Improved yield of wheat: changes in crop physiology and implications for agronomy

Funded by the GRDC Water Use Efficiency Initiative. Conducted by Victor Sadras and Chris Lawson, SARDI

Key findings

- Modern wheat varieties have a higher demand for nitrogen and agronomic practices need to take this into account
- The most critical period for setting grain yield potential is between stem elongation (GS31) and flowering
- Current varieties are well beyond the potential 20kg grain/ha per mm water benchmark. This needs to be updated to 24kg grain/ha per mm water

Why do the trial?

Wheat breeders select primarily for grain yield whilst trying to maintain or improve agronomic performance, grain quality and disease tolerance. In selecting for yield, crop traits can change; some of these changes have agronomic implications. In these trials we asked:

- What are the main changes in crop traits behind yield improvement?
- Are there agronomic practices that need to be adjusted to account for these changes?

How was it done?

Trials were established to compare 13 wheat varieties released between 1957 and 2007: Heron (1958), Gamenya (1960), Halberd (1969), Condor (1973), Warigal (1978), Spear (1984), Machete (1985), Janz (1989), Frame (1994), Krichauff (1997), Yitpi (1999), Wyalkatchem (2001), and Gladius (2007).

These trials were sown at Hart, Roseworthy and Turretfield in 2010, and Hart and Roseworthy in 2012. In 2012, crops were grown under low and high nitrogen rates.

We measured yield and growth (grain number, head number, grains per head, 1000 seed weight), biomass and harvest index. We also measured crop photosynthesis, and water use and nitrogen uptake. Water use efficiency and nitrogen use efficiency were calculated.

Results

There was a sustained yield improvement in wheat varieties released between 1957 and 2007. After accounting for differences in background environment and yield potential, the rate of improvement of Australian breeding was similar to the rate reported for overseas breeding programs. Australian wheat breeders are doing a world-class job.

<u>Harvest index</u>

There was a sustained increase in harvest index between the 1957 and 2007 varieties. During this period the proportion of biomass in the grain increased by approximately 8%, contributing substantially to the higher yield of current varieties.

Crop water use

Crop water use did not change significantly between the 1957 and 2007 varieties. Wheat varieties have increased yield under the same water uptake, hence water use efficiency has improved. The major advances in breeding have come through improved harvest index and biomass production rather than improved water uptake. Halberd wheat, a variety typical of the 1970s, had a potential of 20kg/ha per mm of growing season rainfall whereas current varieties can reach 24kg/ha per mm (see Figure 1). Growers and advisors need to update their water use efficiency benchmark to account for current varieties.

Photosynthesis

There was a sustained increase in pre-flowering crop photosynthesis between varieties released in 1957 and 2007. This has been proven to be an important driver of improved yield. Enhanced photosynthesis was related to changes in canopy architecture, i.e. shorter varieties, better leaf angle and better distribution of light in the canopy. Leaves at the bottom of the canopy are also greener in newer varieties. To capture the improved photosynthesis of modern varieties, nitrogen fertilisation is critical to maintain a green canopy, particularly between stem elongation and flowering.

Nitrogen uptake

There was a significant increase in nitrogen uptake with later variety releases. Modern varieties take up to 40 kg/ha more nitrogen than older varieties. A “mining” effect is likely over the long term if fertilisation practices and management of soil fertility do not account for the enhanced nitrogen uptake of new varieties. There is also a risk of declining protein in grains unless nitrogen rates are adjusted accordingly.

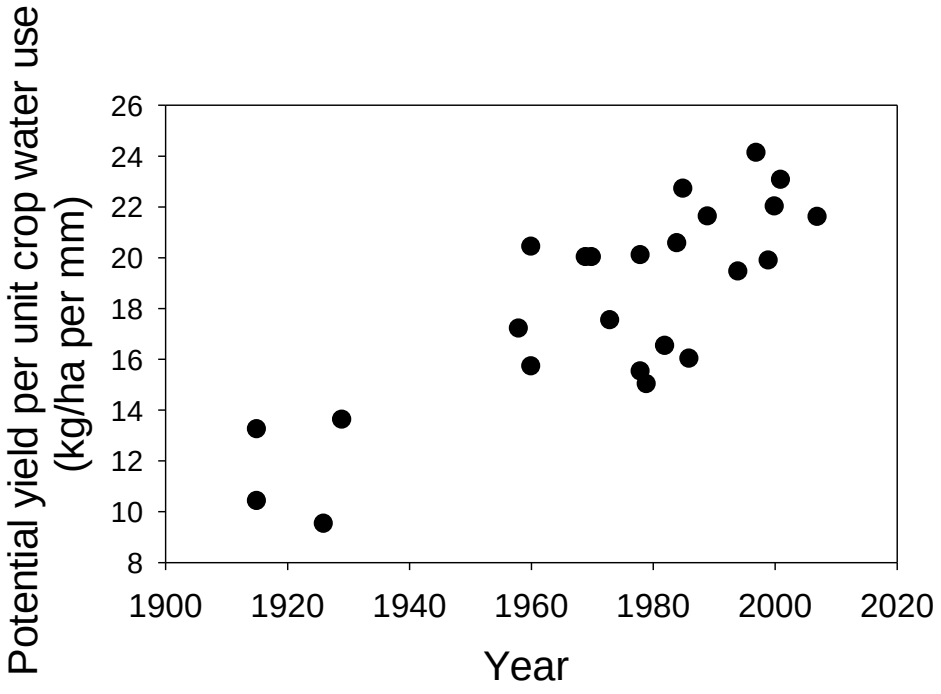

Figure 2: Progress in water use efficiency during a century of breeding for wheat yield in Australia.