Lime and Crop Rotations for Weed Seedbank Management in New Pastures

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ABSTRACT

In 1999, soil cores collected from a long term field experiment at Neville, located on the central tablelands of NSW, were used to examine the viable seedbank resulting from a limited range of lime and crop combinations. Soil from the cores was placed in trays and germinating seedlings identified and recorded over a five month period. A total of 20 grasses and 28 broadleaf species were recorded. Grasses including annual ryegrass (*Lolium rigidum*), vulpia (*Vulpia* spp.), and brome (*Bromus* spp.) were the dominant weeds but density varied between crop and pasture treatments. Ryegrass density was higher in new pasture than in wheat or canola, and was inversely related to the rate of lime applied. Brome density was higher in the degraded pasture but did not respond to lime. Vulpia response varied significantly depending on lime application rate, incorporation depth and crop and pasture treatments.

KEY WORDS

Weed seedbank, soil acidity, crop/pasture integration, lime incorporation.

INTRODUCTION

Sown perennial pastures are an important forage resource for production in the central tablelands of NSW (8). However, producers face declining farm incomes as the productivity and quality of sown pastures decline due to weed invasion. Soil acidity and grazing management systems also contribute to this decline. Resown pasture is expensive (10) as is the loss of potential productivity of degraded pastures.

Soil acidity in this region must be addressed to improve long term pasture productivity (6). The most commonly adopted amelioration is the addition of lime to raise the pH, reduce aluminium toxicity and improve soil fertility. Effective weed management is essential for long term pasture productivity (7). While herbicides remain an effective tool for weed control there is increasing pressure on producers to reduce herbicide use to prevent herbicide resistance in weeds like ryegrass and to minimise any impacts on the environment.

Integrated weed management systems that reduce the soil weed seedbank are a vital key for long term weed control (9). A short crop rotation combined with lime application may be a viable management option to finance pasture improvement. The aim of this study is to examine the potential of lime application rates, incorporation methods and crop rotations to manage the weed seedbank prior to and during pasture improvement.

METHODS

The site is located approximately 5 km southwest of Neville (33^{o} 43’ South, 149^{o} 13’East), on the central tablelands of NSW. Altitude is 960 m and average annual rainfall is 760 mm. The soil is a gradational red earth, with clay loam texture and is moderately well drained. The unamended soil pH ($CaCl_2$) is 4.5 (0-10cm), while the profile has a pH_{Ca} of less than 5 to a depth of 100 cm. Prior to commencing this study the pasture consisted predominantly of annual grasses, spear thistle and a variety of broadleaf weeds.

The field experiment was set up as a split plot, within a block design, with three replicates including three main effects: lime application at; zero, 2.5 t/ha and 5 t/ha; lime incorporation at three depths (zero, shallow and deep) and eleven crop and pasture sequences over a three year period. Discussion in this paper is limited to the consequences of the first crop sequence (Table 1).

Table 1. Crop and pasture sequences.

	1998	**1999**
D/D	Degraded pasture	Degraded pasture
CF/D	Chemical fallow	New pasture
D/CF	Degraded pasture	Chemical fallow
D/D	Degraded pasture	Degraded pasture
P/P	New pasture	New pasture
W/C	Wheat	Canola
W/F	Wheat	Faba beans
W/P	Wheat	New pasture
C/F	Canola	Faba beans
C/W	Canola	Wheat
C/P	Canola	New pasture

New pastures and crops were fertilised with 30 kg/ha nitrogen, 24 kg/ha phosphorus and 24 kg/ha sulphur, applied below the seed at sowing. Routine chemical weed control measures were taken in crops, but no post emergent weed control in pastures.

Soil for the seedbank study was sampled in 1999, following seed fall and recruitment from weed seedbanks in 1998, but before seed fall in 1999. These data represent outcomes of the early stage of a longer term rotation sequence. Two sets of ten cores were taken from each plot, dried and broken up. Samples were then mixed, divided in half, laid approximately 1 cm deep in trays and regularly watered. Over five months weed seedlings were periodically identified, recorded and removed. Data were transformed ($\sqrt{x}$) and analysed using Genstat 5 for analysis of variance.

RESULTS

Forty eight weed species were identified in the seed bank, 20 grasses and 28 broadleaf weeds. 65% of the viable weed seed population were grasses. Annual ryegrass accounted for 56% of all grass seedlings, followed by vulpia (21%), brome (13%) and the remaining 10%, a mix of other grasses.

The overall population of annual ryegrass seed was higher following crops and pastures sown in 1998 than in chemical fallow or degraded pastures (P<0.002). Wire weed was higher in the new pasture than any of the crops or degraded pastures (P<0.001). Brome was higher in the degraded pasture than any treatments that had been disturbed (P<0.001). Vulpia was greater on the canola (C/W), new pasture (P/P) and wheat (W/C) (P<0.034) (Fig. 1).

The implication for pastures following these treatments is that a preceding 12 month chemical fallow effectively reduced the annual ryegrass seedbank. However in commercial practice this may not be a financially viable option. Wheat and canola were more effective in controlling the explosion of annual ryegrass and wire weed following disturbance than new pasture (Fig. 1).

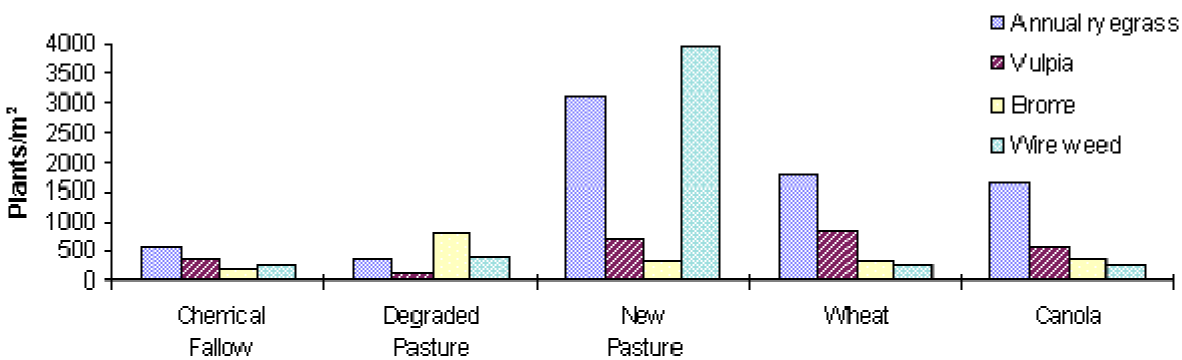

Figure 1. Effect of different crops and pastures in 1998 on the weed seedbank. Data have been retransformed (√x).

Annual ryegrass and vulpia decreased with increasing levels of lime, This result however, may be attributed to the increase in competitive ability of the crops and new pasture species. Where lime is applied there is no significant difference between annual ryegrass seed in wheat or canola. But in the absence of lime wheat is more effective than canola in reducing ryegrass (data not presented). Lime application had no significant impact on brome or wire weed (Fig. 2).

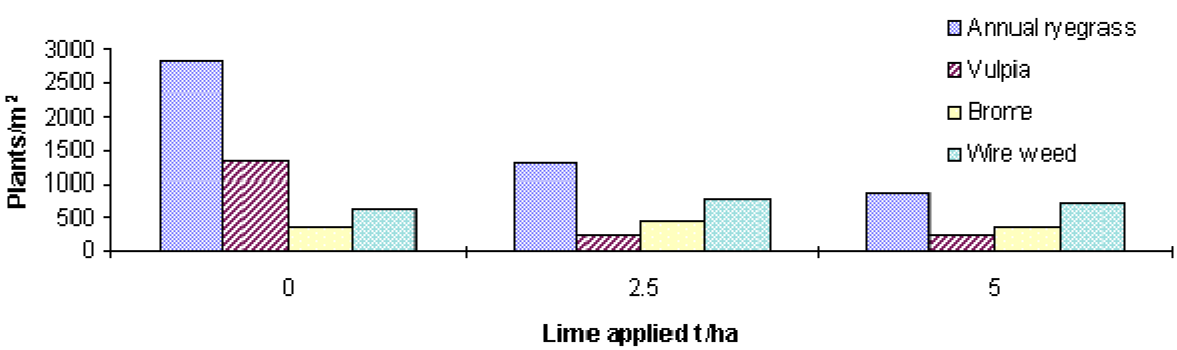

Figure 2. Effect of lime application rate on the weed seedbank. Data have been retransformed (√x).

Lime incorporation method had very little overall impact on weed populations (Fig. 3). However there were some important relations between incorporation method and crop rotation (data not presented). Deep incorporation significantly increased wire weed in the new pasture (P<0.010). Vulpia was significantly higher in the unlimed, unincorporated plots, where the small soft seed was not buried and crop competition was not increased (P<0.001).

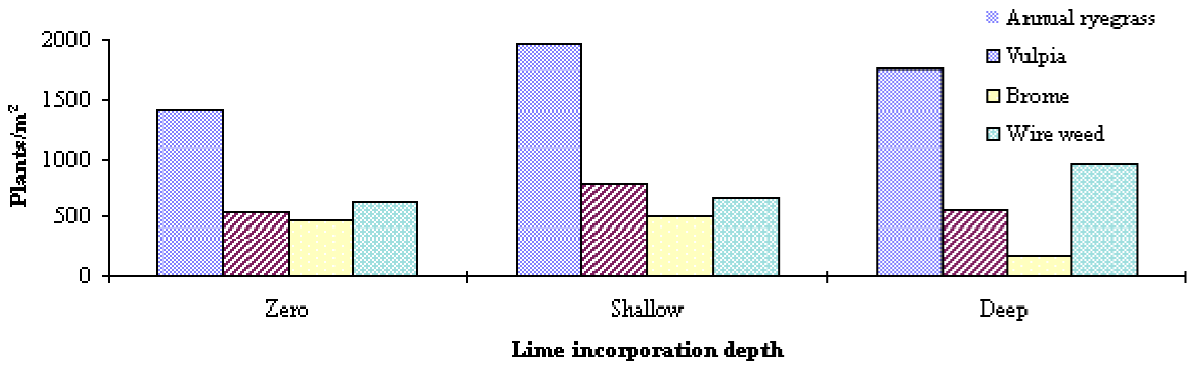

Figure 3. Effect of lime incorporation depth on the weed seedbank. Data have been retransformed (√x).

DISCUSSION

Dominance of the seedbank by a few species is typical of a continuous farming system where the dominant weed species are those well adapted to the management regime (3) of the degraded pasture. Introduction of new pasture and crop rotations changes the soil fertility, herbicide applications, tillage operations, and grazing management, tipping the balance in favour of the crops and new pastures.

Grasses can have a major impact on the seed bank because a small number of plants can produce a large amount of seed in a single season. This is demonstrated by the difference between the ryegrass seed population under the new pasture after one year compared to the degraded pasture (Fig. 1). Between 60% and 95% (5) can germinate in the following season. Though not all of these will survive to establishment, an effective change in management can be expected to have a significant impact on the seedbank over a similar time period. The explosion of annual ryegrass seed in the new pastures and crops is evidence that these changes in management practices may also favour it over vulpia and brome.

Brome performs better than annual ryegrass under the lower soil fertility of the degraded pasture but seed production is reduced under competitive pressure (4). Shifting the system in favour of crops and new pastures may explain the lower incidence of brome seed in the improved pasture.

CONCLUSIONS

After only one year of crop or pasture it appears that lime application and crop rotation can be used to manipulate the weed seedbank structure. It appears to do so by improving the competitive ability of the crops and new pastures that respond to soil fertility.

While a crop rotation can be used to finance lime application and pasture establishment, it can also improve the competitive ability of the crop and pasture by introducing agronomic options into the system, for example, it allows for a greater variety of herbicides and other weed control methods to be used. The effectiveness of crop rotations for reducing the weed seedbank depends on maintaining good weed control during each phase of the rotation (1 and 2). The full benefit of crop and pasture rotations therefore, cannot always be realised in the first phase of the rotation.

A long term pasture improvement program requires lime and fertiliser to improve soil fertility. It requires ongoing management to maintain the competitive advantage of the sown perennial pasture, which also includes; grazing management, weed control by both chemical and cultural methods (eg silage and hay cutting) and ongoing fertiliser application.

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