

Undersowing *Poa pratensis* L., *Festuca rubra* L., *Festuca pratensis* Huds., *Dactylis glomerata* L. and *Lolium perenne* L. in Five Cover Crops.

II. Effect of the Cover Crop Plant Density on the Seed Yield of the Undersown Grasses.

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ABSTRACT

The effects of cover crop plant density on seed yield of undersown grasses were investigated over three seasons. The grass species were smooth stalked meadow grass (*Poa pratensis* L.), red fescue (*Festuca rubra* L.), meadow fescue (*Festuca pratensis* Huds.), cocksfoot (*Dactylis glomerata* L.) and perennial ryegrass (*Lolium perenne* L.), while the cover crops were winter rape (*Brassica napus* L.), winter wheat (*Triticum aestivum* L.), spring barley (*Hordeum vulgare* L.), field bean (*Vicia faba* L.) and field pea (*Pisum sativum* L.). The cover crops were established at three plant densities. The best seed yields for all five grass species were obtained when they were undersown in winter rape. In this cover crop, winter rape sowing rates between 4 and 8 kg ha⁻¹ had no effect on grass seed yields. When the grasses were undersown in field bean, grass seed yields were lower than for other cover crops, and those of smooth stalked meadow grass, red fescue and cocksfoot decreased as cover crop plant density increased. Generally the greatest effect of cover crop plant density was recorded in these slow establishing grasses, where seed yields were reduced by increased cover crop plant density. Meadow fescue and perennial ryegrass seed yields were not affected by cover crop plant density.

Additional index words: winter rape, winter wheat, spring barley, field bean, field pea, plant density, crop yield, seed yield, fertile tillers.

INTRODUCTION

Grasses sown for seed production in Denmark are undersown in a cover crop to provide a longer establishment period. Various combinations of cover crop and undersown grass species have been tested in Denmark, and considerable differences in grass seed yield have been found (Nordestgaard, 1979; Boelt, 1997). The undersown grasses and the cover crop compete for resources. When the cover crop is dense, the undersown grasses often develop poorly until the harvest of the cover crop. Poor vegetative development in the establishment year will consequently result in lower seed yields in smooth stalked meadow grass and red fescue (Meijer, 1984).

When tall fescue (*Festuca arundinacea* Schreb.) and cocksfoot (*Dactylis glomerata* L.) were established in spring sown wheat, barley and oats, the cereal cover crop reduced the photosynthetic photon flux density intercepted by the undersown grasses, and the soil water content (Chastain and Grabe, 1989a,b). This resulted in a lower tiller and dry matter production by both undersown grass species. In the autumn after harvest of the cover crop, tiller formation was decreased when the grasses had been established in a cover crop. This led to a lower number of fertile tillers, and first year seed yields were reduced by 61% and 46% in

tall fescue and cocksfoot respectively.

When red fescue (*Festuca rubra* L.) was established in winter wheat, soil moisture was not reduced (Chastain and Grabe, 1988) but still the tiller number and the dry matter production were reduced. It was concluded that the negative effect on the undersown red fescue was due to competition for light. The negative effect on red fescue development could to some extent be alleviated by increasing row distance of the winter wheat from 15 cm to 60 cm. Consistent with these findings Nordestgaard (1984b, 1988) found that the seed yield of smooth stalked meadow grass (*Poa pratensis* L.) was increased when the cover crop (winter barley or winter wheat) was established at a row distance of 24 cm rather than 12 cm, or cover crop sowing rate was reduced.

Establishing tall fescue in spring barley at cover crop sowing rates higher than 75 kg ha⁻¹ reduced seed yield compared to sowings in a pure stand (de Ruiter and Hare, 1993). Increasing the sowing rate reduced the incident radiation intercepted by the undersown tall fescue plants, and they became etiolated. The herbage nitrogen concentration and the nitrogen uptake were significantly higher when tall fescue was established without a cover crop, but the nitrogen content was not influenced by the barley sowing rates.

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The present trial was initiated to find the optimum crop management system for the cover crop and the undersown grasses when grown for seed production. Results for the yield of the cover crop and the seed yield of the undersown grasses were presented by Boelt (1997). In this paper the effects of three cover crop plant densities on grass seed yield are discussed. The final paper in this series will discuss the optimal amount of autumn nitrogen applied to the undersown grasses.

MATERIALS AND METHODS

In a field experiment at the same site and for three seasons, five grass species for seed production were undersown in five cover crops. The grass species were smooth stalked meadow grass (*Poa pratensis* L.) cv. Erte, red fescue (*Festuca rubra* L.) cv. Rubina, meadow fescue (*Festuca pratensis* Huds.) cv. Senu, cocksfoot (*Dactylis glomerata* L.) cv. Amba and perennial ryegrass (*Lolium perenne* L.) cv. Borvi. All the cultivars were forage types. The cover crops were winter rape (*Brassica napus* L.) cv. Ceres, winter wheat (*Triticum aestivum* L.) cv. Kraka, spring barley (*Hordeum vulgare* L.) cv. Grit, field bean (*Vicia faba* L.) cv. Cargo and field pea (*Pisum sativum* L.) cv. Solara. The trials were conducted from 1988-1992 at the Danish Institute of Agricultural Sciences, Department. of Cereals, Seeds and Industrial Crops on a sandy loam soil. The procedure of establishment was described by Boelt (1997). The five cover crops were sown at the following rates: 4,6,8 kg ha⁻¹ (winter rape), 153, 198, 247 kg ha⁻¹ (winter wheat), 107, 154, 190 kg ha⁻¹ (spring barley), 125, 204, 277 kg ha⁻¹ (field bean) and 134, 202, 276 kg ha⁻¹ (field pea) to establish the three desired plant densities (x,y,z - Table 1) for each species. In the autumn sown cover crops, the number of plants m² were recorded approximately one month after sowing in autumn and again in spring. In the spring sown cover crops the number of plants m² were recorded approximately one month after sowing.

The sampling techniques used, methods for the harvest of the cover crops and the grass seed crops as well as the statistical analyses are as described by Boelt (1997). The trial included the use of three nitrogen levels in autumn. Results presented in this paper are an average of these

nitrogen levels and of the three experimental years. The grass seed yields are adjusted to 100% purity and 13% seed moisture.

RESULTS

Cover crop plant density was close in all cases to the desired plant density (Table 1), with the exception of spring barley where the recorded plant density was 19% lower than desired.

The interaction between plant density and grass species had a significant effect on the seed yield of the grasses. Therefore results are presented individually for the grass species.

Smooth stalked meadow grass

Winter rape and field pea plant density had no effect on the seed yield of undersown smooth stalked meadow grass (Table 2). When undersown in winter wheat or spring barley, reducing the cover crop plant density increased grass seed yield by 52 kg ha⁻¹ in winter wheat and by 46 kg ha⁻¹ in spring barley. The grass seed yield at the intermediate plant density was not statistically different from that at the high or low densities. When undersown in field bean, the smooth stalked meadow grass seed yield was highest at the lowest cover crop plant density.

On average over the five cover crops, the highest number of smooth stalked meadow grass fertile tillers was obtained when undersown in winter rape (Table 3). Winter rape and winter wheat plant density had no effect on smooth stalked meadow grass fertile tillers. When established in spring barley, the number of fertile tillers was increased (by 228 tillers m²) when plant density decreased from highest to lowest. In field pea the number of fertile tillers was highest at the lowest plant density, while in field bean, the number of fertile tillers was reduced by 331 m² at the highest plant density (Table 3).

Smooth stalked meadow grass plant density in spring was reduced at high cover crop plant density for all five cover crops (data not presented).

Red fescue

Red fescue seed yield did not differ with cover crop plant

Table 1. The desired plant density in winter rape, winter wheat, spring barley, field bean and field pea and the actual number of plants recorded approximately one month after sowing.

	Winter rape (pl.m ⁻²) ¹		Winter wheat (pl. m ⁻²)		Spring barley (pl. m ⁻²)		Field bean (pl. m ⁻²)		Field pea (pl. m ⁻²)	
	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual
yc ²	120	126	400	391	350	292	40	48	60	57
x ³	80	91	300	305	250	205	25	30	40	38
y	120	128	400	388	350	290	40	47	60	58
z	160	167	500	493	450	351	55	62	80	76

¹ plants m²

² no undersown grass species.

³ x = low, y = intermediate, z = high density.

Table 2. The effect of cover crop plant density¹ on the seed yield² (kg ha⁻¹) of undersown smooth stalked meadow grass.

	Winter rape	Winter wheat	Cover crop Spring barley	Field bean	Field pea
x	788	512	425	519	667
y	768	486	392	472	656
z	767	460	379	446	631

LSD P<0.05 = 41

¹ See Table 1.² 13% seed moisture content and 100% purity.**Table 3.** The effect of cover crop density¹ on fertile tillers (no m⁻²) of undersown smooth stalked meadow grass.

	Winter rape	Winter wheat	Cover crop Spring barley	Field bean	Field pea
x	1775	1402	1244	1197	1681
y	1782	1421	1118	1080	1422
z	1750	1320	1016	866	1580

LSD P<0.05 = 165

¹ See Table 1.

density in winter rape, winter wheat, spring barley or field pea (Table 4). However, when undersown in field bean, red fescue seed yield was significantly increased (by 50 kg ha⁻¹) when the cover crop plant density was reduced from 55 to 25 plants m⁻². Seed yield at the intermediate cover crop plant density did not differ from the higher or lower densities.

In red fescue the number of fertile tillers m⁻² was not influenced by the plant density of the cover crop, although the highest plant density of the five cover crops decreased the plant density of the undersown grasses in spring compared to the lowest cover crop plant density (data not presented).

Meadow fescue

The seed yield of meadow fescue was not influenced by the cover crop plant density, averaging 1089, 1053, 1005, 1080, and 1080 kg ha⁻¹ when undersown in winter rape, winter wheat, spring barley, field bean or field pea respectively. There was also no effect of cover crop plant density on the number of fertile tillers. The meadow fescue plant density in spring was highest at the intermediate cover crop plant density.

Cocksfoot

On average for the five cover crops, the seed yield of cocksfoot was not increased when the cover crop plant density was decreased from the high to the intermediate density (Table 5). Reducing cover crop plant density from

the intermediate to the low density resulted in higher seed yields when cocksfoot was undersown in spring barley, field bean or field pea. In field bean and field pea, the cocksfoot seed yield was significantly reduced at the highest plant density compared to the lowest (Table 5).

Cover crop plant density had no effect on the number of fertile tillers or on the cocksfoot plant density (data not presented).

Perennial ryegrass

Plant density of the five cover crops had no effect on seed yield of perennial ryegrass, which averaged 1488, 1498, 1478, 1298 and 1377 kg ha⁻¹ when undersown in winter rape, winter wheat, spring barley, field bean and field pea respectively. Similarly no effect of cover crop plant density on the number of perennial ryegrass fertile tillers or plant density was recorded (data not presented).

DISCUSSION

Sowing winter rape at 4, 6 or 8 kg ha⁻¹ had no effect on the seed yield of the undersown grasses, and at these sowing rates, winter rape yield did not differ (Boelt, 1997). Boelt (1977) also found that higher seed yields were obtained when grasses were undersown in winter rape compared to the traditional spring barley cover crop. Increasing the plant density of spring barley reduced the seed yield of the undersown smooth stalked meadow grass and cocksfoot, a result consistent with Hare and de Ruiter

Table 4. The effect of plant density¹ on the seed yield² (kg ha⁻¹) of undersown red fescue.

	Winter rape	Winter wheat	Cover crop		
			Spring barley	Field bean	Field pea
x	1455	1220	1202	1148	1194
y	1453	1203	1175	1126	1162
z	1436	1186	1164	1098	1187

LSD P<0.05 = 41

¹ See Table 1.² 13% seed moisture content and 100% purity.**Table 5.** The effect of cover crop plant density¹ on the seed yield² (kg ha⁻¹) of undersown cocksfoot.

	Winter rape	Winter wheat	Cover crop		
			Spring barley	Field bean	Field pea
x	1017	914	894	943	952
y	997	888	859	901	882
z	1000	899	888	899	893

LSD P<0.05 = 35

¹ See Table 1.² 13% seed moisture and 100% purity.

(1993) and Nordestgaard (1984a). In smooth stalked meadow grass and cocksfoot the highest seed yields were obtained at the lowest plant density (250 plants m⁻² established from a sowing rate of approximately 107 kg ha⁻¹). Reducing spring barley plant density from 450 to 250 plants m⁻² resulted in a barley yield decrease of 0.30 t ha⁻¹ (Boelt, 1997). The optimal cover crop plant density of spring barley must therefore be calculated according to the actual price relationship between the barley grain and the grass seed. Consistent with results by Deleuran and Boelt (1997), no effect of spring barley plant density was recorded on perennial ryegrass seed yield.

Nordestgaard (1984b) found that decreasing winter wheat sowing rate from 200 kg ha⁻¹ to 100 kg ha⁻¹ increased seed yield in smooth stalked meadow grass. This result was confirmed in the present trial. Plant density did not affect the winter wheat grain yield (Boelt, 1997). Therefore a plant density of 300 plants m⁻² (from a sowing rate of approximately 153 kg ha⁻¹) is optimal when grasses for seed production are undersown, particularly for smooth stalked meadow grass.

When undersowing grasses in field pea, decreasing the plant density from 80 to 40 plants m⁻² reduced the yield of field pea by 0.84 t ha⁻¹ (Boelt, 1997) while the seed yield of cocksfoot increased by 59 kg ha⁻¹. Nordestgaard (1994) reported that increasing the pea plant density from 50 to 75 plants m⁻² reduced smooth stalked meadow grass seed yield by 54 kg ha⁻¹ but the yield of field pea decreased by 120 kg ha⁻¹. In the present trial the field pea yield was lower, which probably explains the higher yield reduction in the field pea and the lower yield increase in the grass seed crop. A

pea plant density of 50 plants m⁻² is recommended, in agreement with Nordestgaard (1994).

With field bean as the cover crop, all the grasses except perennial ryegrass produced the highest seed yield at the lowest cover crop plant density. Field bean is harvested approximately one month later than the other cover crops, which limits the development of tillers in the autumn. Meijer (1984) emphasised the importance of autumn tillering to optimise seed yield in smooth stalked meadow grass and red fescue. Decreasing plant density from 80 to 40 plants m⁻² decreased field bean yield by 0.93 t ha⁻¹.

Altering the management system of the cover crop can increase seed yield of the undersown grasses (Meijer, 1987). However, the optimal management system must take into account the price relationship between the cover crop and the grass seed in question.

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