Effects of crop residues and management practices on weeds in a wheat crop in Canterbury

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Abstract

The effect of different crop residues and their management on subsequent weed biomass and wheat yield in a wheat crop was studied for three years in a field experiment in Canterbury. Treatments were applied in the first year only; they included four crop residues: white clover, perennial ryegrass, wheat and peas and four management practices: burning, ploughing, rotary hoeing and mulching. Wheat was sown every year in the plots. Half of the experiment received nitrogen fertiliser in the third year. In the first year, higher dry weights of weeds were recorded after white clover and wheat than after perennial ryegrass and peas. After white clover and wheat, dry weight of weeds was higher in the mulching treatment while ploughing reduced weeds dry weight significantly. Dry weight of weeds was not affected by crop residues in the second year but was significantly higher after the mulching treatment. The effect of nitrogen application on weed density and growth was species' specific. For example, the number of field speedwell (*Veronica arvensis* L.) plants decreased while their vigour, measured as the average plant dry weight, increased when nitrogen was applied. On the other hand, wild oats (*Avena fatua* L.) density increase but vigour decreased in fertilised plots. The results highlight the significance of management practices in the crop-weed interaction.

Additional key words: *burning, cultural weed control, integrated weed management, mulching, nitrogen fertiliser, ploughing, rotary hoeing, rotation.*

Introduction

Increasing concerns about total reliance on chemical weed control means efforts should be directed into integration of different control options. Certain control techniques, such as biological control are not yet available for weed control in cereals. Mechanical control is either impractical, uneconomical or might cause damage to the crop (Stiefel and Popay, 1990; Popay *et al.*, 1993). In order to make the best use of cultural practices in weed management, an understanding of the complex inter-relations between the crop, the diverse weed populations and the environment is necessary. All management practices have an effect on this relationship.

The arable cropping system in the Canterbury Plains of New Zealand is generally characterised by a rotation involving 1 - 5 years of grass/legume pasture followed by 1 - 5 years of arable crops including small grains and legumes (Nguyen *et al.*, 1995). While it is generally believed that rotation is a necessary part of a sound integrated weed management programme, the effect of preceding crops on weed composition and densities in cereals is not well understood. Both crop residue and its management can influence weed seed germination in the soil (Teasdale *et al.*, 1991). Crop residues are commonly burnt, although some farmers incorporate them into the soil or leave them on the soil surface as a mulch. Very few studies in New Zealand have examined the effects of crop residue or management practices on weeds. Hartley (1990) reported a greater decline in the number of weeds in non-cultivated plots than in plots with cultivation over a three-year period. Popay *et al.* (1992) found no consistent or significant pattern on weed density following different winter manure crops or primary cultivation methods. Undersowing with legumes did not show any advantage in reducing weed mass and caused competition to wheat (Popay *et al.*, 1992; Deo *et al.*, 1993).

Nitrogen fertiliser is another important factor which can affect the interaction between weeds and the crop, but this factor has received little attention in New Zealand. Studies from other countries have shown that amount, timing and placement of nitrogen produced marked effects on weeds and their competition with the crop (Cochran *et al.*, 1990; Anderson, 1991; Ball *et al.*, 1996).

This paper reports the effect of four crop residues (two legumes and two graminaceous plants) and four management practices (burning, ploughing, rotary hoeing or surface mulching) on growth of a wheat crop and weeds over a three-year period. The effect of nitrogen fertiliser on different species of weeds was investigated in the third year.

Materials and Methods

A field experiment was established on a Templeton silt loam soil at the Henley farm of Lincoln University during 1993 using a split plot design with six replicates. Main plots (20 x 30 m) were sown with white clover (*Trifolium repens* L.) at 3 kg/ha, perennial ryegrass (*Lolium perenne* L.) at 30 kg/ha, winter wheat (*Triticum aestivum* L.) at 130 kg/ha or field peas (*Pisum sativum* L.) at 170 kg/ha. In January 1994, perennial ryegrass, wheat and field peas were harvested and in February 1994 white clover seed was harvested and the stubble was desiccated using glyphosate (Roundup at 2 l/ha). All crop residues were shredded using a mulching mower prior to imposing the management practices. These were allocated randomly to subplots (4 x 35 m) and included ploughing to a depth of 25 cm, rotary hoeing to a depth of 15 cm, mulching and burning the residues. Wheat cv. Monad was sown at 130 kg/ha in 15 cm rows in May 1994 and all plots were rolled. In 1995 and 1996, all plots were ploughed, disced and rolled in May and wheat (cv. Monad) was sown in June. No fertiliser was added during these years but in 1996 half of the experiment (three replicates) received a broadcast application of urea as a split application of 100 kg N/ha at early stem elongation and 50 kg N/ha before anthesis. The experimental plots were irrigated in 1993-96 but not in 1997.

Grain yield of wheat and total dry weight of weeds were determined for the first and second year crops. In the third year, density (number of plants/ m^2) and dry weights of individual weed species were also determined prior to harvesting wheat. All plant measurements were made using three 0.1 m^2 quadrats for weeds and six 0.5 m^2 quadrats for wheat randomly placed in each plot. Analysis of variance was performed on the data and LSD test ($P \leq 0.05$) was used to separate the means.

Results and Discussion

First year

In the first year, significant interactions were found between crop residues and management practices for dry weight of weeds. After white clover residue, the highest dry weight of weeds (106 g/m^2) was observed in the mulch treatment and the lowest (33 g/m^2) in the ploughing treatment (Table 1). This could have been due to deep burial of weed seeds by ploughing. Mulching wheat residue gave the highest weed dry weight (99 g/m^2) and more than 90% of these weeds were wild oats. Other workers have also found higher weed mass under zero tillage than conventional tillage (Blackshaw *et al.*, 1994; Arshad *et al.*, 1995). Management practices after perennial ryegrass and peas did not significantly affect weed dry weight (Table 1). When averaged across all management practices weed dry weights were lowest for peas < perennial ryegrass < wheat < white clover, while for management treatments the order was burning < ploughing < rotary hoeing < mulching.

Across all management treatments, mean grain yield of wheat was the lowest after wheat residue which is expected in a monoculture situation. Significant interactions were found between crop residues and management practices for wheat grain yield. Wheat grain yield was the lowest following wheat under mulch treatment (Table 1). The addition of straws with high C:N ratio such as ryegrass and wheat can lead to immobilisation of soil nitrogen which adversely affects crop yield (Biederbeck *et al.*, 1980; Mary *et al.*, 1996). When residues were ploughed in, the highest grain yield was obtained after white clover. This could be due to a higher amount of nitrogen added to the soil by white clover residue (Kumar, 1998).

Second year

The only significant effect in the second year was from management practices (Table 2). The highest wheat grain yield was obtained after mulching in the previous season. This was probably due to the release of nitrogen from crop residues left on the soil surface. Surface residues decompose more slowly than buried residues and release comparatively more nitrogen in the second year (Christensen, 1986; Varco *et al.*, 1989).

Table 1. Effect of different crop residues and their management practices on wheat grain yield and dry weight of weeds (values in brackets) in the first year. Data are g/m^2.

	Management			
Crop residue	Ploughing	Rotary hoeing	Mulching	Burning
White clover	755 (33)	693 (65)	551 (106)	628 (62)
Peas	665 (25)	613 (35)	473 (12)	565 (9.3)
Ryegrass	520 (41)	513 (36)	442 (45)	495 (32)
Wheat	366 (47)	358 (53)	239 (99)	456 (35)
$LSD_{p \leq 0.05}$	97.5 (29.6)			

Mulching also gave the highest dry weight of weeds although this did not differ from ploughing (Table 2). Besides the release of nitrogen as explained above, mulched plots probably had carry-over of weed seeds from the previous year, while ploughing may have brought deeply buried seed into the germination zone.

Third year

No significant effect from cropping and management practices used during 1993-1994 on total weed dry weight was observed in the third year, but the addition of nitrogen resulted in a significant increase in wheat grain yield and total weeds dry weight (Table 3). Lower grain yield in unfertilised plots in this year was the result of depletion of nutrients during the course of the experiment.

The major grass weed species present included wild oat (*Avena fatua* L.), browntop (*Agrostis capillaris* Sibth.), and annual poa (*Poa annua* L.). The major broadleaf weeds included field speedwell (*Veronica arvensis* L.), scentless chamomile (*Matricaria inodora* L.), and yarrow (*Achillea millefolium* L.). Minor broadleaf weeds were field pansy (*Viola arvensis* L.), sheep's sorrel (*Rumex acetosella* L.), hawksbeard (*Crepis capillaris* L.) and scarlet pimpernel (*Anagalis arvensis* L.).

Individual weed species differed in their responses to the addition of nitrogen fertiliser (Table 4). The addition of nitrogen fertiliser increased the number of wild oat plants, decreased the number of plants of field speedwell, yarrow and browntop, and had no effect on the other species (Table 4). The stimulation of seed germination by nitrogen has been reported for several weed species including wild oat (Andersen, 1968; Agenbag and De Villier, 1989). On the other hand a decrease in the number of other weed species in fertilised plots may be related to seedling mortality due to greater competition from wheat.

Table 2. Second year wheat grain yield and total dry weight of weeds as affected by different management practices in the first year.

Management	Wheat grain yield (g/m^2)	Weed dry weight (g/m^2)
Ploughing	303.1 b[1]	70.7 ab
Rotary hoeing	301.0 b	59.9 b
Mulching	367.1 a	88.2 a
Burning	328.7 ab	50.7 b

[1] for each column, means followed by different letters indicate significant differences at P≤0.05.

Different weed species also differed in their response to nitrogen. Average dry weight per plant increased for field speedwell but decreased for wild oats and scentless chamomile in fertilised plots, while no significant differences were observed for other weed species present (Table 4). Weeds are known to be efficient users of resources; however, the data showed that crop competition against certain weeds can be enhanced with the addition of nitrogen. Responses of wheat and different weed species to the addition of fertilisers need to be determined in more detail to provide a basis for developing a sound integrated weed management programme.

Table 3. Effect of nitrogen fertiliser on wheat grain yield and total dry weight of weeds in the third year.

Nitrogen level (kg/ha)	Wheat grain yield (g/m^2)	Weed dry weight (g/m^2)
0	289.4	132.6
150	520.0	189.3
F test	P≤0.05.	P≤0.05.

Table 4. Plant density and average plant weight of weed species as affected by the addition of nitrogen fertiliser (0 or 150 kg N/ha) and different crop residues in the third year.

	Density (plants/m^2)		Dry weight (g/plant)	
Nitrogen	0	150	0	150
Grass weeds				
Annual poa	41.5a	34.4a	0.24a	0.86a
Browntop	47.9a	28.7b	0.95a	1.00a
Wild oat	8.0a	18.4b	5.35a	1.70b
Broadleaved weeds				
Field speedwell	187.9a	39.0b	0.07a	0.89b
Scentless chamomile	10.0a	7.1a	0.76a	0.08b
Yarrow	9.2a	3.0b	0.20a	0.67a
Minor weeds[1]	84.0a	108.3a	0.13a	0.58a

[1] Minor weeds are listed in Results and Discussion.
[2] For each measurement of a particular weed species, means followed by different letters indicate significant differences at P≤0.05.

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