INFLUENCE OF MATURITY AND FREQUENCY OF HARVEST ON THE NUTRITIVE QUALITY OF COOL SEASON FORAGE LEGUMES

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ABSTRACT

Eight cool season legumes of the genera **Medicago, Trifolium, Ornithopus** and **Vicia** which gave good forage yields in Northland were chosen for analysis of forage nutritive quality. Forage harvested on three dates from mid-winter to mid-spring showed a progressive decline in protein and digestibility, paralleled by a fall in the proportion of leaf tissue. A single mid-spring cut maximised yields, but reduced protein content and digestibility. Substantial species variations were apparent, with later flowering **Medicago** spp. and **Trifolium** spp. retaining quality longer than earlier flowering types. **O. sativus** and **V. dasycarpa** also retained good protein content and digestibility. The level of some mineral nutrients (P, K, Na) also varied with maturity and between species, while others (Ca, Mg) remained relatively constant.

The nutritive quality of most of these legumes would meet animal production requirements if grazed at two monthly intervals. However, if the legumes are conserved after six months growth, species variation in nutritive quality is likely to be more marked and some types would find definite preference, depending on the class of livestock consuming the forage.

INTRODUCTION

The use of annual winter growing legumes in double cropping systems has recently been discussed by Taylor and Hughes (1976). Field plot trials with thirty-six legumes of the genera **Medicago, Trifolium, Vicia** and **Ornithopus** have subsequently been run close to Kaitaia in Northland. Several of the better lines produced approximately 6,000 kg DM/ha in a three-cut system and between 7,000 to 11,000 kg DM/ha in a single-cut system when planted in early April and finally harvested in late October (Taylor *et al.*, in press). These legumes can be grown in rotation with maize and hence fed in conjunction with maize silage. Maize silage is low in protein and some minerals (Anon, 1970), so legumes high in these nutrients would be useful in providing a more balanced total ration for ruminants. A range of the higher yielding legumes which differed in maturity and/or plant habit were selected for forage quality analysis. Dry matter digestibility and levels of nitrogen and of major mineral nutrients were assessed. Forage composition (leaf, stem, seedhead etc.) and fibre content were also assessed in an attempt to explain some of the changes in forage nutritive quality.

EXPERIMENTAL

Trial design

Full details of the trial design and harvest dates are published in Taylor *et al.*, (in press). Two trials were run on different soil types near Kaitaia, but forage from both has been pooled for chemical analysis. Trials were planted in early April and two harvest systems were used, namely, three cuts (June, August, October) and one cut (October). Forage was harvested by hand at a 2 cm cutting height.

Legume species

Three **Medicago** spp. which yielded well but which differed in maturity were chosen for analysis. **Medicago tornata** cv. Tornafield was one of the earliest to flower; **M. polymorpha** SA 4364 was intermediate and **M. intertexta** SA 5788 was the last to flower.

Trifolium incarnatum (Australian commercial) and **T. vesiculosum** cv. Yuchi were two of the better yielding of the more erect growing **Trifolium** spp. **T. incarnatum** was past full flower at the time of the final harvest and was beginning to senesce; while **T. vesiculosum** was commencing flowering at the time of the final harvest. **Trifolium subterraneum** cv. Woogenellup is a mid-season cultivar in Australia (Barnard, 1972) with large leaflets, long petioles and reputed good winter growth.

Vicia dasycarpa cv. Namoi was the most consistent yielding of the vetches, largely because of better basal tiller production and disease resistance. Namoi was in full flower at the time of the final harvest.

Ornithopus sativus (W48, French Serradella) was the highest yielding legume on the sandy site and has also yielded well on coastal sands in the Manawatu (Williams *et al.*, 1975). Serradella had just commenced flowering at the time of the final harvest.

Analytical techniques

Plant material was dried in a forced draught oven at 95°C for 12 hr and ground by microhammer mill to pass a 1 mm screen. Dry matter digestibility was assessed using an enzymic hydrolysis technique (Roughan and Holland, in press). Dry ground plant material was extracted initially with neutral detergent and the residue hydrolysed with fungal cellulase. **In vivo** dry matter digestibilities were predicted from cellulose digestibilities using a regression equation derived by hydrolyzing samples of measured **in vivo** dry matter digestibility.

Plant nitrogen was measured after micro-Kjeldahl digestion by a colorimetric technique (Chaney and Marbach, 1962). Cell wall content was measured as neutral detergent fibre (NDF) by extraction with sodium lauryl sulphate (Van Soest and Wine, 1967). Minerals were extracted from dry ashed plant material with 2N HCl and measured by flame photometry (K, Ca, Na) or atomic absorption spectrometry (Mg). Phosphorous was measured colorimetrically after wet ashing of plant material (Haslemore and Roughan, 1976).

RESULTS AND DISCUSSION

Dry Matter digestibility

When legumes were cut three times during their cool season growth period, dry matter digestibility of their forage fell by 3 to 11 percentage points from the early (June) to the late (October) harvest. When cut only once, the generally larger bulk of late cut material was 1 to 15 percentage points lower in digestibility than that of total forage harvested in the three-cut system. These seasonal and cutting frequency induced changes in digestibility were probably caused by an increase in the proportion of stem tissue (fall in leaf tissue; Table 1) in the forage and possibly a decrease in the digestibility of stem tissue (Demarquilly and Jarrige, 1974). Substantial amounts of flowering tissue (**T. incarnatum**) or of seed pod (**M. tornata**) were associated with lowest forage digestibilities measured in the trial. Similar seasonal changes have been reported overseas where the dry matter digestibilities of **Medicago scutellata** in Australia (Jones and McLeod, 1971) and of **Trifolium vesiculosum** in the U.S.A. (Smith *et al.*, 1975) fall slowly from around 80% at an early vegetative stage to 70% at flowering and then to drop more rapidly as seed development and senescence progresses.

Later flowering legumes generally maintained higher digestibilities through to mid-spring than earlier maturing types, particularly in the single-cut

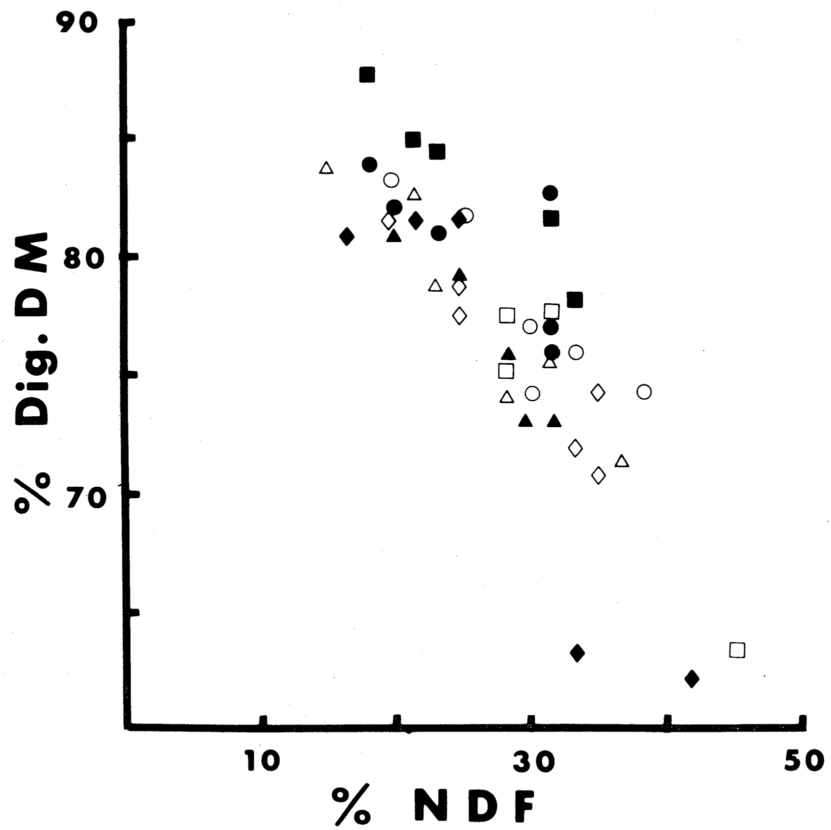

FIG. 1: Relationship between dry matter digestibility (% Dig. DM) and neutral detergent fibre (% NDF) in a range of legumes.

Medicago tornata (□), **M. polymorpha** (○), **M. intertexta** (△), **Trifolium vesiculosum** (■), **T. incarnatum** (♦) **T. subterraneum** (●), **Vicia dasycarpa** (◊) and **Ornithopus sativus** (▲).

TABLE 1: Influence of harvest frequency on protein content, dry matter digestibility and proportion of leaf in the forage of some selected cool season legumes

	Percentage on DM basis	3 cut system				1 cut
		H1	H2	H3	Mean[1]	system
Medicago tornata cv. Tornafield	Protein[2]	30.0	28.7	18.7	24.4	14.4
	Digest.	81.1	77.3	76.9	78.1	63.0
	Leaf	87.7	48.5	33.0	51.0	14.0
Medicago polymorpha SA 4364	Protein	30.0	31.2	25.0	28.1	12.5
	Digest.	82.6	81.3	76.6	79.4	75.7
	Leaf	75.4	67.0	30.4	51.8	26.8
Medicago intertexta SA 5788	Protein	28.1	28.1	16.9	21.9	16.9
	Digest.	83.5	82.5	75.6	78.7	70.9
	Leaf	81.4	56.5	33.5	47.5	17.1
Trifolium incarnatum Aust. commercial	Protein	27.5	28.7	13.1	18.1	14.4
	Digest.	80.3	81.4	62.9	68.8	61.8
	Leaf	100.0	87.5	24.0	45.9	17.2
Trifolium vesiculosum cv. Yuchi	Protein	28.1	31.9	20.0	23.1	17.5
	Digest.	87.4	84.8	80.9	82.2	77.5
	Leaf	97.9	86.0	62.5	70.0	40.7
Trifolium subterraneum cv. Woogenellup	Protein	28.2	30.6	26.2	27.5	14.4
	Digest.	83.2	81.6	76.8	78.9	75.5
	Leaf	99.7	95.5	43.0	64.3	47.9
Vicia dasycarpa cv. Namoi	Protein	31.1	35.0	25.0	28.7	26.2
	Digest.	78.2	77.0	71.4	74.2	73.7
	Leaf	72.3	66.0	41.7	54.0	38.1
Ornithopus sativus W 48	Protein	25.0	26.9	20.0	22.5	18.7
	Digest.	80.3	79.0	72.5	75.6	72.5
	Leaf	88.8	63.5	46.2	58.7	25.4

[1] Weighted mean based on total forage produced in the 3 cut system.

[2] Protein equals nitrogen x 6.25.

system. An exception was the late flowering **M. intertexta** which develops thicker, more erect stems and tends to have a lower proportion of leaf in its forage than other **Medicago** spp.

Dry matter digestibility of these legumes was related to their fibre content (Fig. 1) as would be expected (Van Soest and Wine, 1967), but some cultivar differences were apparent. At any particular fibre content, for example, **T. incarnatum** and **O. sativus** tended to have a lower digestibility than **T. subterraneum** cv. Woogenellup and particularly **T. vesiculosum.** Plant fibre content, while easy to determine, does not appear to give sufficiently accurate estimates of digestibility when considering such a wide range of legumes.

Protein content

Forage nitrogen content fell in the same general manner as forage digestibility with advancing crop maturity and reduced harvest frequency (Table 1). At the first harvest in June, all legumes had a protein content (N x 6.25) between 25 and 30%, while the lowest levels (12.5 to 14.5%) were measured in forage of the earlier flowering **Medicago** spp. and **Trifolium** spp. harvested as a single cut in October. The later flowering **M. intertexta** and **T. vesiculosum** maintained higher protein contents in the single-cut system. Highest forage protein contents in the single-cut system were, however, maintained by **Ornithopus sativus** and **Vicia dasycarpa.** This feature of **Vicia** and **Ornithopus** has previously been noted by Gladstones and Loneragan (1975) in Australia, who tested a substantial range of annual winter growing legumes and grasses.

Mineral content

Mineral content (Ca, Na, P, Mg, K) of the legumes did not undergo major seasonal changes during the period of this trial, so weighted means for the three-harvest system have been given in Table 2. Levels of potassium in the earlier flowering lines fell slowly in successive harvests of the three-cut system and those measured under the single-cut system were less than the mean of the three-cut system, but K levels were always substantially above those required for animal nutrition (Anon, 1970, 71). Sodium levels showed considerable species variation and in some cases were below those required for lactating animals (Anon, 1971). Phosphorous levels also varied among species and were affected by cutting frequency. Levels were higher in young regrowth (three-cut system) and fell with increased harvest interval; this being most pronounced in the two earlier flowering **Medicago** spp. Highest levels of phosphorous were present in **V. dasycarpa**, although most of the legumes contained sufficient to maintain good animal

TABLE 2: Influence of harvest frequency on the mineral nutrient content of cool season legumes. Data are presented as percentage dry weight and weighted means given for the 3 cut system.

		K	Ca	Mg	Na	P
M. tornata	3 cut	3.65	1.02	0.30	0.29	0.40
cv. Tornafield	1 cut	1.73	0.86	0.22	0.31	0.26
M. polymorpha	3 cut	3.52	1.06	0.26	0.33	0.41
SA 4364	1 cut	2.15	0.90	0.26	0.32	0.26
M. intertexta	3 cut	4.05	1.00	0.33	0.55	0.35
SA 5788	1 cut	4.78	0.93	0.27	0.39	0.32
T. incarnatum	3 cut	3.23	1.21	0.24	0.17	0.41
Aust. Commercial	1 cut	2.45	1.33	0.27	0.23	0.40
T. vesiculosum	3 cut	4.07	1.06	0.20	0.12	0.39
cv Yuchi	1 cut	4.15	1.24	0.26	0.20	0.32
T. subterraneum	3 cut	3.54	1.25	0.26	0.35	0.31
cv. Woogenellup	1 cut	2.57	1.37	0.27	0.45	0.27
V. dasycarpa	3 cut	3.90	0.93	0.23	0.17	0.45
cv. Namoi	1 cut	4.43	0.88	0.25	0.14	0.44
Ornithopus sativus	3 cut	3.63	1.16	0.26	0.39	0.43
W 48	1 cut	2.42	1.22	0.25	0.60	0.31

TABLE 3: Nutrient content (% DM) of theoretical high dry matter silages prepared from a cool season legume, from maize and from a composite ration of the two. Animal nutrient requirements for moderately high levels of lactation and live weight gain are also noted as a basis for evaluation.

	Protein		Metabolisable energy					
	Crude	Dig.	Mcal/kg	Ca	Na	P	Mg	K
Medicago intertexta silage Single harvest	16.9	11.0*	1.88*	0.93	0.39	0.32	0.27	4.78
Maize silage ** Whole Plant with good cobs	8.1	4.7	2.57	0.27	0.03	0.20	0.18	1.05
Composite ration (maize:medic = 2:1)	11.0	6.8	2.34	0.49	0.15	0.24	0.21	2.29
Lactating cow requirements** 20-30 kg milk/day	15.0	11.4	2.3	0.47	0.18	0.35	0.10	0.7
Finishing steers ** 300 kg body weight; 1.1 kg/day gain	12.2	8.1	2.67	0.37	0.10	0.27	0.08	0.7

* Data for Medicago sativa; wilted, ensiled at early bloom (Anon, 1970).
** Data from Anon, 1970, 1971.

production (Table 3) provided they were not allowed to become over mature before harvesting. Calcium and magnesium levels were not affected greatly by harvesting treatments, were reasonably consistent between species and were substantially above animal requirements.

Legumes in balanced ruminant rations

A double-crop system involving maize and a winter growing legume in Northland could produce annual paddock yields of 18,000 kg DM/ha maize plus 9,000 kg DM/ha for the legume, with both harvested as a single cut. The legume could be conserved as wilted or acid-treated silage and fed with the maize silage as a composite ration. The probable nutrient content of a typical legume conserved as wilted silage, of maize silage, and a composite legume/maize silage ration are shown in Table 3, along with the feed compositions needed to sustain a moderately high level of animal production either as milk or live weight gain. **Medicago intertexta** has been chosen as typical of the legumes tested.

It is apparent that the composite maize/legume ration is closer to animal requirements than either of the individual silages, but that further supplementation would improve animal production.

Minor additions of salt (NaCl) and phosphorous are likely to be required for dairying use. Digestible protein levels in the composite ration are relatively low. If urea was used to increase "protein" content, then growing steers and lactating cows would require 4.5 g and 16 g urea/kg of silage dry matter, respectively. Up to 16 g urea/kg (1.6%) in a ration should not be toxic (van Horn *et al.,* 1967), but a lower level would probably be preferred.

Energy content of the composite ration is marginally sufficient for dairying cows, but is too low to finish steers at a live weight gain of 1.1 kg/day. Grain additions to the diet would be required to enable the steers to achieve this rate of live weight gain. It is apparent that improvement in the digestible protein and energy content of the legume would be beneficial. If the legume was grazed two or three times rather than conserved as a single-cut silage, then its protein content and digestibility would be sufficient for high levels of animal production.

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