

Dissecting drought-response strategies of perennial ryegrass (*Lolium perenne* L.)

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Introduction

Periodic drought is a severe constraint on the profitability and sustainability of pastoral production. As a result of climate change, drought events are anticipated to increase in frequency and intensity even in regions where annual precipitation is unchanged, as well as where it is reduced.

Many studies have been carried out on drought resistance of forage species (Holloway-Phillips and Brodrigg 2011). However, for most experiments, it is unclear which mechanism(s) are responsible for variation in plant performance under moisture stress, whether drought response mechanisms were triggered, or whether differences in performance were simply the result of intrinsic plant vigour. The objective of the reported research was to understand the underlying physiological and genetic mechanisms responsible for production of perennial ryegrass under summer drought and recovery and regrowth after drought.

Methods

Plant material

Perennial ryegrass mapping population RM4 is a random sample of the full-sibling F1 progeny from a pair cross between a genotype from the New Zealand cultivar 'Grasslands Samson' and a Moroccan genotype. The maternal 'Grasslands Samson' parent is the same genotype used to develop a previously-described mapping population (Sartie *et al.* 2011) and is widely used in New Zealand farming systems. The Moroccan genotype was sourced from an accession (PI 598854) obtained from the National Plant Germplasm System of the USDA-ARS with anecdotal evidence of good dry matter production during drought.

Experimental design

This experiment was conducted in a rainout shelter in the field. A total of 164 genotypes were clonally propagated to make plants available for two treatments (drought and control) and three replicates within each treatment. Soil water content, leaf elongation rate, tiller survival after trimming, and shoot dry matter yield were measured from each plant of the mapping population progeny, after

plant establishment and exposure to mild drought (Mild), severe drought (Severe) and after recovery (Post). The resulting progeny-by-trait matrix was used to detect quantitative trait loci (QTL) for the various traits.

Discussion

There was no genotype effect detected on soil water content and leaf elongation rate but a significant genotype effect on tiller survival (Table 1). This suggests that some genotypes could be suitable for grazing during drought.

Vigour and drought tolerance can both independently enhance plant performance during moisture deficit. This was shown by the presence of both drought-resistant genotypes and genotypes for which performance was reduced when compared to their irrigated clones, yet was high enough for those genotypes to be in the top half of the population both at the beginning of the experiment and during severe drought (Fig. 1).

These results were in accordance with those from the QTL analysis (Fig. 2). The LG2 QTL affects tiller

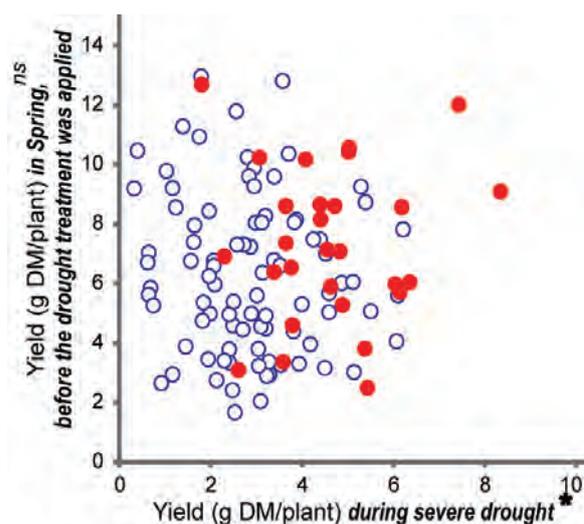


Figure 1. DM yield potential during the severe drought treatment and the extent of DM yield reduction compared to irrigated clonal replicate, (75% of plants with the greatest reduction in yield within each sampling date; ●, top 25% within each sampling date, respectively; ns, $P > 0.05$; * $P < 0.05$).

Table 1. Wald tests for fixed effects on genotypes for volumetric Soil Water Content (SWC), Tiller survival (TS) and Leaf Elongation Rate (LER) for perennial ryegrass plants subjected to severe drought.

Fixed term	Wald statistic	d.f.	Wald/d.f.	P	
Genotypes _{SWC}	139.23	137	1.02	0.431	ns
Genotype _{Tiller survival}	167.96	137	1.23	0.037	*
Genotype _{LER}	143.08	135	1.06	0.301	ns

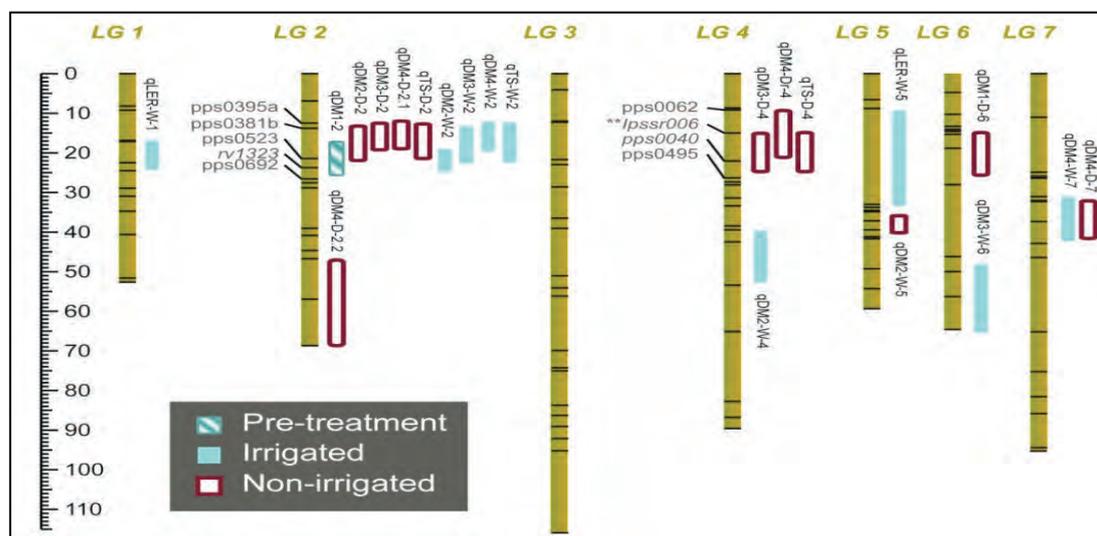


Figure 2. The genetic linkage map showing seven linkage groups (LG1 - LG7) representing the seven ryegrass chromosomes and QTL discovered for traits measured in the drought response experiment: DM (dry matter), TS (tiller survival) and LER (leaf elongation rate).

survival after defoliation and Dry Weight for irrigated and non irrigated plants. It is therefore related to traits for both vigour and drought tolerance. The LG4 QTL occurs only for non-irrigated so it represents a true drought tolerance effect.

Conclusion

Data suggest that the vegetative growth of perennial ryegrass during the summer drought treatment was influenced both by genes that control intrinsic plant vigour and by genes that triggered a response to drought stress.

References

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