The effect of weeds on wheat grain yield in limed and unlimed soils

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Abstract

Wheat and weed dry matter at anthesis and harvest, were monitored over 4 years, 1999-2002. Two pasture/crop rotation systems, each with lime and without lime application, were used, annual pasture/crop rotation (AP/C, 2-year rotation) versus perennial pasture/crop rotation (PP/C, 6-year rotation). The pasture in AP/C was subterranean clover dominated pastures with voluntary grass weeds whereas pasture in PP/C was a mixed sward of perennial ryegrass and subterranean clover with voluntary grass weeds. The crop in AP/C was wheat whereas crops in PP/C were triticale, lupins and wheat. However, only the wheat crop and its relationship with weeds are discussed in this paper. Lime significantly increased dry matter of wheat and suppressed weed dry matter at anthesis and harvest. The grain yield on the limed treatments was 3.1 t/ha whereas on the nil lime treatments it was 1.3 t/ha. There were strong negative relationships between wheat and weed DM at anthesis and harvest. Liming could be used to increase wheat grain yield and suppress weeds on highly acidic soils in high rainfall zones.

Media summary

Liming suppressed weeds, increased crop early vigour and doubled wheat grain yield on highly acidic soils in a high rainfall zone.

Key words

Wheat, lime, acid soils, crop/pasture rotation

Introduction

Weeds are most important contributors to yield reductions in the grain industry in Australia. In a field survey in southern NSW in 1993, 50 weed species from 19 families were identified. The grass weeds such as annual ryegrass (*Lolium rigidum*) and *vulpia* spp. were the most common weeds (Lemerle *et al.* 1996). Weeds compete for available N supply and light in the early growth stage (Cousens 1996) and for soil moisture during grain filling in southern Australia (Lemerle *et al.* 1995), reducing both vegetative DM and grain yield (Mason and Madin 1996). Weed competition could be greater under lower soil fertility conditions, such as highly acidic soils, as ryegrass has a greater ability to take up N than wheat (Reeves 1976). Thus, on infertile acid soils, crop options were reduced to a limited range of acid-tolerant cultivars (Cregan *et al.* 1989; Helyar *et al.* 1990; Li *et al.* 2001). Managing Acid Soils Through Efficient Rotations (MASTER), is a long-term agronomic field experiment established in 1992 (Li *et al.* 2001). The primary objective was to develop agricultural systems that are environmentally sustainable and economically viable on the highly acidic soils in south-eastern Australia. Wheat establishment, crop and weed DM at anthesis and harvest, and grain yield were monitored over 4 years from 1999-2002. Wheat production and its relationship with weeds are discussed in this paper.

Materials and methods

The experiment was on the farm property 'Brooklyn', operated by the Hurstmead Pastoral Company Pty. Ltd, at Book Book (147?30′E, 35?23′S), 40 km south-east of Wagga Wagga in a 650 mm rainfall zone. The soil at the site is a subnatric yellow sodosol with some red phases over the site (Isbell 1996). The average pH_{Ca} in the 0-10 cm surface soil was 4.0 and sub-surface pH_{Ca} was below 4.5 to at least 20 cm. Exchangeable aluminium exceeded critical toxic concentrations for sensitive species to 40 cm in depth, which was typical of the more acidified soil in the region. An initial lime application (average 3.7 t/ha) was incorporated to a depth of 10 cm and a maintenance application of lime (average 2.6 t/ha) was top-dressed every 6 years in the limed treatments.

The experiment was a fully phased design with two replicates. Plot size was 30 x 45 m. There were two pasture/crop rotation systems, each with lime and without lime application. These were annual pasture/crop rotation (AP/C, 2-year rotation) and perennial pasture/crop rotation (PP/C, 6-year rotation). The pasture in AP/C was subterranean clover dominated pastures with voluntary grass weeds whereas pasture in PP/C was a mixed sward of perennial ryegrass and subterranean clover with voluntary grass weeds. The crop in AP/C was wheat whereas crops in PP/C were triticale, lupins and wheat (Li *et al*. 2001). However, in PP/C treatment only the wheat phase is reported here. Wheat establishment, tiller counts, crop and weed DM were measured each year. Grain yields were taken from the whole plot and harvest index was calculated from hand harvest samples.

All crop plots received one application of Roundup?[1] (glyphosate 450 g/L) just prior to sowing for weed control. Pre-emergent herbicides Treflan? (trifluralin 400 g/L) or Yield? (oryzalin + trifluralin 125 + 125 g/L,) were alternately used to control grass weeds and minimise the development of herbicide resistance. Post-emergent herbicide was used only if necessary on both limed and unlimed treatments.

Results

Wheat density at establishment was higher on the limed treatments than the unlimed treatments. There were more tillers per plant in the tillering stage, more DM, at both anthesis and harvest, and much less weed DM on the limed treatments compared with the unlimed treatments (Table 1). Wheat grain yield on the limed treatments was 3.1 t/ha whereas grain yield on the unlimed treatments was 1.3 t/ha and grain protein was about 0.6% higher. The harvest indices on the limed treatments were slightly higher than the unlimed treatments (Table 1).

Table 1. Average wheat and weed DM at anthesis and harvest, and grain yield in 1999-2002

Treatment	AP/C-	AP/C+	PP/C-	PP/C+
Establishment (plant/m^2)	117	136	114	138
Tillers/plant	3.8	4.9	3.7	5.3
DM at anthesis (t/ha)				
Wheat crop	3.11	6.33	2.84	6.74
Weeds	2.52	0.73	3.06	0.54
DM at harvest (t/ha)				
Wheat crop	3.70	7.86	3.72	7.92
Weeds	1.97	0.59	2.05	0.40

Grain yield (t/ha)	1.31	3.05	1.35	3.15
Protein (%)	12.0	12.6	12.5	13.1
Harvest index	0.35	0.39	0.36	0.40

There were strong negative relationships between wheat grain yield and weed DM at anthesis (Figure 1a). The grain yield was reduced by half a tonne per ha as the weed DM increased by one tonne per ha (Figure 1a). The relationship between wheat DM at anthesis and grain yield was positively correlated. The greater crop DM accumulated at anthesis, the more grain yield produced at harvest time (Figure 1b).

Discussion

The better performance of wheat crops on the limed treatments was due to improved soil fertility compared with the unlimed treatments. On the limed treatments, the subsurface soil acidity has been gradually ameliorated over the past 12 years of liming (Li *et al.* 2002). The exchangeable aluminium, the major limiting factor for the root growth, has decreased from 42% in 1992 to about 15% in 2002 at the 15-20 cm soil depth. Thus wheat crops on the limed treatments had better soil fertility status, hence had stronger competitive capability compared to wheat crops on the unlimed treatments.

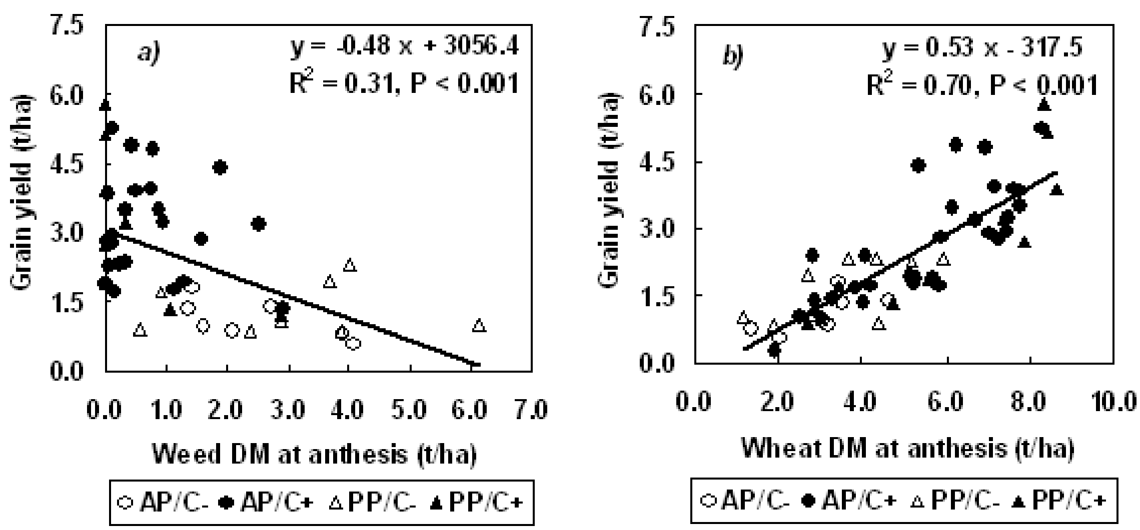

Figure 1. Relationships between grain yield and wheat and weed DM at anthesis in 1999-2002.

Smith and Levick (1974) found that weeds and wheat compete for nitrogen and light during early growth stage (tillering), for nitrogen from jointing to anthesis, and for moisture from anthesis to maturity. On the limed treatments, the improved soil water and nutrients status offer wheat crops stronger early vigour compared with crops on the unlimed treatments as evidenced by higher plant density and more tillers per plant on the limed treatments (Table 1). During the later development stage, wheat crops with less weed burden at anthesis on the limed treatments had potentially more soil water available for grain filling, thus higher grain yield compared to the unlimed treatments. Crops with a heavy weed burden can lose grain yield of up to 60% in the case of the unlimed treatments (Table 1).

The heavy weed burden not only reduced grain yields significantly as shown on the unlimed treatments (Table 1), but also had a detrimental effect on the following crops due to an unmanageable weed population. Farmers have to rely heavily on herbicide options to control weeds. However, the rapid development of herbicide resistance in weeds and environmental imperatives, have forced the consideration of non-chemical tactics such as crop competition for weed management (Lemerle *et al.* 2001). The results from this research showed that liming could be used to increase wheat grain yield and suppress weeds on highly acidic soils in high rainfall zones.

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[1] Registered trade name