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International Grassland Congress Proceedings | 23rd International Grassland Congress

Revolutionary Self-Sustaining Pasture-Crop Rotation Systems Developed by Researcher-Farmer Collaboration for Southern Australian Farming Systems

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The 23rd International Grassland Congress (Sustainable use of Grassland Resources for Forage Production, Biodiversity and Environmental Protection) took place in New Delhi, India from November 20 through November 24, 2015.

Proceedings Editors: M. M. Roy, D. R. Malaviya, V. K. Yadav, Tejveer Singh, R. P. Sah, D. Vijay, and A. Radhakrishna

Published by Range Management Society of India

Presenter Information

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Paper ID: 310
Theme: 3. Sustainability of grasslands - social and policy issues
Sub-theme: 3.1. Multi-stakeholder learning platforms for grassland management

Revolutionary self-sustaining pasture-crop rotation systems developed by researcher-farmer collaboration for southern Australian farming systems

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Keywords: Pasture-crop rotation, Self-regenerating

Introduction

Mixed farming pasture-crop rotation systems in southern Australia have traditionally relied on subterranean clover and annual medics. Concern over the long-term persistence of these species was raised in the 1980's with the cessation of manufacture of suction harvesters required for seed production. Subsequently, their adaptation has been tested due to climate change. More frequent droughts, particularly the millennium drought (2002-2009), increased incidence of false breaks and dry spring conditions causing decline or complete loss of seedbank reserves and failure of new sowings. A concerted effort developing new legume species for Australian farming systems, led by Western Australia, resulted in domestication of biserrula, bladder clover and gland clover and development of new cultivars of French and yellow serradella. These species/varieties possess characteristics including one or more of the following: higher hard seed content, deeper root systems, greater acid soil tolerance in symbiosis, increased herbage and seed production, wider tolerance to pest and diseases. They can also be harvested with conventional cereal harvesters reducing seed cost and enabling farmers to produce their own seed (Loi *et al*., 2005). A survey of farmers showed adoption of new species was limited by a lack of detailed management information on how to grow and manage them, to maximise their impact on crop and livestock productivity (Hackney *et al*., 2012). This paper reports on efforts made over a decade by a multidisciplinary WA and NSW team of plant breeders, rhizobiologists, agronomists and animal scientists, formed to develop new self-sustaining pasture-crop rotation systems to fill the void left by the failure of traditional rotation systems. The critical role and early recruitment of 'champion' farmers in achieving the successful adoption of new technology is discussed, as is the difficulty in organizing and funding systems research.

Materials and Methods

An extensive survey of farmers was made prior to developing new pasture-crop rotation systems ensuring farmer needs were met in the development of such systems. In this process, farmer 'champions' were identified in research target regions. Farmer champions hosted replicated field experiments; furthermore, they committed to sow 5-10 ha of one or more of the new legumes and were encouraged to undertake 'research' within these areas, evaluating the suitability of each legume to their farming systems. The first studies implemented in WA and NSW evaluated "twin sowing" involving late-autumn sowing with the last year of the crop rotation of unscarified or in-pod hard seed of the legumes together with the use of a rhizobial inoculant capable of colonising the soil in the absence of the host. The legume hard seed breaks down over 12 months emerging on first rains in the following autumn. Twin sowing does not require reduction in sowing rate of the final crop and removes competition between the crop and the pasture at establishment compared to conventional cover cropping – a practice used by 80% of NSW farmers which requires up to 50% reduction in crop sowing rate and the use of scarified pasture seed (Hackney et al. 2012). The second stage of experiments investigated "summer sowing" compared to conventional autumn sowing of scarified seed. Summer sowing also utilizes unscarified (or in-pod) seed and relies on the high summer temperatures to break down hard seed with emergence on opening autumn rain. Summer sowing requires a long-life rhizobial inoculant tolerant of soil temperatures above 50^{o}C at the time of sowing (Loi *et al*., 2008). Recently, livestock production and health studies have been undertaken. Further, the capacity to utilize biserrula's lower palatability in grazing systems through winter and spring to selectively remove the problematic but highly palatable cropping weeds, especially annual ryegrass (*Lolium rigidum*) have been studied (Hackney and Quinn, 2015).

Results and Discussion

The development and optimization of practices for managing pasture-crop systems based on new hard-seeded annual legumes are ongoing processes. Key findings so far are:

i. Significant differences in regeneration occurred between WA and NSW, particularly with respect to biserrula, with little regeneration in the year following sowing in WA necessitating cropping in the second year to allow hard seed to break down for regeneration in year 3. In NSW, biserrula regenerates strongly in the second year allowing paddocks to be grazed or cropped.
ii. In WA and NSW twin sowing is a successful method to establish French serradella and bladder clover. In NSW, twin sowing has also been successful in establishing biserrula. In NSW conventional cover cropping using scarified seed caused significant reduction (15-90%) in seed yield and seed size (up to 50%) of sown legumes decreasing production compared to twin sown treatments (Hackney *et al*., 2012, Butcher and Butcher, 2015).
iii. Summer sowing is successful in establishing French serradella and bladder clover in WA and NSW. In NSW, biserrula has been established *via* summer sowing. Overall summer sowing increased forage yield in the establishment year by 2-16 times compared to conventional sowing (Hackney and Quinn, 2015).
iv. Twin and summer sowing provide an opportunity for rapid legume growth in early autumn, prior to the onset of frost. For French serradella, utilizing pod negates the expensive process of dehulling to remove seed from the pod, which is required for conventional sowing. Summer sowing allows sowing of a pasture at a time of year when farmers are less busy using conventional sowing machinery.
v. Crop yield and quality without N-fertilizer addition, in replicated plots and broadacre sowings, has been equivalent to, or better than with a continual cropping system where N-fertilizer is provided (Hackney *et al*., 2012, Butcher and Butcher, 2015).
vi. Hard seed break down rates are higher in NSW than WA. However, there does not appear to be a linear relationship between breakdown rates and the number of crops that can be grown over an established seedbank without affecting regeneration. For example, in WA, bladder clover is usually used in a one year crop-one year pasture rotation, whereas in NSW, bladder clover has regenerated strongly where regeneration is only allowed one-year-in-four in broadacre sowings. Biserrula regeneration has been observed four years following last seed set in both states
vii. High livestock production from new legumes was recorded by Hackney and Quinn (2015) with average weight gain of 350 g/head/day for crossbred lambs grazing biserrula over an eight week period in an on-farm study. In a replicated experiment, lactating merino ewes grazing biserrula over a six week period gained over 200 g/head/day, and their lambs over 250 g/head/day. Counterpart ewes grazing typical volunteer pasture lost 75 g/head/day and their lambs grew at less than half the rate of those on biserrula. The sheep grazing Casbah biserrula pasture effectively removed ryegrass selectively over the grazing period, confirming anecdotal reports in broadacre situations of less reliance on herbicides in following crops.
viii. Primary photosensitisation can occur on biserrula-dominant pastures but its incidence is greatly reduced by presence of other species, even at very low levels in the pasture sward. Photosensitisation is not observed once plants begin to senesce. If 'managed', photosensitisation appears to have no long-term impact on livestock performance (Hackney and Quinn, 2015)
ix. In both WA and NSW, farmer 'champions' have been instrumental in ensuring adoption as producers want 'proof' that new technology is robust outside of the confines of well-manicured replicated plots.

Conclusion

Self-sustaining pasture-crop rotation systems are poised to revolutionize southern Australian farming systems. Further research is required, particularly to develop suitable hard-seeded, deep-rooted annual legumes and associated pasture-crop rotation systems for the truly low rainfall cropping region and for the vast alkaline soil regions of Victoria and South Australia, where currently available legumes are limited in their adaptation. Achievement of long term whole-farm systems research as presented in this paper is now rare and has only been achieved here by the collaborative effort of participants with individual projects identifying the need for integration of their respective projects to achieve an overall systems outcome. Systems research, covering the span of crop, pasture and livestock, is scientifically and organizationally complex and requires sustained and significant funding for elucidation of robust, region-specific results. Unfortunately, systemic research, development and extension such as this is difficult to fund, in part because these activities in institutions and funding bodies are grouped separately according to commodities (wool, meat, grain). Yet it is only through commitment to systems research that robust farming systems with adequate diversity to cope with current and future biological, climatic and economic constraints can be developed to ensure long-term viability of the Australian agricultural sector and its impact on world food and fibre production.

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