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SUMMER NEWSLETTER

Volume 36 – Issue 2, December 2024

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Editor's Note

Welcome to the Pastures & Grazing NSW Summer Newsletter. It's a busy time of year for many of us, but with Christmas and New Year fast approaching, I hope you all get the opportunity to spend some time with friends and family.

In this issue of the newsletter, we provide an update about what's new on our website (see below) and there are three interesting articles; an overview of tropical grass adoption in inland NSW (Page 4), guidance about the sowing depth of mixed species fodder crops (Page 8) and new approaches to managing soil acidity (Page 10), which follows on from the article published in the last newsletter.

I hope you enjoy the newsletter. The next issue will be distributed in March next year, so send me an email at editor@pgnsw.com.au if you would like to contribute something.

Jonathan McLachlan
Director/Editor

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What's new on our website?

Our website is continually being updated with additional information and resources since its launch in September. You'll now find the following content easy to locate and view:

Documents

- **2024-27 Strategic Plan**: Gain an insight into our immediate goals and plan for the future.
- **2023/24 Annual Report**: Looking back over the past year, this report outlines the transition to P&G NSW, and our accomplishments to date.
- **2024 AGM minutes**: If you missed the meeting on 29 October, find out the details here.

Links

- **Farming Forecaster**: You'll find the links to the LLS's Farming Forecaster regions here (about halfway down the page, under 'Weather and Climate Information').

Videos

- **NSW Pasture Updates**: We've collated recent and previous Pasture Update videos here, so you can recap at your leisure. Keep an eye out for the videos of the recent Tamworth Pasture Update – they will appear here soon! *(Note: all videos have been funded by Local Land Services NSW)*.

Tropical grasses in inland NSW: their history, ongoing importance and considerations looking forward

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A brief history

It's hard to appreciate why tropical grasses, as a major pasture option, took so long to occur throughout NSW (except for coastal areas). NSW Department of Agriculture, CSIRO, Universities, and other entities involved in agricultural research were generally more interested in pastures like temperate perennials such as phalaris, annual grasses and legumes, and lucerne.

Evaluation of tropical perennial grasses first occurred in northern, inland NSW to a limited degree in the 1950s. Eric Darling, who was the Moree district agronomist in the 1950s, expressed interest. Inverell district agronomist Vic Gidley, in the late 1950s and 1960s, played an important role in the release of Inverell Purple Pigeon grass. Years later, Inverell district agronomist Bob McGufficke noted long term survival of Premier Digit in Vic Gidley's trials. The NSW Soil Conservation Service and John Fahey, a 1960s NSW Department of Agriculture northern research agronomist and later an agricultural consultant, were also involved in these studies. However, no one led a concerted evaluation and promotion program in this era. A few farmers adopted tropical grasses, but they received no significant attention from entities such as the NSW Department of Agriculture. Consequently, no major expansion occurred.

That all changed in the 1980s. Perhaps the spark that initiated renewed interest was research conducted in the central west Binnaway district, on light-textured acidic soils that were once regarded as almost useless. NSW Department of Agriculture research across several sites around the Coonabarabran district, from 1968 onwards, identified serradella as suited to these difficult soils.

Research and success with serradella followed in the 1970s, expanding to the Dubbo, Mudgee, and Narrabri districts, and even further afield into the 1980s. Successful soil fertility studies with serradella then followed with phosphorus and sulfur deficiency found to be the main issues. But what could grow once the winter annual legume serradella hayed off in spring and would not re-establish until the following autumn?

Bill Johnston, Soil Conservation Service Wagga Wagga, led research that resulted in the release of the tropical grass Consol lovegrass in the mid-1980s. It persisted in hostile soils and situations like roadside cuttings that were often hostile and acidic. Consol was originally one of several lovegrass lines from South Africa and first assessed at Temora by NSW Department of Agriculture research agronomist Roger Southwood in the 1960s. His program of work was terminated by head office who considered it not appropriate at the time.

Consol lovegrass seed supplied to the Coonabarabran Department of Agriculture in the mid-1980s was included into their acidic soils research program, initially on Binnaway farms owned by Col Carslake and Stan King. It persisted, was productive, and if soil fertility was good, mainly via the inclusion of the legume serradella, feed quality was excellent. Col Carslake added to the success of Consol lovegrass by successfully developing a seed production business.

NSW Department of Agriculture, combined with local farmers and agribusiness firms, ran annual field days at Binnaway during the 1980s and 1990s promoting the inclusion of serradella, the need for superphosphate, and from 1985 onwards the important role of a tropical grass, initially Consol lovegrass. Over 300 farmers attended these events, which also received widespread media attention. The role and success of tropical grasses began to be appreciated and they were quickly adopted.

Around 1987, Inverell district agronomist Bob McGufficke and Manilla district agronomist Lester McCormick (NSW Department of

Agriculture) provided fellow district agronomists with trial kits of a wide range of tropical grasses for sowing across the central and north west regions. Premier Digit was among the species tested. In a trial on an extremely acidic soil (pH_{Ca} 4.1 with 40% aluminium as part of the CEC) at Binnaway, on Mark Beresford's property, Premier Digit and Consol lovegrass were the only grasses to survive and thrive. A second extremely acid tolerant tropical perennial grass had been identified.

Premier Digit persisted well in this and other trials, and from the early 1990s onwards was promoted to and adopted by landholders. Bambatsi Panic, via these trials across central and northern inland NSW, also proved to be persistent and suited to heavier textured soils.

Since 2010, extensive tropical grass research led by Suzanne Boschma (Tamworth, NSW DPI) and Carol Harris (Glen Innes, NSW DPI) also confirmed the long-term persistence and high productivity of Premier Digit and Bambatsi Panic over extensive areas of NSW. Tropical grass variety trials have also been established across the state over a wide range of soil types and environments. Studies by Suzanne Boschma and research colleague Sean Murphy have also added greatly to our understanding of the establishment and management of these grasses.

Megamax™049 and Megamax™059 are two new varieties added to the range of tropical grasses that came from Carol Harris's extensive evaluation program. Other tropical species, not listed above, also have valuable roles in various areas. For example, some varieties of Buffel grass suit hotter, north-western areas while the native Mitchell grass is valuable in heavier textured soils in the hotter western regions. Kikuyu is drought hardy and especially productive in high rainfall or irrigation situations, while paspalum is very tolerant of water logging.

Key producers have played a major role in the adoption and promotion of tropical grasses. In particular, George Avendano along with his wife Maree, and sons Matthew and Richard. In conjunction with NSW DPI, the University of New England, and private agronomists, the Avendano's have hosted well over 20 field days since the 1980s, often attracting 100 or more producers and agronomists. They have turned a once poorly regarded, light-textured soil property into one of the most successful farms in NSW and currently have over 3000 ha of tropical grass pastures.

Why tropical grasses?

Tropical perennial grass-based pastures represent an opportunity for thousands of properties to boost livestock productivity and profitability. If carefully chosen, carefully established and reasonably managed, these can last indefinitely (some are 35 years old and still thriving), suit the variable rainfall environment well, can provide high quality feed, coexist well with annual legumes, and commonly suit a range of soil types including those often regarded as second class.

They suit the climate of northern, central, and southern NSW, from low rainfall western areas to higher rainfall and higher elevation tableland as well as coastal areas. There are successfully established stands at 1000 m above sea level in the tablelands, to western areas with annual average rainfall of 400 mm.

On a long-term annual average rainfall basis, most of central and northern NSW receives at least roughly the same amount of rainfall per month each month of the year (commonly referred to as the uniform monthly rainfall belt). In the south, farmers are growing tropical grasses to the Victorian border because, even in these southern areas, on average quite a bit of rain falls outside the growing period of winter annuals and summer dormant perennials.

Because of the erratic nature of rainfall distribution within a year, and from one year to the next, the reality is that for most of NSW rain does occur at any time of the year. Tropical grasses are able to use this over the warmer months when few other species can.

South to become more like North says climate study

Various climatologists predict that summer rain will become a higher proportion of total annual rainfall for much of NSW, especially in southern NSW. If such trends occur, it reinforces the logic of pasture types that can effectively use late spring, summer and early autumn rain in both cropping and pasture systems.

Tropical perennial grasses as part of year-round feed supply

Tropical perennial grasses grow from mid-spring through to late autumn (Fig. 1). Even in higher altitude cooler environments, their growth period is often more than six months and they grow compatibly with winter legumes. They use moisture when winter annual legumes have hayed off. For example, in a year with a dry late winter/early spring, winter annuals commonly hay off early. Tropical grasses effectively use late spring through to mid-autumn rains when few other species effectively do, especially in lower altitude hotter environments.

Long-term persistence

Testimony to the persistence of tropical grasses was a study conducted in the lower rainfall Mallee region of southern Australia with less than 300 mm annual average rainfall. The six-year study detailed persistent tropical grasses with production ranging from 1500–3000 kg/ha peaking at 9000 kg/ha in wetter years (Descheemaeker *et al.* 2014).

Lighter soils that are less suited to cropping (due to their lower water holding capacity) are particularly suited to tropical grasses. They can respond quickly to small rain events even after a protracted dry period. Furthermore, they don't drop leaves as a consequence of dry weather and can retain good quantities of reasonable quality feed going into a long dry period.

Heavy sodic soils, less suited to cropping, have also supported long term tropical perennial grasses. Their advantage over cropping is that, once well established, they provide a friable soil surface via litter and organic matter from pasture residues. In contrast, cropped sodic soils commonly need reasonably regular inputs of gypsum or other amendments.

Tropical perennial grasses high feed quality

Tropical grasses provide excellent quality feed, provided soil fertility is high. Like all grasses, quality reflects the stage of growth, with young regrowth the highest quality and rank dry growth the lowest quality. Research at Tamworth (Suzanne Boschma and colleagues) noted that tropical grasses grown on high fertility soils were typically 6.6% higher in protein than in low

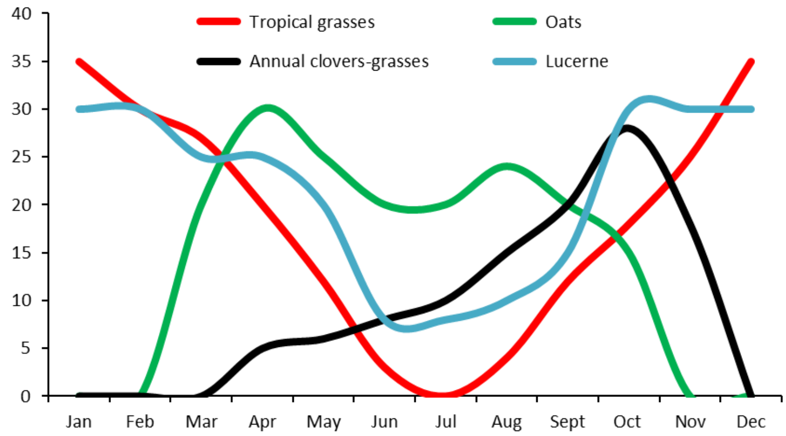

FIGURE 1.

Typical average daily growth rates (kg DM/ha/day) for various crop and pasture types in environments like central west and north west NSW.

fertility soils. Energy levels were also typically higher.

Weed control

Fighting 'fire with fire' is critical to the success of defeating weeds such as spiny burr grass, galvanised burr, wire grass, khaki weed, rock fern, catheads, Bathurst burr, dwarf marigold, thistles, blue heliotrope, Paterson's curse, Coolatai grass, African lovegrass, and fleabane.

The stronger the tropical perennial grass, the greater its ability to outcompete weeds. While in some cases weeds can't be totally eliminated, reinvasion from roadsides (e.g. Coolatai grass and African lovegrass) is greatly slowed by strong perennial grass pastures. A summer growing perennial grass such as Premier Digit grows at least at the same time as most summer weeds and importantly also begins strong growth earlier and finishes later than these weeds. Before establishing a tropical grass pasture, it is important to firstly eliminate the weed seed bank and kill out existing weed problems. Generally, a three-year summer fallow with winter cropping is enough to largely eliminate the soil weed seed bank, provided no weed seed set occurs over the fallow and in-crop weed control is effective. Also, three years provides more than ample opportunities to kill out existing weed populations, including especially problematic weeds like blue heliotrope.

Looking forward

Unfortunately, assessing new tropical perennial grasses requires long term trials for adequate evaluation of persistence. While a 10 year well-managed trial provides a lot of information, even longer would provide far more useful information. Hence, a plea to research funders to consider investing in longer-term trials.

Following the end some years ago of the NSW DPI extension section (with these staff running research such as species comparisons, fertiliser trials and the like), not much applied research is now undertaken. There is clearly a need to examine how a more coordinated effort, for both research and extension, can be conducted for aspects such as pasture variety testing. This means that there is an important role that independent advisors and leading producers can take in promoting tropical grasses.

References

Descheemaeker, K., Llewellyn, R., Moore, A., Whitbread, A. (2014) Summer-growing perennial grasses are a potential new feed source in the low rainfall environment of southern Australia. *Crop and Pasture Science* **65**, 1033-1043.

ABOVE:

An example of a high-quality tropical grass pasture, which includes the all-important winter legumes such as serradella.

What's the best depth to place seed when sowing a mixed species fodder crop?

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Background

Annual fodder crops are an important component of livestock enterprises as they provide high quality feed for growing animals. Traditionally, these crops comprise a single species such as forage oats, a forage brassica or a dual-purpose crop. However, mixed species fodder crops are becoming more widely sown. There are many factors that determine the composition of these mixes, including regional suitability and producer preference. Complexity varies from simple two-species mixes such as oats and ryegrass, to multi-species mixes that contain ten or more species. Seed sizes in these mixes can therefore be highly variable, ranging from small seeded species like brassicas to large seeded species such as vetch. During discussions with producers and advisors, we have been regularly asked what the optimum sowing depth is for these more complex mixes. This is an important consideration when seed of the species are sold mixed or a seeder only has one seed box. We conducted a demonstration to provide some insight into this question.

Methodology

Plots of a locally acquired and commercially available multi-species mix were sown in March 2023. The mix was comprised of 10 species (Table 1). Seed was sown at 37.5 kg/ha (1.5 times the recommended sowing rate) into 13 x 3 m plots using a disc seeder with 0.25 m row spacings. There were four sowing depths: 10, 20, 40 and 80 mm. The seed shoe was clear of the soil surface for each sowing depth, ensuring precise seed placement in the soil, except for the 80 mm depth. At this depth, the shoe disturbed the soil surface meaning that the depth was greater than 40 mm, but not necessary 80 mm.

Plant establishment was assessed four weeks after sowing. Plant counts were recorded for the four component groups in the mix: cereal, annual ryegrass, brassica and legume along 16 lengths of 0.5 m row (i.e. total of 8 m row). Individual counts were converted to plants/m^2 and standard errors were calculated.

Results and Discussion

At sowing, there was good soil moisture below 30 mm, which meant that seed sown at the 10 and 20 mm depths were placed into dry soil whereas seed sown at the 40 and 80 mm depths were placed into adequate soil moisture to germinate the seed. Good rainfall immediately following sowing removed this difference in soil moisture.

The cereals and annual ryegrass emerged well at the 10–40 mm sowing depths, establishing with 42 and 62 plants/m^2 on average, respectively (Table 2). At 80 mm, emergence was almost half that of the shallower depths. Seedling emergence of the brassicas was highest at 40 mm, followed by 10–20 mm and lowest at 80 mm. Legume emergence was highest when this component was sown at 20 mm and lowest at 80 mm.

TABLE 1.

Component species and their sowing rates (kg/ha) of the commercial multi-species mix

CEREAL	ANNUAL RYEGRASS	BRASSICA	LEGUME	TOTAL
7.5 + 7.5	4.5	0.75 + 0.75 + 0.75	5.25 + 7.5 + 1.5 + 1.5	37.5
Ryecorn + triticale	Annual ryegrass	Tillage radish + purple top turnip + forage rape	Vetch + field pea + arrowleaf clover + balansa clover	

Total plant densities were highest when the multi-species mix was sown to 20–40 mm depth (Table 2). Plant densities were less than half of the maximum when seed was sown at a depth of 80 mm.

For the 10 species included in this multi-species mix, placing seed at a depth of 20–40 mm resulted in the optimum seedling emergence. The recommended sowing depths for the individual species in the mix varies. For example, a depth of 0–10 mm is recommended for tillage radish, 5–20 mm for annual ryegrass and clovers, through to 20–50 mm for cereals and 30–50 mm for grain pea.

This demonstration suggests that, when choosing a sowing depth for mixed seed, selecting a depth that is maximum for the species requiring the shallowest depth (generally the smallest seeded species) is a good rule of thumb. Placing seed deeper into soil moisture at sowing is often an advantage, but could compromise the emergence of some species resulting in poor or failed establishment of these species if the depth is too great.

Acknowledgements

This project was funded by Meat and Livestock Australia and NSW Department of Primary Industries as part of the '*Mixed species annual fodder crops to increase grazing animal production (P.PSH.1358)*'. Seed was provided by AMPS, Tamworth.

TABLE 2.

Plant densities (plants/m^2) of the four components of the multi-species mix sown at four depths with a disc seeder. Values show the average ± standard error of the 16 counts within each treatment, while the treatment average shows the average plant density across the four sowing depths

SOWING DEPTH (MM)	CEREAL	ANNUAL RYEGRASS	BRASSICA	LEGUME	MIX TOTAL
10	44±4.2	59±7.2	23±3.7	30±4.8	156±10.0
20	40±3.3	64±7.0	26±5.1	46±6.5	176±14.4
40	42±4.5	62±8.6	35±3.6	39±4.8	178±15.9
80	25±3.5	31±3.3	11±2.9	15±2.6	81±5.9
Treatment Average	***38***	***54***	***23***	***32***	***147***

New approaches to managing soil acidity: revised targets and triggers, and the role for lime incorporation

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[B] Charles Sturt University and NSW Department of Primary Industries and Regional Development
[C] Holbrook Landcare Network

Key points

- Traditional liming programs with lime applied to the soil surface targeting pH_{Ca} ~5.2 in the 0–10 cm surface soil do not address subsurface acidity that is present in most contemporary, productive farming systems.
- Initial, CAPITAL lime rates targeting pH_{Ca} ~5.8 promote downward movement of alkali into subsurface layers below 5 cm.
- Follow-up MAINTENANCE lime applications that keep pH_{Ca} above 5.5 in the 0–10 cm layer provide the additional alkali needed to increase the depth of amelioration and counter ongoing acidification.
- Incorporation of lime into the acidic layers, if possible, improves reaction of lime and fast-tracks subsurface amelioration.

Introduction

The widely adopted, one-size-fits-all approach to managing soil acidity evolved from guidelines developed in the late 1990s, when conventional cultivation incorporated lime to a depth of ~10 cm. It is based on analyses of 0–10 cm soil samples, with liming commonly triggered by pH_{Ca} of 0–10 cm reaching <4.8 and exchangeable aluminium (Al_{ex}) ≥5%, with lime rates targeting pH_{Ca} ~5.2.

Surveys of soil collected in 5 cm depth increments from productive agricultural soils of Central and Southern NSW detected acidic layers within depths of 5–15 cm (Burns *et al*. 2018; Burns *et al.* 2024). The widespread occurrence of severely acidic subsurface layers clearly demonstrated that historic acid soil management practices are inefficient in contemporary, productive farming systems.

Traditional liming programs have not kept pace with acidification rates from the higher production levels of current agricultural systems. Furthermore, analyses of soil samples collected at depths of 0–10 cm often mask the presence of acidity. The measured pH of a 0–10 cm sample is the average pH of the 0–5 and 5–10 cm layers. Often the 5–10 cm layer is acidic, but this is not apparent in a 0–10 cm average, which results in underliming (Burns *et al.* 2024).

To ensure lime can address acidity deeper in the soil profile, and balance the acidification of contemporary farming systems, it is important to target and maintain pH_{Ca} above 5.5 in the surface 10 cm. This was shown to enhance downward movement of alkali and increase pH in subsurface layers by Li *et al.* (2019). Over 18 years, they demonstrated a gradual increase in soil pH of 0.80 and 0.36 at depths of 10–20 cm and 20–30 cm, respectively, at a severely acidic, long-term research site near Wagga Wagga.

The increase in subsurface pH was achieved with an initial 'capital' lime application of 3.7 t/ha (incorporated to 10 cm), followed by three topdressing events that kept soil pH_{Ca} above 5.5 in the surface 0–10 cm. Topdressed lime rates ranged from 0.7–1.8 t/ha, for a total lime application of 8.6 t/ha over 18 years.

Urgency to update acid soil management guidelines prompted Pastures & Grazing NSW (PGNSW) to invest in a two-year National Landcare Program (NLP) project (2019–21), in collaboration with Holbrook Landcare Network (HLN) and Department of Primary Industries and Regional Development NSW (DPIRD), with financial support from the Federal Government.

Preliminary findings from this project, previously described in Newsletter Vol 34, No. 3 and Vol 36, No.1, are discussed in this report. They present opportunities to improve the efficiency of acid soil management efforts through the adoption of revised pH targets, triggers that prompt timely re-liming events, and the role for lime incorporation in (i) amelioration of deep, severely acidic soils; and (ii) prevention of subsurface acidification in moderately acidic soils.

Field sites typical of the regions' acidic soils

Central to the project are three field sites; at Morven (Southern Slopes), and at Lyndhurst and Toogong (Central Slopes). The 2.0 ha sites, established in 2019/20, are on soils typical of the medium to high rainfall zones. The severely acidic Morven and Lyndhurst sites were under degraded pastures, with no lime history. The Toogong site, with moderately acidic layers at depths of 5–15 cm, had a long history of mixed farming, receiving a total of 4.5 t/ha of lime in three applications since 1997.

Soil pH_{Ca} and Al_{ex}% analyses of 5 cm increment samples collected prior to establishing the sites are shown in Table 1.

While severely acidic soils have been the focus of most acid soil research and on-ground management efforts, the inclusion of the Toogong site was important. The purpose being to (i) raise awareness of subsurface acidity that is present, but often not detected, in highly productive soils with soil CEC as high as 15; and (ii) highlight the risk of failing to effectively manage acidity before production is compromised by declining pH in subsurface layers.

Soil data collected from these sites to date and at regular time intervals into the future, is informing the development of tailored management guidelines that address the subsurface acidity status of soils of the region.

Case A: Amelioration of deep, severely acidic soils, i.e. the Morven and Lyndhurst sites; and

Case B: Prevention of subsurface acidification in moderately acidic soils, i.e. the Toogong site.

Treatments

Seven common treatments across four replicates (28 plots) were applied at each site to compare the influence of traditional versus updated acid soil management options on soil pH_{Ca} and Al_{ex}%, and the role for incorporation to fast-track amelioration of acidity to depth (Table 2).

High quality, fine-grade lime (neutralising value >95%) was applied to the soil surface with a small plot, direct-drop lime spreader: to the Morven site in October 2019, and to the Lyndhurst and Toogong sites in February 2020.

Key treatment comparisons test pH_{Ca} targets of 5.2 and 5.8 in the 0–10 cm surface layer after liming; and the role for incorporation of lime into acidic subsurface layers before sowing versus surface application and incorporation by sowing.

TABLE 1.

Analyses of initial soil samples, collected prior to establishing field sites, for soil pH_{Ca}, exchangeable aluminium (Al_{ex}%) and cation exchange capacity (CEC) (0–10 cm average) at the severely acidic Morven and Lyndhurst sites, and the moderately acidic Toogong site.

SOIL DEPTH (CM)	MORVEN SOUTHERN SLOPES YELLOW CHROMOSOL: CEC - 2.9		LYNDHURST CENTRAL TABLELANDS RED CHROMOSOL: CEC - 2.3		TOOGONG CENTRAL SLOPES RED KANDOSOL: CEC - 10	
	pH_{Ca}	Al_{ex}%	pH_{Ca}	Al_{ex}%	pH_{Ca}	Al_{ex}%
0–5	4.5	10	4.1	31	5.2	< 1
5–10	4.2	27	4.1	47	4.8	1.8
10–15	4.3	27	4.2	50	4.9	1.3
15–20	4.4	20	4.3	48	5.3	1.1

Treatment *pH_{Ca} 5.8 0–5 cm Surface* assessed whether surface applied lime was more effective when topdressed regularly at relatively low rates.

Treatment *pH_{Ca} 5.8 0–15 cm Incorporated* assessed whether deep incorporation of lime, at rates targeting pH_{Ca} ~5.8 to the depth of incorporation, could accelerate amelioration down the soil profile.

Composites of 20 soil cores (24 mm diameter) were collected from the seven treatments (28 plots) at each site, 12 and 24 or 36 months after treatments were applied. Cores were cut into 2.5 cm increments within depths of 0–20 cm and into 5 cm increments from 20–30 cm for analyses

Note that the 2.5 cm intervals reported are for research purposes. Recommended sampling intervals for on-farm decisions remain at 5 cm for the surface 0–20 cm.

TABLE 2.

Treatment descriptions, lime rates and application method at the Morven, Lyndhurst and Toogong field sites. Lime was surface applied and either incorporated immediately prior to sowing or incorporated with minimum mixing by the sowing operation using knife-points.

TREATMENT IDENTIFICATION	DESCRIPTION AND ONGOING MANAGEMENT STRATEGY	MORVEN INCORPORATED TO 10 CM: DISC HARROWS	LYNDHURST INCORPORATED TO 20 CM: HORSCH™ TIGER	TOOGONG INCORPORATED TO 10 CM: DISC HARROWS
		*** RATE OF LIME APPLIED (T/HA)**		
Control	**Nil lime**, no pre-sowing cultivation	0	0	0
pH_{Ca} 5.2 Surface **pH_{Ca} 5.2 Incorporated**	***Traditional approach:*** **Target pH_{Ca} ~5.2** in 0–10 cm layer **Trigger** for re-liming when pH_{Ca} approaches ~5.0.	3.0	5.0	1.0
pH_{Ca} 5.8 Surface **pH_{Ca} 5.8 Incorporated**	***Revised approach:*** **Lime application to target pH_{Ca} ~5.8** in 0–10 cm layer Maintain target in 0–10 cm at pH_{Ca} >5.5. **Trigger** for re-liming: before pH_{Ca} in 0–10 cm layer decreases to 5.5.	4.0	6.0	2.8
pH_{Ca} 5.8 0–5cm Surface	**Target pH_{Ca} ~5.8** in 0–5 cm layer Maintain target in 0–5 cm at pH_{Ca} >5.5. **Trigger** for re-liming: before pH_{Ca} in 0–5 cm layer decreases to 5.5.	2.0	3.0	1.4
pH_{Ca} 5.8 0–15cm Incorporated *'Once-in-a-generation'*	**Lime application to target pH_{Ca} ~5.8** in 0–15 cm layer Maintain target in 0–10 cm at pH_{Ca} >5.5. **Trigger** for re-liming: before pH_{Ca} in 0–10 cm layer decreases to 5.5.	6.0	7.0	3.8

*The amount of high quality fine-grade lime applied was determined using the decision support system described by Hochman *et al.* (1989) that considers the starting pH, organic carbon and cation exchange capacity of each site.

Results and Discussion

Soil samples were collected from Morven 15 and 26 months after treatments were applied (Fig. 1); from Lyndhurst after 12 and 36 months (Fig. 2); and from Toogong after 12 and 24 months (Fig. 3). Analyses of soil pH_{Ca} and Al_{ex}% are presented as graphs of the profiles to the sampling depth of 30 cm. The magnitude and depth of change in soil pH and Al_{ex}% indicate the effectiveness of treatments in reducing toxic soil conditions and improving the soil environment for plant production.

The data presented only indicate the short- to medium-term influence of the treatments, as the applied lime may not have fully reacted. Therefore, alkali movement is incomplete, and soil chemical properties would not have reached an end point by the latest sampling event reported.

The responses to treatments at the severely acidic sites at Morven and Lyndhurst, presented as Case A below, indicate opportunities to effectively ameliorate deep acidic subsurface layers. Data from the Toogong site is presented as Case B, highlighting the role for early intervention aimed at preventing severe subsurface acidification.

Case A: Amelioration of deep, severely acidic soil – Morven and Lyndhurst

Figures 1a and 2a show that ~12 months after site establishment, the depth to which pH increased when lime was surface applied was influenced by the lime rate needed to achieve the higher pH target. With the larger amount of lime applied under treatment *pH_{Ca} 5.8 Surface*, there was a significant pH increase in all layers to a depth of 12.5 cm at Morven and to 10 cm at Lyndhurst. However, there was no significant pH increase below 5 cm when lower lime rates were surface applied at either Morven or Lyndhurst (i.e. *pH_{Ca} 5.2 Surface* and *pH_{Ca} 5.8 0–5 cm Surface*).

Incorporation of lime into acidic subsurface layers at Morven and Lyndhurst (*pH_{Ca} 5.2 Incorporated* and *pH_{Ca} 5.8 Incorporated*) improved the effectiveness of lime reaction and increased the magnitude of pH increase in most layers, to a depth of 12.5 cm and 15 cm, respectively, compared with the control.

Note that decreased Al_{ex}% is usually associated with a corresponding increase in soil pH. However, at Morven and Lyndhurst, under all lime treatments (Fig.1a & 2a), the depth to which Al_{ex}% had significantly decreased is deeper than the depth of significant pH increase. This indicates that some of the alkali released from the dissolving lime has moved down and reacted with Al_{ex} to convert it to harmless forms (i.e. no longer plant available). The conversion of Al_{ex} into non-toxic forms acts as a buffer, benefiting plants, but reducing the magnitude of measured pH increase.

Twenty-six months after treatment application at Morven (Fig. 1b), the difference in soil pH between surface applied and incorporated treatments of the same lime rate, which was evident after 15 months (Fig. 1a), had decreased in the surface 7.5 cm.

There were no significant differences in the pH of soil layers between treatments targeting pH 5.2 or 5.8 in 0–10 cm when lime was surface applied, nor between those rates when it was incorporated. However, incorporation did increase the magnitude of pH change to a depth of 10 cm compared with surface application within layers from 5.0 to 12.5 cm.

The greatest increase in pH and decrease in Al_{ex}% was achieved with incorporation of the highest rate of lime under *pH 5.8 0–15 cm Incorporated*.

At the Lyndhurst site, a similar treatment response was observed 12 months after application (Fig. 2a): there was little difference in pH between lime rates to achieve pH 5.2 or 5.8, but large differences in pH existed between surface applied and deep lime incorporation with the Horsch™ Tiger.

After 36 months post treatment application, the deep incorporated treatments produced a significantly higher pH and lower Al_{ex}% than the corresponding surface treatments in all layers from 7.5 to 20 cm (Fig. 2b).

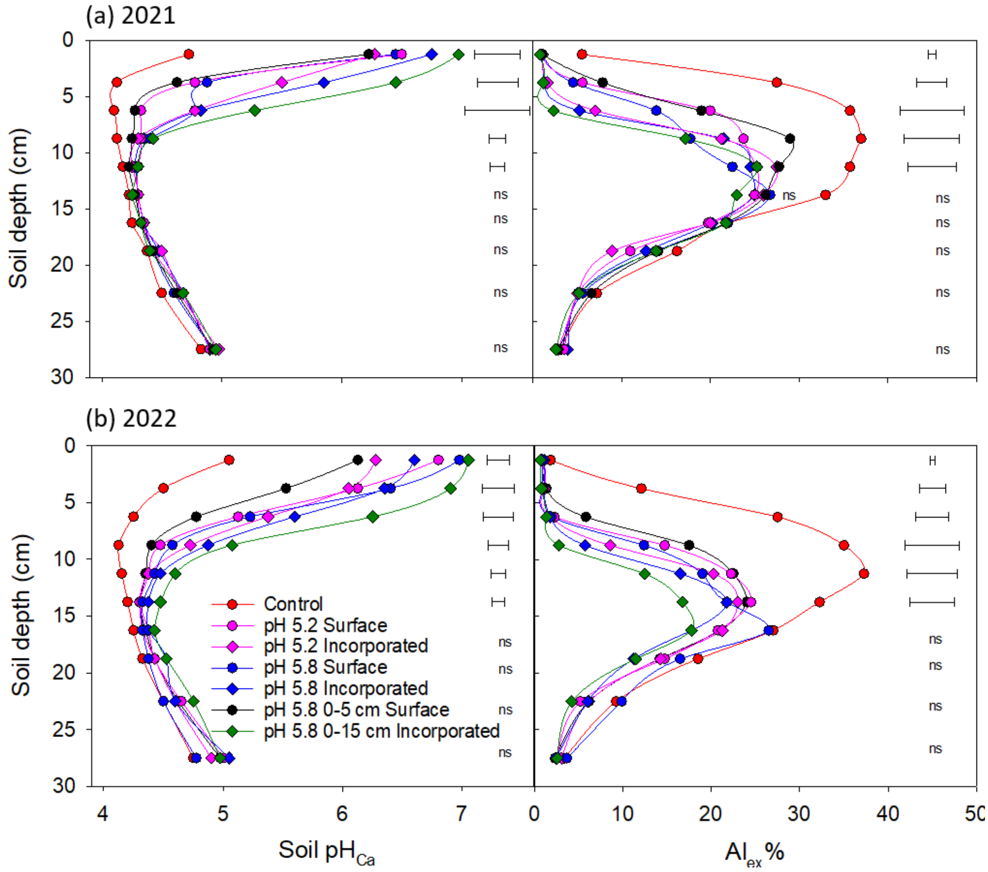

FIGURE 1.

Soil profiles for pH_{Ca} and exchangeable aluminium percent (Al_{ex}%) at Morven showing treatment effects (a) 15 and (b) 26 months after establishment of 7 treatments in 2021 and 2022, respectively. Control (nil lime), pH_{Ca} 5.2 Surface and Incorporated (3 t/ha lime); pH_{Ca} 5.8 Surface and Incorporated (4 t/ha lime); pH_{Ca} 5.8 in 0–5 cm layer Surface (2 t/ha lime), and pH_{Ca} 5.8 in 0–15 cm layer Incorporated (6 t/ha of lime). Horizontal bars represent l.s.d. (p<0.05); ns = no significant difference.

The improvement in soil condition between the first and second sampling events, at both sites, highlights that lime reacts and moves slowly. It reinforces (i) the need to delay sowing of acid-sensitive species for at least 2 years after liming severely acidic soils, and longer if lime is not effectively incorporated; and (ii) the importance of follow-up soil testing to check that amelioration efforts have been effective and soil conditions have improved sufficiently for sensitive species to be sown.

Between the two reported sampling events at Morven and Lyndhurst, the surface treatments produced a small increase in pH in the 7.5–10 cm layers (Figs. 1 & 2). The limited downward movement of alkali over that period suggests that the lime influence may have stalled. There is a risk that the rate of alkali movement into the subsurface layers may be too slow to counter the concurrent reacidification processes. This will be checked with future sampling.

In contrast, treatment *pH_{Ca} 5.8 0–15 cm Incorporated*, designed to supply adequate lime to remove acidity to at least 15 cm or beyond the depth of incorporation, should in theory continue to increase pH with depth. This trend can be seen in data from Morven (Fig. 1b) but is less apparent at Lyndhurst (Fig. 2b), perhaps due to the greater volume of soil mixed by deeper incorporation at the latter site.

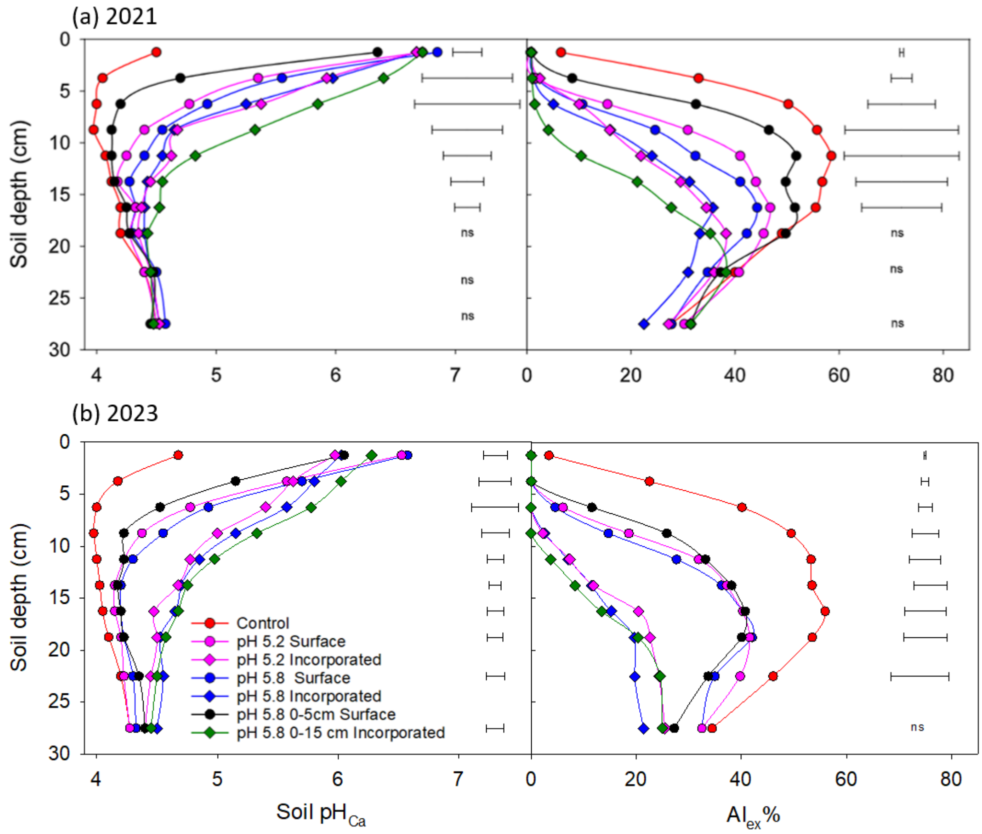

FIGURE 2.

Soil profiles for pH$_{Ca}$ and exchangeable aluminium percent (Al$_{ex}$%) at Lyndhurst showing treatment effects (a) 12 and (b) 36 months after establishment of 7 treatments in 2021 and 2023, respectively. Control (nil lime), pH$_{Ca}$ 5.2 Surface and Incorporated (5 t/ha lime); pH$_{Ca}$ 5.8 Surface and Incorporated (6 t/ha lime); pH$_{Ca}$ 5.8 in 0–5 cm layer Surface (3 t/ha lime), and pH$_{Ca}$ 5.8 in 0–15 cm layer Incorporated (7 t/ha of lime). Horizontal bars represent l.s.d. (p<0.05); ns = no significant difference.

ABOVE:

Root development and shoot growth of phalaris plants sown at Lyndhurst in 2021 show the benefit of improved soil condition under the seven lime treatments. From left to right; control, pH$_{Ca}$ 5.8 Surface, pH$_{Ca}$ 5.8 Incorporated; pH$_{Ca}$ 5.2 Surface, pH$_{Ca}$ 5.2 Incorporated, pH$_{Ca}$ 5.8 in 0–5 cm Surface, and pH$_{Ca}$ 5.8 in 0–15 cm Incorporated. (H Burns; February 2022)

The Lyndhurst data highlights the opportunity for rapid amelioration of deep subsurface acidity when sufficient lime is effectively incorporated. Comparing soil pH and Al_{ex}% data from 2021 (Fig. 2a) and 2023 (Fig. 2b), the separation between profiles of surface and incorporated treatments demonstrates improved lime effectiveness when it is mixed into acidic layers.

The data from soil samples collected in 2022 from Morven and 2023 from Lyndhurst indicated that only in the *pH_{Ca} 5.8 0–15 cm Incorporated* treatments was soil pH_{Ca} > 5.5 in all layers to a depth of 10 cm. Based on Li *et al.* (2019), only in that treatment was sufficient residual lime and/or alkali present to continue processes that neutralise acidity and significantly increase pH in layers below 10 cm.

Based on critical pH values nominated to trigger reliming events (Table 2), maintenance lime rates were topdressed onto *pH_{Ca} 5.8 0–5 cm Surface* at Morven and Lyndhurst, and *pH_{Ca} 5.8 0–10 cm Surface and Incorporated* at Morven in 2024.

CASE B: Arresting subsurface acidification in moderately acidic soil – Toogong

The soil at the Toogong site had no obvious chemical or physical constraints. It is typical of soils that support highly productive mixed farming systems in the medium to high rainfall zones of Central and Southern NSW.

Despite a 20-year history of lime application, preliminary soil samples identified stratified soil pH and a moderately acidic layer (pH_{Ca} 4.8–4.9) at depths of 5–15 cm (Table 1).

Twelve months after treatments were applied, there was a small but significant response to lime rate and incorporation treatments (Fig. 3a). The relatively small treatment effect at Toogong, compared with those at the severely acidic Lyndhurst and Morven sites, was expected. Starting soil pH influences lime reaction, so the applied lime was slower to react at the higher starting soil pH.

This was most evident for the *pH_{Ca} 5.8 0–15 cm Incorporated* (3.8 t/ha) treatment, which did not produce significantly different pH compared to the *pH_{Ca} 5.8 Incorporated* (2.8 t/ha) treatment. The additional 1 t lime/ha may have been enough to decrease the reaction of the lime applied at the higher rate, rendering it less effective. However, increase in lime rate with treatments *pH_{Ca} 5.2 Incorporated* (1 t/ha), *pH_{Ca} 5.8 0-5 cm Surface* (1.4 t/ha) and *pH_{Ca} 5.8 Incorporated* (2.8 t/ha) caused pH increases of corresponding magnitudes in the surface 2.5 cm (Fig. 3a).

As occurred at the Morven and Lyndhurst sites, 12 months after application, incorporation of lime resulted in greater pH change and to a greater depth than surface liming.

Analyses of samples collected in 2022 (Fig. 3b) indicated no alkali movement into layers below 5 cm for treatments *pH_{Ca} 5.2 Surface, pH_{Ca} 5.2 Incorporated* or *pH_{Ca} 5.8 0–5 cm Surface*, over the previous 12 months. This reinforced the conclusions drawn from previously reported surveys of commercial paddocks; i.e. lime application rates targeting pH_{Ca} ~5.2 supply insufficient alkali to neutralise acidity and increase pH in subsurface layers.

Over that same period, treatments *pH_{Ca} 5.8 Surface, pH_{Ca} 5.8 Incorporated* and *pH_{Ca} 5.8 0–15 cm Incorporated* achieved soil pH_{Ca} >5 throughout the profile, with a significant pH increase in all layers under these treatments, to a depth of 7.5 cm.

The increase in soil pH in layers within depths of 2.5–7.5 cm under those treatments translated into a significant reduction in Al_{ex}% in those layers. This demonstrates the importance of higher pH targets and maintaining pH_{Ca} >5.5 if the aim is to ameliorate acidity in layers below 5 cm.

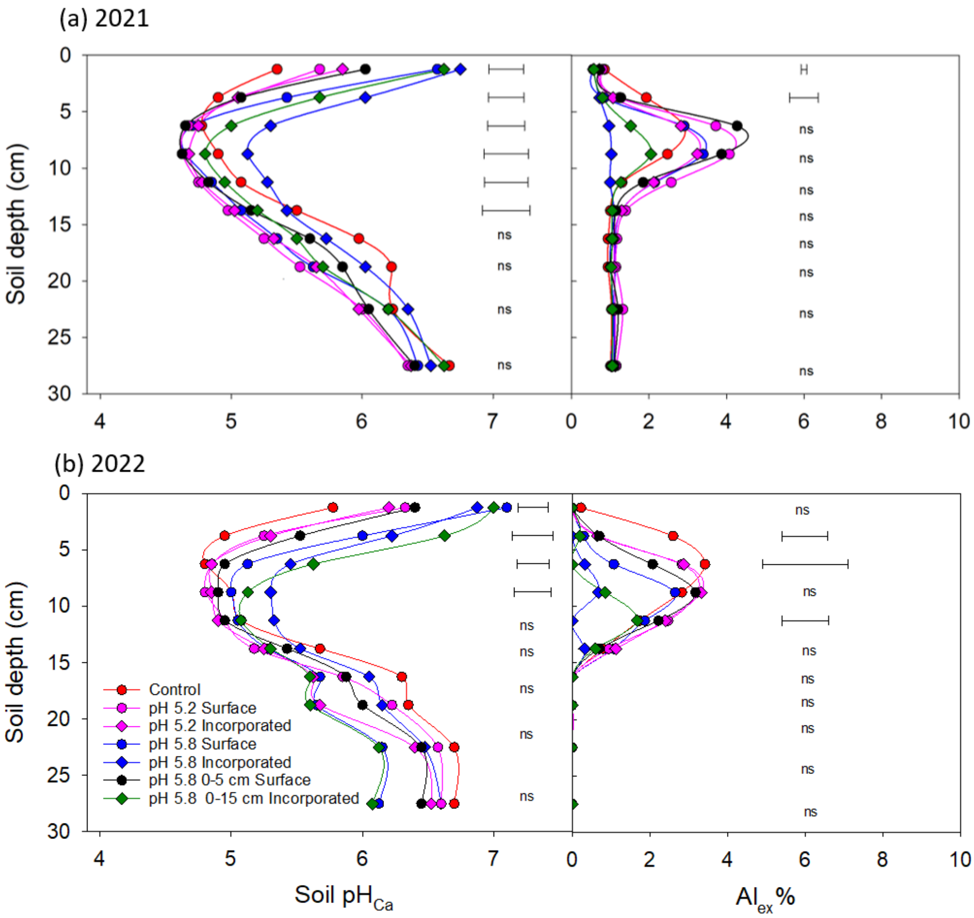

FIGURE 3.

The soil profiles for pH_{Ca} and exchangeable aluminium percent (Al_{ex}%) at Toogong showing treatment effects (a) 12 and (b) 24 months after establishment of 7 treatments in 2021 and 2022, respectively. Control (nil lime), pH_{Ca} 5.2 Surface and Incorporated (1 t/ha lime); pH_{Ca} 5.8 Surface and Incorporated (2.8 t/ha lime); pH_{Ca} 5.8 in 0–5 cm layer Surface (1.4 t/ha lime), and pH_{Ca} 5.8 in 0–15 cm layer Incorporated (3.8 t/ha of lime). Horizontal bars represent l.s.d. (p<0.05); ns = no significant difference.

Conclusions

Knowledge of the depth and severity of acidity in subsurface layers is essential when developing effective acid soil management strategies. Sampling in 5 cm intervals to a depth of 20 cm is recommended to determine how bad and to what depth acidity exists.

Amelioration of deep, severe subsurface acidity is a long-term commitment requiring capital investment in lime to achieve pH_{Ca} ~5.8 in soil overlying acid layers. The pH will need to be maintained at pH_{Ca} >5.5 with follow up lime applications. Incorporation can increase lime reactivity and effectiveness and, provided pH_{Ca} is >5.5, accelerate alkali movement below the depth of incorporation.

Results from the Toogong site demonstrated that early action can arrest and ameliorate shallow, moderately acidic subsurface layers within 24 months, when appropriate rates of lime are applied to achieve target pH_{Ca} of 5.8, with or without incorporation.

The proactive approach demonstrated at the Toogong site is particularly relevant when incorporation is not an option. If liming were delayed until the subsurface pH drops to critical values in layers below 10 cm (e.g. pH_{Ca} <4.8), production may already be compromised.

Amelioration efforts will become increasingly difficult, more expensive and less efficient.

Irrespective of the acidity status, effective management of soil acidity in the medium- to long-term must include a program of regular soil testing to prompt timely action and maintenance applications of lime.

References

Burns, H.M., and Norton, M.R. (2018) Subsurface acidity threatens central and southern NSW cropping areas. In 'Proceedings of the National Soils Conference 2018'. Canberra, 18–23 November 2018. Soil Science Australia. pp 352–353.

Burns, H., Condon, J. and McGrath, N. (2024) Subsurface acidity not a problem! Have you checked? Pastures & Grazing NSW, Volume 36, Issue 1.

Hochman, Z., Godyn, D.L. and Scott, B.J. (1989) The integration of data on lime use by modelling. In 'Soil acidity and plant growth' (Ed. AD Robson) pp. 265–301. (Academic Press: Sydney)

Li, G.D., Conyers, M.K., Helyar, K.R., Lisle, C.J., Poile, G.J. and Cullis, B.R. (2019) Long-term surface application of lime ameliorates subsurface soil acidity in the mixed farming zone of south-eastern Australia, *Geoderma* **338**, 236-246.

ABOVE:

Although there was no obvious plant response to lime treatment at the Toogong site, incorporation of sufficient lime did ameliorate the acidic subsurface layers and improve root development as shown in the comparison of canola root growth in plants from treatment pH_{Ca} 5.8 Incorporated (left) with pH_{Ca} 5.2 Surface (right). Note the green/purple colour of the soil core on the left from pH_{Ca} 5.8 Incorporated, produced with a field soil pH kit, which shows pH_{Ca} was increased to >5.0 in all layers within 12 months, compared with pH_{Ca} 5.2 Surface, where the green/yellow colour indicates that surface applied lime did not ameliorate the acidic layers from 5–15 cm. (H Burns; May 2020)

Monitoring the effect of lime application methods on soil condition and management of the field sites has been possible via various funding sources, including the Community Partnerships Program of Cadia Valley Operations – at Lyndhurst and Toogong (2021–2022) and GRDC – at Morven (2022–23). A new phase of investigations at the sites, supporting continued monitoring of soil condition (biennial) and seasonal pasture responses, will continue under a project funded by the MLA Donor Company and DPIRD (*High performance pastures for acidic soils*), including establishment of new field sites and expansion into Northern NSW.

Acknowledgements: The information presented here is due to the considerable effort, support and enthusiasm of the landowners hosting the field sites. Their commitment and contribution to this research is very much appreciated.

Research Update

Keeping you up-to-date with the latest pasture and grassland research in Australia. We reprint the abstracts of recently published research articles so you can follow up the full paper if you wish.

Developmental patterns of flowers and pods and the effect on seed number in French serradella (*Ornithopus sativus*) and yellow serradella (*Ornithopus compressus*) cultivars

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Abstract

Context

Reliable seed production is a key requirement for successful year-on-year regeneration of annual pasture legumes.

Aims

The study aims were to investigate the developmental patterns of flowers and pods and the effect on seed number among cultivars of French (*Ornithopus sativus* Brot.) and yellow serradella (*O. compressus* L.); and to assess the effects of early flower loss.

Methods

Four cultivars of each species were grown in a glasshouse under non-limiting growth conditions. Date of flowering and numbers of flowers, pods and seeds were assessed for up to 20 reproductive nodes on two stem axes per plant (n = 5 plants). A flower removal treatment was imposed to assess whether early flower loss affected flower and/or pod production.

Key results

Flowering in the serradellas was indeterminate, but for all cultivars there was a peak period of flower and pod production, with the timing and duration of the peak period differing among cultivars. Peak flowering occurred primarily because the proportion of plants flowering began to decline, but the number of flowers per reproductive node and the number of pods formed per node also declined with time. Compensation for early flower loss was observed for most cultivars because of a longer duration of pod formation and/or greater numbers of pods developed on higher reproductive nodes.

Conclusions

This study demonstrated that there is diversity in the patterns of flowering and podding and number of seeds initiated among serradellas.

Implications

Diversity in flowering and podding patterns combined with a capacity to compensate for early flower loss may be used to develop serradellas better able to cope with environmental stressors (frost, drought, heat) experienced during the flowering window.

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Next Newsletter

The next edition of the newsletter will be distributed in March 2025.

If you wish to submit an article, short item, a letter to the Editor or a photo please email your contribution to: editor@pgnsw.com.au

The deadline for submissions is Friday 14 February 2025.

Christmas wishes from the Board

Dear Valued Members,

As we approach the festive season, I and the Board of Pastures & Grazing NSW would like to extend our warmest greetings to you and your families. This time of year offers an opportunity to reflect on the achievements of the past twelve months and to express our gratitude for your ongoing support.

2024 has been a year of resilience, innovation, and growth. Our organisation has rebranded and restructured, establishing a robust governance framework. Our new website has launched and the quarterly newsletter has been reinvigorated and distributed to members.

One of the highlights of the year has been the progress we've made in adopting and promoting sustainable grazing practices. With your participation, we have launched several initiatives aimed at improving soil health, enhancing biodiversity, and reducing our carbon footprint. These efforts have not only benefited the environment but have also contributed to the long-term viability of our industry.

The sense of community among our members has been inspiring. We've seen an increase in participation in our workshops, seminars and field days, all of which have provided valuable learning opportunities and fostered a spirit of collaboration. Your willingness to share knowledge has been instrumental in building a resilient and informed community.

We're excited about the opportunities that lie ahead. Our focus will continue to be on sustainability, innovation, and community engagement. We have several projects in the pipeline that aim to further enhance our practices and support the growth and success of our members.

In 2025, we will be launching the updated *Pasture Varieties Used in NSW* booklet, which was last produced by the NSW Department of Primary Industries in 2012–2013. We'll also continue our involvement in regional pasture updates with agencies and the private sector.

We recognise the importance of strong partnerships in achieving our goals. Next year, we'll be working closely with government agencies, research institutions, and industry leaders to improve communication and adoption of sustainable grazing practices.

We wish you and your family a Merry Christmas and a Happy New Year, and may the coming year be one of productivity and success.

With warmest regards,

Lester McCormick
Chairperson (on behalf of the Board)
Pastures & Grazing NSW