Development of a new mid-season cultivar of subterranean clover conforming to a predefined ideotype

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Summary. The National Subterranean Clover Improvement Program has selected a new subterranean clover, *Trifolium subterraneum,* cultivar called Goulburn, to replace the mid season cultivar Woogenellup, a major cultivar in southern Australia for over 40 years. Goulburn has greatly improved resistance to diseases limiting the productivity of Woogenellup, including clover scorch, *Kabatiella caulivora,* and tap root rot, *Phytophthora clandestina, as* well as a higher level of hardseededness to improve persistence. The selection of Goulburn demonstrates the ability of a nationally coordinated breeding program to construct an ideotype based on desired characteristics, and, through appropriate screening and field evaluation, to isolate and release a substantially improved cultivar.

Introduction

The mid-season maturity subterranean clover cultivar, Woogenellup, and the later maturing cultivar, Mount Barker, have been grown in eastern Australia for over 40 years. Together these two cultivars have made a major contribution to the cereal and animal industries in the 500 mm and above annual rainfall zone. Seed sales of Mount Barker however declined dramatically following the release in 1985 of the new cultivar Karridale which was designed for the higher rainfall areas of southern Australia.

Woogenellup has been a popular cultivar in the 500-600 mm rainfall zone due to its vigorous seedlings, erect growth habit and suitability for hay production, and has been a dominant cultivar in both dryland and irrigation areas. In the late 1970s, its performance in inland irrigation areas in southern NSW declined. In 1985, *P. clandestina,* was identified and Woogenellup was found to be highly susceptible (2). It was later concluded that *P. clandestina* was playing a major role in the loss of productivity of subterranean clover pastures (1) and the root rot tolerant cultivar, Trikkala, quickly replaced Woogenellup as the major cultivar in irrigation areas. The cultivar Junee was released in 1985 as a Woogenellup replacement in the drier zone of the Woogenellup belt. Its higher level of hardseededness, improved scorch resistance and moderate tolerance to root rot satisfied some of the requirements but its earlier maturity and more prostrate growth habit made it less attractive for the higher rainfall and irrigation areas.

The National Subterranean Clover Improvement Program commenced a program in the 1980s to find a replacement for Woogenellup. The program established that the new cultivar should have certain attributes if it was to successfully replace Woogenellup, namely, significant resistance to leaf rust, *Uromyces trifolii,* clover scorch disease, *K. caulivora,* tap root rot, powdery mildew, *Erysiphe polygonii,* and a level of hardseededness higher than Woogenellup. It should also be as productive *as* Woogenellup under disease free conditions. By predefining these minimum parameters required in the new ideotype, the cultivar would be most likely to be adapted to the environment previously dominated by Woogenellup. This paper describes the performance of the new cultivar selected as a result of the national screening program.

Methods

A group of 102 lines was selected from the national collection which conformed to the broad requirements defined by collaborators on the program and sown in preliminary screening trials in 1982. Following evaluation of these lines in each of the southern states, a group of nine experimental lines and six standard cultivars; Junee, Woogenellup, Mount Barker, Karridale, Trikkala and Seaton Park, were sown at 15 sites within NSW in 1987. Inoculated and lime pelleted seed was sown at 20 kg/ha in prepared seedbeds with 200 kg molybdenum superphosphate (9% P, 10% S, 0.04% Mo). The experimental designs were randomised complete blocks with four replications and, plot sizes of 2x4 m. Plots were grazed by sheep in common with the farmers paddock but closed up periodically to enable measurement

of pasture production. Pasture yields were estimated by taking 10 to 15 readings per plot using a calibrated pasture capacitance probe (3). Seed reserves were measured in December each year by excavating a strip of soil 2 m long x 10 cm wide x 2 cm deep from each plot. The burr were washed from the soil in a sieve, dried, and then thrashed to obtain a clean sample. Seed reserves were also harvested in winter at some locations to determine the level of hardseed present.

Data from three typical sites, located at Wagga Wagga, Cowra and Temora, are presented. The data were analysed using the SAFE statistical program with log transformations being used where appropriate.

Results and discussion

At the completion of field evaluation, the experimental line 89830F was found to most closely approach the ideotype. This line was later given the cultivar name, Goulburn. The relative levels of disease resistance in Goulbum and Woogenellup, are shown in Table 1.

Table 1. Disease resistance ratings for the subterranean clover cultivars Woogenellup and Goulburn.

Disease	Cultivar	
	Goulburn	Woogenellup
Clover scorch	2.8	7.7
Powdery mildew	0.4	2.4
Tap root rot	0.7	10.0
Leaf rust	0.3	1.0

0 = very resistant, 10 = very susceptible.

These data represent the results of screening programs by members of the National Program in Western Australia and Victoria. They indicate that tolerances to all the major diseases known to affect the performance of Woogenellup have been improved considerably.

Herbage yields

Data from the three sites show that the herbage yield of the cultivar Goulburn was equal or superior to Woogenellup on each of the 13 occasions the lines were compared (Table 2). Tap root disease does not usually occur in dryland stands for the first three years after establishment and hence increased root rot tolerance should not convey an advantage initially. However, even under disease free conditions, Goulburn was able to equal Woogenellup's productivity. Some root disease was apparent in 1990 at all three sites and this may explain the decline in the productivity of Woogenellup observed at the Wagga and Temora sites.

The data also indicate that the cultivar Junee, while appearing to be less productive than Woogenellup, because of its shorter petioles and more compact growth habit, usually yielded as much *as* Woogenellup. The major limitation of Junee is its inability to utilise late season rainfall due to its earlier maturity. This limits its role to the drier Woogenellup zone where earlier maturity is an advantage in ensuring a reliable seed set.

As the trials were grazed after all yield measurements, diseases such as clover scorch and mildew, which are more prevalent in thick clover swards, were not apparent. However, should stands of these cultivars

be left ungrazed for fodder conservation purposes, the greatly increased clover scorch tolerance (Table 1) should prove valuable.

Seed reserves and hard seed levels

The seed reserve of Goulbum was equal to Woogenellup on nine of the 11 occasions seed yields were measured. Although Goulburn is eight days later flowering than Woogenellup at Wagga, Goulburn has the ability to produce similar seed yields to Woogenellup in the drier margin of the Woogenellup zone (520 mm annual rainfall), indicating that later maturity should not affect its persistence. Replacing Woogenellup with a later maturing type has the advantage of extending the clover growing period and allowing it to exploit extended seasons when they occur. The proportion of seed that had not germinated by winter was much greater ($P<0.05$) in the cultivar Goulburn than in Woogenellup. The hard seed levels of Goulburn at Cowra and Wagga in the winters of 1987 and 88 were 23 and 37% respectively, while the corresponding figures for Woogenellup were 4 and 5%. The increased level of hardseededness in Goulburn, relative to Woogenellup, should assist in ensuring a large carryover of seed if seed set is restricted by low rainfall.

Table 2. Herbage yields of the subterranean clover cultivars Goulburn, Woogenellup ar Junee at three sites.

Site	Herbage yield (t/ha)				
COWRA					
Cultivar	*Oct. 88*	*Oct. 89*	*Jun. 90*	*Aug. 90*	*Oct. 90*
Goulburn	5.64	4.14	2.99	3.71	4.35
Woogenellup	4.96	3.00	1.82	3.14	3.73
Junee	5.79	3.70	2.88	3.34	4.02
l.s.d. (P =0.05)	0.46	0.39	0.30	0.37	0.27
WAGGA					
Cultivar	*Oct. 88*	*Aug. 89*	*Oct. 89*	*Sept. 90*	
Goulburn	4.62	2.06	4.25	3.00	
Woogenellup	3.13	1.09	3.35	1.08	
Junee	3.38	1.56	4.13	1.39	
l.s.d. (P=0.05)	0.81	0.41	0.57	0.62	
TEMORA					
Cultivar	*Apr. 89*	*Aug. 89*	*Sept. 90*	*Oct. 90*	
Goulburn	2.48	2.71	2.36	2.58	
Woogenellup	2.11	2.18	1.93	1.84	
Junee	2.56	2.07	2.05	2.13	
l.s.d. (P=0.05)	0.19	0.34	0.68	0.53	

Table 3. Seed reserves (In transformed) of the cultivars Goulburn, Woogenellup and Junee in December at three sites. Reserves in kg/ha are shown in brackets.

Site	Seed reserves			
Cultivar	*1987*	*1988*	*1989*	*1990*
COWRA				
Goulburn	5.88 (358)	5.20 (181)	6.69 (804)	-
Woogenellup	6.53 (699)	5.37 (215)	6.57 (713)	-
Junee	5.97 (392)	4.99 (147)	6.61 (743)	-
l.s.d. (P=0.05)	0.41	0.61	0.50	-
WAGGA				
Goulburn	5.09 (162)	4.69 (109)	6.70 (812)	6.89 (1075)
Woogenellup	5.67 (290)	5.53 (252)	6.50 (665)	6.61 (742)
Junee	5.64 (281)	5.67 (290)	6.98 (1075)	7.05 (1153)
l.s.d. (P=0.05)	0.39	0.91	0.36	0.51
TEMORA				
Goulburn	6.57 (713)	6.06 (428)	6.11 (450)	6.27 (528)
Woogenellup	6.61 (742)	5.69 (296)	5.89 (361)	6.07 (433)
Junee	6.70 (812)	6.76 (862)	6.39 (596)	6.85 (944)
l.s.d. (P=0.05)	0.42	0.40	1.29	0.87

The development of the new cultivar Goulburn demonstrates that the National Subterranean Clover Improvement Program can define a new ideotype based on knowledge of the intended environments, carry out a selection and evaluation program and finally release a cultivar with major improvements in several important characteristics.

Acknowledgements

Mr P.G.H. Nichols and Mr D.J. Gillespie of WA Department of Agriculture provided scores on clover scorch, mildew and leaf rust and Ms S. Flat provided scores on resistance to Phytophthora. The Wool Research and Development Corporation on the recommendation of the Australian Wool Corporation financially supports the National Subterranean Clover Improvement Program.

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