Photosynthetic variation in genotypes of perennial ryegrass (*Lolium perenne* L.) selected to map drought tolerance

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ABSTRACT

Two contrasting perennial ryegrass genotypes were grown with and without water stress using hydroponics. Water stress was imposed through the addition of polyethylene glycol to the hydroponic media. These genotypes were of North African or Northern European origin and were selected from cultivars previously shown to have contrasting abilities to survive summer drought. The North African genotype has previously been shown to survive summer drought well, while the European genotype was less tolerant of summer drought. Drought conditions were shown to reduce the maximum rate of photosynthesis for both genotypes, with the North African genotype having a lower maximum CO_2 assimilation rate. This was in contrast to the rate of photosynthesis of the two genotypes when grown in well-watered conditions where the genotype of northern European origin had a lower maximum rate of photosynthesis and reached the maximum value at a lower light intensity.

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 strategies among 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 plants to maximise photosynthetic capacity, and water use efficiency is important in maintaining growth and survival under conditions of stress. 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). Differences in the quantum efficiency of perennial ryegrass genotypes have been observed with Danish populations of perennial ryegrass reaching light saturation at lower light intensities than populations from Algeria (3). This paper describes the photosynthetic characteristics of two contrasting 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 and photosynthesis was measured 11 days after the onset of water stress. Photosynthetic responses to changing light conditions were measured using the LiCor 6400 photosynthesis system fitted with a 670 nm/465nm red/blue LED light source.

RESULTS AND DISCUSSION

Under well watered conditions the north African genotype was shown to have a higher maximum rate of photosynthesis (24 μmol/m^2/s) than the genotype from cv. Aurora (16 μmol/m^2/s) (Fig 1). The plants that were used to develop the cultivar Aurora were originally derived from a collection from the Zurich uplands in Switzerland. This difference in quantum efficiency **-** photosynthetic rate per unit irradiance at high irradiance **-** between diverse perennial ryegrass genotypes is consistent with previously published results (1). The ecological significance of these results is unclear but it has been hypothesised that differences in photosynthetic activity may be related to the increased cool-season growth and water-soluble carbohydrate storage that may be observed in ecotypes and cultivars of forage grasses adapted to Mediterranean climates (2).

The rate of photosynthesis of leaves of both genotypes was greatly reduced by imposition of water stress with the North African genotype having a maximum assimilation rate of 2 μmol/m^2/s and Aurora 6 μmol/m^2/s. Similar large reductions in the photosynthetic capacity have been observed in perennial ryegrass swards in drought conditions (4). Whilst drought has been shown to reduce the quantum efficiency of perennial ryegrass swards it is also possible that the effects that we observed were magnified due to a reduced ability of a plants to acclimatise to drought under controlled conditions (4). However, it is also possible that a reduction in the photosynthetic rate of the North African genotype was associated with decreased stomatal conductivity and a general reduction in the activity of this summer-dormant genotype under drought conditions.

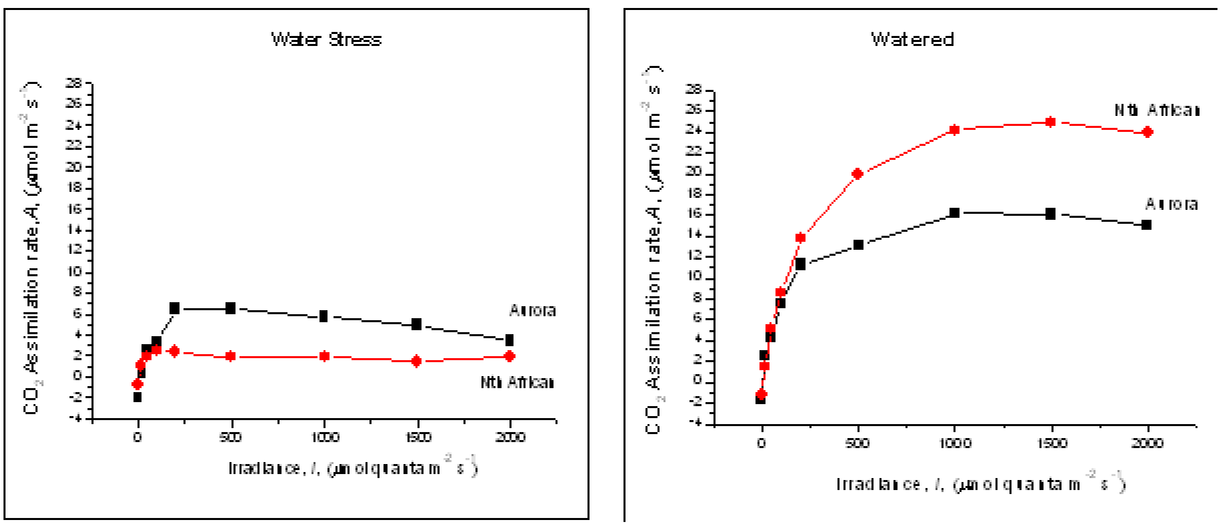

Figure 1. Photosynthetic rates in the youngest, fully-emerged leaves of perennial ryegrass genotypes.

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