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IRRIGATED WHEAT IN THE MURRUMBIDGEE, MURRAY FACT SHEET

GRDC
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SOUTHERN NSW, NORTHERN VICTORIA

LIFTING YIELDS FROM 5T/HA TO 8T/HA … OR MORE

Growing irrigated wheat in southern New South Wales and northern Victoria is more than simply adding water to dryland varieties. Higher yields require increased monitoring and correct management practices to avoid yield penalties.

KEY POINTS

- Growing 8t/ha of irrigated wheat requires more monitoring and management than 5t/ha.
- Variety selection is integral to success for high grain yield potential and need for irrigation adaption.
- Nitrogen supply at sowing should be 100-120kg N/ha, including the amount already in the soil and amount to be applied.
- To avoid lodging, avoid shoot numbers exceeding 800/m^2 at the first node stage (growth stage 31) through precise seed rate calculation and placement. Use varieties with a lodging rating closer to 1 than 9.
- Maintain three green leaves per shoot at flowering through use of nitrogen topdressing, timely irrigations, foliar fungicides for stripe rust and other diseases.
- Use a layout which allows irrigation and drainage in less than 12 hours.

PHOTO: DEANNA LUSH

Variety selection and management of nitrogen, disease and weeds, canopy and irrigation are key aspects to achieve 8t/ha irrigated wheat yields.

In the past 10 years, growing wheat under irrigation has evolved with the use of specific agronomy packages to maximise yields of adapted irrigated cultivars.

While the focus was irrigated wheat yields of 5 tonnes per hectare, the bar has been raised to 8t/ha – and beyond – in the regions covered by the Murrumbidgee Irrigation Area, Murray Irrigation Limited and Goulburn Murray Water.But it is not easy to consistently achieve the extra 3t/ha production.

The risk in targeting an 8t/ha crop is not much greater than targeting 5t/ha up until the first-node growth stage (GS31). If crop prices are poor or crop potential or water is lacking, then growers can decide at GS31 to maintain a 5t/ha target.

Growing higher yields requires more monitoring and more management. Failure to do so can lead to a significant reduction in yield potential. Constraints to achieving 8t/ha include late sowing, poor tillering, low water allocations that prevent the correct number of spring irrigations, inadequate nutrition, lodging, lower wheat prices or other agronomic factors.

Extra management is required in five key areas for crops to yield an extra 3t/ha or more:

- Variety selection and sowing
- Nitrogen use
- Disease and weed control
- Canopy management
- Irrigation application

Crops must be frequently checked otherwise growers can only guess the cause if yields do not make 8t/ha. Correct timing of all operations is vital.

Variety selection and sowing

Variety selection is integral to achieve 8t/ha because grain yield potential under irrigation

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varies. Growers cannot simply add water to a dryland variety because lodging may be an issue.

Recent trials have screened wheat varieties for irrigation suitability. The project was funded by GRDC with New South Wales Department of Primary Industries and the Irrigated Cropping Forum and trialled 96 cultivars in a high input irrigation system from 2007 to 2010.

The best varieties in terms of yield and lodging resistance under full irrigation were Chara$^{\Phi}$ at 8.7t/ha and 3.1 lodging and Yenda$^{\Phi}$ at 8.7t/ha and 2.3 lodging (rated from 1-9 where 1 is no lodging and 9 is fully lodged and plants are flat to the ground).

Other solid performers in the trial included Scout$^{\Phi}$ at 8.7t/ha but with a lodging rating of 4.5. Derrimut$^{\Phi}$ and Merinda$^{\Phi}$ yielded 1 percent lower than Chara with lodging scores of 4.3 and 3.7 respectively. The full results of this trial are available in a spreadsheet for growers to assess performance of each variety (see Useful Resources).

CSIRO research: Early sowing benefits

NEW CSIRO research has found that sowing slow-maturing varieties earlier – allowing more time for root establishment and biomass growth – could be the key to unlocking higher irrigation yields.

CSIRO partnered with FarmLink, Southern Farming Systems and NSW DPI, with funding from the GRDC, to test how slow-maturing, milling quality spring wheats sown early into stored soil water yielded in comparison to mid-fast varieties sown in the usual sowing window.

Overall, the trial found that very slow or slow maturing wheat varieties sown in mid to late April averaged an extra 0.8 tonnes per hectare more than mid to fast varieties sown in mid-May.

While it was a dryland trial, the principles of achieving the extra yield can be applied to irrigation. This is because growers can choose when to water or pre-irrigate for sowing to allow the right variety to be chosen for the season, without relying on an autumn break.

The reasons for the yield increase were:

- Early-sown crops are higher yielding because, when the soil profile fills with water, their roots grow deeper and use more moisture.
- Canopy development is faster in early-sown crops so less soil moisture is lost to evaporation, instead it is converted to dry matter more efficiently.
- Early-sown, slow-maturing spring varieties have a longer stem elongation phase which means they intercept more radiation and grow more during this period, increasing grain number and yield.

While irrigators might normally sow in May, they may be able to pre-irrigate or 'water-up' to establish varieties like Bolac$^{\Phi}$ or Lancer$^{\Phi}$, with a lower plant population at the end of April, even though temperatures are warmer than May. This will take advantage of a longer growing season to make a higher grain number, and hence yield.

Three key points that growers need to keep in mind if they are going to sow early include:

- **Variety choice.** Choose the correct variety, pick a mid-slow spring variety with good straw strength, such as Bolac or Lancer.
- **Canopy management.** Get the plant population right to avoid any canopy management problems later in the season. For a crop sown in mid-April, that may be 65-80 plants/m^2 but in May would be 160 plants/m^2.
- **Crop nutrition and irrigation.** Use appropriate nitrogen and irrigation management for the crop.

Growers need to protect the crop at head emergence and into flowering by pushing the first irrigation period forward, compared with when they would normally irrigate (see Figure 1 below). In very dry springs, the crop may need an irrigation between the first node stage and head emergence. In some seasons, a third irrigation in spring may be required.

Figure 1. Irrigated wheat management practices by growth stage

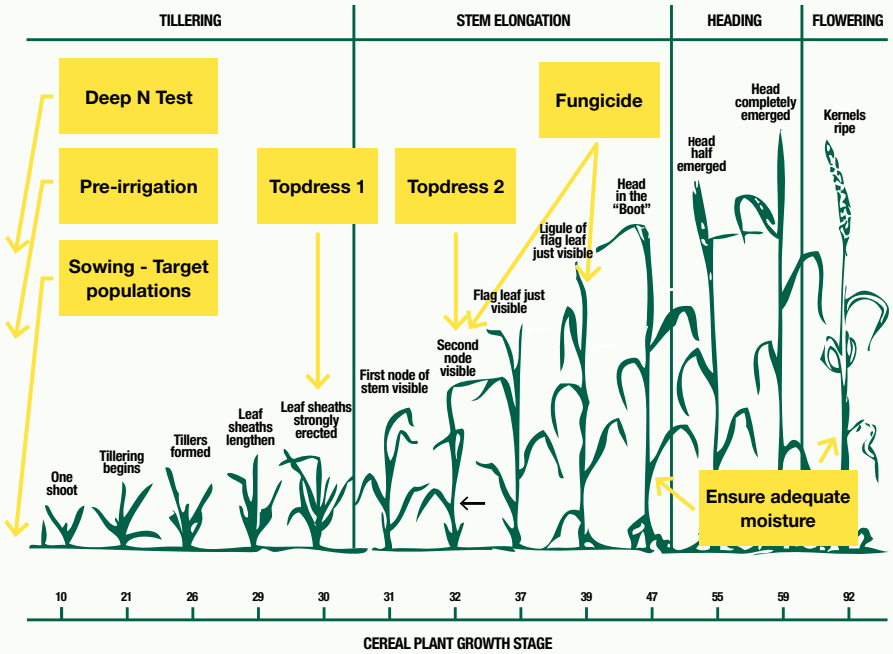


Figure 1: *If sowing early, it is vital the crop is not moisture stressed at head emergence or during the first 10 days after flowering – these are the critical stages for determining grain number and size. Other key management practices include timing of nitrogen application.*

Source of management practice information: Rob Fisher, ICC

Variety selection must also consider quality and disease resistance traits and a grain grower's ability to manage these risks on-farm.

Key 8t checks

- Choose paddocks with moderate to good soil structure.
- In southern NSW/northern Victoria, sow mid-season maturity varieties in late April to early May to target flowering in late September.
- Aim for 120-180 plants/m^2 at plant emergence stage which, depending on soil type, requires a sowing rate of 80-110 kg/ha – a higher rate for heavy soils and a lower rate for lighter soils.

Nitrogen management

If growers are targeting an 8t/ha crop with 11.5 per cent protein, then a total N supply of 320 kilograms of nitrogen per hectare is required. If there is little mineral nitrogen in the soil and in-crop mineralisation is as little as 60-80kg/ha, there is a large requirement for fertiliser N. These amounts should not all be applied at sowing otherwise the crop will develop a huge canopy and be more prone to lodging and leaf disease.

PHOTO: DAMIAN JONES

The rate and timing of nitrogen application strongly influences grain protein. Applying nitrogen at the growth stage when awns are visible gives a higher protein level than when it is applied at early tillering or stem elongation.

To avoid this, limit nitrogen at sowing and top dress later. Target sowing nitrogen supply – including what is already in the soil and what is being applied – at 100-120kg N/ha. Use a deep soil N test to determine soil supply, conducted as close to sowing as possible.

The late tillering to first node stage is important in deciding whether the crop will be managed for 8t or 5t yield potential. Shoot numbers must be counted to determine nitrogen topdressing rates. CSIRO and NSW DPI recommend two N topdressings, with application timing dependent on crop shoot numbers (see checklist).

The rate and timing of nitrogen applications strongly influences grain protein. NSW DPI research has found that applying nitrogen at the growth stage when awns are visible gives a higher grain protein level than when nitrogen is applied at early tillering or stem elongation. The head emergence stage that occurs after awns are visible is the time for the second nitrogen topdressing which gives yield and protein benefits.

The nitrogen requirements for plants at 320kg N/ha can be considered as an equation – N in soil, the amount of N mineralised during the season, N added at sowing, then two or three N topdressings during the season, depending on yield target. This is an estimate of the minimum – it may not be completely accurate or take into account impacts on soil carbon, but it will serve as a guide.

Key 8t checks

- **Pre-sowing/sowing:**
  - Measure nitrogen down to a depth of 60cm. Do not chose paddocks with more than 120kg N/ha because, even in an average rainfall season, there is a higher risk of excessive growth and lodging.
  - At or before sowing, apply nitrogen if necessary so that total soil and fertiliser nitrogen is 100-120kg N/ha.
  - Apply 4kg of phosphorus for each tonne of target yield, banded near the seed. The 4 kg P/t rule applies to May-sown crops and can be cut back by 10-20 percent for April-sown crops. An 8t target means 32kg P/ha which could be 160kg DAP/ha or 145kg MAP/ha. However, these rates can affect seedling germination particularly with disc seeders and wider row spacings.
- **Tillering:**
  - If there is an obvious N deficiency before first node development stage, topdress with 30-45kg N/ha at mid-tillering.
- **Stem elongation:**
  - The rate of nitrogen topdressing between first and second node stages depends on shoot number – the target is 500-800 shoots/m^2 for an 8t/ha yield.
    - Shoots at 750-800/m^2 – no need to topdress.
    - Shoots below 750/m^2 – topdress at 30-45kg N/ha
    - Shoots below 400-500/m^2 – achieving 8t yield is limited and usually 500/m^2 or more is needed to guarantee more than 8t.
    - Shoots above 800/m^2 – the crop is too thick and there are increased lodging and disease risks. At this point, growers still need to ensure crops are not deficient and in some cases, a growth regulator may be appropriate.
- **Head emergence:**
  - Topdress 60-90kg N/ha (125-188kg urea/ha) between booting to head emergence and water fertiliser in if the crop is on track for 8t/ha.

Disease and weed management

One of the key risk factors in irrigated wheat not yielding 8t is disease, particularly foliar diseases, such as *Septoria tritici* blotch, stripe rust and yellow leaf spot. Regularly monitor crops for disease and apply foliar fungicides as required.

Monitor weed germination and density, particularly during the first six weeks. Reducing weed competition early will result in more moisture for crop use, and higher yields. Use a pre-emergent herbicide rather than spraying after the crop has tillered.

Key 8t checks

- Use a paddock which had a break crop or non-grass pastures in the previous season to minimise disease risk.
- Control weeds pre- and post-sowing to avoid yield loss.
- Maintain three green leaves per shoot at flowering from nitrogen topdressing.
- Seed treatments and foliar fungicides for stripe rust and other diseases.

Grain number key yield influence

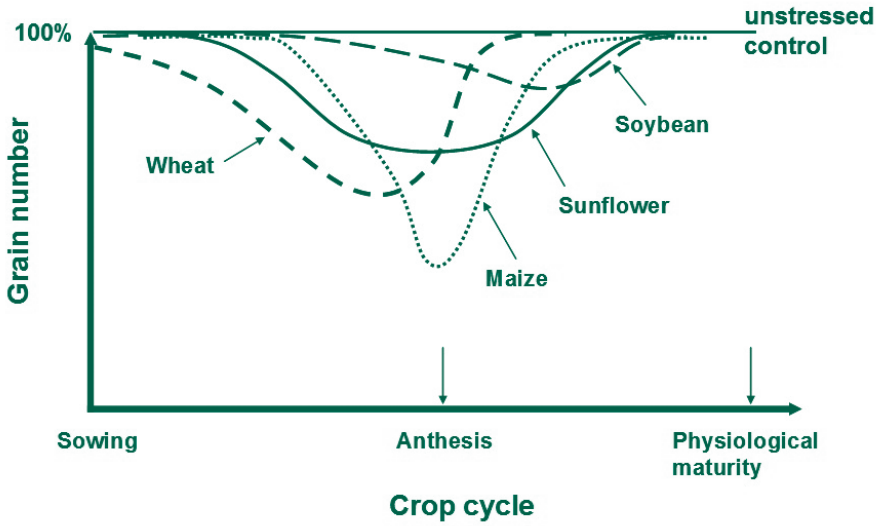
While there is a huge focus on managing crops through grain fill to maximise yield, crop yield is more a function of grain number than grain size.

A plant's grain number is defined during stem elongation at GS31 and the period either side of anthesis – from about 25 days before flowering to about 10 days post-flowering (see figure 2).

Crop stress during this period could limit the number of heads, the number of grains per head and the accumulation of carbohydrate reserves in the plant. Stress could include disease, nitrogen deficiency or lack of moisture. This is managed through variety choice, foliar disease control, nitrogen and timely irrigations. Use of fungicides for plant health is vital.

Source: SARDI Crop Ecophysiologist Victor Sadras.

Figure 2. Critical windows of stress vulnerability



Calviño PA, Monzon JP (2009) Farming systems of Argentina: yield constraints and risk management. In: Sadras VO, Calderini DF (eds) Crop physiology: applications for genetic improvement and agronomy. Academic Press, San Diego, pp 55-70

Figure 2: *The period either side of anthesis (flowering) – from about 25 days before flowering, during stem elongation at growth stage 31, to about 10 days post-flowering – can affect grain set by a wheat plant.*

PHOTO: DAMIAN JONES

Lodging is more likely in irrigated wheat if soils are saturated during irrigation and there is excessive vegetative growth during winter and spring.

Canopy management

Excessive vegetative growth during winter and spring combined with soils that are saturated during irrigation will make lodging more likely. It reduces root depth and the anchoring strength of plants, particularly at high densities.

Lodging can reduce yield by 30 per cent through high screenings, low test weight, increased risk of weather damage and a slower harvest. Some varieties are more prone to lodging than others and growers should consult variety guides for lodging ratings.

Key 8t checks

- Avoid shoot numbers at GS30 exceeding 800/m^2, otherwise the risk of lodging increases.
- Use varieties with a lodging rating ranked closer to 1 than 9.

Irrigation application

Crops with an 8t/ha yield potential have more biomass and use more soil water than those with a 5t/ha yield potential. A short period of moisture stress without good rainfall in a potentially high-yielding crop will cause a large reduction in potential.

Depending on the amount of rain in late autumn and winter, growers may choose to pre-water before sowing or water-up after sowing so crops are not stressed during winter.

If a wet winter is forecast, the best pre-watering timing is February or early autumn to enable the topsoil to dry out, reducing waterlogging risks. If a wet winter is not predicted well-drained paddocks can be pre-watered or watered-up until mid-April. Heavy, flat paddocks are pre-irrigated in mid to late March while well-drained paddocks are pre-irrigated from late March to late April, matched to variety sowing time. Late watering can be risky if a large season break causes waterlogging and delays sowing.

Waterlogging can be avoided by using an irrigation layout in which water application and drainage occurs in less than 12 hours. This could include beds, steeper border check layouts, terraced bankless channels or spray irrigation. Waterlogging can cause nitrogen deficiency, lack of tillering, poor grain fill and lower grain weight.

Plant growth is rapid and water use high during stem elongation so it is more important to maintain good soil moisture between elongation and the mid dough stage than at the tillering growth stage. The most critical moisture stress stages are head emergence and the first 10 days after flowering, when grains are enlarging and forming that determines grain size.

Key 8t checks

- Use a layout which allows irrigation and drainage in less than 12 hours.
- Avoid moisture stress in the first 10 days after flowering because it can reduce grain size.
- Soil moisture needs to be 50 percent or more from stem elongation to mid-dough stage. Make regular checks down to 60cm using a soil moisture monitoring device. Once below 50 percent, plants may not be able to extract soil water fast enough resulting in reduced growth.
- Ensure there is a minimum of 50 percent available soil moisture at sowing to a depth of at least 60cm. This will avoid moisture stress in dry winters and provide a longer window before the crop needs its first spring watering.
- Budget for two to three spring irrigations – at head emergence, post-flowering, and the early milk stage (which ensures moisture to fill grain) up to mid-dough stage.

Best management practice checklist

The steps throughout the season to achieve 8t/ha irrigated wheat yields include:

☑ **Pre-sowing:**
- Monitor the crop and keep records for the entire season so if 8t is not achieved, you will know why and what to improve next time.
- Consider the end market – what are the likely returns and costs?
- Choose a paddock with a break crop or non-grass pasture in the previous season.
- Pick a well-supplied and drained irrigation paddock that can achieve water on and off in less than 12 hours.
- Select a paddock with low risk of root disease, either because a break crop grew in the previous year, or because a Predicta B test shows low pathogen levels.
- Do a fertiliser and deep nitrogen test. Avoid paddocks with high nitrogen (over 120kg N/ha).
- Pre-irrigate by the middle of April.
- Use pre-emergent herbicides to control weeds before sowing.

☑ **Sowing:**
- If a mid-season variety has been selected, sow in the first week of May. Aim for 120-180 plants per square metre.
- At or before sowing, apply nitrogen so that total soil and fertiliser nitrogen is 100-120 kg N/ha.
- Fertilise with 4kg of phosphorus for each tonne of target yield.

☑ **Post-sowing:**
- Control weeds pre- and post-sowing to avoid yield loss.

☑ **Tillering:**
- Aim at 4-6 tillers per plant through use of nitrogen top dressing, or about 500-800 shoots/m^2.
- Time nitrogen application and rate to promote healthy tiller growth with the aim of producing 500-600 heads/m^2. This could be increased with use growth regulators.

☑ **Late tillering:**
- Decide whether to manage for 8t or 5t by assessing wheat price, irrigation allocation, and crop health.
- Check crops for the following diseases, use a fungicide if necessary – Septoria tritici blotch, leaf, stripe and stem rust, and yellow leaf spot.

☑ **Stem elongation:**
- Apply a second nitrogen topdressing of 60-90kg N/ha (125-188kg urea/ha) between booting and head emergence and water-in the fertiliser.
- Time the first irrigation before flowering. Manage irrigations to maintain 50 percent soil moisture from stem elongation to the mid dough stage, budgeting two to three spring irrigations.

☑ **Flowering:**
- Maintain three green leaves per shoot at flowering using foliar fungicide sprays for stripe rust and other diseases.

☑ **Grain fill:**
- Plan the last irrigation at the early milk stage to allow good grain fill up to the mid dough stage.

**Source: NSW DPI and Irrigated Cropping Council*

PHOTO: DEANNA LUSH

Avoid waterlogging by using a layout which allows irrigation and drainage in less than 12 hours, such as terraced bays (pictured) with bankless channels, steeper border check layouts and spray irrigation.

PHOTO: DAMIAN JONES

Trial results have shown a narrower row spacing, such as 17.5 centimetres (above), can give higher yields in irrigated wheat than wider row spacings.

FREQUENTLY ASKED QUESTIONS

Is row spacing important to irrigated crop production?
Trial results have shown narrower row spacing gives higher yields. There is a trade-off between narrower rows and wider rows for easier stubble retention.

Why is soil testing vital in irrigated environments?
The level of soil mineral N is extremely sensitive to moisture. In wet or irrigated environments, denitrification – the conversion by soil microbes of nitrate in the soil to nitrogen gases, including nitrous oxide (N_2O), nitric oxide (NO) and di-nitrogen (N_2) – can mean more soil N is lost to the environment than crops remove from the soil. With these fluctuations in soil N, combined with the amount that the crop removes, soil tests are vital to ascertain N needed to produce an 8t crop.

While a sampling depth of 60cm is optimum for most paddocks, the results need to be interpreted cautiously. Soil with no physical or chemical limitations, for example acidity, salinity or high boron content, will allow crops to grow roots down to about 1.5 metres and take up nitrate from the whole profile.

A poor pasture or late sown, badly diseased or failed crop will leave some nitrate in the soil because of poor uptake. After rain or irrigation, this can leach into the subsoil and form a 'bulge' of nitrate, some of which may be below the normal sampling depth of 60cm.

USEFUL RESOURCES

Winter Cereals 2007-10 Irrigated Trials Results spreadsheet
GRDC, NSW DPI and Irrigated Cropping Forum
Available by contacting Andrew Milgate

Water use efficiency of grain crops in Australia: principles, benchmarks and management
GRDC Bookshop (GRDC660)
Free phone: 1800 11 00 44
Email: ground-cover-direct@canprint.com.au

The best varieties for high yields under irrigation
IREC Farmers' Newsletter, No 185 Spring 2011
www.irec.org.au (Search cereal zoo)

Economic returns from high and low input irrigated wheat
IREC Farmers' Newsletter, No 184, Autumn 2011
www.irec.org.au (Search irrigated wheat returns)

Nitrogen in irrigated wheat
IREC Farmers' Newsletter, No 181, Spring 2009
www.irec.org.au (Search nitrogen in wheat)

Checking is essential for 8t/ha of wheat
IREC Farmers' Newsletter, No 172, Autumn 2006
www.irec.org.au (Search checking is essential)

MORE INFORMATION

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