GREEN MANURES - BENEFITS FOR WEED CONTROL?

A.I. POPAY¹, W. STIEFEL² and M. DALY³

*AgResearch, ¹Private Bag 11008, Palmerston North, ²Flock House
Agricultural Centre, Bulls and ³PO Box 60, Lincoln.*

SUMMARY

Four experiments examined effects of green manure and/or greenfeed winter crops on yields of, and weed populations within, the following spring wheat or pea crop. Winter crops affected both weeds and yields, but in three experiments neither density nor biomass of weeds was correlated with crop yields. In the fourth experiment, more weeds were present. Grazing the winter crop once significantly increased weeds and reduced yields in the subsequent wheat crop. Weed density in late October explained 15% of the variation in wheat yields.

Keywords: cereals, green manures, non-chemical weed control, peas, weeds.

INTRODUCTION

Farmers have long used, in their crop rotations, strong, interfering 'smother crops' to prevent the weed proliferation that occurs on unoccupied ground (Putnam 1988). Such crops, when incorporated into the soil, affect later crops by altering soil characteristics, such as nutrient supply, or by leaving allelochemicals in the soil. Putnam and DeFrank (1983) found that residues of grass crops differentially influenced subsequent establishment and growth of lettuce, radish, tomato and weed plants. Green manures, or crop residues, might therefore be used to both improve the soil, and to selectively control weeds in subsequent crops. The experiments described here were designed to examine the effects of green manures on weed/crop balance.

METHODS

Crop residues incorporated into the soil were tested for their effects on later crops on 'organically' farmed land in four experiments. Two were on Manawatu silt loam at Flock House Agricultural Centre. The first (FH1), in 1990/1991, compared the effects of 15 winter crops - Grasslands Tama Italian ryegrass (*Lolium multiflorum*), oats (*Avena sativa*), ryecorn (*Secale cereale*), blue lupin (*Lupinus angustifolius*), tick bean (*Vicia faba*), vetch (*Vicia sativa*), fodder radish (*Raphanus sativus*), white mustard (*Sinapis alba*), Wairau brassica (*Brassica napus* ssp. *oleifera*), Tama + blue lupin, Tama + fodder radish, Tama + mustard, Tama + tick bean, Tama + vetch, uncultivated fallow) - on a following wheat crop. The crops were sown in four randomised blocks in February 1990. Plot size was 20 x 3 m. Winter green manure crops were mulched and ploughed 6 weeks before wheat (cv. Otane) was sown in October 1990. Weed seedlings were counted in ten 0.1 m² quadrats in each plot in late October; wheat was harvested in March 1991.

Wheat yields were higher in the experiment than in the surrounding area, which had been grazed before the wheat was sown. The second experiment (FH2), in 1992/93, therefore compared the effects of grazed or ungrazed winter green manure crops on a following wheat crop. Two main treatments (ungrazed versus grazed once by cattle in late August) were replicated four times. Sub-plots (1.6 x 13 m), randomly arranged within each main plot, were five different crops, sown in March 1992 (Table 1) and mulched and cultivated before wheat (cv. Norseman) was sown in early October 1992. Weed seedlings were counted in ten 0.1 m² quadrats in each plot in late October. Just before crop harvest on 17 February 1993, plant material was harvested from a representative 0.5 m² quadrat in each plot, separated into species, dried and weighed.

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Experiments L1 and L2 were at Lincoln, on Wakanui silt loam, in 1992/1993. The site of Expt. L1 had been previously cropped for 2 years, and that of Expt. L2 was in pasture. In each experiment, there were two uncultivated fallows and seven winter green manure crops (Table 3) which were grown from March 1992 until they were mulched on 22 September and the residues incorporated into the soil with a rotary hoe on 5 October. Plot size was 13 by 4.5 m and treatments were arranged in four randomised blocks. Peas (*Pisum sativum*), cv. Bolero, were sown on 30 October (Expt. L1) or 3 November (Expt. L2). In each experiment, one of the plots previously in uncultivated fallow was tine weeded on 26 November. No weed control was attempted on the other plots. Weeds were counted on 17 December in five 0.1 m² quadrats per plot, and weed biomass was assessed from four randomly positioned 0.1 m² quadrats at pea harvest on 25–26 January 1993.

RESULTS AND DISCUSSION

In the first Flock House experiment (FH1), some green manure crops resulted in significantly higher wheat grain yields than others. Grasslands Tama Italian ryegrass (*Lolium multiflorum*) plus blue lupin (*Lupinus angustifolius*) residues gave the highest wheat yield (7936 kg/ha) and ryecorn the lowest wheat yield (6678 kg/ha). There was no significant effect on weed numbers in the wheat crop in October, nor was there any significant correlation between weed numbers in October and crop yields. Average number of weed seedlings was 27/m², the main weed species being black nightshade (*Solanum nigrum*), scrambling speedwell (*Veronica persica*) and fathen (*Chenopodium album*).

The second Flock House experiment (FH2) was much weedier than the first, with an average of 275 weeds/m² in late October. The main weeds were couch (*Elytrigia repens*) and black nightshade. Although the winter crop itself had no significant effect on weed numbers, grazing that crop increased the numbers of weeds, other than couch, in the wheat (Table 1).

Wheat yields were significantly affected by previous crop species and grazing, and the interaction between these factors (Table 1). Yields were lower where the winter crop had been grazed, and a winter crop of tick beans, with or without Tama, tended to give higher wheat yields than other crops. The regression of plot wheat yields on total weed numbers in late October was significantly greater than zero ($P=0.05$) and the significant ($P=0.05$) correlation suggested that 15% of the variation in wheat yield could be attributed to the size of the early weed infestation. The significance of this

TABLE 1: Expt. FH2. Effect of previous crop and its grazing management on weeds/m² in wheat on 28 October 1992, and on wheat grain yields (t/ha). Weed data transformed by $\ln(x+1)$ before analysis; back transformed numbers in brackets.

Previous	Weeds/m ²				Wheat grain (t/ha)	
	couch		all other weeds		grazed	ungrazed
	grazed	ungrazed	grazed	ungrazed		
tick beans	4.4 (80)	4.1 (59)	5.8 (329)	4.5 (89)	2.36	4.09
radish	4.1 (59)	4.1 (59)	5.6 (269)	4.2 (66)	2.30	3.01
Tama	4.3 (73)	4.2 (66)	5.5 (244)	4.4 (80)	1.80	2.52
mustard	4.6 (98)	3.8 (44)	5.8 (329)	4.5 (89)	2.20	2.79
tick beans	4.4 (80)	4.5 (89)	5.5 (244)	4.3 (73)	2.79	3.32
+ Tama						
graz. x crop	n.s.		n.s.		0.886	
LSD ($P=0.05$)						
mean	4.34 (76)	4.13 (61)	5.63 (278)	4.36 (77)	2.29	3.14
means LSD	n.s.		0.340		0.616	
($P=0.05$)						

correlation was mainly due to the differences in weediness and wheat yields between grazed and ungrazed winter crops.

At harvest, late-germinated sow thistles (*Sonchus oleraceus*) had become obvious in most plots, especially where winter crops had been grazed. Late-germinating stinking mayweed (*Anthemis cotula*) was apparent in plots close to the paddock margin. Weed biomass at crop harvest was not significantly affected by winter crop species, and was not correlated with wheat yields. The weeds dominating the crop at harvest time may have emerged and grown too late to affect crop yields, whereas the weeds present early in the crop had a greater effect on crop yields.

Grazing compacted the soil and reduced air permeability, soil respiration and earthworm numbers (Springett and Gray, in prep.). Winter crops also affected these soil characteristics differently. Just before cultivation, fodder radish had the highest earthworm numbers and soil respiration. Interactions between crops and grazing were obvious. For example, ungrazed Tama plots had the lowest soil penetration resistance to a depth of 15 cm, but grazed Tama plots had the highest soil penetration resistance. All or any of these factors could have affected subsequent crop and weed growth.

In the Lincoln experiments, winter green manure crops significantly affected yields of the following pea crops (Table 2), but the effects were very different in the two experiments, possibly because of flow-on effects from earlier paddock use for crops or pasture. Until reasons for these differences are known, selection of green manure crops will remain difficult.

Weed density was not high in these experiments (Table 2). The main weeds in Expt. L1 were wireweed (*Polygonum aviculare*), spurrey (*Spergula arvensis*), sheep's sorrel (*Rumex acetosella*) and black nightshade, and in Expt. L2 wireweed, narrow-leaved plantain (*Plantago lanceolata*) and spurrey. Previous winter crop affected weed density in Expt. L1, where a winter Italian ryegrass crop resulted in more weeds than some of the other winter crops. Weed biomass was also affected in Expt. L2, with a winter vetch crop resulting in a high weed biomass. Tine weeding reduced weed numbers and biomass (Table 2), but did not increase crop yield, probably because the gains due to reduced weeds in the crop were offset by crop damage (Popay *et al.* 1992). Here, pea plant density was reduced 8.6% by tine weeding.

TABLE 2: Weed densities on 17 December 1992, weed biomass (g/m²) at crop harvest, and yields of vined peas (t/ha), as affected by previous winter crops in the two Lincoln experiments, L1 (ex onion crop) and L2 (ex pasture).

Previous crop	Weeds/m ²		Weed biomass		Vined pea yield	
	L1	L2	L1	L2	L1	L2
weedy fallow	18.3	20.1	133	167	6.90	5.59
fodder radish	14.9	20.9	257	298	6.69	5.13
weedy fallow (weeded)	6.5	9.8	88	113	6.52	5.01
vetch	15.3	18.6	295	365	6.11	6.01
blue lupin	16.2	20.0	198	230	6.10	5.85
Italian ryegrass	24.6	18.3	181	107	6.05	5.53
(Grasslands Moata)						
white mustard	14.0	20.6	286	211	6.04	6.03
ryecorn	15.4	17.1	281	100	6.00	5.66
tick bean	21.1	18.8	139	107	5.80	6.10
LSD (P=0.05)	8.5	4.8	n.s.	167	0.742	0.735

Except for spurrey, the weeds in the pea crop were different from those in the winter crops, so that the smothering effect of the winter crops on weed growth had little influence on weed numbers in the pea crop. There was no significant correlation between weed numbers in December or weed biomass at harvest and vined pea yield.

Historically, green manure crops were thought to have affected successive crops by maintaining and improving soil qualities such as granulation, water infiltration, nutrient content and soil biota content (National Research Council 1989). Work by Putnam (1988) and his colleagues suggested that green manure crops may also affect the balance between following crops and weeds. The work reported here confirms that green manure crops can affect both the yields of following crops and the weed numbers or biomass within them. However, grazing management of the winter crop can have a greater effect on later crop yields and weeds. Only a small amount of crop yield variation could be attributed to the numbers and biomass of weeds. Green manure crops were incorporated into the top 15 cm of the soil, thereby perhaps diluting any chemical effects on later crop/weed balance. In experiments now in progress, we are looking at the effects of different incorporation techniques and depths for grazed or ungrazed green manure crops on subsequent crops and their weeds. However, green manure crops are unlikely to be selected only for weed control - their other effects on following crops must also be beneficial.

REFERENCES

- National Research Council, 1989. *Alternative Agriculture*. National Academy Press, Washington, D.C. p.119.
- Popay, A.I., Stiefel, W. and Sorenson, E., 1992. Tine weeding effects on cereals with few weeds. *Proc. 45th N.Z. Plant Protection Conf.*: 93-94.
- Putnam, A.R., 1988. Allelopathy: problems and opportunities in weed management. Pp 77-88 *In: Weed Management in Agroecosystems: Ecological Approaches*. M.A. Altieri and M. Liebman (Eds), CRC Press, Inc., Boca Raton FL33431.
- Putnam, A.R. and DeFrank, J., 1983. Use of phytotoxic plant residues for selective weed control. *Crop Protection* 2: 173-181.