MINERAL COMPOSITION AND NUTRITIVE VALUE OF SOME COMMON PASTURE WEEDS

K.C. HARRINGTON[1], A. THATCHER[2] and P.D. KEMP[1]

[1]*Institute of Natural Resources, Massey University, Palmerston North*
[2]*Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North*

Corresponding author: K.Harrington@massey.ac.nz

ABSTRACT

Organic dairy farmers often introduce alternative pasture species, such as chicory (*Cichorium intybus*) and narrow-leaved plantain (*Plantago lanceolata*), to their swards because of their higher mineral contents, yet they are concerned about the presence of weed species such as docks (*Rumex* spp.) and dandelion (*Taraxacum officinale*). The mineral content and nutritive value of both desired and less desired pasture components from an organic dairy farm were analysed and compared. Minerals such as magnesium, manganese, copper, zinc, boron, cobalt and selenium were often significantly higher in species such as chicory, narrow-leaved plantain, dandelion, broad-leaved dock (*Rumex obtusifolius*), Californian thistle (*Cirsium arvense*) and hairy buttercup (*Ranunculus sardous*) than the perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) components of the sward. Likewise the crude protein levels of these species plus Yorkshire fog (*Holcus lanatus*) were significantly higher than for perennial ryegrass. Implications of these findings are discussed in terms of animal nutrition and health.

Keywords: pasture weeds, mineral composition, nutritive value, hairy buttercup, broad-leaved dock, Californian thistle, chicory, narrow-leaved plantain, dandelion, Yorkshire fog.

INTRODUCTION

Advisors within the organic agriculture movement are often keen to increase the diversity of plant species present within pastures, calling such mixtures "herbal leys" (Foster 1988). One reason for seeking plant diversity is that many of the species planted in herbal ley mixtures have higher mineral contents than New Zealand's two main pasture species of perennial ryegrass and white clover, and this is considered to be desirable for animal health reasons. Chicory is one species advocated to be planted in herbal leys, as it has been shown to have higher levels of potassium, sodium, calcium, sulphur, boron, manganese and zinc than do perennial ryegrass or white clover (Hare et al. 1987). Likewise, narrow-leaved plantain is considered a useful addition to pasture swards due to its higher mineral content and favourable nutritive value (Sanderson et al. 2003).

At the organic dairy unit at Massey University, five of the main weed species are hairy buttercup, broad-leaved dock, Californian thistle, dandelion and Yorkshire fog. All of these have been observed being eaten by the cows, although Californian thistle is most likely to be eaten if mown prior to grazing. The objective of this work was to determine whether the mineral content and nutritive value of these unwanted plant species differs from the more desired species of perennial ryegrass, white clover, chicory and narrow-leaved plantain.

MATERIALS AND METHODS

Plant samples were taken from both the organic dairy unit and the adjacent conventional dairy unit within the Dairy Cattle Research Unit of Massey University on 25 January 2005. These two units are on a Tokomaru silt loam, and organic farming principles have been used on the organic unit since 1 August 2001, with full AgriQuality organic certification obtained on 1 August 2003. Details about the running of the two units have been described elsewhere (Kelly et al. 2005). Within the 12 months prior to taking plant samples, organic paddocks had been treated with 200 kg/ha of Revital Vermicast (Revital Fertilisers 2006) and 200 kg/ha of reactive phosphate rock (RPR) on 14 May, and within the previous 2 months with 1 tonne/ha of Revital 30, 200 kg/ha Biophos, 15 kg/ha elemental sulphur and 5 kg/ha of boron. Conventional paddocks received 150 kg/ha nitrogen (as urea), 215 kg/ha superphosphate and 27 kg/ha Selenium Ultra in April 2004, then 500 kg/ha potassic superphosphate in December 2004. Herbicides are seldom applied on the conventional unit, and when they are it is in new pastures or for spot-spraying weeds such as ragwort (*Senecio jacobaea*) and hemlock (*Conium maculatum*). Measurements of weeds in November 2004 showed an average weed composition of 10.4% in organic paddocks compared with 5.3% in conventional paddocks (Kelly et al. 2005), mainly due to less docks and hairy buttercup in the latter.

A 100 g (fresh weight) sample of each species listed in Table 1 was sampled from across each of three paddocks on the organic unit, and also from three conventional paddocks for perennial ryegrass, white clover, broad-leaved dock, hairy buttercup, dandelion and Californian thistle. The material was dried to 65°C and sub-samples were finely ground prior to the mineral composition of the samples being determined by Analytical Research Laboratories Ltd in Napier. They used a CEM Corporation closed vessel microwave to digest 0.5 g samples of dried plant tissue with 5 ml of concentrated nitric acid and 3 ml of hydrogen peroxide at a maximum temperature of 210°C. The resulting solution was diluted to 25 ml in reverse osmosis water and analysed with an inductively coupled plasma spectrophotometer, comparing results against a linear series of standard solutions of increasing concentration. The nutritive value of the samples was determined by FeedTECH, AgResearch, Palmerston North. Samples were analysed using near infrared reflectance spectroscopy (NIRS) as described by Corson et al. (1999) to determine the acid detergent fibre (ADF), ash and total crude protein content.

All data were subjected to analyses of variance using SAS, and least significant differences (LSD) were calculated at P=0.05 for each variable where significant differences were found.

RESULTS

All of the broad-leaved species tested contained at least one macronutrient at a significantly higher level than that found in either perennial ryegrass or white clover (Table 1). Both chicory and narrow-leaved plantain had significantly higher levels of phosphorus, sulphur and sodium, with calcium higher in narrow-leaved plantain and magnesium higher in chicory. High macronutrient levels in more weedy species included elevated levels of phosphorus, magnesium and sodium in dandelion, sulphur and calcium in Californian thistle, and phosphorus and sodium in hairy buttercup.

Although chicory and narrow-leaved plantain had significantly higher levels of some micronutrients when compared with perennial ryegrass and white clover, a number of the weedy species also had elevated micronutrient levels (Table 2). Zinc was significantly higher in chicory, narrow-leaved plantain, Californian thistle, dandelion and hairy buttercup. Copper and cobalt were also higher in several species, while manganese was high in broad-leaved dock and molybdenum was high in Yorkshire fog.

TABLE 1: The macronutrient composition (% of dry matter) of pasture and weed species from organic dairy pastures. Figures in bold are significantly higher than in either perennial ryegrass or white clover.

	N	P	K	S	Ca	Mg	Na
perennial ryegrass	3.77	0.370	3.80	0.347	0.42	0.173	0.182
white clover	4.56	0.347	2.83	0.213	1.19	0.237	0.205
chicory	4.35	**0.663**	3.80	**0.627**	1.18	**0.393**	**0.591**
narrow-leaved plantain	3.37	**0.480**	1.97	**0.530**	**1.77**	0.253	**0.618**
broad-leaved dock	4.50	0.430	4.10	0.287	0.80	**0.520**	0.026
Californian thistle	2.80	0.357	2.93	**0.570**	**1.87**	0.307	0.047
dandelion	3.60	**0.570**	3.43	0.393	0.96	**0.353**	**0.420**
hairy buttercup	2.93	**0.457**	3.03	0.323	1.16	0.250	**0.433**
Yorkshire fog	2.70	0.400	3.20	0.260	0.36	0.173	0.175
LSD (P<0.05)	0.84	0.071	1.06	0.148	0.473	0.074	0.161

TABLE 2: The micronutrient composition (mg/kg) of pasture and weed species from organic dairy pastures. Figures in bold are significantly higher than in either perennial ryegrass or white clover.

	Fe	Mn	Cu	Zn	B	Co	Se	Mo
perennial ryegrass	151	99	7.9	22.0	19.0	0.193	0.023	0.640
white clover	109	55	8.6	22.0	28.7	0.173	0.073	0.223
chicory	167	161	**18.6**	**57.7**	**38.3**	0.273	0.043	0.420
narrow-leaved plantain	182	109	**15.1**	**37.7**	23.3	**0.360**	0.053	0.270
broad-leaved dock	95	**283**	7.6	30.7	23.0	**0.560**	0.047	0.420
Californian thistle	139	120	**17.0**	**41.7**	29.3	**0.330**	0.033	0.210
dandelion	115	93	**14.2**	**37.0**	**35.0**	0.180	0.043	0.373
hairy buttercup	117	150	**18.4**	**41.7**	27.7	0.253	0.043	0.497
Yorkshire fog	116	142	5.7	19.3	16.0	0.163	0.027	**1.243**
LSD (P<0.05)	67	70	2.8	12.0	5.4	0.105	0.075	0.261

Three indicators of nutritive value are presented for each species in Table 3. ADF levels are a measure of indigestible portions of the feed, and none of the weed species had ADF levels as high as perennial ryegrass. Ash measures the mineral content of the species, and broad-leaved dock had a significantly higher ash content than ryegrass or white clover. All of the weed species had total crude protein levels similar or higher than those found in white clover.

For all variables measured, there were very few significant differences between plants from conventional dairy pastures compared with those in organic dairy pastures, so they have not been presented here. All trends presented above were the same.

DISCUSSION

Underwood & Suttle (1999) have reviewed the mineral requirements for animals, and discussed the problems caused by deficiencies of macro- and micronutrients. There has been interest for many years in growing "herb" species in pastures to help ensure minerals are not deficient, especially those not present in high concentrations within perennial ryegrass and white clover (Foster 1988).

The results of the present work confirmed that chicory and narrow-leaved plantain are species that will provide significantly higher levels of some minerals than perennial

TABLE 3: The levels of acid detergent fibre (ADF), ash and total crude protein (all expressed as g/kg of dry matter) of pasture and weed species from organic dairy pastures. Figures in bold are significantly higher than in either perennial ryegrass or white clover.

	ADF	Ash	Protein
perennial ryegrass	281	117	232
white clover	228	129	270
chicory	261	147	**307**
narrow-leaved plantain	256	119	283
broad-leaved dock	245	**151**	**305**
Californian thistle	247	128	292
dandelion	262	130	287
hairy buttercup	233	123	278
Yorkshire fog	261	116	295
LSD (P<0.05)	18	20	33

ryegrass and white clover, but also showed that many of the weed species routinely present in pastures also contain high levels of minerals (Tables 1 and 2). Also, their feed quality is often comparable with that of perennial ryegrass and white clover (Table 3).

Some minerals are more useful than others at elevated levels for general animal health (Underwood & Suttle 1999). On the Massey University dairy farms elevated levels of magnesium are considered useful to assist with metabolic problems and copper deficiency has been diagnosed in cows following drought conditions. Chicory, broad-leaved dock and dandelion contained significantly higher levels of magnesium, while copper was found at significantly higher levels in five different species compared with perennial ryegrass and white clover. Higher levels of copper have been measured from dairy cows on the organic unit than the conventional unit (A. Thatcher, unpubl. data), and copper accumulating plants are considered to be the most likely explanation. Chicory is present only on the organic unit.

Some weed species are not eaten readily, due to chemicals in the leaves, such as ranunculin in hairy buttercup (Connor 1977) and condensed tannins in broad-leaved dock (Waghorn & Jones 1989), or spines, such as Californian thistle. However, observations at the two dairy units have shown that most weed species are eaten to some extent at various times of the year, especially if pastures are mown prior to cows entering a paddock.

Although some weed species are difficult to tolerate within high producing pastures due to their low palatability, presence of toxins and effect on pasture utilisation, farmers should not ignore the high mineral content of many weed species and thus their potentially useful role within the diet of their cows, especially in organic farming systems where less medicinal remedies are available.

Mineral contents were higher in some plant species than others regardless of whether they were growing on the organic or conventional properties. This is probably because most minerals are at similar levels on both properties despite differences in the types of fertiliser used. Differences in accumulation rates of some minerals between species appear to be much greater than differences in soil mineral levels between the properties.

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