Wheat Variety Evaluation for Irrigation in the Southern Region

Summary
Varieties and management factors were evaluated as strategies to avoid lodging and poor grain quality in high-yielding, irrigated wheat. Trials were conducted on research stations and farms, and included nitrogen (N) test strips at commercial scales in 10 to 18 Chara\textsuperscript{0} wheat paddocks a year across the Lachlan, Murrumbidgee and Murray Valley regions. Sowing rate, plant growth regulators (PGRs), N timing and quantity were the management factors. Lodging risk assessment included measuring plant strength in the field and assessment of plant characteristics. Grain quality was assessed through standard grain and dough testing across varieties and management treatments.

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Conclusions

General

Lodging was a major factor affecting high target yields and returns. Stem and anchoring strengths were found to be important for reducing lodging risks and consistently achieving yields above 8t/ha, but heavily dependent on genotype, environment and management (G,E&M). Avoiding lodging produced more grain/mL of irrigation water with returns/mL usually better than summer crops.

Varieties

Choice of variety was found to be the most important factor to achieving high yields in existing farming systems because available management options, such as growth regulators, did not guarantee prevention of lodging.

Growing conditions under irrigation seem conducive to late maturity alpha-amylase (LMA) development and resulting low falling number (FN). This, surprisingly, appears not to affect Chara dough quality.

Varieties suitable to achieving consistently 8t/ha under irrigation with efficient use of resources were identified as needing a combination of the following traits, mainly associated with yield being the main driver of returns: stem strength (e.g. Chara), high sink strength (e.g. H45), high harvest index, restricted tillering capacity (e.g. H45), early maturity (e.g. H45; high harvest index), big kernels (e.g. Arrivato; yield advantage and reducing risk of screenings), and not susceptible for LMA and black point (BP). Once yield is secured, grain quality characteristics can deliver premiums.

In variety evaluation for high-yielding wheat under irrigation, the project demonstrated the difference between the use of six, eight and 10-row plots. Lodging occurrence has less impact on yields of six-row plots, especially when harvesting the whole plot under wide inter-plot paths sown in eight-row plot spacings.

Management

The project demonstrated that management was an effective way of achieving higher yields under irrigation. Delaying canopy closure by using lower sowing rates and restricting early growth, and tillering by late N topdressing, improved stem strength. Higher available N meant weaker stem strength. Soil management was confirmed to be important for achieving the best anchorage of plants through strength and number of roots.

It was also demonstrated on one of the on-farm trial paddocks that improving flood irrigation method can markedly affect irrigation water use efficiency (WUE), increasing it from 50% to 78% by doubling flow rate.

Recommendations

A variety with better straw strength than most, Chara needs to be selected under irrigated conditions and appropriate
management. A targeted breeding program is recommended to obtain such a variety. Links with breeding for the high rainfall zone (HRZ) are also recommended.

Management factors to build a crop structure for achieving high yields with expected quality include:
1) Soil conditions allowing good anchorage for roots.
2) Variety with stem and straw strength.
3) Sowing after Anzac Day.
4) Flowering in the last week of September.
5) Restricting tillering to attain 600 to 800 shoots/sqm.
6) Limited early growth with less than 70% ground cover at early stem elongation.
7) Avoiding water stress during stem elongation to maintain highest yield potential.
8) More than three green leaves per shoot at flowering to maintain the highest yield potential.

Outcomes
1) A more efficient method of variety evaluation for high-yielding wheat crops under irrigation.
2) Increased irrigated wheat yields and sowings through improved varieties and associated crop husbandry.
3) More efficient use of irrigation water by high-yielding wheat and reduced groundwater recharge and salinity with early sowing.
4) A strong, active network of producers, researchers, advisers, breeders and millers concerned with high-yielding wheat in irrigation and high-rainfall areas of the southern region.

Achievements/Benefits
Varieties and management factors were evaluated to avoid lodging and poor grain quality in high-yielding irrigated wheat. Lodging is a major factor for not achieving high target yields and returns. Lodging and disease-protected H45 yielded 9.6 t/ha compared with 6 t/ha for control, with protein from 11.2-11.4%, but screenings from 2.3-6.9%, FN from 453-384 seconds, and test weight from 83-78 kg/HL.

Stem and anchoring strengths are important for reducing lodging and consistently achieving yields above 8 t/ha. Delayed canopy closure by using a lower sowing rate and restricting early growth and tillering, with late N topdressing, improves stem strength. Soil management is important for achieving the best anchorage of plants through the strength and number of roots. Growing conditions under irrigation appears conducive to LMA development and the resulting low FN.

Chara, the variety most suited to irrigation and the chosen standard in this project, is affected by LMA, but dough testing showed this does not affect dough quality when protein content is correct. Generally FN was higher and more stable for more and later N applications.

Varieties suitable to achieving 8 t/ha consistently under irrigation with efficient use of resources were identified as needing a combination of the following traits, mainly associated with yield being the driver of returns: stem strength (e.g. Chara); high sink strength (e.g. H45); restricted tillering capacity (e.g. H45); early maturity (e.g. H45, result in highest harvest index); big kernels (e.g. Arrivato (durum), yield advantage and reducing risk of screenings); not susceptible for LMA and black point (BP).

Once yield is secured, grain quality characteristics can deliver premiums.

In variety and breeding line evaluation for high yielding wheat under irrigation, the project demonstrated that lodging occurrence has less impact on yields of six-row plots, especially when harvesting the whole plot under wide inter-plot paths from eight-row plot spacings. For example, hybrids in trials were performing at average compared to well above average in New South Wales Department of Primary Industries (NSW DPI) evaluations.

On-farm trials on a commercial scale were conducted during the three seasons at 10 to 18 farms across the Lachlan, Murrumbridgee and Murray Valley regions. Bay-length N test strips were created by collaborating growers during fertiliser applications, e.g. splitting pre-sowing strips with different topdressings to achieve similar total nitrogen (TN) fertiliser
applications at different timings. Strip yields were up to 9.4t/ha (2002), 8t/ha (2003) and 9.3t/ha (2004) with gross margins well above $1000/ha for good paddocks. Paddock records were kept to aid analysis. It was also demonstrated on one of the on-farm trial paddocks that improving flood irrigation methods can markedly affect irrigation WUE, increasing it from 50% to 78% by doubling flow rate.

Other N top-dressing trials were conducted with Chara and Arrivato at the Griffith site to evaluate impact of timing on yield and protein content. Topdressing as late as decimal code (DC) 32 could lift yields by more than 1t/ha. Later applications of 75kg/urea/ha produced yield differences between -0.5t/ha to +0.5t/ha with the protein response between 0.5-16%, but generally remained below 12% for yields above 8t/ha. Results of all N trials and treatments make available TN uptake, protein and fertiliser efficiencies in relation to application amounts, timing, and irrigation management. That information, together with grain and dough testing results from the Agricultural Research Institute (ARI), Wagga Wagga, NSW, will help in deriving management guidelines linking yield, protein and grain quality with N management for varieties and quality grades.

Trial results from two seasons with three varieties showed low sowing rates of 35kg/ha yielding the best in a season affected by lodging and nearly as good (above 8t/ha) in a season less affected. A trend to higher commercial sowing rates, above the recommended 100kg/ha, appears not warranted and may associate the wrong cause to the effect of having low yields. Sowing rates could be lowered from the recommended rates when using good seed (more than 80% emergence) in a good seedbed with low weed pressure, especially under high to medium fertility conditions and early sowing where tillering would raise shoot numbers above 800/sqm.

The 2004 PCR results add to the complexity of their use. No single or combined product treatment was found, with either single or multiple applications, that showed consistent results across varieties and seasons. The most recent product released overseas seems to create nil, or negative, results when plants experience stress during or following applications, e.g. frost or water stress. Three varieties with different genetic backgrounds were used, showing increased yields between 0.6-1.1t/ha in one season, but +0.1 to -0.5 t/ha for the same treatment in another season. The dependency of results on variety and seasonal factors appears to make the use of PGRs unwarranted.

Durum varieties Arrivato and Bellaroi appear well suited to the high yielding irrigation environment because they yielded well. Late topdressing of N was evaluated on Arrivato at Griffith (on-farm test strips) and demonstrated the difficulty in reaching required quality at 8t/ha or more. Quality tests by the national durum quality laboratory at Tamworth will give more information about the prospects of high yielding durum production under irrigation with N management strategies.

Dough quality tests at ARI for Chara samples with a range of FN 150-500, selected from various project experiments and trial sites, showed big variations between and within neighbouring trials. Milling Chara samples with LMA was not effective in removing the alpha-amylase, and FN remained low in the flour. But LMA did not appear to have any detrimental effect on the quality parameters measured on Chara with appropriate protein. Only weather damaged samples had quality defects. Given these results, careful thought needs to be given to LMA testing because of the extreme variability between trial replicates and treatments.

Interaction with wheat growers in both irrigation and high rainfall areas was achieved through the presentation of project derived variety evaluations and management guidelines at eight GRDC Updates in the Southern Region and one in the Northern Region. An active network of researchers, breeders, advisers and producers was established in the Southern Region through the Project Steering Committee. This was facilitated by providing regular reports in Irrigated Cropping Forum (ICF) newsletters and GRDC communications, and by holding up to 26 pre-season meetings - workshops, paddock walks and field days in each year of the project. A booklet summarising the key findings of the project, describing factors contributing to high wheat yields under irrigation, is scheduled to be released before the 2006 growing season.

Other research

N availability affects straw strength and leads to profound lodging when using fertiliser to gain yield. To avoid this, the project evaluated irrigated wheat under biological agriculture as an alternative management strategy. Biological agriculture is a low-input management system which minimises freely available N by maximising the effectiveness of soil biota, including N fixers, phosphorus (P) releases and balancing soil nutrients. The approach led to increased stem strength and much lower lodging for similar yields. It was found to be a general phenomenon, e.g. lucerne crops grown under such conditions showed solid stems. Herbicide use (especially pre-sown) and fertiliser choice - sulphate of ammonium, rather than anhydrous, and amounts, less then 100kg/ha product, are important to avoid negative impacts on this fine balance in soil biota and mineral
availability. A rating for impact on the soil-food web is required to guide choice, frequency and quantities of herbicides and fertilisers used.

The above is not only for biological farming, but also to protect and not worsen soil biology in existing farming systems. Relevance of soil biology research outcomes to practice could depend on such factors. However, they are ignored. Varieties need evaluation under such conditions to maximise effectiveness of the good soil microbiota preventing diseases. This is also relevant for the organic industry because Australia does not meet organic grain demand.

Potential benefits of biological agriculture worthy of further study:

1) Quantify the soil biota/organic matter (OM), disease and weed status influenced by management practices and expressed in yield, quality, improved soil parameters (e.g. reclaim salinity) and reduced fertiliser and chemical inputs.

2) Quantify systems in paired sites (same soil and climate) across existing organic, biodynamic and biological farming paradigms to obtain a range of parameters for health of soil. An important output would be state-of-the-art diagnostic tools for commercial use and areas of research to elucidate and solve specific problems identified. Adaptive research is important in any agriculture to help transport solutions and opportunities across the landscape, but this requires a big picture, systematic approach, rather than trying to explain how it works because there are too many interactions in the complex farming system that will remain hard to quantify.

3) Identify outcomes to guide and encourage growers to make changes to pursue sustainable agriculture with the least impact on the environment - producing mineral-dense (grain) food for healthy people.

4) Generate resource efficient, high yielding wheat varieties because it is important to be working across the breeding/selection/variety release/agronomy/farm adoption scales. Genotypes need to be selected as best performing under low and high-yielding conditions, reflecting seasonal variability in the HRZ. Therefore, genotype evaluation early in the breeding program, under side-by-side full-irrigation and limited water treatments, will allow determination of sensitivities in yield and quality to lodging, screenings, test weight, FN and BP. Such an approach needs to be part of multi-site evaluation and connected with a National Variety Trial (NVT). It could include an International Maize and Wheat Improvement Centre (CIMMYT) and GRDC spring wheat nursery evaluation, presently conducted in Queensland (Qld) for local breeders to obtain firsthand knowledge of performance of CIMMYT lines within the southern region wheatbelt environment.

Additional information

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