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Coolamon subterranean clover (*Trifolium subterraneum* L. var. *subterraneum*)

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Abstract. Coolamon is a mid-season to late-season flowering F_4-derived crossbred subterranean clover of var. *subterraneum*, developed by the collaborating organisations of the National Annual Pasture Legume Improvement Program. It is a replacement for Junee and has been selected for release on the basis of its greater herbage production and persistence, and its resistance to both known races of clover scorch. Coolamon is recommended for sowing in Western Australia, New South Wales, Victoria, South Australia and Queensland. It is best suited to well-drained, moderately acidic soils in areas with a growing season of 6.5–8 months that extends into November. Coolamon is best suited to phase farming and permanent pasture systems. It can also be used in cropping rotations, but at least 2 years of pasture are required between crops. Coolamon has been granted Plant Breeders Rights in Australia.

Origin

Coolamon subterranean clover [*Trifolium subterraneum* var. *subterraneum* (Katz. et Morley) Zohary and Heller] was bred by P. G. H. Nichols at the University of Western Australia Field Station (UFS), Shenton Park, Western Australia. It is derived from the cross 84S20 made by J. S. Gladstones in 1984. The seed parent was the F1 hybrid Junee/CPI 89881E and the pollen parent was the F1 hybrid 75S13–2/69S37–3 (Dinninup//Daliak/Toodyay C///Midland B/Northam C).

Plant 84S20.14 was selected in 1986 at UFS as 1 of 14 F_2 single plants from cross 84S20. It was sown and harvested in 1987 as a bulk F_3 population in a clover scorch [*Kabatiella caulivora* (Kirchn.) Karak] disease screening plot at Denmark, Western Australia and was selected for further development on the basis of its resistance. In 1988, 84S20.14.7 was selected at UFS as 1 of 9 F_4 spaced plants from 84S20.14 to form the basis of Coolamon. Further between-line selection was conducted from 1989 to 1991 in 1-m rows at UFS and 1-m^2 clover scorch screening plots at Denmark. Selection criteria were as follows: (i) midseason maturity, (ii) low formononetin content (less than 0.2% of dry matter) using the procedure of Francis and Millington (1965), (iii) moderate hardseededness, using the laboratory procedure of Quinlivan (1961), (iv) moderate-strong burr burial, (v) strong winter and spring vigour, (vi) resistance to Races 1 and 2 of clover scorch and (vii) the leaf mark of CPI 89881E.

In 1992, Coolamon was selected as 1 of 62 midseason breeding lines of var. *subterraneum* for Stage I field evaluation in Western Australia, New South Wales, South Australia, Victoria and Queensland. In 1996, Coolamon was selected as 1 of 19 breeding lines to enter Stage II field evaluation trials in Western Australia, New South Wales, South Australia, Victoria and Queensland. Field evaluation was conducted as part of the National Annual Pasture Legume Improvement Program (NAPLIP). Stage I field evaluation was conducted under the code name 84S20–13, while Stage II evaluation was conducted under the code name SM012. The following collaborators of NAPLIP conducted field evaluation and final

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selection of Coolamon: P. G. H. Nichols and P. Si (Department of Agriculture and Food Western Australia), G. A. Sandral and B. S. Dear (New South Wales Department of Primary Industries), A. D. Craig and C. T. de Koning (South Australian Research and Development Institute), P. M. Evans (Department of Primary Industries Victoria) and D. L. Lloyd (Department of Primary Industries and Fisheries, Queensland). M. J. Barbetti, D. J. Gillespie and M. P. You (Department of Agriculture and Food Western Australia) conducted screening for disease resistance. D. J. Gillespie conducted screening for red-legged earth mite [*Halotydeus destructor* (Tucker)] resistance. P. G. H. Nichols and P. F. Smith (Centre for Legumes in Mediterranean Agriculture) conducted hardseed screening. The University of Western Australia conducted isoflavone analyses.

Coolamon was selected for release as a new cultivar in 2000. Selection was based on resistance to Races 1 and 2 of clover scorch, strong regeneration capacity, high winter and spring herbage production and high production and maintenance of seed reserves. The population for cultivar release was derived from 30 uniform plants selected in 2001. Coolamon is recommended for registration by the collaborating organisations of NAPLIP. It has been granted Plant Breeders Rights in Australia and is described in Nichols (2005). The Department of Agriculture and Food Western Australian will maintain breeders' seed.

Coolamon is named after the town of the same name in southern New South Wales.

Morphological description

Coolamon has a distinctive leaf mark inherited from its CPI 89881E parent. Leaves produced early in the season have broad, pale green A_3 arms (Nichols *et al*. 1996) with no central crescent. However, a pale green central C_2 crescent (Nichols *et al*. 1996) extending halfway to the leaf margins, is also present in leaves produced later in the season. Leaves have no anthocyanin flush but have occasional flecks. Indentation of the distal margin is moderately strong. Stipules commonly have red veins under closed canopies, while calyx tubes have no pigmentation. Petioles, peduncles and stems (runners) are all glabrous, while leaflet upper surfaces are weakly pubescent. Seed colour is black, with about 130 000 seeds per kg when grown under ideal conditions. Further descriptions and photographs of distinguishing features are given in Nichols (2005) and Nichols and Barbetti (2005).

Agronomic characters

Coolamon is a mid-season to late-season flowering variety, according to the terminology of Nichols *et al*. (1996). In Perth, it flowers about 131 days after sowing in early May, a few days later than both Junee and Woogenellup and about 9 days earlier than Goulburn (Nichols 2004).

Formononetin content in fresh leaves of spaced Coolamon plants is about 0.06% of dry matter (Nichols 2005), indicating a low potential to cause sheep infertility problems. The levels of genistein and biochanin A are about 2.4 and 0.5% of dry matter, respectively (Nichols 2005).

Coolamon is moderately hardseeded for its maturity. Over 6 seasons, Coolamon seeds derived from 1-m single rows averaged 42% hardseed after 16 weeks in a 15/60°C cabinet, using the standard laboratory procedures of Quinlivan (1961), while York, Junee, Seaton Park and Woogenellup had 58, 32, 25 and 5% hardseed, respectively. Laboratory results from spaced plants (Nichols 2005) showed hardseededness of Coolamon was not significantly different from Junee, but greater than Woogenellup. With this level of hardseededness, Coolamon can be used in cropping rotations, but at least 2 years of pasture are required between crops for reliable persistence.

Coolamon is highly resistant to both Race 1 and Race 2 of clover scorch disease caused by *Kabatiella caulivora*. Coolamon had a disease severity rating of 0.0 in a Race 1 field screening trial at Mt Barker, Western Australia, compared with scores for Seaton Park, York, Junee, Goulburn and Daliak of 7.0, 5.0, 3.0, 3.0 and 2.5, respectively (increasing disease severity scale of 0–10). In a Race 2 screening trial at Condingup, Western Australia, Coolamon had a disease severity rating of 1.0, compared with Goulburn with 0.3, Daliak with 4.4, York with 6.6, Junee with 6.5 and Seaton Park with 7.1 (increasing disease severity scale of 0–10) (You *et al*. 2005*a*).

Coolamon is resistant to cercospora leafspot (*Cercospora zebrina* Pass.). Inoculated field plots of Coolamon suffered no leaf collapse, while its cercospora leafspot incidence score was similar to Junee and Denmark, but less than Mt Barker, Esperance, Seaton Park and Dalkeith (Barbetti and Nichols 2005*a*).

Coolamon has some susceptibility to leaf rust (*Uromyces trifolii-repentis* Liro). Inoculated field plots of Coolamon had a high rust incidence and its disease severity score of 6.0 (increasing disease incidence scale of 0–10) was more than Mt Barker and similar to Denmark, but less than Seaton Park, York and Green Range (Barbetti and Nichols 2005*b*). Field observations also indicate that Coolamon is susceptible to powdery mildew (*Erysiphe polygonii* DC), but less so than Junee. This suggests that Coolamon may suffer herbage and seed production losses from both leaf rust and powdery mildew under ideal epidemic conditions in disease prone areas when paddocks remain ungrazed for extended periods in the spring.

Coolamon is moderately resistant to Race 001 and susceptible to Race 173 [formerly known as Race 0 and Race 1, respectively, and recently re-coded by You *et al*. (2005*d*)], two of the most widespread races of root rot caused by *Phytophthora clandestina* Taylor, Pascoe and Greenhalgh (You *et al*. 2005*b*). It is more resistant to Race 001 than Woogenellup, has similar resistance to Urana, but is less resistant than Seaton Park, York, Goulburn, Riverina and Junee. Coolamon is as susceptible to Race 173 as Woogenellup, Urana, Dalkeith, Goulburn and York, but is more susceptible than Seaton Park, Riverina, Denmark and Junee. Some production losses from Phytophthora root rot could occur in disease prone areas.

Coolamon is moderately susceptible to root rots caused by *Pythium irregulare* Buisman and *Fusarium avenaceum* (Fr.) Sacc. You *et al*. (2005*c*) showed Coolamon suffered similar *Pythium* tap root rot damage to Dalkeith, Woogenellup and Trikkala but more damage than York, Riverina, Seaton Park, Junee, Goulburn, Denmark and Urana. Lateral root rot damage comparisons were generally similar. You *et al*. (2005*c*) also showed Coolamon suffered similar *Fusarium* tap and lateral root rot damage to all cultivars tested. For both diseases,

Table 1. Mean field performance data of Coolamon (as a percentage of Junee) in 15 field trials across southern Australia
Not all traits were measured at each site in every year

Variety	Winter herbage Years 1–3	Spring herbage Years 1–3	Seed bank Years 1–3	Seedling regeneration density Years 2–4
Coolamon	110	114	104	112
Junee	100	100	100	100

however, seedling survival rate for Coolamon was no different from uninoculated controls, although mean shoot dry weight was significantly less than uninoculated controls following *F. avanaceum* inoculation.

Coolamon has similar susceptibility to other cultivars to red-legged earth mite, *H. destructor*, particularly at the cotyledon stage. In growth room tests on 2-week-old seedlings, mean cotyledon damage ratings were 5.8 for Coolamon, 4.1 for Urana, 5.2 for Junee, 5.7 for Seaton Park, 5.8 for Goulburn, 5.9 for York and 6.4 for Dalkeith, (on an increasing damage severity rating of 0–10).

Field performance data of Coolamon in 15 replicated Stage II trials across southern Australia under grazing managements typical of each district, is shown in Table 1. Comparisons are made with Junee, a common treatment at each site. The most outstanding features of Coolamon are its high herbage production and persistence. Over all trials, herbage production of Coolamon averaged 10% more in winter and 14% more in spring, than Junee. Its seedling regeneration densities were also 12% higher than Junee over the first four seasons from sowing. In one trial at Wundowie, Western Australia, persistence was measured into the sixth season. At this site, Coolamon had 58% more seedlings than Junee and 7.6-times the density of Woogenellup. Mean seed bank of Coolamon was slightly higher than Junee in the first 3 years from sowing.

Potential use

Coolamon can be regarded as a direct replacement for Junee (and to Woogenellup in areas where it is still grown), with improved field performance and resistance to Races 1 and 2 of clover scorch. It is recommended for sowing in Western Australia, New South Wales, Victoria, South Australia and Queensland. Coolamon is best suited to well drained, moderately acidic (pH_{Ca} 4.5–6.5) soils in areas with a growing season of 6.5–8 months that extends into November. Its resistance to clover scorch makes Coolamon well suited to areas where the disease is prevalent. Coolamon is adapted to permanent pasture and phase farming systems and also to cropping rotations, but at least 2 years are required between crops for reliable persistence.

Coolamon is well suited to mixtures with Urana, Seaton Park or York in the drier part of its target zone, while in the higher rainfall parts, it is suited to mixtures with Goulburn or Denmark. In paddocks with areas prone to waterlogging, Coolamon can be mixed with Riverina, or with Trikkala in drier regions and with Gosse or Napier in higher rainfall regions.

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Seed licenced to: Premier Seeds, PO Box 40, Forbes, NSW 2871, Australia.

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