Managing Sowing Date and Variety Selection to Minimise Risk and Maximise Yield

AGT

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What triggers maturity in wheat?

The final yield of a wheat crop can be significantly compromised by either frost or heat stress regardless of the early season potential.

Although there is some variety difference in grain yield response to these events, at extreme temperatures (below -2°C and above 35°C) all varieties are very similarly affected.

Damaging frost or heat events during flowering will result in a reduction in grain number, whereas grain size will be reduced if frost or heat events occur during grain fill. As there are currently no other forms of protection from these risks, altering sowing times to reduce exposure to frost and heat events during the sensitive growth stages (booting through to the end of flowering) is the best risk management option.

However, as the scale of grain production systems continues to increase, completing sowing within the optimum sowing window becomes more difficult. This is where variation in the time to flowering for different varieties (maturity types) can be used as a risk management tool, allowing growers to adjust sowing date but still achieve an optimal flowering date.

The maturity types of wheat can be roughly allocated into one of three groups:

The first group are photoperiod sensitive varieties (eg. Yitpi) which require day length to be greater than 10 hours before flowering will occur. This photoperiod requirement can be satisfied by the longer days in autumn and therefore sowing photoperiod sensitive varieties before April may result in early flowering.

The second group are vernalisation responsive (eg. Wyalkatchem). These varieties require minimum temperatures below 10°C (optimum 6°C) over periods ranging from 2 to 8 weeks for the plants to move from vegetative phase to reproductive phase, depending on variety.

The final group display minimal or no sensitivity to both photoperiod and veranalisation (eg. Axe). These varieties mature predominately in response to temperature.

Once photoperiod or vernalisation requirements have been satisfied there is still variation in maturity rate between varieties. This is described as 'Earliness per se' and reflects multiple factors influencing maturity progression independent of vernalisation and photoperiod sensitivity.

Table 1 shows the vernalisation, photoperiod and 'Earliness per se' requirements of the well known varieties Axe, Wyalkatchem and Yitpi. Alternative varieties are shown in Table 2, grouped according to their photoperiod and vernalisation requirements. However, the requirements for vernalisation or photoperiod vary between each variety within each group. For example, Yitpi and Estoc are more sensitive to photoperiod than Gladius, and therefore flower later than Gladius, while Bolac combines vernalisation and photoperiod sensitivity and therefore flowers later than both Mace and Yitpi.

Strategic use of these different maturity types can extend the sowing period while minimising the risk of grain yield loss due to frost and heat events. In this report we have featured Mace and Estoc as higher yielding replacements for Wyalkatchem and Yitpi, respectively.

How was the experiment done?

Table 1 / Thermal time (cumulative daily temperature) required for three contrasting variety types[1].

Variety	Vernalisation	Photoperiod	Earliness per se
Axe	0	525	910
Wyalkatchem	221	840	924
Yitpi	0	1974	1176

Table 2 / Maturity triggers of common wheat varieties.

Minimal photoperiod and vernalisation sensitivity	Vernalisation sensitive	Photoperiod sensitive
Axe	Bolac *(moderate)*	Correll *(moderate)*
Bonnie Rock	Cobra *(moderate)*	Estoc *(strong)*
Corack	Janz *(moderate)*	Frame *(strong)*
Emu Rock	Mace *(moderate)*	Gladius *(moderate)*
Hatchet CL Plus	Naparoo *(strong)*	Grenade CL Plus *(moderate)*
Scout	Shield *(moderate)*	Justica CL Plus *(moderate)*
Wallup	Wedgetail *(strong)*	Trojan *(moderate)*
Westonia	Wyalkatchem *(moderate)*	Yitpi *(strong)*

AGT conducts time of sowing (TOS) trials to characterise new varieties with regard to maturity type, and to evaluate grain yield response of new and existing varieties to different sowing times.

These trials provide information on how different varieties develop and progress through their life cycle, how this influences grain yield and ultimately allows us to characterise their frost and heat risk profiles.

Trials are sown at 2 to 3 week intervals, starting when the season permits. In 2014, sowing dates were 24th April, 8th May, 22nd May and 12th June. All plots are regularly monitored and growth stages are recorded.

What happened?

Variety response to temperature and day length

In this data set, the thermal time (cumulative daily temperature) from sowing to the end of grain fill is longest in Wedgetail and shortest in Axe, with Estoc between these varieties (Figure 1). This is principally because Estoc requires long days to initiate flowering and Wedgetail has a strong requirement for vernalisation, whereas Axe matures independently of day length and vernalisation. Therefore, we observe that the development of Axe is closely linked to daily temperatures, and when sown early with warm autumn temperatures, Axe has rapid early growth, quickly reaching the reproductive growth stages and therefore increasing the likely exposure to the critical frost risk period (Figure 2). Another consequence of this rapid growth is less tillering and biomass development.

In contrast, Mace, Estoc and Wedgetail spend a larger proportion of the total growth period in the vegetative growth stages. This means that they spend more time tillering and developing biomass, which increases the yield potential of the plant. In addition to this, Mace, Estoc and Wedgetail have a faster grain filling period, spending at least 20% less time than Axe in the grain filling growth stage (Figure 1). This allows these varieties to ripen quicker, reducing the risk of heat stress during grain fill.

Figure 1 / Thermal time required to reach head emergence and physiological maturity of varieties sown at Roseworthy on 24th April 2014.

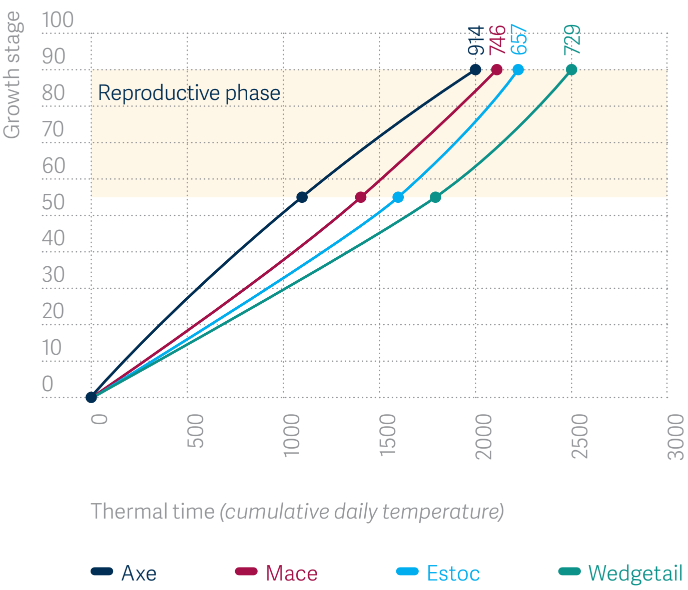
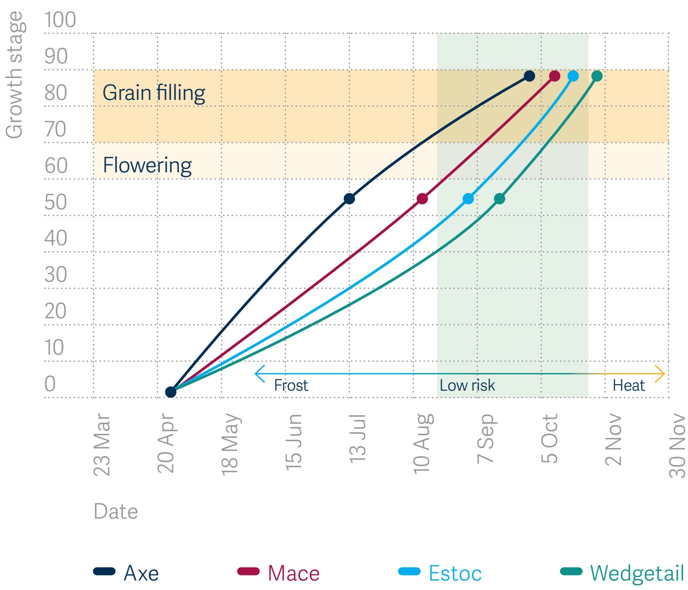


Figure 2 / Differences in maturity times of varieties sown at Roseworthy on 24th April 2014[2].



Impact of sowing date on yield

The data collected over multiple years demonstrated that the yield of each variety varied according to sowing time, with the previous four years shown in figures 3a-3d. In general, over these trials the yield of Estoc was greatest with early sowing, reducing as sowing was delayed. The yield of Mace was relatively constant but peaked when sown in mid May, while the yield of Axe peaked at a similar point, but suffered less yield penalty when sown later.

Frost in 2014 affected Mace and Axe when sown very early, exacerbating the yield penalty of sowing these varieties before their optimal sowing window (Figure 3d). A similar result was observed in 2013 when hot, strong north winds caused shattering in early sown Axe (Figure 3c).

Figure 3a / Yield v sowing date, Roseworthy, 2011.

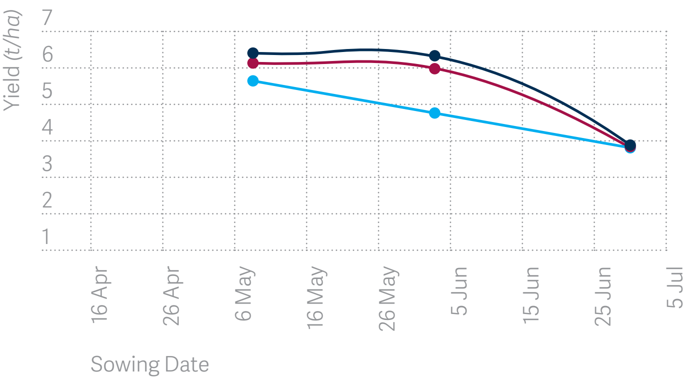


Figure 3c / Yield v sowing date, Roseworthy, 2013.

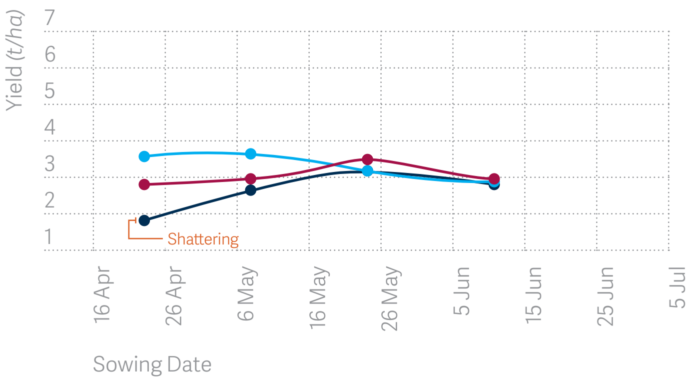


Figure 3b / Yield v sowing date, Roseworthy, 2012.

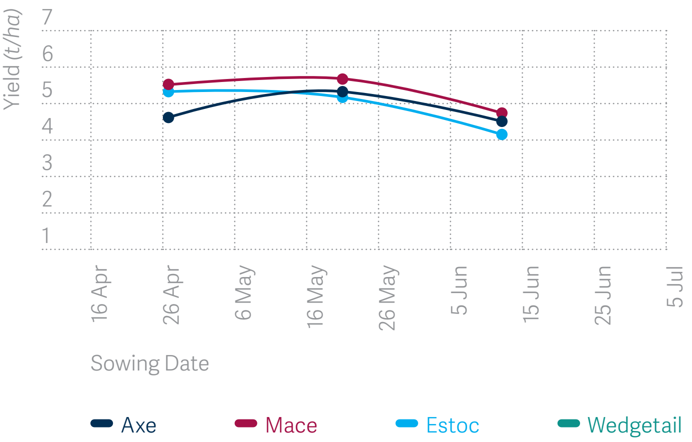
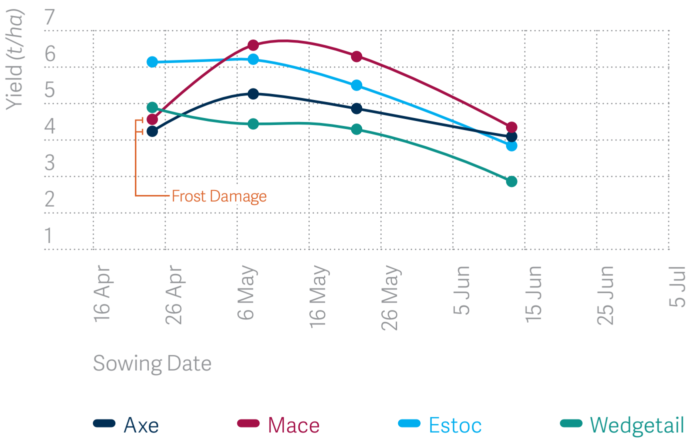


Figure 3d / Yield v sowing date, Roseworthy, 2014.

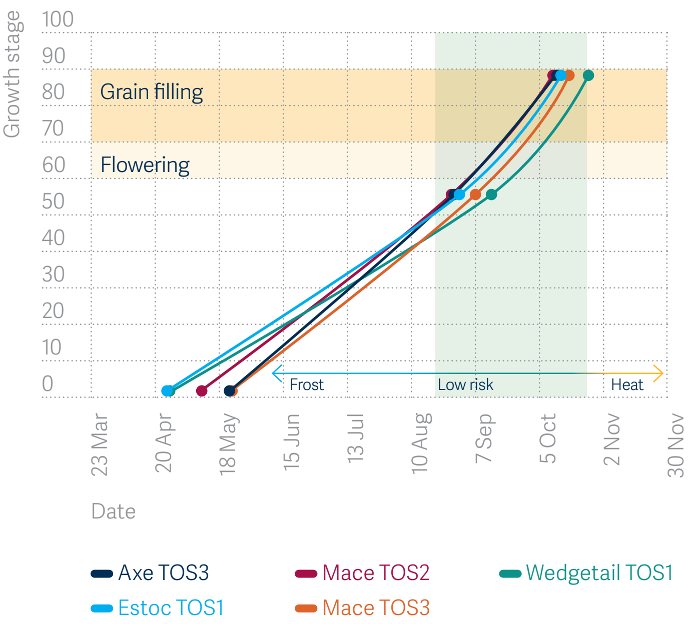


What does this mean?

Selecting varieties to optimise flowering date

The length of the sowing window can be maximised by selecting a range of varieties with contrasting maturity, such as Estoc, Mace and Axe. As an example, Estoc could be used for sowing in late April to early May, Mace for the majority of the sowing period (May) and finishing with Axe for those paddocks that might need to be sown in June. While Figure 2 shows the potential exposure to frost risk from sowing Axe or Mace in April, Figure 4 shows how a strategy of careful variety selection based on maturity type allows all paddocks sown within a 20th April to 10th June sowing operation to flower and grain fill during the lowest risk period when there is a less than 20% chance of either a frost or heat stress event occurring. Currently there are no adapted varieties that can be safely sown prior to 20th April in South Australia. Trials at Roseworthy suggest that although the highest yield for the winter wheat Wedgetail is when it is sown in April, it is still lower than that of Estoc (Figure 3d).

Figure 3d / Yield v sowing date, Roseworthy, 2014.



Selecting varieties to optimise grain yield

In order to maximise yield from any particular variety, it is important to time the sowing of each variety to match its yield potential. The best time to sow Estoc is late April to early May, Mace from early May to early June, and Axe from mid May to mid June. Although it is important to consider optimum sowing time to maximise the yield of an individual variety, the actual yield potential of each of these varieties at all sowing times should also be compared. Figures 3a-3d suggest that Mace and Estoc will yield higher than Axe at all but the latest sowing dates, in the majority of seasons.

Selecting varieties to reduce the frost and heat risks is currently the best available management practice to reduce the potentially substantial losses caused by extreme temperature events. This is achievable with the range of maturity types available in varieties that are commonly grown in southern Australia. Using Estoc, Mace and Axe as contrasting examples, this report illustrates how grain yield from each variety can be maximised while minimising the risks of yield loss due to frost and heat stress.

However, using a variety with a higher inherent yield potential that may suffer some yield loss as a consequence of exposure to frost and heat events during the sensitive reproductive and grain filling growth stages may actually achieve higher returns than a lower yielding variety grown for its specific maturity type. For example, Mace will have a higher yield than most varieties in most environments, even when sown outside of its optimum sowing window. In this case, variety selection would reflect the growers attitude to risk and return.

The experiments used to generate the data described in this article were grown at Roseworthy, SA. Therefore, it is important to note that the results should be interpreted and adapted to the local environmental conditions with reference to local climatic data and grower experience.

Acknowledgements

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References

[1] Brougham, M. 2006, 'The relationship between vernalisation sensitivity, photoperiod sensitivity, basic vegetative period and grain yield in Australian wheat germplasm' Honours Thesis, University of Adelaide

[2] Zheng, B, Chen, K, Dreccar, MF and Chapman, SC. 2012, 'Breeding for the future: what are the potential impacts of future frost and heat events on sowing and flowering time requirements for Australian bread wheat (Triticum aestivum) varieties?' Global Change Biology, vol. 18, 2899-2914

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