A preliminary evaluation of perennial legume persistence on the Southern Tablelands of NSW

RC Hayes[A, F], MT Newell[B], WB Badgery[C], CA Harris[D], GD Li[A], Price[A], NR Munday[C], RS Stutz[E] and RA Culvenor[E]

[A]Wagga Wagga Agricultural Institute, Pine Gully Rd, Wagga Wagga, NSW 2650
[B]Cowra Agricultural Research and Advisory Station, Binni Creek Rd, Cowra, NSW 2794
[C]Orange Agricultural Institute, 1447 Forest Rd, Orange, NSW 2800
[D]Glen Innes Agricultural Research Station, 444 Strathbogie Road Glen Innes NSW 2370
[E]CSIRO Agriculture and Food, GPO Box 1700, Canberra, ACT, 2601
[F]Corresponding author: richard.hayes@dpi.nsw.gov.au

Abstract: *Perennial legume persistence was evaluated over three years at sites near Gurrundah, Tirranna, Middle Arm and Paling Yards on the Southern Tablelands. The persistence of white clover was the most consistent across all sites, and of 6 cultivars tested, cv. Haifa consistently had the highest year 3 frequency and cv. Nomad the lowest. Lucerne, strawberry, Talish and Caucasian clovers persisted adequately at the Paling Yards and the Tirranna sites but failed at the Gurrundah and Middle Arm sites. It remains uncertain whether any perennial legume cultivar is suitably robust to persist across a broad range of Southern Tablelands environments. The persistence values reported here are in pure swards where there is limited competition. The ability of perennial legumes to persist in these environments with a productive perennial grass is doubtful. Nevertheless, niches clearly exist for species such as lucerne for certain environments.*

Introduction

Environments across the Southern Tablelands of New South Wales (NSW) are generally considered to be high rainfall, nominally receiving >650 mm of average annual rainfall. However, there is no seasonal pattern to rainfall with similar average totals recorded for each month. In practice, this means that substantial rainfall can occur at any time during the year but periodic droughts are also common and not restricted to a particular month or season.

Temperate perennial pasture species have adaptive advantages in such environments compared to temperate annual species due to their capacity to utilise rainfall when it occurs. Established perennial plants have a root structure already in place and reserves of carbohydrates and nutrients to draw upon to facilitate early growth, potentially giving them a competitive advantage over annual species regenerating from seed that have to grow a root system with only the reserves in the endosperm from which to draw. Moreover, in Tablelands environments where pasture growth is constrained by cold winter temperatures, species that can grow beyond the confines of the normal winter-spring growing season may be at an advantage.

For these reasons it is perhaps not a surprise that the landscape of the Southern Tablelands in its native state was dominated by year-round and warm-season perennial rather than cool-season annual species (Culvenor 2009). The irony is that grazing systems still rely overwhelmingly on cool-season annual legumes to underpin production, predominantly subterranean clover (*Trifolium subterraneum*). Legumes remain the key source of nitrogen for pastures, raising the fertility of soil and increasing the quantity and quality (especially protein content) of forage for livestock. The objective of the present study was to assess the persistence of a broad range of perennial legume species that might augment or substitute for subterranean clover in Southern Tablelands environments.

Methods

Sites and experimental design

Four field experiments were sown in May 2018 near the rural localities of Gurrundah (34°38'S, 149°20'E; average annual rainfall (AAR) 700 mm), Tirranna (34°56'S, 149°41'E; AAR 670 mm), Middle Arm (34°35'S, 149°43'E; AAR

700 mm) and Paling Yards (34°10'S, 149°43'E; AAR 800 mm), all on the Southern Tablelands of NSW. The Middle Arm site is on an acidic shale-derived soil that is relatively low in P, S and K fertility. The Gurrundah site is on a deeper soil with influences from both granite and basalt parent material. Although a rich red colour, initial cores have shown that soil acidity and aluminium toxicity exist to depths of at least 1 m. The Tirranna site is on a relatively deep, acidic, sedimentary-derived soil rich in quartz stones and also low in K fertility. The Paling Yards site, by contrast, is on a red basalt soil and has few known chemical constraints, despite the existence of many basalt 'boulders' across the site. All perennial legume species were sown as a pure stand, replicated three times, as listed in Table 1. The self-regenerating annual legume, subterranean clover cv. Leura, was included as a control. Plots were 7.5 × 2 m (6 × 2 m at Tirranna), sown with a cone seeder set at 15 cm row spacings and fitted with narrow points and press wheels. Lime was surface-applied at 3.5 t/ha to all sites immediately prior to sowing and molybdenised superphosphate (8.8% P, 11% S, 0.25% Mo) was applied at 150 kg/ha at sowing to all sites except Tirranna where it was top-dressed in autumn of year 2. All cultivars were inoculated with rhizobium strain TA1 inoculum prior to sowing, except for Caucasian clover (strain CC283b), lucerne (RRI128), birdsfoot trefoil (SU343) and subterranean clover (WSM1325). Cultivars SARDI Grazer lucerne, Nomad and Tribute white clover were sown as pre-coated seed without re-inoculation. Sowing rates of each cultivar were adjusted for seed quality to deliver 2 kg/ha of germinable seed for white clover; 4 kg/ha birdsfoot trefoil, strawberry clover and Talish clover; 5 kg/ha red clover, 6 kg/ha Caucasian clover; 8 kg/ha lucerne; and 10 kg/ha subterranean clover. The same seed source was used for each cultivar across all sites. Poor seedling emergence at Tirranna required the site to be sprayed out and resown on 5 September 2018.

Sampling and analysis

Basal frequency (%) was used as an index of persistence. It was determined by laying a 1 m × 1 m quadrat, divided into 10 cm × 10 cm cells (n = 100), at two fixed locations within each plot and counting the number of squares containing the base of a sown legume, that is, cells in which shoots of a sown legume emerged from the soil surface. At the Tirranna site quadrat sizes were 1.0 × 0.75 m, divided into 10 cm × 15 cm cells (n = 50). The initial measurement

Table 1. A list of treatments tested (•) at the four experimental sites, Gurrundah (Gh), Tirranna (Ta), Middle Arm (MA) and Paling Yards (PY).

	Species	Common name	Cultivar/Line	Site			
				Gh	Ta	MA	PY
1	*Lotus corniculatus*	Birdsfoot trefoil	LC07AUYF	•	–	•	•
2	*Trifolium ambiguum*	Caucasian clover	Kuratas	•	•	•	•
3	*Medicago sativa*	Lucerne	SARDI Grazer	•	•	–	•
4	*Medicago sativa*	Lucerne	Titan 9	•	•	•	•
5	*T. pratense*	Red clover	Astred	–	•	–	–
6	*T. pratense*	Red clover	Relish	•	–	•	•
7	*T. pratense*	Red clover	Rubitas	•	•	•	•
8	*T. fragiferum*	Strawberry clover	Palestine	•	•	•	•
9	*T. subterraneum*	Subterranean clover	Leura	•	•	•	•
10	*T. tumens*	Talish clover	Permatas	•	•	•	•
11	*T. repens*	White clover	Haifa	•	•	•	•
12	*T. repens*	White clover	Nomad	•	•	•	•
13	*T. repens*	White clover	Storm	•	–	•	•
14	*T. repens*	White clover	Tribute	•	–	•	•
15	*T. repens*	White clover	Trophy	•	•	•	•
16	*T. ambiguum × T. repens*	White × Caucasian clover	Aberlasting	•	•	–	•

occurred in late spring in year 1, between the 12 November–10 December 2018, while the final measurement was undertaken in year 3 on 3 March at Gurrundah, 9 April at Paling Yards, 6 August 2020 at Middle Arm and 14 September 2020 at Tirranna. Data from each site was analysed individually for each sampling date with an analysis of variance.

Results

Most species established adequately in year 1 (Figure 1), despite the generally drier than average seasonal conditions received across all sites in 2018 (data not shown). There was no difference in basal frequency at the Middle Arm site with frequency of approximately 20% for all treatments. Values were similar at the Paling Yards site although frequency of Caucasian clover cv. Kuratas (11%) was the lowest of all treatments at that site and Haifa white clover (36%) was the highest. Initial basal frequency at the Gurrundah site was around 40% for the white and red clover cultivars, significantly higher than strawberry (6%), Caucasian (19%) and Talish (19%) clovers, and birdsfoot trefoil (16%). Lucerne cultivars were intermediate at that site. At the Tirranna site, there was a significant difference in frequency between treatments with up to 75% for Astred red clover and only 21% for strawberry clover.

All species had relatively higher basal frequency in year 3 (2020) at Tirranna compared to other sites although there was something of a reversal in the order of treatments at this site with strawberry clover having the highest basal frequency (95%) and Astred red clover the lowest (19%). Frequency values for all other cultivars were above 60%. A similar trend was observed at the Paling Yards site although frequency was much lower than at Tirranna, not exceeding 41%. Red clover had diminished to negligible values, as had birdsfoot trefoil in year 3 while lucerne and the white clovers (except cv. Nomad) retained the highest basal frequencies at the Paling Yards site. At the Gurrundah site, only the white clovers persisted to year 3 with basal frequency of cv. Haifa the highest (47%) and cv. Nomad the lowest (10%). At the Middle Arm site, none of the perennial legume species persisted to year 3 (Figure 1).

Discussion

The key insight from this study was that no single cultivar had uniform performance across all sites. The white clovers were probably the most consistent species across the sites, and of those, cv. Haifa consistently had the highest frequency and cv. Nomad the lowest in year 3. There was no apparent advantage in persistence of cv. Aberlasting, a white × Caucasian hybrid, compared to either white clover or Caucasian clover at any site. Lucerne, strawberry, Talish and Caucasian clovers persisted adequately at the Paling Yards and Tirranna sites but failed at the other two sites, likely associated with higher levels of acidity and at Middle Arm, lower soil fertility. The difference in performance across sites are not easy to determine, with soil type and seasonal conditions being probable contributors. This makes general recommendations of viable perennial legume species for the Southern Tablelands problematic because our study demonstrates that the best performer at one site is no guarantee of similar performance at other sites in the same region. It also probably impacts further development of perennial legume cultivars as the potential market size of any new cultivar is likely to be constrained by differences in soil type and conditions within a given region.

Care should be taken in the interpretation of frequency data because it can bias towards or against different plant forms. For example, it is likely that stoloniferous or 'creeping' plant types will have higher values of basal frequency compared to more erect types. This perhaps contributes to the relatively favorable performance of white clover in the present study. The higher apparent values reported for the Tirranna site could be partly attributed to the different quadrats used as well as the later sampling time in year 3 compared to other sites, as well as a more fertile and less acidic soil compared to the Middle Arm and Gurrundah sites. Frequency data is therefore best used as a relative measure of persistence over time at a given site. The frequency data presented here does not capture herbage yield of cultivars which

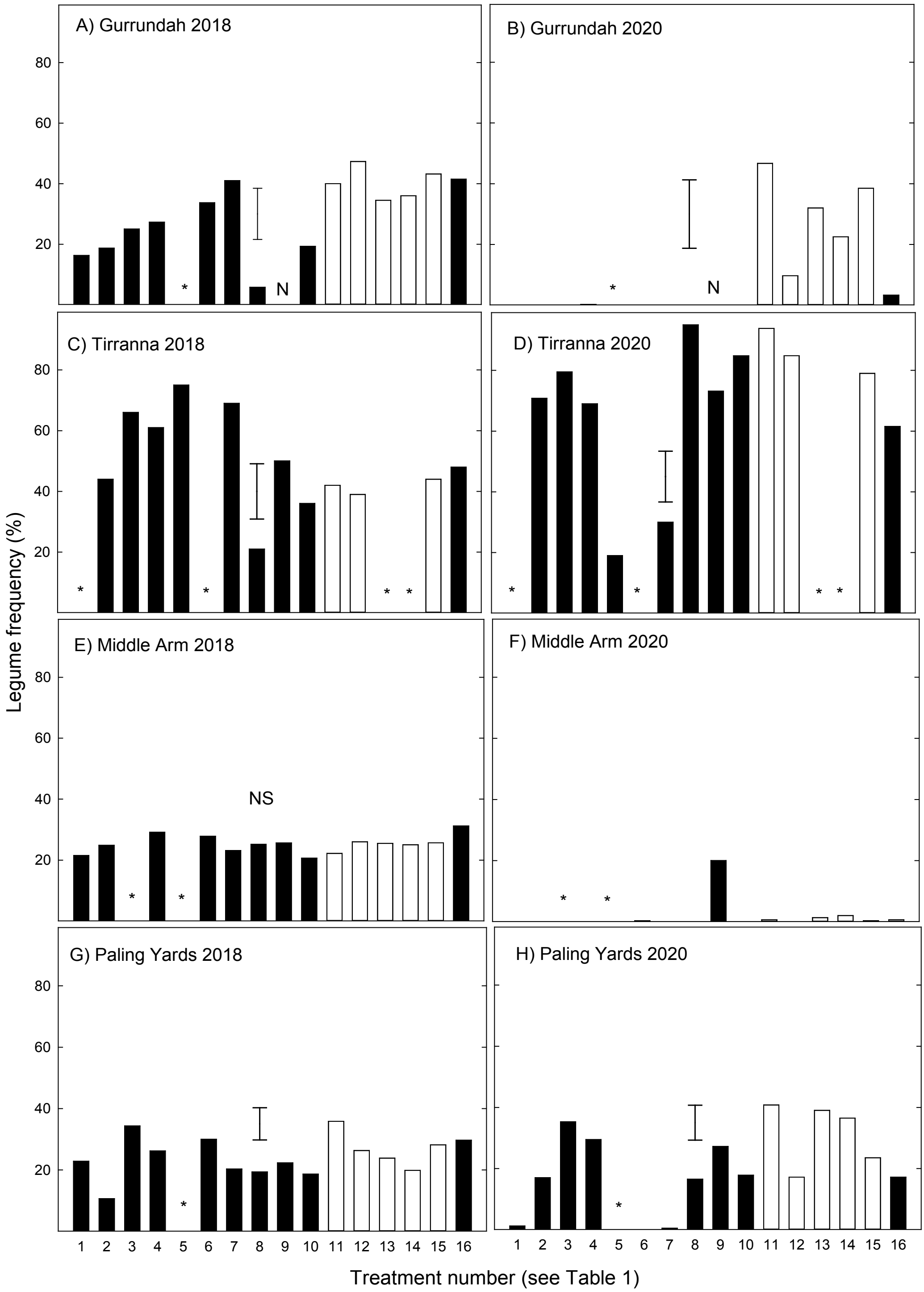

Figure 1. Basal frequency (%) of legumes at Gurrundah (A & B), Tirranna (C & D), Middle Arm (E & F) and Paling Yards (G & H) in the year of establishment, 2018 (A, C, E, G) and in year 3, 2020 (B, D, F, H). Error bars indicate significant differences at $P = 0.05$; NS, differences not significant; N, plots not sampled; *, treatment not included at that site. Species are as follows: 1, birdsfoot trefoil; 2, Caucasian clover; 3–4, lucerne; 5–7, red clover; 8, strawberry clover; 9, subterranean clover; 10, Talish clover; 11–15 (open bars), white clover; 16, white × Caucasian clover.

of course would also need to be considered in an evaluation of legumes. Nevertheless, where basal frequency is negligible as it was for most perennial legume cultivars at two of our four sites, we can assume herbage yield to also be negligible.

It remains uncertain whether any perennial legume cultivar is suitably robust to persist across a broad range of southern Tablelands environments. Our data would suggest that white clover is perhaps 'the best of a bad bunch' but even white clover seems marginal in these environments. The persistence values reported here are in pure swards where there is limited competition. The ability of these species to persist in these environments among a productive perennial grass-based sward is doubtful. This is a sobering finding when considered in the context of a previous study on the Southern Tablelands that showed there were very limited viable annual legume options besides subterranean clover (Hayes *et al.* 2015). Nevertheless, niches clearly exist for lucerne and some of the other perennial species. Further research is required to define those niches and determine the value that suitable alternative species might add to production systems in those environments.

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