Breeding phalaris for better survival under adverse conditions

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The winter-active phalaris cultivars released by CSIRO Plant Industry collectively comprise nearly 80% of the phalaris sown each year in Australia. Increased seedling vigour and autumn and winter growth rates were the basis for selection during the development of these cultivars. Since 1980, the main thrust of the CSIRO breeding program has been increasingly towards producing cultivars better adapted to adverse conditions. This has occurred for a number of reasons. Firstly, there is a perception that the winter-active cultivars, represented mainly by cv. Sirosa, are not persisting as well as the old cv. Australian under heavy grazing. Secondly, the widespread acidification of soils and occurrence of naturally acid soils in south eastern Australia has led to persistence problems as the area sown to phalaris has expanded. Thirdly, as the desire to sow perennial species in the cropping zone increases, there is a need for a more summer-dormant cultivar able to survive in areas with longer summer droughts. This paper briefly describes two cultivars about to be released by CSIRO for use in specific adverse conditions, and then describes continuing work to breed more persistent phalaris.

Two new cultivars

Cv. Landmaster (BP92) is the first phalaris cultivar bred specifically for use on acid soils. It was selected on shallow, acid soils derived from sedimentary rocks in hill country in central and north eastern Victoria where excess rainfall entering groundwater systems is causing dryland salinity (Oram 1996), and is intended for use in these situations in Victoria and other states. Landmaster was 20% more productive than Holdfast and Sirosa

after 2 years at 2 sites in Victoria, only 9% the year after the 1994 drought but 18% in 1996. Seed should be available in 1997.

A new cultivar, 'Perla Retainer', will be a seed-retaining replacement for the discontinued cv. Sirocco. It is highly summer-dormant, and also has high seedling vigour and winter activity. This cultivar was selected from sward trials at Coolah, Merriwa and Wagga Wagga over 3 growing seasons, including the 1994 drought year. Perla Retainer is designed for persistence in areas with long, dry summers which are interrupted by brief wet spells. First supplies of seed should be available in 1998.

The current breeding program

The current breeding program concentrates on improving persistence under sub-optimal grazing and soil conditions. Major breeding objectives are:

- to replace Sirosa/Holdfast with a more grazing-tolerant cultivar. Several winter-active populations have been selected for 2 generations under heavy grazing, mostly set-stocking, on both acid and less acid soils.
- breed an acid soil-tolerant cultivar containing genes from *Phalaris arundinacea*, a more Al-tolerant species than *P. aquatica*. Several extra cycles of selection on acid soils should result in a population even more acid soil-tolerant than Landmaster.
- develop modifications of the Australian cultivar whilst trying to retain its high persistence under grazing. Two approaches are being tried here. First, the chromosome number of a Uneta x Australian population was doubled to generate plants with large seedlings for better establishment, but with the grazing-tolerance of cv. Australian. Second, crosses and backcrosses between Uneta x Australian and Perla Retainer are being selected for new combinations such as a more summer-dormant, Australian type for better grazing tolerance in drier locations.

Other aspects of the breeding program include selecting for lower alkaloid levels. A phase of testing at locations around south eastern Australian to select parents of new cultivars will commence if funding for the breeding program is maintained.

Results from early generations

Breeding a grazing-tolerant, winter-active type

Four populations are being developed. Two were selected from a broadly-based winter-active population growing on a limed, acid soil. This population was grazed intermittently for 3 years, then set-stocked at 15-30 wethers/ha for 3 years. Plants from the densest families were screened for Al tolerance in nutrient solution and the best intercrossed in 2 separate groups (BBP1, BBP2). The third population (Hf-GT) was selected from the densest of the 45 families which comprise Holdfast, and the fourth (Perla-GT) from swards of an early generation of Perla Retainer. These were sown on limed and unlimed acid soil, and grazed rotationally (2 weeks on, 4 weeks off) at 15 wethers/ha for 3 years.

Progeny of the plants were sown at 2 sites on yellow podzolic soil near Canberra, one (Wallaroo) acid and infertile ($pHCaCl_2$ 4.1, Bray P 2 mg/kg), the other (Stockade) more fertile but still quite acid ($pHCaCl_2$ 4.3, Bray P 12 mg/kg). Stockade has received 200 kg/ha superphosphate and Wallaroo 100 kg/ha annually since sowing. Set-stocking rate is 15-20 wethers/ha rate at Stockade, 10-13 wethers/ha at Wallaroo.

Swards were sown in mid-April 1994, a drought year. Establishment was very slow and paddocks were not grazed until early 1995. Scores indicating the proportion of the plot with satisfactory phalaris density on a 0-10 scale are presented in Table 1.

Breeding populations BBP1, BBP2 and Hf-GT had similar means, but BBP1 had the densest individual families. The lower mean for Perla-GT probably indicates sensitivity to acid soil. However, it may be useful in drought-prone environments with less acid soils. The breeding populations and Landmaster were superior to Sirosa and Sirolan at the Stockade site. Porto cocksfoot was clearly superior in density to phalaris at the low fertility Wallaroo site. Genetic analysis suggests a reponse to selection at Stockade is likely to be achieved in all populations except for BBP1. BBP1 and BBP2 are likely to be very responsive at Wallaroo. Across sites, narrow-sense heritability was moderate (approx. 0.4).

Evaluation trials

Two trials are in progress to test various populations that are under development. The first trial was set up to test the establishment and grazing tolerance of populations similar in type to cv. Australian

Table 1. Mean density scores and range of component families for winter-active breeding populations and controls at an acid, low fertility site (Wallaroo) and a more fertile site (Stockade) near Canberra.

Population/ Cultivar	Wallaroo	Stockade
Breeding populations		
BBP1	4.0 (2.3-6.3)	5.5 (3.9-8.1)
BBP2	3.8 (1.1-5.1)	5.4 (2.5-7.6)
Hf-GT	4.1 (2.1-5.6)	5.4 (2.5-7.3)
Perla-GT	3.2 (1.6-4.8)	4.7 (2.5-7.2)
l.s.d. (P<0.05) between means approx. 0.5		
Controls		
Sirosa	4.2	3.5
Sirolan	2.5	3.5
Landmaster	4.3	6.5
Australian	4.9	5.0
Porto cocksfoot	7.1	5.4
l.s.d. (P<0.05) approx. 2.0		

Table 2. Basal area in mid-November of second year.

Population/Cultivar	Basal area (%)
Australian	21.9
Uneta x Australian	16.0
Octoploid Uneta x Australian	10.4
Holdfast	11.1
BBP1	16.7
Hf-GT	13.5
Perla-GT	12.8
Grasslands Maru	13.2
l.s.d. (P<0.05) = 6.1	

under heavy set stocking. This trial has been grazed to less than 2 cm since Feb. 1996 (sown spring 1995). Estimates of basal area obtained by counting hits on live tiller bases at intersections of a 10 cm grid (50 x 50 cm quadrat, 4 quadrats per 14 m^2 plot, 4 replications) are shown in Table 2.

Australian (represented by the most vigorous of 9 certified seedlots) was higher in basal area than Uneta x Australian and the winter-active types. However, a bulk of the same generation of BBP1 described above was not significantly lower in area than Australian and was significantly higher than the typical winter-active control, Holdfast. This result is encouraging in that it suggests that BBP1 is a spreading winter-active type which might survive well under heavy grazing. The octoploid form of Uneta x Australian was not persisting as well as its tetraploid counterpart despite its higher initial seedling establishment.

The second trial was set up to test the performance of Landmaster, a *P. aquatica x P. arundinacea x P. aquatica* backcross population ("Acid-tolerant") and other entries at two sites, one sod-sown in autumn and one in spring, on acid soil low in P under set stocking. Phalaris presence was measured by counting the number of 10 cm squares with phalaris present out of 25 squares/quadrat (Table 3). Estimates in May of the second year did not reveal significant differences at the autumn-sown site despite higher seedling numbers for Acid-tolerant

Table 3. Percent presence of sown perennial grass at autumn- and spring-sown sites.

Population/Cultivar	Autumn-sown	Spring-sown
"Acid-Tolerant"	39	34
Landmaster	41	32
Holdfast	31	28
BBP1	40	30
Hf-GT	43	26
Perla-GT	40	30
Porto cocksfoot	34	51
l.s.d (P<0.05) not significant		

and Landmaster compared with Holdfast in the first year. Similar results were obtained at the spring-sown site except that Porto cocksfoot was clearly superior to phalaris, possibly because of its ability to compete with the existing *Bothriochloa*-dominated pasture present at this site. Progress from breeding appears to be limited on these strongly acid, infertile soils.

Conclusion

The CSIRO phalaris breeding program aims to develop cultivars with improved persistence under the adverse conditions provided by high grazing pressure and sub-optimal soil pH and fertility often encountered in practice. New cultivars, Landmaster for shallow acid soils and 'Perla Retainer' for dry, marginal areas, are in the process of release. Top priority is now given to breeding a more persistent replacement for Sirosa/Holdfast adapted to the main phalaris-growing areas by 2003.

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References

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