time clock. Those fitted with probes within the coils – to initiate and terminate 'defrost on demand' – can save energy.

3. STORAGE CONTROL:

With any store, it is important to ensure that the store is being controlled accurately and adequately. Make sure, wherever possible, that probes are well spread around the store to get a handle on the range of crop temperatures in the building. Only by investing time in placing a network of probes in the store, can a picture be built up of the way the store works and which parts of the building are prone to variation. It is this variation which prompts the need for interventions (such as recirculation) which has an energy cost and, sometimes, a more direct effect on weight loss.

Automated controllers should always be favoured as they are designed to optimise the way the store runs. Often this data can be accessed via a web platform which can be useful in larger businesses for sharing information on store performance. Also, it is worth noting that these systems have moved up a gear in recent years with much better integration with on-farm generation from renewables, such as Solar PV, for example. This means fridges can be run more during the daytime when power is available off-grid. Tariff management can also be crucial to getting better value from some mains supplies, by keeping fans and fridges off during the tea-time and evening periods, for example.

4. STORAGE TEMPERATURE

In the light of current pressures, it is recommended that close consideration is given to the temperature needed for the store to run at. In general terms, is the current regime compensating for poor air distribution by lowering the set point rather than fixing the cause of, for example, an avoidable hot spot? Is it feasible to run the store warmer to save energy?

In cold stores, particularly if there is a sprout suppressant option (such as *ethylene* or *maleic hydrazide*) available, it may not be necessary to run at 2.5°C. Trials at Sutton Bridge back in 2014 showed little change in the disease threat from running stores slightly warmer (Table 1). Taking temperatures up to 4°C from 2.5°C reduced energy use by 7%. Unfortunately, these savings could still be swamped by the rises in costs starting to affect the industry.

Table 1: Silver scurf severity across four ware varieties stored at Sutton Bridge CSR in 2013/14 [2: AHDB]

Silver scurf Severity (%)									
		Desiree		King Edward		Marfona		Maris Piper	
Storage duration (months)	Treatment	mean	sd	mean	sd	mean	sd	mean	sd
2	2.5 °C	1.65	0.72	3.43	1.51	0.39	0.18	1.65	0.72
	2.5 °C + CIPC	1.76	0.53	5.32	1.88	0.70	0.44	1.76	0.53
	4 °C + CIPC	1.51	0.62	6.50	3.16	0.84	0.28	1.51	0.62
	5.5 °C + CIPC	2.23	0.58	4.27	3.64	0.65	0.26	2.23	0.58
4	2.5 °C	2.43	1.39	5.64	1.70	0.61	0.10	2.43	1.39
	2.5 °C + CIPC	2.38	0.95	4.83	1.28	0.62	0.15	2.38	0.95
	4 °C + CIPC	2.07	0.96	6.03	1.56	1.08	0.88	2.07	0.96
	5.5 °C + CIPC	1.49	0.23	8.42	4.04	0.87	0.43	1.49	0.23
6	2.5 °C	2.50	1.79	5.51	0.69	0.60	0.44	2.50	1.79
	2.5 °C + CIPC	2.77	1.53	4.17	3.08	1.22	1.02	2.77	1.53
	4 °C + CIPC	3.00	1.16	4.56	3.90	1.49	1.49	3.00	1.16
	5.5 °C + CIPC	2.37	0.77	3.33	0.79	1.16	0.49	2.37	0.77

Further, sector-specific considerations are given in Section 7.

5. SPROUT SUPPRESSION

For around 70 years the potato sector enjoyed the use of chlorpropham (CIPC) as its primary sprout suppressant. That all changed in 2020 when CIPC lost its approval across Europe. The result has been the need to rapidly adopt a range of other sprout suppression solutions, most notably in the processing sector which was hugely CIPC-dependent.

Beyond the use of temperature (alone) to control sprouting, there are now five other products available. These are summarised generally below but further, sector-specific considerations on use are given in Section 7.

Maleic hydrazide (MH)

Long-established product used in the UK since the 1980s for volunteer control, MH is a field-applied spray which is taken up by the growing plant and translocated to the tubers. Sprout suppression has been a secondary benefit but, if uptake is good, the chemical is held within the crop and provides 'residual control' – ie sprout suppression over time rather than simply in immediate response to a treatment. It has, for many, now become the baseline product supporting the use of other volatile, contact-action treatments such as spearmint oil and orange oil. MH has performed well in this role across the industry in 2020 and 2021 but uptake of treatments is expected to be poorer in 2022 due to the extended period of dry weather in the summer. The maximum residue level (MRL) for MH is 60 mg/kg.

Always check with markets that they are happy with its use before application.

Ethylene

Ethylene is applied as a pure gas to stores as a dormancy enhancer. It is available from cylinder as SafeStore or, alternatively, can be generated from ethanol using Restrain's catalyst-based system. It is a plant hormone and, as such, is very impactful in the store at very low concentrations; some markets have recently been using it at just 4 ppm rather than the original level of 10 ppm. In all cases, it must be introduced to the store at a very slow rate (known as 'ramping') and specialist advice should be sought from the suppliers on this. After entering the market in the early 2000s, it was used primarily for fresh market but, since the loss of CIPC, has now been adopted for use in processing across their full portfolio of varieties by McCain. Ethylene exhibits a strong varietal interaction and in some cultivars is known to induce some reducing sugar accumulation which affects fry colour. There is no maximum residue level for ethylene.

Spearmint oil

Spearmint oil first entered the potato market 10 years ago in November 2012 where it has long been used in the fresh sector to give additional ad-hoc control beyond that provided by refrigeration. However, since the demise of CIPC, it also became heavily used for control of sprouting in processing potatoes. It is active in the volatile phase, so stores need to be kept closed for 48 hours immediately after application. It has the benefit of having no MRL and a nominal 12 day withdrawal period, which can be shortened by further ventilation. It is primarily a contractor-applied product.

Orange oil

Orange oil made its debut to market in the UK in November 2021. Like spearmint oil, it is active in the volatile phase; again, stores should be kept shut for 48 hours immediately after application. It too has no MRL and no fixed withdrawal period. Application is by hot fog.

1,4-dimethylnaphthalene (DMN)

DMN is a new product that has entered the market in Great Britain (not NI) in 2022. It has been in use in the USA since the 1990s and in parts of Europe for 5 years +. It is another product which acts as a dormancy enhancer so works best if applied early in the storage period, once the crop has been dried and cured. It performed very well in comparison trials undertaken at Sutton Bridge Crop Storage Research ***[3]*** *in 2017-21. DMN has a 30-day withdrawal period after application of the final treatment and an MRL of 15 mg/kg.*

6. ENERGY SOURCING

There is a great deal of activity taking place within the industry with users trying to secure electricity supply contracts at affordable and sustainable prices.

Many will be sourcing their power through central purchasing contracts but it is becoming evident that some groups have secured fixed price deals whilst others are tied to shorter term pricing which could rise sharply but, on the other hand, has the advantage of benefitting from any price falls.

It is currently a very volatile situation and one which it is suggested warrants seeking specialist input and advice from the energy sector. NFU members, for example, can gain access to services from NFU Energy. There is also a number of independent advisors working in the agricultural energy supply sector.

On-farm generation

Recent concern about unsustainable price hikes for new electricity contracts has led to growers considering on-farm generation to run stores.

Beyond the use of renewable sources, this means diesel generation, but would it be cost effective?

Energy specialist Tim Pratt [4] says 1 litre of diesel will yield 10.25 kWh of energy. The efficiency of the generator will vary but expect this to be around 20-30%.

Rebated (red) diesel costs about £1.10 per litre = 110/10.25 = 10.7 p/kWh at 100%. But efficiency is only 25% so this equates to 43p/kWh which is still cheaper than many new contract quotes. Some businesses may not qualify to use rebated diesel so their costs would be closer to 60p/kWh.

Cold stores running for 6 months could be expected to use around 75 kWh/tonne (based on AHDB study R439) so, if you already have access to a generator, this equates to £32 per tonne at the lower rate. If the capital cost of a generator has to be added, this could be at least a further £5K per year for a 50kVA unit (1000 tonnes), raising running costs for electricity alone to nearer £40 per tonne for the season.

7. SECTOR-SPECIFIC MEASURES FOR STORAGE

a. SEED

The key issues for seed growers in trying to manage their stores efficiently is to focus on a few main questions:

- What temperature is preferable to store at?

  Maintaining adequate sprout and disease control will be at the forefront of any decision making with temperature as the primary means of achieving this. Some crops will break dormancy early, especially if they have been subjected to a lot of accumulated heat in the field, but growth should be suppressed in the majority of varieties if temperatures are maintained below 4C. Of course, a setting of 4C on the control box does not necessarily mean all of the store is at this temperature, so allowances have to be made for whatever tolerance is required around the selected set point. This will also be impacted by any need to access the store to remove stocks for grading, for example.

Prolonged periods where the doors are left open for access purposes should be discouraged, however inconvenient it may seem. If warm air can seep into the store, there is a high risk at the generally cool temperatures being used that re-wetting will take place. For high throughput stores, high speed industrial roller shutter doors can be a useful solution.

- How best to manage risk?

  The primary threat to high-grade seed crops comes from disease ***[5],*** so it is important not to skimp on hygiene measures. Keep the store clean and free from the risk of disease carryover. This means maintaining a good hygiene routine, removing dust prior to each season as it can potentially transfer disease spores from one season to the next. Use an appropriate cleaning regime (vacuuming is always recommended for spore removal) followed by a disinfectant treatment, such as fog-applied peracetic acid (PAA).

  For further comments on disease control, please see section 4 above.

- What can I do to minimise the need to recirculate?

  Get to know the store. Some stores that are both well sealed and well insulated, especially those that have sprayfoam, can hold temperatures well – particularly in winter – and therefore there is not a big need to keep stirring up the air with intermittent recirculation. If there is a lack of historical information or experience, start with a modest recirc regime, such as ½ hour in every six hours, and then adjust frequency up or down to try to keep temperatures within ½C of the set-point.

b. FRESH MARKET

Many of the points discussed earlier and for seed (above) apply to fresh market too, but clearly the choice of sprout suppression may extend beyond temperature alone for some growers. This may be a matter of providing tighter control to meet supermarket specifications (many markets have a zero tolerance on sprout growth on red varieties for example) and also include a need for residual control to prevent growth during shelf life after unloading.

Any chemical sprout control treatment used needs to be effective; there is simply no latitude for failed or unsuccessful treatments. This means paying attention to timing of treatments and implementing condensation control measures in particular as the new generation of products all have the capacity to burn or scorch potatoes (and ruin the skin finish) if the product is applied too quickly or put on when there is any moisture around – even the thinnest film of condensation.

Loading and unloading times are important issues to keep control of, particularly the latter. From a grower perspective, lobbying packers and markets to clear stores quickly is important as running part-filled stores is VERY inefficient, will result in a loss of control and is therefore to be avoided at all costs.

c. PROCESSING

When considering processing markets in their many forms, the same general principles apply. Load the store quickly and efficiently, instigate control from day one and maintain it right through to the day the store is completely empty.

Planning is a key component of store management and steps must be taken to avoid mis-matched varieties in the same store, to ensure stores are fully filled to permit efficient operation and, again, quick and effective clearing.

Temperature control needs to take advantage of ambient cooling if it is available, but increasingly matching and automatically controlling ventilation to maximise use of renewable generation on-farm will be important (see Section 3). Storage regimes should also be optimised for temperature and intended storage period so as not to adversely affect weight loss or to require extra ventilation (weight loss is proportional to fan running time ***[6]***). In general, processing crops contracted for the long-term can be stored a bit cooler than those required for earlier delivery.

Most processing stores are continuing to store crops at quite warm temperatures (> 7C) but, it should be remembered, the new sprout suppressants available, are generally less effective than CIPC and the higher the temperature, the more these products are put under pressure.

The way products like spearmint oil and orange oil act is to burn away sprout tissue as a contact-action chemical; even a dormancy enhancer like 1-4 DMN has limited residual impact, so processing crops are relying to a large extent on the residual action of maleic hydrazide to be most effective. All come at a significant price when used alone or in combination.

The adoption of ethylene as a sprout control measure for processing has helped to mitigate costs in some sectors, but is very market-specific. Without detailed information on the varietal interaction with the product and the extent of any influence on fry colour caused in the presence of carbon dioxide, there is an element of risk for many growers. Whilst McCain are happy to underwrite their own supplies and can cope with fry colour variance in their factory, the options for others supplying, for example, the chip shop trade are much more restricted and the risks are much higher. As costs come under threat, the opportunities for exploring these solutions further are reducing.

As a strategic move, changing to varieties with better dormancy characteristics should be a long-term goal ***[7],*** so that fewer interventions are necessary whilst the crop is held in storage. This however will be market-led and may take time to achieve, despite the current pressure on production costs.

8. AUTHOR

This report was compiled by **Adrian Cunnington, BSc (Hons) (Agric), AIAgrE, MBPR (Stored Potatoes).**

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Adrian was formerly Head of Sutton Bridge Crop Storage Research for 31 years, a specialist research and knowledge transfer facility for potato storage, operated by AHDB until December 2021.

9. REFERENCES

[1] Farm Energy Handbook (1983): Potato Storage. The Electricity Council EC4457.

[2] AHDB study R458 (2014): Storage at warmer temperatures: effect on potato physiology and skin finish. https://archive.ahdb.org.uk/storage-at-warmer-temperatures-effect-on-skin-finish-and-cost-benefit-analysis

[3] AHDB study 11140043 (2021): Efficacy of sprout suppressants used alone, or in combination, to control sprouting of stored potato. https://potatoes.ahdb.org.uk/11140043-alternative-sprout-suppressants-processing

[4] Pratt, T, Now Then Energy Ltd (2022) personal communication

[5] Cunnington, AC (2018) AHDB Potato Store Managers' Guide. 3rd edition. 48 pp. https://archive.ahdb.org.uk/potatoes

[6] Rastovski, A; Van Es, A et al. (1987) Storage of potatoes: post-harvest behaviour, store design, storage practice, handling. Pudoc, Wageningen, 183-211.

[7] Cunnington, AC (2022) Developments in automated potato storage management. *Potato Research* (in press).

NOTES: