Developing molecular markers for traits associated with drought tolerance in perennial ryegrass (*Lolium perenne* L.)

K.M. Guthridge[2, 3], K.F. Smith[1, 3], N.M. McFarlane[1, 3], B.D. Kirkwood[1, 3], E.S. Jones[2, 3] and J. W. Forster[2, 3]

1. Agriculture Victoria, Pastoral and Veterinary Institute, Private Bag 105 Hamilton, Vic.
2. Agriculture Victoria, Plant Biotechnology Centre, LaTrobe University Bundoora, Vic.
3. Cooperative Research Centre for Molecular Plant Breeding.

ABSTRACT

Two populations of perennial ryegrass were selected that had previously been shown to have contrasting levels of drought tolerance. The North African population has been shown to survive summer drought well, while the European population is less tolerant of summer drought. Individuals from these populations were grown in hydroponics with and without water stress, with water stress being imposed through the addition of polyethylene glycol to the hydroponic media. The drought-associated traits root length, fructan concentration, relative water content, herbage growth and photosynthetic characteristics were measured. Significant variation for root length was observed within, as well as between populations. Two individuals with contrasting root lengths were crossed to produce an F_1 population. The progeny of the cross between these two genotypes are now being evaluated for variation in photosynthesis with the intention of developing molecular markers for aspects of drought tolerance in perennial ryegrass.

KEY WORDS

Perennial ryegrass, *Lolium perenne*, drought, photosynthesis, molecular markers.

INTRODUCTION

The productivity and sustainability of the grazing industries of Australia are limited by the susceptibility of perennial ryegrass to annual summer drought. The evaluation of drought tolerance in the field is time consuming and expensive. Hence the need exists to develop mechanistic tests of drought-tolerance in perennial ryegrass genotypes. Perennial ryegrass genotypes of Mediterranean origin have been shown to be more tolerant of drought than commercially available cultivars that are derived from Australian or New Zealand germplasm (1).

The ability of perennial ryegrass to survive drought has been associated with a number of traits including: root length and mass, photosynthetic characteristics and water-soluble carbohydrate concentrations. Water stress has been shown to decrease photosynthesis in perennial ryegrass due to reductions in leaf area, increased stomatal resistance and a decrease in the quantum efficiency of photosynthesis, depending on the rate of onset and the extent of water stress (4). Research in Mediterranean France has demonstrated that the morphological and physiological traits most strongly associated with summer survival in cocksfoot (*Dactylis glomerata* L.) were (i) deep roots and water uptake at depth; (ii) tolerance to dessication; (iii) increased concentrations of high-molecular weight fructans; (iv) low accumulation of proline in stubble; (v) rapid nitrogen uptake and recovery after rewatering (5).

This paper describes the variation in some traits related to drought tolerance between two perennial ryegrass genotypes; one of North African origin from a population that has previously been shown to survive well through summer drought (1) and another from the cultivar Aurora of Swiss origin. Aurora has previously been shown to be susceptible to drought in Mediterranean France (5).

MATERIALS AND METHODS

Clonal replicates of two genotypes of perennial ryegrass were grown hydroponically and either allowed free access to water or were exposed to water stress through the addition of polyethylene glycol 6000 (PEG) to the hydroponic solution. PEG concentrations were raised to 20% over a 23-day period. Plants

were harvested at the commencement of the water stress period and at 35 or 70 days after the onset of water stress. At each harvest leaf area, leaf mass, tiller number, pseudostem mass, root length (length of longest root) and root mass were measured. Photosynthesis was measured on the plants several times during the experiment. Samples were freeze dried immediately after dissection to allow the measurement of dry weight of the root and shoot components and the determination of fructan concentrations in the pseudostem. Data were analysed using REML procedures in Genstat 5.4.1 with harvest date, drought treatment and location in the glasshouse accounted for during analysis.

RESULTS AND DISCUSSION

The maximum root length of the genotypes at each harvest has been analysed and the root lengths of the parents of the mapping cross (Nth African6 x Aurora6) are presented in Figure 1. The roots of Nth African6 were significantly (P<0.05) longer than those of Aurora6 at each harvest, both with and without imposed drought treatments. These data are consistent with data from other experiments where plants from the cultivar Aurora have generally been shown to have shorter roots than other cultivars (Guthridge *et al.*, Smith *et al.* unpublished). There was also variation between genotypes within cultivars (data not shown) demonstrating the need for accurate phenotyping of parental genotypes when developing mapping crosses in outcrossing forage species. Differences in the photosynthetic capacity of these genotypes were also measured in these genotypes (McFarlane *et al.,* these proceedings). Data on the other parameters measured in this experiment are currently being analysed. The F_1 progeny of the cross between these genotypes are currently being analysed for genetic variation in growth rate, biomass partitioning and photosynthesis in both water-stressed and control conditions. DNA from these plants has been extracted and a map constructed using amplified fragment length polymorphism (AFLP) and simple sequence repeat (SSR) markers. These data will then be combined to map QTLs for traits associated with drought tolerance in perennial ryegrass.

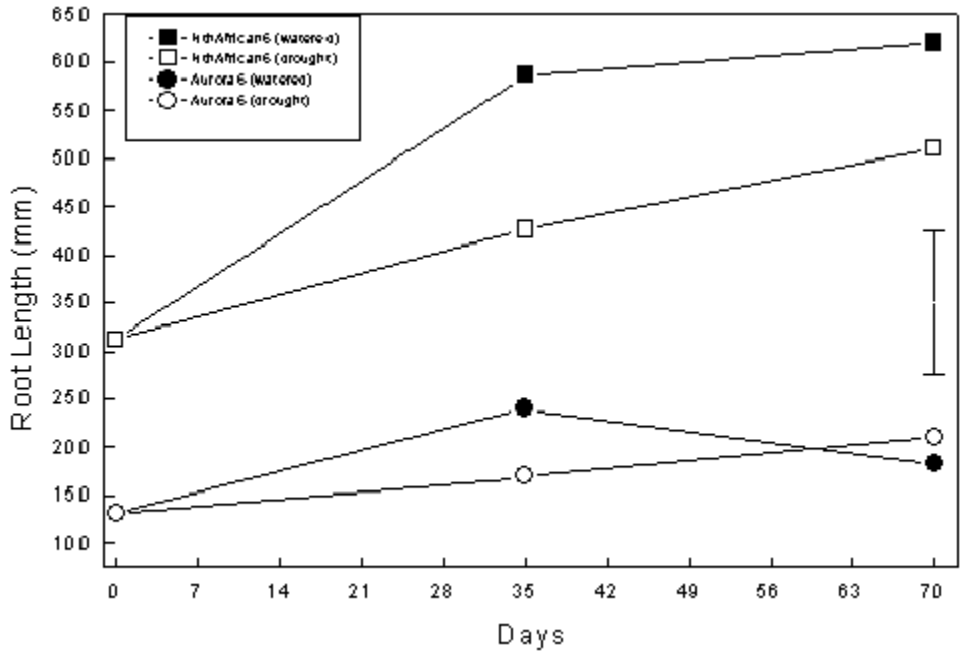

Figure 1. Length of the longest root of perennial ryegrass plants grown in hydroponic culture with and without the imposition of polyethylene glycol mediated water stress. Bar represents l.s.d. (*P*=0.05) for comparisons within harvest date.

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