Managing frost risk

GRDC
Partner Project

NATIONAL FROST INITIATIVE

Case studies of growers in Western Australia

An initiative of the Kwinana East Regional Cropping Solutions Network

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PHOTO: GRDC

Members of the GRDC's Kwinana East Regional Cropping Solutions Network (RCSN) in early 2016. Managing frost risk in the eastern grainbelt has been identified by this group as a priority RD&E area. PHOTO: Cox Inall Communications

Frost damage to crops late in the growing season has been identified as a major constraint impacting on grower productivity and profitability in Western Australia's eastern grainbelt.

The Grains Research and Development Corporation (GRDC) has long acknowledged the severe implications of frost on crop production and since 1999 has invested more than $13.5 million nationally in 60 frost-related research, development and extension (RD&E) projects.

From 2014, these projects came under the umbrella of the GRDC's multi-disciplinary National Frost Initiative (NFI).

This is a five-year project that is tackling frost from several angles to deliver growers a combination of genetic, management and environmental solutions to help mitigate risk. It is also exploring tools and tactics to help the grains industry better plan for, predict and respond to frost events.

Through the GRDC's Regional Cropping Solutions Network (RCSN), the Kwinana East port zone group has identified frost risk management as a high priority area for RD&E in its region.

Growers in this port zone are facing increased risk of grain losses from more severe, frequent, prolonged and/or unseasonal frost events, due to variable climatic, environmental, agronomic and market conditions and a widening of the frost event window in late winter and spring.

This booklet features six growers who are using novel and successful frost management techniques in WA's lower rainfall areas to reduce their business risks. In some cases, frost is costing them average yield losses of 10-20 per cent per year across their total cropping programs in a 10-year period.

But the tactics they are adopting illustrate what can be possible when a customised, individual approach is taken to making decisions and using an integrated plan to address frost issues pre-season, in-crop and post-frost event.

The unpredictable and sudden nature of frost in cropping systems in parts of WA means its impact can be very emotive. Complex management decisions are required and in some circumstances, this can drive the adoption of conservative practices by growers and result in missed opportunities.

While it is useful to seek objective assessment of frost risk, it is important to avoid a one-size-fits-all approach to managing this risk.

Frost risk plans used by the case study growers tend to start with an assessment of their approach to business risk and close consideration of their property's exposure to frost risk.

Several growers are identifying and compiling zones and/or maps that identify the range of frost susceptibility of paddocks. This enables them to adopt diverse or alternative agronomic practices or enterprises to spread production and financial risk.

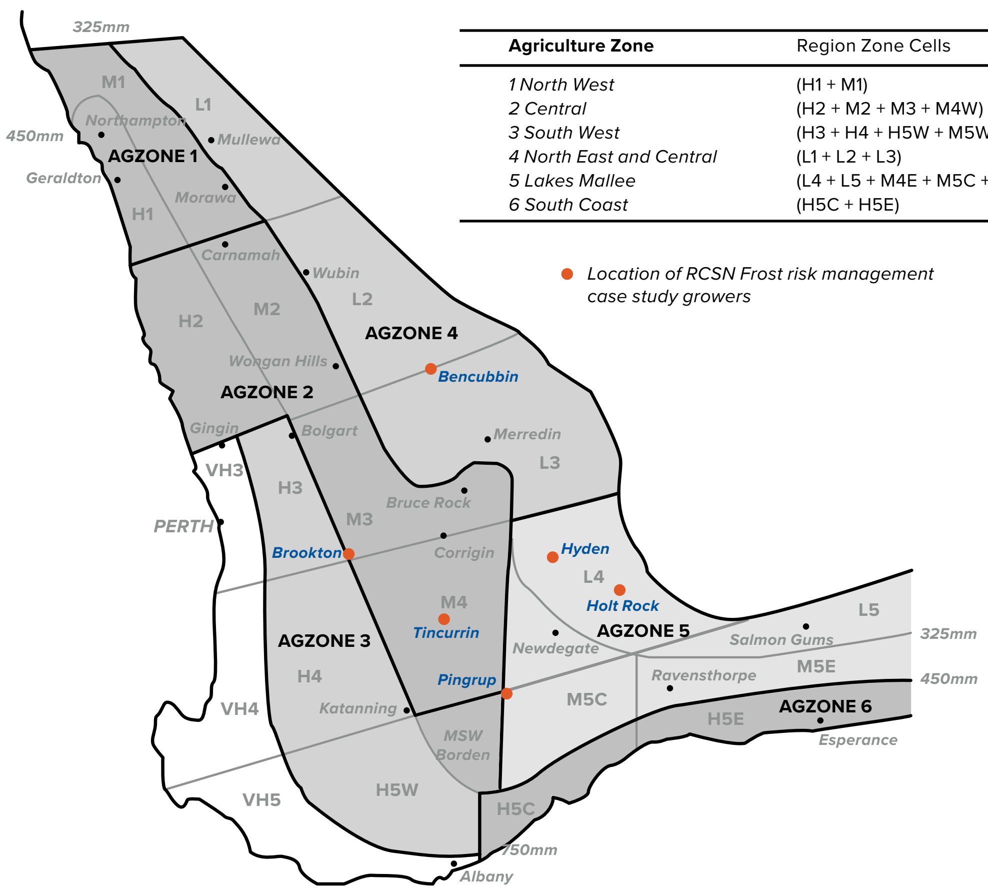
For the future, the frost case study growers say they are keen for GRDC to continue funding genetics research into development of more frost-tolerant wheat and barley germplasm and ranking current wheat and barley varieties for susceptibility to frost.

Through the NFI, frost susceptibility rankings have now been made available for most commercial wheat varieties used in WA to help growers compare varieties and time of sowing when planning frost risk management strategies.

This data is based on three years of national research into field-based frost damage, including at research sites near Merredin and Wickepin, and rankings can be accessed through the GRDC's National Variety Trials website.

RCSN members with a particular interest in frost sit on a 13-member National Steering Committee for the NFI, chaired by GRDC Western Panel chairman Peter Roberts, and have input to the NFI's RD&E priorities and project development.

GRDC Research Code: CIC00027



Agriculture Zone	Region Zone Cells
1 North West	(H1 + M1)
2 Central	(H2 + M2 + M3 + M4W)
3 South West	(H3 + H4 + H5W + M5W)
4 North East and Central	(L1 + L2 + L3)
5 Lakes Mallee	(L4 + L5 + M4E + M5C + M5E)
6 South Coast	(H5C + H5E)

USEFUL RESOURCES

GRDC Regional Cropping Solutions Network: www.rcsn.net.au

GRDC Tips and Tactics *Managing Frost Risk*: www.grdc.com.au/ManagingFrostRisk

GRDC Wheat, Oats and Canola GrowNotes (western region): www.grdc.com.au/GrowNotes

GRDC NFI PlayList: www.grdc.com.au/GRDC-Video-NationalFrostInitiativePlaylist

GRDC *Managing Frost Risk – A guide for southern Australian grains*: http://grdc.com.au/Resources/Bookshop/2007/06/Managing-Frost-Risk-a-guide-for-southern-Australian-grains

DAFWA, Frost and cropping: www.agric.wa.gov.au/frost/frost-and-cropping

GRDC-DAFWA Flower Power: http://grains.agric.wa.gov.au/flower-power

GRDC National Variety Trials website: www.nvtonline.com.au

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IS THERE A DIFFERENCE BETWEEN A 'GOOD' DECISION AND A 'RIGHT' DECISION? AS A GRAIN GROWER, HAVE YOU STOPPED TO CONSIDER THIS?

BY CAM NICHOLSON, NICON RURAL

We often describe 'good' and 'right' decisions interchangeably, but there is a useful distinction. A 'good' decision is an informed decision and to be informed you need to:

- Appreciate the consequences of the various actions you could take
- Have the least regret if it doesn't go according to plan
- Increase the chances of a favourable outcome.

A 'right' decision can only be judged in hindsight – it becomes a matter of time. Also remember, the decision made today might be different to the decision made tomorrow. Things do go wrong – and they will.

Nicon Rural adviser Cam Nicholson outlines how grain growers can make well informed decisions about frost risk management. PHOTO: Nicon Rural

Recently, a group of consultants including me, Bill and Jeanette Long, Danielle England and Barry Mudge put together a compilation of our many years of insights and experiences from working with growers in the GRDC-supported Grain and Graze program.

The contents are loosely based on important concepts that we believe need to be strengthened so that growers can make good, informed decisions. The booklet has broad applicability across farming industries and for a range of decision-making challenges on-farm, including in the development of frost risk management plans.

Decisions can be classified as simple where there are a few variables and there is a clear right or wrong answer, and complicated where there are a number of variables involved but the relationship between the variables is clear and well documented, or complex. These are decisions where a number of complicated decisions come together and interact, and the variables and trade-offs are difficult to quantify or to assess against each other.

Recent work through the Grain and Graze program has explored the influence that the head (logic), heart (values and beliefs) and the gut (intuition) play in making complex decisions.

Historically, consultants and advisers have focused on the head part of the decision, presenting facts and analysis that is supported by the evidence they find.

Unfortunately, this approach neglects the heart element of the decision. This component includes a person's values, beliefs, stage of life, goals and personality. Personality is hugely important, as it determines how a person learns and how they approach risk in a farming business.

Frost has been considered among the risks associated in farming with the individuals and groups I have worked with over many years. Managing frost within farming systems requires complex and challenging decisions.

Frost is often associated with dramatic grain loss and understandably, we want to minimise that risk as much as possible. However, in making a decision to minimise the losses from future possible frost events, growers may become too risk-averse and trade away potential gain when there is no frost. This is especially the case with some personality types.

It is important to acknowledge that any risk combines likelihood and consequences. So with frost, it is important to estimate the probability of this occurring on your property and the size of a potential loss if it occurs.

The impact of frost can be very emotional, as it can be quick and have a devastating impact. The stress it causes often clouds decision-making.

When making decisions, consider how well thought-out the actions are that you have planned for dealing with a frost event. The time to think through these actions and the circumstances of when they should be applied are much better made before the event, rather than in the middle of all the disappointment and despair of frost-ravaged crops.

GRDC Research Code: SFS00028

PHOTO: GRDC

USEFUL RESOURCES

The full Grain and Graze, GRDC-supported report '*Farm Decision Making'*, by Cam Nicholson, Bill Long, Jeanette Long, Danielle England, David Cornish and Barry Mudge (with contributions from Nigel McGuckian and Tanya Robertson) is available at: www.grdc.com.au/FarmDecisionMaking

GRDC Frost Management Tips and Tactics, decision framework for frost management: www.grdc.com.au/ManagingFrostRisk

MORE INFORMATION

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Sheep help reduce frost risk at Bencubbin

SNAPSHOT

OWNERS: Nick and Tryphena Gillett

LOCATION: North Bencubbin

FARM SIZE: 9000 hectares arable

ENTERPRISES: Cropping, Dorper sheep

AVERAGE ANNUAL RAINFALL: 300mm

SOIL TYPES: 50 per cent mallee, 25 per cent heavy/salmon gum, 25 per cent gravel/sand

2016 CROP PROGRAM: 5500ha wheat, 2000ha barley, 500ha oats, 750ha canola, 600ha lupins, 1200ha pasture/fallow

TYPICAL ROTATION: Light soil: Pasture/fallow then wheat-wheat-barley/oats and opportunistic canola/lupins; heavier soil: wheat-wheat-wheat-barley-rotational fallow.

Crop grazing to delay wheat flowering windows is used as a frost risk management tool by Bencubbin grain grower, Nick Gillett.
PHOTO: Fairfax Regional Media

Running more sheep and using crop grazing in early winter have become key tactics to help manage frost risk on the Bencubbin property of Nick and Tryphena Gillett.

Although the pair have escaped the scourge of frost in recent years, a run of extreme incidences around the late 1990s and early-2000s means this issue remains central to their long-term business risk management planning.

Nick says their 9000 hectare property was severely affected by frost in late winter or early spring in 1998, 2001, 2002 and 2005.

This experience underlies a renewed interest in using the sheep enterprise to help mitigate risk in the cropping operation.

Sheep numbers on the Gillett's property were steadily increased after 2005 and have since plateaued in recent years to an 800-head breeding flock of Dorper ewes, which are run on pastures that now make up about 10 per cent of total arable farm area.

The sheep are used for strategic crop grazing in conducive seasons to help optimise livestock enterprise productivity and profits, as well as reduce frost risk by delaying flowering dates for wheat crops.

Nick estimates the 1998 frost that hit their property during spring completely wiped-out yields from 20 per cent of wheat plantings. And in 2005, about 40 per cent of the total wheat program was lost.

"Most of the severe spring frost years were also low rainfall years, including three of the worst winter growing seasons on record," he says.

"We lost up to 1 tonne per hectare from the 2t/ha crops we were relying on for income."

MEASURING FROST

In 2005, T-TEC temperature loggers were placed at crop canopy height on the Gillett property, based on Nick's research that found these data recorders were accurate and commonly used in the Australian refrigeration and transport sectors.

That season, the loggers showed three frost events with durations of six to seven hours below -2°C between August and mid-October (the final event was highly unseasonal).

Nick says, in that period, there were almost weekly frosts – of lesser severity – that resulted in production losses in each cereal variety at each time of sowing.

"After that year, we decided to stop pushing so hard on continuous cereal rotations and allocated more frost-prone land to pasture and running sheep to spread risk," he says.

"We identified frost-prone areas using several years of yield maps, coupled with our local knowledge and experience."

USING SHEEP TO GRAZE CROPS

In the past five years, the Gilletts have been pushing stocking rates higher to boost sheep production and bottom-line returns from this enterprise.

We decided to stop pushing so hard on continuous cereal rotations and allocated more frost-prone land to pasture and running sheep to spread risk.

NICK GILLETT, BENCUBBIN.

Part of this strategy has involved being able to graze cereal crops in the early vegetative stage when sheep feed is in short supply due to seasonal conditions.

The Gilletts grow Mace⦶ and Calingiri wheat and Hindmarsh⦶, Scope⦶ and Litmus⦶ barley and, to date, have used both wheat varieties for early-season grazing if required.

Barley crops have not been grazed on the property, as Nick says they are less susceptible to frost damage than wheat. But he has not ruled this out if needed in future.

Often WA growers will earmark crop varieties and areas for grazing prior to sowing and plant these paddocks early.

But Nick says, in his area, time of sowing is not so important because grazing can be used as a tactic to slow the advancement of crops if they are getting away too fast or to target crops in lower-lying, frost-prone areas.

"Knowing we can graze our cereals without a yield penalty means we can use early sowing opportunities to get a crop in the ground and established if we get really early rain and be confident that we can slow it down later – by about one week of development for every two weeks of sheep grazing," he says.

Nick says in 2015, good summer and autumn rain meant pastures got away well and there was no need to graze cereal crops because sheep feed was adequate.

In years when the Gilletts do use crop grazing, they only put sheep into cereal paddocks sown before May 10 and when crop plants are at the two-three leaf stage (GS13-14).

All classes of sheep (except lambing ewes) are used for crop grazing on the property and stocking rates can be as high as 10 dry sheep equivalent (DSE)/ha.

"If we get good growing conditions, it is hard for us to get enough sheep on to crops to graze them down," Nick says.

"In my experience, you can never have too many sheep on the crop and the faster the crop is crash grazed, the better.

"This seems to work better than prolonging grazing with fewer sheep."

Nick says the grazing period depends on when crops are sown, but he works on the general WA rule-of-thumb that if he wants to extend flowering by one week, he will graze crops for two weeks.

All sheep are removed from crops before they reach the recommended GS30-31 (the start of stem elongation).

The Gilletts no longer use heavier soil types for crop grazing, as these tend to dry out more quickly than lighter soil types and can suffer yield penalties, but their mallee soils are proving to be ideal.

Nick says in any one year, about 5 per cent of cereal crops would be grazed (if needed) and the major benefits are either slowing the advancement of crops/pushing back flowering windows or providing valuable sheep feed – depending on how the season is unfolding.

He says grazing crops also allows him to give pastures a spell and provides an opportunity to control grass and broadleaf weeds without compromising sheep feed.

Grazed areas require more nitrogen (N) and Nick uses a post-grazing application of 10kgN/ha for crop recovery.

FUTURE PLANS

The Gilletts acknowledge that frost is a complex constraint to deal with in their farming system, with losses of up to 3t/ha experienced even in good years, and they recognise that a comprehensive risk management plan is required.

Nick was awarded a GRDC-supported Nuffield Scholarship in 2014 to pursue his keen interest in innovations in agriculture that will improve crop yields and profitability in marginal conditions and a drying climate.

In coming years, he is planning to continue investigating soil moisture measuring, mechanical measures to improve the seedbed, hydro-priming of seed before planting to boost the inbibition process and soil ameliorants to help retain moisture in the plant root zone.

Nick is also a member of the GRDC's RCSN Kwinana East group, which has identified frost risk management as a big research priority for this port zone.

MORE INFORMATION

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DUAL BENEFITS FROM CROP GRAZING

TIPS FOR CROP GRAZING SUCCESS:

- Make a livestock plan to profitably use the extra winter feed
- Select a suitable paddock (consider weeds, stubble, stored water)
- Be prepared to sow early
- Use suitable crops and varieties for the region
- Target early populations of 150 plants/m^2 (wheat); 40 plants/m^2 (canola)
- Protect early-sown crops from pests and diseases
- Provide sufficient nitrogen (N) for early biomass production
- Start grazing sheep based on twist and pull test – typically 1.5t/ha biomass is needed (three to four-leaf stage in wheat and four to eight-leaf stage in canola)
- Consider animal health issues
- Adjust stocking rates to feed on offer
- Lock-up time is crucial – graze for up to two weeks and remove stock before GS30-31 (stem elongation) in wheat and bud elongation in canola
- Top-dress N post-grazing for crop recovery.

Source: CSIRO: www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Managing-dual-purpose-crops-to-optimise-profit-from-grazing-and-grain-yield-north

Using sheep to graze crops is an increasingly popular strategy in the eastern grainbelt for manipulating flowering windows and reducing frost risks associated with early sowing.

Central to success is grazing early, at the crop three to four-leaf stage for cereals (GS13-14 or earlier) and four to eight-leaf stage for canola. Crops are best grazed hard and only for a short period of time – about two weeks maximum and up to stem elongation for wheat (GS30-31) and bud elongation for canola.

A Kwinana East RCSN-supported trial at Merredin on a duplex-loam soil type in 2015 found grazing canola early – at the three to five-leaf stage – did not reduce final crop yields when grazed for 20 days at about 1.5 times district stocking rate.

ConsultAg trial coordinators Geoff Fosbery and Brad Joyce planted the trial in early and late April (with crops germinating on April 2 and April 20), on the back of significant February and March rainfall, into a paddock that had been in a nine-month fallow.

As shown in Figure 1, grazing the canola did not lead to a significant yield penalty – except where plots were grazed early and late, which reduced yields by up to 0.3 tonnes per hectare.

ConsultAg adviser Steve Curtin checks a crop grazing trial of Hindmarsh barley at a site near Newdegate in 2015. PHOTO: Sue Knights, NFI

Brad says the trial confirmed a rule-of-thumb from previous WA crop grazing research that for every one day of grazing, the flowering window was pushed back by half a day (when grazed prior to flowering).

Sheep weights were recorded at the start and end of each grazing time and, as shown in Figure 2, liveweight increased as the stock made use of the green feed – without the need for supplementary feeding.

The results from the 2015 Merredin trial were consistent with RCSN-supported cereal trials conducted by ConsultAg advisers Steve Curtin and Ben Whisson in the upper Great Southern region in 2012-13.

Their RCSN-initiated research was pivotal in identifying the '2:1' rule-of-thumb estimate of the extent of cereal flowering delay caused by crop grazing in WA conditions.

Their trials also found the best results from using grazing to help mitigate the risk of frost damage in cereals came from:

- Sowing the crop early to maximise early growth
- Using only long-season varieties
- Grazing crops early (three to four-leaf stage) to optimise recovery
- Grazing for a short period of up to two weeks.

In these trials, all plots were frosted several times during spring and those that were grazed produced higher grain yields worth up to $92/ha more than returns from ungrazed plots (not including the value of the grazed crop for sheep feed).

A 2015-16 GRDC-funded study by CSIRO Agriculture Flagship's John Kirkegaard (and

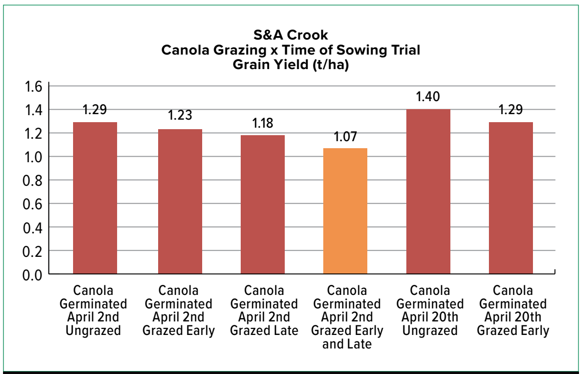

FIGURE 1: Kwinana East RCSN-supported Merredin early sown canola trial yield results, 2015. SOURCE: ConsultAg

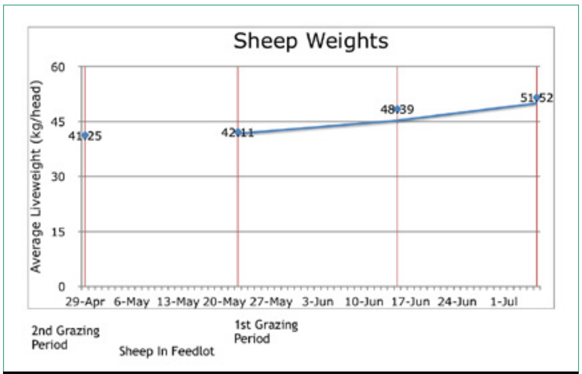

FIGURE 2: Kwinana East RCSN-supported Merredin early sown canola trial sheep weights, 2015. SOURCE: ConsultAg

associates) found net returns from grazing cereal or cano 1.61.41.21.00.80.60.40.20.0 la crops in dual-purpose systems can be as high as $600/ha when there are early sowing opportunities and good management.

Dr Kirkegaard says dual purpose grazing can also widen crop sowing windows, reduce crop height, fill critical stock feed gaps and allow pastures to be spelled.

He says, based on 10 years of national trial data, simulation studies and collaborative on-farm validation, the key to optimising profits and reducing risk from crop grazing is the timing of lock-up.

As illustrated in Figure 3, Dr Kirkegaard says the overall grazing window can be split into ‘safe’, ‘sensitive’ and ‘unsafe’ periods that relate to the impact on grain yield:

- Early/safe grazing – when the crop is well anchored and there is time for recovery after grazing.
- Sensitive – the crop has not started to elongate and knowledge of the level of residual biomass is vital to reach a specified target grain yield.
- Late/unsafe – when the crop’s reproductive parts (spikes in wheat/buds in canola) are elongating above the ground and can be removed by stock.

He says each stage can be identified by testing crop anchorage to determine when to start grazing and checking crop development stage to stop grazing and lock-up the paddock.

Further results from this CSIRO analysis can be found at: www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Managing-dual-purpose-crops-to-optimise-profit-from-grazing-and-grain-yield-north.

GRDC Research Codes: DAW00218; DAW00229; CSP00178; DAW00249; DAW00253; SYN00008, CSP00132, CSP00160,

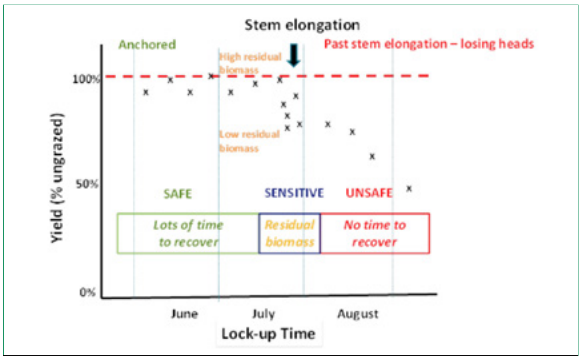

FIGURE 3: Yield recovery (percentage of un-grazed crop) of grazed dual-purpose crops highlighting the safe, sensitive and unsafe periods of grazing. Yield recovery from grazing during the sensitive period for a given target yield is affected by the residual biomass at lock-up. Late grazing reduces the time for recovery, so more residual biomass is needed. SOURCE: CSIRO

USEFUL RESOURCES

GRDC Wheat and Canola GrowNotes:
www.grdc.com.au/GrowNotes

GRDC *Dual-Purpose Crops* Fact Sheet:
www.grdc.com.au/Resources/Factsheets/2009/07/DualPurpose-Crops-Fact-Sheet

GRDC-DAFWA *Crop Variety Sowing Guides*:
www.grdc.com.au/Research-and-Development/National-Variety-Trials/Crop-Variety-Guides

GRDC-DAFWA Flower Power decision-making tool:
www.agric.wa.gov.au/frost/flower-power

Yield Prophet®: www.yieldprophet.com.au

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Small devices help drive frost response at Pingrup

SNAPSHOT

OWNERS: Paul and Siobhan Hicks

LOCATION: Pingrup

FARM SIZE: 3750ha

ENTERPRISES: 100 per cent crop

AVERAGE ANNUAL RAINFALL: 320mm

SOIL TYPES: Duplex-sand/gravel; sand/clay

2015 CROP PROGRAM: 1300ha wheat, 1300ha barley, 700ha lupins, 480ha oats, 65ha field peas

TYPICAL ROTATION: cereal-cereal-canola/lupin

Paul Hicks, of Pingrup, is using a range of new spatial technologies to help reduce the risks of frost impact. PHOTO: ©Evan Collis Photography.

As night time temperatures dipped across southern parts of Western Australia at the start of September 2015, Paul Hicks was busy placing a series of tiny temperature loggers on frost-prone parts of his Pingrup property.

The size of a watch battery, these data recording devices are proving to be an invaluable technology in Paul's efforts to identify frost events in cereal crops and formulate responses to minimise losses.

Paul and his wife Siobhan crop 3750 hectares in WA's eastern grainbelt where cereals are often exposed to frost events in September and October, coinciding with the flowering and grain fill stage of plants and causing significant yield losses in some years.

In 1999, the farm experienced a severe early spring frost that resulted in a wheat crop with the potential to yield 3.5 tonnes/ha producing a total of only eight tonnes of grain at harvest from a 120ha paddock.

Paul says frost incidence on the property is random, regularly affects about 10 per cent of cropping land and can be severe every three to four years.

He says the severity depends on the exact stage of the crop maturity, the degree of cold and the duration, as well as the variety and agronomy used on the paddock.

Aside from selecting better suited wheat and barley varieties and manipulating sowing time to spread flowering windows, Paul and Siobhan decided several years ago to add oats to their crop rotation (for export oaten hay production) as another frost risk mitigation tactic.

GRDC-funded research has shown that oats are less susceptible to frost than wheat.

The Hicks have now developed reliable export hay market contacts, sell hay into domestic dairy and feedlot markets when necessary and use their oaten hay enterprise for opportunistic sheep grazing of the hay stubbles.

"Depending on how the lamb market is travelling, we buy-in lambs to fatten on oat stubbles after mowing in September/October," Paul says.

"We then run the lambs on cereal stubbles after harvest and it works really well."

If sheep are not bought in, the Hicks spray out the oat stubbles with glyphosate for annual ryegrass control as well as regrowth of oats.

They also adopt careful nutrient management in crops following hay in the rotation, as nutrient exports can be high.

MONITORING FROST

On the back of the success of their export oaten hay business, the family is now using temperature monitoring and paddock mapping technologies to underpin post-frost management of cereal crops to optimise returns.

Armed with more precise data, they are able to quickly determine if frost-affected cereal crops should be mowed, baled and sold as hay, or retained to harvest for grain.

"We need to be well informed, as we only have a two-week window after a frost to decide if we will mow the crop or hold off and harvest it," Paul says.

"Our preference is to harvest but this can be costly if we misjudge the frost damage."

PADDOCK MAPPING

In 2012, using GRDC funding, Paul mapped and analysed specific areas on the farm that were regularly affected by frost using remote digital multispectral image maps (with two-metre pixel resolution) and then overlaying this data onto Dual Electromagnetic (EM) and Gamma-radiometric (GR) soil data maps that had been collected in prior years.

The EM maps measure the conductivity of the soil and identify areas of sand through to clay. The GR maps identify thorium, potassium and uranium.

The technology shows thorium has a strong correlation with gravel areas. Potassium – or the lack of it – can also indicate areas that are susceptible to frost.

Maps were overlayed with digital elevation model (DEM) topographic data to pinpoint lower, frost-prone areas.

"The best correlation with actual frost damage was the DEM slope map," Paul says.

"The cold air mass that comes with a frost is similar to pouring liquid nitrogen on a flat table – if you tilt the table, the liquid nitrogen will slide down the surface.

"A frost is similar because the cold air will pool in lower areas where the air has nowhere to escape."

Paul says his mapping data led to the development of 'frost prescription' maps that can be uploaded to his John Deere self-propelled mower to selectively mow frosted cereal crops.

In 2013, 60 per cent of the Hicks' worst-affected barley paddock was mown. It yielded 3.5t/ha of hay and returned $416/ha (net), compared to adjoining frosted areas that were harvested and yielded only 0.6t/ha of grain worth $109.75/ha (net).

Paul says the break-even point for barley in his business is about 1-1.2t/ha, so the decision to mow the worst affected frosted crop delivered an extra $305.75t/ha, as opposed to harvesting it.

He says in recent years he has moved to Normalised Difference Vegetation Index (NDVI) biomass imagery mapping, buying his own camera.

He sees big potential for using this with unmanned aerial vehicles (UAVs) in the future to help identify frosted areas soon after a frost event.

"Before we get our biomass imagery, we need to know if there has been a frost and where it has hit and that's where the temperature loggers come in," he says.

TEMPERATURE DATA

In September 2015, Paul and Siobhan placed 10 small, durable iButton® devices across frost-susceptible paddock areas (identified through previous mapping and yield results) to record temperature variations in these zones.

For a relatively inexpensive cost of $40-50 per unit, these are programmed to measure temperature data every 30 minutes.

The data is downloaded via USB and used – in conjunction with data from two permanent weather stations on the Hicks' property – to build graphs and monitor frost incidence and severity.

Paul says the portable temperature loggers are a very cost-efficient way to measure what's happening as it's happening.

"We put them up and down slopes at head height in the crop to see where the biggest areas of frost risk are," he explains.

The overriding aim is to manage the farm's exposure to frost and reduce it.

"Collecting the temperature data is a critical step and arms us with the information we need should we get that killer frost in September," Paul says.

DECISION TIME – CROP MANAGEMENT AFTER FROST

The threshold for cutting wheat and barley crops for hay post-frost is a yield potential of about 1-1.2t/ha, depending on the prevailing market conditions for grain and hay.

"Our usual rule of thumb is if we think we will get less than 1t/ha of grain after a cereal frost, we will consider cutting it for hay," Paul says.

"If we had planned on a 2t/ha grain crop from the cereals, generally speaking we will expect to get about 3.5-4t/ha of hay from that crop, if it is cut at the right time and still has plenty of green leaf on the plant.

"But to make the economics stack up there needs to be ready access to hay facilities and markets and in the past 10 years we have become self-sufficient in our hay equipment and storage."

Once the hay is cut, and given favourable weather, the Hicks aim to bale and store it within 10 days, reducing the risk of weather damage in late September and early October.

MORE INFORMATION

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TRACKING FROST WITH ADVANCED TECHNOLOGY

New tools to spatially assess frost risk and pinpoint crop damage rapidly and accurately are being tested to improve understanding of frost and fine-tune farm-scale responses.

Frost damage occurs as a result of both cold and freezing conditions, which can vary according to the micro-climate created by topography, soil type and cold air drainage across a paddock. Figure 1 illustrates the stages of crop growth during which wheat is more susceptible to frost.

A national consortium of researchers, supported by GRDC's National Frost Initiative (NFI), is investigating a range of spatial tools, sensors and temperature loggers with potential to help measure micro-climate variations and map areas of frost damage, with the aim of linking frost damage to crop yield.

Led by CSIRO climate scientist Dr Steven Crimp, this research in WA is being carried out in collaboration with The University of Western Australia (UWA) and Department of Agriculture and Food WA (DAFWA).

At sites in WA, South Australia (with Agrilink Agricultural Consultants) and Victoria (with the Department of Economic Development, Jobs, Transport and Resources), researchers are trialling:

- Satellite and other spatial information to develop high-resolution frost risk maps
- Remote sensing approaches and temperature loggers to assess and map frost damage in wheat
- A range of platforms for the sensors, including satellite, unmanned aerial vehicles (UAVs), hand-held and static mounted.

There is potential to use the data generated from these sources in paddock zoning and planning, along with other precision agricultural data such as topographic, electro-magnetic and yield maps; temperature monitors; and the grower's own experiences.

Dr Crimp says information about environmental factors at the time of a frost is highly valuable in mapping susceptible areas of farms/paddocks and determining the most appropriate strategies to reduce risk in these zones.

"In the aftermath of a frost, high resolution farm-scale maps, temperature sensors and hand-held

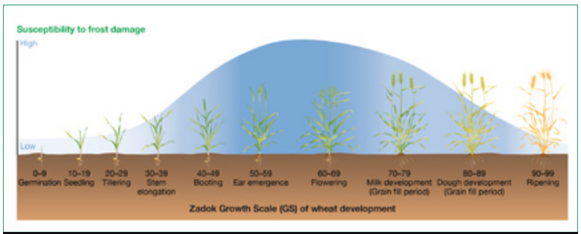

FIGURE 1: An illustration of the susceptibility of wheat crops to frost damage at various stages of crop growth. SOURCE: GRDC National Frost Initiative

devices – in conjunction with adviser support and training – will equip growers to assess frost damage in a timely manner and make prompt decisions to maximise their recovery and income," he says.

GRDC Research Code: CSP00198

USEFUL RESOURCES

GRDC Tips and Tools *Managing frost risk*: www.grdc.com.au/ManagingFrostRisk

GRDC Ground Cover Frost Supplement: www.grdc.com.au/GCS109

Overview of the GRDC National Frost Initiative: www.grdc.com.au/GRDC-Video-NationalFrostInitiativePlaylist

GRDC Back Pocket Guides: www.grdc.com.au/GRDC-BPG-FrostCereals and www.grdc.com.au/GRDC-BPG-FrostPulses

GRDC Hot Topic *What to do with a frosted crop*: www.grdc.com.au/FrostedCrop

GRDC Hot Topic *Pre-seeding Planning to Manage Frost Risk in WA*: www.grdc.com.au/HT-PreseedingForFrostManagement

iButtons®: www.maximintegrated.com/products/ibutton/

Tinytag: www.geminidataloggers.com/data-loggers/tinytag-plus-2/tgp-4017

MORE INFORMATION

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Stubble's subtle impact on frost management

SNAPSHOT

OWNERS: Steve, Tracey and Kyle Angwin

LOCATION: Tincurrin

FARM SIZE: 3850ha arable

ENTERPRISES: 65 per cent cropping, 35 per cent livestock

LIVESTOCK: 3100 Merino ewes mated to Merino rams, 1600 Merino ewes mated to crossbred rams for prime lambs, 1700 wethers, 1500 ewe hoggets

LAMB MARKING 2016: 100 per cent (expected)

TOTAL SHEEP NUMBERS (SPRING): 12-13,000 head

AVERAGE ANNUAL RAINFALL: 375mm

PREDOMINANT SOIL TYPES: Light-medium white gum, sandy loam

2016 CROP PROGRAM: 950ha wheat, 180ha canola, 375ha barley, 440ha oats, 180ha hay, 235ha lupins, 1070ha pasture/fallow

Tincurrin grower Steve Angwin aims to start the cropping year with a stubble load of about two tonnes per hectare for a range of reasons, primarily the need for efficient and smooth seeding operations.

But GRDC-funded research in his port zone has indicated his chosen ground cover target may also assist in reducing the risk of frost in cereal crops later in the season.

By maintaining this level of stubble cover, Steve is manipulating the capacity of the soil heat bank, which is a key factor in managing the risk of frost risk in his local system.

The dynamics of the soil heat bank are changed by stubble, with higher levels of cover exacerbating frost effects and cutting crop yields by:

- Reflecting more sunlight during the day
- Insulating the soil
- Storing less heat and moisture in the soil
- Radiating less heat into the crop canopy at night
- Reducing night-time temperatures at canopy head height.

While results vary in some trials, lower stubble levels have been shown to reduce frost damage and increase crop yields by:

- Trapping and storing more sunlight in the day
- Storing more heat and moisture in the soil

Kyle Angwin, of Tincurrin, during this year's crop seeding and spraying program. Time of sowing and stubble management are major frost risk management tactics used by Kyle and his parents Steve and Tracey. PHOTO: Steve Angwin

- Radiating more heat into the crop canopy at night
- Increasing night-time temperatures at canopy head height (by up to 2°C in some trials).

Past trials in WA and South Australia have indicated that in low rainfall zones (LRZ) that produce average cereal yields of 2t/ha or less, stubble loads of more than 2t/ha can increase spring frost duration and severity by up to 0.6°C in low-lying areas.

As a general rule of thumb, a 2t/ha cereal crop will produce 5t/ha of stubble (assuming a harvest index of 0.4) and this can be reduced to about 2.5t/ha by cutting low, raking and/or windrow burning.

Steve, who farms with his wife Tracey and son Kyle, says 2t/ha is his target stubble load, mostly to ensure seeding equipment operates at maximum efficiency.

"We use finger tine harrows and no press-wheels because we have about 1000ha of pastures each year and we want even plant coverage in these areas," he says.

"If there is a lot of stubble it becomes very difficult to sow through the paddock with our seeding equipment.

"We don't specifically manage our stubbles to reduce frost risk, but if this could reduce the severity and duration of spring frosts by even 0.5°C, that would be a bonus."

Rob Corker, an employee of the Angwins, is responsible for seeding plant and operations on the property which has an integrated frost risk management plan spanning the whole year. PHOTO: Steve Angwin

Each year we work on losing up to 20 per cent of yield due to frost right across out total cropping program – wheat, barley, canola and lupins.

STEVE ANGWIN, TINCURRIN.

FROST SITUATION

Steve considers his frost risk is 'pretty high', with 50-60 per cent of the property at moderate risk during spring and the remainder at low risk.

"Each year we work on losing up to 20 per cent of yield due to frost right across our total cropping program – wheat, barley, canola and lupins," he says.

"Even our best paddock that never gets frosted was hit in 2012 by a severe spring frost that decimated wheat yields by up to 1.2t/ha on average.

"We can almost count on having a severe and prolonged spring frost about once every three years that will reduce cereal and even lupin yields by up to 1t/ha, and a mild event every other year."

THE WHOLE-FARM FROST PLAN

In response to the past decade's increased frost incidence and severity, the Angwins have employed a range of risk mitigation strategies including the focus on stubble management.

They use a mix of crop species and varieties that are matched to appropriate zones in the landscape according to frost susceptibility, have significantly expanded oat plantings and will undertake crop grazing in some seasons.

Low-lying, frost-prone paddocks are not sown to wheat, as this species is considered probably the most susceptible to frost damage.

A selection of wheat, barley, canola and oat varieties are used and time of sowing is varied to spread flowering and early grain-fill windows.

"We tend to start the sowing program with canola, usually around mid to late April but in early April this year (2016), then we plant oats, followed by lupins in late April, barley and hay crops in early May and then wheat," Steve says.

"With the wheat program, we start with Yitpi(D between about May 10-15, as it is less susceptible to frost at flowering than Mace(D.

"This is followed by a mix of Yitpi(D and Mace(D from May 15-20 and then Mace(D with the aim to finish by the end of May.

In recent years we have burned or raked stubble on our heavy paddocks to reduce levels to about 2t/ha.

STEVE ANGWIN, TINCURRIN.

"It is hard to quantify the yield benefits of spreading out our time of sowing, but the Yitpi⦸ does perform as well as Mace⦸ and allows us to start sowing earlier."

Oat plantings have increased on the Angwin's property, as this crop is less susceptible to frost damage and some of it can be cut for hay before the onset of severe spring frosts.

Depending on seasonal conditions, the family will graze wheat, barley, canola, oat or lupin crops with sheep to slow plant development, shift the flowering window and mitigate potential frost risk at this sensitive time. This strategy also helps to fill any autumn livestock feed gaps and/or let pastures get away.

During the 2015 and 2016 seasons, crop grazing on the property has been minimal because pasture feed was plentiful on the back of good summer and autumn rains. But typically, up to one third of the total cropping program can be grazed in any one year.

"We make our grazing decisions depending on how fast the crop is growing, how much feed we have available and how many sheep we have at the time," Steve says.

"Determining the best stocking rate is difficult, because the sheep tend to graze half the paddock hard and not touch the other half and this can affect crop yields."

STUBBLE MANAGEMENT IN THE FROST PLAN

Manipulating stubble as a tool to help reduce frost risk appeared on the Angwin family's radar when they hosted Facey Group trials in 2012-14.

These were set up with Yitpi⦸ and Mace⦸ on a mid-slope area of 40ha to investigate the severity, duration and yield effects of spring frosts under heavy and light stubble loads.

The trials were part of a GRDC-funded project carried out by the Department of Agriculture and Food WA (DAFWA), Living Farm, Facey Group and the Nyabing Farm improvement group, with support from the RCSN Kwinana East and Albany groups.

Unfortunately for the researchers, the Angwin's trial area was not affected by severe spring frosts during those years.

But when frost hit during the flowering window or in early grain fill at sites near York, Wickepin and Nyabing, a reduced stubble load of 2t/ha in low-lying, frost-prone areas was found to boost wheat yields by up to 0.6-0.8t/ha, compared to the results from retaining higher stubble levels of about 3.5t/ha.

Living Farm research agronomist Rebecca Jenkinson says her group's 2012 stubble management trials at York showed that plots where stubble was burned:

- Were 1°C warmer at canopy height than retained stubble plots during a frost event
- Spent an average of one hour less below 0°C during a frost
- Produced an average wheat yield of 1.7t/ha compared to retained stubble plots at 0.4t/ha.

Subsequent trials in 2013 at Nyabing found, on average, crop canopies in standing stubble during 15 frost events between September and October were 0.6°C colder (at -2.4°C) than canopies in r emoved stubble plots (-1.8°C).

In this period, crops in standing stubble plots spent 50 hours below 0°C, compared to crops in the removed stubble plots that were below 0°C for 35 hours.

The plots with removed stubble produced 0.6-0.8t/ha higher average yields in Yitpi⦸ wheat than the plots with high stubble loads.

These findings prompted Steve to consider stubble management more closely.

"In recent years we have grazed cereal stubbles during summer and burned or raked stubble on our heavy paddocks to reduce levels to about 2t/ha," he says.

"We tend to burn in April so that we get a cooler burn that will take out about two thirds of the stubble, mostly down the header strips, and fires are less likely to get away and remove too much cover.

"This year we got a bit caught out because of the wetter than average early autumn conditions that meant paddocks did not burn very well."

Steve says raking stubble is usually carried out at the end of March and early April, and managing stubble load is just one of many frost risk management tactics used on the property.

"The full benefits are yet to be seen because the timing, duration and severity of frosts in the past two years has been so variable and the 2015 season finish was hot and dry," he says.

Steve says he is watching with interest to see if farming systems research in the GRDC's National Frost Initiative delivers any further refinements to the stubble management message for his production environment.

MORE INFORMATION

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AGRONOMIC PRACTICES, THE SOIL HEAT BANK AND FROST

SNAPSHOT

AGRONOMIC SOIL MANIPULATION TACTICS IN BRIEF:

Soil Inversion

- Typically carried out with a mouldboard plough or deep ripper
- Fully buries repellent topsoil to a depth of 15-35cm
- A one-off soil renovation
- Benefits usually last for seven-10 years
- Topsoil needs to be buried well
- Care needed to minimise erosion risk
- Added benefits from burying weed seeds.

Rotary spading

- One-off deep mixing of repellent topsoil into the subsoil
- Seams of subsoil lifted to the soil surface
- Acts as preferred pathways for water entry
- Improves the 'wetting-up' ability of the soil
- Benefits can last for three-five years
- Useful for incorporating soil amendments e.g. lime and clay.

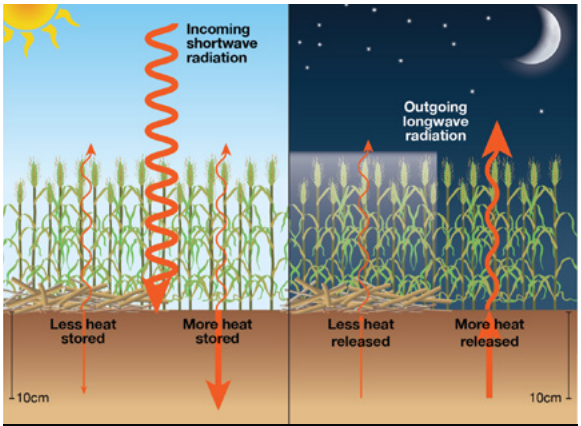
Stubble architecture

- Stubble loads can alter spring frost duration and severity
- Thresholds appear to be site-specific
- Low production environments – 2t/ha or more of stubble loads can increase frost severity and duration
- Medium production environments – 3t/ha or more in stubble loads can increase frost severity and duration
- Rolling may be needed after seeding on some soil types.

Manipulating the soil heat bank using agronomic tactics such as stubble management, soil inversion or deep mixing/spading has been successful in reducing spring frost risk in cereals in some trials in the western region.

The principle behind this research is that by storing more heat in the soil during the day, it will then be re-radiated into the crop canopy at night and lift the ambient temperature at crop head height. This will reduce the potential damage to the head from frost.

Storing more heat in the soil can be achieved by increasing soil moisture levels, incorporating darker soil components – such as clay – in the topsoil and lowering stubble loads.



The soil heat bank has an important role. It captures heat during the day and radiates heat into the crop canopy overnight to warm flowering heads and minimise frost damage. A range of agronomic tactics can be used to increase the capacity of the soil heat bank. PHOTO: GRDC National Frost Initiative

SOIL HEAT TRIALS

GRDC-funded projects in WA and South Australia (SA) have found that heat is transferred into and out of the top 10-30cm of soil each day.

There is more heat stored in this upper layer when the soil is wet, than when it is dry.

There is some evidence that wetter soils can also hold warming properties for more than 24 hours, possibly providing a cumulative benefit over several days.

As outlined in the GRDC's *Managing Frost Risk* book, compiled by Melissa Rebbeck and Garren Knell in 2007, heavier and darker soils retain more moisture – and therefore heat – than lighter textured and coloured soils.

Rotary spading, delving or soil inversion with a deep/mouldboard plough was shown in WA and SA trials (carried out in the early to mid-2000s) to not only increase soil heat storage, but also to improve water infiltration rate and nutrient availability.

These trials indicated that clay brought up to the topsoil increased the amount of moisture the soil could hold and therefore boosted heat storage.

Soil and night-time canopy temperatures were consistently higher in delved soil treatments and this reduced the percentage of frost damage in wheat in the critical four-week period around flowering.

It should be noted that clay delving practices are used primarily to ameliorate water repellent soils and this practice may not be economically viable for stand-alone frost risk mitigation.

Agronomic tactics such as stubble management, soil inversion and deep mixing/spading have been successful in reducing cereal spring frost risk in some trials in the western region. PHOTO: GRDC

Rolling sandy soil and loamy clay soil after seeding can help to reduce frost damage, as this will compact the soil and improve the heat storing capacity. It also prepares the surface for hay cutting, if this is to be used as a salvage measure following a frost event.

MANAGING STUBBLE LOAD

Manipulating stubble architecture to reduce stubble loads – through grazing, burning, slashing, raking, incorporating or cutting crops high or low at harvest – has been shown to change soil heat bank conditions.

The GRDC's *Managing Frost Risk* book says the temperature of the air above stubble is more likely to be colder at night, due to the straw and other mulches acting as an insulator.

This means high stubble loads reflect light during the day, do not hold much moisture and do not conduct heat.

The temperature below thick stubble is also likely to be warmer because it will hold heat in the soil and prevent it from escaping.

Some trials have found varying effects on crop yields from removing or retaining stubble in major spring frost events.

It appears this strategy is site-specific and best used as part of a wider integrated frost risk management plan that also incorporates pre-season, in-season and post-season tactics.

Optimum thresholds for retained stubble are being investigated in the farming systems program of the GRDC's National Frost Initiative (NFI).

To this point in time, WA and SA trials have indicated that in low production environments (averaging less than 2t/ha grain yield), stubble loads of more than 2t/ha can increase frost severity and duration.

In medium production environments (averaging 3-4t/ha grain yield), stubble loads of greater than 3t/ha appear to increase frost severity and duration.

In high production environments (averaging more than 4.5t/ha grain yield) – mostly in eastern States – crop canopy closure occurs and reducing stubble load appears to have no effect on reducing frost severity and damage.

HARVEST OPERATIONS

In WA, current harvest practices of cutting crops low, windrow burning and/or using chaff carts for weed seed management seem to be having a positive effect on reducing frost risk by minimising stubble load, while keeping erosion risks in mind.

As a general rule, WA trials have indicated that a 2t/ha cereal crop will produce 5t/ha of stubble (assuming a harvest index of 0.4). Cutting low and windrow burning reduces this to about 2.5t/ha.

Further trials through the NFI will refine the optimum thresholds for retained stubble in various production environments.

This research so far gives general rules of thumb for stubble levels where moisture conservation benefits start to be outweighed by increased frost risk.

When deciding on the level of stubble to retain, WA growers are advised to consider their attitude to risk and the environmental constraints in which they farm, especially in minimum tillage situations based on the principles of permanent ground cover, limited soil disturbance and reduced compaction.

GRDC Research Codes: CAG00002, DAS00017, DAW00241

USEFUL RESOURCES

GRDC Tips and Tactics *Managing Frost Risk*:
www.grdc.com.au/ManagingFrostRisk

GRDC Wheat and Canola GrowNotes:
www.grdc.com.au/GrowNotes

GRDC NFI PlayList: Stubble management and height:
www.grdc.com.au/GRDC-Video-NationalFrostInitiativePlaylist

DAFWA, Frost and cropping:
www.agric.wa.gov.au/frost/frost-and-cropping

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MORE INFORMATION

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Spading helps soil bank store moisture and heat

SNAPSHOT

OWNERS: Kym and Fleur Wilkinson

LOCATION: East Brookton

FARM SIZE: 3000ha arable

ENTERPRISES: 100 per cent cropping

AVERAGE ANNUAL RAINFALL: 300mm

PREDOMINANT SOIL TYPES: Duplex, sand-over-clay

2016 CROP PROGRAM: 1120ha wheat, 325ha canola, 815ha barley, 345ha oats, 355ha lupins

Deep mixing sandplain soils with a rotary spader to alleviate water repellency issues is likely to have a positive spin-off in managing long-term frost risk for east Brookton grain growers Kym and Fleur Wilkinson.

Since 2014, they have spaded 633 hectares of sandy soil and are reaping productivity gains of up to one tonne per hectare in higher wheat yields and up to 3t/ha more hay from treated areas.

It is expected the clay-rich topsoil created from the spading process will also reduce the impact of severe frosts that hit during the cereal flowering and grain fill windows, by storing more day-time heat in the soil bank and releasing this at night to increase temperatures at crop canopy height.

Kym Wilkinson, of east Brookton, inspects the difference in growth of oat crops in 2015 from a spaded area, left, compared to a non-spaded area, right.
PHOTO: Kym Wilkinson

FROST EXPERIENCE AND COST

History indicates the Wilkinsons will experience a severe spring frost event about once every four to five years.

Kym says flowering wheat crops were hard hit in 1998, 2005, 2008 and 2012.

“We estimate that we will lose an average of 10 per cent of our total 3000ha cropping program to frost every year,” he says.

“In 1998, we had several paddocks of wheat that we thought would yield about 2.6t/ha before they got frosted, but at harvest yielded 1.6t/ha on average.

“Then in 2005 in the same area of the farm, we had a total wipeout of frosted wheat crops on 160ha that was not even worth harvesting, but it had to be so that we could get the air seeder through it the following year.

“That same year, wheat sown into lupin stubble higher up in the landscape yielded 3t/ha.”

Three years later, frost hit the Wilkinsons again, affecting barley crops so badly that the family had to buy-in feed barley to mix with their grain to meet the feed grade.

Kym estimates the 2012 frost – which was severe, prolonged and hit right in the cereal flowering window – cost the business about $600,000.

He says this frost wiped up to 1.25t/ha off wheat yields, with the total wheat program producing an average yield of only 0.85t/ha.

This was down from the five-year peak average wheat yield of 2.8t/ha (achieved in 2007).

The Wilkinsons had a reprieve from severe spring frosts in 2013 and 2014, when wheat yields climbed to average 2.85t/ha and 2.17t/ha respectively.

But average yields fell back to 1.9t/ha in 2015 on the back of moisture and heat stress, rather than frost events, at the end of the growing season.

“Our experience in the past decade clearly shows the significant impact frost is having on our cropping productivity and costs per hectare in wheat yield losses,” Kym says.

The windscreen is bigger than the rear-view mirror and we are optimistic at the start of each season in planning to maximise our yields and minimise our risks.

KYM WILKINSON, EAST BROOKTON.

"But the windscreen is bigger than the rear-view mirror and we are optimistic at the start of each season in planning to maximise our yields and minimise our risks."

FROST RISK PLANNING

The Wilkinson's integrated frost management plan starts with wheat and barley variety choice and time of sowing.

Included in the crop mix are the short season Mace⦶ and longer season Magenta⦶ wheat; La Trobe⦶, Scope⦶ and some Spartacus⦶ barley varieties; ATR Stingray⦶ canola; and Carrolup oats.

"To spread the flowering window and our stem frost risk, we mix up sowing time by sowing some short season wheat early and some late, and some longer season wheat early and some later," Kym says.

"If we get a very early start to sowing as we did in 2016, we will slow down towards the end of the wheat program.

"Historically we always aimed to start sowing wheat on April 25, but in recent years this has come forward to about April 15 if conditions are good.

"We get going earlier with canola plantings, then lupins, oats, barley and aim to finish the wheat program by the end of May."

Kym and Fleur have not mapped the frost-prone areas of their property, but know from experience where these are. They tend to sow flatter, downslope areas later in the program if machinery and paddock logistics make it feasible.

During the growing season, these more frost-prone areas receive the same in-crop nutrition regime and treatments as other cropped areas.

Post-frost event risk management strategies include a plan to cut affected crops for hay, although they have not had to do this for cereal crops to date.

Kym says this would be a viable strategy if needed, as the business already produces export hay and has equipment, contract balers and ready markets available.

Kym and Fleur Wilkinson have treated 300ha this year with a new Imants 57SX spading machine to help address soil constraints. PHOTO: Kym Wilkinson

Spaded area, left. PHOTO: Kym Wilkinson

SPADING TO AMELIORATE SOIL CONSTRAINTS

In 2014, the Wilkinsons experimented with 30ha of rotary spading to address water repellency on some of their worst performing sandplain area.

They had tried clay spreading in the early-2000s but found it expensive and lacking a high enough yield response to be cost effective.

Kym says the first year of spading looked promising and they subsequently treated 200ha in 2015 with a hired machine and another 300ha in 2016 after purchasing an Imants 57SX spader.

They are targeting areas with a high subsurface clay content at a depth of 30-40cm and are also incorporating lime at a rate of 3t/ha.

The Imants 57SX spading machine in action in wet conditions in 2016.
PHOTO: Kym Wilkinson

“What we are achieving in one-pass is incorporation of lime through the topsoil down to 30-40cm, disbursement of the non-wetting topsoil and bringing up the clay-rich subsoil to the surface,” Kym says.

“We are seeing cereal yield increases of up to 1t/ha and up to 3t/ha more hay produced on these areas in the first year or two of treatment.”

Research in WA has shown these yield gains are achieved by the spading operation aiding water infiltration, reducing compaction and changing the distribution of organic matter and nutrients.

The spades lift seams of subsoil to the surface, creating more preferred pathways for water entry and improving the wetting-up of the soil.

Department of Agriculture and Food WA (DAFWA) researchers have found rotary spading can be more successful than complete soil inversion (such as with a mouldboard plough or deep ripper) at incorporating clay and/or lime into the soil.

This is because the mouldboard plough completely buries these amendments, rather than mixing them through the working depth.

Trials have shown rotary spaders are one of the few tools able to effectively incorporate high rates of clay rich subsoil.

It is estimated about two thirds of the topsoil is buried through spading and the remaining third is mixed through the topsoil.

DAFWA says growers using spading need to take care not to bury the clay subsoil so deep that the effect of the clay in ameliorating topsoil water repellence is lost.

The spading brings the rich, dark clay to the surface and this will hold more daytime heat in the soil for longer than the lighter sandplain soil.

KYM WILKINSON, EAST BROOKTON.

MACHINERY MATTERS

The Imants 57SX spader used by the Wilkinsons is 4.5 metres wide, pulled at a speed of 7 kilometres per hour and cultivates to a depth of 30-40cm.

It is towed with a 320 horsepower front-wheel-assist tractor, which Kym says is more power than the spader needs most of the time, but occasionally it causes the tractor to stall.

He says the power is needed to lift the spader rather than pull it, as it weighs more than five tonnes.

“Spading machines are now available with tyres on the rear, which would provide a much better finish,” he says.

“We did consider mounting land packers on the back of our machine but that was a difficult exercise and added more weight.”

Kym says the spader leaves the ground smooth, which can be problematic on soils that tend to get eroded by wind, but the incorporated clay helps to contain this.

“We found seeding in spaded areas in 2016 was a little problematic, due to wet conditions that resulted in us getting bogged 14 times in four days over 270ha,” he says.

“But once sown, the country settles down a lot and we look forward to the benefits of this process in coming years – or hopefully generations.

“Hopefully spading is a once in a lifetime treatment that will last forever. Time will tell, but it is a nice feeling to be able to ‘change’ your soil – something we have never been able to do before.”

SPADING AND FROST

Kym says lack of severe frosts in the past two spring seasons has meant they have not been able to gauge any definitive benefits of spading in reducing crop damage following frost events.

But he expects in future, it will be an important risk management tool.

“The spading brings the rich, dark clay to the surface and this will hold more daytime heat in the soil for longer than the lighter sandplain soil,” he says.

Seeding gets underway in 2016 at the Wilkinsons. PHOTO: Kym Wilkinson

Spading in some old bales of hay on some blowout sands on the Wilkinson's east Brookton property in 2016. PHOTO: Kym Wilkinson

Getting bogged in early 2016 at the Wilkinson's east Brookton property. PHOTO: Kym Wilkinson

Research has shown that by improving soil wetting-up, spading also assists in boosting stored moisture which in turn, further increases heat storage in the soil.

There is some evidence from WA and SA trials, funded by GRDC, that wetter soils can hold warming properties for more than 24 hours – possibly providing a cumulative benefit over several warm/ hot days.

Kym and Fleur plan to continue their spading program each year and aim to have 50 per cent of the property treated by 2020.

They say grappling with poor soil types and increasing climate variability are two of the biggest challenges to their cropping business in the long term.

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MORE INFORMATION

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Grazing frosted crops an option for Hyden lotfeeders

SNAPSHOT

OWNERS: Trevor and Sharon Hinck, son Craig and his wife Lauren

LOCATION: South East Hyden

RAINFALL/AGRICULTURAL ZONE: M3

FARM SIZE: 7000ha arable, split over multiple locations

ENTERPRISES: 70 per cent cropping, 30 per cent livestock

LIVESTOCK: 250 head Droughtmaster females (mated to Angus sires); 2800 head-capacity feedlot

AVERAGE ANNUAL RAINFALL: 320mm

PREDOMINANT SOIL TYPES: Variable, sandy-clay mallee

2016 CROP PROGRAM: 2000ha wheat, 700ha canola, 2200ha barley, 200ha oats, 560ha pulses, 500ha pasture/spray fallow

The ability to run cattle on frost-damaged wheat crops is integral to loss-minimising strategies for the Hinck family, of Hyden.

Trevor and Sharon Hinck, their son Craig and his wife Lauren crop 5500 hectares in Western Australia's Medium Rainfall 3 (M3) zone, as well as operating a 250-head Droughtmaster-Angus breeding herd and a 2800-head capacity grainfed beef operation called Kerrigan Valley.

The family's property has only small areas that are specifically frost prone, but their crops are affected each year to some extent by frosts that occur in the cereal flowering and grain fill windows.

Trevor says experience shows that spring frosts have the potential to slash 0.5-1.5 tonnes per hectare off their wheat yields.

Trevor Hinck has tried grazing frosted crops as part of his risk management strategies to minimise the impact of frost on his family's property at Hyden. PHOTO: Sharon Hinck

That was a much better outcome than simply absorbing the loss from harvesting a 2.5t/ha potential crop that would yield only 0.25t/ha of grain.

TREVOR HINCK, HYDEN.

Traditionally, these severe and widespread frost events could be expected to occur in about one year each decade.

But in the past eight years, the incidence of severe late season frosts has been higher – hitting the property in 2008, 2010 and 2015.

Being able to graze cattle on frost affected wheat crops significantly reduces the potential whole-farm losses in those seasons, according to Trevor.

GRAZING SEVERELY FROST-AFFECTED CROPS

In 2008, a seven-hour stretch of temperatures below 2-3°C during the night of September 28 slashed the Hinck's potential wheat yields right across the property from a forecasted 2.5t/ha to about 0.25t/ha and barley crops from a potential 3t/ha to 1.8t/ha.

Trevor says in that year, 800ha of wheat was so badly frosted that the returns would not cover the cost of harvesting.

As a trial, 55ha of this frost-affected, standing green wheat – with an estimated feed biomass potential of 5-6t/ha – was grazed by 210 head of cattle for 35 days.

At a wheat price of $280/t, he says the returns generated from the livestock enterprise in that period – estimated from cattle weight gain at prevailing beef prices – were the equivalent of harvesting a 1.2t/ha wheat crop.

"That was a much better outcome than simply absorbing the loss from harvesting a 2.5t/ha potential crop that would yield only 0.25t/ha of grain," Trevor says.

He says some of the remaining frost affected wheat crop that year was spray-topped (a pre-harvest crop dessication) for potential feed value and weed control. But subsequent unseasonal spring and early summer rain caused it to rot, rendering it worthless for cattle feed.

"The frosted area of wheat that we left not harvested, not spray-topped and not grazed stayed green until Christmas," he says.

"If we had grazed more of those crops I think we could have achieved even higher livestock returns – potentially the equivalent of a 2t/ha wheat crop.

Lauren and Craig, left with daughter Emily, and Trevor and Sharon Hinck have an integrated plan for managing frost events that are becoming more frequent. PHOTO: Sharon Hinck

"It made us realise that, if necessary, we can bank on putting cattle in frosted crops as an alternative strategy for recovering from severe frost events.

"It is another use for crop biomass, but the break-even points need to be carefully calculated to see if it will be economic."

POST-FROST INTEGRATED PLAN

Trevor says in the family's operation, post-frost wheat crop management now hinges on economic analysis of:

- Harvesting affected crops for grain – for sale or use in the on-farm cattle feedlot
- Cutting these crops for hay to use on-farm
- Grazing the standing crops with cattle.

The decision about whether to harvest frosted grain is based on the likelihood of achieving sufficient quality grades to make a return above harvesting costs.

Some harvested frost-affected grain might be used in the cattle feedlot, but for adequate nutrient value it requires a minimum test weight of 77kg/hectolitre and a high starch content.

Frosted wheat will be cut for hay if the quality is good enough to use on-farm.

If needed, the standing frosted crop could be used for grazing.

But Trevor says the family produces silage as a standard part of the crop rotation, so this available, high quality roughage needs to be taken into account when feed budgeting and deciding if frost-damaged crops are actually needed for the livestock enterprise.

"Our experience in 2008 has shown we can bank on putting cattle in a frosted crop and generating a return but often we need to draw the line somewhere," he says.

Craig, left, and Trevor Hinck take frost planning seriously for the next generation, which includes Craig's daughter Emily. PHOTO: Sharon Hinck

If we had grazed more of those (frosted wheat) crops, I think we could have achieved even higher livestock returns – potentially the equivalent of a 2t/ha wheat crop.

TREVOR HINCK, HYDEN.

"A downside to grazing frosted crops with cattle is stubble management.

"If it is a high biomass crop and cattle trample it without eating all of it, the remaining high stubble load can be hard to manage and will require raking and windrowing – our preference – or burning paddocks, which we don't like doing.

"In 2008 we also found that in the event of high rainfall preceding the frost event, there was potential for damage to the soil structure when the crop area was grazed at high stocking rates. This is difficult in our no-till, stubble retention system."

LONG-TERM FROST PLANNING

Trevor takes a pragmatic approach to mitigating frost and drought risk, which he says are highly difficult to manage and plan for.

"The only solutions to the frost and drought problems we face are breeding resistant cereal varieties and having comprehensive multi-peril crop insurance policies," he says.

The Hinck family's approach to time of sowing is to start when there is adequate soil moisture and get their crops in the ground as fast as possible.

"There are not enough cereal varieties with significant enough differences in phenology that will spread flowering and grain fill windows very widely," Trevor says.

"Also, our cropping areas are spread over a 50-60 kilometre radius, so we tend to work on completing sowing at one block before moving to the next for practical and logistical reasons.

"We take advantage of our sowing opportunities as they arise and in recent years, these have been getting earlier and earlier in the year.

"On average, we lose more yield from late sowing and poor finishing rains than we do from frost at flowering time."

This year, the Hincks started sowing their 600ha canola program just before Easter, on the back of 27mm of rain that took their 2016 year-to-date rainfall figure to a promising amount of about 130mm at one block and 165mm at another block.

The next crops in the ground were barley for silage and oats, followed by barley for grain and wheat, and the program was finished by late May.

Trevor says the family has a passion to ensure the integrity of their grain and beef production systems.

On-farm grain storage is quality assured and audited and the Kerrigan Valley feedlot is registered and quality assured through the National Feedlot Accreditation Scheme.

Most of the Hinck's wheat and barley is stored on-farm and barley for livestock use is tested for protein and energy, cleaned, tempered, rolled and prepared for the daily ration fed to cattle in the feedlot.

MORE INFORMATION

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Crop grazing with sheep (or cattle) can be an option to salvage returns from crops after a frost event. PHOTO: GRDC

WHAT TO DO WITH A FROSTED CROP – CHECK AND PLAN

Grazing frost-damaged crops late in the season with livestock is one of several options to salvage a return from these areas.

There may also be opportunities to harvest the grain, cut and bale the crop for hay/fodder conservation, undertake green or brown manuring or crop desiccation (spray-topping), based on gross margin analysis.

In the aftermath of a severe or prolonged frost event, rapid recognition and assessment of crop damage are the first steps in a management plan.

GRDC has detailed frost identification guides – with photographs, information and links to resources – for cereals, pulses and canola in its Back Pocket Guides at www.grdc.com.au/GRDC-BPG-FrostCereals and in its Wheat, Canola and Oats GrowNotes at www.grdc.com.au/GrowNotes

Symptoms

Some symptoms of frost damage in cereal, pulse and canola crops may appear in the first 24 hours after an event. But most damage takes at least a few days to appear and it is recommended frost-prone paddocks are monitored for up to two weeks after a suspected severe or prolonged frost.

Cereals are most susceptible to frost damage after growth stage GS49 (the start of ear emergence) and during flowering at growth stage GS59-GS70. Frost can also damage grain kernels during early grain fill at growth stage GS80-89 (refer to diagram on p14).

Pulse and canola crops are most susceptible to yield reduction if frost occurs from early flowering to late pod growth and seed fill.

Options

If frost damage is identified, the next step is to develop a management plan for affected areas to optimise returns. Several strategies have been successful in WA.

1. Grazing and/or crop-topping

As the Hinck family has found, grazing frosted crops with livestock can be a viable and profitable option when:

- There is little or no chance of plants recovering
- Hay production is not possible or profitable
- Livestock are part of the current system
- It is profitable to buy or agist stock to run on the area
- The economics and viability stack up
- Weed seed control is a problem.

2. Take through to harvest for grain

If frost in cereals occurs before or around growth stage GS31-32, most plants can produce more tillers to compensate for damaged plants (if spring rain is adequate). If frost is later in the season, there is less time for compensatory growth.

For all crop types, it is recommended gross margin analysis is used to determine the required grain yield to recover harvest costs.

3. Cut and bale/fodder conservation

This is an option for cereal crops when late frosts occur during flowering and grain fill. If a frosted crop is going to be baled, it is necessary to make a timely decision to ensure optimum quality of the product.

Some considerations for this strategy include evaluating:

- Demand from and accessibility to off-farm hay markets
- On-farm requirements for hay/fodder
- Costs versus returns
- Equipment requirements and availability
- Benefits from reducing stubbles, lowering the weed seed bank, disease breaks and rotation options in the following year.

4. Green or brown manuring/desiccation

Frosted plant matter can rot and harbour disease, so there can be benefits to the farming system in ploughing-in or desiccating the crop for:

- Returning organic matter and nutrients to the soil (particularly lupins)
- Managing crop residues and reducing disease loads
- Managing weeds and weed seeds
- Improving soil fertility and structure.

Making informed decisions, acting fast, preparing future business plans, discussing impacts with financiers and developing integrated management strategies are key tactics to help businesses recover from frost.

GRDC Research Codes: DAW00229, DAW00234

USEFUL RESOURCES

GRDC Wheat, Oats and Canola GrowNotes:
www.grdc.com.au/GrowNotes

GRDC Back Pocket Guide Cereals – *Frost identification*:
www.grdc.com.au/GRDC-BPG-FrostCereals

Cutting and baling for hay can be an option for frosted cereal crops. PHOTO: GRDC

Oaten hay helps insulate property against frost

SNAPSHOT

OWNERS: Gavin and Hayley Hill

LOCATION: Holt Rock

FARM SIZE: 6260ha arable

ENTERPRISES: 100 per cent cropping

AVERAGE ANNUAL RAINFALL: 300mm

SOIL TYPES: 40 per cent light ironstone ridge-mallee-yellow sand and 60 per cent heavier valley floors-morrell-loam-over-clay

2016 CROP PROGRAM: 1980ha wheat, 1230ha oaten hay, 1720ha barley, 600ha canola, 475ha field peas, 185ha lupins, 70ha oats

TYPICAL ROTATION: Heavier country – cereal-cereal-cereal-legume and lighter country – hay-canola-wheat-barley-(occasionally) lupins

As Western Australia's most frost-tolerant crop at the reproductive stage, oats are a key part of the Hill family's integrated frost risk management plan for their Holt Rock property.

Gavin and Hayley Hill estimate 90 per cent of their 6260 hectare cropping area is susceptible to frost during the flowering time for cereals, especially in low-lying areas and in paddocks facing west, where soil takes longer to heat up in the mornings.

In the early 2000s a run of severe frost events at flowering time prompted the Hills to increase the area they now sow to oats for export hay production.

Equally important for the Hill's frost-prone areas is to spread the flowering time of their cereal crops, which is managed by time of sowing and variety choice.

"We don't withhold sowing specifically for frost, as you can lose a large amount of your potential yield by delaying the flowering window on account of our other main constraint, being moisture," Gavin says.

"I guess we are quite risk averse in cropping, in terms of cropping more heavily in years with good summer rainfall and reducing our program in years where we endure a very dry start."

FROST EXPERIENCE

Gavin says during the past six years, the Holt Rock property has experienced only one severe frost at cereal flowering time, in 2014.

Holt Rock grain grower Gavin Hill has expanded oaten hay production as a key frost risk management tool. PHOTO: Gavin Hill

But between 2002 and 2010, there were six extreme frosts in late winter or spring – almost one every year at the most susceptible time for crop damage.

These lasted between one and four hours, with a Department of Agriculture and Food WA (DAFWA) weather station measuring temperatures of about -1°C, and led to significantly damaged wheat crops and low yields.

"We usually get temperatures below -1°C and can get away with frosts at that temperature and at that time of the year if they only last for an hour or two," Gavin says.

"But there is a lot of damage in terms of flowers killed, pinched grain and stem frost damage when the duration of the frost is three to five hours at -1°C, and that's what we experienced regularly in that period of 2002-10."

Economic analysis indicates frost has cost the Hills an average of $40/ha every year for the past 11 years due to reduced wheat yields. But this figure can range from $0/ha in years where there is no frost in the cereal flowering window, up to $100/ha (averaged across the farm) in years when frost does hit at flowering.

Gavin estimates that frost has cost him almost $1 million in total lost grain production since 2002 and frost incidence remains highly unpredictable, with significant frost events recorded on the property from mid-August through to early October in some years.

He says while early frosts can slash yields, late frosts cause quality problems that can lead to downgrading of grain.

We are using oats for weed control, as well as to hedge our bets against frost damage in cereal crops.

GAVIN HILL, HOLT ROCK.

ADDING OATS TO THE MIX

After the first year of significant frost damage in 2002, the Hills started producing oaten hay for export on 200ha, initially targeting paddocks with high levels of annual ryegrass *(Lolium ridgidum)*.

This enterprise has steadily expanded and in 2016 covers 1230ha, or about 20 per cent of the total cropped area of the property.

"Frost is the main driver for this enterprise expansion, along with annual ryegrass control," Gavin says.

"We have annual ryegrass that is resistant to clethodim and we are aware that glyphosate resistance is a looming issue.

"So we are using the oats for weed control, as well as to hedge our bets against frost damage in cereal crops.

"Plus oats are a profitable cash crop in the rotation if they are produced and marketed well."

Gavin says the gross margin of his export oaten hay enterprise equals the gross margins for his wheat and barley crops in most years.

But he stresses that oats are a higher risk crop in terms of potential issues with quality if there are adverse weather conditions at, or after, hay cutting.

To open up the time-of-cutting window he uses three oat varieties – Carrolup, Mulgara⟇ and Williams⟇.

These varieties are a permanent part of the crop rotation and are sown from April 15 – dry or wet – to be ready for cutting by mid-September to beat the risk of weather damage.

AGRONOMIC MANAGEMENT

Management of the oaten hay crops starts at the previous harvest, when windrows are created and burned before a full summer weed spraying program that helps to conserve valuable soil moisture from summer rainfall.

Weed control is used if capeweed is problematic due to seasonal conditions.

Gavin says oat crops receive higher nitrogen (N) applications than wheat or barley crops – 60 units of N/ha – and he applies 5-6 units of phosphorus (P)/ha. There has been no yield response to date from application of extra potassium (K).

Diseases and pests have not been problematic in the oat crops aside from aphids during one season and some low incidences of leaf rusts that did not impact on hay quality.

The long-term average yield for export oaten hay crops on the Hill's property is 3.4t/ha but in favourable seasons, yields can be as high as 6t/ha.

Gavin says hay crops are cut in the critical stage from flowering to watery dough when the best feed analysis results occur, and then rapidly lose quality when they hit the 'firm dough' stage.

"Timing of cutting is critical to quality and returns and for this reason, we have moved away from contract cutting and raking and now do these jobs ourselves," he says.

"We have our own baler and use two other contract balers.

"The aim is to have the crop cut within 10 days, dry within 10 days and baled within 10 days to minimise the risks of weather damage."

MARKETING OATEN HAY

Gavin and Hayley sell 95 per cent or more of their export hay production to one of four or five accredited export hay plants in WA each year, with the remainder going into the domestic feed market if bales are damaged or downgraded for any reason.

"It is vital to have a domestic market readily available and we have many producers close to us to whom we can sell any of our excess hay for feed," Gavin says.

He says 2015 was an ideal hay production season, with good summer rain of 100mm followed by 50-70mm pre-sowing in March and another 10mm in April.

He says a dry spell of four weeks in May and again later in June/July did not appear to set oaten hay production back significantly and the season produced crops with an above average yield of 4.8t/ha.

MANIPULATING THE CEREAL FLOWERING WINDOW

Another part of the Hill's frost risk management plan is to have 10 per cent or less of their total wheat crop exposed to frost risk at any one time in the most sensitive cereal flowering window.

This should reduce the chances of widespread crop damage and yield loss, except when frost duration is long and/or severe.

Gavin says variable rainfall patterns in recent years have resulted in more opportunities for earlier sowing times on the property, helping to spread flowering times later in the growing season.

Holt Rock grain grower Gavin Hill has expanded oaten hay production as a key frost risk management tool. PHOTO: Gavin Hill

Less frost-susceptible oaten hay and canola crops kick-start the seeding program from early to mid-April, followed by cereals after April 25.

The first cereals to be planted are the shorter season Mace⫶ wheat along with Mundah and La Trobe⫶ barley.

From May 5-15, the Hills alternately sow a long and a short wheat variety, or a long and short barley variety in adjacent paddocks in the same area of the farm.

At the end of the sowing program, from May 15-25, only long season wheat and barley varieties are sown, including Yitpi⫶ wheat and Scope⫶ barley.

FUTURE PLANS

Gavin says through his local grower group – The Holt Rock Group – he was staying abreast of management strategies that worked in his local area to help mitigate and manage frost risk better.

As the host of a GRDC National Variety Trials (NVT) site, he was also able to watch the performance of up-and-coming wheat varieties on his property.

Oats are a profitable cash crop in the rotation if they are produced and marketed well.

GAVIN HILL, HOLT ROCK.

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MORE INFORMATION

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OATS A GOOD FROST HEDGE IN WA

TIPS FOR GROWING OATEN HAY IN FROST-PRONE AREAS OF WA:

- Ensure correct timing of cutting/mowing and baling to maintain quality and price
- Closely analyse capital expenditure
- Assess transport costs and reliability
- Monitor hay prices, which can be volatile
- Monitor nutrient removal by hay crops, especially potassium (K)
- Include realistic potential hay yields, input costs and likely prices when undertaking enterprise gross margin analysis.

Source: Garren Knell, adviser ConsultAg

Oats planted for the export oaten hay market are mowed soon after flowering, at milky dough stage, which is before grain formation and prior to the frost-sensitive period in WA.

Other advantages of including oats in the rotation as part of a whole-farm frost risk management plan include:

- Enterprise diversification
- Using soils that are typically highly productive in frost-free seasons
- Opportunities for good weed control and less herbicide reliance
- Creating a disease break for cereal crops
- No need for late finishing rains to maximise yield.

But there are potential risks of oat production for hay, including:

- Chance of weather/rain damage during mowing and baling
- The need for capital and infrastructure
- High transport costs to market
- Volatile hay prices
- High levels of nutrient export from paddocks (especially potassium).

ConsultAg Narrogin-based agricultural adviser, Garren Knell, says oat crops can be up to 4°C more tolerant to frost at flowering than wheat crops, and there is virtually no frost risk to hay because there is no need for grain formation.

He says oaten hay crops do not rely on finishing rains and can be a highly profitable break-crop in their own right when managed well.

To successfully grow quality oaten hay, Garren says the main requirements are to cut the crop when it is at the 'watery ripe' stage and avoid rain or weather damage on the crop after it is cut.

"Oaten hay produced in lower rainfall areas, such as the eastern grainbelt, is generally lower yielding (almost droughted) compared to crops in higher rainfall areas, but has higher nutritional value that can lead to higher prices," he says.

"In my experience, export oaten hay can be one of the most profitable crops, by gross margin, for many growers in seasons where there is no weather damage at or after cutting."

Agronomic factors

The most common oat varieties used for export hay production in WA are Carrolup and more recently, Brusher⦻, both of which can be sown early.

Early sown hay crops (in April) have a higher yield potential than later sown crops (in mid to late May). However, early sown crops need to be mowed earlier when the risk of damaging rainfall is higher.

Garren says growers need to take this into account when planting hay.

"April-sown hay in the lower rainfall environments regularly yields 3-4 tonnes per hectare of high quality hay," he says.

"In the higher rainfall areas yields of 5-7t/ha are far more common, but higher yielding hay usually achieves a lower price due to quality limitations."

Narrow row spacing has been shown to increase hay quality and previous WA trials indicate a maximum of 25cm (10") spacings on the seeder are required.

Cutting oat crops for hay can reduce weed burdens by desiccating later maturing weed species before viable seed is set, especially for annual ryegrass and some broadleaf weeds. With care, viable weed seeds can also be removed from paddocks in the baled hay.

Hay production does remove significant nutrients from the soil, especially potassium (K), but late-season uptake of nutrients is reduced. This means hay can be less depleting to the soil than harvesting grain and cutting straw or harvesting grain and burning stubbles.

Hay production can not only help manage frost risk in susceptible areas, but can also provide a break for cereal diseases such as crown rot – the effects of which can be seen in this emerging cereal crop. PHOTO: GRDC

Export hay production also offers eastern grainbelt growers another break crop option in continuous cereal rotations to disrupt disease cycles. This can be particularly useful in crown rot management, as oats are a non-host to this soilborne disease.

Marketing oaten hay

Garren says the further the distance from an export hay processing plant, the higher the hay quality needs to be to optimise returns.

He says oaten hay has a well-established and expanding market in WA, but if market conditions contract, it can be important to have facilities to store product to sell when prices improve.

USEFUL RESOURCES

GRDC Oats GrowNotes:
www.grdc.com.au/GrowNotes

GRDC Ground Cover Frost Supplement:
http://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS109

GRDC *Managing Frost Risk – A guide for southern Australian grains*:
http://grdc.com.au/Resources/Bookshop/2007/06/Managing-Frost-Risk-a-guide-for-southern-Australian-grains

RIRDC – Producing Quality Oat Hay:
https://rirdc.infoservices.com.au/items/06-002

MORE INFORMATION

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GRAINS INDUSTRY WELCOMES FROST SUSCEPTIBILITY RANKINGS

Western Australian grain growers are able to factor frost susceptibility of wheat and barley varieties into their cropping programs.

Through the GRDC's National Frost Initiative NFI), most commercial wheat and barley varieties have been ranked for their relative susceptibility to spring radiation or reproductive frost, which occurs in late winter to early spring.

The rankings are available through an interactive tool on the National Variety Trials (NVT) website at www.nvtonline.com.au

Dr Tim March, of the University of Adelaide, says in recent years, trials benchmarking current wheat and barley varieties for sterility at flowering under frost conditions had enabled researchers to develop a ranking system, in which varieties can be compared for susceptibility to frost during the reproductive phase of development.

He says three years of data from the trials at GRDC-funded frost screening nurseries in Wickepin, WA; Loxton, South Australia; and Narrabri, New South Wales, have shown that overall, barley is more tolerant to frost than wheat, and that under mild frost events, susceptibility levels can vary between varieties.

"It is important to note that no varieties are completely frost tolerant," he says.

Dr March says the rankings are based on sterility measurements and not yield loss.

"Until we can get that data, growers should first select varieties for local adaptation, yield, optimal flowering time and other key target traits and criteria important for their farming system, and then use the frost rankings to fine-tune risk management of the selected varieties," he says.

"In some cases, it may be that the more frost-susceptible varieties are the best option – you don't want to be on the back foot with yield before you get hit by frost."

Dr March says the data used to determine the rankings was based on each variety's relative susceptibility to reproductive frost at flowering and not stem frost, which occurs early in the growing season.

Assessment of the frost susceptibility of 72 wheat and 48 barley varieties has been carried out under the collaborative Australian National Frost Program (ANFP), which is a key component of the GRDC's NFI.

Dr March says breeding new cereal varieties with improved frost tolerance is one of the solutions to minimising the economic losses from frost, and ongoing research is focused on this goal.

"The GRDC's investment in the ANFP is an example of a significant pre-breeding project that is developing industry capacity and methodologies that will enable not only the independent screening of newly-developed varieties from commercial breeding companies, but also introduced germplasm, to identify increased levels of frost tolerance for Australian growers," he says.

Dr March says it is important to combine genetic, management and environmental strategies to reduce the overall risk from frost.

"As frost exerts a complex production constraint in cropping systems, it requires a package of risk management strategies," he says.

GRDC Research Codes: UA00136, CSP00180, YOU00002, CSP00143, DAW00234, DAW00241, UMU0045, CMA00002, UQ00071, CSE00198, CLT00001

USEFUL RESOURCES

Ground Cover TV:
www.grdc.com.au/GCTV15-FrostRatings

GRDC Ground Cover *Frost Supplement*:
www.grdc.com.au/GCS109

GRDC NFI Playlist: www.grdc.com.au/GRDC-Video-NationalFrostInitiativePlaylist

National Variety Trials website:
www.nvtonline.com.au/frost

MORE INFORMATION

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Back Cover Photo: GRDC