Screening of tolerant and susceptible wheat cultivars to waterlogging in the high rainfall zone of the southwest Victoria

Dhananjay Singh[1, 2], Malcolm McCaskill[2], Kevin F Smith[2], and Robert Belford[2]

[1] DNRE, Pastoral and Veterinary Institute, Hamilton, VIC 3300
[2] QDPI, Farming Systems Institute, Roma Research Station, Roma, QLD 4455
Dhananjay.Singh@dpi.qld.gov.au

Abstract

Waterlogging is one of the major environmental constraints to the wheat production in the high rainfall zone of the southwest Victoria. A glasshouse experiment was undertaken to identify and compare putatively tolerant and susceptible cultivars, with a more waterlogging-tolerant plant species, triticale. Brookton and Frame found to have the greatest biomass accumulation, whereas Amery, Silverstar and Chara had the lowest biomass accumulation under waterlogged conditions. These cultivars could be selected for further understanding of the mechanisms of tolerance, to waterlogging in this region. The winter wheat cultivars, Tennant and More appeared to be less productive.

Introduction

Waterlogging is one of the major environmental constraints to the wheat production in the high rainfall zone of the southwest Victoria. There is a need of high yielding and tolerant wheat lines for a sustainable and viable wheat industry in the region. In order to develop high yielding cultivars for this environment, it is important to understand the mechanisms of tolerance to waterlogging, so that novel characteristics can be incorporated into the existing high yielding cultivars through breeding. The objective of this experiment was to identify and compare potentially tolerant and susceptible, spring and winter wheat cultivars, with a tolerant line of triticale.

Materials and methods

The experiment was a split-split plot design with four replicates. PVC pots 100 cm long and 8.5 cm diameter were placed in a temperature-controlled glasshouse at the PVI, Hamilton, Victoria. Treatments included factorial combination of 2 waterlogging (waterlogged and control) by 3 harvests (H_1, 3 weeks of establishment; H_2, 3 weeks of waterlogging and H_3, 3 weeks of recovery) by nine varieties (8 wheat, 1 triticale). Six spring wheat cultivars, Amery, Silverstar, Chara, Frame, Carnamah, and Brookton, and two winter wheat cultivars, More and Tennant were compared with a triticale cultivar, Muir. Pots were fertilised with triple superphosphate and Aquasol[?] for 75 kg N/ha and 20 kg P/ha in liquid form. Aquasol[?] also provided micronutrients. After two weeks of germination and establishment, pots were thinned to one plant per pot. Plant measurements involved counting of main stem leaf, tiller, seminal and nodal roots, and dry weights of main stem, seminal and nodal root mass at each harvest. Dissolved O_2 concentration in the water was also measured at the end of waterlogging period for three depths surface water, 0-5 cm and 5-10 cm depths.

Results

The triticale cultivar, Muir always produced greater biomass than the wheat cultivars at the different harvests (Table 1). Among the wheat cultivars, the spring wheats Brookton and Frame were the highest yielding. Importantly, the relative growth rates of these lines were also greater than the other lines, particularly under the waterlogged conditions. On the other hand, Amery, Silverstar and Chara appeared to be the most susceptible to waterlogging with respect to biomass production in absolute or relative terms. The root: shoot ratio, an important parameter for the waterlogging tolerance was always greater for the winter cultivars, More and Tennant, followed by the Brookton (Table 2). Nodal root mass, another key parameter was always greater for Muir, followed by Brookton. The soil oxygen concentration decreased progressively from a shallower to a deeper depth. At the 5-10 cm depth, oxygen concentrations were consistently less than 11% relative to fully aerated water.

Table 1: Biomass at the harvest 1 (H_1), harvest 2 (H_2) and harvest 3 (H_3). Values in a column with similar letters do not differ significantly (*P*>0.05).

Cultivar	Biomass (H_1)	Biomass (H_2)		Biomass (H_3)	
	Control (g)	Control (g)	Waterlogged (g)	Control (g)	Recovery (g)
Amery	0.09a	0.35bc	0.28a	0.48a	0.36a
Silverstar	0.10a	0.32ab	0.26a	0.58bc	0.45a
Chara	0.13b	0.45d	0.30a	0.71bc	0.65b
Frame	**0.13b**	**0.50e**	**0.38b**	**0.87d**	**0.72b**
Carnamah	0.13b	0.39c	0.36b	0.73bcd	0.49a
Brookton	**0.17c**	**0.51e**	**0.45c**	**1.06de**	**0.74b**
More	0.10a	0.28a	0.28a	0.88d	0.49a
Tennant	0.16c	0.34b	0.26a	1.12e	0.65b
Muir	**0.20d**	**0.81f**	**0.52d**	**1.36f**	**0.93c**

Table 2: Root: shoot ratio at the harvest 2 (H_2) and harvest 3 (H_3). Values in a column with similar letters do not differ significantly (*P*>0.05).

Cultivar	Root: shoot (H_2)		Root: shoot (H_3)	
	Control (g)	Waterlogged (g)	Control (g)	Recovery (g)
Amery	0.50a	0.30a	0.32ab	0.60b
Silverstar	0.52ab	0.49b	0.35ab	0.24a
Chara	0.66bc	0.40ab	0.45bc	0.33a

Frame	0.47a	0.38ab	0.26a	0.21a
Carnamah	0.74c	0.50cd	0.51cd	0.34a
Brookton	**0.80c**	**0.62cd**	**0.66d**	**0.52b**
More	**1.17d**	**0.65d**	**1.49e**	**1.49c**
Tennant	**1.29d**	**0.83e**	**3.37f**	**1.82d**
Muir	0.73c	0.46b	0.47bc	0.35a

Conclusion

Brookton followed by Frame were found to be the lines most tolerant to waterlogging. On the other hand, Amery, Silverstar or Chara, could be selected as the susceptible lines for further understanding of the mechanisms of tolerance to waterlogging in this region.

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