The establishment of white clover seed crops under spring barley

J. G. H. White, H. K. Keerio[1], D. C. Askin and P. Jarvis

Department of Plant Science, Lincoln University, Canterbury, New Zealand.
[1] Present address: Pakistan Agricultural Research Council, Makli, Thatta, Pakistan.

Abstract

Two field experiments were conducted to measure the effects of root and shoot competition between barley and white clover, and to compare clover sowing direction and barley row geometry on white clover seedling survival when grown with a high-yielding barley grain crop under both dryland and irrigated conditions.

Without irrigation, no clover plants survived to barley harvest under full competition and only 41 plants/m^2 survived under root competition compared to 117 plants/m^2 under shoot competition. With irrigation, more than 100 plants/m^2 survived in all treatments except full competition where only 53 live plants/m^2 remained at harvest.

Drilling white clover across the barley rows improved both survival and size of white clover when compared to parallel drilling. A 20/40 cm barley row geometry also improved clover survival and size when compared to 10/20 cm or 15 cm row geometries.

The practical implications of these results on establishment of white clover seed crops sown with high-yielding spring cereals are discussed.

Additional key words: *plant competition, cross drilling, row geometry.*

Introduction

White clover (*Trifolium repens* L.) seed crops are traditionally established with ryegrass, or a cash crop such as a cereal or peas (White, 1990). Partial or complete failure to establish may occur due to competition with the companion crop for moisture and/or light (Scott, 1974). As farmers have striven for higher yields in companion crops by use of nitrogen fertiliser and irrigation, the competition with undersown white clover has become even greater. In these circumstances some farmers now prefer to establish white clover in early autumn as a pure crop after the cereal or pea crop is harvested (Clifford *et al.*, 1985).

Competition for light and moisture between a companion crop and seedling white clover is not well understood, with only one reported New Zealand study, on the establishment of white clover under winter wheat (Scott, 1974). Most recommendations on companion cropping suggest sowing the crop at rates lower than normal to reduce competition, although studies with wheat (Scott, 1974) and barley (Wynn-Williams, 1976) indicated that sowing rate had little effect on the establishment and survival of the undersown legume. The research described here was therefore designed with the following objectives:

1. To study the relative importance of light and soil moisture in affecting white clover survival when grown under barley in the field.
2. To measure the effects of row geometry and direction of drilling on seedling white clover establishment under both dryland and irrigated conditions.

Materials and Methods

Two experiments were conducted on a Templeton silt loam (NZ Soil Bureau, 1968) at Lincoln University during the 1986/87 season.

Experiment 1: Methods of competition.

The aim of this experiment was to study the relative effects of root and shoot competition for light and moisture on survival of white clover. Roots and shoots of barley and white clover were separated under field conditions using the following treatments:

a) Full competition - barley and white clover grown together.
b) Shoot competition - shoots of both crops were allowed to compete but roots were separated by driving corrugated iron boxes into the soil four weeks after sowing.
c) Root competition - roots of the two crops were allowed to compete but the shoots were separated by fine nylon mesh cloth.
d) No competition - both roots and shoots were separated.
e) Pure crops - pure white clover or barley were grown at the same population as used in other treatments.

A split plot design was used with irrigation as the main treatment and competition as sub-plots.

Barley cv. Triumph was established on 25 October 1986 at 350 plants/m^2 in 15 cm rows drilled in a N-S direction. White clover was undersown at the same time at 3 kg/ha in 30 cm rows parallel to the barley rows. (Fig. 1, geometry 1). Basal superphosphate was applied at sowing, followed by urea at 100 kg N/ha in early November, while recommended chemical weed and disease control was practised. Root boxes 10cm wide, 30 cm long and 50 cm deep were driven into the soil when barley had 3-4 tillers. In the irrigated plots microjets were used to apply water before a limiting deficit of 65 mm was reached.

Surviving white clover populations were measured immediately after the barley was harvested on 3 February 1987. Gravimetric soil moisture determinations and measurements of light transmission to clover were made on four and six occasions respectively. A miniature tube solarimeter was placed along a white clover row in the centre of each treatment for light measurements.

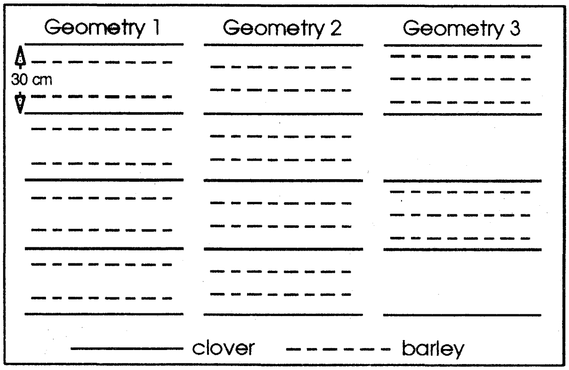

Figure 1. Barley row geometry, Expt. 2.

Experiment 2:
Clover sowing direction and barley row geometry

The aim of this experiment was to compare clover sown parallel with and across the barley row and to examine the effects of sowing barley in different row geometries on clover survival under both irrigated and dryland conditions.

The experiment was a split plot design with the four main treatments being parallel and cross drilling under irrigated and dryland conditions. The subplots consisted of three barley row geometries as follows:

1. 15 cm rows.
2. 10/20 cm geometry - barley was sown in paired rows 10 cm apart leaving a gap of 20 cm where a row of clover was sown (Fig. 1, geometry 2).
3. 20/40 cm geometry - three rows of barley were sown 10 cm apart, leaving a gap of 40 cm where two rows of clover were sown (Fig. 1, geometry 3).

All white clover was sown in 30 cm rows. Establishment and crop management was similar to that described for Experiment 1. Surviving white clover plants were measured on 6 March, one month after harvest. Soil moisture and light measurements similar to those used in Experiment 1 were made in the growing crop.

Results

Double the average rainfall occurred in October and November, but December and January figures were low, with January being a much warmer and drier month than normal (Table 1). These conditions were reflected in the potential soil moisture deficit which was less than the limiting deficit (65 mm, Expt. 1; 80 mm Expt. 2) up to

Table 1. Mean monthly air temperature and total rainfall during the 1986-87 season, and long term means.

	Temperature (°C)		Rainfall (mm)	
	1986/87	Mean	1986/87	Mean
Sept	8.4	9.2	46	56
Oct	11.6	11.3	100	46
Nov	12.9	13.3	95	57
Dec	15.8	15.3	27	53
Jan	18.0	16.8	7	55

mid-December but after that date steadily increased to harvest. Irrigation maintained soil moisture above 20% for all of the growing season (Fig. 2), thus keeping the deficit below a limiting figure.

Experiment 1

The rate of decline in gravimetric soil moisture was greatest under full competition and root competition treatments (Fig. 2) reaching less that 10% near harvest which is below permanent wilting point. Plots where no competition occurred or were in pure clover were intermediate, while the shoot competition treatment declined least.

As expected pure white clover received higher photosynthetically active radiation (PAR) than all other treatments (Fig. 3). Clover receiving no competition or root competition received intermediate levels of light while those under full or shoot competition received less than 30% of the daily PAR for much of the monitored period, compared with pure clover. Both dryland and irrigated clover received similar levels of PAR until 6 January after which the dryland clover received more light (Keerio, 1988).

A significant interaction occurred between irrigation and competition treatments in white clover survival to barley harvest (Table 2). More than 100 plants/m^2 survived under shoot competition and no competition treatments of dryland clover compared with 41 and zero plants/m^2 under root and full competition respectively. However, with irrigation more than 100 plants/m^2 survived under all treatments except full competition where only 53 plants survived. Irrigation increased the number of white clover plants under full competition and root competition compared with dryland plots.

At barley harvest clover plants were very small (10-16 mg/plant) when subject to shoot competition in both moisture treatments, or with full competition under irrigation or root competition under dryland conditions. However those plants under root competition which were irrigated increased four-fold in biomass compared to dryland plants. Clover plants with neither root or shoot competition from barley were larger still, whatever the moisture treatment (Keerio *et al.*, 1993).

Irrigation increased the barley grain yield by 16%, from 6.73 to 7.81 t/ha, while the only competition effects were under root competition or no competition, where yields were reduced by 19 and 23% respectively

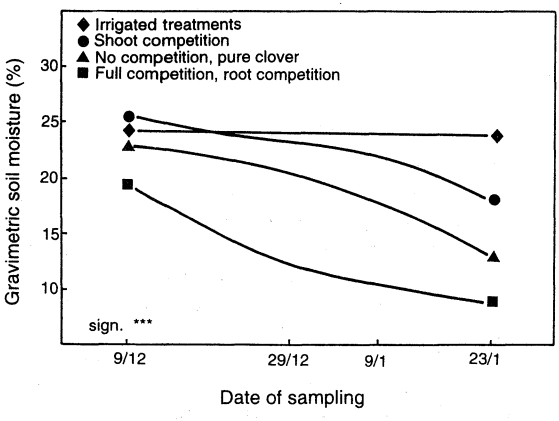

Figure 2. Gravimetric soil moisture under irrigation, and with different competition treatments under dryland, Expt. 1.

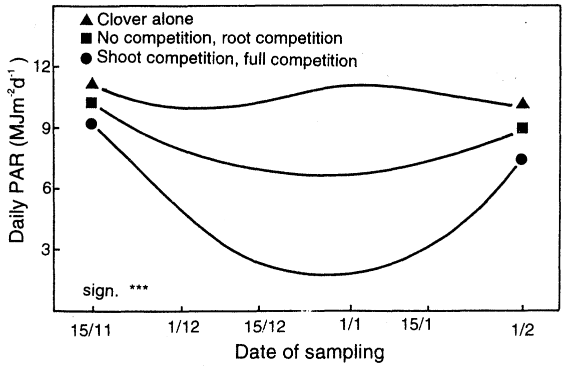

Figure 3. Mean daily photosynthetically active radiation (PAR) under different competition treatments, Expt. 1.

Table 2. Number of surviving white clover plants (plants/m^2) immediately after harvest under different competition treatments, Expt 1.

	Dryland	Irrigated
Full competition	0	53
Shoot competition	117	135
Root competition	41	178
No competition	173	185
Pure clover	170	163
Significance		**
s.e.m.		20

compared to pure barley, due to effects of the fine mesh which damaged barley shoots and affected ear development (Keerio *et al.*, 1993).

Experiment 2

White clover drilled across the barley rows received higher amounts of daily PAR than parallel drilled clover (Fig. 4). Clover sown into 20/40 cm barley row geometry received significantly more light than 10/20 or 15 cm geometries, which received similar amounts of PAR (Fig. 4).

White clover survival after barley harvest was increased 84% by cross drilling rather than sowing parallel with the barley rows (Table 3). Survival was also enhanced by 10/20 row and even further by 20/40 row geometry, compared to the standard 15 cm rows. Cross drilling also resulted in white clover plants being more than twice the mass of parallel drilled plants (Table 3).

The highest barley grain yields were over 8 t/ha. Irrigation increased yield by 24% compared with dryland treatments (Table 4). Grain yields were similar in 15 cm and 10/20 cm rows but declined by 12% in the 20/40 cm geometry.

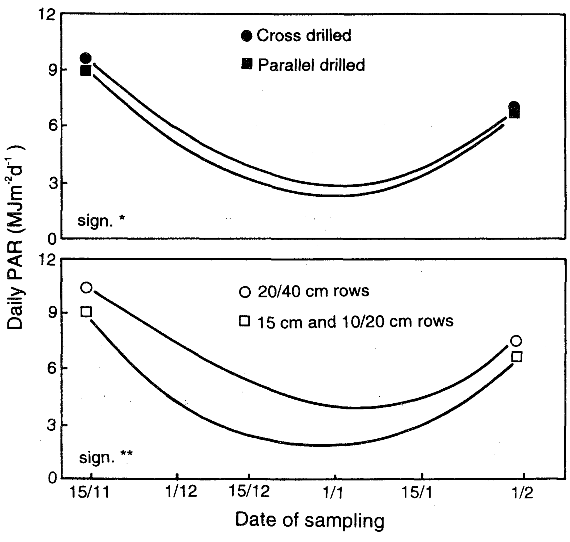

Figure 4. Mean daily photosynthetically active radiation (PAR) available to undersown white clover as affected by drilling direction and barley row geometry, Expt. 2.

Table 3. The effect of drilling direction and barley row geometry on white clover survival and mass to 6 March 1987, in Expt. 2.

	Plant/m^2	mg/plant
Drilling direction		
Parallel	25	57
Cross	46	139
Significance	**	*
s.e.m.	3.3	19.4
Barley row geometry		
15 cm rows	19	51
10/20 cm geometry	30	68
20/40 cm geometry	56	175
Significance	***	*
s.e.m.	2.7	19.0

Table 4. The effect of irrigation and row geometry on barley grain yield (t/ha) in Expt. 2.

Irrigation	Irrigated	7.95
	Dryland	6.44
	Significance	***
	s.e.m.	0.15
Barley row geometry	15 cm	7.49
	10/20 cm	7.47
	20/40 cm	6.69
	Significance	***
	s.e.m.	0.05

Discussion

Competition between the barley and seedling white clover was intense for both light and water, particularly during the very dry December and January period (Figs. 2 and 3). In the dryland plots of Experiment I all clover plants died under full competition and only 41 plants/m^2 survived under root competition. Not only was the plant population of the clover quite low under root competition but it was also unevenly distributed, with several large gaps, while the plants themselves were small in size. Keerio (1988) has shown that when clover is sown in 30 cm rows with a normal farm drill a minimum of about 50-60 plants/m^2 are necessary to avoid gaps of 30 cm or greater down the clover rows.

Competition for moisture was more important than competition for light, as more than 100 plants/m^2 survived under shoot or no competition treatments of dryland clover (Table 2). However, the clover plants were much larger where no competition occurred. With irrigation white clover survival was high in all treatments, except under both root and shoot competition where only 53 small clover plants/m^2 survived. The difference in survival between irrigated clover under combined root and shoot competition or shoot competition only was surprising. However, it is probable that under full competition some of the small clover plants died during temporary water stress between waterings. Irrigation was applied at a potential deficit of 65 mm but competition for water might have started well before this deficit was reached.

These results indicate that adequate numbers of white clover seedlings can survive to barley harvest under a high yielding barley crop of 350 plants/m^2 producing nearly 8 t/ha provided soil moisture levels are adequate. In an earlier experiment Keerio (1988) found that by halving the barley population from 256 to 128 plants/m^2 the clover survival to barley harvest rose from 50 to 280 plants/m^2. However the barley grain yield declined 10% at the lower barley population.

The superior survival and larger plant size of white clover seedlings when drilled across the barley rows can be largely attributed to higher light availability (Fig. 4, Table 3). This work confirms that of Santhirasegaram and Black (1968) who reported that increasing the distance from the wheat row increased the amount of light available to undersown subterranean clover thus increasing the clover dry matter.

Competition for light between clover seedlings and barley was reduced through the change in barley row geometries. White clover under 20/40 cm geometry received higher amounts of light throughout the season (Fig. 4) which resulted in an acceptable number of 56 plants/m^2 surviving to harvest. These plants were evenly distributed with bare ground less than 5%. In contrast the number of clover plants under 10/20 cm or 15 cm geometries was much lower while the plants were smaller (Table 3) and the plant distribution was poor.

The better white clover establishment under 20/40 cm geometry was offset by a decline of 12% in barley grain yield compared to 10/20 cm and 15 cm geometries. This was largely due to a lower initial barley population of 237 plants/m^2 compared with 313 plants/m^2 in the other two geometries, which caused a decline of 14% in the number of barley ears/m^2 (Keerio, 1988).

Conclusion

This research shows the importance of adequate soil moisture in the last two months of a barley crop undersown with white clover, if white clover plants are to survive to harvest. Drought at this time may cause death of all seedling white clover under combined root and shoot competition. These results also show that it is possible to grow a high-yielding barley crop and still obtain an acceptable population of surviving white clover seedlings provided soil moisture is adequate. However, this means that in a Canterbury environment cropping farmers will need to monitor soil moisture right through to barley harvest and may need to irrigate in many seasons especially on lighter soils. These late irrigations are unlikely to improve barley yield and are additional to present farm practice. Because the white clover plants are likely to be small and spindly after harvest further irrigation may be necessary, while stubble grazing with sheep should be avoided until the clover has grown substantially.

Cross drilling of the white clover rather than parallel drilling with the barley will enhance clover survival and is already a common practice. However, changing sowing geometry is not recommended as it has practical difficulties at drilling, while the improved clover establishment may be largely offset by lower barley grain yields.

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