Weed control in "organic" arable crops in New Zealand

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Summary
Increased demands for low-input, sustainable agro-ecosystems, and the food they produce, bring the need to research weed management in systems using neither herbicides nor artificial fertilisers. Information is required on the effectiveness of alternative weed control methods and their possible costs in terms of crop yields, fallow lengths, extra cultivations, longer rotations, damage to soil structure, increased nitrate leaching, and increasing weed populations. This paper deals with the effects of weed control measures such as mechanical cultivation in the crop, increased crop sowing rate and different row spacings, and growing mixtures of crops. Future research needs are discussed.

Introduction
Herbicides are regularly applied to most arable crops as an insurance against weed damage, regardless of real costs. Use of herbicides in crop production may not be sustainable because of increasing herbicide resistance in weeds, adverse effects on the environment, and direct costs. Weeds, however, can cause unacceptable crop losses or damage and some weed control measures may be necessary. This does not necessarily mean weed control within the crop: prevention or avoidance of weed problems may be more important. Research on alternative methods of weed control is described and discussed.

Methods
Over 15 experiments were carried out between 1987 and 1991 at Flock House Agricultural Centre (Manawatu silt loam), in the southern North Island, at Winchmore Research Station (stony silt loam), and at Lincoln University Biological Husbandry Unit (Wakanui silt loam), both in Canterbury. Most experiments were on land farmed to "Bio-Gro" standards, as defined by the New Zealand Biological Producers Council, which precludes use of pesticides and quick-release fertilisers. Only reactive phosphate rock and elemental sulphur were used as fertilisers. Commercially recommended cultivars were used, mostly 'Fleet' barley and 'Otane' wheat. All treatments were replicated at least 4 times, and results, analysed by analysis of variance, are only discussed if significant at the 5% level.

Some experiments compared several factors, including: surface tillage and ploughing as primary cultivations before sowing crop; the effect of different green manures on weed numbers in the following wheat crop; wheat and barley; sowing times; sowing rates; crop spacing; grazing or not grazing crops (and weeds) with sheep; methods and frequency of mechanical weeding; undersowing with various legumes.

Results and Discussion
In Canterbury, the main weeds were speedwells (*Veronica* spp.), fat hen (*Chenopodium album agg.*) and wireweed (*Polygonum aviculare* agg.). At Flock House, main weeds were fat hen and black nightshade (*Solanum nigrum* L.). Losses due to weeds were often small (2).

Effects of treatments before planting crop

Crop rotations

These are often carried out for maintenance of soil fertility and prevention of disease, and may prevent build-up of weed populations specific to a particular crop. Relatively small numbers of weeds in experiments at Flock House (up to 62/m^2) may have been due to effective crop rotations. Daly and Stevenson (2) recorded no crop losses due to weeds in the first year out of pasture. However, no experimental work has yet been done on the effects of crop rotations on weed species and numbers, except for one Flock House experiment, in which different winter green manure crops gave very variable, but not significantly different, weed numbers in the following wheat crop.

Primary cultivations

Ploughing to 15 cm and rotary hoeing to 5 cm were compared as primary cultivation practices before sowing wheat in four Canterbury experiments. In one experiment, weed density was higher after surface cultivation than after ploughing, but wheat and barley yields were unaffected in all experiments.

Effects of within crop treatments

Different crops

Wheat and barley were experimentally compared in two Canterbury experiments. In one experiment, grain yields and weed numbers were similar, but in the other, where the main weed was fat hen, weed density and mass were significantly lower under barley (626/m^2 and 16 g/m^2) than under wheat (828/m^2 and 38 g/m^2). Barley grain yields were higher.

Sowing date

In Canterbury, wheat or barley were sown in June, August or October. June sowing resulted in fewer weed seedlings (201/m^2) than October sowing (1399/m^2), but weed mass at harvest was similar for all sowing dates, and grain yields of wheat and barley were not affected. At Flock House, there was little difference in weed populations between early and late October sown barley crops.

Crop density & sowing method.

Increasing recommended sowing rates of cereal and pea crops by 10% or 15% or using Blackmore coulters (to give a broadcast effect), rather than the usual 12 cm rows, had no effect on weed numbers in the crop, nor on yields of wheat, barley or peas (4) at Flock House. In Canterbury, one experiment showed that increasing wheat or barley seed rate from 100 to 200 kg/ha reduced weed density but did not affect grain yield.

Undersowing

Several experiments tested undersowing with legumes. White and red clovers (*Trifolium repens* L. and *T. pratense* L.) and lotus (*Lotus pedunculatus* Cav.) established well and did not affect cereal yields more than the weeds they replaced. After harvest of the cereal crop, undersown legumes grew rapidly to provide animal fodder.

Grazing

One Canterbury experiment showed no significant difference between yields of barley crops ungrazed or grazed with sheep at the first node stage.

Mechanical weeding

In three Canterbury experiments, a "Planet Junior" adjustable steerage hoe, standard fixed point cultivating harrows and a "Lely" tine weeder were compared. All reduced the numbers of weeds but had no overall effect on crop yields: in one case the hoe reduced weed numbers more than harrows or tines. Twelve experiments at all sites showed that tine weeding reduced weed numbers and weed mass, but had no effect on wheat, barley and pea yields. This happened at both low and high (up to 2000/m^2) weed populations which suggests that damage to crop yields caused by weeds may have been equivalent to that caused by tine weeding itself.

Other weeding methods - sun, flames and brushes.
Experiments on solarisation, flame weeding and brush weeding have been carried out in Canterbury. All are more suited to high value, small area crops. Solarisation, heating the soil by covering it with plastic film, can reduce subsequent weed emergence (1). Flame weeding has been tested in carrots and onions: timing of crop and weed emergence and time of flaming are critical and hard to co-ordinate. Brush weeding, also tested in carrots and onions, is promising, but its effectiveness has not yet been experimentally evaluated.

Often not enough is known about the relationships between weed populations and their effect on crop yields. In many cases, the economic benefit of weed control in a crop is unknown. There is also little information on whether information on weed seeds in the soil, or on weed numbers and species early in the crop, can be used to predict potential crop losses. If such information was available, along with data on emergence patterns, then crop selection and sowing date could be adjusted accordingly. Research is also needed on the fate of weed seeds in the soil and how their loss can be accelerated. More research is also needed on crop rotations, including green manures, and their effect on soil fertility and soil biology. Preceeding crops may leave allelopathic residues, affecting weeds and crops differently, and may affect mychorrhizal fungi populations. Crop rotations may prevent build-up of high crop-specific weed populations. Soil fertility can affect interactions between weeds and crops (3). More work is also needed on within-crop weed control using brushes, and possibly night cultivations.

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