Trophy – a locally adapted white clover cultivar for dry-land pastures

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Abstract. *A breeding project has developed a locally adapted synthetic white clover (*Trifolium repens*) cultivar, Grasslands Trophy that possesses enhanced tolerance of summer moisture-stress. The breeding strategy was an* in situ *breeding cycle i) identifying and selecting superior genotypes, ii) crossing elite germplasm and iii) progeny testing derived breeding lines for the expression of the target traits: early vigour, herbage yield, persistence and seed production capability. Trophy is medium-large in leaf-size, combines intermediate stolon density with intermediate stolon thickness, and expresses high stolon survival and strong autumn regrowth following summer moisture-stress. Agronomic results from sites with contrasting rainfall distribution show that Trophy has broad adaptation, expressing high growth in both cool and warm seasons, and is persistent for potentially at least four years.*

Introduction

Under Australian conditions of extensive grazing, legume-based pastures are an important feed resource because of the contribution of the legume component to feed quality and to the sustainability of soil fertility, water resources and crop production where ley farming is practised. The broad adaptation of white clover leads it to be the main perennial pasture legume for high rainfall temperate regions (Pearson *et al.* 1997).

Limitations of imported cultivars

Pasture improvement based on white clover and superphosphate commenced in southern Australia from the early 1950s, and initially was very successful. This has been attributed to the atypically favourable climatic conditions during the 1950–1960s. However, by the 1980s, poor persistence and high yield fluctuations were recognised as significant problems (McDonald 1988). At this time, Australia was reliant on imported cultivars. Because of poor homoclime match between the country of origin and the Australian white clover zone, the limitations of imported cultivars showed up as wide year-to-year yield fluctuations and lack of persistence, especially under adverse seasonal conditions. This was attributed primarily to poor tolerance of summer moisture stress. Also, growth in winter was restricted by winter cold; performance was poor where soil fertility was low, acidity high and on saline soils; and some cultivars were intolerant of grass competition and close grazing.

Breeding for tolerance of moisture-stress

A fundamental precept of the NSW DPI/AgResearch (New South Wales Department of Primary Industries/ AgResearch Ltd) white clover breeding program that commenced in the early 1990s was that breeding (white clover) for dry-land pasture environments requires genetic improvement of stolon characteristics (to enhance vegetative perennation) rather than to pursue the 'annual habit'. In Australia, naturalised ecotypes of white clover with the annual habit (prolific flowering and seedling recruitment) readily regenerate, but they typically contribute little to the feed supply. By contrast, the characteristic stolon morphology of white clover provides colonizing ability, longevity of the original population and persistence of the clover-stand through perennation.

In the absence of a proven ideotype, *in situ* selection for tolerance of moisture-stress and competitive vigour under grazing are essential components of plant improvement strategy (Ayres *et al.* 1996), and innovative design and analysis enhance the effectiveness of the evaluation phase (Murison *et al.* 2006).

The breeding strategy that developed Trophy placed emphasis on stolon characteristics for stolon survival and vegetative perennation, high herbage yield (including spring growth, summer-autumn regrowth, winter-activity) and high seed production capability. This strategy, based on accessing, breeding and *in situ* evaluation of medium-large leaf and mid-season maturity germplasm from Mediterranean environments,

develops breeding lines likely to possess tolerance of moisture-stress combined with cool season growth potential.

Methods

The characteristics and performance of Trophy were developed through: a) evaluation in northern NSW (Glen Innes) of 140 promising lines (compared with 10 check cultivars) leading to the selection of 20 elite genotypes; b) crossing in New Zealand (Palmerston North) to produce breeding lines; and c) progeny testing in northern NSW (Glen Innes and Armidale) of 17 derived breeding lines (compared with five check cultivars). Parental selection was also applied for seed yield, uniformity of leaf-size, flowering pattern and freedom from diseases and virus symptoms at Lincoln, New Zealand. Finally, broad adaptation was assessed at a winter rainfall site (Manawatu, New Zealand).

Results and discussion

Morphological characteristics

The morphological characteristics of Trophy compared with commercial cultivars are presented in Table 1. Trophy is medium-large in leaf-size similar to NuSiral. Trophy expresses exceptional leaf-size stability under contrasting seasonal conditions, reverting to medium leaf-size only during severe moisture stress. The stolon thickness of Trophy is intermediate between large-leaf types like Haifa and Waverley, and medium-leaf types like Sustain and Irrigation. The stolon density of Trophy is greater than Haifa and comparable with Sustain and Irrigation. Under winter-rainfall conditions in New Zealand, the stolon growing point density of Trophy was 1,500 stolons/m^2 compared with 1,313, 1,219, 1,000 and 438 stolons/m^2 for Sustain, Huia, Nusiral and Kopu, respectively (D.R. Woodfield, unpublished data). Trophy was exceptional in retaining a high level of stolon survival through summer moisture-stress; while the commercial cultivars on average suffered ca. 50 per cent stolon demise (eg. Haifa: 40 per cent, Sustain: 59 per cent, Prestige: 47 per cent) over summer-autumn, the corresponding value for Trophy was 21 per cent.

Agronomic performance

Data for seasonal herbage growth are presented in Table 2, early vigour in Figure 1 and persistence in Figure 2.

Early vigour – Of the check cultivars, NuSiral consistently expressed high early growth-vigour, while Trophy expressed a level of early vigour comparable with Haifa, Irrigation and Prestige.

Herbage growth – Trophy showed high spring-growth and high yield-stability at both the summer- and winter-rainfall sites and across years. The warm-season growth of Trophy was better than the commercial cultivars and cool-season growth was comparable to the highly winter-active cultivars Haifa and Waverley.

Persistence – The presence of all commercial cultivars declined during the third growth cycle under the severely adverse seasonal conditions experienced at

Table 1. Morphological characteristics of Trophy and commercial cultivars grown under field conditions at Armidale, NSW

	Trophy	Haifa	NuSiral	Irrigation	Prestige
Leaf area (mm^2)	188	200	182	167	103
Flowering maturity (days to flowering)	54	51	51	54	54
Flower density (number/m^2)	546	418	744	328	685
Stolon thickness (mm)	2.4	2.6	2.6	2.3	1.8
Stolon density (number/m^2)	560	380	400	447	767

Table 2. Seasonal yield (kg DM/ha) of Trophy and commercial cultivars grown under field conditions at Armidale, NSW. Means with different letters in the same row are significantly different ($P \leq 0.05$)

	Trophy	Haifa	NuSiral	Irrigation	Prestige
Spring growth	854 ab	464 d	831 ab	1021 a	721 bc
(% of Haifa)	(184)	(100)	(179)	(220)	(155)
Summer regrowth	226 a	176 ab	60 de	108 bc	43 de
(% of Haifa)	(129)	(100)	(34)	(62)	(24)
Winter growth	231 a	244 a	140 b	124 bc	106 bc
(% of Haifa)	(94)	(100)	(57)	(51)	(43)

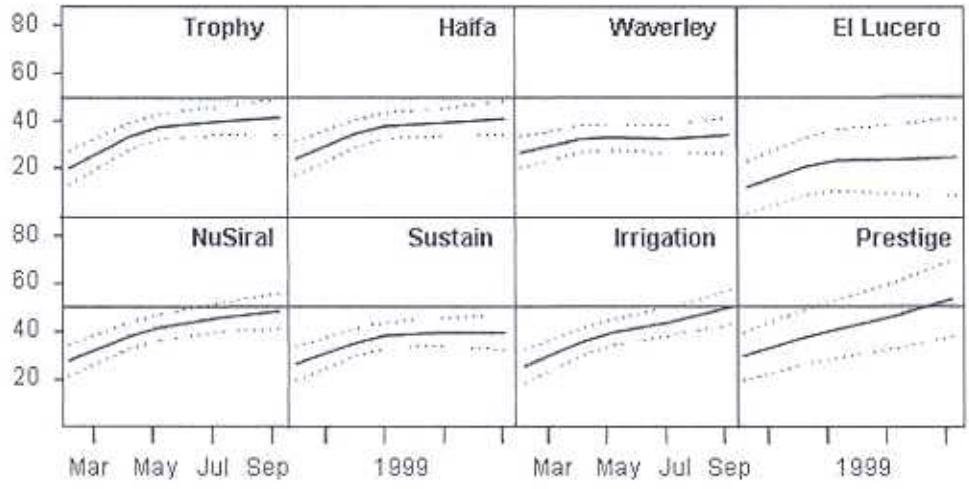

Figure 1. Early vigour (cm row spread in the first growth cycle) of Trophy and commercial cultivars grown under field conditions at Armidale, NSW.

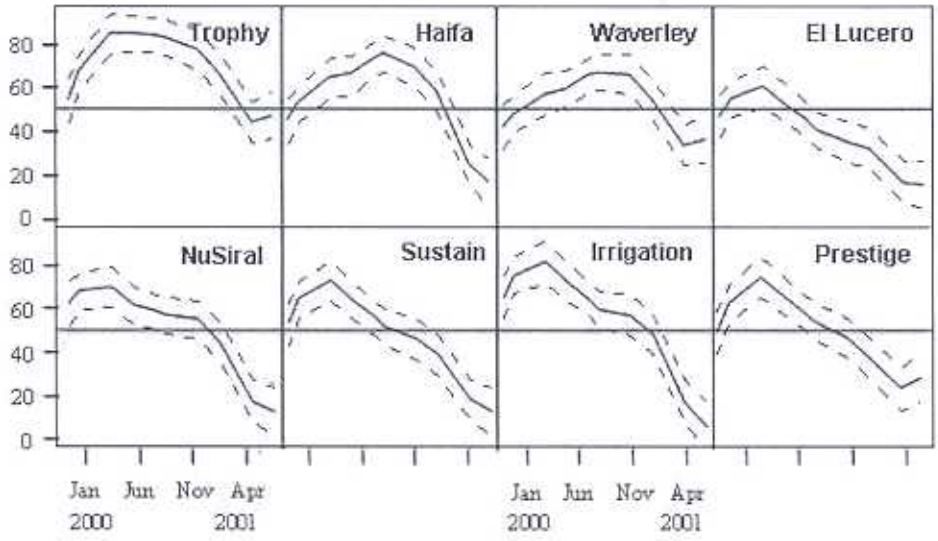

Figure 2. Persistence (% clover presence in growth cycles 2 and 3) of Trophy and commercial cultivars grown under field conditions at Armidale, NSW.

the NSW site. However, Trophy showed exceptional persistence through to the fourth growth cycle when the trial was terminated at the end of the project.

The breeding project has successfully developed a new synthetic white clover cultivar, Grasslands Trophy, using conventional breeding processes. Trophy possesses desirable characteristics, superior yield, agronomic performance and enhanced persistence under dry-land conditions in eastern Australia. Trophy has also expressed excellent seed yield potential with the nucleus genotypes yielding 975 kg/ha at Lincoln, New Zealand. The results [fully reported in Ayres *et al.* (2007)] illustrate the limitations of imported cultivars and highlight the benefits of locally adapted germplasm.

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Seed released by: PGG Wrightson Seeds

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