

Using a companion crop of barley to improve white clover production in the highlands of Turkey

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Abstract White clover was established with barley seeded at 0, 60, 120, and 180 kg ha⁻¹ and cut at milk-dough and ripe grain stage. Sowing barley at 180 kg ha⁻¹ as a companion crop when establishing white clover increased hay production from 3242 kg ha⁻¹ to 6522 kg ha⁻¹. Cutting hay at the milk-dough stage of barley gave a better response than waiting until the grain was ripe. Although white clover and weeds were suppressed by the companion crop, white clover density was not reduced. There was no reduction in hay in the year following the companion treatments, but weed contamination continued to be less. There was no difference between cutting barley at the milk-dough stage and harvesting it for grain, in hay production in the second year. Therefore, white clover can be seeded with a barley companion crop sown at about 180 kg ha⁻¹ under irrigated highland conditions.

Keywords white clover; *Trifolium repens*; companion crop; hay yield; weed content; stand density; barley; *Hordeum vulgare*

INTRODUCTION

Perennial forages are normally harvested only once during the seeding year in the highlands such as Eastern Anatolia, because low temperatures and a

short growing season limit their regrowth. Many growers consider the seeding year of perennial forage crops to have minimal productive value. Additionally, weeds and erosion are serious problems in new seedings. A direct-seeded white clover sward is not as productive in the year it is sown as an established sward. An alternative, but often less satisfactory, technique for establishing a white clover sward is by undersowing it in a cereal crop. A spring cereal cover crop has been used to augment productivity and give an immediate cash return.

Weeds are a problem in pure-sown white clover swards, but can be suppressed by a companion crop. Seeding a companion crop provides more rapid ground cover, which suppresses weeds during legume establishment (Simmons et al. 1995). Recently, new herbicides (pronamide, promoxynil) have made it possible to selectively control most weeds in new clover plantings, thus direct seeding (without a companion crop) has been advocated (Miller & Stritzke 1995). However, concerns of herbicide contamination of the environment, and poor legume growth in the seeding year have heightened interest in retaining and improving the practice of companion cropping.

Although companion crops help control weeds, they may be more competitive with newly sown clovers than the weeds they replace. More recent studies have indicated that the companion competition may be partially controlled by cultural practices such as reducing companion seeding rate and cutting as early as possible. Some researchers (Lee 1985; Smith et al. 1985) have suggested that cereal planting rates should be reduced 25–75% to reduce competition with the clovers and lessen the chance of lodging. Harris (1993) also reported a lower companion crop density could reduce competition and therefore promote growth of white clover plants. Cutting the companion crop prior to maturity can reduce lodging and competition earlier in the season (Miller & Stritzke 1995).

There is limited information on the response of white clover to establishment with a companion crop. Our objective was to determine the influence

of a barley companion crop seeded at different rates and harvested at different maturation stages on hay yield, weed content, and survival of white clover.

MATERIALS AND METHODS

Field experiments were established in the spring months of 2000 (Experiment 1) and 2001 (Experiment 2) at the Ataturk University Agronomy Experiment Farm in Erzurum, Turkey. The altitude of experimental area was 1850 m (39°59'N, 41°41'E). Experiment 1 was conducted in 2000 and 2001; Experiment 2 was conducted in 2001 and 2002.

Erzurum climatic conditions are characterised by relatively low humidity and dry periods. Long-term rainfall and mean monthly temperatures for the growing season (April–September) are 222.2 mm and 12.6°C, respectively. During this study these were 136.0 mm and 14.8°C; 230.5 mm and 14.5°C; 207.9 mm and 14.1°C in 2000, 2001, and 2002, respectively.

The experiment was established on a loamy soil with a pH of 7.08; available P₂O₅ was 25.0 kg ha⁻¹, K₂O was 1150 kg ha⁻¹ and organic matter content was 1.70%.

The treatments consisted of barley (*Hordeum vulgare* var. 'Tokak') as a companion crop between the white clover rows, at four seeding rates (0, 60, 120, and 180 kg ha⁻¹) and cut at two stages (milk-dough for hay, and ripe grain for seed). White clover (*Trifolium repens* L. var. 'Tohum Islah') was sown at 15 kg ha⁻¹ with a 30-cm row spacing. Each study was arranged as randomised complete blocks with four replications. Individual plots were 1.5 × 4 m = 6 m² in size.

Prior to seeding, fertilisers (150 kg ha⁻¹ P₂O₅ and 50 kg ha⁻¹ N) were spread on plots as recommended by Çomaklı (1991) and Serin & Tan (2001) for the seeding year. Plots were irrigated when 50% of available water in the soil was used (Çomaklı 1991). There was no weed control in plots during the seeding year so that the effects of the companion crop on weed suppression could be determined.

In the plots seeded without a companion crop, a single cutting of white clover was performed in the establishment year. Binary mixtures were harvested when the companion crop reached either the milk-dough or ripe grain growth stage. Forage (white clover + weeds) was harvested three times when the white clover was at mid-bloom stage in the subsequent year. Forage and grain yields were determined

by cutting a 2.7 m² (0.9 × 3 m) area. A 500-g hay subsample was taken, weighed fresh, and weighed again after drying at 70°C for 48 h to calculate yields on a dry matter basis. The proportion of barley, weeds, and white clover in the total herbage material was determined by separating, drying, and weighing from a 1 m² area of each plot at all harvests. White clover stand counts were made in September of the seeding year from randomly selected 1-m² quadrats in each plot. Weed contents are presented as the totals of all weeds (broadleaves and grasses). The weed species were spiny sowthistle (*Sonchus asper* L.), redroot pigweed (*Amaranthus retroflexus* L.), common lambs-quarters (*Chenopodium album* L.), and shepherd's purse (*Capsella bursa-pastoris* L.).

All data were analysed by analysis of variance, and the means ranked according to the LSD test ($P < 0.05$). Establishment and subsequent years' data were obtained from the means of both experiments. There was no year × treatment interaction, and so data were combined over 2 years for the establishment and subsequent years.

RESULTS AND DISCUSSION

Establishment year

The addition of the barley companion crop to white clover increased total hay yield (Table 1). A large increase in forage yield was observed at higher barley sowing rates compared with the plots without barley. Total hay yield increased from 3242 kg ha⁻¹ with no barley to 6522 kg ha⁻¹ when the barley seeding rate was 180 kg ha⁻¹. Slightly higher herbage yields (3242–6522 kg ha⁻¹) were obtained from the barley harvested at the milk-dough stage. Dry matter yield of small grain crops increases with maturation through the dough stage and decreases at grain maturity (Cherney & Marten 1982). The interaction of seeding rate × cutting time of companion clover was statistically significant for total hay yield. Seeding the white clover without barley resulted in the lowest yields in both cutting stages (3242 and 3399 kg ha⁻¹), while the sowing with barley at 180 kg ha⁻¹ and cutting at milk-dough stage (6522 kg ha⁻¹) was the highest (Table 1).

When barley was used as a grain crop, the barley seed yields were 1774, 2517, and 2802 kg ha⁻¹ at 60, 120, and 180 kg ha⁻¹ sowing rates, and the straw yields were 2887, 3424, and 3924 kg ha⁻¹ at 60, 120, and 180 kg ha⁻¹ sowing rates, respectively.

White clover grows slowly during early spring in Eastern Anatolia because the growth and leaf expansion rate of white clover are limited by low temperature (Castle et al. 2002), while barley provides quick ground cover. Its growth rate increases with increasing temperature and then decreases during the summer period. Regrowth after cutting perennial legumes such as white clover in the seeding year is poor in the highlands. Thus, using a companion crop increases total hay yield in the seeding year. These results are similar to those of Schmid & Behrens (1972), who also obtained greater hay yields in the seeding year when the companion crop was harvested at the early dough stage compared with solo seedings.

Legume and weed dry matter production during establishment were suppressed by the companion crop (Table 1). Seeding rate of barley had a greater influence on white clover and weed content of hay than did cutting time. Reduction in legume and weed content ranged from 28 to 32% of total hay yield to 6% and from 68 to 72% to 1%, respectively. Greatest reductions in both white clover and weed content occurred at the highest seeding rate of the companion crop (180 kg ha⁻¹). Herbage composition did not differ statistically among cutting stages of the companion crop; legume and weed contents were 15 and 19% at milk-dough stage and 17 and 22% at ripe grain stage, respectively. The interaction between seeding rate and cutting stage of the companion crop

was significant, however, for forage composition. The pure white clover treatment had slightly higher legume and weed contents at both cutting stages.

Reduced forage legume yield was anticipated when a companion crop was used, due to competition for light and moisture (Sheaffer et al. 1988; Lanini et al. 1991). Several studies have demonstrated that companion crops provide excellent weed suppression (Simmons et al. 1995; Spandl et al. 1999). Lanini et al. (1991) reported that the greatest depression in weeds and legumes occurred at high companion crop seeding densities.

Sowing white clover with a barley companion crop significantly increased the number of clover plants at the end of the seeding year (Table 1). Weeds increased mortality of white clover plants because they established in the field and seeded. The lowest numbers of clover plants (190 and 191 plants m⁻²) were found in pure white clover treatments. The losses of white clover during the establishment year affected the subsequent yields, because there is a close linear relationship between herbage accumulation rate and stolon density in white clover (Chapman & Caradus 1997). No differences in white clover stands were obtained between the low and high barley seeding rates (60–180 kg ha⁻¹). These results are the opposite of those reported by Schmid & Behrens (1972), who found alfalfa densities were reduced at the end of the first season when an oat companion crop was sown at 72 kg ha⁻¹, but this did

Table 1 Effects of barley companion crop treatments on total hay yield, legume, and weed content of hay and clover plant numbers in the establishment year. Yields are the average for 2000 and 2001 seedings. NS, not significant.

Companion crop cutting stage	Companion crop seeding rate (kg ha ⁻¹)	Total hay yield (kg ha ⁻¹)	Clover content (%)	Weed content (%)	Clover number (plants m ⁻²)	Barley grain yield (kg ha ⁻¹)	Barley straw yield (kg ha ⁻¹)
Milk-dough	0	3242	32	68	191		
	60	4402	12	5	203		
	120	5208	9	2	216		
	180	6522	6	1	201		
Mean		4844	15	19	203		
Ripe grain	0	3399	28	72	190		
	60	3741	17	6	210	1774	2887
	120	4196	13	5	203	2517	3424
	180	4561	11	3	208	2802	3924
Mean		3795	17	22	202	1773	2559
LSD (0.05)	Seeding rate	508	3.6	3.4	15		
	Cutting time	359	NS	NS	NS		
	Interaction	718	5.1	4.9	21		

not affect the following year's yield. In our study, weeds had a greater potential than barley for light competition with white clover throughout the whole establishment period. Establishment of weeds was inhibited in the field when an annual companion crop was used. Lanini et al. (1991) found alfalfa density was low when no companion crop was planted in a

weedy location during establishment than other locations having low weed density in the experiment.

Second year

The seed rate of the companion crop and interaction of seed rate \times cutting time were significant ($P < 0.05$) in only the first harvest of the subsequent year

Table 2 Effects of barley companion crop treatments on hay yield in the subsequent year (kg ha^{-1}). Yields are the average for subsequent years (2001 and 2002). NS, not significant.

Companion crop cutting stage	Companion crop seeding rate (kg ha^{-1})	Harvests			Total
		I	II	III	
Milk-dough	0	3344	1955	2598	7894
	60	3172	2018	3241	8428
	120	3648	1874	2882	8401
	180	4328	1755	2912	8990
Mean		3623	1901	2908	8428
Ripe grain	0	3057	1948	3052	8054
	60	3334	1934	3067	8335
	120	3108	1799	3064	7977
	180	3760	2060	3125	8948
Mean		3315	1935	3077	8329
LSD (0.05)	Seeding rate	470	NS	NS	NS
	Cutting time	NS	NS	NS	NS
	Interaction	865	NS	NS	NS

Table 3 Effects of barley companion crop treatments on weed content of hay in the subsequent year (%). Values are the average for subsequent years (2001 and 2002). NS, not significant.

Companion crop cutting stage	Companion crop seeding rate (kg ha^{-1})	Harvests			Mean
		I	II	III	
Milk-dough	0	29.4	25.7	7.7	21.3
	60	20.4	15.3	5.2	13.4
	120	13.3	20.5	5.2	12.5
	180	7.8	13.7	3.5	8.9
Mean		17.7	18.8	5.4	14.0
Ripe grain	0	30.2	18.0	7.1	18.4
	60	18.7	8.6	7.1	11.6
	120	17.7	10.8	2.7	10.9
	180	8.2	11.1	2.3	8.4
Mean		18.7	12.1	4.8	12.3
LSD (0.05)	Seeding rate	6.2	NS	1.7	3.8
	Cutting time	NS	NS	NS	NS
	Interaction	8.8	5.4	2.3	5.3

(Table 2). All treatments were similar in the second and third harvests and in total hay yield. Total herbage production increased with companion crop, especially when companion seed rate was the highest, but the increase was not significant. The higher total hay yields (8990 and 8948 kg ha⁻¹) were obtained at the higher 180 kg ha⁻¹ seeding rate of barley. Klebasadel & Smith (1960) reported that although harvesting the companion crop at maturity resulted in thinner alfalfa stands, the stands were apparently adequate to produce yields of alfalfa comparable with the other treatments having slightly higher alfalfa plant populations. Schmid & Behrens (1972) and Brink & Marten (1986) found that forage yields the following year were usually not affected by companion crop treatments.

The residual effects of seed rate of companion crop on weed suppression continued in first and third harvests; the interaction of seed rate × cutting stage was significant in all harvests (Table 3). Weed proportions were reduced from 18.4–21.3 to 8.4–8.9% of the total herbage in the second year. Weed content represented 21.3 and 18.4% of the forage when no barley was used and clover was cut at the milk-dough stage and ripe grain stage of the barley, respectively. Sowing rate of the companion crop at 180 kg ha⁻¹ reduced weed content to 8.9 and 8.4%. Lanini et al. (1991) found that weed density was reduced in the second year of the stand when oats were included at establishment. They determined that an oat companion crop seeded at a higher rate (36 kg ha⁻¹) reduced weed biomass in alfalfa hay by an average of 75%.

As a contrast in this study, many researchers reported that delaying cutting and using a higher seed rate of companion crop were harmful to the density and productivity of perennial forage legumes. But, although seeding the companion crop at higher rates and harvesting at maturity caused poor seedling growth during establishment, the stands were adequate to produce yields of white clover the following year comparable with the low seeding rates and immature cuttings. Therefore, white clover should be sown with a barley companion crop at normal barley seeding rate (180 kg ha⁻¹), and the mixture can be harvested at milk-dough stage or ripe grain stage of barley in the highlands area.

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