Summer dormancy - a drought resistance strategy in perennial grasses

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Abstract
Studies of cocksfoot and tall fescue showed that summer dormancy was a powerful drought resistance trait, whereas dehydration avoidance, while assisting plant survival, was not as potent.

Key words
Summer dormancy, dehydration avoidance, dehydration tolerance, drought resistance, plant survival.

Introduction

Research on drought resistance of plants has primarily focused on annual species, so that most reviews (e.g. Turner 2003) have paid little attention to perennial species. Annual species can utilise drought avoidance and/or drought tolerance mechanisms to survive drought but, ultimately, rely on the seed phase to survive hot dry summers. Perennial grasses (especially from Mediterranean climates) may exhibit these strategies and may also become dormant over summer. Some of the component mechanisms exhibited within the dehydration avoidance and summer dormancy strategies are similar (e.g. cessation of growth, herbage senescence). This could lead to mistaken identification of either of these strategies. Previous research has shown that mechanisms of dehydration avoidance and tolerance can be identified under glasshouse conditions over winter without confounding from summer dormancy, whereas summer dormancy will only become apparent during summer (Volaire *et al.* 2001). Utilising both approaches, we examined relationships between dehydration avoidance/tolerance and summer dormancy in cocksfoot and tall fescue.

Methods

The expression of dehydration avoidance and dehydration tolerance was studied throughout winter in a heated glasshouse. One trial tested cocksfoot (*Dactylis glomerata*) cultivars (cvv) Kasbah, Medly and Lutetia and another evaluated tall fescue (*Festuca arundinacea*) cvv Demeter and Flecha. Plants were maintained in a vegetative state, in a loamy sand in pots of 0.6 m depth and 0.1 m width and grown under non-limiting conditions for 2 months until roots had reached the bottom of the pots. The drying cycle that each species experienced was terminated by rewatering after a visual assessment estimated that 50% of the plants of the most susceptible cultivar were dead. Drying cycles in the cocksfoot and tall fescue trials lasted 84 and 77 days respectively. Mortality was verified after pot rehydration, and drought resistance scores determined as the product of drought duration and cultivar survival (Norton 2007). Dormancy expression of the above cultivars was measured in field swards at Mauguio, France under full summer irrigation in 2002 following the method of Norton *et al.* (2006b). Adjacent field trials evaluated cultivar survival over three summer droughts with a range of intensities in 2002 and 2003 (Norton *et al.* 2006a).

Results and discussion

Early in the drying cycles of the glasshouse trials Kasbah, Medly and Flecha had lower rates of water use than other cvv, indicating drought avoidance (Norton 2007). Kasbah lost no plants, whereas Lutetia, a plant from a moist maritime climate, suffered 42% mortality (Table 1). Medly experienced only 16% mortality, presumably because of its drought avoidance, given the plant's Mediterranean background where seasonal drought is common. As a consequence, Kasbah was assigned the highest drought resistance score, followed by Medly and then Lutetia. In the tall fescue trial, Demeter suffered quite high mortality, an expected result given the moist origins of its parents. Conversely, Flecha experienced significantly less plant death, presumably because its Tunisian origins ensure regular exposure to drought. In the field, Kasbah expressed a high level of summer dormancy,

Table 1. Estimates of plant mortality and drought resistance scores derived under winter glasshouse conditions and summer dormancy scores obtained from a field trial measured under full summer irrigation of cocksfoot (Dg) and tall fescue (Fa) cultivars. Means with same superscripts are not significantly different (P=0.05).

Species	Cultivar	Mortality (proportion)	Drought resistance score[A]	Summer dormancy score[A]
Dg	Kasbah	0[a]	10	9.4
Dg	Medly	0.16[b]	8.5	0.1
Dg	Lutetia	0.42[c]	5.8	0.5
Fa	Flecha	0.18[a]	6.8	5.7
Fa	Demeter	0.59[b]	3.3	0

[A]Scores: (0=minimum ,10=maximum)

in contrast to the two other cocksfoot cultivars which had little dormancy. In the tall fescues, Demeter was not dormant whereas Flecha expressed a moderate level of dormancy.

When tested for summer survival, Kasbah displayed high drought resistance, as it experienced no mortality, even in a drought with cumulative evapotranspiration (CE) of 870 mm (Figure 1). Medly survived well in droughts of up to 780 mm CE, whereas at 870 mm it suffered about 20% mortality. Lutetia was only tested in a drought of 780 mm CE where it survived poorly, with 60% mortality. Flecha survived droughts of up to 870 mm CE well, whereas Demeter suffered 30% mortality even in a moderate drought of 650 mm CE.

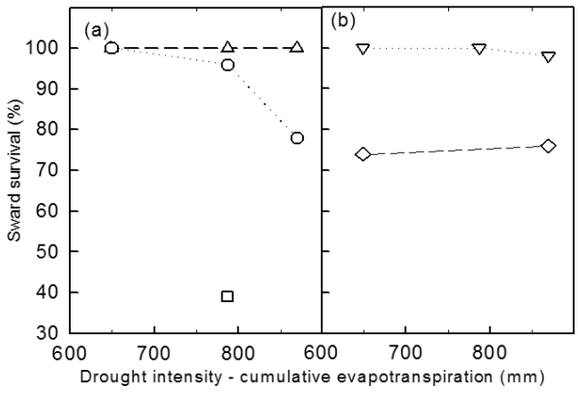

Figure 1. Survival over summer droughts of different intensity by (a) cocksfoot cvv Kasbah (triangle), Medly (circle), Lutetia (square) and (b) tall fescue cvv Demeter (diamond) and Flecha (inverted triangle).

Cultivars of both species with higher summer dormancy had better survival of drought than cultivars with low dormancy, confirming that summer dormancy is a powerful trait for drought resistance. The research with Medly (derived from cv Currie) suggests that, while drought avoidance confers good survival of moderate droughts, this is insufficient to keep plants alive under high intensity drought.

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