Variation for osmotic adjustment in Australian triticale cultivars

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Abstract

The response of ten triticale (X Triticosecale ex Wittm. A. Camus) genotypes to water deficit was investigated by withholding water at the booting stage under greenhouse conditions. Total water potential (ψ) and osmotic potential (π) were measured and used to estimate osmotic adjustment (OA). Variation was observed in OA among the genotypes. The two wheat cultivars showed high OA as expected; moreover many of the triticale cultivars appeared to respond similarly to the wheat cultivars. Linear regressions of relative water content versus π for the cultivars showed significant differences in slope ($P < 0.0001$). Differences in grain yield and yield components were significant between genotypes ($P < 0.001$). There was a significant and negative correlation between OA and sterile tiller number ($P < 0.05$, $r^2 = 0.40$). OA may, therefore, be a factor in improving seed set when triticale is stressed at this stage.

Key words

X Triticosecale, water deficit, booting stage, yield components, osmotic potential, water potential.

Introduction

Triticale (*X Triticosecale* Wittm. ex A. Camus) occupies a relatively small area worldwide but one with increasing production capacity in regions where other cereals have yield limitations. In Australia triticale is grown under dryland conditions which frequently involve varying degrees of water stress. To date we have no information concerning which varieties show improved drought tolerance compared either to other triticales or to other cereals (3).

Osmotic adjustment (OA) has been recognised as an effective mechanism of tolerating drought stress. It has been reported in a number of crops such as wheat (2, 5, 6), barley (4) and sorghum (1). OA is defined as net solute accumulation during the development of a water deficit exclusive of the effects of decreasing leaf water content (5, 9). Various advantages are conferred by OA under drought conditions and the most important of these is turgor maintenance. This in turn affects stomatal conductance and photosynthesis and ultimately plant growth (5).

This experiment is the first in a comprehensive study aimed to improve drought stress performance in new Australian hexaploid triticales.

Materials and Methods

The experiment was conducted in a greenhouse at 27?C/11?C (day/night) at UNE, Armidale (152?E, 31?S), Australia. Plants were grown in 26 cm diameter plastic pots filled with a loam/sand/peat potting mix (3:2:1) (v/v/v). Ten triticale genotypes including one cultivar (cv. Everest) and four breeding lines from the UNE collection (W57, W19, UNE-19 and UNE-12), three cultivars from South Australia (cvs.Treat, Credit, Tickit), one cultivar from Victoria (cv.Tahara) and one cultivar from South Africa (cv.Kiewiet-2) were used. Two wheat cultivars (cvs. Malgara and Hartog) with high OA were included to provide an indication of the sensitivity of the method.

A randomised complete block design with four replicates was used. Plants were kept well watered and supplied with Aquasol? liquid fertiliser weekly. Watering was stopped when 50% of the primary tillers for each cultivar reached booting stage (stage 50 on the Zadoks scale) (8). Samples were taken between 10 am and 12 noon from the flag leaves of primary tillers every two days during the drying period. Water potential (ψ), osmotic potential (π) and relative water content (ζ) were determined from 2 cm^2 of leaf taken from midway along the flag leaf blade. Morgan`s regression method (5, 6) was used to calculate OA; being the difference between the measured and predicted π.

Plants were harvested at maturity and above-ground biomass, grain yield and number of fertile and sterile tillers determined. Data were analysed using S-Plus 2000 and Excel XP.

Results and Discussion

Linear regressions between π and ζ of the flag leaves during the water deficit were used to estimate OA for each cultivar. There was a considerable variability in the response of the cultivars and significant differences were found among the slopes of the regression lines ($p<0.0001$). This kind of response is used to indicate differences between cultivars for OA (5, 7).

OA differed between cultivars over a 7-fold range from 0.2-1.5 MPa (Table 1). These values are of the same degree as found for wheat, 0.2-1.4 (5, 7) and sorghum, 0.4-1.7 (1). This variation could be used in triticale breeding programs as it has been used in other crops such as wheat (6) and barley (4). A relative water content (ζ)of 60% was chosen as the value to compare OA between cultivars, this being near the average relative water content at zero turgor.

Table 1: Grain yield (g/plant), ψ and net solute accumulation (OA) at ζ = 60%. Values for grain yield are mean ? s.e. Cultivars are ranked from highest OA to lowest.

Cultivar	Grain yield (g/plant)	Water potential (Ψ)	OA (MPa)
Treat	7.2±0.9	-3.11	1.48
Hartog	6.9±0.9	-3.1	1.3
WS7	6.3±0.9	-3.27	1.27
W19	8.1±0.9	-3.17	1.21
Malgara	4.8±0.9	-3.08	1.17
Tahara	2.3±1.1	-2.79	0.99
UNE-12	5.8±0.9	-2.71	0.88
Kiewiet-2	4.8±0.9	-2.87	0.87
Everest	9.2±0.9	-2.93	0.68
Credit	5.7±1.1	-2.69	0.67
UNE-19	5.3±0.9	-2.63	0.56
Tickit	4.6±0.9	-2.5	0.21

There was a significant difference between cultivars for grain yield and biomass (both $p<0.001$). The correlation between mean grain yield and the amount of solute accumulation ($r^2 = 0.07$) was not significant in this experiment. However, there was a significant and negative correlation between the number of sterile tillers and OA ($p<0.05$, $r^2 = 0.40$). The capacity to adjust osmotically may enhance spikelet fertility in tillers. Previous studies have found a strong relationship between OA and decreased yield decline under water stress (4, 6). Furthermore, at the booting stage, grain yield may be controlled mostly by stored assimilates in stems and these may have reduced the effect of OA (2).

Conclusion

The high and low OA lines we have identified in this experiment will allow the assessment of the effect of OA in improving grain yield under water stressed conditions. These results will now be tested in a similar experiment under field conditions.

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