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OBSERVATIONS ON THE RELATIONSHIP BETWEEN SOIL FERTILITY, PASTURE BOTANICAL COMPOSITION, AND PASTURE GROWTH RATE; FOR A NORTH ISLAND LOWLAND PASTURE

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Abstract

Soil chemical fertility. pasture composition and pasture production data were collected for seven 'microsites' within two farmlets at Massey University's No. 1 sheep farm, Palmersto" North. The two farmlets had been maintained for twenty years at stocking rates of 26 and 16 s.u./ha, and were found to have gradients (presumed to result from sheep grazing and camping behaviour) of increasing soil fertility away from a road and towards a shelterbelt. Microsites were placed along these gradients to include contrasting fertility levels for the two stocking rates. Mean values for soil pH, Olsen P and 'quicktest' K. tiller density for the various pasture species and pasture production at each of the seven microsites are presented.

A microsite where Olsen P = 109 was barley grass dominant and produced 10.5 t DM/ha/year. For other microsites ryegrass tillers per m^2 increased with P and stocking rate; and white clover and sweet vernal growing points/tillers per m^2 decreased with increasing P. Production ranged from 9.9 t DM/ha/year where Olsen P = 14 to 19.1 t DM/ha/year with different seasonal timing where Olsen P = 66.

INTRODUCTION

Two 12 ha farmlets on Massey University's No. 1 sheep farm had been maintained under sheep grazing at intensive and control stocking rates (26 and 16 s.u./ha respectively) for 20 years (1966 to 1966). In 1966, differences in pasture composition were apparent within and between the two farmlets.

The objectives of the study were (1) to test the hypothesis that fertility gradients occurred within the farmlets, and (2) to investigate the relationship between soil fertility status, stocking rate and pasture composition and production on these two farmlets. Several major studies of this nature have been conducted on hill country (e.g. Suckling 1975; Lambert *et al.* 1966) but not for lowland pastures.

METHODS

Site

The experimental site is located approximately 2 km south of Palmerston North on Tokomaru silt loam, a central yellow grey earth. Altitude is 60m a.s.l. and annual mean rainfall is 1000mm. Soil test, pasture composition and pasture growth data were collected at seven homogenous microsites.

Fertility gradients

Suspected soil fertility gradients were quantified. Soil samples were collected at 10 m intervals along transects and analysed for pH (10g soil: 25 ml water, 16 hr equilibration), Olsen P (Olsen *et a/.* 1954) and 'quicktest' potassium (indices of soil chemical fertility).

Microsite placement and evaluation

Microsites l-5 were on the high stocking rate farmlet. Microsites 1 and 2 were located at opposite ends of a gradient away from a road. Microsites 3, 4 and 5 were located in the next paddock, along a transect towards a shelter belt, and were on the shaded side of the trees. Microsites 6 and 7 were located near a gateway and centre respectively of a low stocking rate paddock. Microsites 1 and 2, and 6 and 7 were purposely placed to contrast high and low soil fertility levels for the two stocking rates. Soil tests were carried out as above, at each microsite.

Pasture composition was measured by a tiller plug method. Pasture growth rate values were obtained by siting three $0.3m^2$ wire netting cages per microsite and periodically harvesting all the herbage within the cages to a simulated grazing height of 3cm. Cutting was continued for one year and the cutting interval was approximately four weeks in summer, and six weeks in winter.

Statistical analysis

Linear regression was used to examine relationships between tiller density of the various pasture species and soil test or stocking rate data. Fourier series equations (Lambert *et al.* 1986) were fitted by multiple regression to generate pasture growth curves. Annual pasture production for each microsite was estimated by multiplying the regression constant by 365. Statistical significance of microsite by season interactions for these curves was calculated by a general linear models procedure.

RESULTS AND DISCUSSION

Soil fertility gradients

In the paddock containing microsites 1 and 2, soil phosphate and potassium levels increased gradually along the transect away from the road and then sharply near a stock camp (Fig 1) suggesting that nutrient transfer in dung (P) and urine (K) by grazing animals had resulted in fertility gradients, Presumably there were also gradients in soil nitrogen and sulphur levels, although not measured. Soil pH was relatively constant along the same transect (Fig. 1). The fertility gradient towards the shelter belt was even more extreme than that away from the road. Olsen P ranged from 109 adjacent to the trees, to 14 in centre paddock (microsites 3, 4 and 5 respectively).

Much smaller differences in Olsen P values were observed between microsites 6 and 7 than between the other two sets of microsites (1 and 2; 3, 4 and 5). In retrospect this was probably due to bad placing of microsite 6 too far to one side of the gateway and away from the highest nutrient concentrations.

The occurrence of fertility gradients associated with stock camping behaviour is well known on hill country (e.g. Suckling 1975). This study indicates that marked fertility gradients can also build up over time in lowland pastures. Awareness of such gradients could have management implications, for example in differential application of fertiliser.

Variation in pasture composition

Over the range of soil fertility values represented there was a transition from barley grass dominance at microsite 3 (Olsen P = 109) through ryegrass dominance at microsite 1 (Olsen P = 66) to mixed pasture with considerable proportions of Yorkshire fog, browntop and sweet vernal at microsite 7 (Olsen P = 17) (Table 1).

Omitting the atypical, very high fertility, barley grass dominant microsite 3, ryegrass tillers per m^2 increased with P and with stocking rate (t values for terms in respective equations 7.56**, 11.36**) and were highest where Olsen P = 66. White clover and sweet vernal growing points/tillers per m^2 decreased with P (t = —6.76**, -3.50' respectively). P level should be considered a general indicator of overall nutrient status in this context. Soil nitrogen more likely explains the effects shown than P per se.

A significant regression for clover growing points per m^2 and K also occurs, however in view of the higher K values for the low stocking rate microsites 6 and 7 (Table 1), this is of dubious interpretation.

Pasture production

Again omitting microsite 3, there was a simple linear relationship between pasture production and microsite fertility (Table 1) (t = 7.7"").

Also of interest was the change of seasonal timing of production with fertility (Fig. 2). Production increases at high fertility were relatively greater in autumn and spring than at other times of the year (interaction LSD (5%) 3.72 kg DM/ha/day; ***). This shift in seasonal

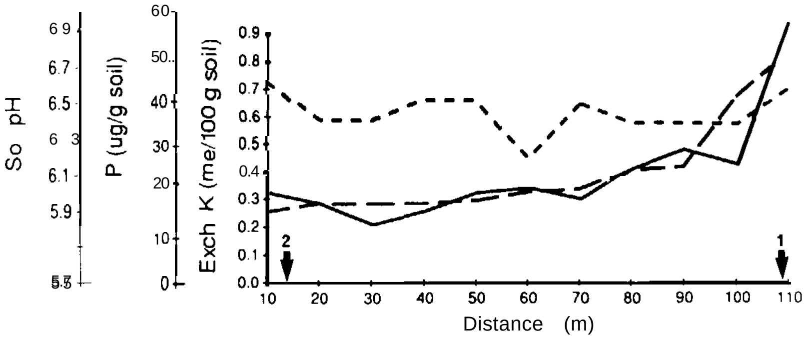

Figure 1: Soil pH (---) extractable P (—) and exchangeable K (- —) along a transect away from a road. Arrows indicate location of microsites.

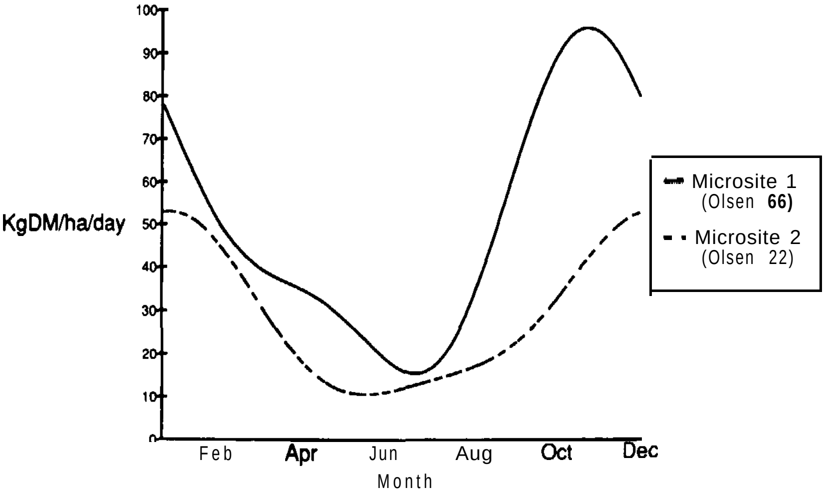

Figure 2: Pasture growth rate for microsites 1 and 2.

timing of production can be explained by a changed grass clover balance or by an increased incidence of low fertility tolerant grasses (Lambert et *al.* 1986). In view of the rather low incidence of such grasses at microsite 2 (Table 1), the former explanation seems more likely. Assuming nitrogen, rather than P *per* se is responsible for these effects, findings that nitrogen boosted pastures do produce a different annual pattern of feed flow (D. Clark pers comm.) are confirmed. Farmers using winter nitrogen would need to allow for this effect in formulating feed budgets and stocking policies.

Technique of microsite evaluation

It is very difficult and expensive to set up controlled experiments that give reliable information about factors affecting pasture production and composition. The alternative approach adopted here was not labour intensive and appears to have produced useful results. A larger study including additional variables such as temperature and moisture could be rewarding.

Table 1: Indices of soil chemical fertility, pasture composition (tillers/growing points per m^2) and pasture production (tonnes DM/ha/year) for seven microsites on No. 1 sheep farm, Massey University.

	Microsite[1]						
	1	2	3	4	5	6	7
Stocking rate/ha	26	26	26	26	26	16	16
Soil tests							
Olsen P[2]	66	22	109	30	14	26	17
Quicktest K[3]	0.52	0.16	1.6	0.25	0.17	0.66	0.44
pH	6.3	6.3	5.6	6.0	6.2	6.2	6.1
Pasture composition[4]							
White clover	762	2220	272	2490	3522	3390	3740
	(155)	(455)	(105)	(383)	(223)	(514)	(348)
Ryegrass	10490	7640	1360	7630	6630	3660	2480
	(651)	(781)	(159)	(214)	(553)	(614)	(167)
Poa spp.	6430	6050	1736	7130	4202	6130	3730
	(542)	(699)	(462)	(879)	(886)	(1022)	(716)
Cr. dogstail	192	695	0	91	529	153	263
	(56)	(130)		(26)	(54)	(68)	(57)
Yorkshire fog	0	153	0	0	635	366	1235
	—	(111)	—		(393)	(124)	(353)
Browntop	0	0	0	463	463	606	3660
				(312)	(160)	(204)	(923)
Sweet Vernal	0	627	0	691	1163	386	1235
		(474)		(635)	(455)	(114)	(342)
Barley grass	6	0	907	0	0		0
	(6)	—	(26)	—	—	(7)	—
Other grasses[5]	39	196	648	45	45	193	312
	(23)	(53)	(408)	(26)	(45)	(56)	(72)
Annual Pasture production[6]	19.1	11.2	10.5	15.4	9.9	14.1	13.1
	(0.66)	(0.74)	(0.60)	(0.69)	(0.77)	(0.53)	(0.50)

[1] For microsite descriptions see text.
[2] mg P/kg soil
[3] m eq. %[4]S.E. in parentheses
[5] mainly *Bromus hordeaceus* (Soft brome)
[6] Calculated from fitted Fourier equations, S.E. in parentheses.

CONCLUSIONS

Soil fertility gradients, thought to be due to nutrient transfer in dung and urine, are very substantial on these flat lowland pastures.

Soil fertility is much more important in explaining variations in pasture composition than stocking rate.

Pasture composition showed a transition from barley grass dominance where Olsen P = 109 through ryegrass dominance where Olsen P = 66 to a mixture of species where Olsen P = 14.

There appeared to be a change in seasonal timing of production with high fertility, which is attributed to a change in grass:clover balance with increased nitrogen input from dung and urine.

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