

Effects of establishment method, seeding rate and soil fertility on the growth and persistence of a prairie grass pasture in the Waikato

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ABSTRACT The production and persistence of 'Grasslands Matua' prairie grass were compared when direct drilled or **oversown** at a low or high seeding rate, and with or without extra fertiliser before planting. To estimate possible effects of insects on prairie grass persistence, insecticide was applied to a small area. Prairie grass growth during the first winter/spring was greater when direct drilled than when oversown, but thereafter treatment effects disappeared. High seed rate plots maintained higher prairie grass plant and tiller densities than low seed rate plots during the first year, but this did not affect annual **herbage** accumulation. Two years from sowing, prairie grass plant and tiller densities had declined to a low level in all plots. At this time, prairie grass tiller density and prairie grass content (% of DM) in **insecticide**-treated areas were about twice those in untreated areas. Mean total annual **herbage** accumulation in the second year had declined by 21% compared with the first. This work shows that prairie grass does not require extra fertiliser at planting when sown into a well maintained high fertility site, and that direct drilling at a low seed rate produces results similar to those of the traditional method of establishment of oversowing at a high seed rate. Insect attack contributed to poor prairie grass persistence.

Keywords *Bromus willdenowii* Kunth, oversowing, direct drilling, pasture botanical composition, major element composition, **tiller** density, insect damage, annual **herbage** accumulation, root yields

INTRODUCTION

Initially, recommendations for establishing prairie grass (*Bromus willdenowii* Kunth) were to **oversow** onto a cultivated **seedbed** using oscillating type fertiliser spreaders at high seed rates (35-50 kg/ha) (Lancashire 1985; Ridler 1985). This method avoided flow problems encountered in fluted-roller type seeders caused by the large prairie grass seeds with barbed awns (Horrell 1979). The installation of special agitators in some drills (Baker 1981) and the de-awning of seed (McCaw 1986) to overcome seed flow problems offer the possibility of using the cheaper establishment option of direct drilling and reduced seeding rate.

'Grasslands Matua' is the only current prairie cultivar, and its establishment has been aided by high soil fertility and **pH** (6-6.5) (Rumball 1974; Rys et al. 1978; Clark 1985). Successful establishment of prairie grass in a cultivated **seedbed** possibly requires higher than usual inputs of elemental fertiliser and lime.

This paper describes 2 years of results from an experiment which examined the effects of method of establishment, seeding rate, and initial soil fertility, on the growth and persistence of autumn-sown prairie grass. The experiment began in April 1987 and concluded in May 1989. Since insect damage during the second year of a previous **farmlet** trial severely reduced the persistence of prairie grass (Thorn et al. 1989b), regular insecticide applications were superimposed on a small area from February 1988 to April 1989.

MATERIALS AND METHODS

Site

The experiment was conducted at the Ruakura Agricultural Centre on a well drained Bruntwood silt loam (P.L. Singleton, **pers. comm.**). Over the previous 10 years the site had received sufficient fertiliser to maintain 90% of maximum pasture yield; in autumn 1986 it received 40 kg P and 49 kg S as single superphosphate. Preliminary soil tests (Table 1) revealed high K and Mg levels and a medium P level. In February 1987, sufficient lime (5 t/ha) to raise soil **pH** above 6 was applied and washed into the soil by 22 mm of irrigation water over 7.5 hours.

Experimental design and treatments

A split-plot experimental design was used with the 4 main plot treatments located at random within 4 block replicates. Main plot (each 6 x 10 m) were either cultivated and **oversown** with prairie grass at a high seed rate (45 kg/ha) or a low seed rate (22 kg/ha) or were uncultivated and direct drilled with prairie grass at similar rates. Subplot (3 x 10 m) treatments were extra fertiliser and lime or maintenance fertiliser applied before sowing.

All blocks were sprayed with glyphosate (Roundup herbicide, 41/ha) on 27 March 1987. Cultivated plots were ploughed to a depth of 15-20 cm on 2 April 1987. Soil cores (15 cm depth) were taken from these plots and from the remaining uncultivated plots (7.5 cm depth) and standard nutrient quick tests were carried out (Table 1). The subplot fertiliser treatment was determined by the amount of

P and K required to return the soil test levels of the cultivated plots to that of the uncultivated plots (Table 1). Before tilage (shallow **discing**, rollatilling and rolling) of ploughed plots, half their area received extra fertiliser (56 kg P, 64 kg K and 75 kg S/ha) and lime (2 t/ha) (EFL), while the remainder received 22 kg P and 27 kg S/ha as maintenance fertiliser (MF). For completeness, these fertiliser treatments were also applied to uncultivated plots.

Fungicide-treated and de-awned Matua prairie grass seed was direct drilled into uncultivated plots or **oversown** onto cultivated plots on 16 April 1987. A mixture of 'Grasslands Pawera' red clover and 'Grasslands Pitau' white clover seeds was also sown on all plots. A sack harrow was used to cover the seed.

Fensulphothion insecticide granules (5 kg ai/ha) were applied to 25% (6 x 2.5 m) of the area of each of the 4 main plots previously ploughed and sown with a high seed rate of prairie grass. Insecticide was applied every **30-40** days after a grazing.

Seedling flatweeds were sprayed during the first winter with MCPB (6 l/ha) and in August all plots received 30 kg N/ha as urea **prills**.

Grazing management

During the study the plots were grazed by dairy cows on 16 occasions, the first 129 days from sowing. About 60 cows were used to graze the plots over 6-7 hours. Grazing interval was from 3-6 weeks except in winter (May-July) when it was extended to 12 weeks. Hard grazing (post-grazing yields 900 kg DM/ha) occurred during autumn and late spring, but the mean post-grazing yield for grazing outside these periods was 1800 kg **DM/ha**. Pre-grazing yields were highest in January/February (4000-5000 kg **DM/ha**) and lowest from May to September (2600 kg **DM/ha**)

MEASUREMENTS

Plant and tiller density

Prairie grass plants were counted on 22 June 1987 in 3 randomly located **quadrats** (each **0.1m²**) per subplot. Subsequent prairie grass plant and tiller counts were made at about 3-monthly intervals over the trial period. Prairie grass plants and tillers on **insecticide**-treated areas were counted on 2 May 1989.

Table 1 Soil quick test data for the trial **site**

Type and Date	pH	Ca	K	P	Mg
Preliminary (29 Jan 1987)	5.8 (0.1)^d	6.8 (0.5)	16.5 (3.7)	17.8 (2.6)	23.3 (1.7)
Post-liming (2 Apr 1987) ^b					
1. Cultivated	5.8 (0.1)	6.1 (0.1)	11.7 (2.6)	13.5 (3.6)	17.1 (3.5)
2. Uncultivated	6.1 (0.1)	8.6 (0.7)	17.9 (3.1)	20.1 (2.8)	27.0 (3.1)
One year from sowing (13 Apr 1988)					
1. Cultivated^b :					
EFL	6.2 (0.2)	11.4 (2.3)	22.3 (8.6)	17.0 (4.0)	20.0 (6.8)
MF	6.1 (0.3)	1.9 (0.6)	18.8 (7.6)	15.5 (4.4)	21.3 (4.8)
2. Uncultivated ^c :					
EFL	6.0 (0.2)	12.8 (2.1)	19.1 (3.3)	23.2 (3.8)	24.4 (3.9)
MF	6.2 (0.3)	11.1 (1.6)	22.4 (8.3)	21.4 (10.0)	23.0 (7.1)

^ameans over the 4 blocks; ^bmeans for 8 subplots per treatment; ^cmeans for 7 subplots per treatment; ^dstandard error of mean.

Table 2 Prairie grass plant density (**plants/m²**) from June 1987 to April 1989

Date	Establishment	Method ^a		Seed Rate			Initial Fertiliser ^b		
	DD	OS	LSD ^c	High	Low	LSD	EFL	MF	LSD
1987									
22 June	135	153	23	173	115	23	154	134	36
1 October	89	119	16	122	86	16	103	104	22
22 December	93	80	21	102	71	21	88	85	9
1988									
29 March	66	63	15	79	49	15	67	62	13
8 July	151	162	100	151	162	100	160	153	61
8 October	65	79	27	69	75	27	73	71	14
1989									
9 January	55	49	11	53	57	11	52	52	12
20 April	46	36	13	44	38	13	35	47	13

^aDD = direct drilled into uncultivated **seedbed**; OS = **oversown** onto cultivated **seedbed**; ^bEFL = extra fertiliser and lime applied before planting; MF = maintenance fertiliser applied before planting; ^cLSD = least significant **difference**, P < 0.05.

Botanical composition

Herbage in each subplot was sampled by ground level clipping, and dissected into prairie grass, *Poa* spp., paspalum, ryegrass, other grasses, red clover, white clover, weeds, and dead material bulked across all species. All components were dried at 100° C for 36 hours before grazing, and began on 20 August 1987 and thereafter was at about 3-monthly intervals. Insecticide treated areas were sampled on 2 May 1989.

Table 3 Prairie grass plant density (plants/m²), tiller density (tillers/m²) and herbage mass (kg DM/ha) for insecticide-treated and untreated areas during 1988/89

Variable	Insecticide	No Insecticide
Density (2 May 1989)		
1. Plant density	124 (38)	102 (38)
2. Tiller density	916 (323)	365 (180)
Herbage mass		
27 April 1988	3782 (874)	3037 (648)
25 July 1988	3136 (622)	2438 (218)
2 May 1989	2608 (410) (940) ^a	2065 (456) (372)

Data are means of 4 reps.
“Prairie grass herbage mass on 2 May 1989.

Herbage mass

Herbage mass on each subplot was estimated pre- and post-grazing using a capacitance probe. Twenty probe readings were made per subplot and seasonal calibration equations for prairie grass (P.J. L’Huillier pers. comm.) were used to calculate dry matter yield per hectare as described by L’Huillier & Thomson (1988). Herbage mass on insecticide-treated areas was estimated on 27 April and 25 July 1989 using the capacitance probe.

Root yield

Prairie grass root yields were estimated from samples taken 16 weeks (4 August 1987) from sowing. Ten

Table 4 Herbage concentrations (% of DM) of Ca and Mg in direct drilled (DD) or oversown (OS) prairie grass during year 1.

Date	Ca			Mg		
	DD	OS	LSD	DD	OS	LSD
1987						
8 July	0.52	0.46	0.03	0.104	0.095	0.005
12 August	0.52	0.47	0.04	0.118	0.103	0.008
16 September	0.51	0.49	0.03	0.139	0.135	0.009
12 October	0.51	0.49	0.03	0.149	0.137	0.008
4 November	0.53	0.50	0.03	0.148	0.141	0.013
8 December	0.45	0.45	0.03	0.135	0.129	0.007
1988						
18 January	0.57	0.55	0.04	0.142	0.131	0.008
19 February	0.75	0.74	0.04	0.161	0.151	0.028
8 March	0.73	0.73	0.04	0.173	0.174	0.011
13 April	0.63	0.58	0.04	0.149	0.140	0.008
23 May	0.49	0.50	0.03	0.156	0.161	0.008

soil cores (15 cm diam. 20 cm depth) per subplot were randomly sampled. Soil was removed by washing before prairie grass roots were separated, dried, weighed and ground in preparation for chemical analyses (see below).

Chemical composition

Sampling of prairie grass herbage from each subplot began on 8 July 1987 and was at monthly intervals until May 1988, and thereafter bi-monthly. Herbage and root samples were analysed for major elements (N, P, K, Mg, S, Ca and Na) using standard procedures (Thorn et al. 1989a).

RESULTS

Climate

Prolonged dry periods occurred in summer/autumn of both years. Rainfall was 77 % of the long term average (335 mm) from January to April 1988, which included a 34-day period in January/February when only 1 mm fell. During February to April 1989, rainfall was 61% of the long term average (264 mm). Plants within one main plot were severely water stressed during their dry periods. Because pasture growth on this plot was consistently low (prairie grass drilled at 22 kg/ha), its data for all variables were excluded from statistical analyses.

Plant and tiller density

Establishment plant counts 67 days after sowing (22.6.87) for prairie grass indicated 52 and 68% of seeds sown at the high (45 kg/ha) and low (22 kg/ha) rates, respectively, formed plants. Plots sown at the high seed rate contained significantly more prairie grass plants than those sown at the low seed rate, a trend which continued until March 1988 (Table 2). Initially, more prairie grass plants were established in ploughed than in drilled plots, but this trend disappeared from October 1987 (Table 2). Fertiliser treatments had no effect on plant density and all treatment effects disappeared after natural reseeding in March 1988. Prairie grass plant density declined throughout the experiment; over all treatments 45 and 28 % of established prairie grass plants remained after 1 and 2 years, respectively. The interactions between treatment variables were seldom significant.

Prairie grass tiller density data reflected the above trends. Before reseeding, tiller density was highest in December 1987 (826/m²) but had fallen by 53% to 441/m² over all treatments by April 1989.

Mean prairie grass plant densities in May 1989 were similar in insecticide-treated and untreated areas, but mean tiller density was 2.5 times higher in treated than in untreated areas (Table 3).

Botanical composition

There were few treatment effects on prairie grass content (% DM). However, in August 1987 there was more prairie grass in plots sown at a high seed rate compared with the low seed rate (63 vs 54, SED

4.0). In both years the prairie grass content over all treatments was highest in late spring (September/October) (65% of DM) and lowest in autumn (February/March) (30% of DM). By May 1989, 2 years from sowing, the prairie content had fallen to 25 %.

Red clover and white clover contents were consistently higher in ploughed than in drilled plots, red reaching a maximum of 29% in autumn 1988 and white a maximum of 14% in early summer. Dead material content was highest in autumn (22 % of DM) and was similar for all treatments. On average over all treatments, volunteer perennial ryegrass did not exceed 7 % of DM.

By the 2 May 1989, insecticide-treated areas contained more prairie grass than untreated (36 vs 18%) and dead material was high (approx. 28% of DM) in both treatments. White clover and red clover contents were greater in untreated than treated areas.

Herbage accumulation and root yields

Pasture herbage accumulation (kg DM/ha) from sowing until the first grazing in August 1987 was greater on drilled than on ploughed plots (2850 vs 2350, SED 100). Thereafter, treatment differences were small and generally not significant. On average over all treatments, total annual herbage accumulation in the second year had declined by 2.1% compared with the first year (16 400 vs 12 950 kg DM/ha). Insecticide-treated areas outyielded untreated areas by 25-29% (Table 3).

Prairie grass root yield estimates in August 1987 were similar for all treatments and averaged 1300 kg DM/ha.

Chemical composition of prairie grass

During the first year, herbage concentrations (% of DM) of Ca and Mg were often higher in plants established by direct drilling than those oversown onto cultivated soil (Table 4). Ca and P concentrations were also higher during the first year for ERL than for MF treatments, reflecting the fertiliser additions before sowing.

DISCUSSION

Few significant treatment effects were revealed by this study. Most treatment effects occurred in the first year and concerned method of establishment.

Soil tests one year from sowing (Table 1) showed that the nutrient status of the cultivated plots was close to that of the uncultivated plots, regardless of fertiliser inputs. Most of the treatment differences relating to

seedbed disturbance had also disappeared after one year. The high soil fertility and pH status of the trial site (Table 1) are considered adequate for prairie grass establishment and growth (Rys *et al.* 1978; Clark 1985; Clough 1990). This implies that where the site chosen for prairie grass has a previous history of regular maintenance fertiliser, extra fertiliser to counter possible dilution effects caused by cultivation (if cultivation and oversowing is the method of establishment chosen) is not justified.

This experiment indicates that direct drilling can be as successful as the traditional method of establishment, oversowing at a high seed rate (35-50 kg/ha) after cultivation, in high fertility dairying areas. Although more prairie grass plants were established where seed rates were high (Table 2), this did not improve overall pasture production. Direct drilling at a low seed rate (20-25 kg/ha) offers substantial cost savings for prairie grass establishment.

Most reports (Rumball *et al.* 1972; Wilson 1978; Crush *et al.* 1989) note the low Mg status of *Bromus* spp. relative to *Lolium* spp. (ryegrasses). Rumball *et al.* (1972) reported a lower spring (September) Mg concentration in prairie herbage than in summer (January). This trend is not supported by the present results (Table 4) or those of Crush *et al.* (1989), who found overall Mg herbage concentrations were higher by 0.02 to 0.04% of DM. Higher initial concentrations of Ca and Mg in prairie grass plants established by direct drilling rather than oversowing (Table 4) could be due to higher soil nutrient availability (Table 1) in the former uncultivated plots during early growth, which allowed for greater plant uptake of Ca and Mg.

A notable feature of the trends in the data presented is the decline in the prairie grass plant population (Table 2) and tiller density over the 2 year study. Although dry summers and autumns affected pasture production in both years, the difference between years of about 20 % in annual herbage accumulation reflects in part the decline in prairie grass population, which by May 1989 was only 25% of pasture DM.

Recent evidence (Black & Chu 1989) suggests prairie grass persistence, as measured by maintenance of tiller density, is favoured by delaying grazing until new replacement tillers have appeared. During the present experiment, grazing decisions were based on herbage accumulation and grazing frequency rather than plant physiological status, and prairie grass may have been occasionally disadvantaged.

Nevertheless, the pattern of good first year pasture production followed by decline in the second year was the same as experienced in recent farmlet and plot evaluations of prairie grass pastures in the Waikato (Thorn *et al.* 1989b; P.J. L'Huillier pers. comm.; G.J. Goold pers. comm.). This decline occurred regardless of grazing management and was illustrated again in the current experiment. By May 1989, the vigour of prairie grass plants (illustrated by tiller density data, Table 3) was much reduced in untreated compared with insecticide-treated areas. These results were

consistent with the finding of 2.5 times the herbage mass of prairie grass in insecticide-treated compared with untreated areas. The insects causing deaths of prairie grass tillers were identified by R.A. Prestidge (pers. comm.) to be Argentine stem weevil and hessian fly, and these have been successfully controlled in a previous experiment (Thorn et al. 1989b) using fensulphothion insecticide. Insect damage was probably a major cause of the prairie grass decline.

CONCLUSIONS

1. In highly fertile soil, maintenance fertiliser only is required. Extra fertiliser is not needed to successfully establish prairie grass.
2. Direct drilling at low seed rates was equal to the traditional method of establishment of oversowing at high seed rates.
3. Insect damage is an important factor limiting persistence of prairie grass pastures in the Waikato. Until economic insecticide or cultural methods are developed or insect-resistant cultivars are bred, prairie grass is not considered a viable alternative species for Waikato dairy farms.

Acknowledgements Staff of the Ruakura Dairy Research Centre for help in the execution of this experiment; staff of the Ruakura Analytical and Biochemistry Group, Ruakura, for provision and application of insecticide; statistical advice and technical assistance were provided by Dr H.V. Henderson and P.A. Allison, respectively.

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