

Effect of Sowing Rate on Seed Production of Amenity Cultivars of Red Fescue (*Festuca rubra* L.).

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ABSTRACT

Three red fescue cultivars, Pernille (*Festuca rubra* L. var. *rubra*), Suzette (*Festuca rubra* L. var. *trichophylla*) and Tamara (*Festuca rubra* L. var. *commutata*) were undersown in 1991, 1992 and 1993 in winter wheat cv. Sleipner and in field pea cv. Solara at two locations, Rønhave and Roskilde, using three sowing rates (200, 400 and 600 viable seeds m⁻² which is equivalent to 2, 4 and 6 kg ha⁻¹). The objective was to determine the optimal sowing rate for these three cultivars which have different growth patterns. The optimum sowing rate for red fescue var. *rubra* was 200-400 viable seeds m⁻², when seed was harvested for two consecutive years. No significant difference among sowing rates was found in the first seed production year, but in the second seed production year the highest sowing rate reduced the grass seed yields. High sowing rates favoured seed yields in the first seed production year in red fescue var. *trichophylla* and var. *commutata*, while in the second seed production year no differences among sowing rates were found. No significant interactions between cultivars and sowing rates or between cultivars and cover crops were found. Whether grass seed yields were greater after establishment with winter wheat or field peas as the cover crop depended on site and season, as no consistent pattern emerged.

Additional index words: *Festuca rubra* L., amenity types, sowing rate, panicle number, seed yields.

INTRODUCTION

Red fescue (*Festuca rubra* L.) is the second largest grass seed crop in Denmark and most of the seeds produced are exported. Red fescue amenity types are often used for recreational purposes, and the demand for seed is high. The average seed yield (1986-1995) has been 1104 kg ha⁻¹ (Danish Seed Council, 1995).

Festuca rubra var. *rubra* has been the preferred type, and has most commonly been established undersown in spring barley. The introduction of *Festuca rubra* var. *commutata* and var. *trichophylla*, which grow more slowly than var. *rubra*, has meant that establishment in winter wheat and winter rape has had to be investigated. Red fescue undersown in winter wheat in the autumn has given satisfactory seed yields in several trials (Liefstingh and Vreeke, 1971; Nordestgaard, 1988).

In the United States red fescue growth did not differ when winter wheat and winter barley were used as cover crops (Chastain and Grabe, 1988a). Nordestgaard and Boelt (1992) found red fescue more competitive in winter wheat than smooth stalked meadow grass (*Poa pratensis* L.), meadow fescue (*Festuca pratensis* L.) and cocksfoot (*Dactylis glomerata* L.), but not as competitive as perennial ryegrass (*Lolium perenne* L.). In the same trials red fescue was more competitive in field peas than smooth stalked meadow grass, but not as competitive as meadow fescue, cocksfoot and perennial ryegrass. The economic gain by establishing a red fescue grass seed crop with cereal cover crops was demonstrated by Chastain and Grabe (1988b).

Fairey and Lefkovitch (1996) reported that seed yields of *Festuca rubra* var. *rubra* could be optimised for two consecutive seed production years by manipulating plant density and row spacing. Meijer (1984) found inflorescence production in red fescue and smooth stalked meadow grass was affected by both the juvenility of tillers and crop density in first year seed crops, and primarily by crop density as the stand aged - high plant density limited seed yields. In tall fescue (*Festuca arundinacea* Schreb.), high plant densities had a negative effect on the seed yield as the stand aged (Wander, 1996).

In this study red fescue amenity cultivars were undersown at different rates in two cover crops. The objective was to determine which red fescue sowing rate lead to the most successful establishment, the most panicles and the highest seed yields in two consecutive seed production years for the three amenity cultivars. The cultivars were Pernille - a long stolon type, which tends to form dense crops, especially if kept for more than one seed production year, and Suzette and Tamara which have short stolons, and no stolons, respectively. Types with short stolons and types without stolons tend to form more open stands.

MATERIALS AND METHODS

Three red fescue cultivars Pernille (*Festuca rubra* L. var. *rubra*), Suzette (*Festuca rubra* L. var. *trichophylla*) and Tamara (*Festuca rubra* L. var. *commutata*) were undersown in 1991, 1992 and 1993 in winter wheat cv.

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Sleipner and in field pea cv. Solara at two locations, Rønhave and Roskilde. Rønhave has a clay soil and Roskilde has a sandy loam soil. The grasses and the cover crops were sown separately (Table 1); the grass seeds immediately after the cover crop at a depth of 1 cm in the opposite direction to the winter wheat and field pea rows. The distance between rows was 12 cm for both the grass and cover crops. Seeds of the red fescue cultivars were sown at three rates, 200, 400 and 600 viable seeds m⁻²

(approximately 2, 4 and 6 kg ha⁻¹), winter wheat at 350 viable seeds m⁻² (approximately 160 kg ha⁻¹) and field peas at 60 viable seeds m⁻² (approximately 220 kg ha⁻¹). In all establishment years the preceding crop was spring barley.

The experimental design was a randomised complete block with two replications for each cultivar at Roskilde, and three replications for each cultivar at Rønhave. The net plot size was 8 m x 2.5 m.

In the establishment year nitrogen at 150 kg N ha⁻¹

Table 1. Sowing, vegetative cutting and harvest dates for red fescue and cover crops.

	<u>Established 1990/1991</u>		<u>Established 1991/1992</u>		<u>Established 1992/1993</u>	
	Roskilde	Rønhave	Roskilde	Rønhave	Roskilde	Rønhave
Sowing dates						
Winter wheat + undersown grass seed	27 Sept 1990 3 Oct 1990	13 Sept 1990 13 Sept 1990	16 Sept 1991 16 Sept 1991	11 Sept 1991 11 Sept 1991	16 Sept 1992 17 Sept 1992	11 Sept 1992 11 Sept 1992
Field pea + undersown grass seed	11 Apr 1991 11 Apr 1991	9 Apr 1991 9 Apr 1991	8 Apr 1992 9 Apr 1992	1 Apr 1992 1 Apr 1992	2 Apr 1993 2 Apr 1993	2 Apr 1993 2 Apr 1993
Cutting date						
	4 Sept 1991 29 Jul 1992	no cutting	15 Sept 1992 20 Sept 1993	no cutting	20 Sept 1993 29 Sept 1994	no cutting
Harvest date						
Winter wheat	22 Aug 1991 29 Aug 1991	21 Aug 1991 22 Aug 1991	30 Jul 1992 29 Jul 1992	6 Aug 1992 23 Jul 1992	26 Aug 1993 28 Aug 1993	19 Aug 1993 18 Aug 1993
Field pea						
<u>The first red fescue seed production year:</u>						
Seed swathed	24 Jun 1992	30 Jun 1992	2 Jul 1993	1 Jul 1993	15 Jul 1994	12 Jul 1994
Seed combined	1 Jul 1992	8 Jul 1992	8 Jul 1993	14 Jul 1993	18 Jul 1994	20 Jul 1994
<u>The second red fescue seed production year:</u>						
Seed swathed	2 Jul 1993	1 Jul 1993	15 Jul 1994	12 Jul 1994	17 Jul 1995	19 Jul 1995
Seed combined	7 Jul 1993	14 Jul 1993	18 Jul 1994	20 Jul 1994	21 Jul 1995	24 Jul 1995

Table 2. Average monthly temperature and total monthly rainfall in 1991, 1992, 1993, 1994 and 1995 and average values (1961-1990) for Roskilde¹.

	Temperature, °C					Average (1961-90)	Rainfall, mm					Average (1961-90)
	1991	1992	1993	1994	1995		1991	1992	1993	1994	1995	
Jan	1.7	2.2	1.7	2.4	-0.3	-0.8	49	35	75	81	77	42
Feb	-1.3	3.0	0.8	-1.3	3.4	-0.6	33	25	20	44	70	28
Mar	3.9	3.9	2.6	3.1	2.8	1.7	12	50	9	77	30	36
Apr	6.0	5.9	7.2	7.4	6.5	7.7	24	33	4	51	61	37
May	9.4	12.7	13.1	10.4	9.9	10.6	31	10	8	44	48	44
Jun	11.7	17.5	13.8	13.0	13.9	14.5	121	1	53	51	44	50
Jul	17.2	17.9	14.5	19.4	17.5	16.3	76	49	120	4	16	66
Aug	17.0	16.4	14.1	17.2	18.7	15.7	40	57	102	57	26	66
Sep	13.3	12.8	10.7	12.8	13.1	12.5	70	34	148	153	91	56
Oct	8.7	6.2	6.9	7.7	11.1	8.9	30	61	59	38	17	53
Nov	4.7	4.5	1.9	6.3	3.1	4.6	59	85	64	59	50	56
Dec	2.6	2.6	2.0	3.8	-2.5	1.1	44	38	83	84	26	51
Year	7.9	8.8	7.4	8.5	8.1	8.1	589	478	745	743	556	585

¹Values for Rønhave are approximately the same.

was applied to the winter wheat, split between early April and May. No fertiliser was applied to the field peas. In the subsequent seed production years an autumn application (in September) of 75 kg N ha⁻¹ after winter wheat, and 50 kg ha⁻¹ after field peas was made. In the spring 45 kg N ha⁻¹ was applied in early March to all plots. Weeds were controlled with Herbalon (a.i. clopyralid, mechlorprop and MCPA) or Gallant (a.i. haloxyfob) when necessary.

Winter wheat and field pea were harvested with a trial combine harvester and the straw was removed immediately after harvest. The stubble was then cut to 8-10 cm height (Table 1).

Contents of nitrate-N and ammonium-N in three soil layers at Roskilde (0-25 cm, 25-50 cm and 50-100 cm) were measured in the autumn, based on a method described by the Danish Plant Directory (1994). Before the onset of winter, red fescue green leaf samples were taken to determine the amount of nitrogen using the Kjeldahl Method (AOAC, 1990). Lodging was assessed at flowering and at harvest, using a scale when no lodging is 0 and full lodging is 10. After flowering, plant heights were measured and before harvest, panicles were counted within frames of 0.25 m².

Red fescue crops were swathed in early July and combined approximately one week later (Table 1). The seed moisture content at swathing and combining was not measured. Immediately after the seed harvest seeds were dried to 13 % moisture. After seed drying and cleaning, one sample from each treatment was analysed for purity at the Danish Plant Directory using internationally standardised methodology (ISTA, 1988). In the autumn the fields were cut to 8-10 cm when plant growth exceeded 10 cm. The trial consisted of three first seed production years and three second seed production years. Meteorological data were collected at both locations by the Danish Institute of Agricultural Sciences, Department of Meteorology.

To predict the effects of the treatments in the trial in any future year, the following statistical procedure was performed. All results are means of three years and the data were analysed as a three-factorial block design regarding year as a random factor. Tests of the main effects of sowing rate, cultivars and cover crops and their two and three way interactions were performed by F-tests. Because of a systematic trend in the fields, the analysis for the seed yields included plot number as a covariance. The denominator in the F-test was the interaction between the effect in question and year. Least significant differences (LSD) at the 5 % probability level were used to separate means of main effects. The analyses were performed using the Statistical Analysis System (SAS, 1989a,b).

RESULTS

Meteorological data

In 1991 growing conditions were favourable, and June especially was relatively wet; 55 mm and 25 mm more rainfall than normal at Roskilde and Rønhave respectively (Table 2). 1991 had no drought periods and the grass seed established well. The 1992 growing season was dry and

sunny from mid May until mid July and rainfall was far below normal (Table 2). This led to poor grass seed establishment, especially at Roskilde. Spring and summer of 1993 had drought periods, but compared to 1992 the situation was not quite as serious, and the rainfall came in time to secure a satisfactory seed harvest at both locations. The grass seed established very poorly in 1993, but 1994 provided favourable climatic conditions for grass seed production. 1995 also provided good climatic conditions for the second seed production year.

The mineral nitrogen analyses indicated nitrate leaching to the lower soil layers after field pea. This tendency was greatest after establishment in 1991/1992 where November was very wet compared to normal.

Panicles

Panicle number did not differ between the sites in either seed production year. Increasing sowing rate tended to increase panicle number in the first seed production year (although not all differences were significant), except in cv. Pernille at Roskilde (Table 3). In the second seed production year no differences were found among sowing rates, except in cv. Tamara at Rønhave, where the two higher sowing rates lead to a higher panicle number than the lowest sowing rate. The number of panicles varied among cultivars in both the first and the second seed production years (Table 3). All cultivars at Roskilde differed significantly in the first seed production year, and in both the first and the second seed production year the highest panicle number was found in cv. Suzette. At Rønhave cv. Tamara had a significantly lower panicle number than cv. Pernille and cv. Suzette in the first seed production year, while in the second seed production year cv. Suzette had a significantly higher panicle number than cv. Pernille and cv. Tamara.

Panicle number in the establishment year 1990/1991 averaged 4654 panicles m² after winter wheat and 4148 panicles m² after field peas. In the establishment years 1991/1992 and 1992/1993 the highest panicle production at both sites was after winter wheat (Table 4). Panicle production was significantly higher at Roskilde than at Rønhave in all years. No significant difference was found in panicle number between the first and the second seed production year (data not presented).

First seed production year

In the first seed production year no seed yield differences were found between the sites. At both sites, cvs. Pernille and Suzette produced significantly greater seed yields than cv. Tamara (Table 3). Seed yield did not differ with sowing rate in cv. Pernille (Table 3, Table 5) but cv. Suzette yielded higher at the highest sowing rate at both sites, as did cv. Tamara at Rønhave..

After establishment in 1990/1991 there was a marked difference in the seed yields at the two locations (Table 4). Winter wheat had a positive effect on the grass seed yields at Roskilde after establishment in 1992/1993 and at Rønhave after establishment in 1991/1992. Seed yields were highest after field pea at Rønhave after establishment in 1992/1993, and at Roskilde after establishment in 1990/1991 and 1991/1992 (Table 4).

Second seed production year

In the second seed production year there were significant differences between sites for cvs. Pernille and Tamara. At Rønhave the seed yields were approximately 250 kg ha⁻¹ higher than at Roskilde (data not presented). Only in cv. Pernille was seed yield influenced by sowing rate (Table 5) because yields decreased when sowing rate

was increased from 200 to 600 viable seeds m⁻². In the second seed production year, the seed yield differences among grass seed cultivars produced in the first seed production did not occur (Table 3). The use of different cover crops for establishment had no effect on seed yield in the second seed production year. No significant difference was found between the two seed production years.

Table 3. Sowing rate effects on the number of panicles and seed yield in the red fescue cultivars Pernille, Suzette and Tamara and among cultivars. Data are the average of three years.

Sowing rate ¹	Panicles (no. m ⁻²)				Seed yield (kg ha ⁻¹) ²			
	Ros 1.y ³	Ros2. y	Ron 1.y	Ron 2. y	Ron 1.y	Ros 2.y	Ron 1.y	Ron 2. y
cv. Pernille								
200	4747	4501	3314	4935	1332	1291	1521	1610
400	4651	4586	3656	5118	1416	1278	1631	1555
600	4989	4437	3725	5006	1347	1168	1684	1489
mean	4796	4508	3565	5020	1365	1246	1612	1551
LSD P < 0.05	ns	ns	377	ns	ns	ns	ns	108
cv. Suzette								
200	5195	5691	3196	5952	1244	1314	1332	1406
400	4954	5173	3786	5778	1263	1280	1472	1395
600	5553	5270	4463	5984	1350	1277	1549	1372
mean	5234	5378	3815	5905	1286	1290	1451	1391
LSD P < 0.05	286	ns	427	ns	78	ns	165	ns
cv. Tamara								
200	3528	4657	2646	4642	1100	1209	1039	1432
400	4093	4503	3264	5110	1145	1209	1229	1479
600	4231	4594	3523	5137	1142	1215	1327	1478
mean	3951	4585	3144	4963	1129	1211	1198	1463
LSD P < 0.05	372	ns	469	483	ns	ns	162	ns
LSD ⁴ P < 0.05 mean	393	620	319	809	110	ns	210	ns

¹ Number of viable seeds m⁻²

² At 13 % seed moisture content and 100 % purity.

³ Ros 1. y refers to Roskilde in the first seed production year. Ron 1. y refers to Rønhave in the first seed production year.

⁴ Among the means of the three cultivars.

Table 4. Effect of cover crops on red fescue panicles and seed yield for the first seed production year after establishment in 1990/1991, 1991/1992 and 1992/1993. Data are the average for the three cultivars.

Panicles m ²	Roskilde			Rønhave		
	1990/1991 ¹	1991/1992	1992/1993	1990/1991	1991/1992	1992/1992
undersown winter wheat	5424	5530	4895	3884	3970	2998
undersown field pea	4840	4615	2656	3456	3087	3779
LSD P < 0.05	440	382	509	249	397	336
Seed yield (kg ha⁻¹)²						
undersown winter wheat	942	1289	1619	1552	1443	1273
undersown field pea	1001	1392	1318	1489	1242	1587
LSD P < 0.05	48	55	55	ns	65	48

¹ Establishment year.

² 13 % seed moisture content and 100 % purity.

Nitrogen mineralisation and nitrogen content in red fescue plants

At Roskilde the nitrate/ammonium ratios after winter wheat were equivalent to 80/20, 83/17 and 52/48 respectively, for the establishment years 1990/1991, 1991/1992 and 1992/1993 and after field pea the ratios were 65/35, 88/12 and 80/20.

The nitrogen content in red fescue plants after establishment in 1990/1991 at Roskilde was 17.1 and 19.1 kg N ha⁻¹ after winter wheat and field pea respectively. After establishment in 1991/1992 and 1992/1993 the nitrogen content was respectively 17 and 10 kg N ha⁻¹ higher after winter wheat than after field pea.

DISCUSSION

Seed yields in cv. Pernille (var. *rubra*) did not differ with sowing rate in the first seed production year but were reduced at the highest sowing rate in the second seed production year. Similar data were reported by Meijer (1984) and Fairey and Lefkovitch (1996). Fairey and Lefkovitch (1996) reported that the natural growth habit of creeping red fescue involves a steady proliferation of tillers which eventually become too dense to form seed heads. Meijer (1984) found inflorescence production to be affected

by both the juvenility of tillers and crop density in first-year seed crops, and primarily by crop density as the stand aged. The high sowing rate limited seed yields, possibly because of competition between reproductive and vegetative tillers. The latter has not been reported, but it is often observed that dense-sown seed crops have a great proportion of vegetative tillers (Meijer, 1984).

Seed yields of cv. Pernille at the highest sowing rate decreased from 1545 kg ha⁻¹ in the first seed production year to 1356 kg ha⁻¹ in the second seed production year (Table 5), although the decrease was not significant. The same pattern was observed in cv. Suzette (var. *trichophylla*) at the highest sowing rate, where second year seed yields were reduced by approximately 6 % at Roskilde and approximately 12 % at Rønhave. In cv. Tamara (var. *commutata*) no specific trend was observed, except at Rønhave in the first seed production year, where the number of panicles and seed yields were higher at the highest sowing rate. In cv. Tamara at the lowest sowing rate only a higher panicle production led to a higher seed yield from the first to second seed production year.

The first year seed yields at Roskilde were very low (< 1000 kg ha⁻¹) after establishment in 1990/1991, but despite the drought in the first year, seed yields at Rønhave were very high (approximately 1500 kg ha⁻¹). At Rønhave the heavier soils provided sufficient water for the grass seed

Table 5. Sowing rate effects on seed yield in the red fescue cultivars Pernille, Suzette and Tamara. Data are averages of three years and two locations

Sowing rate ¹	Seed yield (kg ha ⁻¹) ²	
	First seed production year	Second seed production year
cv. Pernille		
200	1443 ³	1478
400	1542	1440
600	1545	1356
mean	1510	1425
LSD P < 0.05	ns	ns
cv. Suzette		
200	1296	1368
400	1385	1347
600	1467	1332
mean	1383	1349
LSD P < 0.05	100	ns
cv. Tamara		
200	1064	1340
400	1194	1367
600	1251	1369
mean	1170	1359
LSD P < 0.05	112	ns
LSD ⁴ P < 0.05 mean	183	ns

¹ Number of viable seeds m²

² At 13 % moisture content and 100 % purity.

³ Mean of two replicates at Roskilde and three replicates at Rønhave.

⁴ Among the means of the three cultivars.

crop in this dry year and seed yields were 25 % above the Danish average for 1992. In contrast the Roskilde seed yields were 20 % below the average. Approximately similar seed yields were harvested at Roskilde and Rønhave after establishment in 1991/1992, and the highest yields were obtained at Roskilde after establishment in 1992/1993. After establishment in 1991/1992 and 1992/1993 seed yields were above the Danish average seed yields for 1993 and 1994 respectively. Spring and summer 1993 had drought periods, but compared to 1992, the situation was not quite as serious, and rainfall came in time to secure a high seed yield at both locations. The grass seed crops established very poorly in 1993, but in 1994 the climatic conditions were favourable and first and second year seed yields were very high at both locations.

Panicle production was significantly higher at Roskilde than at Rønhave in the first seed production year in all years, but this did not result in higher seed yields. There was a positive correlation between panicle production and seed yield at Rønhave in the first seed production year. Although these differences between panicle production and seed yields were recorded, the two sites showed the same tendencies among cultivars and sowing rates. No significant interactions between cultivars and sowing rates or cultivars and cover crops were found.

In Denmark field pea has previously been used as a successful cover crop for slow establishing grass seed crops such as smooth stalked meadow grass (Nordestgaard, 1994), and winter wheat is known to provide good conditions for the undersown grass seed (Liefstingh and Vreeke, 1971; Nordestgaard, 1988). Results from this study indicated that both winter wheat and field pea are suitable as cover crops for red fescue seed production. Although differences among years were found, no systematic seed yield trend between cover crops was observed. From the data for nitrogen content in the red fescue plants, there was no evidence that field pea leaves more available nitrogen for the grass seed crop than winter wheat.

All sowing rates produced seeds yields above the Danish ten year average seed yield of 1104kg ha⁻¹. For seed production for two consecutive years, sowing rates of between 200 to 600 viable seeds m² will optimize seed yields for red fescue amenity types var. *trichophylla* and var. *commutata*. For red fescue var. *rubra* the recommended sowing rate is between 200-400 viable seeds m².

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