

Shoot growth and herbage element concentrations of 'Grasslands Puna' chicory (*Cichorium intybus* L.) under varying soil pH

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ABSTRACT In the glasshouse chicory (*Cichorium intybus* L.) shoot growth was not influenced by variations in soil pH from 4 to 6. The concentration in shoot dry matter of aluminium, cadmium, iron, magnesium, sodium, phosphorus, tin and strontium was not affected by pH. Zinc, boron, manganese, potassium and sulphur all decreased significantly with increasing pH while calcium increased. Eight elements (arsenic, cobalt, chromium, molybdenum, nickel, lead, selenium, silicon) were below the limits of measurement. The concentrations of major elements in field-grown chicory were similar to those in the glasshouse plants. Potassium, sodium, calcium, sulphur, boron, manganese and zinc in chicory were at levels higher than those normally found in ryegrass and white clover. The results confirm that chicory may supply grazing animals with some minerals at relatively high concentrations.

Keywords chicory, *Cichorium intybus*, element composition, soil pH, pH requirement

INTRODUCTION

Simplification of pasture seeds mixtures may lead to nutrient imbalances for livestock (Thomas *et al.* 1952). The traditional reason for including chicory in pastures is its high concentration of several elements. Chicory has a long, if intermittent, history of use in pastures here (Cockayne 19 15), and recent renewal of interest in the plant resulted in the release of 'Grasslands Puna' chicory (*Cichorium intybus* L.) in 1984.

In his description of the cultivar, Rumball (1986) reports that Puna was considerably lower in nitrogen and iron than ryegrass and red clover, higher in potassium, sodium, zinc and molybdenum and similar or intermediate in the remaining (unspecified) elements measured. Nothing is known about the effect of soil pH on growth and chemical composition of the plant. This was examined in a glasshouse experiment. Chicory from 9 field sites was analysed as a check on the glasshouse plants.

MATERIALS AND METHODS

Glasshouse experiment

Tokomaru soil, a gleyed yellow-grey earth from loess, that had received little or no fertiliser was collected from the 0-20 cm zone of a pasture. A lime response test was done on the sieved soil and calcium hydroxide was mixed through soil samples at rates calculated to produce 6 pH levels between the unamended soil (pH 4.5) and pH 7. Magnesium sulphate and potassium chloride were added as basal fertilisers and the soil was then potted (4.3 kg dry soil/pot). There were 20 replicates of each pH level.

One seedling of Puna was grown in each of the fully randomised pots, and all were irrigated with Middleton & Toxopeus's (1973) nutrient solution. Calcium and zinc were omitted from the solution because we had a particular interest in the effect of pH on uptake of zinc by chicory, and liming can influence extractable zinc.

The plants were grown for 38 days over mid-summer before the shoots were harvested, and regrowth was harvested after a further 27 days. Soil pH was measured in each pot at the start and end of the experiment.

Herbage from the first harvest was analysed for 23 elements by inductively coupled plasma-atomic emission spectroscopy. Ryegrass of known composition and reagent blanks were similarly analysed.

Field samples

Puna herbage samples from trials at 9 sites were collected in autumn 1987 and analysed for nitrogen, phosphorus, potassium, calcium, magnesium, sodium and zinc.

RESULTS

The final pH range in the experiment was 4.0 to 6.0, and this range had no significant effect on shoot DM yields at either harvest. Average shoot DM was 5.6 ± 2.9 g at harvest 1 and 12.8 ± 3.9 g at harvest 2.

Eight elements were below the limits of measurement of the procedure used, and the concentrations of a further 8 elements were not affected by variation in soil pH (Table 1).

Increasing soil pH significantly decreased the concentrations of zinc, boron, copper, manganese,

Table 1 Elements in chicory shoot DM that were below the limits of measurement (column 1) and average concentration and standard deviation of elements that were not influenced by change in soil pH (column 2). All concentrations are mg/kg.

(1)		(2)	
Arsenic	< 15	Aluminium	138 ± 119
Cobalt	< 5	Cadmium	3 ± 0.7
Chromium	< 2	Iron	178 ± 99
Molybdenum	< 1	Magnesium	3063 ± 535
Nickel	< 2	Sodium	4948 ± 1553
Lead	< 8	Phosphorus	7461 ± 1383
Selenium	< 15	Tin	16 ± 2
Silicon	< 8	Strontium	46 ± 13

sulphur and potassium in chicory (Figure 1) and increased calcium.

Chemical composition of the chicory field samples and soil type at the trial site are shown in Table 2.

DISCUSSION

The insensitivity of Puna growth to change in soil pH means the plant itself is tolerant of quite acid conditions. However, nutrients were supplied lavishly in the glasshouse. In the field, where nutrient supply is more influenced by soil biological activity, growing chicory at moderate pH (5.5 - 6.0) would benefit fertiliser economy.

The changes with pH in foliar concentrations of zinc, boron, manganese, copper and calcium follow normal patterns (e.g. Christensen *et al.* 1950) but the reduction in potassium and sulphur with increasing pH was not expected and cannot be readily explained.

The concentration of major elements was similar in the field-grown and glasshouse plants except for that of phosphorus which was generally higher in the glasshouse material. Most values fell in the usual range for chicory herbage (Thomas *et al.* 1952) so the glasshouse plants were normal.

There were some strong contrasts between the chicory and both the laboratory reference ryegrass analysed simultaneously and standards for ryegrass

and white clover, given by Cornforth (1984). Nitrogen, phosphorus, magnesium and copper were within the range of values reported for ryegrass and white clover, but potassium, sodium, calcium,

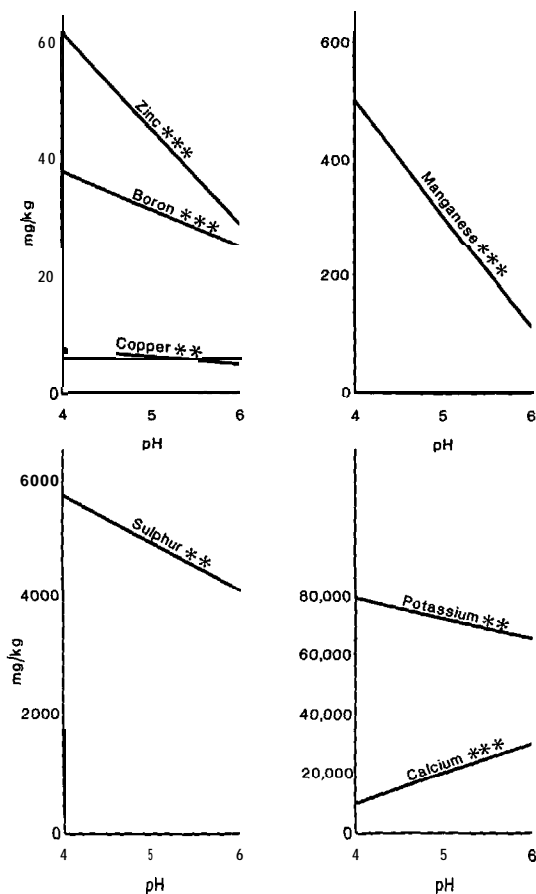


Figure 1 The effect of variation in soil pH from pH 4 to pH 6, on some elements in herbage of chicory.

sulphur, boron, manganese and zinc exceeded that range. In the glasshouse chicory averaged 7.6% potassium in shoot DM and one field sample was 9.2%. These are very high levels by most agricultural standards. Silicon was present in

Table 2 Chemical composition of chicory grown in field trials at different locations

Location	Soil	N	P	K	Na (% DM)	Ca	Mg	Zn (mg/kg)
Lincoln	Wakanui yellow-grey earth	2.65	0.24	4.6	0.60	1.32	0.34	43
Lincoln	Templeton recent soil	3.65	0.32	8.4	0.20	1.04	0.21	31
Taupo	Kaharoa yellow-brown pumice soil	2.65	0.29	6.4	0.20	1.34	0.20	60
Palm. North	Karapoti recent soil	2.50	0.34	7.5	0.40	1.35	0.22	40
Manawatu	Kairanga recent soil	3.20	0.38	7.6	0.25	1.32	0.21	44
Kaikohe	Waiotu brown loam	3.50	0.25	6.0	0.19	1.39	0.32	135
Kaitaia	Houhora yellow-brown sand	2.95	0.24	9.2	0.39	1.09	0.30	263
Kaitaia	Muirika organic-brown earth	3.96	0.58	7.5	0.86	1.64	0.39	51
								385

chicory at very low levels compared with both the reference ryegrass and reported levels in pasture species (Ashton & Morgan 1953). As silicon can alter the mechanical properties of herbage, chicory may be more readily digested than plants in which silica is deposited.

Zinc levels in Puna herbage ranged from 31 to 385 mg/kg in field material, and 12 to 102 mg/kg in the glasshouse. These exceed normal levels in pasture, but are lower than in earlier analyses of Puna and its parent chicory lines (145 to 880 mg/kg, P. Nes pers. comm.). Table 2 shows that there are very significant effects of soil type on zinc uptake, and the glasshouse experiment showed that pH is one important factor.

Zinc is a prophylactic for facial eczema. Sheep grazed on pure chicory swards containing 500 mg/kg DM zinc would ingest only about onequarter of the level of zinc found to be effective against facial eczema (Munday *et al.* 1986). Nevertheless, there may be differences between dietary intake of zinc and intermittent dosing with soluble zinc salts. The effect of regular grazing on zinc-rich chicory in summer, on susceptibility to facial eczema later in autumn, is worth investigating. A more important contribution of chicory may be its ability to provide greenfeed in summer and autumn (Lancashire 1978) when pasture presents a facial eczema hazard.

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