A BIOASSAY OF SOME CAMPBELL ISLAND SOILS

M. N. FOGGO[1] AND COLIN D. MEURK[2]

[1] *Central Institute of Technology, Private Bag, Trentham, New Zealand.*

[2] *Department of Botany, University of Otago, P.O. Box 56, Dunedin, New Zealand.*

Present address: DSIR (Grasslands Division), Private Bag, Gore, New Zealand.

SUMMARY: Growth of *A vena sativa* L. and *Agrostis tenuis* Sibth was measured on peat and mineral soils from sites on Campbell Island in the New Zealand subantarctic. For the peat soils, growth was strongly positively correlated with both pH and Mg levels and less strongly with Ca and Na. With the inclusion of the mineral soil data, only the fit between growth and Ca levels was significant.

KEYWORDS: Campbell Island; subantarctic islands; soil fertility; nutrient content; soil types; mineral soils; peat soils.

INTRODUCTION

Campbell Island is the main island of the subantarctic group at 52°S 169°E. It covers about 11000 ha.

Organic soils blanket most of the island and Campbell (1981) described the major types. He commented on large differences in nutrient status and suggested that these differences may influence plant growth, noting in particular that the shallow peaty soils have a ". . . . far better potential for plant growth because of the more favourable nutrient status".

The potential of the soil to promote plant growth may also influence the distribution and local density of the feral sheep population on the island (Wilson and Orwin, 1964; Wilson, 1979) and hence their contribution to accelerated erosion (Campbell, 1981). Wilson and Orwin (1964), Taylor, Bell and Wilson (1970) and ourselves observed large numbers of sheep on areas of shallow peaty soils (as defined by Campbell, 1981).

The plant growth potential of soils is best measured by actual plant growth (bioassay) on selected soils. A comparison of soil chemistry and bioassay results then allows the prediction of plant growth from soils for which chemical data only are available. Previous papers on New Zealand subantarctic soils (Aston, 1909; Leamy and Blakemore, 1960; Flint and Fineran, 1969; Ross, Campbell and Bridger, 1979; Campbell, 1981) list soil chemical data but have not attempted to determine nutrient availability by bioassay.

This paper reports the results of a bioassay of some Campbell Island soils and the correlation of the growth results with pH and some mineral analyses, expressed in terms of cation concentration per unit volume of soil.

METHODS

In January 1981, samples of five soils were collected on Campbell Island. Four were peat soils (A, B, C, D,) and the fifth was a mineral soil (E), (see Appendix I for a description of the sites from which the samples were taken).

The moisture contents and bulk densities were measured on the island. The samples were transported to New Zealand in the field-moist condition while sub-samples for chemical analysis were air-dried before transport.

In the laboratory, the peat sub-samples were prepared for chemical analysis by removing hard twigs in excess of 5 mm diameter and by putting through a Wareing blender. The mineral soil was seived through a 2 mm seive. Only 37 % by weight of the soil passed through the seive.

Conductivity was determined in a conductivity cell, the pH using a glass electrode and Mg, Ca, Na and K concentrations by ammonium acetate leaching and atomic absorption spectrophotometry (for method see Blakemore, Searle and Daly, 1977).

The mineral results obtained were converted to average mg/ml of soil volume (0-150 mm profile) using the bulk density figures obtained from field samples. For the mineral soil, the mineral levels thus calculated were reduced to 37 % to allow for the proportion of stones

The bioassay samples were stored in New Zealand in a controlled-temperature cool-room, kept moist and under black polythene sheeting. For the bioassay, each soil was broken up, homogenised and put into pots. Ten 120 mm diameter pots, holding approximately 3 l of soil, were used to give five replicate pots for each of *A vena sativa* L. and *Agrostis tenuis* Sibth. The pots were placed in a glass-

TABLE 1. *Physical and chemical analyses of four peat soils (A,B,C,D) and one mineral soil (E) collected from sites (described in Appendix 1) on Campbell Island.*

Soil sample	Soil ph	Conductivity mS	Bulk density g/ml	Mineral levels – mg/ml soil volume Ca	K	Na	Mg
A	4.05	1.06	0.07	0.107	0.036	0.106	0.125
B	4.31	0.92	0.12	0.164	0.096	0.208	0.208
C	4.62	1.10	0.17	0.394	0.086	0.308	0.265
D	4.70	3.40	0.15	0.392	0.057	0.669	0.317
E*	5.57	0.14	1.20	0.160	0.107	0.302	0.058

* *Note:* nutrient values are multiplied by 0.37, the proportion of fine analysed soil to total soil weight including pebbles> 2 mm.

TABLE 2. *Mean mass of dry matter per plant grown on each of the peat soils (A, B,C,D) and the mineral soil (E) from Campbell Island. The yield per soil is based on five plants per pot with five replicate pots per soil.*

Soil sample	*Avena sativa*		*Agrostis tenuis*	
	g/plant	S.E. of mean	g/plant	S.E. of mean
A	0.16	0.015	0.03	0.0002
B	0.77	0.108	0.18	0.027
C	1.09	0.049	0.33	0.041
D	1.36	0.082	0.58	0.020
E	0.36	0.050	0.16	0.007

house in a fully randomised lay-out, within species, and were re-randomised twice during the growing period.

The seeds were sown on 20 March 1982, the plants thinned to five per pot and later harvested on 11 June *(Avena)* and 18 June *(Agrostis)*.

RESULTS

The results of the soil chemical analyses are presented in Table 1. The bioassay results (Table 2) show marked differences between the soils.

The growth of the plants on the four peat soils was positively correlated with the levels of Mg, pH, Na and Ca (Table 3) but not with K or conductivity. When the mineral soil data were included, only the fit between growth and Ca levels was significant.

CONCLUSIONS

We have shown that Mg, pH, Ca and Na levels, in that order of reliability, predict plant growth on Campbell Island peat soils. The simplest index for growth is pH since it can be determined directly without the error~ inherent in mineral assays. These are influenced by extraction efficiency and inaccuracies of determining the bulk density.

Compared to the results from the peat soils, the plant growth on the mineral soil is less than was expected from its higher pH and from previous suggestions (Campbell, 1981) regarding the higher fertility of the shallow peat soils in which the inorganic mineral content was high. Plant growth on the mineraI soil does not appear to fit the correlations for peat soils, except for Ca, and it will be necessary to test a set of such soils to determine the most reliable predictor for them.

ACKNOWLEDGEMENTS

We thank DSIR (Ecology Division) for arranging our visit. L C. Blakemore advised us on soil analysis methods and B. K. Daly's assistance in carrying out the soil analysis has much appreciated. I. Campbell, P. McIntosh, M. R. Rudge and D. Scott made helpful comments on drafts.

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TABLE 3. *Correlation coefficients* (r) *and linear regression equations for mean yield* (g) *of dry weight per plant* (y) *against pH, Mg, Ca and Na levels for peat soils and against Ca for all soils collected from Campbell Island*. (x = *soil factor level;* d.f. = 3 *and* 4 *respectively;* * = p<0.05, ** = p<0.01)

Soil parameter	Correlation coefficients (r) and equations			
	Avena sativa		*Agrostis tenuis*	
Mg	1. 00**	y = -0.5858 + 6.2549x	0.97**	y = -0.3545 + 2.7738x
pH	0.98**	y = -6.6743 + 1.7012x	0.94**	y = -2.9846 + 0.7386x
Na	0.87	y = 0.2509 + 1.8406x	0.98**	y = -0.0222 + 0.9365x
Ca	0.91*	y = 0.0172 + 3.1327x	0.89*	y = -0.0862 + 1.3859x
Ca (all soils)	0.92**	y = 0.0517 + 0.2562x	0.90	y = 0.0923 + 0.5900x

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APPENDIX I

Physical and vegetative descriptions of the sites on Campbell Island from which the soils were collected (peat types after Campbell, 1981)

A. *Peat type:*	Oligotrophic, thick peat
Locality:	Homestead Ridge (the low ridge in middle distance of Campbell's Fig. 12).
Altitude:	23m
Aspect:	E
Slope:	< 5°
Proximity to coast:	0.5 km
Exposure:	Moderately exposed
Vegetation type:	Lowland tall tussock/low scrub /hard cushion bog (= "lanes" of Godley. 1965).
Structural dominants:	Scattered tussocks of *Chionochloa antarctica* up to *c*. 0.7 m tall (being degraded by sheep browsing); edaphically appressed shrubs of *Dracophyllum scoparium* up to *c*. 0.3 m tall; a few low shrubs of *Coprosma cuneata,* C. *ciliata,* and *Myrsine divaricata*.
Ground spp.:	*Oreobus pectinatus. Centrolepis ciliata. Dicranoloma, Scirpus aucklandicus, Bulbinella rossii, Coprosma pumila. Astelia subulata. Phyllachne colensoi.*

B. *Peat type:*	Oligotrophic. thick-thin peat (cf. Campbell's Fig. 12)
Locality:	Leeward Col Ridge, < 0.5 km south of St Col Peak.
Altitude:	200m
Aspect:	SE
Slope:	*c*. 20°
Proximity to coast:	1 km
Exposure:	Moderately sheltered
Vegetation type:	Upland, induced short tussock meadow
Structural dominants:	An open stand of *Poa lito rosa* tussocks up to 0.5 m tall; with *Bulbinella rossii, Polystichum vestitum,* and scattered low shrubs (as in A).
Ground spp.:	Bryophytes with *Sphagnum. Uncinia hookeri, Luzula crinita. Hymenophyllum multifidum, Coprosma pumila,* other graminoids and forbs.

NOTES: The Poa tussocks are very weak compared to those of site D. presumably because of the poor soils which were originally occupied by a more or less continuous *Chionochloa antarctica* tussock grassland until eliminated by burning and grazing. Although *P. litorosa* would naturally be ill-adapted to such impoverished, acid soils, except locally around old albatross nests or flushes, in the absence of competition from C. *antarctica* it can exist in a weakened state aided by its low palatability to sheep (Meurk, 1977, 1982).

C. *Peat type:*	Mesotrophic, thick peat (cf. Campbell's Fig. 4)
Locality:	Leeward footslopes of Beeman Hill
Altitude:	69m
Aspect:	E
Slope:	*23°*
Proximity to coast:	< 0.5 km
Exposure:	Sheltered
Vegetation type:	Dwarf heath forest
Structural dominants:	A canopy to 4 m tall is dominated by *Dracophyllum scoparium. D. longifolium* and slightly shorter *Myrsine divaricata* all with copious epiphytic cryptogams. A subcanopy comprises *Coprosma* spp. and beneath this is *Polystichum vestitum.* and rarely *Histiopteris incisa.*
Ground spp.:	Largely bare peat worn smooth by sealions and possibly penguins-which presumably enrich the soil. Protected spots support bryophyte mats, *Uncinia "aucklandica"* and orchids.

D. *Peat type:*	Eutrophic, thin shallow peat (cf. shoreline in Campbell's Fig. 9)
Locality:	Beeman Point shore, near mouth of Tucker Cove
Altitude:	1m
Aspect:	WSW
Slope:	10°
Proximity to coast:	0 km
Exposure:	Exposed
Vegetation type:	Maritime, tall tussock grassland
Structural dominants:	Vigorous tussocks of *Poa litorosa* up to 1.4 m tall with some *Bulbinella rossii* and *Poa foliosa.*
Ground spp.:	A large number of graminoids and forbs, many being introduced species, make up the intertussock matrix.

E. *Peat type:*	Eroded stony (basalt) shallow peat (cf. Campbell's Figs. 8, 14)
Locality:	Windward upper slopes of Mt Honey
Altitude:	539m
Aspect:	W
Slope:	*23°*
Proximity to coast:	>2km
Exposure:	Very exposed
Vegetation type:	Lichen scree
Structural dominants:	Mobile stones and rocks in matrix of peaty loam. Lichens *(Stereocaulon. Argopsis. Placopsis)* cover the large stones. A few graminoids and forbs cling to precarious footholds.