
THE PERFORMANCE OF PASTURE SPECIES IN CANTERBURY

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Abstract

The seasonal and total production of a number of different grass species and lucerne varieties was compared under grazing over 3 years. Significant differences were obtained in total and component yields in all seasons. Lucerne outyielded all other species in the summer while prairie grass and tall fescue were superior in the autumn, winter and spring. The performance of the different species is discussed in relation to production, botanical composition, climate and insect attack.

INTRODUCTION

PERENNIAL RYEGRASS (*Lolium perenne*) is the most common grass species sown in New Zealand. Where the climate is more extreme, however, such as the sub-humid region of Canterbury (Garnier, 1958), growth of this species rapidly declines under summer conditions of low rainfall, high temperatures, and high evaporation. Canterbury farmers are therefore very conscious of the need for species that will provide feed over these difficult periods and in this respect lucerne has proved most successful. But lucerne has certain disadvantages. It is largely winter dormant and sensitive to grass and weed invasion which can be serious in wet seasons, particularly in autumn, winter, and early spring.

Overseas, greater use has been made of other grass species to combat extremes of summer heat and winter cold and *Bromus inermis*, and *Festuca arundinacea*, for example, are used with success in the United States (Hoover *et al.*, 1948). The work reported is a comparison between such species and major New Zealand species grown under relatively severe climatic conditions of Canterbury.

EXPERIMENTAL

The experiment was carried out at Lincoln Regional Station of Grasslands Division, DSIR, situated in Canterbury on a Wakanui silt loam.

"This study was carried out while author was employed by Grasslands Division, DSIR.

The experimental area was ploughed out of permanent pasture in late summer and a seedbed prepared over the following two months. Lime at 5 tonnes/ha was applied two weeks before sowing and DDT-superphosphate at 250 kg/ha and muriate of potash at 125 kg/ha were applied at sowing. Muriate of potash and DDT-superphosphate at the above rates were applied each autumn and biennial dressings of lime at 1.25 tonne/ha.

The species sown and rates of sowing (corrected to 100% purity and germination) are listed below.

Species	Sowing Rate (kg/ha)
Nucleus seed, perennial ryegrass (<i>Lolium perenne</i>)	22
Nucleus seed, short-rotation ryegrass (<i>L. perenne</i> × <i>L. multiflorum</i>)	22
Nucleus seed, cocksfoot (<i>Dactylis glomerata</i>)	22
Nucleus seed, timothy (<i>Phleum pratense</i>)	9
Tall Fescue S170 (<i>Festuca arundinacea</i>)	*
Yorkshire fog (<i>Holcus lanatus</i>)	15
Meadow Fescue S53 and S215 (<i>Festuca pratensis</i>)	22
Prairie grass (<i>Bromus catharticus</i>)	45
Bromegrass (<i>Bromus inermis</i> leys), Lincoln, U.S.A.	28
Lucerne, N.Z. Certified Strain B (<i>Medicago sativa</i>)	18
Lucerne, Hunter River (<i>Medicago sativa</i>)	18
Lucerne, creeping type (<i>Medicago glutinosa</i>)	18
Mixtures	
Perennial ryegrass + cocksfoot	17+11
Short-rotation ryegrass + perennial ryegrass	17+11
Short-rotation ryegrass + cocksfoot	17+11
Short-rotation ryegrass + timothy	17+7

Owing to the small amount of tall fescue (S170) seed available it was necessary to raise the plants in boxes and transplant them into the field in the autumn at 10 cm spacing and oversow with the clovers. Within twelve months these plantings had developed into productive swards.

The first four species listed above have since received further attention by plant breeders and are currently known as 'Grasslands Ruanui' perennial ryegrass, 'Grasslands Manawa' short-rotation ryegrass, 'Grasslands Apanui' cocksfoot, and 'Grasslands Kahu' timothy.

All species were sown with 3 kg white clover (*Trifolium repens*), 1 kg broad red clover (*T. pratense*) and 1 kg Montgomery red clover (*T. pratense*) per hectare.

All other species were also sown in the autumn, being broadcast by hand. Management throughout the following 15 months

TABLE 1: CLIMATOLOGICAL DATA (LINCOLN COLLEGE) LINCOLN

	<i>Sept.</i>	<i>Oct.</i>	<i>Nov.</i>	<i>Dec.</i>	<i>Jan.</i>	<i>Feb.</i>	<i>Mar.</i>	<i>Apr.</i>	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug.</i>	<i>Total</i>
<i>Rain fall</i>													
Mean (mm)	50.03	43.43	49.60	58.40	55.60	46.04	55.56	48.42	63.10	63.89	69.45	54.70	658.41
70 yr Av.													
Year 1	92.86	56.80	91.28	48.42	36.11	29.19	107.86	97.23	157.16	28.17	90.78	16.27	852.09
Year 2	70.24	37.70	38.89	73.42	75.00	43.45	35.32	88.90	54.76	76.99	14.28	18.25	626.66
Year 3	7.54	50.80	20.40	38.10	21.43	75.00	142.87	78.20	202.00	21.03	30.16	10.71	697.80
Evaporation													
Mean (mm)	63.24	86.60	120.65	131.35	144.20	125.80	96.44	53.18	32.20	19.84	21.82	37.70	932.65
70 yr Av.													
Year 1	59.60	80.96	122.63	125.80	187.50	140.00	92.20	101.20	145.80	31.75	42.46	37.30	1141.00
Year 2	71.83	100.80	122.40	143.66	136.90	118.26	116.60	89.20	63.50	41.20	9.92	34.25	1054.49
Year 3	65.70	96.04	165.10	164.30	220.66	174.10	105.60	62.83	30.16	24.29	13.21	38.16	1123.30.
Mean Grass Minimum Temperature ° C (Grasslands Division Lincoln)													
Year 1	0.5	4.9	6.1	7.8	8.4	9.3	9.8	6.0	2.2	-1.1	-0.4	2.0	
Year 2	2.2	2.9	2.8	6.9	8.0	10.3	7.5	1.0	1.0	-2.0	-1.5	0.3	
Year 3	0.0	6.2	6.4	10.9	10.4	9.3	8.5	4.7	0.1	-3.5	-3.2	-2.1	
Soil Moisture Tension (pf) at 5 cm below ground (Grasslands Division Lincoln)													
Year 1	3.03	3.05	3.57	3.67	4.18	4.51	3.53	3.36	2.92	2.91	2.89	2.94	
Year 2	3.03	3.38	3.37	3.89	3.92	4.09	4.20	4.25	3.28	3.11	3.00	3.04	
Year 3	3.55	3.42	4.41	4.41	4.59	4.49	3.83	3.23	3.04	3.06	3.03	3.15	

was such as to enable the slower growing species to develop into productive pastures.

Difficulty was experienced in the establishment of *Bromus inermis* owing to the slow initial growth and excessive competition from volunteer grasses, particularly *Poa annua*. As a result the assessment of this species was delayed a further 18 months until the brome grass pasture was considered to be well established. The prairie grass pastures were allowed to reseed in the summer of 1956-7 as there was some doubt as to its persistency under sheep grazing. This was later found to be unnecessary and in subsequent years the common grazing management (from 15 down to 2.5 cm) was followed.

The sixteen treatments were in duplicate, randomized in two blocks. Each paddock was 1/100 ha, and fenced to permit separate grazing. Wethers were used for all grazings.

Before every grazing, four sample areas 1.83 x 30 cm were cut in both replicates using the "Tarpen" trimmer. The four samples were bulked for green weight yields and then subsampled for dry matter determination and species contribution to yield. All drying was at 93° C.

The same grazing management was applied to all grass treatments, the pastures being grazed down to 2.5 cm whenever they reached approximately 15 cm in height. All lucerne treatments were allowed to grow to approximately 22 cm before being grazed back to 2.5 cm. Although pastures were grazed independently whenever they approximated the required height, replicates were always grazed at the same time.

The sheep were brought from a common grazing area after pre-feeding for at least 2½ days and stocked at a rate, based on the amount of feed available, to achieve complete utilization over the grazing period of 3 days. After grazing, any uneaten clumps of herbage were cut to approximately 2.5 cm with a sickle mower, and left on the plots.

The seasonal period referred to as spring extends from September to November, inclusive; summer — December to February; autumn — March to May; winter — June to August. Pasture measurements extended over a period of 3 years following the initial establishment period of 16 months.

CLIMATIC CONDITIONS

Table 1 shows monthly rainfall and evaporation data obtained from the official meteorological station at Lincoln College, and

mean grass minima temperatures and soil moisture tensions under short pasture (at 5 cm below ground level) obtained from the microclimate station of the Grasslands Division, Lincoln, over the trial period.

RESULTS

Table 2 presents the annual and seasonal dry matter production data as a mean of three years' results.

For convenience, results are referred to in three sections, first the lucerne varieties, second the single-grass pastures, and third the mixed-grass pastures.

TOTAL AND SPECIES YIELDS

The three lucerne varieties gave highest annual production which was largely due to their marked superiority in the summer.

TABLE 2: ANNUAL AND SEASONAL PRODUCTION

	Total	Annual Sp.	Cl.	Other spp.	Total	Spring Sp.	Cl.	Other spp.
Perennial								
ryegrass	9 670	7250	2260	170	4450	3 790	570	90
S.R. ryegrass	1350	5720	1080	550	4560	3 740	480	340
Cocksfoot	8 550	6500	1330	710	4120	3270	480	370
Timothy	9 800	6 180	2370	1 260	4520	3280	710	530
Tall Fescue (S170)	11 080	8740	1360	980	5590	4460	640	490
Yorkshire fog	10 150	7300	2010	840	4740	3 790	500	450
Meadow fescue (S53 + 5215)	8 830	2900	3150	2780	4050	1 640	860	1550
Prairie grass	11610	7200	1330	3080	5220	2970	390	1860
Bromegrass*	9 090	5470	3060	570	4480	2 440	1 770	270
Lucerne (SB)	14 550	12900	650	1 000	5920	4650	440	830
Lucerne (HR)	12 370	10250	490	1 630	4760	3 120	290	1316
Lucerne (Glut)	13 580	10840	1040	1 700	5 350	3430	490	1 420
S.R. + per ryegrass	9440	7230	1960	250	4390	3710	560	120
S.R. + Cocksfoot	8 790	7210	1310	270	4340	3650	530	160
S.R. + Timothy	8 560	6280	1900	380	4250	3450	610	180
P.R. + Cocksfoot	9620	7870	1600	150	4660	4050	550	70
SE ±	580	540	130	160	250	220	50	80
Sig. diff. at 5% level	1 740	1650	490	480	560	680	250	710

* = Only 1½ years of measurement.

New Zealand Certified Strain B was the most productive lucerne, particularly in the spring and in the summer. There was little difference in the autumn yields and all varieties declined to negligible production in the winter.

Among the single-grass pastures, the total annual production of prairie grass significantly outyielded all other treatments apart from tall fescue and Yorkshire fog. Both the prairie grass and tall fescue pasture maintained relatively high total production throughout the year, with prairie grass tending to be superior in autumn and winter and tall fescue superior in spring. In terms of annual species yields, however, tall fescue tended to be superior to prairie grass.

Apart from the poor growth of meadow fescue, the remaining grasses were all similar in species yield throughout spring and summer. The strong autumn recovery of perennial ryegrass and

(MEAN OF THREE YEARS) (kg DM/ha)

Total	Summer			Total	Autumn			Total	Winter		
	Sp.	Cl.	Other spp.		Sp.	Cl.	Other spp.		Sp.	Cl.	Other spp.
2080	1150	870	60	2 490	1730	750	10	650	580	70	Tr.
1840	1210	490	130	—	—	—	—	950	770	100	80
1750	1270	370	100	2090	1490	420	180	590	480	60	60
2060	1110	660	290	2520	1270	890	370	700	520	110	70
2200	1570	380	250	2240	1850	250	150	1040	860	90	90
2120	1330	650	130	2380	1390	770	200	920	780	80	60
2310	560	610	700	1760	480	930	350	720	220	300	190
2480	1120	640	620	2 690	2140	270	280	1220	980	40	210
1850	1300	460	90	2330	1560	610	170	430	170	210	50
5 990	5 840	80	70	2 650	2 400	170	100	—	—	—	—
4770	4550	90	150	2840	2590	120	120	—	—	—	—
5 3 9 0	4 9 8 0	2 5 0 1	7 0 2 8	5 0 2 4	3 0 3 0	0 1 1 0	—	—	—	—	—
2050	1280	680	90	2310	1630	660	20	680	620	60	10
1880	1430	380	70	1690	1320	350	30	870	800	60	10
1890	1120	650	120	1560	950	540	70	860	750	100	10
2 090	1 490	530	70	2 170	1690	470	10	700	640	60	
230	180	60	50	190	150	50	40	60	90	20	40
710	540	180	150	570	460	160	110	200	280	60	N.S.

improved performance of short-rotation ryegrass in the winter, are also worthy of note. The failure of short-rotation ryegrass to recover in autumn necessitated the treatments being over-sown each autumn, and therefore precludes any accurate comparisons being made with other species.

Yields of the mixed grass pastures were generally not significantly different from those of the comparable single grass pastures.

CLOVER YIELD

Figure 1 shows the significant relationship between yield of clover and yield of grass plus other species. The short-rotation ryegrass treatments were omitted from the analysis because of severe damage from Argentine stem weevil attack.

The original regression (including all grass species except short-rotation ryegrass) showed that cocksfoot and cocksfoot plus perennial ryegrass lay outside the 95% confidence limits presented (Broken line) emphasizing the strong depressant effect of cocksfoot on clover. When these two cocksfoot treatments were excluded from the analysis then a much closer relationship existed between yield of clover and yield of grass plus other species. The regression line and associated 95% confidence limits presented as solid lines, reflects this latter relationship, the regression being $C = (-0.4183 \pm 0.0253) G + 5488$.

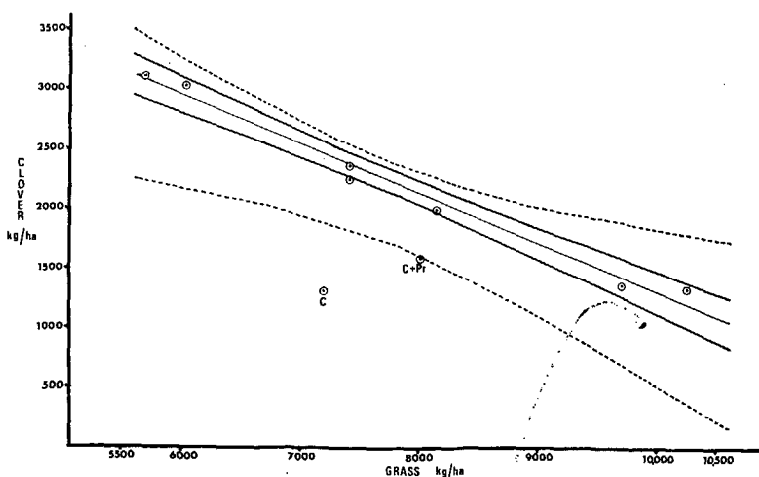


FIG. 1: Relationship between yield of grass and other species, and yield of clover. C = cocksfoot. C + Pr = cocksfoot + perennial ryegrass.

OTHER SPECIES

The main invading species in the lucerne treatments were chickweed (*Cerastium* spp. and *Stellaria* spp.), perennial ryegrass and *Poa annua*, while in the grass treatments they were mainly perennial ryegrass, *Poa annua* and Yorkshire fog.

Prairie grass, meadow fescue and to a lesser extent timothy permitted a noticeable invasion of other species, while the Hunter River and *Medicago glutinosa* treatments contained more weeds than Strain B. Perennial ryegrass, on the other hand, was most effective in maintaining a weed-free stand.

DISCUSSION

The superiority of lucerne under dry conditions in Canterbury has been clearly shown. This is largely attributed to the greater root penetration of lucerne than of grass, as found by Lamba et al. (1948), resulting in a better moisture supply to the plant for growth. Even accepting the fact that lucerne had the advantage in growth from a 22 cm to 2.5 cm management over the grasses with a 15 cm to 2.5 cm management, it is doubtful whether the grass would have achieved similar production under the more lax management, as much of the superiority of lucerne occurred over the summer dry period when grass growth was severely restricted. In spring and autumn, however, lucerne was no better than many of the high producing pastures. In fact, when relatively low temperatures persisted into spring in the second year of the experiment, lucerne was considerably inferior in production to such pastures. This difference could be even greater when it is remembered that the lucerne treatments had the advantage of a 22 cm to 2.5 cm management. In winter all pastures were more productive than lucerne. However, other lucerne varieties as reported by Palmer (1959) may be capable of better winter growth.

The N.Z. Certified (Strain B) variety was generally the most productive lucerne although Hunter River tended to be superior in late autumn, as found by Palmer (1959). The greater yield of the Strain B variety was probably due to its greater stem density. From measurements made in the summer it was found that, while plant numbers were much the same, the number of stems were 745/m² for Hunter River, 1036/m² for *Medicago glutinosa*, and 1080/m² for Strain B.

Many of the pastures compared were similar in annual and seasonal yields. However, there were significant exceptions, particularly the high productivity of prairie grass pasture during late

autumn, winter and early spring and tall fescue pasture in late winter and spring. In terms of species yields, the different grasses were much more diverse, with tall fescue showing a remarkable spread of relatively high seasonal production. Prairie grass, on the other hand, was a relatively low producer from November to March but made a major contribution to total production during the remainder of the year.

Prominent among the environmental factors affecting and possibly causing some of the differences obtained was the Argentine stem weevil (*Hyperodes bonariensis*). The repeated failure of short-rotation ryegrass to recover in autumn is largely attributed to this insect. As reported by Kelsey (1958) short-rotation ryegrass is very susceptible to attack by stem weevil and, in association with low soil moisture and high temperatures, it was sufficient to cause almost a complete kill of the grass each year. This effect was not apparent in the first autumn after sowing as the short-rotation ryegrass recovery was good in spite of a rather severe summer drought. However, after the second summer, which was less severe than the first, it failed completely and needed over-sowing with further seed then and in each succeeding autumn. Although severe summer grazing is known to damage short-rotation ryegrass (Brougham, 1959) this was not considered the major cause of failure as severe weevil damage occurred even in the absence of the grazing animal over this period. Meadow fescue appeared to be similarly affected and until there is a means of effectively controlling this insect both meadow fescue and short-rotation ryegrass will be prone to damage in Canterbury when this insect is present in significant numbers.

Stem weevil damage is not confined to these two grasses as, from a study of the weevil made in a number of the different pastures of this experiment, larvae were found in all the species examined (J. M. Kelsey, pers. comm.). However, there appear to be differences between species in their susceptibility to weevil attack and only in the meadow fescue and short-rotation ryegrass pastures was damage obvious.

The effect of drought conditions on plant survival must also be recognized as both the high temperatures and the low soil moisture levels experienced could have seriously reduced the number of short-rotation ryegrass plants surviving, as shown by Lucanus *et al.* (1960). Mitchell (1955) also showed that there are significant differences among grasses in their ability to grow at different temperatures and it would appear that some of the species studied were 'affected very differently by the wide range

of temperatures, ranging from 40° C in the summer to -12° C in the winter, measured at ground level. For example, brome grass produced well under the hot dry summer conditions of the second year but quickly succumbed to the cold of winter. Prairie grass, on the other hand, was more productive in spring and autumn than in summer, while tall fescue appeared to have a much wider temperature tolerance as it was prominent in all seasons of the year.

In the field, low soil moisture levels can rarely be divorced from the high summer temperatures of Canterbury and the results suggest that tall fescue and brome grass must be very efficient in water utilization, or that, like lucerne, their root systems must be very extensive. The value of deep roots to a plant during dry weather is well known (Jacques, 1941; Laude, 1953). Gist and Smith (1948) showed that brome grass had much greater root development in the deeper soil layers than cocksfoot or timothy, and cocksfoot much greater than timothy. Furthermore, Weaver and Zink (1946) considered that the relative persistence of brome grass roots, compared with species such as perennial ryegrass and timothy which regenerate their whole root system annually (Jacques and Schwass, 1956), greatly aided adaptation to semi-arid and arid climates.

A further factor which could have contributed to the differences obtained is the treading effect of the grazing animal. Edmond (1962) has shown that there are differences among species in their ability to withstand animal treading under both wet and dry soil conditions and that cocksfoot is very susceptible in this respect. This effect may have contributed to the relatively poor performance of cocksfoot as the yield and percentage of invading species showed a steady increase as the experiment progressed.

The content of clover and weed species was a major factor in determining the total production of the different pastures and, as found by Lambert (1954), they tended to compensate for the variations in species productions. Cocksfoot, however, appeared to compete more strongly with clover than did the other grasses, as reported by Hilder (1963). As the nutrient supply was probably adequate, it is considered that competition was mainly for light and soil moisture, although the possibility of nutrient interactions with light or moisture cannot be dismissed.

The performance of these different grasses has been compared under only one grazing management, namely, 15 cm down to 2.5 cm, and it is acknowledged that a different result might well

have been obtained if such species were compared under a different management, as demonstrated by Brougham (1959).

There 'appears to be scope in Canterbury for increased pasture production not only in summer but throughout the year by a greater use of more productive species. For summer, lucerne appears to be the most productive species but for the remainder of the year many grasses are superior and species such as tall fescue and prairie grass are worthy of consideration. Possibilities also lie in the field of pasture mixtures through the association of species having different growth periods. For example, the association of prairie grass and cocksfoot or prairie grass and lucerne may provide more productive pastures and there is a need to test these along with other mixtures in terms of pasture and particularly animal production.

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