Undersown legumes in cereals - effect of sowing date and understorey treatments on wheat yield, grain quality and weed incidence

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Abstract

In wheat (cv. Otane) plots sown at the same site in July, September and October 1991, the effects of four understorey treatments - undersown white clover, undersown red clover, chemical herbicide and an unweeded control (volunteer clovers and weeds) - on wheat yield, grain nitrogen and weed incidence were assessed. Grain yield was significantly reduced in the October sowing, but understorey cover did not affect grain yield at any sowing date. Grain nitrogen was 10% higher ($P < 0.05$) in the October sowing but did not differ among understorey treatment at this sowing date. However for the July sowing, grain nitrogen for the herbicide treatment was 8% greater ($P < 0.05$) than for the other three understories. Red clover was the most productive understorey. Understorey weed mass was lowest for the October sowing and significantly reduced by the herbicide treatment. Undersowing red or white clover did not reduce weed mass at any of the three sowing dates. Weed species incidence varied with sowing date, but fathen *(Chenopodium album* L*)* was the most dominant weed species at all sowing dates. Undersowing clover gives no advantage in terms of weed control, grain nitrogen or grain yield but could provide a source of high quality forage for finishing stock.

Additional keywords: *undersown legumes, quality feed,* Chenopodium album *L,* Solanum nigrum *L, weed mass.*

Introduction

Consumer, environmental, and financial concerns have increased farmer interest in techniques that allow farmers to reduce the level of external inputs in crop production (Lampkin, 1990). Preliminary studies at Winchmore Research Station indicated that undersown legumes may be an effective means of reducing weed infestations in cereal crops grown without herbicides (Moss, 1991, pers. comm.). Legumes are generally undersown to provide a seed, fodder or green manure crop (Scott, 1973; Hassan *et al.*, 1985). Legumes such as lupins, field beans and clovers can be established under cereals and have been sown to provide a net nitrogen (N) benefit to the cover crop (Bulson and Snaydon, 1990; Bardarudin and Meyer, 1989). In Australia, undersowing winter wheat with red and white clover reduced weed biomass and had a slight but positive influence on wheat yield (Hartl, 1989).

However, undersown legumes may compete with the cover crop causing losses in yield. Mann and Barnes (1952) for example found that cereal yields were reduced when undersown with clover. Where soils were deficient in N, clover furnished the cover crop with N, but where the supply of N was ample, clover acted as a competitive crop (Mann and Barnes, 1952).

Strategies to reduce weed competition in crops without herbicides include planting early so that the cereal crop can get a head start on weeds, and planting late to allow time for one or more cycles of weed germination and cultivation before planting the crop (Patriquin, 1988).

The aims of the study were to investigate:

1. The effectiveness of undersown clover species in weed suppression and the extent to which clover and volunteer species interact with the main crop;
2. The effect of different sowing dates on weed incidence, clover establishment, crop yield and grain quality.

Materials and Methods

This study was conducted on Lismore stony silt loam at the Winchmore Research Station in Canterbury. The trial site was chosen because it historically had a high weed potential. The site had been under pasture for two years following oilseed rape, lentil and barley crops. The experiment was laid out in a split-plot design with sowing date as the main treatment and understorey as the sub-plot treatment. Wheat (cv. Otane) was sown at 150 kg/ha in July, September and October. The understorey treatments were: undersown white clover (*Trifolium repens* L. cv. Huia); undersown red clover (*Trifolium pratense* L. cv. Pawera); volunteer clovers without weed control; and a herbicide-treated control. There were five replicates of each treatment. Plots measured 9.0 x 12.5 m. Each main treatment area was cultivated about a month before sowing and 275 kg/ha of rock phosphate and 40 kg/ha of elemental sulphur were applied. Wheat (cv. Otane) was sown at 150 kg/ha in July, September and October.

The understories were established when the wheat reached GS 11 - 12 (Zadocks *et al.*, 1974). White clover and red clover were broadcast at 8 and 11 kg/ha respectively and cultivated into the soil by a tine weeder. Herbicide treated plots were sprayed with Glean at a rate of 20 g/ha after crop emergence. All plots were tine weeded.

The composition of weeds within plots were evaluated using the visual ranking technique of Scott (1989). Six 0.1m^2 quadrats per plot were sampled at wheat inflorescence. At crop maturity six quadrats were hand cut from each plot to determine total crop mass, grain yield, grain weight, grain moisture content, numbers and dry weights of each weed species. Header samples were taken from the centre of each plot (12.5m^2) to assess grain yield. The N content of the grain was also measured using the Kjeldahl method.

Results

Wheat yields for July and September sowings were significantly ($P < 0.05$) higher than the October sowing (Table 1). The understorey treatments had no significant effect on grain yield except in crops sown in July when those undersown with white clover produced more wheat than those with volunteer clover understorey ($P < 0.05$).

Delayed wheat sowing resulted in reduced grain weight. The October sowing showed a significant reduction ($P < 0.05$) in grain weight compared to September and July sowings (Table 2). In September-

Table 1. Effect of sowing date and understorey on wheat yield (kg/ha).

	Understorey Treatment				
Sowing date	White clover	Red clover	Volunteer control	Herbicide control	Mean
July	5680	4880	4660	5460	5170
September	5010	5040	5250	5470	5190
October	3320	3280	3680	3700	3490
Mean	4670	4400	4530	4870	4620

For comparisons within sowing date $LSD_{0.05} = 810$
For all other comparisons $LSD_{0.05} = 850$

Table 2. Effect of sowing date and understorey on grain weight (mg).

	Understorey Treatment				
Sowing date	White clover	Red clover	Volunteer control	Herbicide control	Mean
July	43.5	43.6	45.2	45.2	44.4
September	41.8	42.2	41.0	44.2	42.3
October	34.8	32.7	34.4	35.7	34.4
Mean	40.0	39.5	40.2	41.7	40.4

For comparisons within sowing date $LSD_{0.05} = 2.3$
For all other comparisons $LSD_{0.05} = 2.2$

sown crops, wheat from herbicide treated plots had significantly higher grain weight than either the white clover or volunteer clover species plots. In October sown crops grain weight was reduced in red clover plots, compared to herbicide treated plots ($P < 0.05$).

Late sowing of wheat gave a significant increase in grain nitrogen, with October higher ($P < 0.05$) than both September and July sowings (Table 3). The herbicide treatment had a significantly higher ($P < 0.05$) grain nitrogen than all other treatments at the July sowing. For the September sowing, wheat undersown with red clover and the herbicide treatment had higher grain nitrogen ($P < 0.05$) than the volunteer clover and white clover treatments. There was no difference between the understorey treatments at the October sowing.

Overall a decrease in weed mass was associated with an increase in grain nitrogen (linear correlation = -0.85**).

The red clover understorey produced the greatest herbage mass (Table 4). Sowing date did not influence clover production in crops undersown with red or white clover but in the volunteer treatment there was a significant reduction ($P < 0.05$) in clover mass at the October sowing.

There was less weed mass ($P < 0.05$) in October sown crops compared with those sown in July (Table 5). The weed mass at harvest was significantly lower ($P < 0.05$) in herbicide treated plots than the other understorey treatments (Table 5). There was no difference in weed mass between plots with undersown legumes and those with no weed control.

Chenopodium album L. (fathen) was the dominant weed for all sowing dates (Table 6). *Solanum nigram* L. (black night shade) was only present in the October sown treatments (Table 6).

Discussion

This work has shown that October sowing of wheat reduces yield and grain weight regardless of understorey treatments. This is similar to the findings of Janovec (1984), Marko (1990), and Piech (1990) who reported a reduction in yield of wheat at later sowings. Kolbe (1984) found that sowing at the local customary date generally gave the highest grain yields and early sowing encouraged weed growth. In this experiment too the earliest sowing date gave the highest weed mass at harvest.

Table 3. Effect of sowing date and understorey on grain nitrogen (%).

	Understorey Treatment				
Sowing date	White clover	Red clover	Volunteer control	Herbicide control	Mean
July	1.95	1.92	2..01	2.12	2.00
September	1.92	2.03	1..92	2.04	1.98
October	2.21	2.21	2.17	2.23	2.20
Mean	2.03	2.05	2.03	2.13	2.06

For comparisons within sowing date $LSD_{0.05} = 0.10$
For all other comparisons $LSD_{0.05} = 0.13$

Table 4. Effect of sowing date and understorey on legume mass (Log_{10} of kg/ha). Note: kg/ha in brackets.

	Understorey Treatment			
Sowing date	White clover	Red clover	Volunteer control	Mean
July	1.93(130)	2.69(400)	1.82(150)	2.15(230)
September	1.10(30)	2.02(110)	0.58(10)	1.23(50)
October	1.72(80)	2.05(120)	0.26(5)	1.17(70)
Mean	1.58(80)	2.25(210)	0.71(50)	1.52(110)

For comparisons within sowing date $LSD_{0.05} = 0.79$
For all other comparisons $LSD_{0.05} = 0.84$

Table 5. Effect of sowing date and understorey on weed mass at harvest (Log_{10} of kg/ha).

	Understorey Treatment				
Sowing date	White clover	Red clover	Volunteer control	Herbicide control	Mean
July	2.82	2.73	2.81	2.10	2.62
September	2.80	2.54	2.59	1.71	2.41
October	2.35	2.44	2.36	1.31	2.12
Mean	2.66	2.57	2.59	1.71	2.38

For comparisons within sowing date $LSD_{0.05} = 0.32$
For all other comparisons $LSD_{0.05} = 0.33$

Table 6. Effect of sowing date on weed species present (% incidence).

	July	September	October
Californian thistle	55	60	25
Fathen	85	85	95
Dandelion	45	70	30
Nightshade	0	0	35
Shepherd's purse	50	50	60

The effects on the nitrogen content of the grain may result from the degree of competition for nutrients and water between the understorey, weeds and the wheat crop. The strong negative correlation between weed mass at harvest and grain nitrogen in this study concurs with Blackman (1938) who reported that nitrogen was the sole competitive factor between cereal crops and annual weeds.

The reduction in grain nitrogen in undersown plots and volunteer plots at early sowing suggest that this site was low in nitrogen and that the clovers and weeds competed with the wheat for the available nitrogen. Hartl (1989) and Mann and Barnes (1952) showed that this competition resulted in a reduction in cereal yield.

On this weedy site, early sowing increased grain yields but also weed mass. Understorey clovers did not reduce weed mass over the volunteer clover treatment. Therefore this result did not agree with the early sowing strategies of Patriquin (1988) in controlling weeds. This method of weed control needs to be examined over a range of sites with different farming systems.

The data available indicate that red and white clover, had little affect on the wheat crop in terms of yield, grain nitrogen or less weeds. However this technique could be used to produce high quality parasite free feed (Familton, 1983) between crops for finishing stock. Red clover proved to be the best producing legume especially at the July sowing.

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References

Badarudin, M and Meyer, D.W. 1989. Forage legume effects on soil nitrogen and grain yield, and nitrogen of wheat. *Agronomy journal* ***81***, 419-24.

Blackman, G.E. and Templeman, W.G. 1938. The nature of the competition between cereal crops and annual weeds. *Journal of Agricultural Science* ***28***, 247-71.

Bulson, N.A.J., Snaydon, R.W. and Stapes, C.E. 1990. Intercropping autumn sown field beans and wheat: effects on weed under organic farming conditions. *British Crop Protection Council Monograph* 45.

Familton, A.S. 1983. Internal parasites and the growth of lambs. Animal Industries Workshop, Lincoln College. pp. 165-191.

Hartl, W. 1989. Influence of undersown clovers on weeds and on the yield of winter wheat in organic farming. *Agriculture, Ecosystems and Environment* ***27***, 389-96.

Hassan, M.T., Love, B.G. and Hill, G.D. 1985. The effect of growing cereal/legume mixtures on total biomass accumulation. *Proceedings Agronomy Society of New Zealand* ***15***, 75-79.

Janovec, J. 1984. The effect of some controllable factors on winter wheat yield formation under large-scale production. *Rostlinna-Vyroba* ***30***, 1071-1076.

Kolbe, W. 1984. Studies on the course of development of cereals (1968-1984) in relation to sowing time. *Pflanzenschutz-Bayer* ***37***, 337-423.

Lampkin, N. 1990. Organic Farming Press, Ipswich. 701pp.

Mann, H.H. and Barnes, T.W. 1952. The competition between barley and certain weeds under controlled conditions. *Annals of Applied Biology* ***39***, 11-119.

Marko, F. and Hanobik, A. 1990. Effect of cultural practices in winter wheat yield. *Rostilinna-Vyroba.* ***36***, 827-832.

Patriquin, D.G. 1988. Weed control in organic farming systems. *In* Weed Management in Agroecosystems: Ecological Approaches. (eds., Altieri, M.A. and Liebman, M.) pp. 303-317. CRC Press, Boca Paton.

Piech, M. and Stankowski, S. 1990. Reaction of winter wheat, triticale and rye cultivars to sowing date. *Biuletyn-Intytutu-Hodowli-i-Aklimaty-Zacji-Roslin. No.* ***176***, 25-36.

Scott, D. 1989. Description of vegetation using visual ranking of species. *New Zealand Journal of Ecology* ***12***, 77-80.

Scott, W.R., Dougherty, C.T., Langer, R.H.M. and Meijer, G. 1973. Wheat yield as affected by sowing rate, irrigation and time of white clover introduction. *New Zealand Journal of Experimental Agriculture* ***1***, 69-376.

Zadoks, J.C., Chang, T.T. and Konzak, C.F. 1974. A decimal code for the growth stages of cereals. *Weed Research* ***14***, 15-421.