

# 100 years of wheat Breeding at Roseworthy



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## Key messages

- Data from this trial shows that since 1955 there has been 1.4t/ha improvement in wheat yields, or approximately 1% per year. Prior to 1955, there was no improvement in grain yield
- The largest improvements have been driven by increased funding and the inclusion of semi dwarf varieties
- Since the release of Excalibur (the highest yielding non-PBR variety), grain yield gain per year has averaged 1.3%

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## How was the experiment done?

Forty eight wheat varieties bred at Roseworthy between 1906 (Fan) and 2012 (Shield) were grown at six locations over two years (Clearfield® tolerant varieties were excluded). The locations were: Rudall (2013), Pinnaroo (2013), Roseworthy (2013 and 2014), Angas Valley (2014) and Minnipa (2014).

All varieties in each trial were managed (sowing rate, fertiliser and in-crop treatments) according to current practices for each specific region. Grain yield, protein, test weight, thousand grain weight and screenings were measured and analysed both within individual sites and across sites.

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## Why do the trial?

Wheat breeding has been a key component of the Australian wheat industry for more than 130 years, and Roseworthy, as the longest continual breeding program, has been providing new wheat varieties to farmers for much of that time.

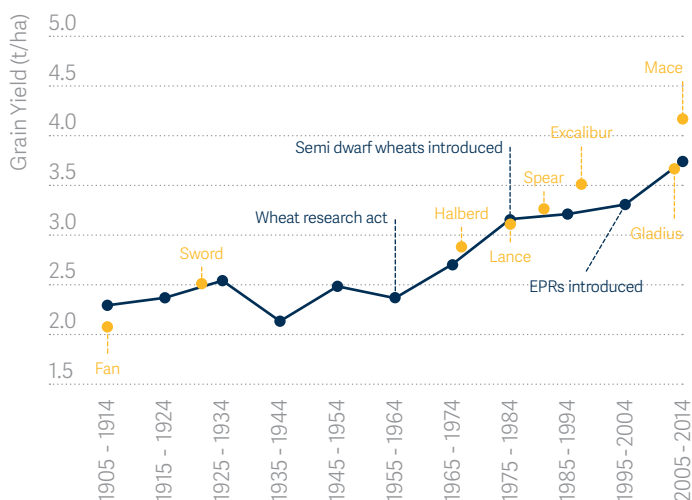
This study was initiated to quantify the historic value of wheat breeding to Australian growers and provide a benchmark for future improvements. This work can also be used to examine what changes have also occurred to other agronomic traits and consequently inform future agronomic research.

# What happened?

## Grain yield

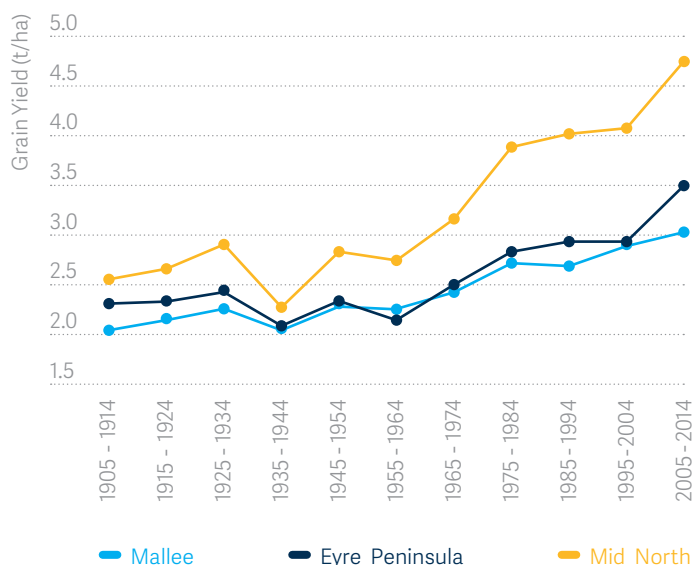
The results from all sites indicated that wheat breeding at Roseworthy has resulted in a 103% yield increase from Fan to Mace, or, 1% per year which amounted to 2.1t/ha (Figure 1). In the early years there was very little yield improvement with a yield increase of only 0.31t/ha or 0.3% per year from Fan to Claymore (1956). The rate of improvement has since risen to 1.47% per year or 1.8t/ha from Claymore to Mace. Three events appear to have had a major influence on grain yield improvement during this time. Firstly, the Federal Government introduced the 'Wheat Research Act' in 1957 which diverted proceeds from the wheat tax into wheat breeding. This enabled wheat breeders to increase the size of the program, improve mechanisation and expand testing into additional environments. The results of this trial indicate a yield increase of 0.64% per year or 0.82t/ha from Fan to Halberd, the first variety with a major yield increase after the "Wheat Research Act".

Figure 1 / Yield of varieties averaged over ten year periods from the beginning of formal wheat breeding at Roseworthy. Important varieties shown.



Secondly, exotic semi-dwarf varieties were introduced into the breeding program in the late 1960s. The first semi-dwarf variety released from the Roseworthy program was Lance in 1975, which corresponded to a yield increase of 0.24t/ha or 0.91% per year from Halberd to Lance. The third event that has had a significant impact on wheat breeding was the introduction of End Point Royalties (EPRs) which enabled wheat breeding to become a commercial enterprise. This has led to an expansion in the size of the breeding programme and increased adoption of new technologies like DNA selection, advanced statistics, precision agriculture and robotics. Excalibur was the highest yielding variety developed at Roseworthy before the advent of EPRs. There was a 0.39t/ha grain yield increase from Lance to Excalibur or 0.9% per year, while the improvement from Excalibur to Mace has been 0.65t/ha or 1.3% per year.

Figure 2 / Yield of varieties at three regions, averaged over ten year periods from the beginning of formal wheat breeding at Roseworthy.



# What happened?

## Protein

As grain yield has increased, the protein dilution effect has led to a small decrease in protein concentration (Figure 3).

Although protein percent has dropped a little, when the protein yield per hectare is calculated, a marked increase corresponding to the large increases in grain yield is evident over the history of wheat breeding at Roseworthy (Figure 4).

This demonstrates the 'protein dilution effect' where nitrogen availability has not met increased demand due to increased grain yield and therefore the protein percent of the grain is lower (diluted).

Although protein percent has reduced from 11.9% to 11.1%, which is approximately 6.2%, grain yield (when averaged in 10 year periods) has increased by 64% and the actual amount of protein harvested has increased 56%, from 268kg/ha to 420kg/ha, due to the increased yield, as shown in Figure 4.

Figure 3 / Protein content (percent) and grain yield of wheat varieties averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

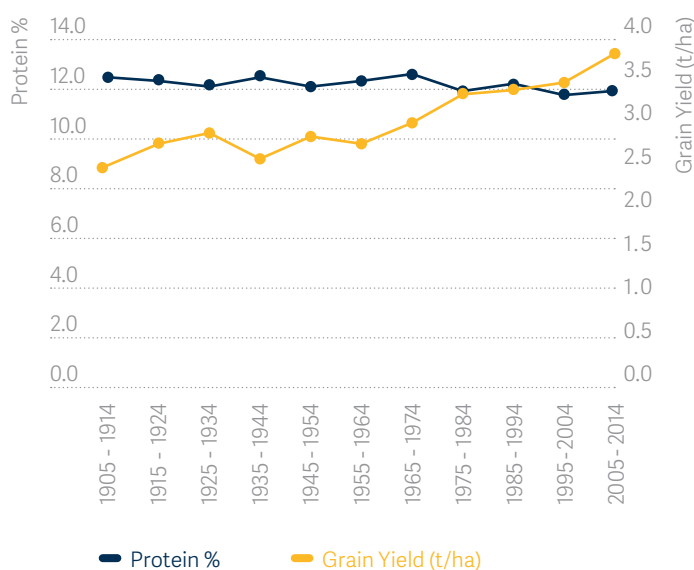
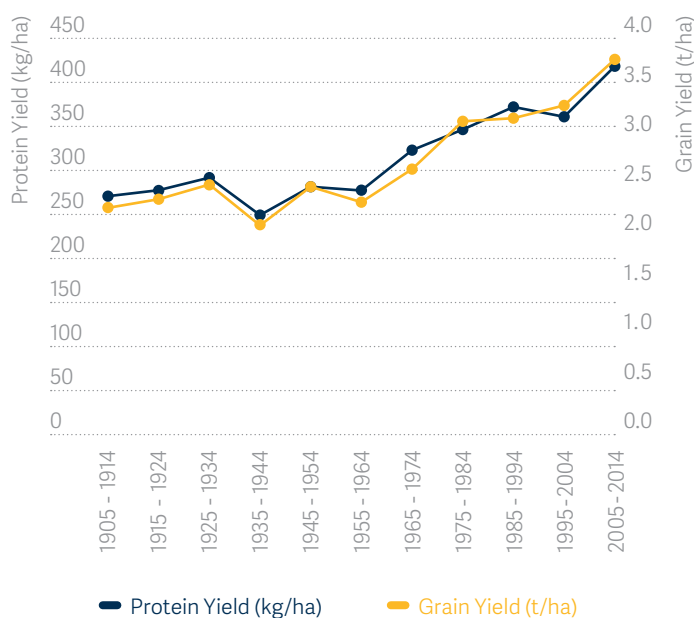


Figure 4 / Grain and protein yield of wheat varieties averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.



### Agronomic traits

Overall, tiller number per plant (data not shown), and grain number per square metre have increased and appear to be the primary drivers of the grain yield increase (Figure 5). This increase in grain number has led to a slight reduction in grain size.

Thousand grain weight has reduced, while the percentage of screenings has increased (Figure 6). It is interesting to note that due to high selection pressure over the last 15 years, grain size has increased (Figure 6), as has test weight (Figure 7), after some previous reductions.

There has been a 2.3% increase in test weight, 8.4% increase in thousand grain weight, and a 19.3% decrease in screenings in this period. The days from sowing to heading has decreased approximately six days since the beginning of formal wheat breeding at Roseworthy.

Lodging and plant height have both reduced over time (Figure 8). This figure shows that the largest improvement in lodging was made with the reduction in plant height associated with the introduction of the semi dwarf wheats.

Figure 5 / Number of grains per square metre of wheat varieties compared to yield, averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

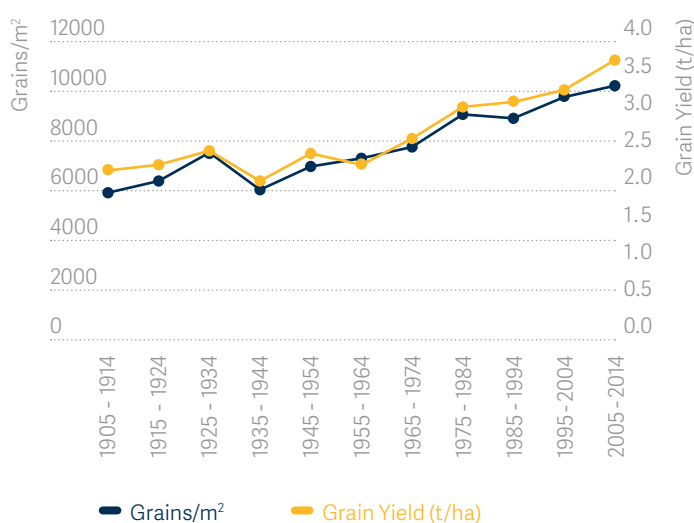
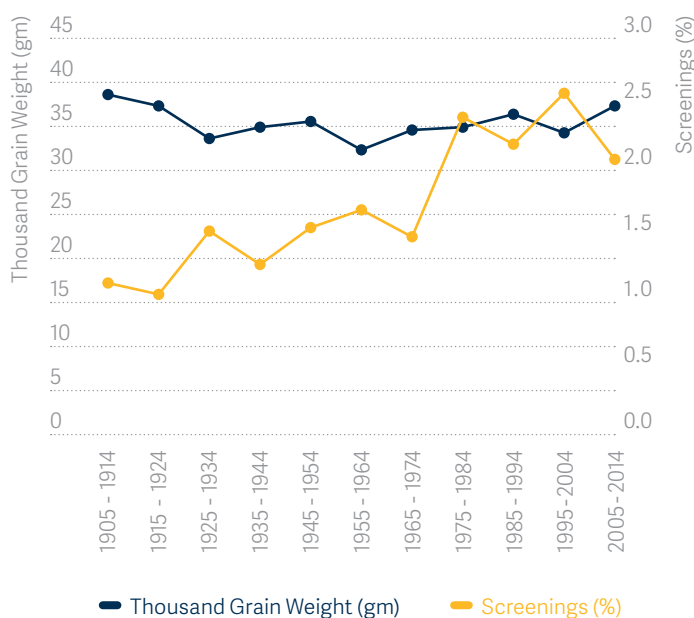


Figure 6 / Thousand grain weight and screenings percent of wheat varieties averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.



# What does this mean?

Figure 7 / Test weight of wheat varieties averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy.

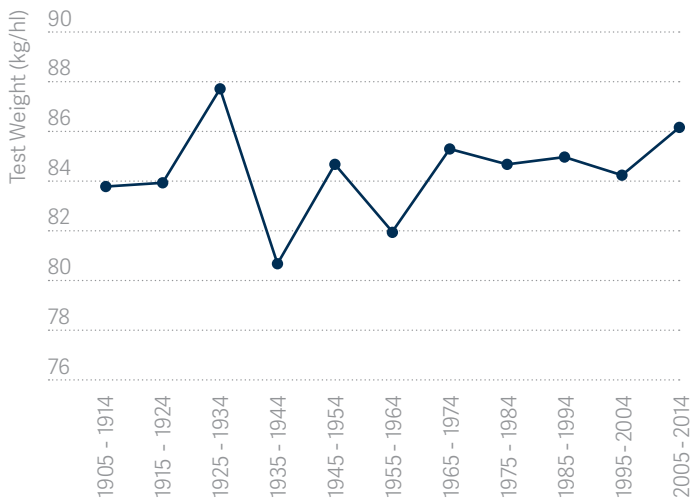
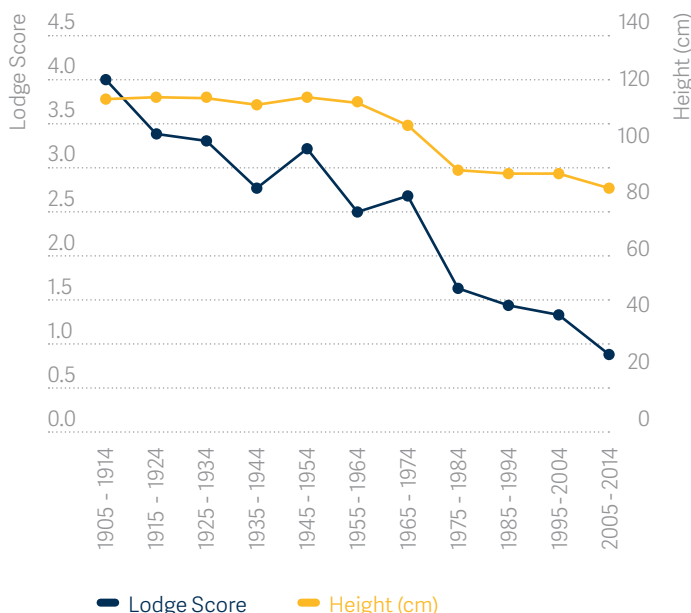


Figure 8 / Lodging score and height of wheat varieties averaged in ten year periods from the beginning of formal wheat breeding at Roseworthy. Lodging score: 0=no lodging, 9=fully lodged.



It is clear that the Roseworthy wheat breeding program has developed improved varieties with significant increases in grain yield achievement. There have been some small, negative aspects associated with the increased grain yield; protein percent has been reduced marginally and there has also been a small decrease in grain size. However, the lower protein percent has been due to the 'protein dilution effect' of higher yields, while the actual protein yield has increased along with the grain yield. Investigations into management options to address the lower protein concentrations are continuing. The smaller grain associated with grain yield increases has started to be reversed through high selection pressure by wheat breeders.

In this article, we have focussed on grain yield, protein and grain size, without reference to improvements in other important traits such as rust resistance, baking quality or Intervix® tolerance. These are other benefits resulting from the breeding program that have a high impact on grower profitability. With the successes so far and building on the increased knowledge resulting from these successes, the future of wheat breeding at Roseworthy, and other AGT breeding programmes, is bright.

## Acknowledgements

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