Balancing enterprises on a whole-farm basis for improved economic viability and improved weed management.

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Abstract

Improved weed management in pastures depends on maintaining vigorous perennial pastures. Maintaining a range of perennial pastures is required to reduce seasonality of production. Grazing management, fertiliser and herbicides all play a role in Integrated Weed Management (IWM) to maintain pasture perenniality and control weeds. For these strategies, there is a need for the effects on the whole-farm to be accounted, by placing appropriate values on the resources used (pasture, soil, water). Financial returns also increase with higher levels of perennial grasses regardless of other pasture components. To balance increased profitability and successful weed control the key is to improve pasture perenniality and vigour.

Introduction

Within the temperate areas of NSW, native, naturalised and introduced pastures are common. The level of introduced species generally increases with the level of inputs (such as fertiliser). Pasture type significantly affects the animal enterprises that can be run and the timing of management activities. For example, fattening enterprises are more likely to be run on fertilised introduced pastures, whereas ewes are commonly lambed in spring to take advantage of forage produced by summer growing native grasses. Matching pasture production to animal requirements requires a deal of planning but when management is also aimed at improving weed control then this adds another level of complexity to the system.

Pasture weeds differ from crop weeds in that they are not always identified as many pasture weed species contribute to production at some stage in their life-cycle. For instance, annual grasses such as barley grass can contribute significantly to winter forage, but this can lead to gaps in the pasture later on which can assist further weed ingression. Weed control in a pasture is more complex than in a cropping system. Often it requires several different methods combined over a number of years formulated as an integrated weed management (IWM) system, to gain control of pasture weeds. The benefits are also long term and are reflected through shifts in the ecological composition from undesirable to desirable species.

This paper deals with weed control practises, and how they are dealt with on the whole-farm basis by looking at the value of resources used over time.

Weed management principles

There are many different types of weeds but the underlying cause of most of them is the same. Disturbance that reduces pasture competition and produces gaps in the pasture is the major cause of weed invasion. Disturbance can be caused by excessive grazing, cultivation, herbicides or fire. Reducing disturbance or altering the timing to minimise its impacts can reduce weed invasion.

Weeds of pastures generally possess one or more characteristic that makes them successful (Taylor and Sindel 2000).

These include:

- an ability to tolerate stress (drought, low fertility);
- high growth rates;
- an ability to respond to increased fertility (especially nitrogen and phosphorus);
- low palatability; and
- an ability to recover quickly from grazing; and short life cycles .

Management will not only vary between weeds with different characteristics, but it will also vary with the density of infestation, the pasture type and the land class.

Pasture weed management is based on three basic principles:

i) Weed seedlings will not establish in a vigorous pasture. Most weed seedlings germinate in autumn so it is important to maintain an active growing perennial pasture at this time.

ii) A vigorous perennial pasture can compete with established weeds to reduce their dominance and possibly reduce seed set.

iii) Herbicide application can be used to control weeds but may not prevent reinvasion if other management (eg grazing system) is not changed or a vigorous perennial pasture is not present.

Pasture perenniality

Pasture perenniality is the key to sustainable production. Results from the Central Tablelands of NSW confirm the value of perennial grasses not only for improving livestock performance (Holst *et al.* 2006), but also for the important role they play in effective weed control (Dowling *et al.* 2006) and water management (Hughes *et al.* 2006). A long term study at Carcoar as part of the Sustainable Grazing Systems program highlighted the important relationship between perenniality and stocking rate, with a potential increase of 3.3 DSE/ha when perennial grass content of pasture is increased from 25% (the current average for the Central Tablelands of NSW) to 70% (a potential optimum for native and sown pastures).

The results indicated a strong inverse relationship between perennial grass content (measured as a percentage of total herbage mass in summer), and the percentage of weeds, mainly annual grasses, in the following spring (Figure 1). For example, the typical tablelands pasture with 25% perennial grass, the relationship predicts a weed content of 60% in the following spring whereas for a pasture with 70% perennial content in summer, the weed content would be reduced to 30% in the following spring. This suggests increasing the perennial content of pastures will also reduce the costs associated with the control of annual weeds. Maintaining a high perennial grass content (60-70%) in pasture will use up to twice as much water as a degraded annual pasture, helping to reduce deep drainage and recharge of the water table.

However, we cannot depend on a one perennial pasture type to achieve weed control in our variable landscape. If only one type of pasture is used over too much of the farm, feed production then becomes seasonal and supplementary feed will be required to fill feed gaps to maintain livestock performance. Pasture productivity will also vary due to landscape factors. Fortunately, different pasture types can be effectively matched to positions in the landscape within individual farms to optimise productivity and provide management flexibility for livestock production and weed control. For example, unimproved native perennial grass based pastures containing winter active wallaby grass (*Austrodanthonia* spp.) or summer active red grass (*Bothriochloa macra*) and kangaroo grass (*Themada australis*) on non-arable hill tops, improved introduced winter active perennial grasses such as phalaris (*Phalaris aquatica*) or cocksfoot (*Dactylis glomerata*) on arable slopes, with specialised summer active forages such as lucerne (*Medicago sativa*) and chicory (*Chicorium intybus*)on valley floors enhance animal production by reducing seasonality of production. Using this pasture type x landscape pattern also improves management of surface and sub-surface water.

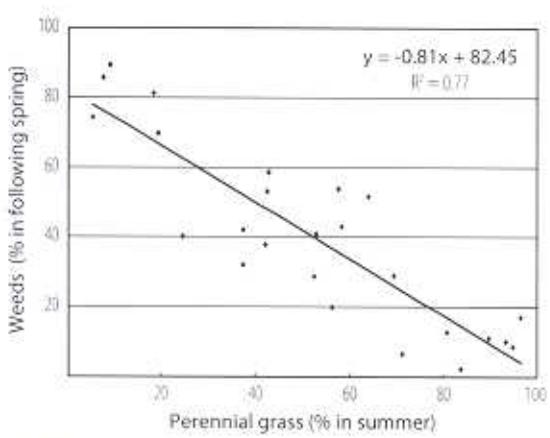

Figure 1 The relationship between perennial grass present in summer (% by weight) and the amount of weed present in pasture in the following spring (% by weight) measured at Carcoar.

Grazing management

Grazing management has a significant effect on pasture composition and perenniality.

Research on the Central Tablelands of NSW has shown that a simple tactical rest over summer can lead to significant and rapid increases in perennial grass content. Perennials such as lucerne and chicory will persist under rotational grazing but don't persist under continuous grazing. Changing from a highly selective grazer such as sheep to a less selective grazer in cattle will also affect pasture composition. Different classes of livestock may alter selectivity or requirements for maintaining pasture productivity. For example, prime lamb production requires higher quality pasture as compared to running wethers for wool production.

These differences in grazing behaviour can be effectively used to manipulate pasture composition. Short duration high intensity grazing assists in the control of annual weeds. Heavy grazing can be used to damage a weed at critical times in its life-cycle. Heavy grazing of saffron thistle seedlings can reduce their effect on pastures, while heavy grazing in the early reproductive stage of barley grass (*Hordeum leporium*) and silver grass (*Vulpia* spp.) can reduce these annual grasses setting seed.

Alternatively, reduced stocking rates help to maintain vigorous perennial pastures and can reduce weed establishment. Research has shown that maintaining minimum biomass levels of 1.5 t/ha and 90% ground cover, using a high intensity short duration grazing system substantially reduce the germination of serrated tussock seedlings (*Nassella trichotoma*) and

prevented any from surviving to adult plants over a two year period (Badgery 2004).

Having a range of perennial pastures enables farmers to strategically rest some pastures when required to improve competitiveness and cover. Holst *et al.* (2006) found that weaning prime lambs in December onto chicory pastures, enabled summer resting of grass pastures to maintain perenniality or reduced grazing pressure on pastures to maintain critical biomass levels to limit ingress by annual species.

Fertiliser

Fertiliser application (mainly superphosphate) is another management tool that can be used to vary pasture composition and increase the content of desirable species. This approach is particularly effective where the pasture has a high proportion of productive, competitive species such as phalaris, cocksfoot, tall fescue (*Festuca arundinacea*) and perennial ryegrass (*Lolium perenne*).

However, our results show fertiliser can have negative impacts when applied to continuously grazed naturalised pastures containing native perennial grasses and annual grasses. These negative impacts are related to the timing of fertiliser application. Since superphosphate is usually applied in autumn, annual grasses are the main beneficiaries of the improved nutrition and due to their high relative growth rate they often out-compete perennial species.

This highlights the importance of assessing pasture composition in the spring preceding fertiliser application. If the perennial content is low at this assessment, a tactical rest should be imposed over summer to increase perennial grass content before applying the fertiliser in the following autumn. Another option is to delay fertiliser application until the annual grasses have hayed off, so that only the actively growing perennial grasses benefit from the fertiliser. In many instances the extra spring feed produced from autumn fertiliser application may not beneficial unless it can be utilised either by increased stocking rates or fodder conservation (hay or silage). The inability to utilise feed before species mature may lead to continued weed problems where annual grassy species dominate spring growth.

Hay and silage

The physical removal of reproductive material by hay or silage making can reduce the incidence of annual grass weeds in pastures, but this depends on the timing of the activity and the subsequent feeding out of the conserved fodder. While high temperatures in ensilage procedures will kill weed seeds, this does not occur with haymaking where annual grass recruitment may dramatically increase with the feeding out of hay made late in the season. To overcome this increase in annual grass recruitment, 'sacrifice areas' may need to be used for feeding out, with intensive annual grass control required later.

However, hay and silage making may also have significant negative effects on desirable species in the pasture, where the spaces initially occupied by annual grasses can be taken over by other non productive species such as broadleaf weeds. Maintaining competitive perennial grasses needs to be a part of a fodder conservation program.

Herbicides

Application of herbicides will have significant effects on pasture composition. Herbicide applications can be at lethal (normal application) or sub-lethal (spray-grazing or spray-topping) rates depending on the situation. Control of targeted species can be obtained, but reapplication of herbicides is often necessary for long term control unless an integrated approach is used. Our research has shown that although good control of silver grass could be obtained after one application of a spray-topping herbicide (glyphosate or paraquat), this did not ensure low silver grass plant densities in the subsequent years. A zero herbicide treatment in the second year led to silver grass numbers significantly exceeding the single spray-topping treatments. As well, the effects on non-targeted species in a spray-topping application (such as subclover), need to be taken into consideration. Compared to paraquat, glyphosate spray-topping will reduce subclover regeneration.

Integrated Weed Management (IWM)

IWM involves the combination of a number of weed control methods that alone would be less effective then when they are used together. IWM management system often involves a combination of two or more of the above mentioned control methods plus additional methods like biological control.

The initial perennial grass content will determine the order in which the IWM components should be applied to achieve maximum benefit (Huwer *et al.* 2005). Where the perennial grass content is low (<5%) the initial focus of IWM is to increase the level of pasture perenniality. Results show that a combination of tactical rest, oversowing and fertiliser application will enhance perenniality. Once the perennial grass content exceeds about 25%, the emphasis of IWM should shift to placing equal emphasis on manipulating perennial grass competitiveness and weed reduction. Studies in pastures infested with Paterson's curse (*Echium plantagineum*) showed that sufficient changes in the perennial component can be achieved in two years of management that included a summer rest to strengthen cocksfoot growth and herbicide to kill the

Paterson's curse. Herbicide or summer rest applied alone could not increase perennial grasses to a level of competitiveness to limit Paterson's curse invasion over the autumn-spring period. When perenniality accounted for >60% of pasture spring biomass IWM should focus almost exclusively on the reduction in the target weed. This was shown in a study of nodding thistle (*Carduus nutans*) where a single spray graze was able to maintain thistle biomass at an acceptable level without tactical grazing because perennial grasses already dominated the pasture.

Another example of a successful IWM system is for the control of serrated tussock. At first herbicide (either glyphosate or flupropanate) is applied to kill adult plants. This is followed by the establishment of a competitive phalaris based pasture to limit seedling reinvasion. However, this is generally not completely successful and spot spraying is required to control isolated plants that do reinvade. Grazing management is also extremely important to maintain the competitiveness of the pasture to prevent further invasion. This technique is extremely successful and combines four methods together into a complete system, lifts production and limits further weed invasion.

Economics

There is a direct relationship between the presence of perennial grasses and financial returns. Regardless of other pasture components financial returns increase with higher levels of perennial grasses (Table 1). Legumes are important to provide nitrogen for perennial grasses and an upper limit of 70–80% perennial grasses should allow sufficient legume (20–30%) to drive the system. Also it should be noted that high levels of utilisation are needed to generate these returns from pastures with a high perennial content and this in turn may cause the perennial content to decrease. Management is therefore extremely important to prevent pasture degradation at crucial times like drought.

For the adoption of changes in pasture management to maintain perenniality and control pasture weeds, such changes must be more profitable. Where reductions in stocking rate and grazing rests are recommended, however, profitability is difficult to demonstrate in the short term. But over the longer term, maintaining and encouraging perenniality can be shown to be profitable by placing appropriate values on the resources (for example, perennial grasses, soil, water) that are enhanced by this process and reducing the need to resow pastures. A simulation model has been developed to measure the benefits and costs of long-term grazing management (Jones *et al.* 2006). The modelling system estimates the net present value (NPV) of economic returns over time (say 20 years) for a range of management scenarios. The NPV is the cumulative annual economic returns, discounted to account for effects of interest and inflation (that is, a dollar today is worth more than a dollar next year). This economic approach provides a more rigorous evaluation of a sustainable grazing system that can be achieved from using more simplistic analysis tools such as gross margin analysis. While the option of summer grazing rest involves sacrificing income for the years when the summer rest is applied, this is more than compensated for in later years, as higher stocking rates can be implemented due to the resulting increase in perennial grass composition.

Table 3 Predicted net returns from various combinations of introduced pasture composition (Dowling and Jones 2002).

Perennial grass (%)	Legume (%)	Annual grass (%)	Broadleaf weeds (%)	Net return ($)
0	0	20	80	-8.42
10	0	10	80	28.46
10	20	40	30	29.72
20	0	20	60	65.66
20	20	20	40	66.43
40	0	20	40	139.74
40	20	20	20	140.48
60	0	20	20	213.82
60	20	20	0	214.59
80	0	0	20	230.79
80	20	0	0	263.04

Note: These figures are based on economic returns (net returns) for various pasture compositions based on forage production (metabolizable energy) and livestock demand throughout the year. Perennial grass value is based on phalaris and cocksfoot pastures.

Summary

Vigorous perennial pastures are important for profitable animal enterprises and limiting weed invasion. Increasing perenniality from an average of 25% to a more desired level of 60 to 70% should substantially increase whole-farm profitability by increasing animal production by lowering weed control costs, which can be particularly high with noxious weeds such as serrated tussock and St. Johns Wort (*Hypericum perforatum*). A balance of perennial pastures is required to reduce seasonality of forage production. Many strategies used in IWM systems are aimed at boosting pasture productivity (eg fertiliser and grazing management) and therefore increase the production from the enterprises grazing these pastures. There are many synergies between the methods used to increase pasture production and to prevent weed invasion. It is therefore possible to balance increased profitability and successful weed control, however, the key is not to over utilise pastures and maintain them in a competitive, productive state.

References

Badgery, W.B. (2004). Managing competition between *Nassella trichotoma* (serrated tussock) and native grasses. PhD, The University of Sydney.

Dowling, P. and Jones, R. (2002). Use perennials to double returns. *Farming Ahead (Kondinin Group)* **122**, 54–55.

Dowling, P.M., Michalk, D.L., Kemp, D.R., Millar, G.D., Priest, S.M., King, W.McG., Packer, I.J., Holst , P.J. and Tarleton, J.A. (2006). Sustainable grazing systems for the Central Tablelands of New South Wales. 2. Effect of pasture type and grazing management on pasture productivity and composition. *Australian Journal of Experimental Agriculture* **46**, 457–469.

Holst, P.J., Stanley, D.F., Millar, G.D., Radburn, A., Michalk, D.L., Dowling, P.M., van de Ven, R., Priest, S.M., Kemp, D.R., King, W.McG. and Tarleton, J.A. (2006). Sustainable grazing systems for the Central Tablelands of New South Wales 3. Animal production response to pasture type and management. *Australian Journal of Experimental Agriculture* **46**, 471–482.

Hughes, J., Packer, I.J., Michalk, D.L., Dowling, P.M., King, W.McG., Brisbane, S., Millar, G.D., Kemp, D.R., Priest, S.M. and Koen, T.B. (2006). Sustainable grazing systems for the Central Tablelands of New South Wales. 4. Soil water dynamics and runoff events for differently grazed pastures at Carcoar. *Australian Journal of Experimental Agriculture* **46**, 483–494.

Huwer, R.K., Briese, D.T., Dowling, P.M., Kemp, D.R., Lonsdale, W.M., Michalk, D.L., Neave, M.J., Sheppard, A.W. and Woodburn, T.L. (2005). Can an integrated management approach provide a basis for long-term prevention of weed dominance in Australian pasture systems? *Weed Research* **45**, 175–192.

Jones, R.E., Dowling, P.M., Michalk, D.L., and King, W.McG. (2006). Sustainable grazing systems for the Central Tablelands of New South Wales. 5. A bioeconomic framework for assessing the long-term economic benefits of grazing management tactics and implications for sustainability. *Australian Journal of Experimental Agriculture* **46**, 495–502

Taylor, U. and Sindel, B.M. (2000). The pasture weed management kit: A guide to managing weeds in southern Australian perennial pastures. Cooperative Research Centre for Weed Management Systems, Adelaide, South Australia.