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New sources of resistance identified in *Trifolium subterraneum* breeding lines and cultivars to root rot caused by *Fusarium avenaceum* and *Pythium irregulare* and their relationship to seedling survival

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Abstract. Breeding lines of *Trifolium subterraneum* were screened for resistance to root rot caused either by *Fusarium avenaceum* or *Pythium irregulare.* One of the tested lines showed good resistance to root rot caused by *P. irregulare*. High levels of resistance to *F. avenaceum* were identified in 19 among 50 tested lines. These sources of resistance will be of significant value to breeding programs as few sources of useful resistance in subterranean clover to these pathogens have previously been identified. There were overall significant negative correlations between root rot severity on either tap or lateral roots caused by *P. irregulare* with shoot dry weight; as there also was between lateral root rot caused by *F. avenaceum* and shoot dry weight. It is noteworthy that specific resistance to root rot caused by either of the individual pathogens was not linked to survival levels of the seedlings. This indicates that selection of lines for field performance should not only rely on specific resistance to root rot, but also on overall ability of seedlings to survive in the presence of these pathogens.

Additional keywords: ssp. *subterraneum*, ssp. *yanninicum*, subterranean clover, disease screening.

Root rot is a serious and widespread problem that greatly reduces the productivity of subterranean clover (*Trifolium subterraneum*) pastures in Australia (Barbetti *et al*. 1986*a*; Greenhalgh and Clarke 1985; Stovold 1974), with reported losses up to 70% in commercial grazed pastures (Barbetti 1984). *Pythium irregulare* and *Fusarium avenaceum* are frequently isolated from rotted roots of subterranean clover and are associated with root rot disorders of subterranean clover across Australia (Barbetti *et al*. 1986*a*; Greenhalgh and Clarke 1985; Stovold 1974). *P. irregulare* is generally considered to be the more pathogenic of these two fungi (Barbetti and MacNish 1978; Wong *et al*. 1985). Although there are various cultural strategies to reduce the effect of root rot of subterranean clover (Barbetti and MacNish 1984), the primary strategy is for farmers to use cultivars with adequate host resistance to these pathogens (Taylor *et al*. 1985; Barbetti *et al*. 1986*a*; Barbetti 1987; Greenhalgh and Flett 1987). Breeding for resistance is the most cost-effective method of disease control, both from an ecological and an economic point-of-view (Wolfe and Gessler 1992). This paper describes the results of a controlled environment study in which 50 late-season and mid-season *T. subterraneum* ssp. *subterraneum* and late-season *T. subterraneum* ssp. *yanninicum* breeding lines from the Australian National Annual Pasture Legume Improvement Program were screened in relation to root rot and survival in the presence of *P. irregulare* or *F. avenaceum*. The work also aimed to identify sources of resistance for further development as cultivars, or for use as parental material in the subterranean clover breeding program.

All disease screening experiments were carried out in a controlled environment room at 12/17°C with a 12 h photoperiod (light intensity of 165 W/m^2). A complete randomised design was used with four replicates for each breeding line, fungal isolate (or nil control) combination. Single isolates of *P. irregulare* (WAC4953) or *F. avenaceum* (WAC3920) (Department of Agriculture Western Australia, Culture Collection) were used in these studies. Isolates had been stored as lyophilised cultures for 10 years and revived for this study by subculturing onto cornmeal agar or potato-dextrose agar (PDA), respectively. Fifty stage II breeding lines comprising 17 late-season *T. subterraneum* ssp. *subterraneum* lines, 20 mid-season ssp. *subterraneum* lines and 13 late-season *T. subterraneum* ssp. *yanninicum*

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lines from the Australian National Annual Pasture Legume Improvement Program and 16 control cultivars across both ssp. *subterraneum* and ssp. *yanninicum* (Table 1) were also tested for comparison of their host responses to *P. irregulare* or *F. avenaceum*.

Sterile millet seeds (*Panicum miliaceum*) were prepared by soaking 200 g seed in de-ionised water in a 1 L flask for 12 h, draining the excess water and then autoclaving at 121°C for 20 min on three consecutive days. *P. irregulare* and *F. avenaceum* isolates were grown initially on cornmeal agar and PDA, respectively, at 17°C in the dark. The sterile millet seed in the flask was inoculated with 1-cm squares of either *P. irregulare* or *F. avenaceum* colonies on agar cut from the leading edge of colonies. The inoculated millet seed was then incubated on a laboratory bench at 22°C for 14 days and shaken vigorously every second day to ensure even fungal colonisation of the seed.

The colonised seed was mixed with pasteurised U.C. Mix (University of California Soil Mix; Baker 1957) at a rate of 0.5% (w/w) in a cement mixer and ~750 g of the resulting mixture used to fill each 10-cm-diameter pot. The pasteurised soil mix was prepared using aerated steam for 90 min at 70°C. Twenty subterranean clover seeds of each line or cultivar were sown in each pot at 1 cm depth. As lines tested can vary in relation to germination rate, all disease effects in relation to seedling survival were assessed against respective nil disease controls. Pots were watered every day with de-ionised water to field capacity. Four weeks after sowing, the plants were removed and the roots washed free of soil under running tap water. Tap and lateral roots were rated individually for disease severity using a 1–3 scale (Barbetti and MacNish 1984) where 1 = root completely healthy to slight root rot (not exceeding 10% of root tissue affected by root rot), 2 = moderate root rot (11–70% of root tissue affected), and 3 = severe root rot (71–100% root tissue affected or rotted off). A root rot score of <1.5 or <1.3 was considered as showing resistance against *P. irregulare* or *F. avenaceum*, respectively. Plant dry shoot and dry root weights from each pot were also recorded. Isolations were made from diseased tissues to confirm that disease symptoms observed were caused by the respective pathogens. Results were analysed using the analysis of variance and linear regression functions of Genstat V. Least significant differences were calculated and applied as appropriate.

In the late-season *T. subterraneum* ssp. *subterraneum* lines, one line (SL016) showed resistance to root rot (disease score <1.5) caused by *P. irregulare* in relation to both tap and lateral root rot (Tables 2 and 3). Of the mid-season lines of *T. subterraneum* ssp. *subterraneum* and late-season lines of *T. subterraneum* ssp. *yanninicum* tested, none showed resistance to *P. irregulare* in relation to root rot on either tap or on lateral roots. It was interesting to note that control cvv. Riverina, Larisa, York and Leura all showed lower levels of tap root disease from *P. irregulare* than nearly all tested breeding lines across the three maturity categories, highlighting the success of earlier programs,

Table 1. Australia National Annual Pasture Legume Improvement Program advanced breeding lines and control cultivars tested

Stage II late-season ssp. *subterraneum*	Stage II mid-season ssp. *subterraneum*	Stage II late-season ssp. *yanninicum*	Comparison cultivars ssp. *subterraneum*	Comparison cultivars ssp. *yanninicum*
SL001	SM001	YL001	Daliak	Gosse
SL002	SM002	YL002	Denmark	Meteora
SL003	SM003	YL003	Dinninup	Trikkala
SL004	SM004	YL004	Goulburn	Larisa
SL005	SM005	YL005	Woogenellup	Riverina
SL006	SM006	YL006	Dalkeith	Urana
SL007	SM007	YL007	Junee	
SL008	SM008	YL008	Leura	
SL009	SM009	YL009	Seaton Park LF	
SL010	SM010	YL010	York	
SL011	SM011	YL011		
SL012	SM012	YL012		
SL013	SM013	YL013		
SL014	SM014			
SL015	SM015			
SL016	SM016			
SL017	SM017			
	SM018			
	SM019			
	GR-508			

Table 2. Response of breeding lines and control cultivars to root rot of tap roots caused by *Pythium irregulare*

Mid-season lines ssp. *subterraneum*	Tap root rot severity	Late-season lines ssp. *subterraneum*	Tap root rot severity	Late-season ssp. *yanninicum*	Tap root rot severity	Cultivar	Tap root rot severity
SM008	1.6	SL016	1.2	YL005	1.8	Riverina	1.0
SM003	2.0	SL017	1.9	YL003	1.8	Larisa	1.0
SM010	2.1	SL008	2.8	YL007	1.9	York	1.0
SM005	2.1	SL015	2.2	YL006	2.0	Leura	1.1
SM011	2.2	SL011	2.5	YL012	2.0	Junee	1.3
SM007	2.2	SL003	2.5	YL002	2.1	Seaton Park LF	1.3
SM014	2.3	SL010	2.6	YL004	2.1	Urana	1.5
SM009	2.4	SL001	2.6	YL011	2.1	Denmark	1.8
SM006	2.4	SL009	2.7	YL001	2.4	Goulburn	1.9
SM004	2.4	SL002	2.8	YL008	2.4	Meteora	1.9
SM015	2.5	SL007	2.8	YL010	2.5	Dinninup	2.0
SM019	2.6	SL014	2.8	YL009	2.7	Daliak	2.0
SM018	2.6	SL006	2.8	YL013	2.4	Gosse	2.4
SM016	2.6	SL004	2.9			Dalkeith	2.4
SM001	2.7	SL005	2.9			Woogenellup	2.5
SM012	2.7	SL012	2.9			Trikkala	2.6
SM002	2.7	SL013	2.9				
SM017	2.7						
SM013	2.9						
GR-508	3.0						

Significance of genotypes $P < 0.001$; LSD ($P \leq 0.05$) = 0.50.

Table 3. Response of breeding lines and control cultivars to root rot of lateral roots caused by *Pythium irregulare*

Mid-season lines ssp. *subterraneum*	Lateral root rot severity	Late-season lines ssp. *subterraneum*	Lateral root rot severity	Late-season ssp. *yanninicum*	Lateral root rot severity	Cultivar	Lateral root rot severity
SM008	2.7	SL016	1.2	YL005	3.0	Riverina	2.0
SM003	2.9	SL017	2.4	YL003	2.7	Larisa	2.0
SM010	2.8	SL008	3.0	YL007	2.9	York	2.2
SM005	2.8	SL015	2.9	YL006	3.0	Leura	2.0
SM011	2.9	SL011	2.9	YL012	3.0	Junee	3.0
SM007	2.8	SL003	2.9	YL002	3.0	Seaton Park LF	2.1
SM014	3.0	SL010	3.0	YL004	3.0	Urana	2.6
SM009	3.0	SL001	3.0	YL011	3.0	Denmark	2.5
SM006	2.9	SL009	2.9	YL001	3.0	Goulburn	2.4
SM004	2.9	SL002	2.8	YL008	3.0	Meteora	2.9
SM015	2.5	SL007	2.9	YL010	3.0	Dinninup	2.6
SM019	3.0	SL014	3.0	YL009	3.0	Daliak	2.8
SM018	3.0	SL006	3.0	YL013	3.0	Gosse	3.0
SM016	3.0	SL004	3.0			Dalkeith	3.0
SM001	2.8	SL005	2.9			Woogenellup	3.0
SM012	3.0	SL012	3.0			Trikkala	3.0
SM002	3.0	SL013	3.0				
SM017	3.0						
SM013	3.0						
GR-508	3.0						

Significance of genotypes $P < 0.001$; LSD ($P \leq 0.05$) = 0.36.

such as Barbetti *et al*. (1986*b*), which identified host resistance to this pathogen.

Of the mid-season *T. subterraneum* ssp. *subterraneum* lines tested, eight lines SM017, SM005, SM015, SM016, SM014, SM009, SM006 and SM007, showed resistance to root rot (disease score <1.3) caused by *F. avenaceum* on both tap and lateral roots (Tables 4 and 5). Of the *T. subterraneum* ssp. *subterraneum* late-season

Table 4. Response of breeding lines and cultivars to root rot of tap roots caused by *Fusarium avenaceum*

Mid-season lines ssp. *subterraneum*	Tap root rot severity	Late-season lines ssp. *subterraneum*	Tap root rot severity	Late-season ssp. *yanninicum*	Tap root rot severity	Cultivar	Tap root rot severity
SM017	1.1	SL009	1.2	YL010	1.1	Seaton Park LF	1.0
SM005	1.1	SL010	1.2	YL008	1.1	Daliak	1.1
SM015	1.1	SL014	1.2	YL002	1.1	York	1.1
SM016	1.1	SL004	1.3	YL001	1.3	Riverina	1.2
SM014	1.2	SL006	1.3	YL004	1.3	Meteora	1.2
SM009	1.3	SL001	1.3	YL011	1.3	Goulburn	1.2
SM006	1.3	SL012	1.3	YL013	1.3	Dinninup	1.2
SM007	1.3	SL005	1.3	YL005	1.3	Leura	1.2
SM019	1.3	SL002	1.4	YL006	1.3	Trikkala	1.3
GR-508	1.3	SL016	1.4	YL003	1.4	Denmark	1.3
SM018	1.3	SL013	1.4	YL007	1.4	Urana	1.4
SM011	1.3	SL008	1.4	YL009	1.4	Junee	1.4
SM013	1.3	SL011	1.4	YL012	1.6	Gosse	1.5
SM008	1.3	SL015	1.5			Dalkeith	1.6
SM012	1.4	SL003	1.6			Woogenellup	1.6
SM003	1.4	SL017	1.6			Larisa	1.6
SM001	1.4	SL007	1.7				
SM004	1.4						
SM002	1.5						
SM010	1.6						

Significance of genotypes $P < 0.001$; LSD ($P \leq 0.05$) = 0.43.

Table 5. Response of breeding lines and cultivars to root rot of lateral roots caused by *Fusarium avenaceum*

Mid-season lines ssp. *subterraneum*	Lateral root rot	Late-season lines ssp. *subterraneum*	Lateral root rot	Late-season ssp. *yanninicum*	Lateral root rot	Cultivar	Lateral root rot
SM017	1.1	SL009	1.2	YL010	1.1	Seaton Park LF	1.0
SM005	1.1	SL010	1.2	YL008	1.3	Daliak	1.1
SM015	1.1	SL014	1.2	YL002	1.1	York	1.1
SM016	1.1	SL004	1.3	YL001	1.3	Riverina	1.1
SM014	1.2	SL006	1.3	YL004	1.2	Meteora	1.0
SM009	1.3	SL001	1.3	YL011	1.3	Goulburn	1.2
SM006	1.3	SL012	1.3	YL013	1.0	Dinninup	1.2
SM007	1.2	SL005	1.3	YL005	1.3	Leura	1.2
SM019	1.2	SL002	1.3	YL006	1.3	Trikkala	1.3
GR-508	1.3	SL016	1.3	YL003	1.3	Denmark	1.3
SM018	1.2	SL013	1.3	YL007	1.3	Urana	1.3
SM011	1.2	SL008	1.4	YL009	1.4	Junee	1.3
SM013	1.3	SL011	1.3	YL012	1.6	Gosse	1.5
SM008	1.6	SL015	1.5			Dalkeith	1.4
SM012	1.3	SL003	1.5			Woogenellup	1.5
SM003	1.3	SL017	1.6			Larisa	1.2
SM001	1.3	SL007	1.6				
SM004	1.4						
SM002	1.3						
SM010	1.5						

Significance of genotypes $P < 0.001$; LSD ($P \leq 0.05$) = 0.42.

lines, five, SL009, SL010, SL014, SL004 and SL006, showed resistance to root rot caused by *F. avenaceum* (Tables 4 and 5). Six late-season *T. subterraneum* ssp. *yanninicum* lines, YL010, YL008, YL002, YL001, YL004 and YL011, showed resistance to root rot caused by *F. avenaceum* (Tables 4 and 5). No tested lines showed resistance to both pathogens. The levels of root disease obtained with *F. avenaceum* were clearly sufficient to be

Table 6. Effect of root rot caused by *Fusarium avenaceum* on shoot dry weight (mg) per plant

Late-season lines ssp. *subterraneum*	Control	*F. avenaceum*	Mid-season lines ssp. *subterraneum*	Control	*F. avenaceum*	Late-season ssp. *yanninicum*	Control	*F. avenaceum*	Cultivar	Control	*F .avenaceum*
SL001	28	34	SM001	22	22	YL001	31	18	Daliak	22	24
SL002	26	34	SM002	35	41	YL002	31	20	Denmark	39	20
SL003	28	35	SM003	16	17	YL003	30	15	Dinninup	19	20
SL004	22	25	SM004	23	19	YL004	28	8	Gosse	33	26
SL005	27	29	SM005	52	21	YL005	26	17	Goulburn	18	21
SL006	29	37	SM006	61	17	YL006	25	20	Meteora	34	33
SL007	40	30	SM007	43	27	YL007	33	23	Trikkala	32	35
SL008	23	36	SM008	42	29	YL008	22	14	Woogenellup	27	40
SL009	39	43	SM009	24	18	YL009	32	24	Dalkeith	29	30
SL010	32	28	SM010	31	19	YL010	31	32	Junee	17	32
SL011	45	41	SM011	30	20	YL011	28	19	Larisa	18	21
SL012	41	14	SM012	29	42	YL012	28	27	Leura	26	27
SL013	29	19	SM013	32	23	YL013	35	41	Riverina	33	31
SL014	19	15	SM014	31	19				Izmir	25	16
SL015	24	26	SM015	35	25				Seaton Park LF	19	25
SL016	37	32	SM016	32	23				York	29	25
SL017	30	31	SM017	32	23						
			SM018	33	22						
			SM019	25	29						
			GR-508	32	17						

Significance of genotypes $P < 0.001$; LSD ($P \leq 0.05$) = 9.0.

of biological significance; for example, as demonstrated by more than half of the mid-season lines showing significant reductions in shoot dry weight.

There was overall a significant negative correlation between root rot severity on either tap or lateral roots caused by *P. irregulare* with shoot dry weight ($r = -0.26$, $P \leq 0.001$; $r = -0.2$, $P \leq 0.001$, respectively). There was a significant positive correlation between tap root rot and lateral root rot caused by *P. irregulare* ($r = 0.64$; $P \leq 0.001$). Similarly there was a significant positive correlation between shoot dry weight and root dry weight ($r = 0.17$; $P \leq 0.01$) for *P. irregulare* infected plants.

There was a reduction of shoot dry weight from root rot caused by *F. avenaceum* (Table 6). There was a negative correlation between lateral root rot caused by *F. avenaceum* and shoot dry weight ($r = -0.19$; $P \leq 0.01$). There was a positive correlation between tap root rot and lateral root rot caused by *F. avenaceum* ($r = 0.85$; $P \leq 0.01$). Similarly, there was an overall positive correlation between shoot dry weight and root dry weight ($r = 0.38$; $P \leq 0.01$) for *F. avenaceum* infected plants.

Both *P. irregulare* and *F. avenaceum* reduced ($P \leq 0.05$) seedling survival on some breeding lines and cultivars compared with non-inoculated controls (Table 7). However, *F. avenaceum* did not significantly reduce seedling survival in 14 late-season and 15 mid-season lines of *T. subterraneum* ssp. *subterraneum* or in one line of late season *T. subterraneum* ssp. *yanninicum*. *P. irregulare* did not significantly reduce seedling survival in five late-season and six mid-season lines of *T. subterraneum* ssp. *subterraneum*. In contrast, all but one (YL006) late-season *T. subterraneum* ssp. *yanninicum* tested showed reduced seedling survival in response to presence of *P. irregulare* and, despite this, one of these lines, YL012, has since been released as the new cultivar 'Napier'. However, some lines showed high seedling survival against both *P. irregulare* and *F. avenaceum.* These included five late-season lines of *T. subterraneum* ssp. *subterraneum*, SL012, SL013, SL014, SL015 and SL016, and six mid-season lines of *T. subterraneum* ssp. *subterraneum* SM003, SM009, SM010, SM012, SM018 and SM019. One of these lines, SM012 has since been released as the new cultivar 'Coolamon'. In contrast, none of late-season lines of *T. subterraneum* ssp *yanninicum* showed good seedling survival against both pathogens (Table 7). No root rot was observed on any controls (nil treatment).

Lines identified from this study with resistance to root rot caused by *F. avenaceum* or the single line with resistance to *P. irregulare* could be utilised as cultivars in their own right, providing they contain other suitable agronomic characters, or used as a parental source of resistance to these pathogens within subterranean clover breeding programs. Clearly, more breeding lines need to be screened for resistance to root rot caused by *P. irregulare* to identify additional sources of host resistance to this pathogen.

Our results confirmed the earlier findings by Barbetti (1984) and Wong *et al*. (1986) that root rots caused by

Table 7. The effect of *Fusarium avenaceum* (F) and *Pythium irregulare* (P) on seedling survival rate (%) (C = Control)

Late-season lines ssp. *subterraneum*	C	F	P	Mid-season lines ssp. *subterraneum*	C	F	P	Late-season ssp. *yanninicum*	C	F	P	Cultivar	C	F	P
SL001	28	14	9	SM001	85	59	30	YL001	81	36	53	Daliak	74	58	58
SL002	60	40	28	SM002	51	49	36	YL002	70	43	46	Denmark	69	56	61
SL003	40	36	23	SM003	60	59	63	YL003	59	31	18	Dinninup	83	48	66
SL004	53	54	15	SM004	56	54	29	YL004	73	39	44	Gosse	84	43	65
SL005	33	21	14	SM005	59	60	44	YL005	84	51	63	Goulburn	90	68	78
SL006	54	41	26	SM006	71	64	46	YL006	91	49	80	Meteora	58	35	46
SL007	55	33	35	SM007	61	50	35	YL007	88	51	53	Trikkala	66	64	58
SL008	39	30	21	SM008	64	43	41	YL008	73	36	50	Woogenellup	63	30	69
SL009	49	45	24	SM009	44	45	41	YL009	60	50	43	Dalkeith	81	33	34
SL010	68	35	48	SM010	56	53	53	YL010	81	26	56	Junee	80	34	66
SL011	60	54	46	SM011	71	45	50	YL011	83	46	60	Larisa	79	41	78
SL012	30	24	25	SM012	63	56	51	YL012	64	26	38	Leura	74	38	71
SL013	28	29	24	SM013	53	50	36	YL013	78	21	53	Riverina	86	51	59
SL014	26	23	30	SM014	75	58	49					Izmir	65	35	63
SL015	31	21	28	SM015	69	74	49					Seaton Park LF	86	56	61
SL016	55	54	66	SM016	76	69	39					York	85	59	73
SL017	50	51	39	SM017	81	69	51								
				SM018	54	64	58								
				SM019	53	43	49								
				GR-508	76	48	29								

Significance of genotypes $P < 0.001$; LSD ($P \leq 0.05$) = 14.0.

P. irregulare and *F. avenaceum* can significantly reduce plant shoot and root dry weights. *P. irregulare* caused more severe root damage than *F. avenaceum* and also larger reductions in root and shoot dry weights and in seedling survival. *P. irregulare* is recognised as the more pathogenic of the two pathogens (Barbetti and MacNish 1978). In our study, although some lines showed high seedling survival in the presence of *P. irregulare* or *F. avenaceum*, the same lines often showed little or no resistance to root rot, or *vice versa*, suggesting that both these characters need to be screened for, as both poor seedling survival and root disease on surviving plants are causes of losses in pasture productivity (Barbetti *et al*. 1986*a*). It was likely that damping-off was caused by hypocotyl damage whereas root rot on surviving seedlings was mainly a consequence of root damage. The differential responses of lines to damping-off and root rot indicate that at least in some lines genetic resistance to these fungi is not the same for both hypocotyls and roots. A similar behaviour was reported by Schmitthenner (1985) where they found that soybean lines similarly differed in their resistance to hypocotyl and root rots caused by *Phytophthora megasperma* var. *sojae*. Specific resistance effective at the seedling and adult plant stage is assumed to follow the gene-for-gene relationship (Flor 1959), and the combination of different specific resistance genes has resulted in cases of remarkable progress in the stability of resistance to plant diseases in different regions and over some years (Börner *et al*. 1999). However, the vulnerability of specific resistance to a quick adaptation by the pathogen could be a disadvantage. For resistance to *P. irregulare* and *F. avenaceum*, we suggest that plant breeders target non-specific resistance which can be present in plants that are susceptible at the seedling stage but resistant at the adult plant stage (Börner *et al*. 1999). The *P. irregulare* resistant line we identified showed resistance to tap and/or lateral root rot and also maintained high seedling survival whereas none of the control cultivars we tested showed such combination of tap and/or lateral root rot resistance in combination with good seedling survival. Poor seedling survival has been demonstrated as the primary factor in yield losses in subterranean clover pastures in root rot areas in Western Australia (Barbetti and MacNish 1978, 1984). Therefore, the lines with seedling resistance we have identified may well have a non-specific type resistance to root rot of significant value to subterranean clover breeding programs. Of particular interest was the line SL016 which showed overall good seedling survival and root rot resistance to *P. irregulare*, a widespread pathogen in the grain belt of Western Australia (Sivasithamparam 1993). It is interesting to note that this line, in addition to resistance to *P. irregulare*, has also shown significant resistance to race 0 of another serious oomycete pathogen of subterranean clover, *Phytophthora clandestina*, but not to race 1 or race 3 (unpublished data). This line is of importance as it offers potential to significantly improve subterranean clover productivity from its use as either a cultivar in its own right or as parental material to subterranean clover breeders.

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