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Too wet, too acid, too saline?

Pastures for acid soils in the north and central west

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As recently as 20 years ago light acid soils in central and northern inland NSW were regarded as almost useless (Freebairn 1990). However with a better understanding of soil acidity, the discovery of acid tolerant plants, research showing the benefits of lime, a better appreciation of correcting soil deficiencies, and better plant management, light soils are now widely regarded as productive and sustainable. Research continues to find improved plants and gains in soil quality resulting from improvement programs.

The northwest is regarded as a region of deep fertile clay soils, but over one million hectares comprises light acid country. The central west also contains a similar area of light acid soils.

Up to the 1980s, much of this light country was regarded as "poverty soil" with property owners always in financial difficulties, land overgrazed, and soils degraded. Little was know about the need for acid tolerant plants, the use of lime, or the need to address soil nutrient deficiencies. Current research has substantially been able to improve the viability of these soils and hence the worth and viability of these areas.

At the present time the main areas of study include investigation of more productive serradella varieties, more efficient rhizobia for serradella, the feasibility of biserrula, (a promising and acid soil tolerant annual legume), and testing a range of introduced perennial grasses. Long-term studies on the benefits and residual worth of lime are also underway, as well as developing cost effective fertiliser programs, developing strategies to combat light soil weeds (such as spiny burr grass and blue heliotrope) and the examination of soil quality changes. Limited work is beginning on the usefulness and management of native grasses.

Introduced annual legumes

Serradella

Varieties

Serradella is a deep rooted winter annual legume suited to soils with moderate as well as extreme soil acidity (Freebairn 1992). Main variety advances occurred with the release of Avila in 1987, Elgara in 1988, Madeira in 1988, and Paros in 1989.

The variety Cadiz which was released in 1996, possibly has an important role in NSW (B. Nutt, *pers. comm.*). It is an *Ornithopus sativus* type (pink flower) compared to the standard *O. compressus* types (yellow flower). The main advantages of Cadiz are believed to be better winter vigour, softer seed (therefore greater germination rates in early establishment years) and higher seed yields (cheaper seed). While hard seed is a drought survival mechanism, WA research indicates Cadiz has the ability to not germinate in response to out of season rainfall (B. Nutt, *pers. comm.*). It appears there may also be sufficient hard seed for long-term persistence.

Cadiz has so far performed equal to the best of 14 varieties in the Coonabarabran district (Table 1 - data average of four trials). It is similar maturity to Madeira, the current standard early maturing line. Assessments from trials at Trangie, Warren (A Bowman, *pers. comm.*) and Elong, showed Cadiz to be the outstanding variety in growth from one year's testing.

Santorina, a WA release in 1996, is to date showing no special advantages in the Coonabarabran,

Table 1. Serradella comparisons, Coonabarabran district, 1995-1996 data.

Cultivar	Production % Mean	Flowering Date (+)[1]
87GEH72.2A	100	0.0
87GEH72.1A	88	7.2
87GEH74A	92	10.3
Paros	90	3.7
87GEH56	101	9.2
87GEH69A	94	8.7
Santorini	90	12.8
MCD111	91	10.8
Madeira	96	14.5
Elgara	118	18.4
Cadiz	118	14.0
WA1208.1	96	17.7
Avila	70	32.0
Mean (kg/ha)	4318	22.8

[1]Compared to 87GEH72.2A

Elong, Warren, Trangie or Parkes trials. The line 87GEH72.2A may prove to be important for drier areas. It has the earliest maturity yet found.

Rhizobia

Research conducted across NSW over the past four seasons has led to the 1997 commercial release of an improved rhizobia bacteria strain for use in all serradella varieties (Gamel and Hartley, *per. comm.*). The new strain, WSM471, is replacing WU425, until now used for both lupins and serradella.

The research has shown that WSM471 is more efficient and likely to boost winter productivity of all serradella varieties. Another strain, WSM480, is undergoing further testing, and is probably superior to WSM471.

Biserrula (Biserrula pelecinus)

Biserrula is a winter annual legume, in many respects similar to serradella. In WA biserrula is believed to be potentially more appropriate than serradella on the very low clay content deep sands (B. Nutt, *pers. comm.*). It has been tested in NSW since 1995.

Coonabarabran, Elong, Trangie and Warren trials suggest biserrula has promise and is performing well. The biserrula accession, MOR99, at Trangie Warren and Parkes equalled performance of the best serradella varieties. Of seven accessions tested at Baradine and Binnaway in 1996, MOR99 is so far the most promising biserrula line.

Flowering of MOR99 is five days later than Madeira, but 12 days earlier than Avila (Coonabarabran data). Observations in 1995 suggest MOR99 may be more susceptible to blue green aphids than serradella (mainly resistant), but less susceptible than subclover (cv. Dalkeith).

Subterranean clover

Research over the last 15 years has found that sub clovers play a very important role in many of the moderately acid soils in central and northern inland NSW. The release of hard seeded earlier maturing cultivars such as Nungarin and Dalkeith have made a very significant contribution because of their long term persistence and productivity. In the higher rainfall areas mid season hard seeded cultivars such as Junee, York, and Seaton Park LF have also proven to be productive and persistent. Large areas of pasture across the region now contain subclover as the major winter legume component.

Caucasian clover

Preliminary testing suggests caucasian clover may have a valuable role in moderately acid soils in the better rainfall parts of the region. Caucasian clover is a perennial and in southern NSW has been more persistent than white clover (B. Dear, *pers. comm.*).

Table 2. Perennial grass variety trial, Binnaway. Sown 1987, assessed summer 1997.

Species	Plant frequency (%)
Consol	100.0
Bahia	91.5
Pioneer Rhodes	9.5
Perennial Veldt	0.0

Table 3. Perennial grass variety trial Binnaway. Sown 1991, assessed summer 1997.

Species	Plant frequency (%)
Consol	100
Premier Digit	85
Pioneer Rhodes	20
Bahia	10
Other grasses[1]	0

[1] Includes Gayndah buffel, Gatton panic, Hatch creeping blue, Bowen Indian blue grass, Petrie green panic, Purple pigeon grass, wallaby grass, Callide rhodes grass.

Introduced perennial grasses

A number of trials testing summer perennial grasses have been running across the region for up to 10 years. Depending on degree of soil acidity, soil type, and climate, Consol lovegrass, Premier digit grass, Pioneer Rhodes grass and bahia grass have overall been the best performers. For example, on soils with low aluminium, Pioneer Rhodes performs extremely well, whilst on higher aluminium soils, Consol lovegrass excels.

On a very acid site at Binnaway, pH 4.16, and more acid with depth, (aluminium 27.4% of CEC), Consol and bahia grass have been the outstanding performers (Table 2).

An adjoining trial compared a larger number of grasses (Table 3). Consol and Premier digit are the best performers. A trial on a similar acid soil at Coonabarabran has shown that Consol is the superior variety in terms of persistence and productivity of some 18 different perennial grasses.

In a less acid site at Tomingley (pH approximately 4.7, low aluminium) Pioneer and Katambora Rhodes grass and Consol have been the best performers (Table 4).

Native Perennial grasses

Little research has been undertaken to test the suitability of native perennial grasses for acid light soils in our region. Observations suggest a number of species are suited and some of them have potential for commercialisation. Trials with domesticated lines of Wallaby grass (cv. Taranna) indicate they have potential on light soils. Although it was slow to establish, the Tomingley trial is a good example of this potential (Table 4).

Table 4. Summer grass trial - Tomingley (Granite Sandy Loam). Sown March 1992.

Species/ cultivar	Performance[1]			
	1993	1994	1995	1996

Table 6. Soil microbial activity in fertiliser/lime trials.

Location	Fertiliser/ lime treatment	Basal Respiration[1]	Microbial C[2]
Mendooran	Nil	0.58	

2.7
1.9
1.5
1.2
1.2
1.0
1.0
0.3
0.3
0.0
0.0
0.0

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, but much native pas- nclude red some wal- ed a winter es are cor- es periodic ot reserves. persistent. agement to persistence,

the region ersal phos- Freebairn *et* also impor- 10 kg P/ha upled in the dual values uction from

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Applied annually
100
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100

pared with the

these relatively low rates of fertiliser ran down substantially over 4 years (Table 5).

Soil "quality"

Kathy King (*pers. comm.*) examined the microbial activity of soil collected from a number of central and northern inland NSW pasture fertiliser and lime trials, including some from lighter soils (Table 6). These trials have shown large production responses to relatively low rates of S and P, and, on acidic soils, good responses to lime.

King uses several biological indicators to assess the health of soils (K. King, *pers. comm.*). These are based on the activity and biomass of soil microbes, bacteria and fungi that are universally present in all soils, and are vital to nutrient cycling in soils. Respiratory rate of soils reflects the activity of microbes while microbial biomass (or microbial carbon levels) measures the total abundance of microbes in that soil.

Soil organic matter (organic C) doubled following 9 years of pasture improvement in a fertiliser trial conducted at Ulamambri in central western NSW (A. Freebairn, *pers. comm.*). Other characteristics that improved included microbial activity, soil N and P, moisture infiltration following rain, ground cover levels (which equate to less soil ero-

Table 7. Soil and other features measured in a fertiliser trial at Ulamambri.

Parameters	Treatment		% change
	No fertiliser	Fertiliser	
Organic C(%)	1.8	3.6	100
Infiltration rate (mm/min)	1.3	10.5	707
Plant cover (%) (July 1996)	60	100	66
WUE (DM/ha/mm rainfall)	2.03	11.13	448
Basal respiration (mg CO_2/hr/100g soil)	0.222	1.146	416
Microbial C (mg/100g soil)	95.03	175.19	84
Winter/spring DM (kg/ha/year)	567	3111	448

...nodes	3.4	3.5	2
Bambatsi panic	2.0	2.5	2
American buffel	1.3	1.0	1
Petrie green panic	1.0	1.3	1
Gatton panic	1.0	2.2	1
WA buffel	1.0	1.0	0
Purple pigeon	2.0	1.8	2
Pensacola bahia	1.0	2.5	0
Birdwood grass	1.0	1.0	1
Hatch creeping	1.0	0.6	0
Competitor bahia	0.7	2.5	0
Bisset creeping	5.0	3.0	1

Note: Bowen bluegrass and Curly Mitchell failed ning; [1]1= poor, 5= good.

Present research findings are limit anecdotal information is known abou tures. Species with a good reputation grass, windmill grasses, kangaroo gra laby grasses and warrego grass. Prov legume is added, soil nutrient deficie rected and grazing management incl rests for recruitment and rebuilding of native pastures can be productive a However a better understanding of m encourage regeneration and long term as well as high productivity is required

Soil factors

Fertility

Several trials conducted througho on light country identified almost u phorous (P) and sulphur (S) deficiency *al.* 1996). Molybdenum was sometime tant. Production gains from applying and 11-14 kg S/ha generally was qua first year. A trial at Binnaway testing r of fertiliser found that dry matter pr

Table 5. Dry matter production from re rus (8.6 kg/ha) and sulphur (11 kg/ha)

Year	Fertiliser applicati	
	Nil	Applied Year 1 only
1	21[1]	100
2	21	73
3	22	51
4	23	45

[1]Figures denote % dry matter (production) c treatment where fertiliser was applied every year

Table 8. Changes in soil pH with time after liming, "Katella" Dubbo

Year	pH ($CaCl_2$), 0-10 cm depth		
	Nil lime	1.25 t/ha lime	2.5 t/ha lime
1982[1]	4.25	4.25	4.25
1983	4.10	4.90	6.00
1984	4.25	4.60	5.10
1985	4.30	4.60	5.05
1986	4.28	4.65	4.78
1987	4.30	4.60	4.70
1989	4.22	4.50	4.70
1991	4.25	4.35	4.60
1992	4.30	4.40	4.65
1993	4.30	4.50	4.70

[1] (pre-liming)

sion), and a five fold improvement in water use efficiency (Table 7).

Lime

Research at Dubbo (Mullen 1997) has shown that 2 to 2.5 t/ha of good quality lime is sufficient to correct major soil acidity problems for many lighter soils, especially those with acid top soil but non-acid sub-soil. After 10 years, pH levels in areas which were initially limed were less acid than those in non-limed areas (Table 8). Continuing improved productivity suggests lime in limed plots has gradually moved down the soil profile and has improved the environment for root growth in the sub-soil.

Weeds

Spiny burr grass (*Cenchrus incertus; C. longispinus*), and blue heliotrope (*Heliotropium amplexicaule*) are major summer weeds of light soils throughout NSW (Auld and Medd, 1987). They thrive in degraded pastures and are encouraged by soil disturbance. A number of summer growing perennial grasses have been assessed at Coonabarabran and Gilgandra for their ability to out-compete spiny burr grass.

A trial sown in January 1995 on a sandy loam soil with pH 4.4 and 20% exchangeable aluminium, evaluated 26 summer grasses for their ability to out-compete spiny burr grass (Table 9). Consol was the only pasture to persist at a high frequency (Freebairn and Mathews 1996). Within 12 months it had largely out-competed spiny burr grass. Weed levels were down in all plots (because of no soil disturbance) in the second and third season, but remained high in the nil and failed grass plots. Premier digit grass which is suited to acid soils, did not germinate because of poor quality seed.

Table 9. Spiny Burr grass control, Coonabarabran.

Treatment	Spiny burr grass (plants/m^2)		
	1995	1996	1997
Consol lovegrass	328	10	6
No perennial grass	328	166	85

Table 10. Spiny burr grass control, Gilgandra.

Species/cultivar	Spiny burr grass (plants/m^2)
Pioneer rhodes grass	0.2
Gatton panic	1.3
Kazangula setaria	1.8
Narok setaria	1.9
Callide rhodes grass	2.8
Bambatsi panic	5.0
Nandi setaria	5.5
American buffel grass	6.7
Gayndah buffel grass	8.7
Control	8.7

A trial at Gilgandra, on a sandy loam soil with pH 4.8 and low exchangeable aluminium showed that Pioneer rhodes grass almost totally out-competed spiny burr grass within 18 months (Mullen 1985). Other species were not so competitive (Table 10).

Thousands of hectares have been successfully sown to Pioneer rhodes grass and Consol lovegrass to combat spiny burr grass in central and northern NSW. Mixtures of the two have also been very successful. Consol is preferred in the more acid soils, whereas rhodes grass thrives in the lower aluminium situations. Digit grass is also proving successful across the very acid as well as less acid light soils.

While only limited trial data exists, several landholders have demonstrated excellent results in controlling blue heliotrope with competitive summer perennial grasses.

Conclusion

Big advances have been made in the selection of suitable legumes and their rhizobia, developing feasible soil nutrient correction programs, strategies to correct soil acidity, the discovery of persistent and productive perennial grasses, and the control of major weeds. Preliminary research suggests these developments are greatly improving the sustainability and quality of light soils. Future research is needed on native species and their grazing management, to further explore improved legumes, and to better document environmental aspects such as soil quality.

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