Winter cereals for tropical Australia

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Abstract
There is significant scope to grow irrigated winter cereals in tropical Australia. Grain grown in tropical Australia provides a valuable local feed source during poor grazing periods. It can also facilitate beef cattle finishing as well as supplementary feeding of dairy cattle, plus feeding of intensive livestock and poultry. Northern Queensland has large areas of suitable soils often co-located with potential irrigation sources. Wheat in particular is already widely cultivated in tropical areas outside of Australia, producing germplasm which could potentially be adapted for use in the Australian tropics.

Field trials were conducted with winter cereals wheat, triticale, barley and oats in northern inland and coastal Queensland. Trials were grown on a wide range of soils to determine suitability, optimum sowing times as well as to monitor pests and diseases. Results indicated that hexaploid wheat, triticale and forage oats can be successfully grown. However, barley and durum would require improved disease resistance.

A range of wheats were tested at 7 sites. Genotypes requiring vernalisation or with a longer crop cycle duration were found to be less suitable than shorter duration lines. Wheats from the International Maize and Wheat Improvement Centre (CIMMYT) were among the highest yielding and exhibited superior yields compared to cultivars adapted to sub-tropical southern Queensland. One genotype has since been released as the variety Buchanan and is being successfully grown in north Queensland.

Thus, wheat could fit well into rotations with, maize, soybean, forage and grain sorghum, plus spring sown sugar cane.

Keywords
Tropics, wheat, barley, oats, triticale

Introduction
A strong feed grain market exists in tropical northern Australia with feed mills already established at Atherton and Mareeba in Queensland. Increased grain availability would allow additional locations for new feed mills in towns with existing hay markets, such as Charters Towers in Queensland. Selection of high yielding adapted cereals and optimisation of agronomic practices would reduce production costs and augment expansion of the feed grain industry through lower costs and improved availability of raw material.

There has been interest in adapting summer cereals including sorghum and maize to cultivation during the wet months in tropical Australia (CRC-NA 2020). There has been less focus on production of winter cereals during the dryer season when irrigation is more important. However, where irrigation water is co-located with suitable soils in north Queensland, a small number of growers are currently achieving high yields of wheat. These producers can receive a considerable premium above prices in central and southern Queensland; that is equivalent to a large proportion of the costs of transporting grain from central Queensland (often > $100 per tonne; Collis 2017).

Wheat (*Triticum aestivium* L.) is one of the most widely adapted cereal crops in the world, being cultivated from latitudes near the arctic circle to the equatorial tropics and at a wide range of altitudes.

There is a significant international breeding effort for wheat for the tropics already underway producing breeding lines that could be tested in northern Australia (Byerlee and Dublin 2009). Other winter cereals including durum wheat (*Triticum turgidum* ssp *durum*), barley (*Hodreum vulgare*), oats (*Avena sativa*) and triticale (× *Triticosecale*) may also have potential for use in tropical Australia.

The aim of this study was to test multiple genotypes of a range of winter cereals in field trials in northern inland and coastal Queensland on a wide range of soils to determine potential tropical adaptation, optimum sowing times as well as to identify potential tropical pests and diseases.

Methods

Identification of suitable phenology and sowing dates

In 2008, 35 bread wheat, durum and barley varieties were sown in 2 rep yield trials on 2 separate sowing dates at both Kairi (Atherton Tablelands) and Ayr. Phenology trials were also sown at Bundaberg, Mackay and Kairi, consisting of 38 varieties sown on up to 7 planting dates. Using these preliminary findings, genotypes and sites were chosen for subsequent trials.

Yield trials

Prior to trials in 2009, Australian breeding companies and research institutions were asked to nominate entries for the yield trials in tropical Queensland. These included Australian Grain Technologies (AGT), InterGrain, Longreach and HRZ as well as CSIRO Plant Industry, Barley Breeding Australia, and University of New England (Triticales). Forage oats for observation plots were provided by the Department of Agriculture and Fisheries Queensland (DAFQ). All wheat varieties listed in the DAFQ and GRDC publication "Wheat Varieties for Queensland 2009" were also included. In addition, wheat introductions from CIMMYT that had shown promise in trials in southern Queensland were included. In the period from late April to early May of 2009, 55 longer maturity cereal lines were sown in 2 rep yield trials at sites near Longreach, Sesbania (between Corfield and Richmond), Pentland (100km west Charters Towers), Atherton, Home Hill, Mackay and Childers in Queensland. Two weeks later 200 faster maturing ("main season") cereal lines were sown in 2 rep yield trials at the same locations. In addition, a further 420 CIMMYT wheats and controls were sown in 2 rep yield trials at Atherton and Home Hill. The 2009 season was very dry; there was close to zero rainfall between sowing and harvest and growers irrigated the trials as they determined necessary. Flowering dates of each genotype at each site were recorded. All trials were successfully harvested and grain transported to Toowoomba for grain quality assessment.

Results

Short to mid duration and early planting were most adaptive

Trials in 2008 clearly demonstrated that cereal genotypes with a vernalisation requirement (eg bread wheat cultivar Wylah) or very long maturity (eg Sunzell) were not well adapted at the northern trial sites. Trends in yield for various flowering dates in 2009 suggested that varieties with short to medium periods from sowing to flowering were associated with highest yields at 4 of the 5 sites (Figure 1a). Observations of both flowering and maturity dates in phenology trials demonstrated that the length of the grain filling period was dramatically reduced by late sowing. Hence yield potential from late sowing is likely to be low. The low frost risk in northern areas would allow considerably earlier sowing dates than those used in southern Queensland. Sowing as soon as soil temperatures drop low enough to allow establishment of winter cereals are suggested such as dates in April and early May.

Some pests and diseases were common to other cropping regions while some were not

Many common diseases of cereals in cropping regions south of the tropics were identified. However, diseases not commonly reported in more southerly areas were also observed. This indicated that breeding for these more tropical diseases may be required when adapting certain winter cereals to northern Australia.

Disease symptoms observed for bread wheat and durum wheat were consistent with pathogens including spot blotch (*Cochliobolus sativus*), yellow spot (also known as tan spot, *Pyrenophora tritici-repentis*), head scab (Fusarium head blight, *Fusarium graminearum*) and crown rot (at Sesbania only, *Fusarium pseudograminearum*). For barley, spot blotch, net blotch (*Pyrenophora teres*) and leaf rust (*Puccinia hordei*) were observed while in oats crown rust and leaf rust (*Puccinia coronata var. avenae*) were recorded. Genetic variation for resistances to all of these diseases was observed.

Most CIMMYT wheats demonstrated strong resistances to spot blotch and yellow spot. Varieties with good disease resistance to the observed diseases were identified for wheat, triticale and forage oats. This suggests that selection of multiple disease resistant germplasm could provide suitably adapted varieties of these species. In contrast, all barley lines tested were susceptible to at least one of the observed diseases. This suggests that this species may require improved disease resistance.

Winter cereals may provide a useful break crop for nematodes in some rotations

Some parasitic nematode numbers declined where winter cereals were grown. The cereal trials and surrounding wheat crop followed peanuts and preceded maize at Atherton, followed maize and preceded sorghum at Home Hill, followed sugar cane and preceded soybean at Mackay while they followed soybean and preceded cane at Childers. The cereal trials were grown on a potato farm at Pentland. From soil core samples taken at sowing and at harvest at each yield trial site, types and numbers of soil parasitic nematodes were determined. Numbers of parasitic nematodes declined at each site and of significance was the decline of *Meloidogyne* sp left after peanuts at Atherton and the decline of *Pratylenchus zea* left after maize at Home Hill. Thus, by potentially providing a break crop for some nematodes, winter cereals could fit well into rotations with peanuts, maize, soybean, potatoes, spring sown sugar cane, plus forage and grain sorghum. Winter cereals would be difficult to fit into sugar cane rotations where cane is planted in March but systems where cane is sown in spring a rotation of soybean followed by quick maturing winter cereal preceding spring planting of cane could be worthy of investigation.

CIMMYT lines ranked high for yield

Analysis of 2009 yield results clearly demonstrated that simply growing wheat varieties in the tropics that are introduced from sub-tropical southern Queensland or elsewhere in Australia would likely result in sub-optimal performance. Cultivars adapted to Australian regions outside of the tropics were generally ranked in the bottom 25% of lines for most, if not all trials. As examples of this Baxter and Sunvale are indicated in yield data for 2009 at Pentland (Figure 1b). Lines consistently ranked in the top 25% at all 5 trials were almost all either breeding lines or cultivars introduced from CIMMYT but not previously used in Australia. The outstanding performance of CIMMYT germplasm relative to Australian wheat varieties could be a consequence of selection in the Sonora desert of Mexico where temperatures during the growing season are higher than at selection sites in most Australian breeding programs. Heat tolerance is likely to be an essential adaptation for winter cereals in the tropical north. One wheat genotype that was consistently ranked in the top 25% of lines (and in the top 10% for 3 of the 5 trials) has been named “Buchanan” and released as a commercial variety since these trials were conducted (Figure 1b). Buchanan is being successfully grown by a small number of producers in northern Queensland (Collis 2017).

The best performing flour milling wheats also included CIMMYT-derived genotypes. The highest yielding milling wheats included Rees, Kennedy, Espada, Ventura, Sunstate and Hartog which all ranked in the middle 50% for yield in the main season trials. This suggests that export grade milling wheats could be produced in the region but selection for heat tolerance and resistance to tropical diseases would be required for optimal performance.

Some triticale genotypes were outstanding in both early and main season trials. Further investigation of feed quality of the triticales would be warranted.

Performance of barley genotypes was quite variable. Leaf diseases severely affected some genotypes at coastal and tableland sites.

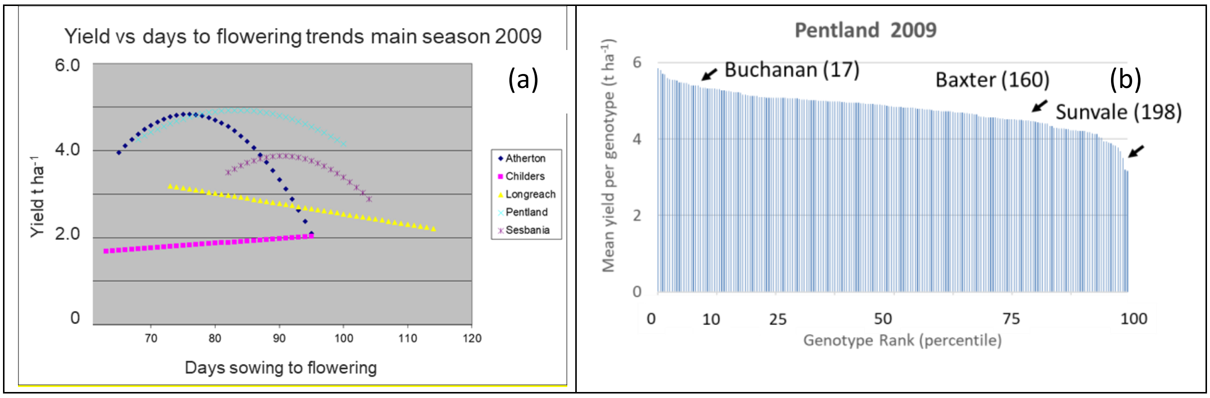

Figure 1. Trends in yield versus days from sowing to flowering during trials at 5 locations in northern and coastal Queensland in 2009 (a) and mean yield for individual wheat genotypes at Pentland in 2009 in descending order from left to right, rank out of 200 genotypes given in parenthesis (b).

Conclusion

Winter cereals exhibited potential fit for several crop rotation systems in northern Australia, in trials conducted in northern and coastal Queensland. Varieties with early to mid, crop durations from sowing to flowering were favoured as were early sowing dates. Varieties with tolerance to observed diseases were identified among lines of hexaploid wheat, triticale and forage oats, indicating that some existing types have adaptation to the north. In contrast, the tested barley and durum varieties would require improved disease resistance for successful adaptation. In addition, at some sites, winter cereals exhibited potential to provide a break crop for certain parasitic nematodes in rotations. Taken together, results suggest that winter cereals may fit into rotations with peanuts, maize, soybean, potatoes, spring sown sugar cane, plus forage and grain sorghum.

Acknowledgements

This work was jointly funded by DAFQ and the GRDC project DAQ00140. The authors thank DAFQ farm staff for excellent technical support and particularly Mr. James Henderson. Growers at all trial sites are also thanked. Plant pathologists at DAFQ are also gratefully acknowledged for assistance with identifying pathogens most likely associated with the observed symptoms.

References

Cooperative Research Centre for Developing Northern Australia (CRCNA) (2020) Broad acre cropping in northern Queensland (https://crcna.com.au/resources/publications/broadacre-cropping-northern-queensland)

Collis C (2017) Wheat shows its tropical credentials. GRDC Ground Cover, 128, (https://grdc.com.au/resources-and-publications/groundcover/groundcover-issue-128-may-june-2017/wheat-shows-its-tropical-credentials)

Byerlee D, Dublin HJ (2009) Crop improvement in the CGIAR as a global success story of open access and international collaboration. International Journal of the Commons, 4, 452-480 (http://doi.org/10.18352/ijc.147)