Establishment trials on acid soils with phalaris cultivars varying in aluminium tolerance

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Abstract

Breeding to improve phalaris performance on acid soils has resulted in two cultivars with higher aluminium (Al) tolerance; the commercial cultivar Landmaster and an experimental "AT" cultivar with even higher Al tolerance bred in from a related species. We compared the establishment of Landmaster and AT with other phalaris cultivars at sites on the Southern Tablelands, to see if greater Al tolerance in phalaris improves reliability of establishment on acid soils, particularly under unreliable seasonal conditions. Generally, AT and Landmaster established at higher densities than less Al-tolerant cultivars, but little difference was observed between AT and Landmaster in density in the second or later years. However, AT demonstrated higher average second-year yield than Landmaster and its commercial release is being pursued.

Key words

Acid soil, Al tolerance, establishment, phalaris.

Introduction

Improved performance on acid soils is a key selection aim in the CSIRO phalaris-breeding program. The first cultivar with improved adaptation to acid soils, Landmaster, was aimed at hilly land with moderately infertile, acid and shallow soils (Oram 1996). Work has continued on an "AT" population in which genes for tolerance to soluble Al, a major limiting factor in strongly acidic soils, were bred in from a more Al-tolerant *Phalaris* species (Oram *et al.* 1990). Despite AT clearly having higher Al tolerance when measured in nutrient solution (Requis and Culvenor 2004), the benefit of this higher tolerance is not always clear in terms of performance on strongly acid soils. Culvenor *et al.* (2004) found little variation in establishment and persistence between AT and older cultivars at 3 sites sown in autumn of a year with good rainfall, but AT was clearly superior in establishment on an acid soil when sown in early spring of a later year, possibly because of better root penetration as the soil profile dried during spring.

We hypothesise that improved Al tolerance in phalaris improves reliability of establishment on acid soils in the face of unreliable seasonal conditions. To address this hypothesis, an "AT cultivar" formed from the AT population, Landmaster and several other cultivars were sown twice a year at 4 acid sites from 2004-2006, a period of notably unreliable and often below average rainfall.

Methods

Experiments were conducted at 4 sites on the Southern Tablelands of NSW and 2 in NE Victoria. Surface (0-10 cm) pH in CaCl2 ranged from 3.9-4.2 and Al saturation ranged from 20-30% in the 0-10 cm layer and 20-60% in 10-30 cm layer. Due to late autumn breaks, trials were sown in August and September in 2004 and 2006, and in late June and August of 2005. Most sowings in 2006 failed completely because of severe drought. Plots were 4 m^2, and were sown with a cone seeder into shallow cultivation with 250 kg superphosphate/ha incorporated. Phalaris cultivars were AT, Landmaster, Holdfast, Sirosa and Australian II plus the 1998 generation of the AT population (AT98), all sown at 3 kg/ha. There were 4 replicates at each site. Density was measured as frequency, the proportion of squares in a grid containing live base of the sown grass. Successful establishment was indicated by second year frequency and a single measure of plot yield in early spring of the second year by cutting quadrats (NSW) or estimation (Victoria).

Results and discussion

Performance of phalaris was consistent across sites with the site × cultivar interaction generally being non-significant ($P>0.05$) or small. Establishment and survival at Victorian sites were lower than at NSW sites. Frequency measurements in the sowing and subsequent years (Table 1) showed that by the second year, phalaris cultivars segregated into 3 groups broadly related to their known Al tolerance. The top group for establishment density contained AT98, AT and Landmaster, the higher mean for Landmaster in 2004-sown trials being due to much better establishment in the second sowing at the least acid site (Bookham), when some parts of the second sowing were damaged by rainfall. This was the only occasion when AT and Landmaster differed significantly (P<0.05) in establishment density. An intermediate group contained Holdfast and Sirosa, and Australian II was the least dense cultivar, consistent with its low Al tolerance. Although these results partially confirm our hypothesis that Al tolerance can assist establishment on acid soils, the higher Al tolerance of the AT population compared with Landmaster did not result in denser establishment, and it appears that Landmaster has a useful level of acid soil tolerance.

In contrast to plant frequency measurements, the AT cultivar and the AT98 generation were clearly the highest-yielding phalaris lines in the second year averaged across sites for both years of sowing (Table 1). This difference was most clearly shown at the more acidic NSW sites, with differences at the Victorian sites and the least acid NSW site being smaller. These results were confirmed at Dick's Creek (NSW) for 2006-sown trials where plots sown in August 2006 survived through severe drought and gave the following yield scores on a 1-10 scale in March 2007: AT04 6.75, AT98 6.50, AT cultivar 6.40, Sirosa 3.50, Landmaster 3.12, Australian 2.62, Holdfast 2.25, LSD (P=0.05) 3.22.

Conclusion

AT and Landmaster generally established at higher density than cultivars with lower Al tolerance. Little difference was observed between AT and Landmaster in density in the second and later years, indicating that Landmaster has an agronomically useful degree of acid soil tolerance. However, the AT population demonstrated higher average second-year yield than Landmaster, suggesting that it may be able to cope better with variable climates. Work to develop AT as a commercial cultivar is continuing.

References

Culvenor RA, Wood JT, Avery AL, Dempsey W, McDonald SE, Ronnfeldt G, Veness PE (2004) Multi-site evaluation on acid soils of a *Phalaris aquatica* × *P. arundinacea* × *P. aquatica* backcross population bred for acid soil tolerance. *Australian Journal of Agricultural Research* **55**, 681-692.

Oram RN (1996) Register of Australian herbage plant cultivars A. Grasses 3. Phalaris (a) *Phalaris aquatica* L. (phalaris cv. Landmaster). *Australian Journal of Experimental Agriculture* **36**, 913-914.

Oram RN, Ridley AM, Hill MJ, Hunter J, Hedges DA, Standen RL, Bennison L (1990) Improving the tolerance of *Phalaris aquatica* L. to soil acidity by introgression of genes from *P. arundinacea* L. *Australian Journal of Agricultural Research* **41**, 657-668.

Requis J, Culvenor RA (2004) Progress in improving aluminium tolerance in the perennial grass, phalaris. *Euphytica* **139**, 9-18.

Table 1. Frequency of live base and second-year plot yield of sown grass averaged across 6 sites for trials sown in 2004 and 2005.

	2004-sown trials				2005-sown trials		
Phalaris	Frequency (%)			DM yield (kg/ha)	Frequency (%)		DM yield (kg/ha)
cultivar	2004	2005	2006	2005	2005	2006	2006
AT	46.6	42.2	47.9	1190	42.1	27.4	641
AT98	48.0	48.3	50.9	1411	44.3	31.1	683
Landmaster	54.8	46.1	53.2	862	42.8	27.7	469
Holdfast	42.8	35.4	41.3	802	39.0	22.5	349
Sirosa	48.1	36.3	41.0	879	38.2	21.0	435
Australian II	53.0	28.8	31.4	636	37.4	14.0	205
LSD (*P*=0.05)	3.3	5.0	5.8	278	4.0	4.4	146