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Response to moisture stress of wheat near-isogenic lines varying at *Ppd* and *Vrn* genes – Yanco 2018

Dr Lance Maphosa and Kathryn Bechaz (NSW DPI, Yanco); Dr Felicity Harris (NSW DPI, Wagga Wagga)

Key findings

- Under moisture stress conditions, early flowering and long grain-filling duration were advantageous in 2018.
- Short-season spring type near-isogenic lines (NILs) yielded better than winter types under moisture stress growing conditions at this site in 2018.
- The highest yielding line under moisture stress conditions had spring alleles in all *Vrn* genes and insensitive alleles in all *Ppd* genes.
- Under irrigated conditions the highest yielding lines had at least one spring *Vrn* allele and one *Ppd* insensitive allele.

Introduction

Plant development is affected by genotype × environment × management interactions. At the genetic level, it is mainly affected by three groups of genes:

1. Photoperiod (*Ppd*): day-length response, with the insensitive types able to switch from the vegetative to reproductive phase regardless of day length.
2. Vernalisation (*Vrn*): cold temperature requirement, with the sensitive (winter) types requiring a minimum threshold to be met before switching from the vegetative to the reproductive phase.
3. Earliness: the residual genetic control when all the photoperiod and vernalisation requirements have been met (Fischer 2011).

This experiment aimed to look at the response to moisture stress of lines differing at the *Ppd* and *Vrn* genes.

Site details

Location	Yanco Agricultural Institute
Soil type	Merungle loam to Merungle sand
Previous crop	Field peas
Sowing	Irrigated and moisture stressed experiments were both sown on 18 May 2018
Target plant density	135 plants/m^2
In-crop rainfall	123 mm (1 May–30 November 2018)
Supplementary watering	158 mm pre-sowing watering 223 mm for the irrigated experiment 98 mm for the moisture stressed experiment
Soil nitrogen (N)	Available nitrate N to 180 cm depth 455 kg N/ha (155 kg N/ha available to 30 cm)

Starter fertiliser	Mono-ammonium phosphate (MAP) fertiliser at 100 kg/ha, treated with Intake®
Weed management	Post-emergent weed control: Boxer Gold® (800 g/L prosulfocarb and 120 g/L S-metolachlor) at 2.5 L/ha (13 June); Precept® (125 g/L MCPA as 2-ethylhexyl ester and 25 g/L pyrasulfotole) at 1 L/ha and Lontrel® (600 g/L clopyralid) at 60 mL/ha (25 June)
Disease management	Stripe rust application: Prosaro® (210 g/L prothioconazole and 210 g/L tebuconazole) at 150 mL/ha (24 July) and at 300 mL/ha (24 August)
Insect management	Aphid control: Transform® (500 g/kg sulfoxatlor) at 50 g/ha (24 July); Dominex Duo® (100 g/L alpha-cypermethrin) at 125 mL/ha (24 August)

Treatments

A set of 32 NILs on a Sunstate⁽ᵗʰ⁾ (wheat variety) background with allelic variation at the *Ppd* and *Vrn* genes was used to understand how the different moisture conditions affected wheat development and yield. Check varieties (Sunstate Delta ft mutant, Sunstate1006 mutant, Suntop⁽ᵗʰ⁾ and WinterSuntop3_12) were also included in the experiment.

The experiments were sown on 18 May 2018. Due to the dry conditions in 2018, pre-sowing watering was needed to ensure successful establishment – 158 mm was applied. The experiments were treated the same way until flowering when watering was stopped on the moisture stressed experiment. However, the lines had different flowering dates, so an average peak flowering date of 2 September was used. The irrigated experiment received a further 125 mm of water during grain filling.

Results

Phenology

There was substantial variation in phenological development of the NILs measured as days to stem elongation (Z31), flowering (Z65) and physiological maturity (Z90). Vegetative growth phase conditions were identical and moisture stress was imposed at flowering and therefore did not have an effect on phasic development up to Z65. NILs with both winter type growth habits requiring vernalisation and photoperiod sensitivity were the slowest to reach Z31, Z65 and Z90.

Yield

Moisture stress after flowering significantly reduced grain yield for all the NILs and check varieties (Figure 1). Yield also varied within the NILs for both the irrigated and moisture stressed experiments, probably driven by differences in development rate.

Under moisture stress conditions there was a high correlation between days to flowering and grain yield ($r^2 = 0.79$), with the early flowering lines having higher yields. However, under irrigated conditions there was no linear correlation between days to flowering and yield (Figure 2). At Yanco, the optimum flowering period is generally considered to be late September, once the risk of frost damage has reduced for irrigated wheat. This corresponded with some of the highest yielding lines in this experiment, which flowered 129–136 days after sowing (21–28 September).

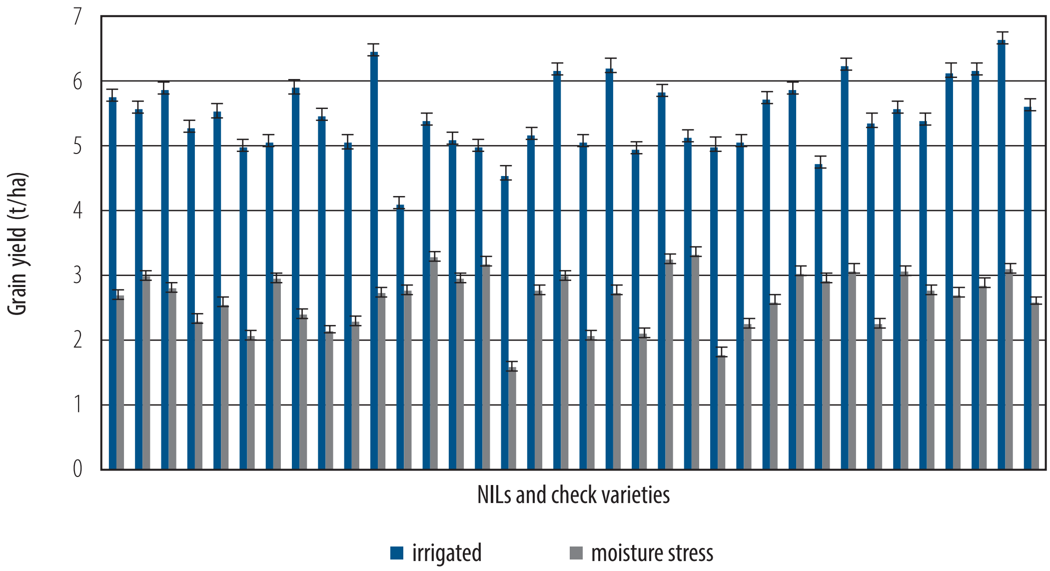

Figure 1. Grain yield for the 32 NILs and check varieties (last four on the right, Sunstate Delta ft mutant, Sunstate1006 mutant, Suntop$^{\Phi}$, and WinterSuntop3_12) under irrigated and moisture stress conditions.

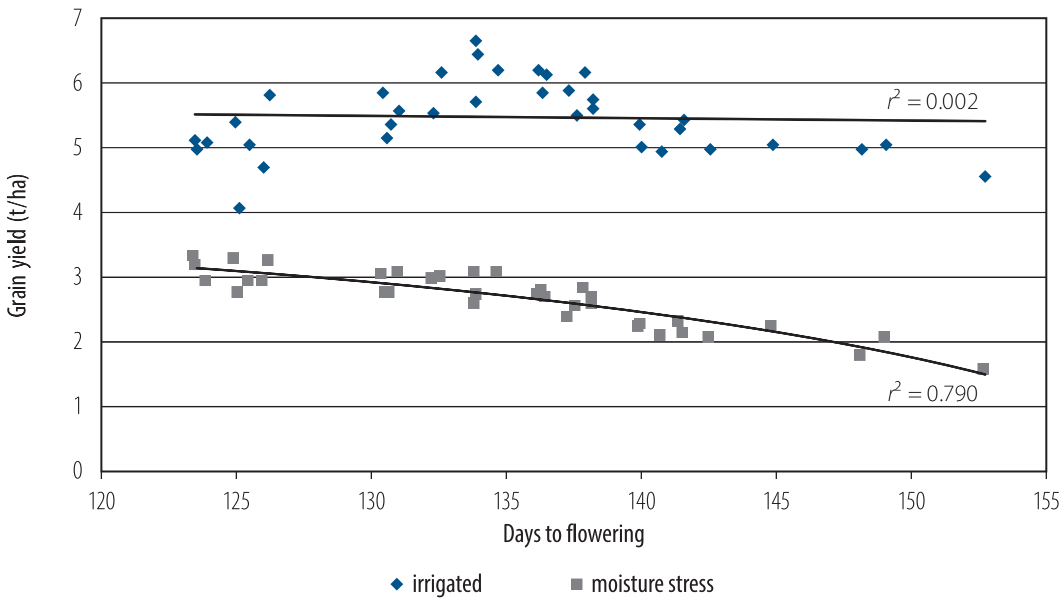

Figure 2. Relationship between days to flowering and grain yield of 32 NILs and check varieties grown under irrigated and moisture stress conditions.

A similar trend was observed for the relationship between yield and days to physiological maturity. Under moisture stress there was a high correlation (r^2 = 0.72) with the early-maturing lines yielding better than the late-maturing lines, but under favourable conditions there was no correlation. At Yanco, the optimum time for maturity for irrigated wheat is generally considered to be mid November. After this date, late season heat stress increases the risk of decreased yield. This window corresponded with some of the highest yielding irrigated lines in this experiment, which matured around 180 days after sowing (11 November). The irrigated experiment matured later, and time to maturity for all the lines spanned 10 days (175–185 days), compared with the moisture stressed treatment, which ranged from 155 days to 175 days (spanned 20 days).

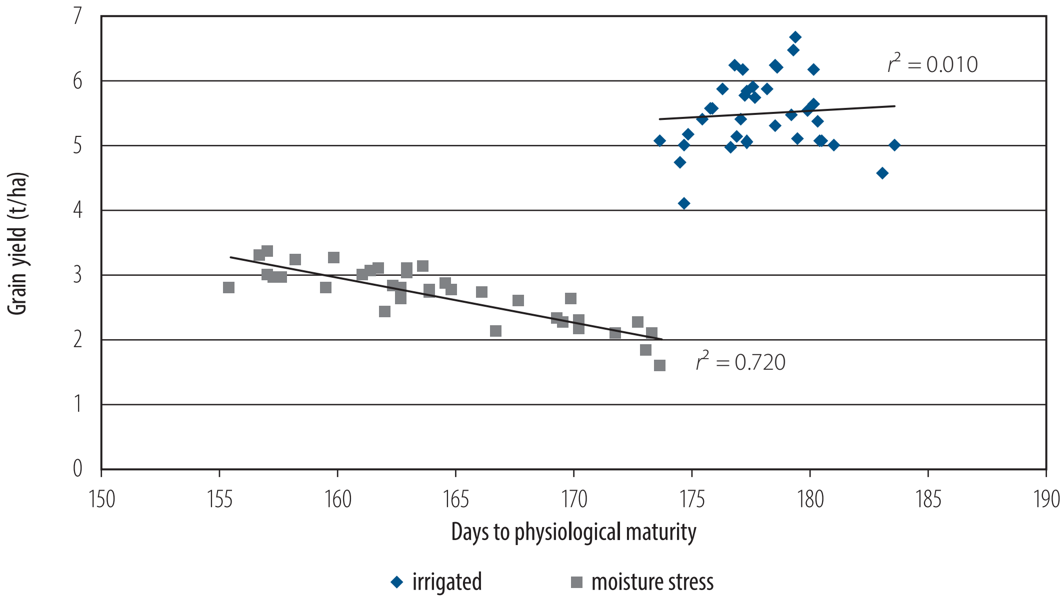

Figure 3. Relationship between physiological maturity and grain yield of the 32 NILs and check cultivars grown under irrigated and moisture stress conditions.

Grain filling characteristics

There was a correlation between the grain filling duration, defined as time from heading to physiological maturity, and grain yield ($r^2 = 0.79$) under moisture stress conditions (Figure 4). Under moisture stress conditions the longer the grain filling period the higher the yield, a pattern that was not observed under irrigated conditions.

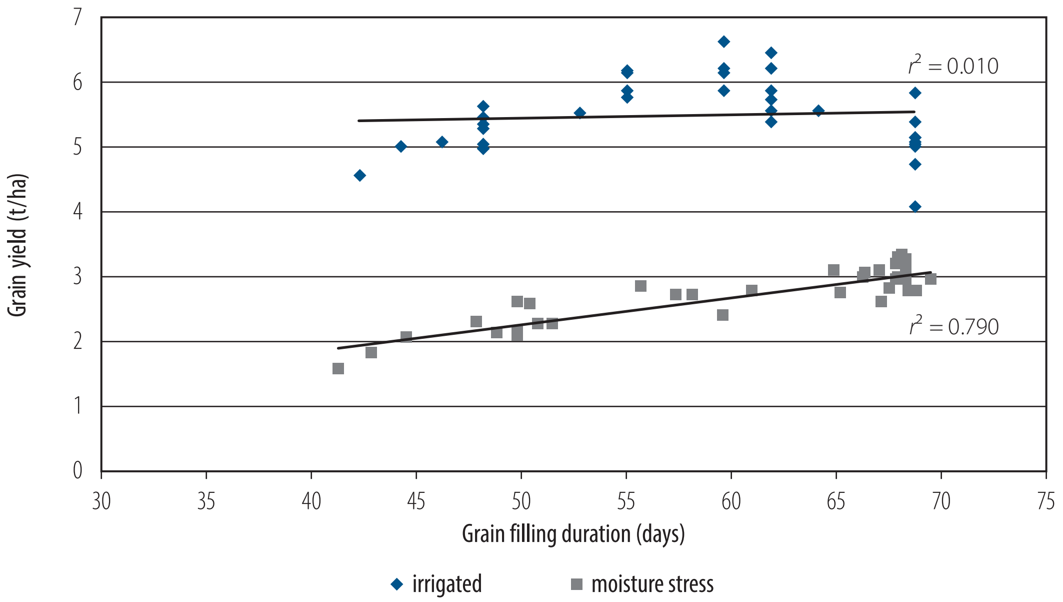

Figure 4. Relationship between grain filling duration and grain yield of the 32 NILs and check cultivars grown under irrigated and moisture stress conditions.

However, under both moisture stress and irrigated conditions there was no linear correlation between grain filling rate and yield (Figure 5).

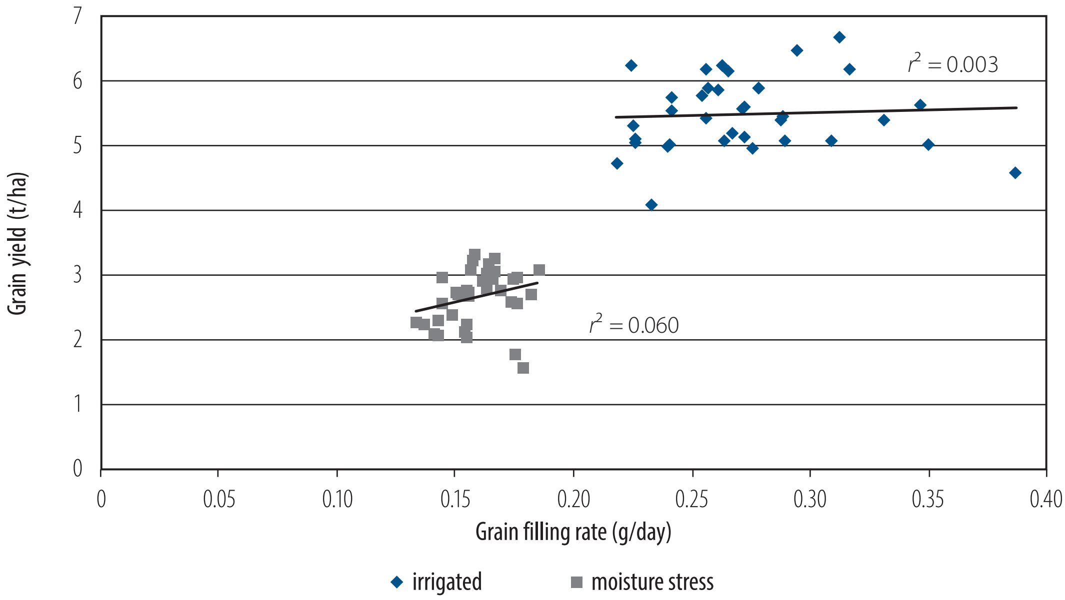

Figure 5. Relationship between grain filling rate and grain yield of the 32 NILs and check cultivars grown under irrigated and moisture stress conditions.

Grain quality

There was a moderate to high linear correlation between percentage screenings and thousand grain weight under both moisture stress ($r^2 = 0.62$) and irrigated ($r^2 = 0.70$) conditions (Figure 6). Screenings were higher and grain weight was lower under moisture stress conditions than under irrigated conditions.

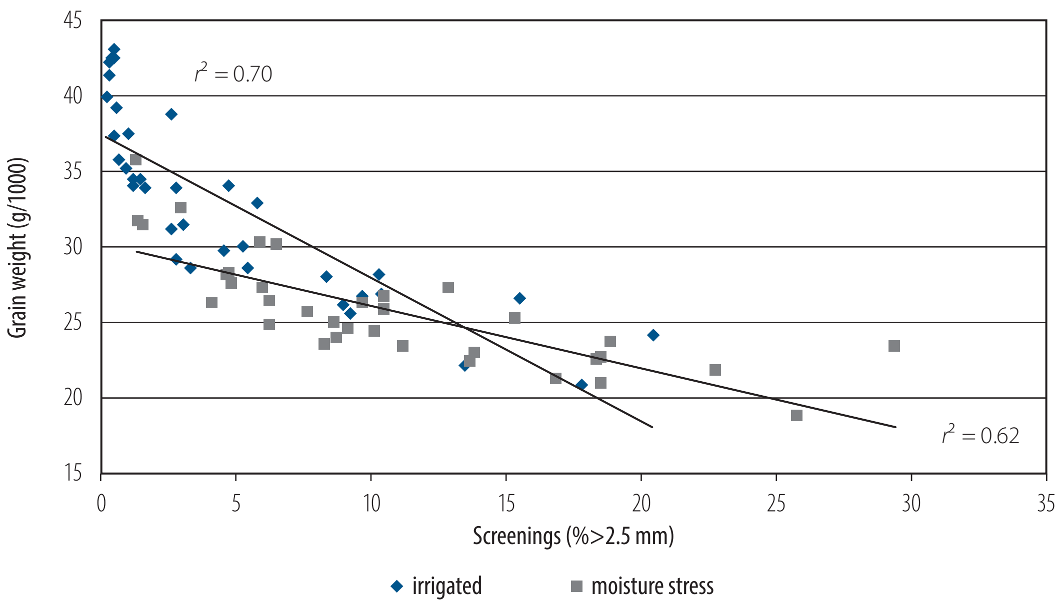

Figure 6. Relationship between percentage screenings and thousand grain weight of the 32 NILs and check cultivars grown under irrigated and moisture stress conditions.

Conclusion

The NILs varied widely in phasic development such as time to stem elongation, flowering and physiological maturity. Under terminal moisture stress conditions, as is often experienced in the Australian wheat belt, early maturing, short-season lines were the highest yielding in 2018. Terminal moisture stress affects grain filling duration leading to a higher percentage of screenings, decreased grain weight and yield compared with irrigated conditions. This highlights the importance of correct sowing time (Harris et al. 2018), especially if there is frequent terminal moisture stress affecting the growing environment. However, under irrigated conditions, the NILs yielded well regardless of the developmental differences between the lines.

References

Fischer RA 2011. Wheat physiology: a review of recent developments. *Crop and Pasture Science*, vol. 62, pp. 95–114.

Harris F, Kanaley H, McMahon G and Copeland C 2018. Influence of sowing date on phenology and grain yield of wheat – Wagga Wagga 2017; D Slinger, T Moore and C Martin (eds). *Southern NSW research results 2018*. NSW Department of Primary Industries.

Acknowledgements

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